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On the Evolution of the Heavenly Spheres: An Enactive Approach to Cosmography

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ON THE EVOLUTION OF THE HEAVENLY SPHERES
An Enactive Approach to Cosmography

by

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Abstract

The ability to view the world from multiple perspectives is essential for tackling complex, interconnected challenges. Yet conventional academic structures are designed to produce knowledge through ever-increasing specialization and compartmentalization. This fragmentation is often reinforced by tacit dualistic assumptions that prioritize linear thinking and abstract ways of knowing. Though the need for integrated approaches has been widely acknowledged, effective techniques for transcending disciplinary boundaries remain elusive.

This thesis describes a practical strategy that uses immersive visualizations to cultivate transdisciplinary perspectives. It develops an enactive approach to cosmography, contending that processes of visualizing and interpreting the cosmos iteratively shape ‘views’ of the ‘world.’ The archetypal trope of the *heavenly sphere* is examined to demonstrate the significance of its interpretations in this history of ideas. Action research and mixed methods are employed to elucidate the theoretical considerations, cultural relevance, and practical consequences of this approach.

The study begins with an investigation into the recurring appearance of the *heavenly sphere* across time, in which its embodied origins, metaphorical influence, and material embodiments are considered. Particular attention is given to how cosmographic tools and techniques have facilitated imaginary ‘flights’ through the heavens, from the ecstatic bird’s eye view of the shaman to the ‘Archimedean point’ of modern science. It then examines how these cosmographic practices have shaped cosmological beliefs and paradigmatic assumptions. Next, the practical utility of this approach is demonstrated through the development of *cosmographic hermeneutics*, a

technique using visual heuristics to interpret cosmic models from transdisciplinary *world views*. Finally, the performative practice of *cosmotroping* is described, in which *cosmographic hermeneutics* are applied to re-imagine the ancient dream of the transcendent ‘cosmic journey’ within immersive vision theaters. This study concludes that the re-emergence of the *heavenly sphere* within the contemporary *Digital Universe Atlas* provides a leverage point for illuminating the complexity of knowledge production processes. It is claimed that this research has produced a practical strategy for demonstrating that the ultimate Archimedean point is the ability to recognize the limits of our own knowledge, a crucial first step in cultivating much-needed multi-perspectival and paradoxical *spherical thinking*.

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Charles Eames once observed, “Eventually everything connects—people, ideas, objects. The quality of the connections is the key to quality per se.” I’m infinitely grateful for the multitude of quality connections that have made this work possible.

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I also extend thanks to my *Planetary Collegium*, *Transtechology Research*, and *i-DAT* colleagues for exploring so many ideas from seemingly diverse areas of inquiry that always somehow connected, the *Alternate Realities Corporation* for showing me the potential of immersive vision, the *Worldviews Network* for integrating scientific rigor with planetary compassion, the *Whidbey GeoDome* crew for perennial encouragement, the *Mythica* team for helping me understand the lessons of the stars, the remarkable comprehensivists at the *Buckminster Fuller Institute* for giving me the gift of trimtabs, the *Bok Globule*, *Hayden Planetarium*, *NCSA*, and *SCISS* teams for making it possible to interrogate the visible universe, the *Fulldome* community for their contributions to the evolving the medium, all of my friends in Asheville for helping to test out cosmic ideas at a local scale—including the *Black Mountain College Museum + Arts Center* for connecting me to our lineage, the *Black Box Studio* crew for your provocations and companionship, and the *Media Arts Project* for exploring the potential of media arts from quarks to quasars—my *UNCA* and *UNC* mentors for encouraging explorations of the creative possibilities of mediated perception, Drika Horton for your recent unconditional provocations, Jax for your constant companionship and lessons of inter-species communication, Sandor Hamilton and Septimbor Whited for the early opening of cosmic portals, and to the countless complex entanglements that have enabled the realization of this project.

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I am also deeply grateful to my director of studies, Michael Punt, secondary supervisor, Mike Phillips, and founder of the *Planetary Collegium*, Roy Ascott at Plymouth University for creating a space within the Academy that has encouraged and enabled the wide-ranging, transdisciplinary nature of this investigation.

And finally, in honor of Mom, Mimi, Papa, Nanny, and Granddaddy, I dedicate this work to all of our relations on Earth and in the heavens—past, present and future...

Author's Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Committee.

Work submitted for this research degree at Plymouth University has not formed part of any other degree either at Plymouth University or at another establishment. The author personally financed this study.

A program of advanced study was undertaken with the Planetary Collegium, which included nine in-person sessions lasting ten days each over three years.

Relevant scientific seminars and conferences were regularly attended at which work was often presented; external institutions were visited for consultation purposes and several papers prepared for publication.

Word count of main body of thesis: 86,005

Prologue

*“Knock on the sky
and listen to the sound!”
(Shigematsu, 1981, p. 78)*

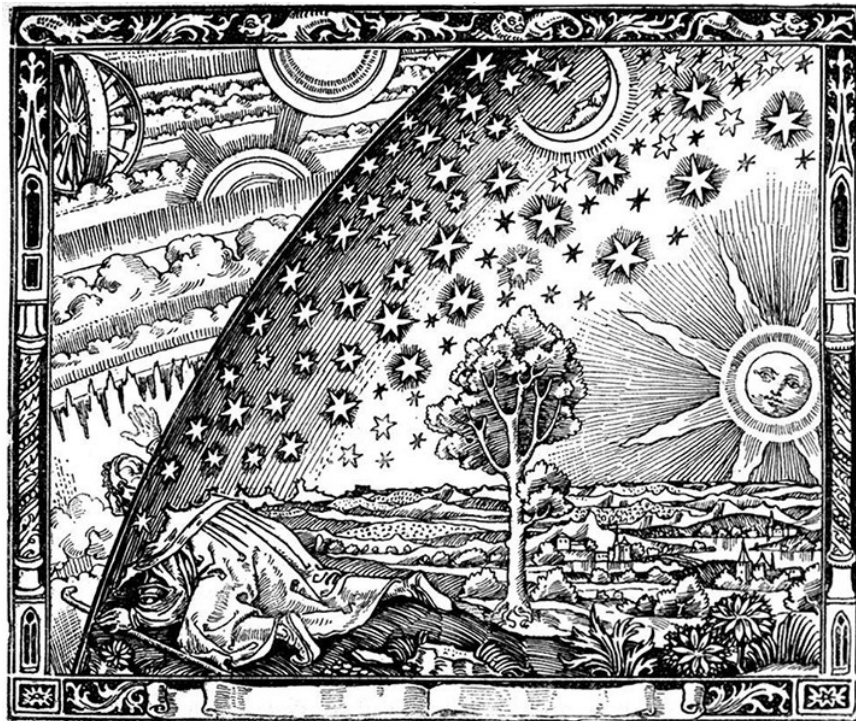


Figure 1. Wood engraving from Camille Flammarion's *L'Atmosphère: Météorologie Populaire* (1888).

Zen Buddhist practitioners commonly use paradoxical sayings, parables, or questions to provoke examinations into the nature of reality. These kōans are meant to induce a state of conceptual befuddlement by requiring contemplation of apparent contradictions. When successful, they “confound the discursive intellect” and “trigger an awakening to an ineffable state” to focus students on the limits of conventional dualistic logic (Foulk, 2000, p. 15).

The present inquiry was instigated by my own unexpected encounter with a kōan-like riddle whose bewildering implications confounded my discursive intellect—and, by extension, my sense of reality, logic, and the universe. But instead of the traditional form of written or verbal kōans, this paradox was conspicuously hidden within a 3D virtual atlas of the observable universe. And it has taken nearly a decade of grappling with the questions this cosmic conundrum instigated to respond in the form of this dissertation.



Figure 2. *Bok Globule* installation at *Burning Man* (Fritz, 2004).

This encounter occurred in August of 2004 at the *Burning Man* festival (2013), where I was participating in the creation of an art installation entitled *Bok Globule* (Emmart & Villareal, 2004). Conceived as a miniature Hayden Planetarium for that year's "Vault of Heaven" theme, *Bok Globule* was a geodesic dome theater mounted with LED lights, within which various experiments were projected (Figure 2). These included interactive visualizations of the NASA-funded *Digital Universe*

Atlas, described by its creators as “most complete and accurate 3D atlas of the Universe” (AMNH, 2011c). At the time, displaying the *Atlas* within immersive environments was a complicated and expensive proposition, requiring multiple projectors and specialized supercomputers. *Bok Globule* provided the impetus to refine these technologies, entailing the integration of a fisheye video projector, a homemade geodesic dome screen, a desktop computer, and a customized version of the Hayden’s scientific visualization software. The result was the first interactive visualizations of the *Atlas* within a portable installation.

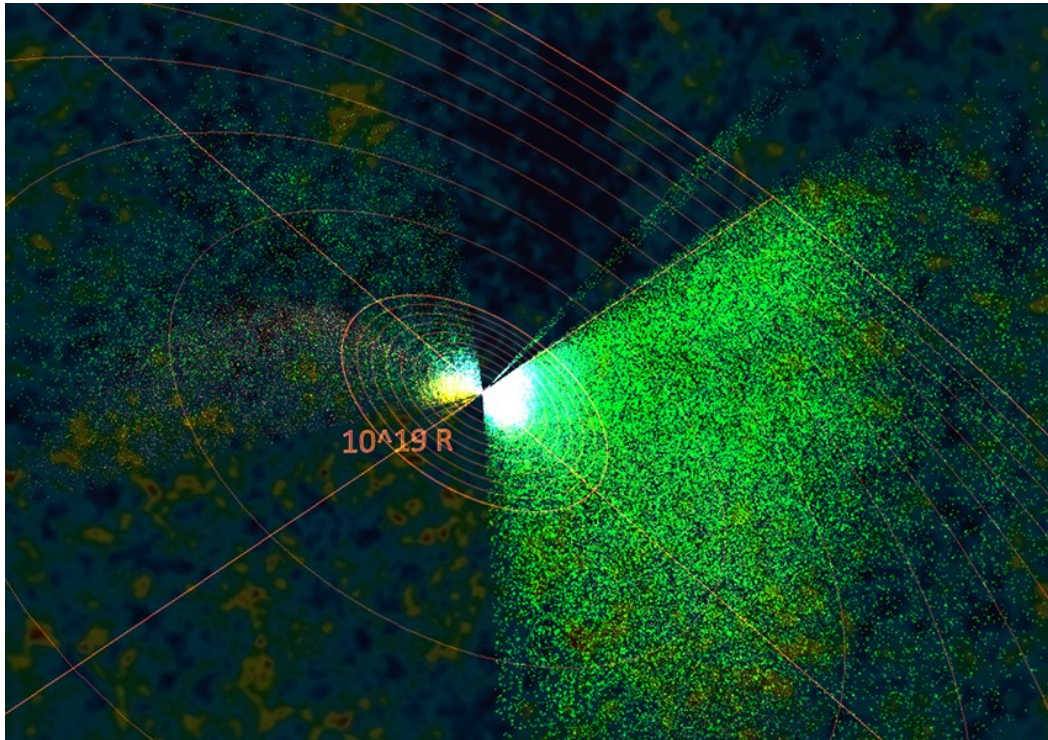


Figure 3. AMNH/NASA *Digital Universe Atlas* visualizations of all-sky surveys, WMAP, and orders of magnitude indicator rendered in *Uniview*.

My participation afforded a rare opportunity to participate in numerous interactive ‘tours of the universe’ over the course of the festival. Guided by Carter Emmart, the Hayden’s Director of Astrovisualization, each presentation began with a

virtual model of Earth hovering over the audience, nearly filling the 30' diameter screen. Like the cosmic zoom of Charles and Ray Eames' (1968) *Powers of Ten*, Carter would gradually pull back to reveal different aspects of the *Atlas*, logarithmically accelerating the simulated speed and distance as the perspective moved further and further away from the center. Over the course of 30 minutes, we flew beyond the planetary orbits of the solar system, satellite trajectories, and the stars of the Milky Way, eventually reaching the intergalactic scale. As thousands of colored data points symbolizing galaxies and quasars came into view, they appeared in a wing-like pattern emanating from the center of the model (Figure 3). We then approached, and flew beyond, the outer boundary of the *Atlas*, a speckled spherical image of the leftover radiation from the early universe. This, he explained, was humanity's 'cosmic horizon,' representing the furthest distance light had traveled since the beginning of the cosmos. From this perspective, the sphere of this 'cosmic microwave background radiation' enveloped the entire *Atlas*, resembling a hermetically sealed bubble floating within an infinite void (Figure 4). The journey then reversed, rapidly zooming back through the datasets and eventually arriving back at the model of Earth at the central axis of the *Atlas*.¹

¹ An annotated video of a similar flight path through the *Digital Universe Atlas* is available online. Called *The Known Universe* (Emmart, 2009), it was recorded by Emmart for the Rubin Museum of Art's (2009) *Visions of the Cosmos* exhibition. It has been viewed over 12 million times on YouTube.

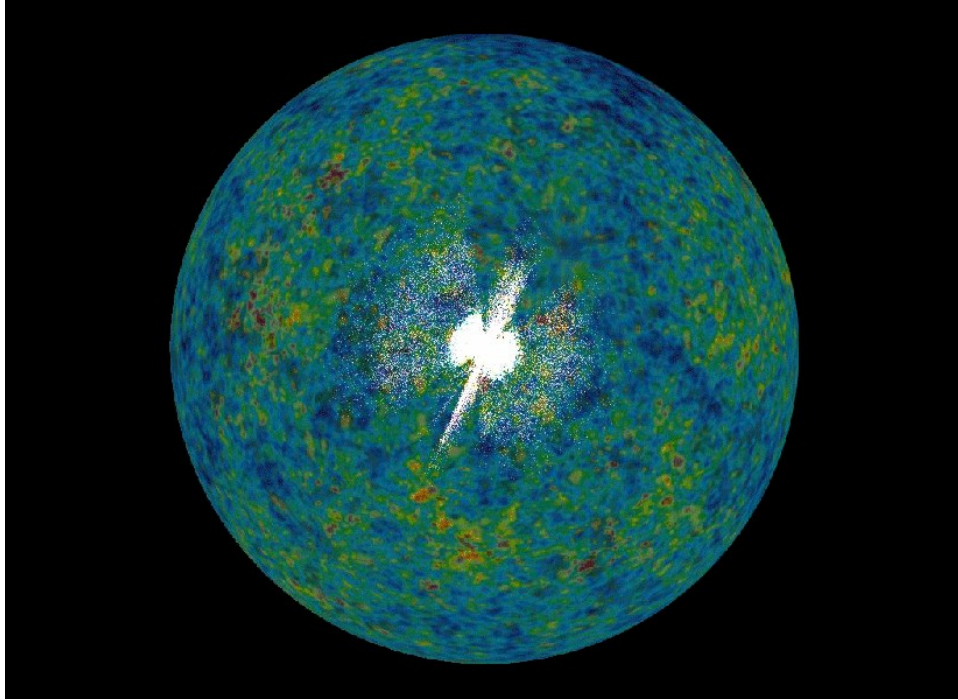


Figure 4. Visualization of the WMAP cosmic microwave background radiation enclosing the AMNH/NASA *Digital Universe Atlas*. Rendered in Uniview.

As the sublime visualizations revealed ever more overwhelming scales of phenomena, I found the experience of these ‘cosmic tours’ to be both profoundly humbling and sublimely transcendent. The immersive projections of the vast scales of scientific observations instigated an imaginative overload through a sensory gestalt, inducing within me a curious sense of ego dissolution. Judging by the awe-struck gasps and reverential silence of other participants, I was not alone.

During the weeklong installation, I was fortunate to attend a series of these live sessions, each comprised of slight variations on Carter’s impromptu trajectory and narrative. This gave me many opportunities to contemplate my intellectual and emotional responses to the experience, as well as to analyze Carter’s interpretations of the visualized datasets. As the intensity of my initial sense of astonishment

eventually dissipated, I became increasingly conscious of an ambivalent mix of intrigue and befuddlement stirring within me.

Through repetitive viewings, I grew particularly fascinated—and flummoxed—by both the *Atlas*'s apparent geocentric configuration and its enclosure by the spherical map of the cosmic horizon. I was already familiar with the Hayden Planetarium's movie productions, widely promoted as scientifically accurate 3D representations of the cosmos. But the pre-rendered trajectories of these productions had stopped short of going beyond the map of the cosmic microwave background, so these extraordinary structural features were not apparent. Given the importance of the Copernican 'paradigm shift' away from a geocentric universe in Western history, I found it peculiar that this spectacular return of a spherical, Earth-centered cosmic model had not been more widely reported or discussed.

When I asked Carter about these curious features of the *Atlas* during the installation, he described them as consequences of the finite speed of light. When modeling astronomical observations, he explained, the place from which the observations are made is inevitably the relativistic 'observational center.' This reasoning made sense, and I assumed my befuddlement concerning the ironic shape of this new cosmic model derived from my own lack of familiarity with the complexities of contemporary astrophysics. But as I participated in one virtual cosmic journey after another, this explanation seemed increasingly unsatisfying and incomplete—gradually generating many more questions than it answered. If these maps of our cosmic environment were unique to humanity's perspective, I asked myself, shouldn't it more accurately be described as one of many possible perspectives on the universe? And since the entire cosmos appeared to be centered on

us, wouldn't that imply that observers are central to acts of observation? And if we're inseparable from our measurements, wouldn't that suggest an inextricable relationship between 'internal' consciousness and the 'external' cosmos? As I attempted to make sense of these questions over the course of the installation, they became dizzily circular, and I had a difficult time finding the appropriate words to express my bewilderment.

Pondering these conundrums, I became increasingly curious about the connection between the *Atlas*' presumed 'objectivity' and the significance of its spherical, geocentric configuration. Either I was missing something exceedingly obvious, or its observer-centricity illuminated a perplexing contradiction within the Hayden's description of its cosmic datasets as "three-dimensional map of the *real* universe" (Druyen & Soter, 1999, p. 2) within earlier productions. The more I thought about it, the more difficult it became to distinguish clear boundaries between 'objective' scientific measurements and 'subjective' perceptions, and by extension, between empirical observations, mathematical models, technological mediations, scientific theories, and artistic decisions.



Figure 5. Mariko Mori's *Dream Temple* (Learoyd, 1999).

Prior to *Bok Globule*, I had spent many years developing media and technologies for dome-based projection environments by participating in the design of museum exhibits and art installations. I'd previously served as technical director for Mariko Mori's *Dream Temple* (1999a, 1999b), an immersive art installation inspired by an eighth century Buddhist temple. Like *Bok Globule*, this project projected visualizations of a virtual journey traversing microcosmic and macrocosmic realms, though the *Dream Temple* portrayed meditative instead of scientific realms (Figure 5). I'd also collaborated in the design on the unrealized *Museum of World Mythology*, which was conceived as a public attraction exploring the contemporary significance of recurring mythic narratives identified by Joseph Campbell (2004) as the "hero's journey," "monomyth," and "cosmogonic cycle." These projects catalyzed my interest in the use of dome theaters as "knowledge spaces" (Turnbull, 2000, p. 19), eventually culminating in my co-founding of the Elumenati (2009b) design and engineering firm with optical engineer D'ardo Colucci in 2003. This enabled further

creative and technical explorations of using visuospatial immersion to demonstrate different “ways of knowing” (Abram, 1996, p. 270).

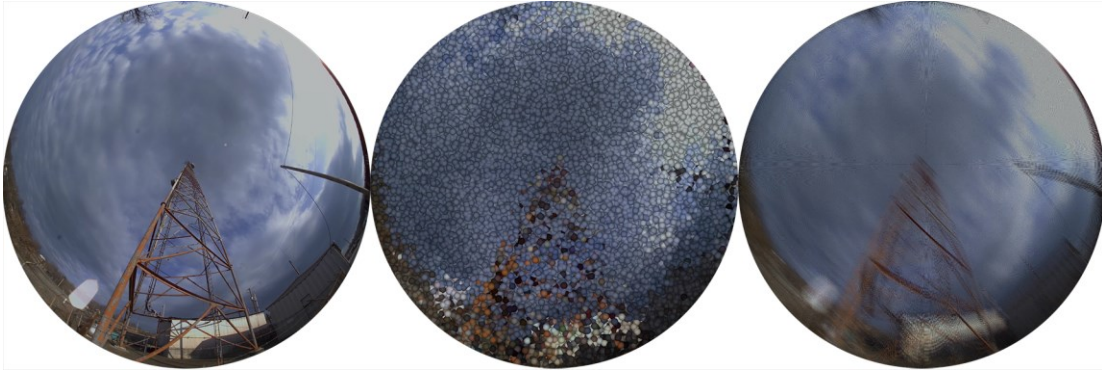


Figure 6. Stills from *Optical Nervous System* (McConville, 2004a).

While collaborating in the development of Elumenati’s custom hardware and software tools, I began exploring how domed environments could phenomenologically demonstrate ideas about the nature of perception. My early experiments culminated the short film *Optical Nervous System* (McConville, 2004a) (Figure 6). It visualizes a monologue by philosopher Alan Watts, in which he addresses the ambiguous relationship between the ‘inner’ mental world of experience and the ‘outer’ physical world of colors and shapes:

Most of us are brought up to feel that what we see out in front of us is something that lies beyond our eyes—out here. That the colors and the shapes that you see in this room are out there. Now in fact that is not so. In fact, all that you see is a state of affairs inside your head. All these colors, all these lights, are conditions of the optical nervous system. There are, outside the eyes—quanta, electronic phenomena—vibrations. But these things are not light; they are not color, until they are translated into states of the human nervous system. So if you want to know how the inside of your head feels,

open your eyes and look. That is how the inside of your feels. But we are normally unaware of that, and project it out.”

The film is composed of time-lapse fisheye footage shot with a high-resolution digital camera. The monologue was sampled within a musical soundtrack to synchronize with visual effects illustrating Watts’ explication of sight.²

During *Bok Globule*, screenings of *Optical Nervous System* were interspersed with Carter’s interactive cosmic tours. I’d created the film earlier that year, so my attention was already drawn to paradoxical nature of perception. When I encountered the peculiar configuration of the *Digital Universe Atlas*, I immediately recognized similarities between my exploration of visuospatial cognition and the Emmart’s explorations of the observable universe. Floating in the virtual space beyond the map of the cosmic microwave background, I sat transfixed and perplexed as I contemplated the profoundly ambiguous relationship between ‘cosmos’ and ‘consciousness.’

I couldn’t shake the sense that this new cosmic model represented something more—and even more significant—than just “the most complete and accurate 3D atlas of the Universe” (AMNH, 2011c). My experience at *Burning Man* seeded a succession of perplexing questions that continued to germinate long after the festival. The more I contemplated the kōan-like riddle of the *Atlas*, the more irresistible it became. Its answer seemed as elusive as it was conspicuous. This cosmic paradox enticingly challenged conventional dichotomies: blurring distinctions between art and

² *Optical Nervous System* was awarded the inaugural Domefest (2014) Best of Fest ‘Domie’ award in 2004.

science, theory and praxis, concepts and percepts, mind and body, as well as imagery and the imagination. To understand how the *Atlas* could be interpreted as a scientific complement to my artistic research with *Optical Nervous System*, I instigated this current investigation into the ambivalently ambiguous relationship between ‘inner’ and ‘outer’ worlds.



Figure 7. The Elumenati Immersive Vision Theater at SIGGRAPH 2005.

An auspicious opportunity to explore these questions arrived a few months after *Burning Man* when the Elumenati was asked to replicate the *Bok Globule* installation in a commercial setting. At the suggestion of the Hayden Planetarium’s technical director, the graphics hardware company NVIDIA contacted us requesting that we fabricate a trade show exhibit emulating the Hayden’s interactive capabilities. At the time, most digital dome theaters were used to present pre-rendered—not interactive productions. Additionally, rigid domed structures generally required days of setup time. Inspired by the ephemerality of inflatable and collapsible art and architecture (Dessauce, 1999; Herzog, 1976; Lewallen, Seid, & Lord, 2004;

Mollerup, 2001; Topham, 2002), we designed a rapidly deployable 30' diameter pneumatic structure with an internal projection screen.³ Building on the efforts of *Bok Globule*, we once again reproduced the Hayden in miniature, replacing the geodesic dome with our new inflatable structure that could be installed in hours instead of days. This new portable immersive vision theater premiered at the SIGGRAPH 2005 computer graphics conference (Elumenati, 2013) (Figure 7), once again including presentations of the *Digital Universe Atlas* by Carter Emmart and screenings of *Optical Nervous System*.⁴

Shortly thereafter, I began developing my own performative practice to experiment with alternate interpretations of the *Atlas*. While experimenting with narratives and trajectories through its virtual cosmic datasets, it became evident that I would need to traverse subject areas across the arts, sciences, and humanities. I became increasingly fascinated in connections between contemporary and historic cosmographic practices, particularly in recurring spherical tropes embodied within domes and spherical cosmic models. But as I sought to contextualize my interests and evolving practice, I only found sparse and scattered references to domed

³ It's worth noting the synchronicity of the premiere of this inflatable environment with Peter Sloterdijk's proposed *Pneumatic Parliament* (Sloterdijk & von der Haegen, 2005) for ZKM's *Making Things Public: Atmospheres of Democracy* (Latour & Weibel, 2005) exhibit. This concept is described by one reporter as a "fanciful stab at deflating some transparently flimsy assumptions at work" in processes of rapid democratization" as well as "a conceptual device for discovering the pneumatic origins of modernity" (Dillon, 2006). My practice has employed our pneumatic derivative of *Bok Globule* as a device for examining the consequences of inflating the underpinnings of modernity to their cosmological extreme within the *Digital Universe Atlas*.

⁴ The Elumenati (2009b) has since commercially productized this creation under the name *GeoDome*TM (Elumenati, 2009a). The design of the components were sufficiently novel to have been granted patents for the inflatable *OpenDome*TM screen (Colucci, McConville, & Hooker, 2008) and custom *OmniFocus*TM fisheye optics (Colucci, McConville, & Hooker, 2009). We have also continued development on the *OmniMap*TM spherical projection application programming interfaces (Shimizu, Terhorst, & McConville, 2008), which has been incorporated into numerous software applications (1.03 Spherical Container)

architectures, the spherical field of vision, and domed projection environments within the nascent field of media art history (Comment, 2000; Grau, 2004; Manovich, 2001; Oettermann, 1997; Packer & Jordan, 2001; Rheingold, 1992; Shaw & Weibel, 2003). To formalize this inquiry, I sought an academic program that could assist in structuring a project using appropriate historical, theoretical, and practical research methods. Upon discovering the *Planetary Collegium*, I submitted a proposal entitled *The Discourse of Domes: The Evolution and Application of Domed Visualization Environments* (McConville, 2006a).⁵

Upon my acceptance into the program in 2006, I initiated a review of the history of hemispherical projection environments. This resulted in my creation of a preliminary outline of predecessors to contemporary immersive vision theaters throughout the twentieth century (McConville, 2007a). Noting recurring cosmic and cognitive themes within this history, I extended the inquiry to identify the reasons and motivations underlying the persistent appearance of domed architectures in cultures worldwide (McConville, 2007d). As I ruminated on the return of a spherical, geocentric cosmic model, it dawned me that the history of domes was intimately entangled with the history of attempts to visualize the heavens. I realized that the consequences of these perennial efforts to make sense of the archetypal architecture of the cosmos could be examined through the recurring trope of the *heavenly sphere*.

⁵ Founded by Roy Ascott (2014) in 1994, the *Planetary Collegium* is an international, transdisciplinary research platform that promotes the integration of art, science, technology, and consciousness research based at the University of Plymouth.

Introduction: The Perennial Pursuit

*“It may be that universal history is the history
of the different intonations given a handful of metaphors.”*

(Borges, 1951/1975, p. 9)



Figure 8. Tibetan cosmic mandala (Sherpa, 2011), Ptolemaic world system (Müteferrika, 1732), and scenography of the planetary orbs encompassing Earth (Cellarius, 1660).

Few images in the history of ideas have been more influential than that of the *heavenly sphere*. In his short essay “Pascal’s Sphere,” Luis Borges (1951/1975) reminds us that the metaphor of the sphere has presided over the ‘cosmos’ since its conceptual inception in ancient Greece. Twenty-five centuries ago, Xenophanes [c.570 – c.475 BCE], wary of anthropomorphic traits attributed to the gods, proposed that the Greeks substitute a single god in the form of an eternal sphere. Parmenides [early fifth century BCE] (1983) further extended the analogy, using it to account for the paradoxical finitude of being:

But since there is a furthest limit, it is complete on every side, like the body of a well-rounded sphere, evenly balanced in every direction from the middle; for it cannot be any greater or any less in one place than in another. For neither is there what is not, which would stop it from reaching its like, nor

could what is possibly be more in one place and less than another, since it is all inviolable. For being equal to itself in every direction it nevertheless meets with its limits. (Fragment 8)

This quest to geometricize the image of ultimate creation was again repeated within Empedocles' [c.490–430 BCE] (2001) cosmogony of the *Sphairos*, in which earth, air, fire, and water form an endless elemental sphere:

For two branches do not dart from its back
nor feet nor swift knees nor potent genitals,
but it indeed is equal <to itself> on all sides and totally unbounded,
a rounded sphere rejoicing in its surrounding solitude. (p. 233)

Soon thereafter, Plato [c.424-c.348 BCE] (1892) established the foundations for the orderly notion of the Greek geocentric *kosmos* in his *Timaeus*, proclaiming, “the universe is in the form of a sphere” (sec. 62d). He declared that the sphere is the most perfect and uniform shape because all of its extremities are equidistant from the center— that the “centre of the world cannot be rightly called either above or below, but is the centre and nothing else” (sec. 62d).

The most famous elaboration of the spherical metaphor first appeared in the twelfth century: “God is an infinite sphere whose center is everywhere, whose circumference is nowhere” (Harries, 1975, pp. 7–8). This has been traced to the pseudo-Hermetic *Liber XXIV philosophorum*, attributed to the mythical ancient

Egyptian magus Hermes Trismegistus, though its actual origins are likely medieval.⁶ Theologian Alan of Lille [c.1116– c.1203] (as cited in Brient, 1999) shortly thereafter (Brient, 1999, p. 579) interpreted the metaphor as “an intelligible sphere” (p. 579)—a formulation repeated by Alexander of Hales [c.1185 – 1245], Thomas Aquinas [1225 –1274], Bonaventura Cavalieri (1598 – 1647) and others. According to Elizabeth Brient (1999), it was Meister Eckhart [c.1260 – c.1327] who returned to the original translation of the “infinite sphere” (p. 579). She describes this as an unambiguous metaphor for the “ineffable essence of God” in a “paradoxical formulation which pictures the coincidence of divine immanence with divine transcendence” (p. 576).⁷

However, it was Nicolas Cusanus’ [1401 – 1464] reassignment of the “infinite sphere” from God to the Universe that shifted the metaphor from theology to cosmology (Harries, 2001, p. 30). Karsten Harries insists that the “metaphor’s transference preceded and helped prepare the way for the new astronomy” (p. 31), becoming an explosive thought experiment echoed in various forms throughout the history of Western science, philosophy, and mysticism. Giordano Bruno [1548 – 1600] (Yates, 1964, p. 309), Blaise Pascal [1623 – 1662] (1910, p. 27), Ralph Waldo Emerson [1803 – 1882] (1888, p. 324), Madame Blavatsky [1831 – 1891] (1888, p.

⁶ Elizabeth Brient (1999) suggests that the *Book of Twenty-Four Philosophers* (citing the research of Baeumker and Hudry) was written by an unknown medieval author and that attribution to Trismegistus is far from consistent (p. 578). Francis Yates’ (1964) *Giordano Bruno and the Hermetic Tradition* details how seventeenth century scholar Isaac Casaubon demonstrated that that the Hermetic texts were dependent on Platonic and Christian sources, making it impossible that they were written by the legendary Egyptian (pp. 398–403).

⁷ Brient (1999) points out that the distinction may be negligible, since an “‘intelligible’ sphere whose ‘center’ is everywhere and whose ‘circumference’ is nowhere must in fact be conceived of as infinite” (p. 580). G.R. Evans (1983) similarly credits Alan of Lille with using his *Theological Rules*—namely “Only the Monad is Alpha and Omega without Alpha and Omega (Rule 5)” and “God is the intelligible sphere, whose centre is everywhere and his circumference nowhere (Rule 7)” —to excite wonder, admiration, and dazzle the mind with the apparent incomprehensibility of paradox (p. 72-73).

65), Friedrich Nietzsche [1844 – 1900] (1977, p. 330), Alfred Jarry [1873 – 1907] (Parshall, 2002, p. 22), Aleister Crowley [1875 – 1947] (1938), Joseph Campbell [1904 – 1987] (1988, p. 18) and others have subsequently called upon the infinite sphere to invoke the sublime and inconceivable essence of God, Nature, and/or the Universe (see Appendix II: Metaphors of the Sphere).⁸

Speculating about the *raison d'être*, meaning, and relevance of the sphere—whether as symbol, metaphor, object, or process—is a curious task. From a young age, this archetypal form has intrigued me, prompting my eventual involvement with the development of spherical displays.⁹ As I have explored the creative possibilities of simulating visions of the heavens within immersive vision theaters (IVTs), I have encountered evidence of the sphere’s ubiquitous presence in cultures across time, visualized in the form of domes, circles, mandalas, and other symbolic embodiments and inscriptions (Figure 8) (McConville, 2007d, 2011). Interpretations of its meaning and structure have defined conceptions of the world since antiquity, setting universal contexts for existence and guiding the trajectories of civilizations. Yet its persistent appearance is so conspicuous that confronting its conundrums have proven to be as evocative—and potentially perilous—as posing questions about the will of God or the laws of Nature. Depending on the nature of the inquiry, the facts of the matter often appear definitively settled or hopelessly elusive.

⁸ For extended treatments of this topic, see Karsten Harries’ (1975) “The Infinite Sphere: Comments on the History of a Metaphor” and *Infinity and Perspective* (2001), Elizabeth Brient’s (1999) “Transitions to a Modern Cosmology: Meister Eckhart and Nicholas of Cusa on the Intensive Infinite,” and Robin Small’s (1983) “Nietzsche and a Platonist Tradition of the Cosmos: Center Everywhere and Circumference Nowhere.”

⁹ See the Prologue of this dissertation. Descriptions of example projects and installations can also be found on the *Elumenati* (2009b) web site.

The seemingly anachronistic character of this central motif further complicates this investigation. As we moderns are all too aware, the *heavenly sphere* doesn't physically exist, and the very notion of a crystalline container enclosing Earth is a mythical artifact of credulous cosmologies. It is a spectacular illusion—a perceptual trick resulting from observations of the celestial realm from the surface of a rotating, orbiting planet. This is frequently cited as a founding insight of the modern era, commonly attributed to the influence of Polish astronomer Nicolas Copernicus' [1473 – 1543] celebrated conceptual reconfiguration of the heavens.

Yet, as the title of his book *On the Revolutions of the Heavenly Spheres* (1543) indicates, Copernicus didn't actually challenge the existence of the *heavenly spheres*. Instead, he proposed a sun-centered arrangement of the celestial orbs in an attempt to elegantly reconcile confounding problems with the Platonic *kosmos*, inherited by the medieval Church by way of Aristotle and Ptolemy. Nevertheless, his efforts have been widely credited with instigating a 'paradigm shift' within the European imagination (Kuhn, 1964), often heralded as 'dethroning' humanity from its cosmic perch (Hainesworth, 2012, p. 35; Perry, 2010, p. 247; Pruet, 2012, p. 29; Rees, 1997, p. 100; Sciama, 1971, p. 42; John A. Wheeler, 1988, p. vii). By some accounts, Copernicus' calculations delivered the first of many "great demotions [. . .] delivered to human pride" (Sagan & Druyan, 1997, p. 26) by science, purportedly liberating humanity from the dark ages of anthropocentric ignorance.

Numerous scholars (Barker, 2002; Danielson, 2001; Singham, 2007), however, challenge this uncritical narrative, pointing out the fallacy of presuming correlations between the spatial centrality and cosmic significance—between *geocentrism* and *anthropocentrism*. They argue that mythologizing the so-called

‘Copernican revolution’ perpetuates dubious misconceptions, including the assumption that the heroic ‘dethroning’ of humanity by scientific rationality instigated a radical break between ‘modern’ and ‘premodern’ worlds (Danielson, 2001, p. 1034; Latour, 1993, p. 68). They call for a more critical ‘big picture’ narrative about the origins of modern science (A. Cunningham & Williams, 1993), one which takes into account the complex contingencies—and sometimes paradoxical consequences—of what Peter Sloterdijk (2011) calls the “age of progressive decentralizations” that resulted in the “shattering of the celestial domes” (p. 24).

The direct consequences of the ‘Copernican shift’ have been a topic of considerable debate (Andersen, Barker, & Chen, 2006; Blumenberg, 1985, 1989; Koyré, 1968; Kuhn, 1957, 1964; N. Turnbull, 2006). However, a general consensus has emerged that the shift solicited a growing sense of existential dread and a quest for certainty over the course of the past few centuries (Toulmin & Goodfield, 1962; N. Turnbull, 2006). Beliefs in the once immutable boundary separating the eternal heavens and corruptible Earth gradually gave way to visions of a homogenous and infinite relativistic void. At the same time, natural philosophers—assisted by new observational instruments and calculation techniques—seemed increasingly capable of discovering deterministic laws established by God to govern his clockwork universe.

Yet even as leading thinkers overturned the *heavenly spheres* and geocentric configuration of Aristotle’s physics, they maintained and fortified the dualistic logic

underlying his metaphysics.¹⁰ As faith in the potential of the rational intellect to discern an ‘Archimedean view’ on the cosmos increased, so too did beliefs in rigid distinctions between mind and body, subject and object, as well as humans and nature. Richard Tarnas (1991) contends that these dualistic reifications instigated a “triple estrangement” (p. 419) in the Western mind, cosmologically initiated by Copernicus but carried to epistemological and ontological extremes by Kant and Descartes. He likens the unresolved consequences of “confronting an unconscious, purposeless, and impersonal universe” (p. 420) to Gregory Bateson’s notion of a “double bind,” (Bateson, Jackson, Haley, & Weakland, 1956, p. 251), in which “mutually contradictory demands” eventually produce an “impossibly problematic situation” (Tarnas, 1991, p. 419) that can lead to a kind of schizophrenia. The subsequent shifts in the Western cosmological imaginary, Tarnas contends, resulted in a widespread alienation and sense of disconnection from the world.

Today, the “Copernican cliché” (Danielson, 2001, p. 1029) that humanity was ‘dethroned’ from its privileged position continues to be mythologized within narratives about the history of modern science.¹¹ The tacit assumption of a radical break between reason and faith over the course of the ‘scientific revolution’ continues to inform contentious debates about the presumed antimonies of science and religion. At the same time, the dualistic logic of Aristotle has been deeply ingrained in Western thought, tacitly reinforcing divisive boundaries between the “two cultures”

¹⁰ *The Law of Non-Contradiction* (Priest, Beall, & Armour-Garb, 2004) provides a succinct introduction to Aristotle’s logic, particularly the introduction, *At the Intersection of Truth and Falsity* (Beall, 2004).

¹¹ The complex relationship between science and mythology has been addressed by scholars elsewhere (Allchin, 2003; Latour, 1993; Midgley, 2003; Schrempp, 2012; Sheldrake, 2012), but will be considered through the lens of the *heavenly sphere* throughout this dissertation.

(Snow, 1959/1993) of the sciences and humanities.¹² The resulting antagonism and perceived divisions often exacerbate habituated disputes and knowledge fragmentation.

Like all good myths, however, the ‘Copernican revolution’ appears to have come full circle. The modern scientific quest to demonstrate a transcendent, god’s eye view on the cosmos has culminated within the NASA-funded *Digital Universe Atlas*, presented as the “most complete and accurate 3D atlas of the Universe” (AMNH, 2011c). This collection of international astronomical surveys rendered within a three-dimensional Cartesian virtual world has become a mainstay of public outreach efforts to highlight the achievements of scientific cosmology. However, when viewed as whole, its configuration bears an uncanny resemblance to the medieval world system purportedly overturned by Copernicus. A model of Earth rests at its center, surrounded by the *heavenly sphere* of humanity’s cosmic horizon (Figure 4).

¹² Ralph Foshay (2012) addresses how Aristotle’s “most certain principle of all” (p. 122) has been used to justify ever-increasing disciplinary specialization in *The Law of Non-contradiction: Dialectic and the Possibility of Non-propositional Knowledge*.

Motivation, Aims, and Methods

The return of the *heavenly sphere* within the *Digital Universe Atlas* presents a poetic conundrum of cosmic proportions. It complicates the central origin story of modern science, frequently purported to have originated with the ‘paradigm shift’ away from a geocentric universe. Yet this development has been summarily dismissed as an inevitable consequence of modeling the cosmos from humanity’s ‘observational center.’ Even this explanation, however, points to the need to account for the role of observing systems within observations—a topic that was integral to the ‘paradigm shift’ away from classical to quantum physics in the twentieth century. The appearance of the cosmic microwave background as a sphere conspicuously visualizes the relativistic and situated nature of all observations, raising significant questions about presumed dichotomies between ‘subjectivity’ and ‘objectivity’ and the ambiguous entanglements of ‘consciousness’ and the ‘cosmos.’

The aim of this investigation is to develop practical techniques for examining the complex knowledge production processes from which the archetypal form of the *heavenly sphere* has re-emerged. The ability to interactively visualize the *Atlas* within a 3D virtual world affords a unique opportunity to study the consequences of contemporary cosmographic practices. This research has been led by my performative practice of guiding simulated cosmic journeys within immersive vision theaters, during which I interactively examine scientific datasets and historical imagery integrated into the *Atlas*. This has resulted in the creation of interpretive techniques that demonstrate the utility of transcending conventional disciplinary boundaries when addressing the implications of the *heavenly sphere*’s return.

The project has taken the form of systemic action research (Burns, 2007), employing a process similar to the action research cycle of planning, acting, observing, and reflecting (p. 12). This process has involved moving from personal research to reflexive practice within public performances and back again, operating at multiple scales of engagement to iteratively develop the ideas and strategies presented throughout this thesis. A first-person approach has been essential for the development of my *cosmotroping* practice, which has integrated intensive theoretical, historical, and performative research. Second-person engagements with technical and scientific collaborators have been necessary to create visualization software and immersive projection environments (see Patents in Appendix I). Similarly, ongoing second-person engagements with participants have been key to exploring ways of facilitating collective inquiry into questions enacted by my cosmographic practice (see Select Cosmotroping Performances in Appendix I). Finally, third-person approaches have come about through collaborations with the science education community to implement the strategies developed through this research (see Worldviews Network Presentations in *Appendix I*).

To accommodate the broad scope of this inquiry, I have employed a mixed methods approach. Mixed methods research has been described as providing “an antidualistic and syncretic philosophy and set of approaches or possibilities for merging insights from diverse perspectives; its working goal is to provide pragmatic, ethical solutions to local and societal problems” (Johnson, 2009, p. 449). Additionally, mixed methods researchers are said to “generally reject either/or logic (such as qualitative or quantitative beliefs *in toto*) and advocate thinking in terms of continua on multiple philosophical and methodological dimensions” (p. 451). This

resonates with the spirit and intention of this investigation. A nondual, syncretic, and transdisciplinary approach has been essential for examining the “different intonations” (Borges, 1951/1975, p. 9) given the *heavenly sphere*. I have attempted to cultivate my own ability to maintain a paradoxical perspective: one that is synoptic yet situated, everywhere and nowhere simultaneously. More precisely, this is not one perspective but many that co-exist and fluidly shift over time (6.14 World Views). Through these mixed methods, I examine how cosmographic practices have enactively shaped views of the world, and how interpretations of cosmographic visualizations can illuminate paradigmatic assumptions that exacerbate complex social-ecological problems.

This process entails the integration of traditional and emergent methods. I use historical research to situate contemporary cosmographic practices within the history of ideas. I use metaphor analysis (Todd & Harrison, 2010) to scrutinize the origins of the *heavenly sphere* and the influence of its interpretation within varying cultural contexts. I adopt a reflexive ethnographic approach (Davies, 2008; Hufford, 1995) to continually question how my own positions and assumptions are transformed through the research process. Finally, my performative practice (Leavy, 2010) provides an opportunity to communicate and iterate these findings within social settings, during which feedback from participants is incorporated to further inform and refine the trajectory of this research. By self-referentially integrating historic findings and metaphorical understanding while *cosmotropeing*, I seek to increase my transparency as well as to invite others to contribute to the interpretive process. These methods are used to elucidate the theoretical considerations, cultural significance, and practical consequences of the persistent recurrence of the *heavenly sphere*. Additionally, I use

spherical illustrations to create enactive ‘tools for thinking’ in the form of visual heuristics designed to facilitate ‘views’ of the ‘world’ from multiple perspectives. The purpose of this research is to produce useful, practical knowledge and techniques that facilitate transdisciplinary interpretations of cosmographic visualizations within immersive vision theaters to cultivate shifts from linear to *spherical thinking* (6.15 Spherical Thinking).

Structure of this Thesis

Chapter 1: Aesthetics of Meaning

This thesis begins with an examination of the pre-conceptual and embodied origins of the recurring metaphor of the sphere, arguing that it derives from visual experiences shaped by the curved morphology of the human visual field. The theoretical foundations of this investigation rest on metaphor theory, cognitive semantics, and Gestalt theories within the sociology of scientific knowledge. I describe correlations of the term ‘worldview’ with other examinations of ‘universes’ and ‘structures of consciousness.’ Finally, I describe the distinctions between the key terms *cosmology* and *cosmography* used throughout this dissertation.

Chapter 2: Domesticating the Universe

Next, I investigate the role of image making within the deep history of observing, imagining, and mediating patterns in the heavens. By summarizing numerous studies from the fields of cognitive archaeology, anthropology, and archaeoastronomy, I argue that material artifacts and environments have long functioned as integrated ‘tools for thinking’ within enactive processes of orientation and domestication. After reviewing a brief history of cosmographic visualizations, I contend that the recurring symbolism of domes and spheres—and their use as tools for facilitating imaginative ‘flights’ between worlds—derives from their ancient association with the heavens.

Chapter 3: Globalizing the World

This chapter reviews examples of the art of ‘sphere-making’ and its central role in shaping views on the world since antiquity. I argue that the totalizing notions *cosmos*, *world*, and *universe* emerged through processes of material engagement as

physical embodiments of these ideas provided essential cognitive scaffolding. I cite numerous examples of the integral role of images and environments in shaping individual imagination and cultural imaginaries, including a discussion of how shifting metaphors, visualization devices, and other factors contributed to the transformations associated with the ‘Copernican revolution.’ This chapter concludes with a consideration of the role of visual technologies within the practices that gave rise to the materialist understanding of science. This includes the ways in which they simultaneously reinforced and complicated ideas about distinctions between ‘subjective’ perception and ‘objective’ reality.

Chapter 4: Cosmological Cinema

This chapter explores how the development of immersive visualization environments in the twentieth century enabled continued reinforcement of beliefs in the veracity of the ‘objective’ ‘Archimedean point.’ I compare this to the ways in which they also enabled experimentation with sensory gestalts for exploring novel ‘subjective’ experiences. I sketch a tentative history of immersive vision theaters, briefly reviewing the history of projections of celestial simulations and moving imagery within hemispherical screens. I then examine the diverse motivations underlying the development of these environments, including desires to create pedagogical tools, art installations, popular entertainment, and government propaganda. I argue that the designers of these environments sought to experientially illuminate novel perspectives on the world by simulating and stimulating the spherical gestalt of vision. This section concludes with a summary of more recent efforts to push the dream of cosmic flight to its virtual extreme, the consequences of which are explored in the remainder of the dissertation.

Chapter 5: Eternal Return

This chapter examines interpretive tensions among the *Digital Universe Atlas*' creators enacted by the re-emergence of the *heavenly sphere*. This is accomplished through an analysis and comparison of transcripts from Hayden Planetarium productions with professional discussions concerning the appropriate role and interpretation of scientific cosmology within public outreach efforts. I recall the findings of previous chapters to explicate the tacit philosophical assumptions informing these interpretive approaches and how they inform efforts to mythologize the cosmological theory upon which the *Atlas* is based. This chapter concludes by pointing out parallels between the Hayden's efforts and historic precedents to highlight the unintended social and ecological consequences of perpetuating the 'Copernican cliché' and the ideal of an 'Archimedean point.'

Chapter 6: Visualizing World Views

I next describe the theoretical and practical aspects informing my efforts to expand interpretations of the *Atlas* beyond 'subjective' and 'objective' perspectives. I review key philosophical frameworks and fields of study addressing complex, paradoxical, and multi-perspectival ways of thinking. Next, I explain how these have informed my development of a 'third space' using immersive visualization environments to guide virtual 'tours' through the *Digital Universe Atlas*. This chapter concludes with a description of *cosmographic hermeneutics*, my technique of using a system of visual heuristics to facilitate interactive interpretations of cosmic models from transdisciplinary *world views*.

Chapter 7: Transcalar Imaginary

This chapter describes what I call the *transcalar imaginary*, the hybrid ‘third space’ that emerges through the integration of immersive environments, scientific visualizations, social interactions, and collective imaginings. I provide a reflexive account of *cosmotroping* through the *transcalar imaginary*, including an example narrative compiled from recordings of my performances. By recounting the ways in which *cosmographic hermeneutics* informs my interpretative process, I illustrate the necessity and utility of considering contemporary and historic cosmic models from transdisciplinary *world views*. I recount how this mixed methods research has transformed my own thinking and creative process, including how I understand the significance of the ‘eccentric’ CMB sphere and the ‘centric’ Earth within the *Atlas*. Finally, I describe how this research continues to catalyze and inform my current and future projects.

Conclusion: Spherical Leverage

I conclude with a summary of the enactive approach to cosmography developed throughout this dissertation, including its consequences for how the origins, history, and potential of cosmographic practices are understood. I contend the perennial cosmic conundrums illuminated by the Hayden’s effort to push the ‘Archimedean point’ to its cosmographic extreme emerge from the paradoxes of self-consciousness. I maintain that *cosmographic hermeneutics* provides a practical strategy for demonstrating that the ultimate leverage point for shifting paradigms is cultivating the ability to transcend paradigms. But to do this, we must first become conscious of the limits of our own knowledge—the process at the heart of the shift from *linear* to *spherical thinking*.

Chapter 1: Aesthetics of Meaning

*“We find certain things about seeing puzzling,
because we do not find the whole business of seeing puzzling enough.”
(Wittgenstein, 1953, p. 212)*

Introduction

This chapter introduces key theoretical concepts developed throughout this dissertation. I begin with an examination of the pre-conceptual and embodied origins of the recurring metaphor of the sphere, primarily informed by the fields of metaphor theory and cognitive linguistics. I then review efforts to depict and map the perspective of the human visual field. I argue that its curvilinear morphology generates the common experience of visual consciousness as a spherical gestalt. The metaphorization of this archetypal form is considered and correlated with frameworks describing the history of human cognitive development under the rubrics of ‘worldviews,’ ‘universes,’ and ‘structures of consciousness.’ Finally, I distinguish the key terms *cosmology* and *cosmography* used throughout this dissertation.

1.01 Archaic Stratum



Figure 9. Milky Way galaxy and stars (Wander, 2010).

According to Hans Blumenberg (1997b, 2010), attempting to reconstruct the meaning of metaphors using theoretical language alone is an inherently paradoxical endeavor. In his elucidation of ‘metaphorology,’ Blumenberg (1997b) describes metaphors as “fossils that indicate an archaic stratum of the trial of theoretical curiosity [. . .] beyond the resources of any descriptive language” (p. 82). They are, he insists, a limited special case of ‘nonconceptuality,’ the inherently ineffable realm of human experience and imagination beyond conceptual reducibility and expressibility. As Wittgenstein (1922) describes, “There is indeed the inexpressible. This shows itself; it is the mystical” (p. 90). Blumenberg (1997b) concurs, contending, “Nonconceptuality wants more than ‘form’ of processes or states; it wants their ‘gestalt’” (pp. 96-97).

By “providing a point of orientation,” Blumenberg (2010) writes, metaphorical models determine a “particular attitude or conduct” to “give structure to a world.” These provide images in place of conceptual understanding, he claims, to stand in for an “objectively unattainable whole” by “representing the nonexperienceable, nonapprehensible totality of the real” (pp. 14-15). When it comes to making sense of the “supposedly unknowable product of the divine *potential*

absoluta,” he suggests, “Man puts what he ‘can do’ (or ‘could do’) *in place of* the unknown” (p. 68). He contends that metaphors act as models to compensate human beings “for their lack of fit with a world in which they must act in order to stay alive. But, he writes, it is paradoxically a world in which “they can only act at all purposefully if their actions are informed by a foreknowledge of what that world is and how they stand in relation to it” (p. 143).

1.02 Cosmological Metaphors

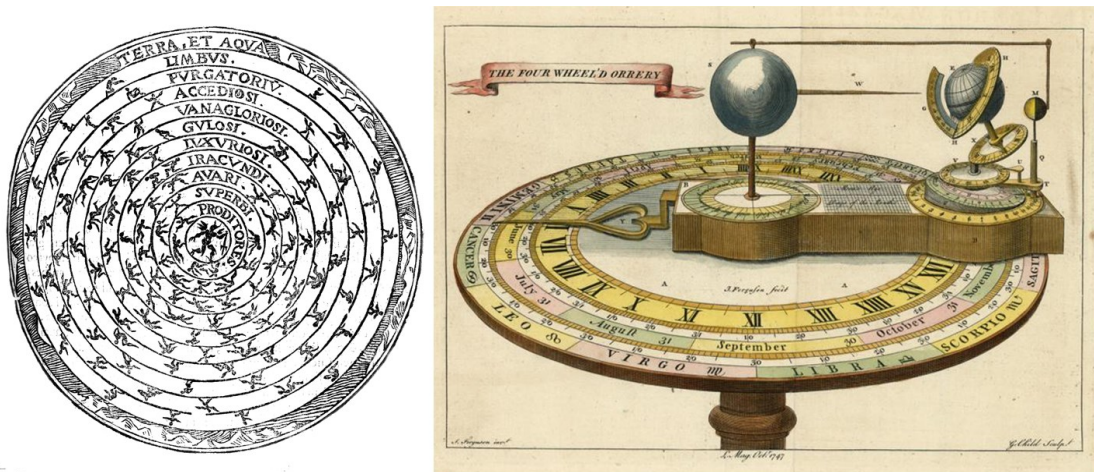


Figure 10. *Theatrum Mundi* (Gallucci, 1588) and *Four-Wheel'd Orrery* (Child, 1747).

Blumenberg (2010) also considers how the shifting status of the sphere as concept, metaphor, and symbol have influenced the European imagination. In what he calls ‘cosmological metaphors,’ Blumenberg explores how interpretations of the heavens—through the metaphors of *cosmic polis*, *world organism*, *theatrum mundi*, and *clockwork universe* (Figure 10)—have guided the European civilization’s interaction with the life-world (p. 16). He contends these are “*foundational elements* of philosophical language,” fundamental to shaping understanding of the catalytic, non-conceptual realm from which the universe of concepts constantly renews itself (pp. 3-4).

Blumenberg (1997b) inspects the patterns, processes, and logics of these models, describing the difficulties of accounting for the interconnected—though often ambiguous—relationships and processes leading to concept formation (p. 93). He identifies the challenge of ascertaining and analyzing their “conceptually irredeemable expressive function” (2010, p. 3) as no less than one of the essential

tasks of conceptual history.¹³ Yet, Blumenberg (1997b) suggests, any attempt to analytically deconstruct the mythic function of these metaphors invariably employs new metaphors. Describing this cyclically recursive process, he writes, “Demythification is in large measure nothing more than remetaphorization” (p. 94).

¹³ Blumenberg (2010) initially described ‘metaphorology’ in *Paradigms for a Metaphorology* in 1960, arguing that the field of the history of concepts (*Begriffsgeschichte*) should include a history of metaphors. He (1997b) later narrowed the scope of ‘metaphorology’ to a “limited special case of nonconceptuality” in his *Prospect for a Theory of Nonconceptuality*. Blumenberg (1993) also introduced the paradoxical concept of “nonconceptuality” (*Unbegrifflichkeit*) in his 1957 essay “Light as a Metaphor for Truth: At the Preliminary Stage of Philosophical Concept Formation” and developed it throughout his career.

1.03 Spherical Container



Figure 11. Long exposure photograph of Jupiter, Venus, the Moon, and Stars captured with a fisheye lens (Porto, 2012).

The paradoxical challenge of theoretically deconstructing the metaphor of the *heavenly sphere* has motivated the exploration of ideas presented throughout this thesis. While Blumenberg (2010) suggests that an “absolute metaphor” leaps “into a void, inscribing itself on the tabula rasa of theoretical unsatisfiability” (p. 132), it is necessary to ground this study using a less theoretical foundation. To do so, I have identified more practical approaches that address the common embodied origins of recurring spherical tropes. For this, insights from the field of cognitive linguistics—particularly conceptual metaphor theory—have proven essential.

This theory holds that basic metaphors arise from and are grounded within physiological experiences, providing the basis for ways of understanding and

conceptualizing categories of the world (Lakoff & Johnson, 1980/2003, p. 26). Like ‘metaphorology,’ it theorizes that imaginative capabilities are central to thought and reason—rather than peripheral and inconsequential adjuncts to the literal. Cognitive metaphor theory emphasizes the importance of embodiment in contributing to the meaning of metaphor, metonymy, and mental imagery (Lakoff, 1987, p. xi). In short, it describes how metaphorical concepts derive from preconceptual and prelinguistic experience shaped by humanity’s shared physiology.

Cognitive linguists postulate the existence of ‘image schemas,’ defined by Hampe (2005) as “highly *schematic* gestalts which capture the structural *contours* of sensory-motor experience” (p. 1) that integrate information from multiple modalities. These are proposed to exist as “*continuous* and *analogue* patterns beneath conscious awareness, prior to and independently of other concepts” (p. 2). By functioning as a metaphorical bridge between perception and conception, they claim, *image schemas* provide embodied anchors that shape the imagination and language-based understanding.

The theory of image schemas provides a practical means for understanding the cognitive origins of the recurring and persistent associations of spherical metaphors with the heavens. Mark Johnson (1989) describes how patterns of image schemas structure the understanding of abstract domains of experience through imaginative, metaphoric, and metonymic projections (pp. 112–114). One such pattern structure, called CENTER-PERIPHERY,¹⁴ is intimately connected to the sphere, as it originates in

¹⁴ The convention in cognitive linguistics of using small capital letters to denote image schemas and conceptual metaphors is employed throughout this dissertation.

the fundamental survival skill of discerning between objects in the center and periphery of the perceptual horizon. He claims this constitutes a fundamental imaginative contour that is crucial to our most basic preconceptions.

Johnson (1987) also describes a CONTAINER schema as emerging from “one of the most pervasive features of our bodily experience”—namely the “encounter with containment and boundedness” that enables “repeatable spatial and temporal organizations” (p. 21). Johnson (1989) argues that the combination of the CONTAINER and CENTER-PERIPHERY schemas yields the common metaphors of UNDERSTANDING IS SEEING and THE VISUAL FIELD IS A CONTAINER. The, he claims, structure experiences of the visual field as well as its “metaphorical projection onto the epistemic domain” (p. 113). As a consequence, he proposes, “the logic of our visual experience is mapped onto our understanding of knowledge” (p. 114), and visually important objects are mapped on epistemically significant ideas.

Johnson (1987) contends that this CONTAINER schema marks off a bounded mental space, giving rise to metaphorical categories for characterizing something as either ‘in’ or ‘out’ of a container (p. 39). Lakoff and Johnson (1999) deem that the perceived polarity of this image schema produces “logical constraints” that are built into the very structure of visual perception. Though these “are not physical containers,” they suggest, the image schemas are “conceptualizations that we impose upon space” (p. 380). They further attribute the CATEGORIES ARE CONTAINERS and PREDICATION IS CONTAINMENT image schemas to this sense of polarity, arguing that they informs a fundamental embodied logic.

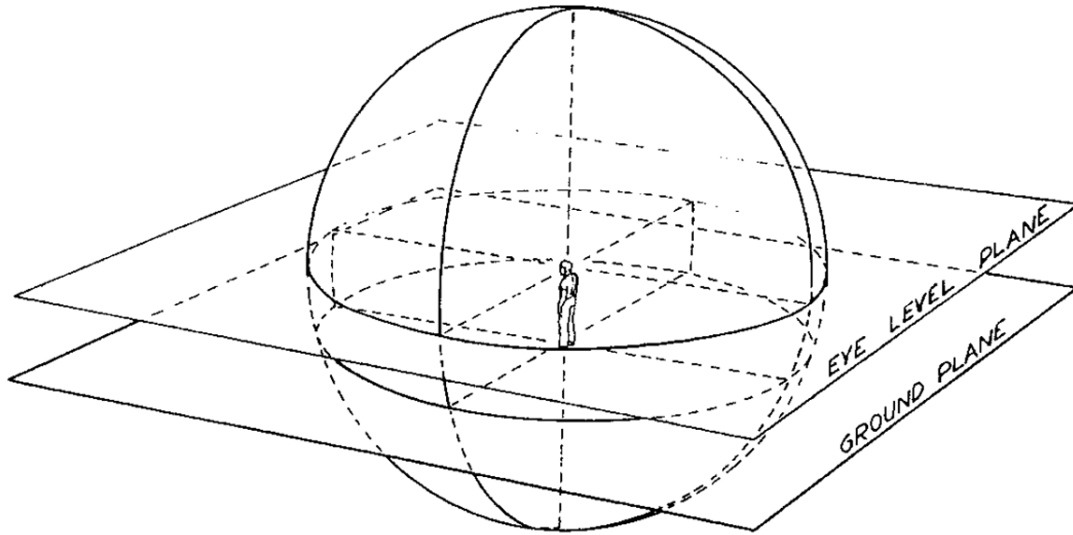


Figure 12. *Spherical Field of Vision* by John Boone (Wonders, 1993, p. 207).

But what is the shape of the phenomenological CONTAINER of human vision?

Though analysis of ‘one-point’ linear perspective has dominated the study of the morphology of sight since the Renaissance, numerous references to the ‘sphere’ of vision can be found dating back to antiquity. First suggested in Euclid’s *Optics*,¹⁵ references to the curvature of the visual field has fascinated artists and astronomers alike, appearing in the writings of Johannes Kepler,¹⁶ Leonardo da Vinci,¹⁷ William Hershel,¹⁸ Erwin Panofsky (1924), Ernst Gombrich (1972), and others (Tyler, 2009;

¹⁵ Kim Veltman (2004, p. 15) reviews the debate concerning the degree to which Euclid’s *Optics* was a precursor to either linear or spherical perspective in *Literature on Perspective: Sources and Literature of Perspective*.

¹⁶ Kepler writes, "But our vision has no surface like that of a painting on which it may look at the picture of the hemisphere but only that surface of the sky above in which it sees comets, and it imagines a sphere by the natural instinct of vision. But if a picture of things is extended in straight lines into a concave sphere, and if our vision is in the center of this, the traces of those things will not be straight lines, but, by Hercules, curved ones" (Galilei, Drake, & O’Malley, 1960, pp. 354–355)

¹⁷ James Elkins (1988, 1994) summarizes the dispute surrounding da Vinci’s position on the curvature of vision in “Did Leonardo develop a theory of curvilinear perspective?” and *The Poetics of Perspective*.

¹⁸Hershel (1869) writes, "In celestial perspective, every point to which the view is for the moment directed, is equally entitled to be considered as the "centre of the picture," every portion of the surface of the sphere being similarly related to the eye. Moreover, every straight line (supposed to be indefinitely prolonged) is projected into a semicircle of the sphere, that, namely, in which a plane

Veltman, 1994). Though these observations have been overshadowed by analysis of single-point ‘linear’ perspective, these curvilinear speculations form a tradition that, according to Panofsky (1960), “considered our sphere of vision quite literally as a ‘sphere’” (Figure 12). This assumption, he insists, “more nearly agrees with physiological and psychological reality than that which underlies Brunelleschi’s rectilinear construction” (p. 128).

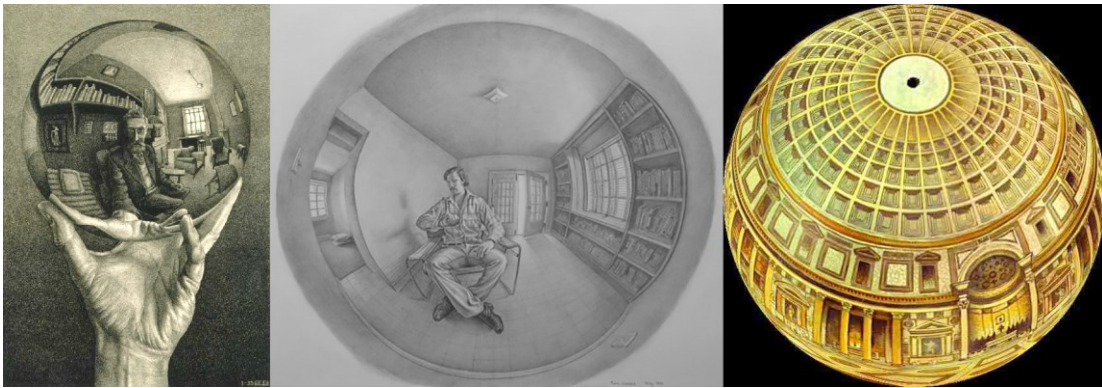


Figure 13. *Hand with Reflecting Sphere* (Escher, 1935), *Transitorio* (Casas, 1981), *The Pantheon* (Termes, 1998).

The veracity of Panofsky’s claim has been borne out by recent scientific and artistic research. Physiological studies suggest that the perceived curvature of visual experience derives from retinal curvature (d’ Alessandro, 2008) and/or eye movement and orientation (Tyler, 2009). Artists have also developed methods to empirically depict the full gestalt of the visual field within drawings and paintings (Figure 13). To explain this process, they have developed techniques that geometrically demonstrate

passing through the line and the eye cuts its surface. And every system of parallel straight lines, in whatever direction, is projected into a system of semicircles of the sphere, meeting in two common apices, or vanishing points, diametrically opposite to each other, one of which corresponds to the vanishing point of parallels in ordinary perspective; the other, in such perspective has no existence” (p. 70).

how to generate ‘spherical perspective’ by expanding from one to six vanishing points (Termes, 1991, p. 289) (Figure 14).¹⁹

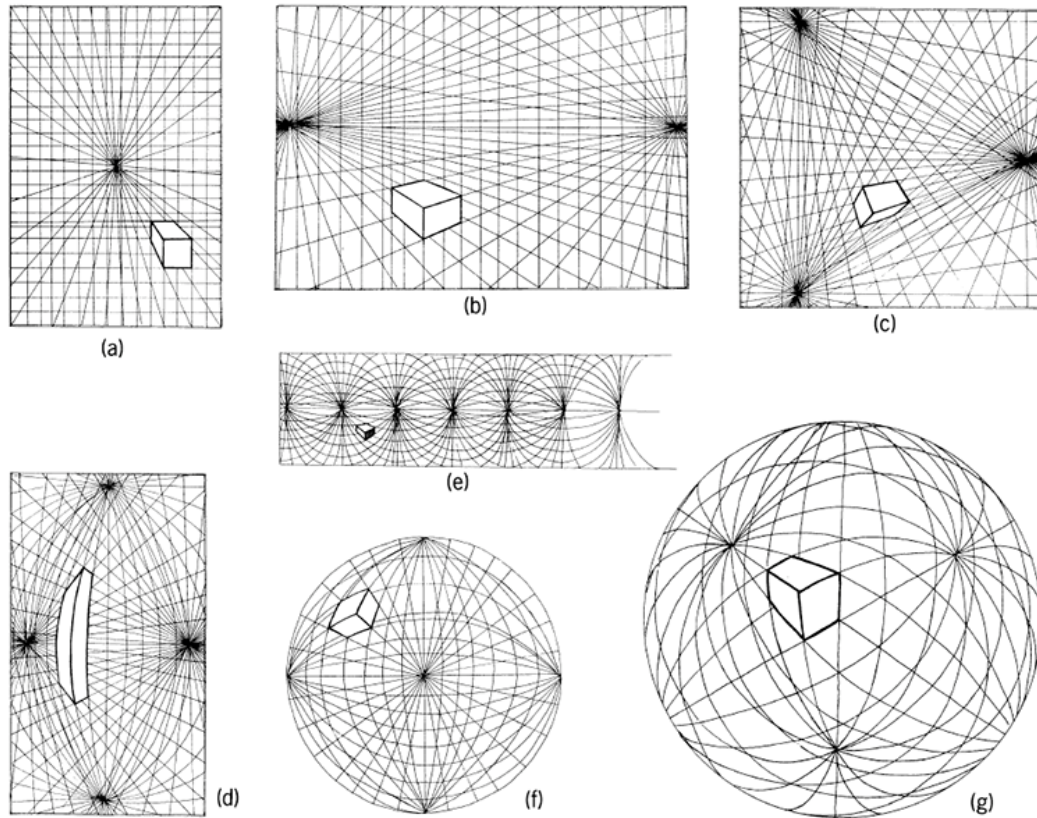


Figure 14. (a) One-point perspective grid (b) Two-point perspective grid (c) Three-point perspective grid, (d) Four-point perspective grid, (e) Continuous four-point perspective grid (f) Five-point perspective grid (g) Six-point perspective grid (Termes, 1991, p. 290).

Considering these findings, it can be assumed that the perception of a spherical visual field fundamentally structures THE VISUAL FIELD IS A CONTAINER image schema at its preconceptual, phenomenological foundation. This gives visuo-

¹⁹ The lack of broader recognition of spherical perspective is attributable in part to the numerous names used to describe disparate attempts working towards similar goals. These have occurred under the rubrics of *natural* (da Vinci, 1970), *celestial* (Herschel, 1869), *curvilinear* (Flocon & Barre, 1988; Herdman, 1853), *spherical* (Macnair, 1957), *hyperbolic* (Hansen, 1973), *curved* (Turner, 1976), *omnidirectional* (Fuller, 1975), *tetraconic* (Adams, 1976), *flat-sphere* (Casas, 1983), *polar* (Casas, 1984), *fish-eye* (Moose, 1986), *six-point* (Termes, 1991), and *radial* (Cresswell, 1998) perspective.

morphological form to what Helmuth Plessner (1928) describes as the inherent tension between ‘centricity’ and ‘eccentricity’ of the human experience (p. 290). He contends *Homo sapiens*’ self-consciousness results from our ability to contemplate the practical center of experience occurring ‘within’ the body from the theoretical perspective of being ‘outside’ the body. This ‘ex-centric positionality,’ he contends, produces an inherent sense of imbalance and alienation from not feeling at home in our own body or in the environment, which we address through cultural processes to envision and construct our ‘worlds.’ Plessner writes (as cited in Balthaser, 1990) that this center maintains “a certain distance from itself, so that, by means of this distance, it facilitates the total reflexivity of the life system” (p. 339).

When considered together, these theories suggest that the experience of the ‘inside’ and ‘outside’ of a corporeal boundary of the lifeworld is enclosed within the CONTAINER of a perceptual horizon. This appears to emerge, at least in part, from the preconceptual and pre-linguistic ‘archaic stratum’ of phenomenological perception. Since image schemas are derived from shared human physiology, this would account for how “universal principles working in individual cognition” would result in the recurrent spherical archetypes (Hampe, 2005, p. 6). And since THE VISUAL FIELD IS A CONTAINER image schema extends to the furthest horizon, it would have been dominantly circumscribed by the apparent sphericity of the heavens for most of human history (Figure 11).

Additionally, experiences of vision and self-consciousness are inevitably interpreted through contingent cultural influences. Cognitive linguists acknowledge the importance of “culture-specific, affect-laden experiences and bodily practices” that give rise to specific world views and ways of seeing (Hampe, 2005, p. 8). This is

particularly apparent within the special cases of metaphor called metonymy and synecdoche, in which sets of correspondences are conceptually mapped across domains.²⁰ Categorized as PART-WHOLE schemas, these are said to structure relationships and provide axiological value by metaphorically relating the meaning of THE PART FOR THE WHOLE or THE WHOLE FOR THE PART (Lakoff & Johnson, 2003, p. 36; Velasco, 2001). In other words, culturally specific metonymic and synecdochic metaphors structure beliefs in correspondences between the macrocosm and the microcosm.

Blumenberg's (2010) description of the orienting power of metaphors and their foundational function as models for human action highlights the metaphorical significance of the *heavenly sphere*. Interpretations of correlations between the heavens and Earth have profoundly influenced ideas about relationships between individual experience, human society, and the structure of the 'world.' These invariably emerge from complex interactions between image schemas and cultural contingencies, and—as will be discussed throughout this dissertation—material engagements with cosmographic practices. As Johnson (2005) notes, the embodied structures of *perceiving* and *doing* that flow from these interactions shape our *understanding* and *knowing*, which are essential for the emergence of meaning, imagination, and reason (p. 16).

²⁰ Metonymy is defined as “a figure of speech consisting of the use of the name of one thing for that of another of which it is an attribute or with which it is associated (as “crown” in “lands belonging to the crown”)” (Merriam-Webster, 2013a). Synecdoche is defined as “a figure of speech by which a part is put for the whole (*as fifty sail for fifty ships*), the whole for a part (*as society for high society*), the species for the genus (*as cutthroat for assassin*), the genus for the species (*as a creature for a man*), or the name of the material for the thing made (*as boards for stage*)” (Merriam-Webster, 2013b).

1.04 Gestalt Switching

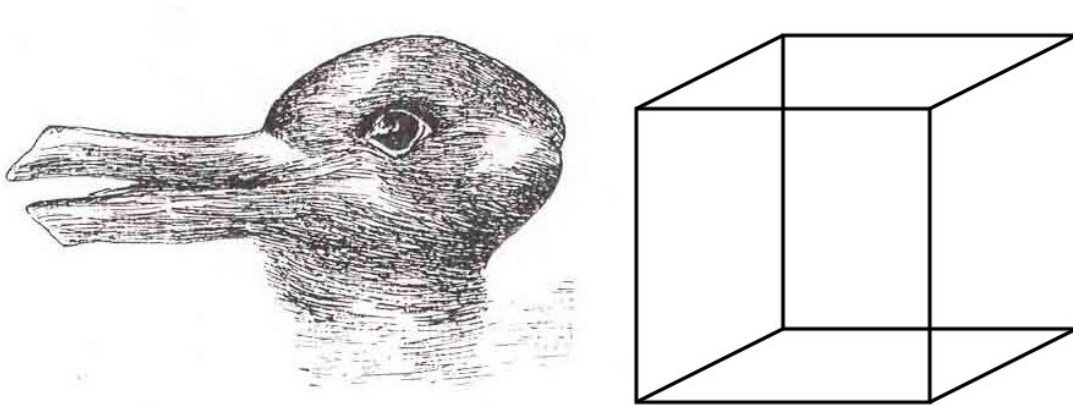


Figure 15. The duck-rabbit and Necker cube gestalt illusions (Jastrow, 1899).

The structure of the visual gestalt also relates to Thomas Kuhn's (1964) speculations about the relationship between thought and metaphors of vision in his influential *The Structure of Scientific Revolutions*. He equates the development of scientific knowledge with map-making (pp. 111–127), complementing the idea from cognitive linguistics that concepts emerge from embodied, visuospatial experiences. Kuhn argues that conceptual maps necessarily guide researchers through explorations of the immense complexity of nature, inextricably linking together the ways in which theory, methods, and standards are acquired. As is so often the case with metaphors, however, Kuhn treats the mapping metaphor as if it is self-explanatory and does not elaborate on its sensorimotor implications. Nevertheless, he also employs numerous other vision-oriented metaphors to describe mental processes.

Kuhn (1964) relates the conversion experiences of scientists between paradigms to a transformation via a “gestalt switch,” during which he claims “perceptions” are reconfigured as they learn to “see” a new “world view” incommensurate with previous assumptions (pp. 111-135). He borrows this analogy

from Norwood Hanson's (1958) discussion of the contextual significance and interpretive complexity of "reversible perspective figures." Hanson analogizes the to the "conceptual Gestalt(s)" (p. 90) of scientific theories in his *Patterns of Discovery*. He paraphrases Ludwig Wittgenstein to demonstrate his point, suggesting, "The psychological is a symbol of the logical" (p. 17), a pithy affirmation of Lakoff and Johnson's (1999) theory of embodied logic they call "philosophy in the flesh" (p. 551). Wittgenstein (1953) also discusses the paradoxes of relating image and imagination, citing the psychological switch between 'seeing' different forms in the famous duck-rabbit illusion, contending, "Seeing as . . . ' is not part of perception. And therefore it is like seeing, and again not like seeing" (p. 197).²¹

Kuhn (1964) calls upon perceptual phenomena—including the mutually exclusive orientations of the duck-rabbit and Necker cube—to demonstrate how a single image can be seen in different ways (Figure 15). He suggests that in the course of what he calls a "paradigm shift" (p. 66), the "scientist's perception of his environment must be re-educated [. . .] to see a new gestalt," and that, "the world of his research will seem, here and there, incommensurable with the one he had inhabited before" (p. 112). Though Kuhn's thesis has been critiqued as an oversimplification of the importance of gradual and integrating processes within the accumulation of scientific knowledge (Andersen et al., 2006; Toulmin, 1972), it has profoundly influenced the discourse concerning the compatibility—and incommensurability—of different ways of knowing.

²¹ For details on the history of the duck-rabbit image, see John Kihlstrom's (2004) *Joseph Jastrow and His Duck -- Or Is It a Rabbit?*

Kuhn (1964), however, does not directly attribute visual experiences to the “sudden and unstructured event” (p. 122) of a gestalt switch he associates with scientific insights. Yet he continually uses visual metaphors like ““scales falling from the eyes” of scientists. He also cites the “‘lightning flash’ that ‘inundates’ a previously obscure puzzle,” that enables “its components to be seen in a new way that for the first time permits its solution” (p. 122). Nevertheless, he ultimately maintains a strictly conceptual perspective on the gestalt switch. His reluctance to discuss the role of visual perception within this process suggests an ambivalence towards sight and its connection (or lack thereof) to conceptual abstraction. As will be discussed in coming chapters, this ambivalence has permeated Western thought since Plato.

Kuhn (1964) famously references the transformation from a geocentric to heliocentric world view as the seminal example of a “paradigm shift” (p. 66). Harrison (2003) also characterizes this as a defining element in the transition from the *medieval to infinite universes* (1.06 Worldviews and Universes). This celebrated example of a ‘paradigm shift’ has been extensively analyzed, though these generally focus on the theoretical causal factors. However, visual technologies at the time also influenced the shift in cosmic cartography. ‘Mapping’ was not simply a figurative metaphor but an integral part of efforts to correlate astronomical observations and theories. Bruno Latour (1990) addresses the importance of visual inscriptions and their enabling technologies within this transformation, connecting visualization to cognition through what he calls “thinking with the eyes and hands” (p. 1). The importance of visual media in cosmographic practices is apparent in Kuhn’s (1957) earlier work, *The Copernican Revolution*, in which he makes extensive use of visual maps of celestial phenomena to demonstrate the centrality of *sight* in the development

of both ancient and modern Western cosmology. Though Kuhn cites the telescopic observations of stars and comets as major contributors to the shift in vision necessary to accommodate the ‘Copernican revolution,’ he modifies his own perspective to rely heavily on mapping as a metaphor within *The Structure of Scientific Revolutions*.

The shifting status of ‘vision’ and ‘mapping’—from perceptual activities to metaphorical concepts—between these two publications epitomizes the general confusion cited by Blumenberg (2010) that arises from the ambiguous use and interpretation of metaphors. All of this illustrates David Turnbull’s (1989) astute observation in *Maps are Territories, Science is an Atlas* that, “there is no clear understanding among scientists, philosophers or cartographers as to what either a theory or a map is” (p. 1). Though a resolution to this conundrum may not be apparent, Kuhn’s (1964) struggle with this ambiguity situates the development of scientific ‘paradigms’ within a long history of cosmographic practices—as the subsequent chapters of this dissertation demonstrate—in which visual mapping techniques have been used to enactively construct knowledge about the world.

1.05 Polycentric Thought-Forms



Figure 16. Details from Hieronymus Bosch's *Garden of Earthly Delights* (1505).

To chart a path beyond the contentious binary polemics of 'paradigms,' Peter Sloterdijk (2004b, 2011) emphasizes the philosophical significance of imagery and visuospatial metaphors. He challenges the postmodern "incredulity toward metanarratives" (Lyotard, 1984, p. xxiv) and distrust towards "ocularcentrism" (Levin, 1993), using imagery to construct his own metanarrative of the history of the modern age. Just as Kuhn cites the importance of the overall gestalt in the process of 'seeing' new paradigms, Sloterdijk calls upon visual gestalts to point to the spatial aspects of unstable relationships between the microcosms of the self ('bubbles'), macrocosms of the world ('globes'), and the mesocosms of the social ('foams'). These images, which Sloterdijk (2005b) alternately refers to as "metaphors", "thought-images," and "thought-figures" (para. 11), provide the foundation for his "spherology," the visuo-morphological philosophy developed in his *Spheres* trilogy (2004b).

Sloterdijk draws attention to intimate interconnections between images, imagination, and cultural imaginaries (Elden & Mendieta, 2009, p. 11). Breaking

from the dualistic tendencies of rigid positivist dogma and slippery relativist critiques—often characterized as debates between the “two cultures” (Snow, 1959/1993)—he exhaustively argues for the necessity of acknowledging the complexity and spatiality of interrelations between individual, social, ecological, and cosmic domains. Instead of shying away from the use of imagery, he pushes Heidegger’s (1938/1977) “age of the world picture” to the extreme, using spherical ‘thought-figures’ to clarify and cultivate new ways of ‘seeing.’ Sloterdijk re-imagines the process of modernization through the lens of spherical metaphors, including the mother’s womb, celestial spheres, and planetary atmospheres, running the gamut of Western history from ancient Christian and Greek cosmology to contemporary networked cultures.

Though sections of the *Spheres* trilogy have only recently been translated into English, I have found them to be quite complementary to the general orientation of the current study. I am pleased to find strong resonances with Sloterdijk’s ‘spherology,’ though I developed the majority of this thesis independently of an awareness of Sloterdijk’s work. While he has arrived at the use of spherical themes through philosophy, I have arrived at philosophy through postphenomenological experiments with hemispherical projection environments (6.08 Learning to See). I believe this reveals a certain truth about the theoretical and pragmatic utility of applying these thought-images to understand aspects of culture, cognition, and the cosmos. Like ‘spherology,’ I attempt to shed light on the complex processes and polycentric perspectives that shape notions of the world, by “making the image a part of thought—or even better, by making thought a part of the image” (Jongen, 2011, p. 215) (6.14 World Views).

1.06 Worldviews and Universes

These theoretical foundations relate to the underlying structure employed to cohere the overall gestalt of this investigation. The quintessential recurring thought-form of the sphere serves as the literal and figurative lens through which I examine the emergence and continued presence of ‘worldviews’ and ‘perspectives.’ To interrogate how ideas about the sphere have shifted between different conceptual, metaphorical, and symbolic interpretations—as well as the cognitive, cultural, and material contexts within which these have taken place—it is necessary to further ground this investigation within established historical frameworks. Speculating about the ideas and lifeworlds of the distant past is fraught with complications, not the least stem from anachronistic projections of all-encompassing notions that are relatively recent inventions, including *world*, *cosmos*, and *universe*.

Since I cannot escape the conceptual trappings of contemporary language and concepts, I will attempt to acknowledge these influences by employing a visual heuristic structure for referencing various “world views” associated with wide-ranging cosmological visions.²² For this, I draw on two primary sources: Alan Combs’ (2009) *Consciousness Explained Better: Towards an Integral Understanding of the Multifaceted Nature of Consciousness* and Edward Harrison’s (2003) *Masks of the Universe: Changing Ideas on the Nature of the Cosmos*.

Combs (2009) primarily draws on Jean Gebser’s (1984) seminal account of the evolutionary “structures of consciousness.” Combs’ model proposes six distinct

²² I explain the development of the heuristic methodology I call *cosmographic hermeneutics* in Chapter 6: Visualizing World Views. Illustrations of different ‘world views’ provide ‘lenses’ through which I interpret visualizations of cosmic models within my *cosmotroping* practice.

structures representing “complete ways of understanding and relating to the world” (p. 62), composed of *archaic, magic, mythic, mental-rational, pluralistic, and integral worldviews*. Similarly, in his *Masks of the Universe*, Harrison (2003) proposes distinguishing the “Universe” from “universes,” defining the former as “everything and includes us experiencing and thinking about it” and the latter as “models of the Universe that we construct to explain our observations and experiences” (p. vii). He contends that while the “universes are the masks of the Universe,” the “unmasked Universe itself [. . .] remains forever beyond full human comprehension” (p. vii). He proposes the categories of *magic, mythic, geometric, medieval, infinite, and mechanistic universes* to chronicle admittedly broad conceptions of the cosmos across time. Both of these heuristic frameworks serve as touch points throughout this thesis. This is meant to acknowledge the shifting nature of not only conceptions, but also the perceptions, practices, and environments within which they are inextricably embedded.

Combs (2009) and Harrison (2003) present their rubrics chronologically, with each broadly representing ways of perceiving, understanding, and relating to lifeworlds across different historical epochs. Neither suggests these are all-encompassing or mutually exclusive, but propose them as heuristics for understanding the emergence and influence of dominant structures of consciousness and interpretations of existence across human history. I interchangeably use Combs’ (2009) *worldviews* and Harrison’s (2003) *universes* to draw on insights from both as well as to make explicit associations between the structures of consciousness and interpretations of universes.

The foundations of these heuristics elegantly connect to Blumenberg's (2012) 'metaphorology' via his notion of 'nonconceptuality.' The starting point of Combs' (2009) worldviews is a preconceptual, transitional *archaic* consciousness, while Harrison's Universe points to the *Universe* (capital U) as an unspeakable realm of existence inaccessible to discursive description or comprehensive quantification. Gebser (1984) refers to this primordial structure as the "ever-present origin" of consciousness from which all other states emerge, describing its potentiality as a "wakeful presence" (p. 42).²³ These attempts to conceive of the *nonconceptual* highlight the significant influence of language in structuring conceptual understanding.

Though Blumenberg (2012) and Harrison (2003) come from different fields of inquiry, they employ related metaphors to explain the functioning of metaphors. Blumenberg (1997b) calls on Montaigne's notion of the "the world's face" (p. 84) to describe the ways in which humans anthropomorphically identify meaning within metaphors, while Harrison (2003) asserts, "A universe is a mask fitted on the face of the unknown Universe" (p. 1). Harrison's series of 'masks'—synonymous with his notion of 'universes'—is analogous to Combs' (2009) use of 'worldviews.' These three metaphors connect the conceptions of the world to processes of 'seeing,' a relationship that will be explored in depth throughout this thesis.

²³ Nonconceptual cognition (*Śūnyatā*) is also a primary concern of Buddhist philosophy and practice. *The Buddhist Tradition of Samatha: Methods for Refining and Examining Consciousness* (Wallace, 1999) provides a brief summary of Buddhist techniques for examining nonconceptual states of awareness. *Nagarjuna and the Limits of Thought* (Garfield & Priest, 2003) discusses the recognition of paradoxical nature of nonconceptuality in the Buddhist tradition.

1.07 Cosmology and Cosmography



Figure 17. *Le Monde dans une tête de fou* (Unknown, 1590).

Given these inextricable relationships between vision and thought, it is necessary to clarify two key terms used throughout this thesis: *cosmography* and *cosmology*. Remi Brague (2003) defines *cosmography* as “the drawing or description (*graphein*) of the world as it appears at a given moment, with regard to its structure, its possible division into levels, regions, and so on” (p. 3). He specifies that while *cosmography* can be found in ancient Greek, the term *cosmology* first appeared within mid seventeenth century European natural philosophy (p. 229). Though the term *cosmology* is commonly used interchangeably with terms like *worldview* and *cosmovision*, Brague specifies that cosmologies are inherently reflexive—that they are “not that of a simple discourse, but an account of the world in which a reflection

on the nature of the world as a world must be expressed” (p. 4).²⁴ In these terms, this current study is primarily concerned with understanding the enactive role of cosmographic practices and artifacts within cosmological signification.

²⁴ For more on these distinctions, see Rita Cachao’s (2011) *Earth-Sky Cosmologies: A Reflection on Cosmology Through Human Practices* and Stanislaw Iwaniszewski’s (2009) *Did I Say Cosmology? On Modern Cosmologies and Ancient World-views*.

Conclusion

Building on Blumenberg's (2010) 'metaphorology,' Lakoff and Johnson's (1980) 'image schemas,' artistic and scientific studies of 'spherical perspective,' Hanson (1958) and Kuhn's (1964) 'gestalt switch,' Sloterdijk's (2004b) 'spherology,' Combs' (2009) 'worldviews,' Gebser's (1984) 'structures of consciousness,' and Harrison's (2003) 'universes,' the following chapters examine how visualizations of the *heavenly sphere* embody the complex and irreducible processes of knowledge production across the ages. I argue the cosmographic practices of imaging—and imagining—a cosmic order are integral to transforming the lifeworld into an intelligible home. By examining ways in which these practices enact interpretations of the heavens, I venture to illuminate the influence of intricate matrices of interacting conditions and perspectives within human efforts to make sense of existence.

Chapter 2: Domesticating the Universe

“Through habits formed in intercourse with the world, we also in-habit the world.

It becomes a home and the home is part of our every experience.”

(Dewey, 1934/2005, p. 108)

Introduction

In this chapter, I examine the role of image making within the deep history observing, imagining, and visualizing patterns in the heavens. I argue that material artifacts and environments functioned as integrated ‘tools for thinking’ within enactive processes of orientation and domestication, summarizing studies from the fields of cognitive archaeology, anthropology, and archaeoastronomy. After reviewing evidence pointing to the widespread practices of cosmographic visualization, I contend that the recurring symbolism of domes and spheres—and their use as tools for facilitating imaginative ‘flights’ between worlds—derives from their ancient association with the heavens.

2.01 Excavating Deep History



Figure 18. Blanchard Bone interpreted by Alexander Marshack as visualizing moon phases [France, c.30,000 BCE] (Peabody Museum, 2005).

For the vast majority of our species' history, visions of the *heavenly sphere* have shaped humanity's collective imagination. The dome of the sky regularly appeared as the magnificently overarching context of existence. The apparent rotations of the sun, moon, and stars escorted the eternal return of the seasons, providing a universal backdrop for synchronizing with the cycles of life.

According to certain archaeological interpretations, there is strong evidence that numerous Paleolithic era artifacts depict visualizations of the apparent patterns and motions of the sky. These suggest that inscriptions in bone (Marshack, 1972, 1991; Ruggles, 2005a) (Figure 18), carvings in rock (Norris & Hamacher, 2011), and paintings on cave walls (Jung & Rappenglück, 2006; Rappenglück, 2004a, 2004b) attest to the importance of recording solar, lunar, and celestial observations since at least Paleolithic times.

The creation of techniques to keep track of heavenly rotations would have been essential for ancient cultures to orient and integrate themselves within changing

ecosystems. Basic survival required familiarity with the complex relations existing between humans, other species, and their shared environments. Understanding of fertility cycles, foraging, hunting, wayfinding, timekeeping, agriculture, and other essential aspects of human culture were intimately connected to the sky (Campion, 2008; Penprase, 2011). Cosmographic practices related knowledge of ecological, topographical, and astronomical conditions and events across generations (Abram, 1996; Fabian, 2001; Norris & Hamacher, 2011; D. Turnbull, 2000).

Though attempts to construct chronologies of the influence of heavenly observations on early human creative expressions and conceptions of the world are inherently conjectural, interdisciplinary examinations of artifacts offer insights into the distant past. Hybrid fields such as deep history, cognitive archaeology, and archaeoastronomy are challenging sharp distinctions between ‘prehistoric’ and ‘modern’ human beings traditionally drawn by the discipline of modern history—a prejudice attributable to its nearly exclusive dependence on written records.²⁵ The fields employ diverse methodologies to study how engagement with material culture shaped the cognitive life of ‘prehistoric’ humans, combining techniques from cognitive science, evolutionary biology, paleoanthropology, archaeology, astronomy,

²⁵ A pithy statement of this exclusive dependence can be found in the first manual applying scientific principles to historical study: “No documents, no history” (Langlois & Seignobos, 1898, p. 17). As Robert Bednarik (1994) writes, “The term ‘prehistoric’ refers generally to an ethnocentric whim dividing human history by the advent of writing. This division is offensive to the peoples being studied by prehistorians; it is based on the application of an alien cultural concept to their cultures and denotes the ethnocentricity of that approach. It involves an implicit but unsupportable assumption that oral transmission of traditional knowledge is less reliable than its written transmission and its interpretation by ‘specialists’” (p. 141). Recent challenges to the disciplinary narratives and methodologies of modern history are documented within Shryock and Smail’s (2011) *Deep History: The Architecture of Past and Present*.

philosophy, ethology, cartography, semiotics, comparative mythology, and other fields.

These efforts are challenging triumphalist accounts of human and cultural evolution predicated on a narrative of “ever-increasing mastery of culture over nature, of cultivation over mere subsistence, of civilization over mere habitation” (Shryock & Smail, 2011, p. 4). Referring to ancient astronomical knowledge, Magli (2009) notes that we are only now “beginning, very laboriously, to realize that these past thirty thousand years that constitute our history are anything but the slow and steady march of progress” (p. 4).

2.02 Magic Worldview

The earliest remnants of material culture, including portable art and augmented natural environments, originate in the epoch of the *magic worldview*. Though impossible to precisely date this structure of consciousness, Combs (2009) primarily associates it with Paleolithic cultures (p. 63). Harrison (2003) recounts it as a time in which, “the world was animated by life [. . .] the past, present, and future coexisted, and nothing died, but transformed from a corporeal to an incorporeal state” (pp. 19–20). He imaginatively describes indwelling spirits that animated the world, reflecting and magnifying the thoughts and emotions of human beings as life confronted life. “I am inclined to think,” he writes, “that of all known universes, the magic universe was in its own terms the most rational and lucid, and all subsequent cosmological developments have been purchased at the cost of added mystery and perplexity” (p. 22).

2.03 Cognitive Cosmographic Models

While basic survival needs likely motivated the development of mnemonic and phenomenological strategies for visualizing the heavens, Michael Rappenglück (2009a) insists that Upper Paleolithic carvings and cave paintings provide evidence of complex “cosmovisions.” He defines these as “generalized perception(s) of the world, including ideas of its structure (cosmology), its origin and development (cosmogony), and the relation to human life within a specific ecosystem, shared and illustrated by the members of a certain social group” (p. 107).

Rappenglück (2008) argues that materially embodied cosmovisions are integral parts of human ecosystems, enabling cultures to transmit critical information to anyone sharing the syntax, semantics, and pragmatics of communication practiced by a community (p. 31). Through this, he claims, cosmovisions provided critical orienting and integrating functions, informed by and informing conceptions of social, psychical, and physical boundaries across generations. By inventing techniques for referencing and correlating spatiotemporal motions of the heavens with the chronobiology of animals and plants, climatic cycles, and human activities, he suggests communities were able to structure experiences of time and space to establish the dates of important activities essential for adapting to changing environments.

Drawing on Helmuth Plessner’s (1928) concept of ‘eccentricity,’ Rappenglück (2009a) asserts that humanity’s basic need to organize the world into a meaningful system of related parts is repeatedly addressed by changing “wilderness (chaos) into culture (cosmos)” and substituting “the unknown with the well-known” (p. 24). He suggests that while *Homo sapiens* share elementary signification

processes with our pre-human ancestors, our species became aware of a separation from the world through the unique functioning of our self-consciousness. Through our collective quest for centrality, Rappenglück (2008) proposes that ‘cosmographic symbolism’ emerged as a basic expression of the human mind. Identifying symbolic allusions to the apparent rotation of the sun and sky around the polar axis within numerous artifacts, he claims this was perceived as an essential connection between the navel of heaven to the center of the world in early cosmovisions.

By establishing an *axis mundi*, Rappenglück (2009a) contends, cultures sought to communicate with ancestral and cosmic powers that were seen as “exert[ing] their power upon the susceptible earth, producing and preserving the life in the world” (p. 109). “According to such views,” he argues, “the world is a spatiotemporal domain of interacting powers, mostly appearing as individual and collective beings” (p. 107), with little if any discernible separation between these animated “living” systems that today are studied independently under the specialized rubrics of astronomy, geography, meteorology, biology, and other disciplines. “In that world view,” Rappenglück (2004b) concludes, “different experiences of the world and of man himself had been combined into a unified whole” (p 6).

In the context of cognitive linguistics, the preconceptual instinct to establish boundaries associated with the CONTAINER and CENTER-PERIPHERY schemas support what Rappenglück (2009a) describes as the ancient demiurgic impulse to establish a basic polarity between the heavens and Earth through the creation of spatiotemporal enclosures. He writes that “organizing the world” required setting and respecting “physical, psychic and social boundaries” that allowed structuring and directing

activities “to concentrate physical and mental power” to establish and protect human life (p. 23).

Dividing the world into fundamental polarities through ritual activities established outer and inner realms that Rappenglück (2008) calls the ‘exosphere’ and ‘endosphere,’ distinguishing wild from domestic, kinship and foreign, sacred and profane (p. 24). Rappenglück interprets many remnants of material culture as evidence that caves, non-domestic architecture, dwellings, villages, cities, and landscapes served as *cognitive cosmographic models*, enabling communities to orient themselves by ‘domesticating’ the unknown world into an orderly home (p. 21).

His use of the term ‘domesticate’ to describe these orienting processes evokes a revealing double entendre that further illustrates connections between cognition and the cosmos. Though commonly associated with adopting something unfamiliar or foreign for one’s own purposes, its root (from the Latin *domus* or Greek *domos*, meaning *house* or *home*) also conjures images of spaces enclosed with the archetypal architecture of the sphere (1.03 Spherical Container). This etymological ambiguity alludes to the association of the perceived curvature of the sky as the primordial enclosure of humanity’s cosmic ‘home.’ In this sense, the notion of ‘domestication’ serves as a poetic reminder of how inextricably linked needs and desires are expressed through world-making activities for literally and figuratively *making sense* of a cosmic order.

2.04 Complexity of the Caves



Figure 19. *Hall of Bulls* in the Lascaux cave (Aujoulat, 2003).

While Rappenglück's (2009a) description of the relationship between astronomical knowledge and ancient cosmovisions is vast in its speculative scope, his interdisciplinary approach integrates many methodologies for studying Pleistocene era material culture.²⁶ In the past century, extensive analyses have produced numerous—and sometimes conflicting—accounts of the motivations for the creation and use of ancient visual artifacts.

²⁶ Some researchers prefer the geological term "Pleistocene" over the cultural term "Paleolithic" to indicate human artifacts beyond Western Europe that are between 10,000 and 100,000 years old. For a detailed discussion, see April Nowell's (2006) "From A Paleolithic Art to Pleistocene Visual Cultures."

Functionalist hypotheses describe cave paintings as artistic representations of everyday environments (Guthrie, 2005; Mithen, 1991) that may have been aids in sympathetic magic within shamanistic trances for hunting and fertility rites (Bahn & Vertut, 1997; Conkey & Lamberg-Karlovsky, 1989). Structuralist approaches attempt to discern the conceptual content of the images by studying their choice and location, while environmental analyses consider the broader sociocultural, climatic, and ecological conditions within which they were created (Jochim & Bailey, 1983; E. O. Wilson, 2012).

Distributed cognitive approaches contend that physical artifacts provided numerous practical benefits. They served as symbolic memory storage and retrieval devices (Donald, 1991, 2001), changing the functioning of biological memory to such an extent they instigated a profound transition in human cognitive capabilities. Cognitive approaches also argue that the development of calendrical systems for keeping track of celestial and terrestrial phenomena played a significant role in supporting the cognitive development of “mental time travel” (Smedt & Cruz, 2011, p. 64) by enhancing imaginative capabilities to extend past events into the future, correlating the development of Upper Paleolithic artifacts marking ecological cycles with improvements in foraging capabilities (p. 71).

Neuropsychological models propose that the images reflect subjective visual hallucinations in various states of consciousness (Devereux, 1997; Lewis-Williams, 2004; Lewis-Williams & Dowson, 1988). Finally, phenomenological methods focus on the perceptual gestalt of the paintings and settings, taking the perspective that, “one cannot hope to enter the ‘ancient dialogue with the caves’ without experiencing

the images in all the multisensorial richness of the caves themselves” (White, 2003, p. 117).

This diverse array of approaches and methodologies for interpreting Pleistocene art to discern the intentions, contexts, and cognitive capabilities of their creators attests to the inherently complex nature of human efforts to make sense of the world—and, by extension, the irreducibility of knowledge production. Robert Bednarik (2003) contends that discoveries of iconic artifacts hundreds of thousands of years old dramatically extend the temporal horizon of the emergence of self-consciousness and challenge superficial notions of the human past (p. 96). He argues that these ancient artifacts do not yield to overly simplistic analyses. Bednarik describes these ancient examples of hominid creativity as “‘managed’, intentional use of visual ambiguity” (p. 21) that demonstrate the semiotic capacity to draw a link between a signifier (referrer) and the signified (referent). Bednarik (2006) argues that the study of the origins of non-utilitarian artistic expression is critical for understanding how we construct reality, postulating that, “humans can study only one area of human consciousness objectively: that which is called art” (p. 1).²⁷

Though the precise role of the creation of these visual artifacts in human cognitive evolution remains a topic of contentious debate,²⁸ researchers generally agree that it signaled “unparalleled creativity and symbolic expression (Nowell, 2006, p. 240). In *Homo Aestheticus: Where Art Comes From and Why*, Ellen Dissanayake

²⁷ Bednarik (1994, 1994, 2003, 2006) also cites numerous examples of ancient artifacts from around the world to make the case “that the oldest and symbolically most sophisticated palaeoart is that of Asia rather than Europe” (2003, p. 89).

²⁸ Pleistocene art is examined in the context of the evolution of consciousness in Jennifer Gidley’s (2007) “Evolution of Consciousness as a Planetary Imperative” (pp. 203-218) and Robert Bednarik’s (2011) “The Origins of Modern Humanity.”

(1995) suggests these artifacts indicate deliberate acts of “aesthetic making special” (p. 48), differentiating the extraordinary from the ordinary as a way to focus attention on particularly important cultural practices. She holds that this ability to envisage other “worlds” through sensual and emotional signification provided realms through which humans were able to “play around with” ideas, providing “another level of dealing with ‘reality’ above the pragmatic.” The evolution of this universal predisposition of human behavior and mentality, she claims, has enabled individuals to transcend the continuous present and tap into “meta-” or “as-if” realities through participating in interpenetrating and often indistinguishable process of ritual, art, and play (pp. 96–97).

2.05 Tools for Thinking

Recognition of the active role of material artifacts in facilitating epistemic processes integral to self-conscious cognition have led to critiques of ‘representational’ assumptions informing many interpretations of Paleolithic imagery. Broadly assembled under the rubric of *situated cognition*, these *embodied*, *enactive*, and *extended* theories of mind challenge dominant cognitivist theories that assume the brain is an ‘internal’ computational storehouse for receiving and manipulating ‘external’ sensory information (Clark, 1997). Instead, these approaches conceive of the mind as being ‘structurally coupled’ within a network of ongoing interactions (Malafouris, 2007a; Varela, Thompson, & Rosch, 1991).

In this view, objects and environments are active extensions of cognitive processes, with the arising world brought forth by the co-substantial symbiosis of the signifier and signified (Malafouris, 2007a, p. 297). Instead of creating visual representations with symbolic meaning of a passively discovered and pre-given reality, the process of image-making is seen as an aspect of visuospatial cognition, providing essential problem solving techniques that make previously unavailable perceptions of the world possible through ‘epistemic actions’ (Kirsh & Maglio, 1994). By conceiving material artifacts as ‘tools for thinking,’ they are not simply “an expression of intelligent behaviour but very often the necessary condition for the emergence of such behavior” (Malafouris, 2007a, p. 294). In short, humans are said to think *through* things and images, not just *about* them (Malafouris & Renfrew, 2010, p. 1).

By disputing the modern tendency to draw rigid distinctions between ‘internal’ concepts and ‘external’ representations, these situated approaches blur

dualistic boundaries between ‘mind’ and ‘world’ (Shryock & Smail, 2011, pp. 30–31). Within these conceptions, “perception and image are continuous; in changing the one you affect the other and thus you cannot understand the one in isolation from the other” (Malafouris, 2007a, p. 289). Imagery and environments become historically situated and contingent extensions of human cognitive architecture. Objects provide qualitative ‘affordances’ for performing actions, in which sight is no longer passive but analogized to touch (Gibson, 1979; Noë & O’Regan, 2002). These perspectives reconceive perception as an active, iterative process, involving both learning *how to see* and *formulating conceptions* about the world (Gregory, 2005). Thought and experience are interpreted as inseparable from the “constitutive intertwining of cognition and material culture” (Malafouris, 2004, p. 53), a process Lambros Malafouris (2007a) describes as ‘enactive signification’ through ‘material engagement.’

Malafouris (2007a) proposes that the cave paintings in Lascaux and elsewhere brought forth a “new process of acting within this world and at the same time of thinking about it” by “embellishing the natural formation of the rock” (p. 295). He continues:

The boundary between the ‘internal’ concept seen in ‘the mind’s eye’ and its external representation on the wall of the cave should be questioned. The cave wall was not simply a ‘context’ for the ‘mind inside the head’, it was the outward membrane of the ‘mind inside the cave’. The Paleolithic image-maker constructs an external scaffold that affords the world to be seen and experienced in ways that the physiology of the naked eye by itself does not allow. This scaffolding also enables a new direct understanding of the human

perceptual system and thus offers the Paleolithic individual the opportunity to become in some sense, maybe for the first time, the engineer of his or her own perception. The image, as it is also the case with language, enabled humans to *think about thinking*. (pp. 299-300)

Instead of questioning *why* these images were created, situated conceptions often focus on *how* environments served as scaffolding devices for human perception to become aware of itself. By asking “what kinds of minds are constructed by perceiving those images?” instead of “what kind of mind was needed to make those images?” (Malafouris, 2007a, p. 295), the enactive signification approach emphasizes the metacognitive advantages—the ability to “think about ones thinking” (J. K. Gilbert, 2005, p. 9)—of new kinds of perception made possible through image-making. Images are not interpreted simply as translations or projections of pre-existing concepts into the physical world, but as integral aspects of processes that give rise to new ways of perceiving reality.

2.06 Cave as a Cosmos

The situated view of cognition provides a useful lens through which to consider how interactions with materiality shape the way humans imagine and ritually enact cosmovisions within immersive, multisensory environments. Malafouris (2007b) contends that archaeological and anthropological accounts of artifacts addressed solely in terms of mnemonic significance fail to adequately address the “complex affective and multimodal interactions that characterize the phenomenology of religious experience” (p. 1). Referring to the notion of image schemas within conceptual metaphor theory (1.03 Spherical Container), he suggests, “anthropomorphism should be understood as a metaphoric projection” (p. 5). He cites examples of painted human and animal figures appearing to come out of the cave walls as “essentially the conceptual mapping between a familiar or concrete and an unfamiliar or abstract, phenomenal domain” (p. 5-9).

Blumenberg (1997b) similarly regards the identification of faces in the contours of a cave as exemplary of the elusive, subjective, and intuitive quality of anthropomorphic pattern recognition, emphasizing that “not only words and signs but also things themselves” have “incomparable situated meaning” (p. 84). The context-dependent nature of conceptual mapping within the caves is further echoed in David Lewis-Williams’ (2004) *The Mind in the Cave*, in which he argues that environments like the Lascaux grotto provided a kind of sacred theater or Paleolithic temple for enacting ceremonial events and depicting shamanistic visions induced by altered states of consciousness.

Malafouris (2007b) proposes that the material substrate of these environments amplified the complex gestalt of experiences through iterative interactions, anchoring

animistic, fetishistic, and anthropomorphic processes through which a “transcendental stance” (p. 7) could emerge. Viewing the material environment and image-making tools as “continuous and interactive parts of an extended cognitive system” (p. 9), he challenges the notion of early shamanistic contemplative practices as independent of their surroundings (e.g., in Rossano, 2007). Malafouris (2007b) suggests that “if there was a single special element in the process of human becoming then it has to be ‘mediation’ rather than ‘meditation’” (p. 7).

Rappenglück (2004b) uses an “integral methodology” (p. 7) to construct a narrative describing the sophisticated motives behind the creation of the Lascaux paintings, employing multiple perspectives and disciplines to accommodate the possible superposition, complementarity, and paradoxicality that can arise via different forms of analysis. He describes this as an “interdisciplinary approach, which respects and relates data and procedures of archaeology, astronomy, ethnology, cartography, mathematics, mythology, phenomenology, science of art, science of religions, semiotics, symbolism and adjacent sciences” (p. 7).²⁹ Rappenglück (1998) uses this methodology to analyze the multi-layered complexity of these environments, contending, “previously presented interpretations” of Pleistocene cave art, “like a hunting scene, a funeral monument, a cult of the dead, hallucinations, a magic scene, a sexual topic, a divination, a sacrificing rite, a shamanistic totemistic scene or a picture of the sky are not wrong, but must be combined together in a consistent view” (para. 3).

²⁹ Rappenglück’s integral methodology is similar to one I use for *cosmographic hermeneutics* (6.12 Cosmographic Hermeneutics).

Drawing on contemporary understandings of shamanistic traditions

Rappenglück (2004b) suggests that the cave was a place in which important rituals were performed to provide for the social cohesion, health, and wellbeing of communities.³⁰ He contends that these ecstatic rituals established cosmic harmony by arranging communication between heavenly and earthly realms. He describes the individuals conducting these rituals as generalists within their community, embodying “the unity in diversity of feeling, thinking and action in very different fields” (p. 9) by combining the roles of scientist, magician, priest, educator, historian, sorcerer, and artist. Emphasizing the importance of their mastery of cosmography, Rappenglück cites shamanistic healing rituals worldwide that still require intimate knowledge of interacting cosmic figures, structures, events, and proceedings associated with celestial phenomena.

As a result of his extensive study of the Lascaux grotto, Rappenglück proposes extending Lewis-Williams’ notion of “mind in the cave” to the “cave as a cosmos” (Jung & Rappenglück, 2006, p. 78).³¹ Rappenglück (1998) details a theory of how the artificial sky of the cave’s natural subterranean rock ceilings provided an immersive environment within which certain members of the local hunter-gatherer societies could create multidimensional, cosmographic maps to sustain cultural

³⁰ Derived from the term *saman* used by the Tungus people of Siberia (meaning ‘one who is excited, moved, raised’), *shaman* is used here to refer to the “family of practitioners who focus on voluntarily entering altered states of consciousness in which they experience themselves or their spirit(s), traveling to other realms at will, and interacting with other entities in order to serve the community” (Walsh, 1990, p. 11).

³¹ Though the body of Rappenglück’s research covers many sites and artifacts, the cave art research referenced here stems primarily from his doctoral dissertation (1999a), an in-depth analysis of the “Hall of Bulls” and the “Well of the Dead Man” in the cave of Lascaux (near Montignac, Department Dordogne, France).

knowledge of lunar cycles, animal seasons, and celestial patterns. Symbolizing the heart of the world and the womb of the universe, Rappenglück (2004b) describes these as portals housing inaugurations into secret knowledge by enabling “travel through the cosmic strata” (p. 10) to “seek contact with archetypal ancestors” (p. 9) and “learn more about the forces and structures of nature” (p. 10).

2.07 Circumpolar Rotations



Figure 20. Seven-hour exposure of circumpolar star trails (Russ, 1982).

Of particular significance was knowledge of the nightly rotation around the pole star (Figure 20)—along with the shifting positions of the sun, moon, stars, and meteorological phenomena—which physically animated the celestial vault.

Rappenglück (1999b) cites several Paleolithic artifacts interpreted as symbolizing the whole cosmos turning around the polar point of the ‘axis mundi.’ These artifacts often take the form of “one-legged polar beings” (p. 169) (Figure 21), representing the spindle around which the cosmos turns but also functionally used as gnomons of

sundials used to fix the course of the seasons by casting shadows during solstices and equinoxes (1998).

Numerous mythologies describe the pole star as securing the central point of this axis, linking the tripartite cosmic realms of heaven, Earth, and the underworld. Mircea Eliade (1961) describes this as “the infinitesimal point through which passes the Cosmic Axis,” where both time and the sensuous world can be transcended to achieve “*stasis*—the eternal non-temporal present” (p. 75). The ritual circumambulation around a sacred center or cosmic pillar, common to several religions throughout the world (Davidson & Gitlitz, 2002, p. 113), similarly evokes the passage of time experienced through these celestial cycles and their terrestrial corollaries. This ancient association is suggested by the etymological root of ‘universe,’ derived from the Latin *universum* or “everything rotated into one” (Barrow, 2011, p. 297).

2.08 Visions of Flight



Figure 21. *Panel of the Wounded Man* in the Lascaux cave (Aujoulat, 2003).

Circumpolar rotations marking the navel of the universe also persistently connect to the theme of a flight through the cosmic spheres by shamans and bird-men (Rappenglück, 2009b). Ancient cave paintings, rock carvings, and ritualistic artifacts frequently depict vertically oriented figures with arms outstretched, regularly accompanied by ‘spirit helpers’ in the form of solar icons, animal imagery, and geometric forms (Devlet, 2001). Deciphered as transpersonal experiences of bird’s eye flight to access visionary ascension to the heavens, these are interpreted as occurring across mythic time, paradoxically encompassing aspects of both the linear, diachronic, and ‘profane’ world as well as the absolute, synchronic, and ‘sacred’ one

(Eliade, 1959; Ross, 2012).³² By transcending this “door in the sky” (Coomaraswamy, 1997) from lower to higher realms, Rappenglück (1998) contends shamans could get in touch with the potentiality behind phenomena, “travel[ing] to the spheres of the space-time” and communicating with “relatives in the sky” (para. 6).

Rappenglück (1998) describes dangerous journeys between the lower and the upper world of cosmic spheres, during which the shamans pass “the lightning, the thunder, the rainbow and other phenomena,” crossing “the courses of the sun, moon and the wandering stars” to reach “the pole star or the Milky Way” (para. 33). Because of the significance of pole star as the *axis mundi*, “the most powerful of the primeval celestial beings were among the stars and constellations along the course of the Moon (the zodiac), in the Milky Way and the circumpolar ones, especially at or near the celestial pole” (2004b, p. 18). He (2004b, p. 19) interprets the Lascaux “Panel of the Wounded Man” (Figure 21) as a visualized constellation of the ‘summer triangle’ in the plane of the Milky Way, formed by the ‘eyes’ of the bird man, bison, and bird on a stick symbolizing the *axis mundi*.

Symbolically encoding cosmovisions within these environments, Rappenglück (2004b) argues, made it possible for ancient hunter-gatherer cultures to properly regulate the “times and locations at which myths had to be narrated, rituals

³² Claude Lévi-Strauss (1955) notes, “the specific character of mythological time, which as we have seen is both revertible and non-revertible, synchronic and diachronic, remains unaccounted for. Therefrom comes a new hypothesis which constitutes the very core of our argument: the true constituent units of a myth are not the isolated relations but bundles of such relations and it is only as bundles that these relations can be put to use and combined so as to produce a meaning” (p. 431). Elsewhere Lévi-Strauss (1990) suggests that myth is an instrument for the “obliteration of time” and that it only needs time “in order to deny it” (p. 325).

celebrated and initiations executed” (p. 10) by synchronizing them with solstices and equinoxes, certain positions of stars, constellations, and other celestial phenomena. Jung and Rappenglück (2006) describe these ritualistic visualization processes as transforming caves into storehouses of worldviews. They relate this to a kind of Paleolithic era temple-planetarium that enabled their creators to “get in touch with the potentiality behind the phenomena, the spatiotemporal framework and the origin of the world” (p. 78). They liken the caves to “a kind of cosmic vessel, later substituted by sacred temples or alchemistic furnaces, in which the primordial elements being in a state of chaos are collected, mixed and transformed into objects and creatures, so that a cosmos is formed” (p. 66). Cave walls, they suggest, provided a semi-permeable membrane “between the world similar to the lapidary sky vault,” which “offered a unique possibility to explore the inner structure of the cosmos and other worlds” (p. 68).

Jung and Rappenglück further suggest these practices stimulated “the influence of the macro-cosmic transmutation upon the micro-cosmic development of matter to mind” (p. 66) recalling the PART-WHOLE schema through which both metonymic and synecdochic metaphors structure understanding of relationships across domains. They argue that shamans used these environments as ‘transmutation’ technologies supporting “psychonoetic processes of human self-realization” (p. 66). They refer to examples of animals and humans shown coming out of rock walls as anthropomorphic “discoveries,” interpreting them as “new embryonic beings that are the celestial bodies (sun, moon, and stars), plants, animals, humans, and sometimes gods” emerging from the “rocky uterus for the creatures of the world and even for the universe itself” (p. 66).

The sacralization of caves, Rappenglück (2009a) argues, were part of a general processes of cosmogonic domestication, originating with a “separation of sky and earth from a preexisting singularity, often imagined as an egg, as a primordial chaotic substance—mostly water—or as a kind of living being” (p. 111). Through this, Jung and Rappenglück (2006) claim, caves were transformed into sacred places of “initiation, enlightenment, transmutation, oracle, and healing,” providing immersive spaces for the, “early search of man for his and the world’s roots” (p. 78). By providing a contained environment within which ideas and experiences could be iteratively and reflexively explored through material embodiment, the caves afforded the possibility of phenomenologically amplifying and integrating complex cognitive processes as humans in the “magic universe” (Harrison, 2003, p. 22) imagined, experienced, and enacted their worlds over the course of tens of thousands of years.

2.09 Imago Mundi

Claims concerning the astronomical significance of Pleistocene cave paintings are controversial. They exemplify the challenges of interpreting the complex role of material engagements within ‘domesticating’ processes.³³ Moving from simplistic interpretations of images as solely representational to the enactive view forces a reconsideration of solipsistic assumptions about the role of material engagement in human cognition. Far from being peripheral and inconsequential adjuncts to the literal, oral, or contemplative, image making becomes an active agent in catalyzing imaginative processes. Embodying preconceptual metaphoric projections within a material substrate enables intensive iteration of ideations that complement other cognitive modalities.

The discovery of ancient artifacts interpreted as materially embodying astronomical knowledge—and the subsequent attempts to grapple with their implications—challenge modern characterizations of historically distant animistic and mythical cultures as “primitive” (Bird-David, 1999, p. 68). The dominance of a near exclusive emphasis on writing and literacy as hallmarks of cultural sophistication and intelligence, or what Ellen Dissanayake (1995) calls “scriptocentrism” (p. 203), has infused modern consciousness with a blinding sense of superiority over ‘pre-modern’ peoples. Yet, as these embodied, enactive, and extended analyses of Paleolithic art suggest, the historic focus on written language may have occluded the evolutionary and cultural significance of material engagement within cognitive development.

³³ A recent literature survey shows that detailed astronomical observations were common among hunter-gatherers (Hayden & Villeneuve, 2011), supporting proposals that paintings within sacred caves contained allusions to astronomical phenomena.

2.10 Living Models

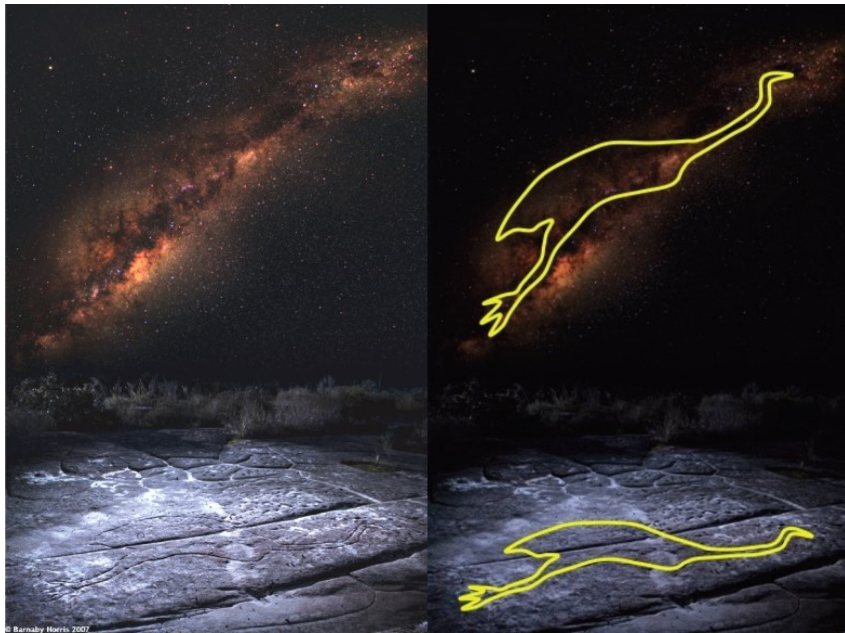


Figure 22. Aboriginal rock carving reflecting the Emu dark cloud constellation in the Milky Way [Ku-ring-gai Chase National Park, New South Wales, Australia, date unknown] (Norris, 2008).

The practices and beliefs associated with the magical universe are not confined to the distant past. Empirical knowledge developed over many generations can be still be found in numerous traditional, folk, and indigenous cultures worldwide. References to sacralized landscapes, celestial patterns, and ecological phenomena are encoded within their narratives, rituals, artifacts, and environments. Understanding these techniques are particularly relevant for contemporary efforts to understand how human societies have synchronized with the cycles of life (Abram, 1996; D. Turnbull, 2000). These cultural practices provide living examples of how knowledge, beliefs, and material engagements are integrated into coherent *cognitive cosmographic models*. These models have emerged from specific geographic

contours, environmental conditions, and cultural practices, producing a wide variety of unique mythical systems.

Relevant to this current study, these diverse traditional ways of knowing consistently reference astronomical, ecological, and meteorological events via microcosmic/macrocosmic correlations (Figure 22). For these cultures, knowledge of solar, lunar, celestial, and terrestrial phenomena remains essential for both synchronizing with the cycles of life and preparing portals to the afterlife. Their persistence over the millennia, often in the face of extreme hardship and active oppression, attests to the importance of the visuospatial imagination for integrating with environments, sustaining life, and maintaining social coherence and cohesion (Abram, 1996; Apgar, Argumendo, & Allen, 2009; Berkes & Berkes, 2009; Helfrich, Metzger, & Nixon, 2005; Maryboy, Begay, & Nichol, 2006; Ruggles, 2009).

For many cultures, metaphorical variations on the *heavenly sphere* continue to reflect the primordial enclosure of humanity's cosmic home. It has long provided a dynamic, and yet predictable, environment and overarching context within which humans have structured their multifaceted cosmovisions. Widespread techniques for making sense of apparent solar, lunar, and celestial phenomena across the visual gestalt of the sky demonstrate common creative strategies among geographically and temporally dispersed civilizations.

Not surprisingly, these mnemonic techniques have evolved through the appropriation and adaptation. For instance, the constellations adopted by Greco-Roman civilizations have conventionally been attributed to the ancient Mesopotamians. Recent scholarship, however, suggests that their development occurred gradually over the course of many thousands of years—perhaps even dating

to the Paleolithic (Pellar, 2012; Rappenglück, 1998). Krupp (2000) argues that it was inevitable that our ancient ancestors would imagine constellations given humanity's innate visual pattern recognition skills. He contends these abilities were essential for the development of creative survival techniques, including "timekeeping, season marking, calendrics, weather signs, concentrations of supernatural power, and symbolic containment of important cultural data" (p. 58). Additionally, analyses of numerous mythologies have demonstrated that tales of mythic characters correlate astronomical patterns with terrestrial landmarks (Santillana & Dechen, 1992; Sullivan, 1996). This human propensity for anthropomorphic pattern recognition and metaphoric projection leads Alex Gurshtein (2005) to contend that the "'domestication' of the immediate living space likely went hand in hand with the 'domestication' of the heavens" (p. 104).

2.11 Mythic Worldview



Figure 23. Detail from the *Egyptian Book of the Dead of Nesitanebtashru* depicting the firmament as the sky goddess Nut [c.950 BCE] (British Museum, 1997).

Contemporary studies of the remnants of material cultures dating from the beginning of the Neolithic era—which Combs (2009) describes as the dawn of the ‘mythic worldview’—demonstrate the many ways in which interactions with visual technologies contributed to the development of cosmological imaginaries.³⁴

Numerous findings from the field of archaeoastronomy illustrate the perennial influence of heavenly visions on the development of gods and goddesses in the

³⁴ Combs (2009) approximates the beginning of ‘mythic worldview’ began with the agricultural revolution brought on by dramatic climatic changes at the end of the last ice age. This coincides with the beginning of the Neolithic period around 10,000 years ago. He correlates the end of this end with the transition of the “feminine emphasis on community” towards “a masculine emphasis on action and agency” (p. 65) in ancient Greece and Mesopotamia. Harrison (2003) contends that this ‘mythic universe’ did not take hold everywhere, as Australasia and other isolated places did not experience the same climatic shifts and cultural conflicts as other parts of the world (p. 29).

mythic universe, made explicit by the orientations and alignments of tombs, village layouts, landscapes patterns, megaliths, and temples to cardinal directions, celestial patterns, and long-term astronomical cycles (Figure 23). Computer-assisted abilities to simulate the appearance of the sky at different times and latitudes have accelerated efforts to decipher precise correlations between man-made and natural environments. As a result, analyses of sites worldwide continue to reveal the intricacy of ancient domesticating strategies for interpreting the cosmic order through reflections in the human domain (Kelley & Milone, 2011; Krupp, 1996; Magli, 2009; Ruggles, 2005b; Santillana & Dechen, 1992).

2.12 Embodying the Macrocosm



Figure 24. Australian Meriam thatched house [Australia] (Queensland Museum, 1993), Apache grass wickiup [North America] (Curtis, 1898), Arbore thatched hut [Ethiopia] (Lafforgue, 2011).

The rise of the mythic universe appears to have coincided with the increased use of domed structures symbolizing the *heavenly sphere* within the terrestrial realm. Thomas Markus (1999) suggests that techniques using light and flexible materials to create curved architectural roofs potentially first came into use during the Neolithic era. Artificial dome-like dwellings constructed from branches, thatch, and skin can still be found in different parts of the world (Figure 24). These could have been perceived as material emulations of the firmament, fusing functional needs of shelter and orientation with cosmographic symbolism. The ongoing use of these structures in African, Australian Aboriginal, and Native American cultures suggest the importance of perennial correlations between the perceived ‘outer membrane’ of the sky and its replication through acts of domestication that metaphorically embody the macrocosm.



Figure 25. Pyramid of Djoser [Egypt, 2648 BCE](Sharp, 2005), Newgrange passage tomb [Ireland, c.3100 BCE] (Shira, 2006), Tomb of Agamemnon [Greece, c.1250 BCE] (Atelier Joly, 2005).

Over time, the invention of new construction techniques afforded the creation of rounded enclosures for burial tombs, kivas, temples, stupas, cathedrals, mosques, and other structures reflecting the *heavenly sphere* (Figure 25 and Figure 26) (Jung & Rappenglück, 2006). Just as the contours of sacred caves may have provided the material substrate for emulating the celestial vault to facilitate journeys to the upper worlds of the tripartite shamanic cosmos, these rounded structures defined the physical and psychic boundaries of sacralized spaces. Domes continue to enclose environments within which the ritualistic interplay of contoured surfaces, lights, shadows, sounds, and smells assist with enacting and re-enacting mythologically significant rites and imaginative cosmic journeys.

E. Baldwin Smith (1950) catalogues construction techniques used to create domed structures across Byzantine, Islamic, and Indian civilizations in his seminal study *The Dome: A Study in the History of Ideas*. He cautions against attempts, however, to understand its history from a purely functional perspective. He points to the “persistent association with the idea of an important house,” referring to it as a “cosmic house” and “heavenly shelter” (p. 5) that symbolizes the preservation of ancestral beliefs and ideas of creation and containment.

Ananda Coomaraswamy (1997) similarly advises that “meaning” and “function” cannot be practically separated when considering the origins of dome symbolism, suggesting they express a “polar balance between the physical and metaphysical” (p. 209). He argues that these structures are “primarily a work of the imagination,” and though they can be considered from archaeological, technical, logical, and aesthetic perspectives, the distinctions dissolve as “function and significance coincide in the form of the work” (p. 209).

Along these lines, René Guénon (2004b) points out “there is nothing ‘profane’ in integrally traditional civilizations” (p. 245). The contemporary distinction between a “house” and edifices for sacred purposes, he insists, have resulted from a “profound degeneration that houses have finally come to be built with no more in view than responding to the purely material needs of their occupants” (p. 245). In this regard, we should approach the analysis of the role, purpose, and influence of domed architecture with the same degree of sensitivity to complex motivations and anachronistic projections that inform interpretations of cave paintings and other ancient artifacts (2.04 Complexity of the Caves).

The dome’s resonance, Smith (1950) argues, can be traced to “the natural and persistent primitive instinct to think in terms of customary memory images and to attribute actual being and inner power to inanimate objects,” preserving “some ancient memory of supernatural beings associated with its form” (p. 5). Hinting at anthropomorphic origins (1.03 Spherical Container), he suggests:

From the time when men began to visualize the unknown in terms of the known and attached so much value to mimesis, many cultures had come to

think of the house, tomb, and sanctuary as a replica, or symbol, of the universe. (p. 49)

Coomaraswamy (1997) similarly contends that the dome's symbolic authority derives from its perception as an "abode of the cosmic order," providing "cosmic or supramundane prototypes" (p. 203) through which to correlate analogical relationships between the macrocosm and microcosm. While shamanistic cultures sought to establish cosmic harmony by connecting with the "divine lords" and "ancestors" by bringing together the heavenly and earthly realms, these mythic domed structures often symbolized the celestial realm of gods responsible for designing and maintaining the order of the world (Harrison, 2003, p. 30).



Figure 26. Sanchi Stupa [India, 3rd century BCE] (Suganth, 2010), Dome of the Rock [Jerusalem, 691 CE] (Bi, 2011), St. Peter's Cathedral [Italy, 1626 CE] (Stuck, 2004).

Though the adornments of different domed environments inevitably reflect the specific worldviews from which they arose and were meant to sustain, their structural designs and symbolism remain consistent across vastly diverse cultures (Figure 26). Internal and external surfaces are often steeped in visually symbolic and geometric significance—with the familiar motifs of a meeting of heaven and Earth incorporated

through orientations of the vault above and plane below, aligned with celestial correspondences and cardinal directions (Coomaraswamy, 1997, p. 196). The vault and plane are usually positioned in relation to a central axis, alluding to the rotation of the sky around a polar point and the ‘center of the world.’ Guenon (2004a) contends that this:

in effect, is not a 'place' in the topographical and literal sense of the word, but rather in a transcendent and principal sense, and consequently can be realized in any 'center' regularly established and consecrated, whence the necessity of the rites which make the construction of a building a veritable imitation of the very formation of the world. (p. 249)

The process of ‘domesticating’ the macrocosm within the microcosm continues to be associated with establishing places of ritual, indoctrination, and transcendence as well as facilitating imaginative ‘flights’ between worlds. Just as visionary journeys along the *axis mundi* are represented within mythologies by the scaling of ladders, stairways, terraces, vines, stalks, columns of smoke or fire, a world tree, or a cosmic mountain (Eliade, 1961, pp. 47–51; Rappenglück, 2009b), domes frequently symbolize their central axis in the form of a central post, hearth, altar, oculus, or spire. Their zenith is often capped with a ‘sky-scraping’ mast or ‘sacrificial post’ symbolizing the *omphalos* or navel of the universe (Coomaraswamy, 1997, p. 205; Govinda, 1976, p. 15; Snodgrass, 1992, p. 163).

An altar or hearth is often situated in this central point in both temples and dwellings, sometimes below an opening at the summit to allow symbolic smoke to rise and connect the microcosm to macrocosm (Guénon, 2004a, p. 250). Apertures at

the pinnacle also represent the ‘eye’ or ‘lantern’ of the dome to enable light from the higher realms to enter into the sacred space. This is both functional and symbolic as a source of illumination and a means of passage (Coomaraswamy, 1997, p. 218).



Figure 27. *Assumption of the Virgin* [Italy, 1530] (Correggio, 1530 C.E.), *Christ Pantocrator* mosaic in the Church of the Holy Sepulchre [Jerusalem] (Werner, 2010), *Apotheosis of Washington* [Washington, D.C., 1865 C.E.] (Brumidi, 1865).

In his review of European domes, Karl Lehmann (1945) writes:

In both the pagan and Christian worlds, the manifold visions of the dome of heaven, with their symbolism in canopies, figures, and structural forms, with the projections of heaven on ceilings, often coupled with an actual or supposed opening in the sky, all reflect the basic experience of man in visualizing the physical as well as the transcendental celestial realm. (p. 27)

Lehmann’s (1945) account of a central dome in a Christian church in

Constantinople inverts the ascension of flight, describing it as calling:

towards it the heavenly God-Man, to come down, and through it, as it were from heaven, to look down, again, on all the sons of men [. . .] I say, indeed, one can see him [. . .] emerging from his navel through the canopy in the summit of the sphere. (p. 27)

Lehmann connects these various traditions across time and cultures, arguing that this “downward movement of the heavenly Savior toward the sons of men is a new and Christian activation of the *ancient contemplative and speculative visualization of gods, stars, elements of nature, and cosmic energies* [emphasis added]” (p.27). Visualizations of heavenly flights are sometimes explicit within artwork adorning concave surfaces of iconic domed structures (Figure 27). In addition to the general celestial symbolism of the structures that house them, these images can contain encoded references to astronomical correlates. It is common, however, for their cosmographic significance and origins to be concealed, interpreted exclusively as religious or mythic symbolism.

Conclusion

This chapter explored theories concerning how visualization techniques and environments have facilitated imagining the heavens across time. It considered domes in the light of the speculative function of sacred caves to illuminate a long tradition of immersive mediated environments conjuring visions of cosmic flight. Persistent associations of hemispherical structures with flights through the *heavenly sphere*, cosmic egg, and celestial helmet point to the orienting and integrating functions of *cognitive cosmographic models*. Caves, dwellings, burial tombs, stupas, mosques, cathedrals, and other domed structures have long guided imaginative visions by immersing participants within symbolically significant environments. The archetypal architecture of the *heavenly sphere* has continued to exert its sublime influence on shaping cosmological imaginaries to the present day. Understanding this history, as will be discussed in the coming chapters, is essential for recognizing how contemporary cosmographic practices connect to the perennial human desire to make sense of a cosmic order.

Chapter 3: Globalizing the World

“The fundamental event of modernity is the conquest of the world as picture.”
(Heidegger, 1938/1977, p. 134)

Introduction

In this chapter, I review examples of the Greek art of ‘sphere-making’ and its enactive role in shaping notions of the cosmos since antiquity. I argue that totalizing notions of *cosmos*, *world*, and *universe* likely emerged through processes of material engagement, with physical embodiments of these ideas providing essential cognitive scaffolding to make them possible. I cite numerous examples of the integral role of images and environments in shaping individual and cultural imaginations. Particular attention is given to how *cognitive cosmographic models* and spherical metaphors influenced the ‘Copernican revolution.’ I conclude that cosmographic practices and visual technologies paradoxically reinforced and complicated key notions within modern science, particularly distinctions between ‘subjective’ sense perception and ‘objective’ physical reality.

3.01 Mental-Rational Worldview

Though the metaphor of the *heavenly sphere* has been used throughout this study to reference visual allusions to the roundness of the firmament, it is important to remain mindful of Blumenberg's (2010) caution concerning confusion between concepts, metaphors, and symbols. Magical and mythical visions of the heavens attributed its curvature to unique interpretations, including gods, heavenly creatures, wombs, eggs, and other anthropomorphic and organic forms. Yet the image of a *geometric* sphere surrounding the world—and even the all-encompassing notions of the *world*, *cosmos*, and *universe*—emerged with the appearance of the necessary philosophical and perceptual scaffolding. In contrast to the innate 'first-person' perspectives afforded by the concave contours of caves and early domes, visualizing creation *from the outside* became a hallmark of the *geometric universe* (Harrison, 2003, p. 45) and the *mental worldview* (Combs, 2009, p. 69). This new perspective radically reconfigured European perceptions of humanity's relationship to the firmament.

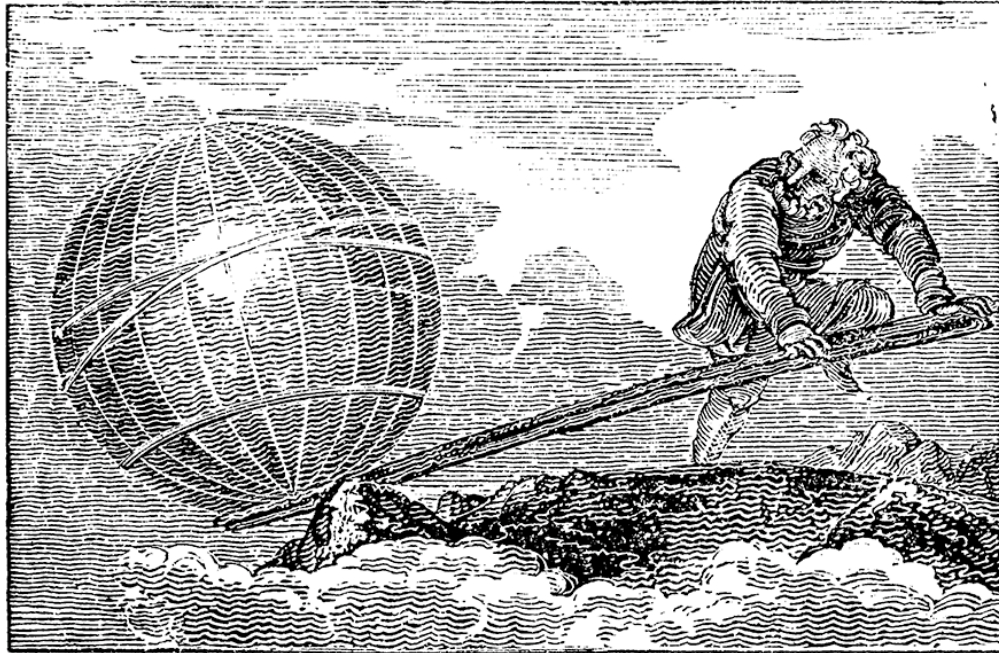


Figure 28. *Archimedes' Lever* (Mechanics Magazine, 1824).

In *The Wisdom of the World*, Remi Brague (2003) investigates the origins of the totalizing concept of the “world,” observing, “for there to have been a word meaning ‘world,’ the idea that it expresses would have had to have reached human consciousness” (p. 12). This required, Brague argues, envisioning both a plurality and a unity, exhaustively dealing with the parts that construe a whole without excluding anything, while at the same time considering that such totality be unified. Prior to this, he writes, “the order of the world was maintained by the intervention of men” (pp. 20-21), citing the ancient Egyptian cosmological conceptions. Before the idea of an autonomous world could arise, the continuity and organic unity that linked the realms of gods and humans to its inhabitants—arguably the central function of magical and mythical practices—had to be broken. Brague traces this conceptual rupture to ancient Greece, where “that ‘distanced’ position would appear,” an “Archimedes point” (Figure 28) from which humanity would become “conscious of

being a subject” and “submit nature to objective research” (p. 14). He claims this imaginative leap to a hypothetically ‘objective’ vantage point gave rise to the distancing necessary to view a physical world as separate from human thought. It is from this seemingly disembodied perspective, Brague argues, that the idea of “nature” (*phusis*) could be derived. He writes that this separated, “that which has its principle in the human activity of fabrication or estimation, i.e. the artificial (*techne*) and the conventional (*nomos*)” from “that which grows by itself, spontaneously, the natural” (p. 14).

Tracing the idea of this separation between humanity and the world through the notion of *kosmos*, Brague (2003) shows how it gained its contemporary meaning through a gradual process of interpretive transformations. Though its etymology is unclear, *kosmos* seems to have referred initially to the descriptive idea of ornamentation of the stars in the *heavenly sphere*, eventually becoming identified with the orderly nature of all things through the work of Plato [c.424-c.348 BCE] and Aristotle [384-322 BCE]. Plato’s *Timaeus* (trans. 1935/1997) provides a description of the *kosmos* as an orderly whole that is both good and beautiful and solely discernible by the human intellect (28a-b). Aristotle (trans. 1921) also explicitly identifies the heavens with the sphere:

The shape of the heaven must be spherical. That is most suitable to its substance, and is the primary shape in nature...since in every genus the one is by nature prior to the many...the circle must be the primary plane figure...the revolution of the heaven is the measure of all motions, because it alone is continuous and unvarying and eternal. (part 4)

Brague (2003) contends that the gradual acceptance of these interpretations removed the need for human participation in constructing or maintaining the order of the natural world. Paradoxically, he writes, “the concept of ‘world’ becomes possible at the moment when man has been excluded from its contents” (p. 25).

Otto Brendel (1977) further links precursors of the notion of *kosmos* to the apparent curvature of the heavens within pre-Socratic philosophy. In *Symbolism of the Sphere: A Contribution to the History of Earlier Greek Philosophy*, he writes:

The spherical quality of the firmament is formally equated with the mythical and personal quality of the oldest god; and out of the two comes eternity, his mythical characteristic. Moreover, the seemingly abstruse, but in this context quite natural and even inevitable, idea of the spherical form of God, arises from it. This was formulated when the concept of the universe as the superior existence was equated with that of the nameless divine which, even as Uranos, was not sufficiently comprehensible. The idea seems to go back to Xenophanes. Consequently, the concept of the new divine being had to unite with the spherical form of the cosmos, as indeed happened. (p. 27)

Brendel (1977) attributes the origins of the pre-Socratic tradition of describing the totality of creation as a sphere to Xenophanes [c.570 – c.475 BCE], citing Cicero’s testimony that “Xenophanes assumed that all is one single whole and immovable; that is god, unborn and eternal, his form is spherical” (p. 27).³⁵ However, even earlier

³⁵ This description of the divine form has been subject to different interpretations. James Reid’s 19th century translation reads, “In Xenophanes at a still earlier time asserted that the universe was one, and that it was not subject to change, and that it was identical with God, without origin and eternal, of a globular form” (Cicero, 1880, sec. 118).

philosophers employed variations on this theme to replace anthropomorphized gods. In his poem *On Nature*, Parmenides of Elea [early fifth century BCE] (1948/1983) writes:

Since, then, it has a furthest limit, it is complete on every side, like the mass of a rounded sphere, equally poised from the center in every direction; for it cannot be greater or smaller in one place than in another. For there is no nothing that could keep it from reaching out equally, nor can anything that is be more here and less there than what is, since it is all inviolable. For the point from which it is equal in every direction tends equally to the limits. (Fragment 8)

The extent to which Xenophanes derived his views from Parmenides is a matter of debate, as is whether Xenophanes held that the god was spherical or identical to the universe (Naddaf, 2005, p. 117; Xenophanes, 2001, p. 101). Regardless, these early visions of a totalizing, non-anthropomorphic god attest to the enactive role of the sphere in shaping Greek metaphysical beliefs in ‘Being’ and ‘existence’ as a unified whole (Schneider, 1931, pp. 455–456).

Brendel (1977) argues that the spherical form successfully addresses the aphoristic riddle of the “not born and eternal” nature of God, which can “indeed be comprehended by the image of the sphere” (pp. 27-28) that has “neither beginning nor end” (p. 24). He suggests that a combination of mythical and mystical piety, as well a desire for unity, attracted numerous philosophers to imagining and spherizing the eternal. This is exemplified in Greek antiquity by Empedocles’s *Sphairos* and Parmenides’s *One* as precursors to the notion of the ‘universe.’ In his commentary on

Parmenides, Martin Henn (2003) contends that the association of “Truth” with the “archetype of roundedness” derives from its perfect *geometrical* sphericity “that cannot be fully grasped by means of the five senses alone.” He contrasts the ideal geometric form “to spheres made of bronze or wood,” maintaining that it is the ideal form that exists within the “exclusive domain of *noêsis*” (p. 10).

These efforts attempted to—in Blumenberg’s (2010) words—“give structure to the world” by using images in place of conceptual understanding to represent the “nonexperienceable, nonapprehensible totality of the real” (pp. 14–15). Thereby, they paved the metaphorical pathway for Plato’s and Aristotle’s use of the sphere. Barry Sandywell (1996) emphasizes the importance of the pre-Socratic, contending, “the Platonic dialectic and the Aristotelian logic were later developed as techniques for the type of problem implicit in Parmenides theory of thinking and being” (p. 333). In summary, the heart of Greek philosophy and the resultant metaphysical foundations of Western thought can be described—at least in part—as responses to and “different intonations” (Borges, 1951/1975, p. 9) given the metaphor of the sphere.

3.02 Cosmopoiesis

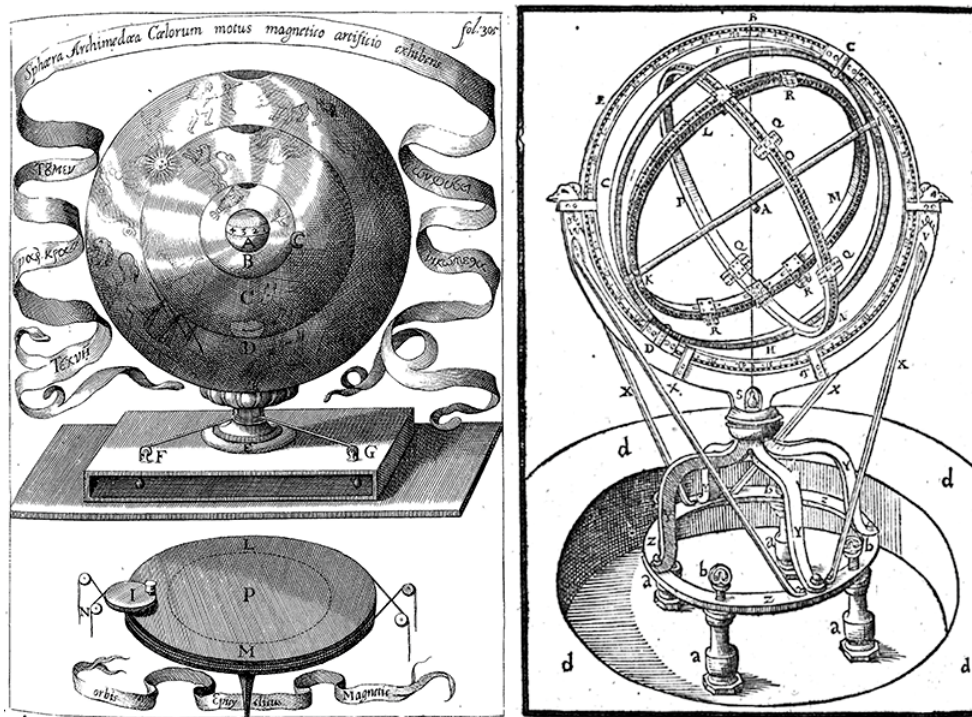


Figure 29. Athanasius Kircher's *Sphere of Archimedes* (1643) and Tycho Brahe's *Armillary Sphere* (1602).

This paradoxical tensions that arises when envisioning the sphere has remained a continuous feature of Western science and philosophy. It symbolizes the ambivalence of conceptualizing relationships between the finite and the infinite as well as the sensible and intelligible. So what was it about *Timaeus* that instigated a new perspective 'outside' of this concept, enabling the 'world' to be imaginatively quantified? I propose that Brague's (2003) concentration on intellectual transformations and the theoretical aspects of knowledge overlooks the use of image-making strategies that may have—once again—provided a key element in the enactive signification of new ideas.

For example, Brague (2003) fails to mention the description in *Timaeus* of the physical, spherical model used by the demiurge. Like earlier “tools for thinking” (2.05 Tools for Thinking), material engagement with a physical model likely played an enactive role in Plato’s ideas. A physical *heavenly sphere* would have provided essential cognitive scaffolding to support his vision of an ‘Archimedean point.’ This may be a conspicuous oversight on Brague’s part, as the namesake of the central idea of his narrative, Archimedes of Syracuse [c.287-c.212 BCE], was a polymath renowned for his knowledge of physics and innovative inventions. Though none of his devices have survived, Cicero (1877) credits Archimedes with the creation of an early mechanical “planetarium” (p. 36) that visualized the movements of the moon, sun, and planets on a globe (Figure 29).

Cicero (trans. 1999) also describes Archimedes’ *heavenly sphere*—a solid celestial globe with the constellations and stars fixed on its surface—which he claims was well known at the time (p. 10). Cicero (trans. 1877) was so impressed with these devices that he credits Archimedes with having more “genius than human nature seemed capable of possessing,” (p. 36) as well as likening him to Plato’s god who built the world in the *Timaeus*. Cicero enthusiastically proclaims that, in building these devices, god acted through Archimedes, reasoning that “what we see in the world could not be effected without a God,” and that “Archimedes could not have imitated the same motions in his sphere without a divine soul” (p. 36). Archimedes’ connection to this god’s eye view is further made explicit by the quote for which he is famously credited: “Give me a place to stand on, and I will move the earth” (Dijksterhuis, 1987, p. 15) (Figure 28).

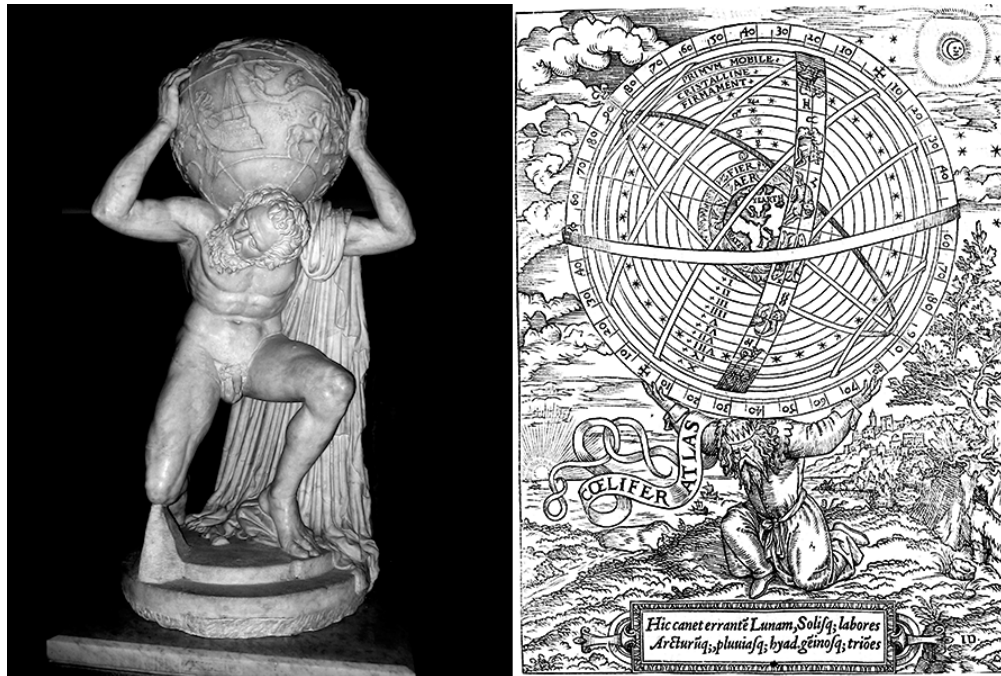


Figure 30. The *Farnese Atlas* [Italy, c. 150 C.E.], the oldest known extant representation of the celestial sphere (Seah, 2006) and an engraving of Atlas holding up an armillary sphere (Cunningham, 1559).

The dates of the first appearance of these spherical models of the *kosmos* are lost to the proverbial mists of antiquity. However, their influence in establishing a theoretical perspective *outside* of the world in the development of cosmological thought was undoubtedly significant. The Farnese Atlas (Figure 30)—a second century Roman copy of a Hellenistic sculpture of Atlas holding up a celestial globe—proves that ancient Greeks visualized the zodiacal ecliptic and other constellatory patterns from this eccentric ‘Archimedean’ perspective.

In the twentieth century, the discovery and analysis of the Antikythera mechanism—a complex geared instrument used for calculating astronomical positions in a planetarium-like instrument—provides additional proof of the early sophistication of ancient Greek mechanical knowledge (Edmunds, 2013; Marchant, 2010). The skill of constructing working models of the *kosmos* was considered

significant enough to include *sphairopoia*—the art of sphere-making—as a branch of ancient Greek mechanics (Evans, 1998, p. 262). Though now lost, historical documents suggest that the only manuscript Archimedes wrote on “practical matters” was *On Sphere-making* (Netz, 2004, p. 13).³⁶

Similarly, Geminus [c. first century BCE] includes a discussion of *sphairopoia* in his *Introduction to the Phenomena*. Geminus (trans. 2006, pp. 51–53) defines it as simultaneously meaning a branch of mechanics, a particular mechanical model, a spherical theory of the world, and the spherical arrangement or system of the world itself that actually exists in nature. Though the precise design of these ancient celestial globes, armillary spheres, planetaria, and other devices are largely unknown, their function as microcosmic models undoubtedly enabled their users to imagine “worlds” to “play around with” new ideas (Dissanayake, 1995, p. 96) (2.04 Complexity of the Caves).

In his epic *Sphären* trilogy, Peter Sloterdijk emphasizes the significance of these devices in the process of joining ontology and geometry in ancient Greece. He (2009) cites both Archimedes’ lost globe of the heavens as well as the Farnese Atlas as examples of how an “objet d’art can awaken nearly noumenal intuitions” (p. 35). Through the “geometricization of the immeasurable,” he claims that for the first time humans “place[d] themselves in an intelligible, formal, and constructive relationship to the totality of the world” (p. 29). Yet, Sloterdijk points out, having a place in this new vision of nature meant defining “a position in a great sphere, whether centrally or

³⁶ The presence of astronomical globes and spheres in China during antiquity has also been well-documented (Kelley & Milone, 2011, p. 79; Moore, 2002b; Needham, 1959, p. 383).

peripherally” (p. 29)—requiring the actual production of spheres and globes alongside new mental representations of the world. He contends this process of philosophical and physical “globalization” served as “the centerpiece of Greek *theoria*.” Sloterdijk coins the term *sphereopoiese* to identify what he calls “the fundamental event of European thought, one that has not ceased to provoke revolutions in the thought and life relations of humans for two and a half thousand years” (p. 30).

The Greek term *theoria* hints at the intimate relationship between image and imagination. While it literally translates as *contemplation*, it is also associated with *speculation*, *a looking at*, and *things looked at* (Harper, 2012b). These double meanings of conceptual and perceptual vision recur throughout philosophical language, with metaphors like *insight*, *enlightenment*; reason as *inner light*, and the *mind’s eye* permeating the history of ideas (Ihde, 2007, p. 8). The origin of the term *phenomena* further exemplifies these ambiguities. While it was originally used to describe the ‘appearances’ of heavenly bodies, Plato consistently maintains that knowledge of their physical movements is key to perfection of the noumenal Intellect (*nous*).

In his analysis of *Timaeus*, Brague (2003) argues that Plato links the cosmological and anthropological by thematicizing the *kosmos* and defining human excellence as a “wisdom of the world” (p. 33). “In order to imitate the cosmos,” Brague writes, “one must have knowledge of it” since “the head in which the individual soul turns in circles has the same rounded shape as the perfect sphere formed by the entire universe” (p. 33). Brague quotes Plato to emphasize the importance of visual observations of celestial phenomena (trans. 1935/1997):

For our part, rather let us speak of eyesight as the cause of this benefit, for these ends: the god invented and gave us vision in order that we might observe the circuits of intelligence in the heaven and profit by them for the revolutions of our own thought, which are akin to them, though ours be troubled and they are unperturbed; and that, by learning to know them and acquiring the power to compute them rightly according to nature, we might reproduce the perfectly unerring revolutions of the god and reduce to settled order the wandering motions in ourselves. (47b-c)

Brague (2003) acknowledges that this passage “expresses through images the connection between the theoretical dimension of philosophy and its practical dimension.” However, he focuses on Plato’s “consideration of invisible mathematical regularities that underlie the visible texture of the heavens” instead of the role of vision in shaping totalizing ideas about the *kosmos* (p. 33).

Other commentators, however, have taken a different approach. In *How to Build a World Soul: A Practical Guide*, Sergio Zedda (2000) interprets Plato’s description of a craftsman-like demiurge constructions of the living, spherical *anima mundi* as a veritable how-to guide for building a physical model of the cosmos. Zedda claims that this section of *Timaeus* (34a-40d) describes “a process of cosmogonic generation”—while at the same time “the act of building a physical representation of it” (p. 23). Instead of reading this as an account of an abstract operation, Zedda argues that Plato meant it as an actual description of the construction process. Plato meant to provide, Zedda writes, an “analogical relationship both with its model, the world soul, and with the image of the world soul constructed in the mind of the person trying to

understand its workings” (p. 38). He points to Plato’s (trans. 1935/1997) explicit warning that a visual model is essential for understanding the *kosmos* generated by the demiurge:

To describe the evolutions in the dance of these same gods, their juxtapositions, the counter-revolutions of their circles relatively to one another, and their advances; to tell which of the gods come into line with one another at their conjunctions, and which in opposition, and in what order they pass in front of or behind one another, and at what periods of time they are severally hidden from our sight and again reappearing send to men who cannot calculate panic fears and signs of things to come—to describe all this without visible models of these same would be labour spent in vain. So this much shall suffice on this head, and here let our account of the nature of the visible and generated gods come to an end. [emphasis added] (40c-d)

Zedda (2000) argues that Plato likely used a *sphairopoiia* model as an experiential heuristic to guide him through writing this passage. He contends that “what we are reading is a description of the actual, practical series of operations needed in order to construct a model, or representation, of the world soul,” claiming that this “model eventually will become the armillary sphere of which [Plato] speaks at 40d2-3” (p. 25). He also identifies inconsistencies between sections as Plato’s complex description jumps between abstract operations and the practical language of the craftsman. He attributes the use of these dual modalities to Plato making “full use of some of the epistemic possibilities opened by forcing the reader to employ at the same time theoretical descriptions and visual representations of objects” (p. 37).

Similarly, Francis Cornford (Plato, trans. 1935/1997) not only agrees that Plato likely had a model before him as he wrote *Timaeus*, but that he believed the “intricate movement of the planets cannot be explained without a visible model” (pp. 74) and likely had one at the Academy.

The complex mix of mythology, mathematics, and practical instructions of this passage—describing the demiurge’s construction and order of the *kosmos*—demonstrates why visual models have perennially accompanied attempts to communicate correlations between the microcosm and macrocosm. To guide his reader towards envisioning the Divine Intellect, Plato employs a combination of metaphor, concept, symbol, and embodiment. This cosmogonic exercise provides a seminal example of the paradoxes that arise when attempting to jump between different cognitive modalities using written discourse alone. Once again, like sacred caves, we see how the physicality of models—even a description of them—affords the ability to *think through objects*, supporting enactive processes of imagining ‘flights’ to upper worlds (2.05 Tools for Thinking).

3.03 Container of the Sky

From the perspective of conceptual metaphor theory, it is not difficult to appreciate the geometric, aesthetic, and even spiritual appeal of using spherical models to explore these ideas. The perennial association of the sphere with the heavens emerges through THE VISUAL FIELD IS A CONTAINER schema (1.03 Spherical Container). Through its obvious relationship to the perceived curvature of the firmament, it provides a metaphorical bridge between finite sensory experience and the infinite mythic imagination. It is not surprising that Plato would integrate the pre-Socratic image of the sphere with the ancient notion of the *anima mundi*. His own metaphorical projection would ground the sense that the CONTAINER of the sky embodied the ensouled, primordial perfection.

Plato's material engagement with the *sphairopoiia* would have likely played a significant role in transforming the image schema of the sphere into the concept of a physical *anima mundi* viewed externally. As *cognitive cosmographic models*, *sphairopoiia* present a significant break from their concave predecessors by literally and figuratively inverting previous perspectives on the heavens—supporting the shift from 'centric' to 'eccentric' views of the *kosmos*. They paradoxically provide a sensorial understanding of an abstract idea about the illusion of the senses, counter-intuitively awakening 'noumenal' intuitions through 'phenomenal' perception. They flip the logic of the CONTAINER metaphor by removing viewers from the inside of the visual field bounded by the spherical horizon, radically repositioning them within the CENTER-PERIPHERY relationship. By disrupting the most basic aspect of the subjective experience of the lifeworld, the *sphairopoiia* experientially demonstrate the

‘distanced’ position of the demiurge from which humanity could become, as Brague (2003) describes, “conscious of being a subject” (p. 14).

Additionally, this eccentric perspective would have intrinsically suggested anthropomorphic relationships between the microcosm and macrocosm through the PART-WHOLE schema. Plato uses the analogy of constructing physical models to support envisioning the demiurge’s exterior view of the world as well as his construction of the cosmos out of chaos. If a model was used when writing the passage about the demiurgic creation, Plato would have imaginatively jumped back and forth between his sensory perceptions and the theoretical view from ‘nowhere’ and ‘nowhen’ of an external, eternal, omniscient being. To conceptualize himself looking down from the world of eternal Being, Plato would have concurrently used his intellectual and perceptual facilities. He would also need to remain aware of the necessity of his description aligning with the observable structure and motions of the heavens. Using a physical model to develop his description in *Timaeus* likely made Plato’s own process of mental gymnastics considerably more concrete.

3.04 Ambivalence of World Consciousness

A consequence of imagining the ‘world’ from the outside—supported by material engagement with physical models—would have been a sense of ambivalence towards the relationship between sensory perception and the intellect that has since permeated the *mental-rational worldview*. This is explicitly illustrated in Plato’s (trans. 1892) famous allegory of the cave, in which he describes everyday perception as a prison of illusory shadows cast from the light of ultimate reality. He explicitly describes the meaning of the cave metaphor:

Now the cave or den is the world of sight, the fire is the sun, the way upwards is the way to knowledge, and in the world of knowledge the idea of good is last seen and with difficulty, but when seen is inferred to be the author of good and right-parent of the lord of light in this world, and of truth and understanding in the other. (517)

Using the metaphor of the sun to describe this source of illumination, he tasks the philosopher with freeing prisoners from their ignorance (what he calls ‘enlightenment’) through the study of mathematics, astronomy, and harmony (528)—requiring, of course, transcending the limitations of embodied perceptions.³⁷ In this view, true knowledge is accessible only to those willing to exit the metaphorical cave

³⁷ Plato’s (trans. 1892) allegory of the cave opens Book VII of *The Republic*, “And now I will describe in a figure the enlightenment or unenlightenment of our nature: Imagine human beings living in an underground den which is open towards the light; they have been there from childhood, having their necks and legs chained, and can only see into the den. At a distance there is a fire, and between the fire and the Republic prisoners a raised way, and a low wall is built along the way, like the screen over which marionette players show their puppets. Behind the wall appear moving figures, who hold in their hands various works of art, and among them images of men and animals, wood and stone, and some of the passers-by are talking and others silent” (514-515).

of subjective experience—the realm of “Becoming”—and philosophically enter into theoretical eternity—the realm of “Being” (518).

Ironically, Plato’s characterization of caves disparages the predecessors of *sphairopoia*. These immersive environments were used for millennia to cultivate cognitive capacities to develop astronomical knowledge—similar to the use of celestial globes and spheres. Descriptions of *sphairopoia* sound remarkably similar to Jung and Rappenglück’s (2006) speculative account of shamans using sacred caves to visualize constellations and embark on flights of the imagination (2.06 Cave as a Cosmos). Just as the caves’ curved contours may have provided primordial models for working through and sharing ideas about the heavens, *sphairopoia* served as rhetorical devices for demonstrating and working towards knowledge of the ideal Forms.

The detailed instructions for constructing an *anima mundi* within *Timaeus* suggest that the intelligibility of the *kosmos* itself is actually contingent on reducing the *heavenly sphere* to a tangible model. That Plato finds it necessary to describe a *sphairopoia* to communicate his ideas exemplifies the ambivalent relationship between ‘noumena’ and ‘phenomena’ within his philosophy. However, if comprehending the demiurgic process of creation requires embodied engagement with a physical model, can the functioning of the intellect ever be considered truly separate from embodied experience?

Plato's (trans. 1892) solution to this conundrum lies in his description of a "divided line" in Book VI of *The Republic* (509d-510a),³⁸ which inserts theoretical boundaries between sensation, opinion, scientific reasoning, and direct knowledge. Within this scheme, planes of existence are separated into the 'lower' visible world of illusions and the 'upper' intelligible world of eternal principles—with the human intellect purportedly uniquely capable of mediating between them. The role of philosophy is to facilitate the 'ascent' upward from the shifting world of appearances towards progressively higher states of existence, eventually revealing the eternal world of Being (Fideler, 1993, p. 8).

Plato's distinctions were more nuanced than the rigid mind-body split that would later reach its pinnacle with René Descartes (3.15 Quantifying the Uncanny). Believing that the whole world emanated from the mind of God, Plato used the continuum of the divided line to demonstrate the possibility of a path to true knowledge among the stars (Campion, 2008, p. 157).

³⁸ The relevant passage reads: "Now that which is the sun of intelligent natures, is the idea of good, the cause of knowledge and truth, yet other and fairer than they are, and standing in the same relation to them in which the sun stands to light. O inconceivable height of beauty, which is above knowledge and above truth! ('You cannot surely mean pleasure,' he said. Peace, I replied.) And this idea of good, like the sun, is also the cause of growth, and the author not of knowledge only, but of being, yet greater far than either in dignity and power. 'That is a reach of thought more than human; but, pray, go on with the image, for I suspect that there is more behind.' There is, I said; and bearing in mind our two suns or principles, imagine further their corresponding worlds—one of the visible, the other of the intelligible; you may assist your fancy by figuring the distinction under the image of a line divided into two unequal parts, and may again subdivide each part into two lesser segments representative of the stages of knowledge in either sphere. The lower portion of the lower or visible sphere will consist of shadows and reflections, and its upper and smaller portion will contain real objects in the world of nature or of art. The sphere of the intelligible will also have two divisions—one of mathematics, in which there is no ascent but all is descent; no inquiring into premises, but only drawing of inferences. In this division the mind works with figures and numbers, the images of which are taken not from the shadows, but from the objects, although the truth of them is seen only with the mind's eye; and they are used as hypotheses without being analysed" (Plato, trans. 1892, sec. 509d-510a).

Nevertheless, by elucidating this cosmic dualism, Plato sets the imaginative stage for what would become a centerpiece of Western cosmology: the belief in eternal truths and universal laws found among the heavens discernible solely through the rational intellect or religious faith. In contrast to situating humanity *within* the world, the eccentric perspective of the *sphairopoiia* began to support *estrangement from it*—providing the necessary perceptual scaffolding for imagining new totalizing notions such as *world*, *cosmos*, and *nature*. By using these devices to rhetorically demonstrate a god’s eye ‘Archimedean point’ from which to perceive the ontological distinction between sensory (terrestrial) and ideal (celestial) worlds, Plato successfully established a centuries-long emphasis on faith in abstract thought and theoretical knowledge as the path to human perfection.

3.05 Saving the Appearances

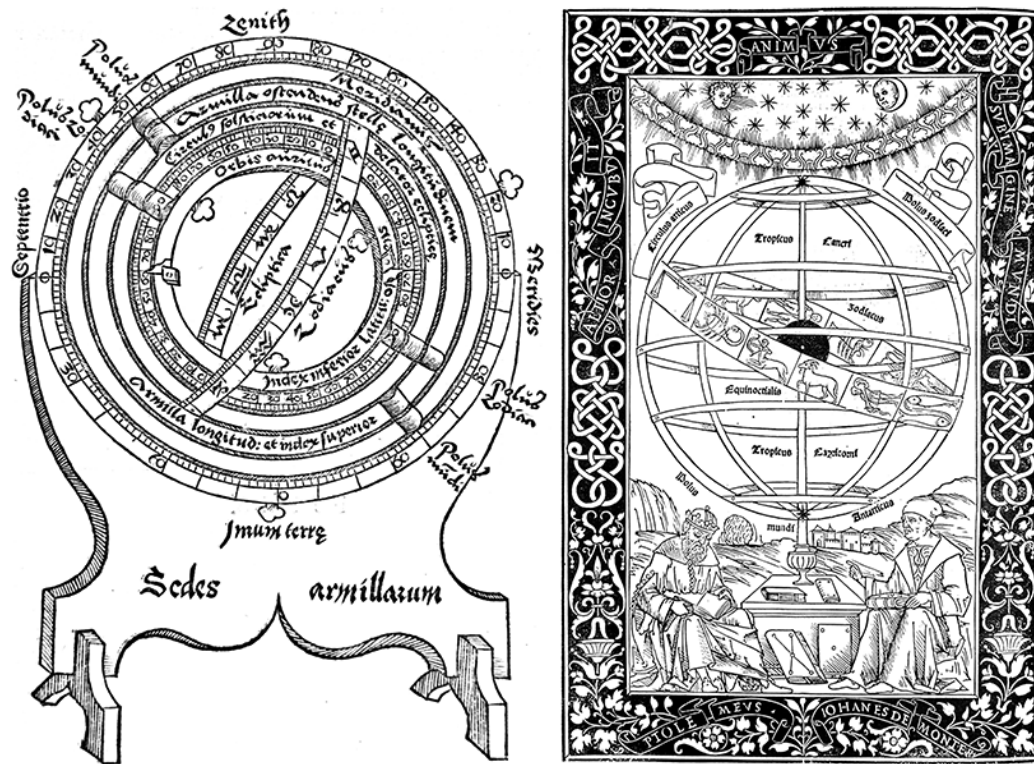


Figure 31. Engraving of an armillary sphere (Unknown, 1771) and frontispiece from Ptolemy's *Almagest* (Ptolemy & Regiomontanus, 1496).

Plato's vision of the spherical *kosmos* served as the foundation of Western cosmological thought for nearly two millennia through a series of interpretive transformations. According to Simplicius (trans. 2013), these began with Plato's challenge to his students at the Academy to 'save the appearances' of planetary motions (sec. 488.21–24). This not only involved developing hypotheses to account for observations, but also finding a way preserve the moral sense that the movements of these 'visible gods' were both uniform and ordered. This challenge was more existential than physical. Plato did not require that the hypotheses be physically true, just intellectually and spiritually satisfying (Walter, 1988, pp. 183–184).

The initial task of refining Plato's cosmic vision fell to his students Eudoxus of Cnidus [c.410-c.347 BCE] and Aristotle. Though Eudoxus' writings have been lost, Simplicius (trans. 2013) credits him with being the first to mathematically describe the planets as sitting on a series of rotating spheres with Earth at their center (sec. 488.18–24). It was Aristotle, however, who sought to do more than 'save the appearances' of Plato's theoretical principles through geometry alone. He elucidated his physics to specify different laws governing the celestial and terrestrial worlds. In the process, he ontologically bifurcated the heavenly and Earthly realms of Plato's cosmos.³⁹ Aristotle (trans. 1933a) defined the innermost 'sublunary' sphere as encompassing the terrestrial 'elemental' realm below the moon, adopting the elements earth, air, fire, and water from Empedocles (sec. 985a). The celestial region above the moon, Aristotle (trans. 1921) proclaimed, belonged to the eternal and unchanging heavens, composed of an imperishable fifth element of *aether* that naturally moved in circles (sec. 269b). He (trans. 1933b) assigned each planet—which he viewed as living beings—individual spheres moving in uniform circular motion. Aristotle envisions a final sphere of fixed stars surrounding and enclosing the entire cosmos (sec. 1072b). This mechanical explanation of Plato's speculative approach became the foundation for the *geometric universe* (Campion, 2008, pp. 167–168; Harrison, 2003, p. 45).

It was Claudius Ptolemy's (trans. 1984) second century CE *Mathematike Syntaxis*—also known by its Arabic name *Almagest*, or "the greatest"—that served as

³⁹ The sometimes-inconsistent details of Aristotle's cosmological theories are spread across his *De Caelo* [*On The Heavens*] (trans. 1921), *Metaphysics* (trans. 1933a, 1933b), *Physics* (trans. 1930), and *Meteorologica* (trans. 1937).

the main vessel through which ancient Greek cosmological ideas survived to influence European and Islamic science and religion (Kunitzsch, 1997). In addition to his numerous other influential works, Ptolemy's synthesis in the *Syntaxis* became the authoritative source for astronomical knowledge until the early Renaissance. Primarily drawing from Aristotle but integrating multiple sources, Ptolemy described the geocentric model of the cosmos in great mathematical detail by introducing the eccentric, epicycle, and equant constructions, attempting to accommodate the perfect circularity of spheres to describe celestial motions. This enabled him to reduce the number of celestial spheres proposed by Aristotle (trans. 1933b) in *Metaphysics*—of which there were as many as 55—to eight, each associated with the Moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn, and the sphere of fixed stars (sec. 1074a). This desire for simplification was likely influenced by Ptolemy's use of his Armillary sphere (Figure 31), described in the *Almagest* as comprising seven interlocking, graduated rings to represent the trajectories of the fundamental *heavenly spheres* (Needham, 1959, pp. 340–341).



Figure 32. Engraving of geocentric heavenly spheres from Peter Apian's *Cosmographia* (1545).

In spite of Ptolemy's impressive synthesis, deep mysteries concerning the causes of celestial motions in the *heavenly spheres* connected Greek astronomy to more ancient cosmographic practices. Even with the seemingly definitive shift to imagining the cosmos from an 'eccentric' perspective, the conundrum of the rotation of the stars and planets continued to generate mythical speculation. In Book X of *The Republic*, Plato (trans. 1892) recounts the *Myth of Er*, describing the cosmos as rotating around the "Spindle of Necessity" (sec. 616). Similar to symbolic celestial spindles and one-legged polar beings symbolized since Paleolithic times (Rappenglück, 1999b), Plato envisioned the axis of the universe passing through the center of Earth. He attributed the rotation of celestial phenomena to sirens and the Fates (the daughters of Necessity) spinning the cosmos on its celestial axis like a spindle whorl (Plato, trans. 1892, sec. 616). Though no images of the cosmos from the time of Plato or Aristotle have survived, Peter Apian's 1545 engraving illustrates

how later geocentric models appropriated the idea of the cosmos spinning around a central axis (Figure 32).

Another similarity to archaic beliefs is Plato's description of how souls pass through the *axis mundi* during their ascent through the celestial spheres between lives. Aristotle provides a different explanation, attributing the circular motions of the heavens to an 'unmoved mover' connected to both the 'active intellect' and God, within which all potential movement is contained (Sachs, 2005). The third century mystic Plotinus (c.204–270 CE) later developed these themes, connecting the pinnacle of human experience to a reunion with the non-conceptual reality he called the "One" via a flight of the soul through the *axis mundi* (Campion, 2008, pp. 260–261). He relates this experience to the primal ecstasy ('*ekstasis*') during which the ego is transcended to stand outside of itself (O'Brien, 1964, p. 24). In his *Ennead*, Plotinus posits the existence of an "intelligible sun," (Ulansey, 2000, p. 166) spatially located beyond the outermost boundary of the heavens. Once again, this account recalls the eccentric perspective of *sphairopoia*, suggesting the importance of the ability to imagine the *heavenly spheres* from a literal god's eye view within the development of philosophical and spiritual thought.

The specific details of the systems devised to account for the journey of souls—as well as the metaphors and 'gods' responsible for universal movement—profoundly influenced spiritual beliefs in the Middle Ages. A number of religions emerged from the syncretic environment of classical antiquity, many of which worshiped anthropomorphized gods believed to be responsible for spinning the cosmos on its axis. Of particular significance was Hipparchus of Nicaea's [c.190–

c.120 BCE] discovery of axial precession recorded in Ptolemy's *Almagest*.⁴⁰ This apparent rotation of the sphere of fixed stars over long periods implied the existence of a cosmic force even greater than that of the sun—or even Plato's metaphoric sun.

⁴⁰ Also known as precession of the equinoxes, this refers to a gradual change in the orientation of Earth's axis induced by gravitational forces. The effect is a complete precessional cycle through the constellations over approximately 26,000 years, or a 1° shift in the apparent position of the stars every 72 years. The significance of the phenomena lies in interpretations of the astrological and mythical relevance of constellations defining "ages" within a "Great Year." Alignments and analyses of archaeoastronomical sites and artifacts must take this cycle into account to decipher imagery created during era in which, for instance, there was a different constellation at the pole star than today (Kelley & Milone, 2011, pp. 66–67; Rappenglück, 1998). There is considerable debate concerning whether Hipparchus was the first to detect this phenomena. Giorgio de Santillana and Hertha von Dechen (1992) address the topic of ancient precessional knowledge at length in *Hamlet's Mill: An Essay Investigating the Origins of Human Knowledge and Its Transmission through Myth*.

3.06 Hypercosmic Sun



Figure 33. Fresco of Mithras slaying the bull [Marino, Italy, 2nd century C.E.] (Tusika, 2011).

Recent interpretations of iconography from one of the most widespread religious movements of the Hellenistic age suggest the spiritual importance ascribed to these phenomena. Remnants of a cult devoted to the worship of the syncretic solar deity Mithras have been discovered throughout the lands occupied by the former Roman Empire. Though little written documentation of the religion remains, thousands of underground grottos—called Mithraic ‘sanctuaries’ or ‘Mithraea’—contain imagery of Mithras slaying a bull, wearing a celestially-lined cape, and surrounded by zodiacal symbolism (Figure 33).

In recent decades, the mysterious symbolism of these images has been the subject to of considerable scholarly debate. David Ulansey (1991) deciphers these images as depicting Mithras as a ‘hypercosmic’ or ‘unconquered’ sun behind the sphere of fixed stars, representing the force behind the precessional movements of the

cosmos. He asserts that the bull symbolizes the constellation Taurus, whose slaughter by Mithras indicates the turning of the “world age” (p. 98). Roger Beck (2007) argues there are more viable explanations without needing to attribute knowledge of precessional movement to the Mithraists. Nevertheless, there is common agreement that the caves served as symbols of the cosmos, with the celestial symbolism and the ‘unconquered sun’ used to facilitate ‘flights’ through the *heavenly spheres* within initiatory rites.

Nicolas Campion (2012) contends that the Mithraic cult institutionalized the ideas of Plato, with the goal of rituals being to unite the souls of participants with the creator among the stars (p. 158). The notion of the ‘unconquered sun’—called *Sol Invictus* by the Romans—originated within the Egyptian text *Corpus Hermeticum*, composed in the first and second century BCE and attributed to the magus Hermes Trismegistus. Hermes (trans. 2000) gives credit for the motion of the cosmos to the sun, the king of the gods:

The sun is the greatest god of the gods in heaven, for whom all heavenly gods give way as to a king and master. He, who is so great, greater than the earth and the sea, supports the turning stars. (book 5, section 3)

Hermes goes on to describe a journey of the soul, passing through each of the *heavenly spheres* to shed the vices of Earthly existence to eventually reunite with god in the realm of the stars. Campion (2012) describes Mithraism as soteriological cult “concerned with individual salvation.” He describes it as a “formalized, ritual adaptation of the Hermetic belief that the soul abandoned its earthly vices as it

ascended through the planetary spheres at death.” Campion contends this was the “most overtly religious application” (p. 158) of Plato’s philosophy.

Ulansey and Beck also interpret scenes of Mithras’ ‘rock birth’ and the celestial scene adorning his cloak as indicating his perspective from ‘outside’ the cosmos. Beck (2007) contends this established a form of symbolic recursion, in which the painted universe “is nested in a three-dimensional image of the universe, the symbolic Mithraic ‘cave’ which in this instance is a real physical cave deep within the earth.” The purpose of these visual techniques, he suggests, was to indicate the “inside is ampler than the outside; the contained contains the container” (p. 107)—a paradox used to induce visions of the soul’s ascent and descent through the *heavenly spheres*.

These analyses suggest intimate connections between the Mithraea and previous *cognitive cosmographic models*. The paintings of Mithras assume the ‘outside’ views of Plato’s demiurge (3.02 Cosmopoiesis), while the participants—like ancient shamans—were immersed within a sacred cave symbolizing the cosmos (2.06 Cave as a Cosmos). The use of underground grottos decorated with stars on the roof recall Jung and Rappenglück’s (2006) description of the transformation of Paleolithic sacred caves as places decorated with worldviews, “a kind of temple-planetaria” (p. 78). This interpretation suggests an inversion of Plato’s famous allegorical cave, since participants in these secret rites would presumably have used these immersive spaces to consciously enact journeys to the upper world of Being—as opposed to being ‘prisoners’ to the shadows cast from Plato’s metaphoric sun.



Figure 34. Mosaic from a Roman villa in Sentinum [c.200-250 C.E.] depicting Aeon, god of eternity, standing inside a celestial sphere decorated with zodiacal signs (Saint-Pol, 2007).

In *Sun of God: Ancient Cosmology and Early Christian Symbolism*, David Fideler (1993, p. 152) further associates the Mithraic mysteries with the Hellenistic god Aeon—the personification of infinite time. Fideler claims Aeon—like his earlier Greek counterpart Apollo—was connected to both the precession of the equinoxes and the rotation of the celestial sphere around the *axis mundi*. Aeon was sometimes depicted spinning the wheel of the zodiac (Figure 34), which was perceived as the most significant part of the outer *heavenly sphere* of fixed stars. Fideler also contends that Mithras, Aeon, and Apollo were all linked with the sun, the celestial pole, or the “unmoved mover” of the pole star, signifying their intimate connection to the center

of sacred geography (p. 152).⁴¹ They therefore represented the unconquered Spiritual Sun of the cosmos, of which the physical sun was merely a reflection, as made explicit by an ancient invocation called the Mithras Liturgy. Initiates proclaimed that with the help of “the great god Helios Mithras,” they would “ascend into heaven as an inquirer and behold the universe.” The account describes the soul’s flight along the cosmic axis, with initiates calling upon “the immortal Aeon” to assist in their spiritual ascent through the celestial spheres (Fideler, 1993, p. 152).⁴²

David Ulansey (1991) suggests that the cult began as a response “by a group of imaginative intellectuals to the unsettling discovery that the universe was not quite as simple as they thought it to be”—but “ended as a religion of soldiers, based on an ideology of power and hierarchy” (p. 125). It was particularly popular among Roman soldiers, who spread the worship of Mithras and built sanctuaries across the Roman Empire from Africa to Scotland (Fideler, 1993, p. 143). In spite of its secretive nature, symbolism associated with the cult’s continuation of the ancient trope of flight through the cosmic spheres can be found conspicuously symbolized within Rome’s most famous domed structure.

⁴¹ Fideler (1993) writes, “In earlier Greek symbolism, the god of the celestial pole is Apollo. Not only is the name Apollo linked with the celestial pole (*polos*) by Plato and other commentators, but his sacred omphalos stone at Delphi, representative of the creative center, was known as “the axis,” the symbolic pole of Greek sacred geography. Put another way, in ancient cosmology the omphalos was symbolic of the celestial axis, while the pole star in the heavens is the omphalos of the celestial vault.”(p. 152)

⁴² In *The Roman cult of Mithras: The God and His Mysteries*, Manfred Clauss (2001, p. 22) analyzes Roman poetry and inscriptions on Mithraic sculptures to demonstrate that the Sun God was equated with both Apollo and Mithras.

3.07 Domestication to Domination



Figure 35. *Interior of the Pantheon* by Giovanni Paolo Panini (1734).

The Pantheon (Figure 35), one of Rome's best-preserved ancient buildings, serves as a spectacular example of the influence of the archaic belief in the *heavenly spheres* and the significance of the *axis mundi* as a portal to the heavens. Though its exact building date, architect, and other details of its construction are debated, much of its reconstruction in the second century is believed to have occurred under the watchful eye of Emperor Hadrian, a member of the Mithraic cult. The 142' diameter concrete dome architecturally embodies the belief in the heavens as a perfect sphere. Following ancient tradition, the dome aligns with the cardinal directions to create a

special astronomical effect through its most distinguishing feature. A 30' diameter oculus in the apex serves as an *axis mundi*, which is designed to ensure that sunlight touches the base of the dome at midday on the equinoxes (Joost-Gaugier, 2007, pp. 166–181).

According to William McDonald (2002), the Pantheon was built, “at a turning point in history, when rites and rules drawn from a very long past were not yet abandoned, but when the surge of a new and utterly different age was already being felt” (p. 88). The inclusion of these archetypally significant elements would have, both literally and figuratively, concretized the symbol of Rome’s efforts to syncretize—and ‘dominate’—the many religions and gods of antiquity into a central power. Though the word ‘pantheon’ designates a temple devoted to ‘all gods,’ its singular architectural focus on the sun exemplifies the Roman synthetic strategy. Consequently, the temple was re-consecrated in 609 CE as a Christian church, one of the first pagan temples in Rome used for Christian worship. This is likely a primary reason the structure has survived, but it also serves as a reminder of the degree to which the ‘pagan’ philosophies of ancient Greece and Rome were re-signified in the formulation of Christian doctrine by the Roman Catholic Church.

Fideler (1993) details how ancient astronomical knowledge, mathematics, mythologies, and practices were appropriated into the symbolism of early Christianity. He cites numerous parallels between Mithras and Jesus, and examples of the geometric significance of many parables within the Bible. His arguments provide compelling examples of how seemingly new belief systems invariably emerge from complex processes that combine, modify, and synthesize previous knowledge. The Pantheon’s adoption into Christianity—and, perhaps more importantly, Christianity’s

adoption into the symbolism of the Pantheon—exemplifies how matrices of knowledge production and appropriation extend into the physical world of artifacts and the built environment.



Figure 36. Celestogramme of the Pantheon dome with oculus (Wackernagel, 1998).

The Pantheon is widely acknowledged for its influence on architectural structures, serving the "ultimate paradigm for all monumental domes" (Grupico, 2011, p. 3) for nearly two millennia. It remains the world's largest unreinforced concrete dome (Grasshoff, Heinzelmann, & Markus, 2009, p. 7) and shares a number of iconic properties with other domes around the world (2.12 Embodying the Macrocosm). Its rounded surface represents the vault of heaven, and its oculus symbolizes the central axis around which the whole world rotates—allowing 'illumination' to enter in from the outside of the cosmos (Figure 36). The combination of Emperor Hadrian's Mithraic beliefs and his claim that Apollo was his

father (Joost-Gaugier, 2007, p. 180) strongly points to the Pantheon's famous oculus as a central visual metaphor. While it unquestionably represents the spiritual, unconquered sun of eternally transcendent knowledge, it may also contain another level of meaning hidden in plain sight. However, like other *cognitive cosmographic models*, interpreting the substance of this encoded message requires interpretive knowledge and a willingness to experience the environment as a gestalt.

3.08 Visible God

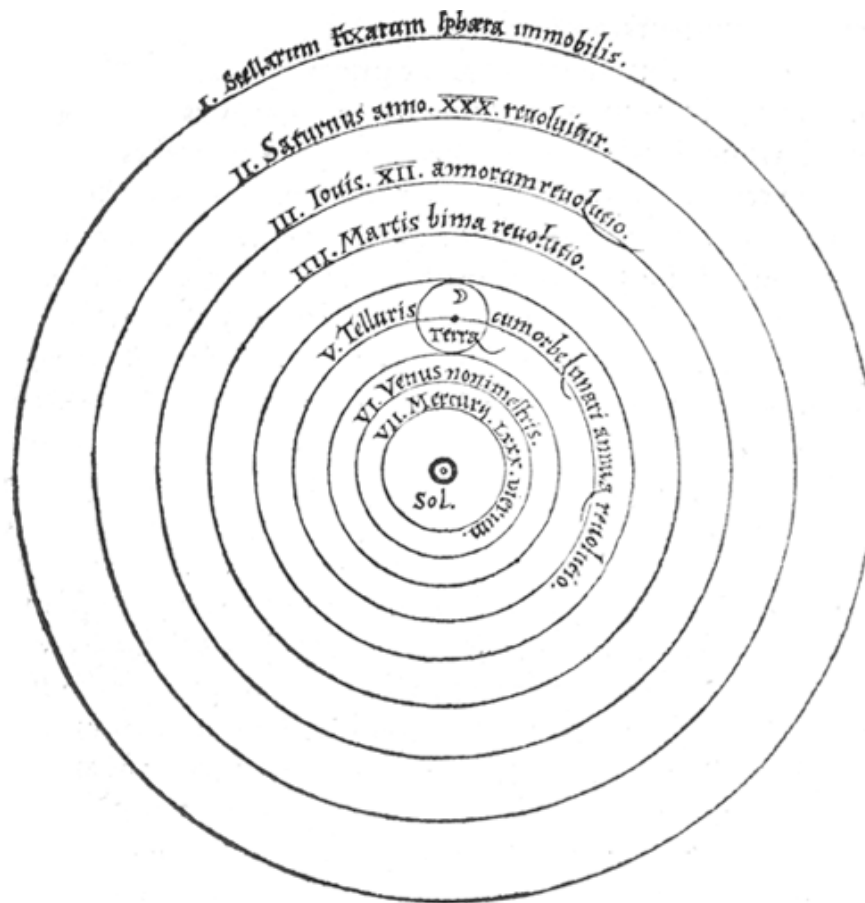


Figure 37. Heliocentric model from Nicolaus Copernicus' *De revolutionibus orbium coelestium* (1543).

Film editor Walter Murch proposes a novel idea that demonstrates how the Pantheon's integration of religious symbolism within a built environment may have triggered a 'gestalt switch' (1.04 Gestalt Switching), setting in motion one of the most celebrated revolutions in the history of ideas (Manough, 2007). According to Murch, the most significant accomplishment of the Pantheon may not have been its function as the "ultimate paradigm for all monumental domes," but the ability of its dome and oculus to facilitate the transmission of a different "ultimate paradigm" across the centuries. He points out that, when viewed from inside and directly below the middle

of the dome, the concentric concrete rings encircling the oculus bear a striking resemblance to Nicolas Copernicus' schematic illustration of a heliocentric universe in his 1543 text *On the Revolutions of the Heavenly Spheres* (Figure 37). The drawing shows a series of concentric circles depicting the *heavenly spheres* associated with the planets. These are enclosed by an outermost sphere representing the 'sphere of fixed stars'—centered on a dot at the center marked by the word 'Sol.' Murch notes the passage accompanying this drawing to emphasize the connection. Copernicus (1543/1978) writes:

At rest, however, in the middle of everything is the sun. For in this most beautiful temple, who would place this lamp in another or better position than that from which it can light up the whole thing at the same time? For, the sun is not inappropriately called by some people the lantern of the universe, its mind by others, and its ruler by others. [Hermes] the Thrice Greatest labels it a visible god, and Sophocles' Electra, the all-seeing. Thus indeed, as though seated upon a royal throne, the sun governs the family of planets revolving around it. (p. 22)

Murch contends that Copernicus not only describes his theory of the arrangement of the *heavenly spheres*, but the structure of the Pantheon as well. "What leaps out from that text," Murch (Manough, 2007) argues, "are the allusions to *this beautiful temple*, illuminated by a central *lamp*—and *lantern* was the architectural term used in Copernicus's time to refer to the central opening in a dome—which *lights up the whole*" [emphasis in original] (para 22). He further points to the "classical references to Hermes Trismegistus and Sophocles," which he argues "are

not the words of a cautious medieval ecclesiastic, but someone deeply influenced by the ancient pre-Christian world” (para 22).

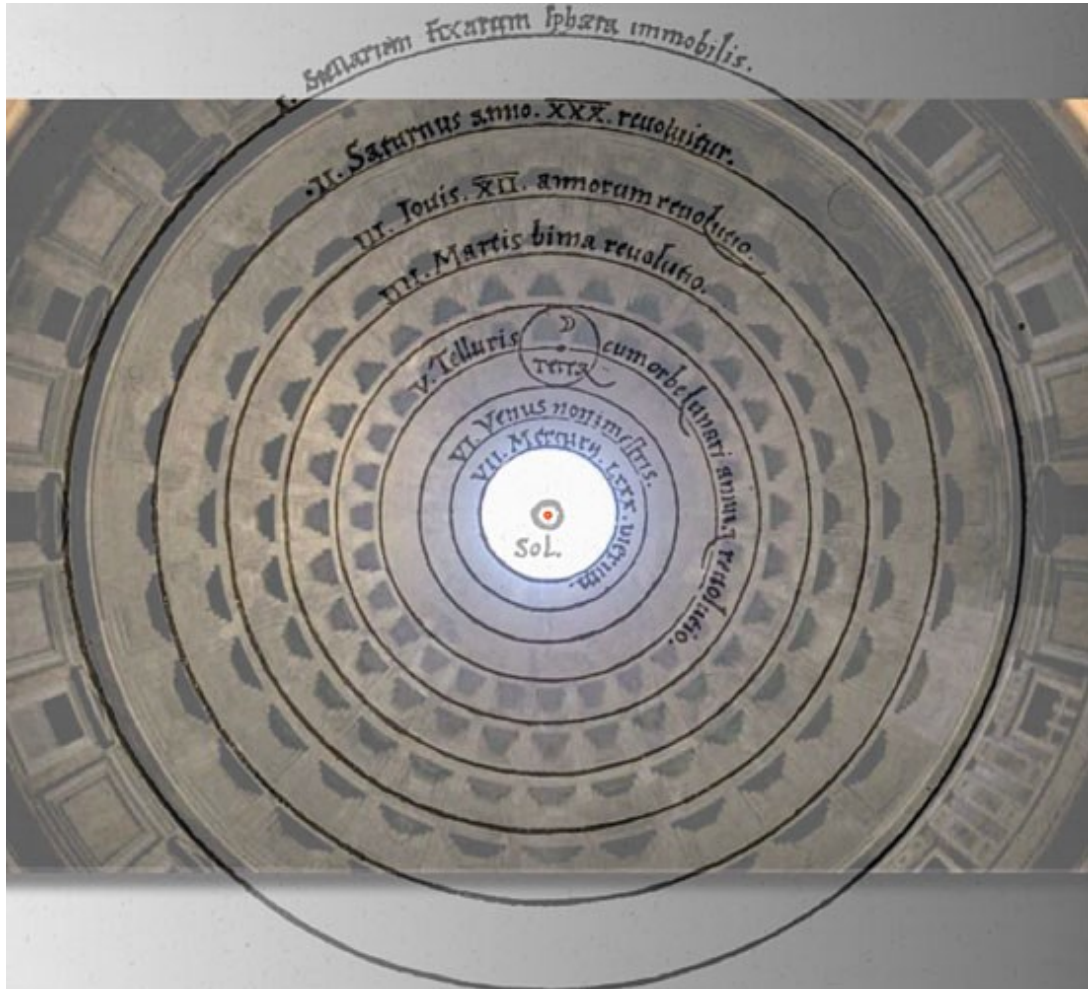


Figure 38. A superimposition by Walter Murch (Manauh, 2007) of Copernicus's diagram of a heliocentric model over a celestogramme of the Pantheon (Wackernagel, 1998).

It is difficult to miss the similarities between Copernicus' illustration of *heavenly spheres* orbiting a central point and the gradual celestial rotations around the pole star (Figure 20) described as the 'Spindle of Necessity' by Plato (trans. 1892, sec. 616). When Murch superimposed Copernicus' inscription on top of a photograph of the inside of Pantheon's dome, he (Manauh, 2007) "found that the ratios of the

circles in his drawing and the ratios of the circles of the Pantheon line up almost exactly” (para. 24) (Figure 38). Relating his own experience to a gestalt, Murch recounts, “Seeing that alignment was one of those wonderful moments where you suddenly feel a strong current of connection with the past.” Murch speculates that the pagan temple built 1400 years before Copernicus may have “secretly encoded within it the idea that the Sun was the center of the universe; and that this ancient, wordless wisdom helped to revolutionize our view of the cosmos” (para. 27).⁴³

Murch (Manauagh, 2007) points out that though the Pantheon is not mentioned in the *de Revolutionibus*, Copernicus did move to Rome in 1500 to take time off from his studies in Bologna. Copernicus was Domenico Novara’s [1454–1504] assistant in Bologna, a well-known astronomer who may have introduced Copernicus to work of the Greek astronomer and mathematician Aristarchus of Samos [310 BCE – c.230 BCE]. Aristarchus devised the first known heliocentric theory of the cosmos—identifying the Pythagorean idea of the ‘central fire’ with the Sun instead of the center of the Earth—as well as the idea that the Earth rotated on its axis every 24 hours (Heath, 1920, p. 27). Though Aristarchus’ ideas were overshadowed by the geocentric theories of Aristotle and Ptolemy, they were preserved, tellingly, in the writings of Archimedes (1897, p. 222).

Taking all of this suggestive evidence into account, a compelling narrative emerges connecting ancient heliocentric theories to the ‘scientific revolution’—by

⁴³ Through personal correspondence with Mr. Murch (2012), I have confirmed that this theory is only published online in *The Heliocentric Pantheon: An Interview with Walter Murch* (Manauagh, 2007). Nevertheless, I find it compelling enough to include within the context of other speculations within this thesis as an example of the enactive function of cosmographic visualizations—in this case the potential triggering that the Pantheon triggered Copernicus’ heliocentric epiphany.

way of an extraordinarily conspicuous *cognitive cosmographic model*. If the Pantheon was designed to visually encode a schema of a heliocentric paradigm, it may have effectively transmitted the idea that the Sun is the source of ultimate knowledge—simultaneously cosmic and hypercosmic, physical and spiritual, real and ideal. By integrating these dualities within an experiential gestalt, the spectacular view of the oculus and interior dome may have triggered a cosmic flight of Copernicus’ imagination—an epiphanic connection to ancient Platonic, Hermetic, and Mithraic beliefs that has dramatically altered the course of history. Some have even proposed that it was this re-connection to neo-Hermetic ‘magical’ beliefs to which the Vatican eventually responded so forcefully, not simply the rational ‘scientific’ shift a sun-centered universe (Picknett & Prince, 2011, p. 26).

3.09 Most Perfect Form



Figure 39. God depicted as the demiurge—alternately a geometer, unmoved mover and craftsman—standing outside of the cosmos. Images from the *Bible Moralisee* [c.1220], Giovanni di Paolo's *The Creation of the World and the Expulsion from Paradise* (1445) and Martin Luther's *Bible* [1534] (2009).

Though Murch's novel theory about the Pantheon as the catalyst for Copernicus' description of the "visible god" and "lantern of the universe" may be highly speculative, the significant influence of ancient Greek and Roman beliefs on Copernicus' overall view of the cosmos are decidedly less so. Copernicus' heliocentric hypothesis maintained many aspects of medieval visions of the heavens, directly informed by Platonic and Aristotelian ideas. These arrived primarily through Ptolemy's *Almagest*, which had survived through the work of Islamic and Christian scholars.⁴⁴ This influence can clearly be seen in Medieval and Renaissance depictions of the Christian God, many of which resemble earlier Greek descriptions of the

⁴⁴ Richard Rubenstein (2004) details the influence of ancient Greek philosophy on medieval thought and religion in *Aristotle's children: How Christians, Muslims, and Jews Rediscovered Ancient Wisdom and Illuminated the Middle Ages*.

demiurge as a divine geometer, unmoved mover, and craftsman presiding over a spherical cosmos (Figure 39).

As the title of Copernicus (1543/1978) *De Revolutionibus Orbium Coelestium* (*On the Revolutions of the Heavenly Spheres*) implies, he did not challenge the dominant notion of rotating *heavenly spheres* supporting the planets and stars. In the initial chapter of his book, Copernicus unambiguously states,

First of all, we must note that the universe is spherical. The reason is either that, of all forms, the sphere is the most perfect, needing no joint and being a complete whole, which can be neither increased nor diminished; or that it is the most capacious of figures, best suited to enclose and retain all things; or even that all the separate parts of the universe, I mean the sun, moon, planets and stars, are seen to be of this shape; or that wholes strive to be circumscribed by this boundary, as is apparent in drops of water and other fluid bodies when they seek to be self-contained. Hence no one will question the attribution of this form to the divine bodies. (p. 8)

Immediately after this passage, Copernicus goes on to claim that the shape of Earth also takes this “most perfect” form, another notion that was widely accepted at the time. However, he diverges from traditional beliefs by insisting Earth not only rotates on and precesses around its axis—citing numerous ancient Greek philosophers to justify his position—but also moves along a circular trajectory like the other planets (a term derived from ancient Greek word for *wanderers*). He challenges Ptolemy’s geocentric model on mathematical grounds, insisting that its epicycles

were inelegant and that a heliocentric model would conform more closely to presumed perfection of the spherical cosmos.

In contrast to oft-repeated story that Copernicus' geocentric theory was purposefully proposed in defiance of Church doctrine, Stephen Toulmin and June Goodfield argue that his heliocentric hypothesis was meant to theoretically sustain Platonic ideals of perfection by reinstating certain claims of Aristotelian physics. In *The Fabric of the Heavens: The Development of Astronomy and Dynamics*, Toulmin and Goodfield (1962) contend, "By reordering the whole system around the Sun instead of the Earth, Copernicus became the first man to carry the programme through to its completion," (p. 173) paving the way for a reunion of "mathematical astronomy" with "the central ideas physics" (p. 171). "The motion of the Earth," they insist, "was a *consequence* of this change, not its main aim, and was forced on him as the only satisfactory way out of an obstinate intellectual quandary" [emphasis in original] (p. 169). Copernicus' vision of a heliocentric universe, it seems, may have not only been motivated by the desire to position the Hermetic all-seeing god as the Pythagorean central fire of the cosmos, but also the need to mathematically sustain the theoretical perfection of Aristotle's *heavenly spheres*.

3.10 Shifting Perspectives



Figure 40. Miniatures from Nicolas of Oresme's *Traité de la sphere* (1368).

Just as ancient Greek ideas concerning the function of *heavenly spheres* shaped Copernicus' cosmic idealism, the speculations of medieval theologians anticipated his 'revolutionary' mathematical hypotheses. In the Middle Ages, the European rediscovery of ancient schools of thought—combining Aristotelian, neo-Platonic, Kabbalistic, and Hermetic philosophies—produced a complex mix of motivations and perspectives (Picknett & Prince, 2011; Yates, 1964). These beliefs informed the work of seminal figures and lesser-known but equally influential characters, broadly influencing the early formulation of modern science and philosophy (Goodrick-Clarke, 2008; Hanegraaff & Pijnenburg, 2009). The ways in which the *heavenly spheres* were interpreted and visualized laid the epistemological and ontological foundations for many aspects of the so-called 'Copernican shift.'

Centuries before *On the Revolutions*, medieval scholastics discussed many ideas commonly associated with Copernicus and his post-'revolutionary' predecessors. In his thirteenth century astronomical treatise *De Sphaera Mundi* (*On*

the Sphere of the World), Johannes Sacrobosco (c.1230/1490) contemplates the spherical shape of both the cosmos and the Earth, speaking of the universe as the *machina mundi*—the machine of the world. Similarly, French scholar and polymath Nicolas of Oresme (c.1400/1968) employed the metaphor of a clock to describe the cosmos, writing “God allow(ing) the heavens to be moved continually” is like “a man making a clock and letting it run and continue its motion by itself” (p. 289).

Oresme (c.1400/1968) also contemplated the possibility that Earth was not static. Citing the convention of a geocentric cosmos established by Plato’s *Timaeus*, he writes, “it seems to me, subject to correction, that one could well support and give luster to the last opinion, namely that the earth, and not the heavens, is moved with a daily movement” (as quoted in Clagett, 1959, p. 600). Though he ultimately rejects the notion of a moving Earth, Oresme’s writings convey the gradual nature of the shift away from Aristotelian physics. His translation and commentary on Aristotle’s (trans. 1921) *On the Heavens* prominently features illustrations of familiar tropes, including an armillary sphere alongside his writing table and God ruling over the *heavenly spheres* (Figure 40)—once again suggesting the enactive role of spherical models as ‘tools for thinking’ (2.05 Tools for Thinking).

3.11 Infinite Sphere

By the early fourteenth century, the revival of the metaphor of the infinite sphere pushed relativistic insights to new extremes. In his *Commentary on Exodus*, German scholar and philosopher Meister Eckhart (trans. 1986) quotes the statement from *Liber XXIV philosophorum (Book of Twenty-Four Philosophers)*, which, like the *Corpus Hermeticum*, was purportedly written by Hermes:

God is the infinite intellectual sphere with as many circumferences as centers and whose center is everywhere and circumference nowhere. He is entire in his least part. (p. 79)

Eckhart (trans. 1986) interprets this to refer to God's omnipresence, insisting, "There is no 'greater' or 'less' in God nor in the One; they are below and outside God and the One" (p. 75). This becomes the foundation of Eckhart's nondual mysticism, in which God can only be conceived non-conceptually. Elizabeth Brient (1999) contends that Eckhart's use of the metaphor to embody this apparent contradiction serves as "a paradoxical formulation which pictures the coincidence of divine immanence with divine transcendence" (p. 576). This infinitization of the real, she writes, "leads to an infinitization of the knowable," in which the "radical shift in ontology grounds a corresponding shift in epistemology." This resulted, Brient contends, in an understanding of human knowledge as becoming "an unending project infinitely extended over time" (p. 575).

The implications of the "infinite sphere" were later taken to new extremes by German theologian Nicolas of Cusa. Alexandre Koyré (1968) describes Cusa's *Gedankenexperiment* with the infinite sphere as an "astonishing transference to the

universe of the pseudo-Hermetic characterization of God” (p. 18). In the process of envisioning an omnipresent center within an infinite cosmos, however, Cusa (1440/1981) also imagined the relative motion of Earth:

The ancients did not attain unto the points already made, for they lacked learned ignorance. It has already become evident to us that the earth is indeed moved, even though we do not perceive this to be the case. For we apprehend motion only through a certain comparison with something fixed. For example, if someone did not know that a body of water was flowing and did not see the shore while he was on a ship in the middle of the water, how would he recognize that the ship was being moved? And because of the fact that it would always seem to each person (whether he were on the earth, on the sun, or on another star) that he was at the “immovable” center, so to speak, and that all other things were moved: assuredly, it would always be the case that if he were on the sun, he would fix a set of poles in relation to himself; if on the earth, another set; on the moon, another; on Mars, another; and so on. Hence, the world-machine will have its center everywhere and its circumference nowhere, so to speak; for God, who is everywhere and nowhere, is its circumference and center. (p. 92-93)

Karsten Harries argues that this transference from God to the physical cosmos was essential for cultivating new relativistic views of the world that paved the way for the ‘Copernican shift.’ He challenges Thomas Kuhn’s (1964) claims that “after Copernicus astronomers lived in a different world” because of the “the very ease and rapidity with which astronomers saw new things when looking at old objects with old

instruments”(p. 117), suggesting it misleadingly implies “this new world had its foundation in the Copernican revolution” (Harries, 2001, p. 31).

Instead, Harries (2001) contends that the “revolution was itself made possible only by a more fundamental shift in the way human beings understood their world, which opened up new perceptual and intellectual possibilities” (p. 31)—asserting that Cusa’s use of the infinite sphere metaphor was “part of, and can furnish a key to a better understanding of that shift” (p. 31). Harries claims that Cusa’s transference of the metaphor of the infinite sphere from God to the universe “preceded and helped prepare the way for the new astronomy” (p. 31), and that this transference was “suggested by the metaphor itself” (p. 31). By providing a “deep and historical systemic connection” between “medieval mysticism and the new cosmology,” Harries contends, “two studies are closely joined” in Cusa’s writings, and “theology leads quite naturally to cosmology” (p. 31).

This progression, Brient (1999) suggests, also induced a radical shift away from Eckhart’s Neoplatonic universalism, exemplified by Plato’s notion of a unified ‘world soul.’ Instead, the universe ceases to be an entity existing independently of individual entities, but becomes relative to “the plurality in which it is present, for it does not exist without contraction” (p. 595). She emphasizes the significance of the Cusa’s “intensive infinitization of the cosmos” (p. 593) in overriding the limitations of finite concepts and discursive reasoning in which the sphere is conceptualized as a solid object. Blumenberg (2010) refers to the results of this kōan-like riddle as “explosive metaphors”—the goal of which was “to ‘detonate’ the metaphor materially” by “exploding what avails itself to the mind’s eye by adding the *infinitum* and withdrawing it from apperception” (p. 123).

By providing the necessary cognitive scaffolding to imagine an infinite cosmos beyond the CONTAINER of the firmament (3.03 Container of the Sky), visions of the infinite sphere paved the way for new “thought-forms” (Sloterdijk, 2011, p. 271) to conceive the previously unimaginable. The metaphorical explosion of the *heavenly spheres* primed the European imagination to confront the implications of their dissolution. As Sloterdijk (2011) points out, this eventually resulted in the loss of the Aristotelian “immune system” (p. 23)—the sublunary sphere that provided an ontological boundary between the eternal heavens and the corruptible Earth.

3.12 Learning Ignorance

The provocative metaphor of the infinite sphere compelled Cusa—and later Giordano Bruno (Yates, 1964)—to reconcile seemingly contradictory views by imagining the inherently dynamic and relational nature of situated perspectives. They not only used this thought experiment to conceive of the apparent rotations of the stars as a consequence of being viewed from a rotating planet, but also to examine the limits of reason, sensory perception, and knowledge. By relating the paradoxical thought-image of the infinite sphere to both God and the universe, Cusa’s technique seeded conditions for the eventual emergence of relational and process-oriented views of the world—toppling long-held and deeply interconnected theological, cosmological, epistemological, and ontological assumptions (further discussed in 5.03 Relativistic Effects).

Cusa the theologian proposed the solution to this quandary with his principle of *learned ignorance*—“not *foolish* ignorance but *learn-ed* ignorance” (Hopkins, 1981, p. 50) which entails “embracing the Incomprehensible incomprehensibly” (p. 1). He (1440/1981) asserts that within human cognition, the timeless intellect and the temporally conditioned senses converge within reason. By envisioning reason on the horizon of the intellect but at the zenith of the senses, he conjoined both facets of human cognition through the metaphor of the sphere—and by extension, both God and the cosmos. This enabled him to imagine the infinite expansion of the Aristotelian boundary between the heavens and Earth, visualizing “things that are within time and things that are beyond time” (p. 127) coinciding through reason.

Through his explorations of the dynamic and process-oriented thought-image of the infinite sphere, Cusa imagines the paradoxical relationship between apparent

contradictions arising from the polarities of sensorial centricity and intellectual eccentricity inherent within self-consciousness. The explosive capacity—and potential threat—of this metaphor rests within the cognitive challenge it poses to rigidly dualistic logic which, according to Lakoff and Johnson (1999), derives from the embodied experience of CATEGORIES ARE CONTAINERS and PREDICATION IS CONTAINMENT image schemas (1.03 Spherical Container). In Cusa's time, the implications of this infinite expansion extended to the belief in physical *heavenly spheres*, visions of which coincided with dualistic metaphysical assumptions of the finite/infinite, corruptible/eternal, endosphere/exosphere divisions between Earth and the heavens. These had been inherited from both the physics and metaphysics of Aristotle, who formulated and established not only the model of the cosmos adopted by the medieval church by way of Ptolemy, but also the binary logic of non-contradiction (Priest, 2006a).

Cusa used the infinite sphere to argue that that opposites coincide within the nonconceptual, absolute infinitude of God as well as the relative infinity of the universe. Erich Meuthen (2010) writes within Cusa's *coincidentia oppositorum*, “there is no negation” within the realm of the senses “because the differentiating ‘no’ does not enter our understanding until the intellect comes into play ... for the senses there is no principle of contradiction” (p. 63).⁴⁵ Through this, Cusa concluded that the

⁴⁵ Carl Jung (1953) has articulated the idea of *coincidence of opposites* in the context of transpersonal psychology, noting, “The self is made manifest in the opposites and in the conflict between them; it is a *coincidentia oppositorum*” (p. 178). Hillary Webb's (2008) brief overview of the relationship between the ideas of Cusa and Jung describes the *coincidentia oppositorum* as “the ‘least imperfect’ name for God” and “a symbol of both spiritual and psychological transcendence” (p. 158).

dualistic logic only held within reason, acknowledging both its intellectual utility as well as its limitations.

3.13 Mythologizing Revolutions

Kuhn and Koyré both acknowledge Cusa's contribution of deriving, as Kuhn (1957) puts it, "the motion of the earth from the plurality of worlds in an unbounded Neoplatonic universe" (p. 144). However, they both dismiss it as secondary to the importance of the mathematical system worked out by Copernicus that purportedly "inaugurated a revolution" (p. 144). Copernicus continues to be credited with being "not only the fruit but also the root of that revolution which established our modern world," (Harries, 2001, p. 30), while the metaphorical significance of the infinite sphere remains largely overlooked.

This is not surprising given complex and often tacit role of metaphorical understanding, as well as the fact that it took the cumulative findings Kepler, Galileo, Newton, and others to dissolve the sublunary spherical boundary between the eternal heavens and corruptible Earth in the European imagination (Andersen et al., 2006). As Koyré (1968) recounts, "the heavenly spheres that encompassed the world and held it together did not disappear at once in a mighty explosion; the world-bubble grew and swelled before bursting and merging with the space that surrounded it" (p. viii). Amidst considerable controversy, the ancient vision of ethereal and immutable *heavenly spheres* rotated by the hand of God—the unmoved mover—eventually gave way to modern ideas of a homogenous cosmos governed by discernible physical laws (Blumenberg, 1989; Wertheim, 1999, 2010).

Johannes Kepler embodied the ambivalence of the era (as cited in Koyré, 1968), who, contemplating Giordano Bruno's use of the "infinite sphere" metaphor, complained that, "This very cogitation carries with it I don't know what secret, hidden horror; indeed one finds oneself wandering in this immensity, to which we are

denied limits and center and therefore all determinate places” (p. 61). Yet it was Kepler’s own calculations that revealed the non-spherical nature of planetary rotations, eventually necessitating the transformation of celestial orbs to planetary orbits (Goldstein & Hon, 2005). Sloterdijk (2011) identifies the dissolution of the *heavenly spheres* as the more significant epoch-defining event than the shift to heliocentrism, writing, “What makes the modern age special is that after the turn to the Copernican world, the sky as an immune system was suddenly useless” (p. 25).

Even Koyré (1968) concurs that during this move from a “closed world to an infinite universe” it was “impossible to separate the philosophical from the purely scientific” ideas, as they were “interdependent and closely linked together” (p. 2). He describes this process as roughly “bringing forth the destruction of the Cosmos, that is, the disappearance, from philosophically and scientifically valid concepts, of the conception of the world as a finite, closed, and hierarchically ordered whole” (p. 2). Consequently, he also points to the role of the ontological disappearance of the *heavenly spheres* in the reification of epistemological bifurcations, suggesting this “implies the discarding by scientific thought of all considerations based upon value-concepts, such as perfection, harmony, meaning and aim, and finally the utter devalorization of being, *the divorce of the world of value and the world of facts*” [emphasis added] (p. 2).

The series of events leading to the realization that “there existed not two sorts of natural knowledge, each appropriate to its proper physical domain, but only one universal knowledge” (Shapin, 2008, p. 2) was essential to the gradual toppling of Aristotelian physics. Yet the significance of this ontological transformation is minimized when the facile narrative of the Copernican shift is mythologized as

signaling an abrupt break from the pre-modern world (Allchin, 2003; Midgley, 2003; Schrempp, 2011; Sheldrake, 2012). As Toulmin (1972) points out, this change was more evolutionary than revolutionary, since, “the ‘Copernican revolution’ took a century and a half to complete, and was argued out every step of the way” (p. 105).

3.14 Promoting Demotion

The shift to heliocentrism is frequently credited as ‘dethroning’ Earth and humanity from a privileged position (Hainesworth, 2012, p. 35; Perry, 2010, p. 247; Pruett, 2012, p. 29; Rees, 1997, p. 100; Sciama, 1971, p. 42; John A. Wheeler, 1988, p. vii). This has become a central tenet of the dominant story of modern science, recounted as the first of many “great demotions [. . .] delivered to human pride” (Sagan & Druyan, 1997, p. 26). In recent decades, however, this “Copernican cliché” (Danielson, 2001, p. 1029) has been challenged on the grounds that it overly simplifies contingent histories that shaped contemporary ideas about the nature of modern science (Barker, 2002; Singham, 2007; Slagle, 2013; Wertheim, 1999, 2010). Most notably, the ‘dethroning’ hypothesis disregards the belief that hell was actually in the middle of the medieval world system. As Dante Alighieri’s (1901) *Divine Comedy* graphically illustrates, a common belief was that the further one moved away from the center, the more the perfection of the cosmos increased. In *The Great Chain of Being: The History of an Idea*, Arthur Lovejoy (1936/2001) contends,

The actual centre, indeed, was Hell; in the spatial sense, the medieval world was literally diabolocentric. And the whole sublunary region was, of course, incomparably inferior to the resplendent and incorruptible heavens above the moon. Thus Montaigne, still adhering to the older astronomy, could consistently describe man’s dwelling-place as, “the filth and mire of the world, the lowest, most lifeless part of the universe, the bottom story of the house.” (p. 102)

Lovejoy also cites John Wilkins' (1640/1802) account of one of the arguments against Copernicanism, that drawn "from the vileness of our earth, because it consists of a more sordid and base matter than any other part of the world, and therefore must be situated in the centre, which is the worst place, and at the greatest distance from those purer incorruptible bodies the heavens" (p. 190). Based on this and other writings of the time, Lovejoy (1936/2001) concludes, "It is sufficiently evident from such passages that the geocentric cosmography served rather for man's humiliation than for his exaltation, and that Copernicanism was opposed partly on the ground that it assigned too dignified and lofty a position to his dwelling-place." (p. 102). As Toulmin and Goodfield (1962) put it, "the universe was (so to speak) a golden apple with a rotten core" (p. 162). Even Galileo (1610/1989) could not have been more explicit about his own position challenging the deprecating dogma of the Church, proclaiming in his *Sidereus Nuncius* that the Earth "is not the dump heap of the filth and dregs of the universe" (p. 57).

When issues of geocentrism, anthropocentrism, and the 'dethroning' of humanity or Earth are conflated, it confuses, and even inverts, the eventual ontological consequences of so-called Copernicanism (Turnbull, 2006, p. 137). Many key figures viewed the elevation of Earth to the status of a planet as a promotion, not a demotion—the reckoning of which also demonstrated humanity's ability to know the mind of God. In stark contrast to being located in a privileged position, the ever-changing Earth was believed to be far removed from the ethereal quintessence of the *heavenly spheres*.

3.15 Quantifying the Uncanny

Though Cusa and Bruno celebrated the dissolution of the *heavenly spheres*, others found the prospect of an infinite, homogenous, and relativistic universe deeply unsettling. According to Borges (1951/1975), Pascal started to write the word *effroyable* in his original manuscript to describe the metaphor, reading "A frightful sphere, the center of which is everywhere, and the circumference nowhere" (p. 9). Elsewhere, Pascal (1662/1910) reiterates, "The eternal silence of these infinite spaces frightens me" (p. 78). Nietzsche's (1882/2012) madman echoed this dis-ease of the modern era, bluntly summarizing the uncanny sense of dislocated homelessness:

"Where is God gone?" he called out; "I mean to tell you. *We have killed him*, —you and I. We are all his murderers. But how have we done it? How were we able to drink up the sea? Who gave us the sponge to wipe away the whole horizon? What did we do when we loosened this earth from its sun? Whither does it now move? Whither do we move? Away from all suns? Do we not dash on unceasingly? Backwards, sideways, forwards, in all directions? Is there still an above and below? Do we not stray, and through infinite nothingness? Does not empty space breathe upon us? Has it not become colder? Does not night come on continually, darker and darker? Shall we not have to light lanterns in the morning? Do we hear the noise of the grave-diggers who are burying God? Do we not smell the divine putrefaction? —for even Gods putrefy! God is dead. God remains dead. And we have killed him. (p. 90-91).

As the assuredness of the *heavenly spheres* dissolved into the ungraspable expanse of the infinite sphere, the newfound imaginative vastness contributed to a growing sense of existential dread—referred to by Freud (1919) as “*das Unheimlich*” (“the Uncanny”). This “psychic homelessness” (Chowers, 2004, p. 106) was intimately connected to—paraphrasing Nietzsche (1882/2012, p. 90)—wiping away the entire horizon to expose the cold winds of cosmic infinitude. Sloterdijk (2011) describes the shattering of the illusory “celestial domes” as depriving Europeans of an “evolved immune system”—the “comforting notion that the earth is enclosed by spherical forms like warming heavenly bodies” (p. 23). Sloterdijk (2005a) likens this cosmic displacement of modernity to the topological message that “people are living beings, living at the edge of an uneven round body—a body which, as a whole, is neither a mother’s body nor a container, and which has no protection to offer” (p. 54).

At the same time, countervailing winds were steering the European imagination in other directions. By the seventeenth century, the quantification of perception was well underway as imperial colonization emphasized knowing the world through weights, maps, and measures (Crosby, 1997; Short, 2004). The reconceptualization of the terrestrial sphere produced a newfound “globalization,” in which “the old open-edged, infinite world system had closed back on itself in all circumferential directions to become a finite system: a closed sphere” (Fuller, 1979, p. xviii). As new cartographic techniques “narrativized the topography to accommodate both an aerial vision and terrestrial human desire” (Punt, 2008, p. 271), they served as mesocosmic counterparts to earlier *sphairopoia*-facilitated flights of the imagination beyond the *kosmos*. Once again, having “a place in nature” meant “to

occupy a position in a great sphere, whether centrally or peripherally” (Sloterdijk, 2009, p. 29).

Neil Turnbull (2006) describes the ontological consequences of these imaginative shifts as reducing Earth to a cosmological representation, from the “site of dwelling...to an object of possible knowledge for modernity’s technological subject” (p. 131). For some, the dissonance brought about by the uncanny expansion and contraction of the spheres instigated a quest for absolute certainty. René Descartes’ [1596-1650] (1641/1901) vigorously sought the assurances of the fabled view from which Plato’s demiurge had constructed the world. He insisted that, just as Archimedes “might transport the entire globe from the place it occupied to another, demanded only a point that was firm and immovable; so, also, I shall be entitled to entertain the highest expectations, if I am fortunate enough to discover only one thing that is certain and indubitable” (p. 225). By insisting on an ontological separation of *res extensa* (material body) and *res cogitans* (the immaterial mind), Descartes effectively supplanted the once rigid distinction between the heavens and Earth realms with an equally rigid separation between thinking and embodied existence.

In the following century, Immanuel Kant’s [1724-1804] (1781/2010) self-proclaimed ‘Copernican revolution’ in philosophy further expanded the sense of uncanny estrangement from the world. Distinguishing between the world of sense perception (‘phenomena’) and the world of objects only accessible to thought (‘noumena’), Kant proposed his “science” of “transcendental idealism” as “the key to the solution of this pure cosmological dialectic” (p. 296). He purported to “do just what Copernicus did in attempting to explain the celestial movements” (pp. 13-14)—

comparing the reversal of the intuition that “all the heavenly bodies evolved round the spectator” to his own reversal of “the intuition of objects” (p. 14).

Yet, like Copernicus, Kant also continued long-standing traditions of Western philosophy. Whereas Copernicus sought to sustain the perfection of Aristotle’s *heavenly spheres*, Kant reified a sense of dualistic separation inherent to Aristotle’s logic of non-contradiction and ontological separation of celestial and terrestrial realms. Just as these bifurcations had previously helped to enact the Christian vision of a perfect heaven, Kant recast the ideal world of God as the sensorially unobtainable *a priori* Universe. He asserted that “everything intuited in space and time, all objects of a possible experience, are nothing but phenomena, that is, mere representations; and that these, as presented to us—as extended bodies, or as series of changes—have no self-subsistent existence apart from human thought” (p. 296). His distinction between ‘noumena’ and ‘phenomena’ heralded an elevated awareness of the role of perception within observation, but it also further ensconced an epistemological chasm between human sensory experience and ‘things-in-themselves’ (Tarnas, 1991, p. 419).

Together, these maneuvers helped to establish the tacit dualistic assumptions framing modernity, appearing to make concrete the inheritance of the mental-rational worldview initiated by Plato’s ideal *kosmos*. This combination of dualistic logic, faith in human reason, and the prioritization of theoretical knowledge became central to modernist epistemological and ontological assumptions, yielding progressively rigid distinctions between mind and body, subject and object, as well as humanity and nature (Nicolescu, 2002, p. 26).

Pascal and Nietzsche refuted these strict dichotomies, employing the metaphor of the infinite sphere to address the importance of ‘learned ignorance’ and ‘perspectivism.’⁴⁶ Like Cusa, they attempted to steer towards a kind of paradoxical logic, advocating for an understanding of humanity as “incapable of certain knowledge and of absolute ignorance” (Pascal, 1910, p. 30) and existing “between the greatness of the world and the smallness of the infinite world” (Nietzsche quoted by Small, 1881/1983, p. 97). By arguing that all knowledge and views of the cosmos are the inherently situated, conditioned, and limited, they continued Cusa’s tradition of acknowledging the limits of knowledge—a tradition intimately connected to the infinite sphere.

Nevertheless, the rigid dualities of non-contradictory logic underlying Aristotle’s metaphysics were maintained and exacerbated—even as his physics describing a spherical, geocentric cosmos were overturned. This led Harries (2001) to observe that, “the authority granted to human reason, bound up with a self-elevation that frees the thinking subject from any particular place” (p. 8) proved to be more important than the shift from a geocentric to a heliocentric world model. “Such self-elevation, a new freedom, and a new anthropocentrism,” he concludes, “go together with a new sense of homelessness” (p. 8).

⁴⁶ For a discussion of the relationship between Cusa, Pascal, and Nietzsche’s ideas, see Robin Small’s (1983) “Nietzsche and a Platonist Tradition of the Cosmos: Center Everywhere and Circumference Nowhere.”

3.16 Entraining Objectivity

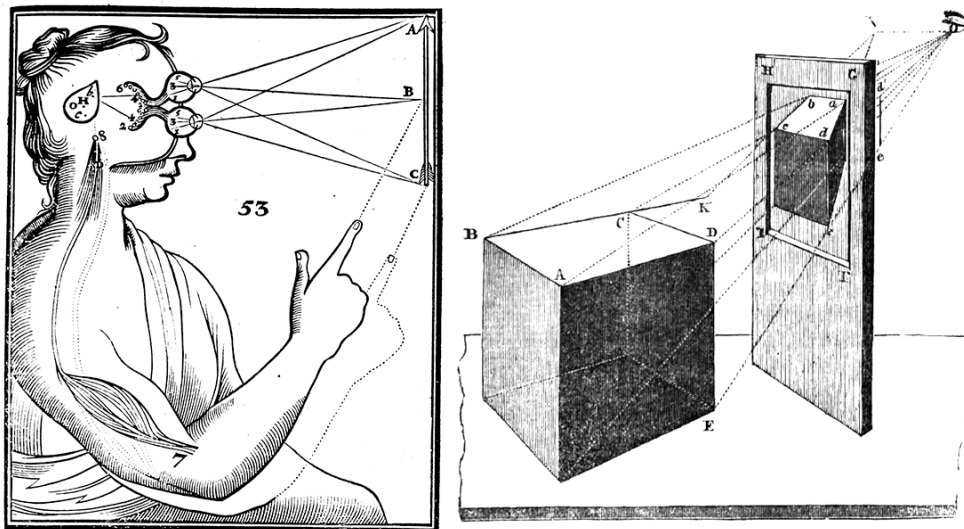


Figure 41. Woodcut diagramming Descartes' theory of vision (1644) and a diagram of visual rays proceeding from a spectator's eye to a cube (Taylor, 1835, p. 9).

Once again, these conceptual shifts were inseparable from the environments and technologies within which they were perceived. In particular, the use of optical devices and image-making techniques provided enactive scaffolding that reinforced dualistic assumptions. The study of optics and perspective transformed Renaissance art, and the configuration of visual instruments acutely influenced the trajectory of modern science (Figure 41). The widespread use of 'linear perspective' not-so-subtly shaped conceptions of reality during the Renaissance and beyond (Bailey, 1989; Wertheim, 1999, pp. 105–224). Experiences of rectilinear, representational 'windows' on the world—enacted by projection devices and single vanishing point perspective—provided central metaphors for what Jonathan Crary (1990) calls the "rational possibilities of a perceiver" (p. 53).⁴⁷

⁴⁷ The epistemological and ontological influence of the magic lantern, camera obscura, and linear perspective are addressed within Lee Bailey's "Skull's Darkroom: The Camera Obscura and

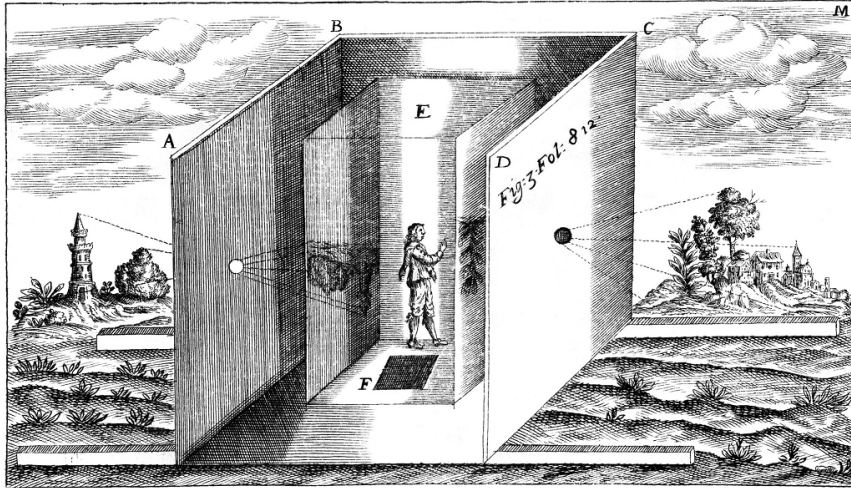


Figure 42. Camera obscura (Kircher, 1646, p. 807).

By entraining perceptual practices, these instruments informed the ways in which relationships between ‘interior’ human consciousness and ‘exterior’ visual phenomena were understood and represented for centuries. The camera obscura (Figure 42) became a model for visual perception, as Kepler, Descartes, and others adopted it as a metaphor to explain how the external physical world was internally ‘projected’ inside of the mind (Bailey, 2005; Ihde, 1998). “Throughout its history,” Lee Bailey (1989) contends,

the camera obscura has quietly but significantly functioned as a guiding root metaphor for our modern view of the soul [. . .] a largely unconscious guiding image that lends plausibility to the narrow, alienating, post-Cartesian idea that the psyche is a purely internal entity contained in a little black box, the dark room of the skull. (p. 64)

Subjectivity” (1989) and “Skull’s Lantern: Psychological Projection and the Magic Lantern” (1986), Owen Barfield’s (1999) “The Harp and the Camera,” Karsten Harries’ (1973) “Descartes, Perspective, and the Angelic Eye,” and Don Ihde’s (2008) “Art precedes science, or, Did the Camera Obscura Invent Modern Science?”.

The enactive role of the *camera obscura* in shaping the modern philosophy of mind is evident within both empirical and poetic influences. In tracing the history of the terms ‘subjectivity’ and ‘objectivity,’ Lorraine Daston and Peter Galison (2010) found that they “originally meant almost precisely the opposite of what they mean today” (p. 29). They write that the medieval scholastic use of *subjective* referred to “things in themselves,” whereas *objective* referred to “things as they are presented to consciousness” (p. 30). They credit Kant with philosophically reviving these terms in the eighteenth century, though his “‘objective validity’ referred not to external objects but to the ‘forms of sensibility’ (time, space, causality) that are the preconditions of experience” (p. 30). However it wasn’t until romantic poet Samuel Taylor Coleridge (1817) inverted the meanings of these terms in the nineteenth century that they became associated with the current interpretations. Contemplating the relationship between the imagination, self-consciousness, and the world, he writes:

Now the sum of all that is merely OBJECTIVE, we will henceforth call NATURE, confining the term to its passive and material sense, as comprising all the phaenomena by which its existence is made known to us. On the other hand the sum of all that is SUBJECTIVE, we may comprehend in the name of the SELF or INTELLIGENCE. Both conceptions are in necessary antithesis (pp. 158-159).

In turn, Coleridge’s views about the nature of cognition were heavily influenced from John Locke’s theories of perception that drew directly from

metaphors derived from the camera obscura.⁴⁸ Locke (1706/1856) writes, “These alone, as far as I can discover, are the windows by which light is let into this dark room: For methinks the understanding is not much unlike a closet wholly shut from light, with only some little openings left, to let in external visible resemblances, or ideas of things without” (p. 109).

Consequentially, Coleridge (1817) coined the term “willing suspension of disbelief” within the same text that he redefines *subjectivity* and *objectivity*, referring to the necessity of cultivating “poetic faith” (p. 4) to convey convincingly romantic and supernatural fictions. The proximity of these ideas within Coleridge’s writings, and the influence of metaphors derived from visualization devices, attests to the importance of both empirical experiences and the poetic imagination at the origins of contemporary paradigmatic assumptions of modern science. As material engagements with these devices shaped phenomenological experience, they transformed into poetic metaphors for understanding consciousness and the world, reinforcing the dualistic sense of an immutable distinction between the metaphysical intellect and the physical universe.

⁴⁸ As Charles Rzepka (1999) writes, “The effects of Cartesian and empirical thought on eighteenth-century and Romantic literature have been amply documented, we recognize now that Romantic poetic theory, particularly the writings of Wordsworth and Coleridge, derives ultimate from Locke’s theories of perception and from the empiricist model of the mind as a camera obscura. Into the “dark room,” argued the empiricists, “ideas” of the outside world enter through the “windows” of the senses, there to be organized into more complex and abstract ideas” (p. 10).

3.17 Cosmographic Dreaming



Figure 43. *The Ecstatic Heavenly Journey* by Athanasius Kircher (1660).

Over time, the advent of a vast array of new instruments, including telescopes, microscopes, and multi-spectral imaging devices—as well as the rediscovery of armillary spheres and other demonstrational devices—not only altered visual and conceptual environments but also transformed the ways in which worlds and universes were imagined. The invention of the printing press, along with new mapping, imaging, and display technologies, enabled the distribution of visual depictions of ideas about phenomena and space (Eisenstein, 1979; Gingerich, 2011; Short, 2004). Citing the importance of what Bruno Latour (1990) calls “immutable mobiles” (p. 7), Denis Cosgrove (2001) argues the “Copernican revolution was

secured through the circulation of cosmographic images that challenged ways of imaging and experiencing not only planetary arrangement and movement but the entire cosmic arrangement in which human existence was created and performed” (p. 6).

As observations of phenomena at previously inaccessible scales birthed new ideas about scientific laws governing the physical world, they also frequently contradicted intuitions of the unaided senses. The once sacred firmament became an acute reminder of the deceptive potential of sensory perception, and formerly deified patterns and motions of the *heavenly spheres* transformed into the modern equivalent of shadows cast on Plato’s allegorical cave. To fill the explanatory void left by the disappearance of the spheres, natural philosophers turned to new visual technologies to confirm the predictive power of mathematical equations—but at the expense of Platonic doubt cast on the veracity of lived experience. The behaviors of the once mysterious and unchanging heavens increasingly appeared to be reducible to universally applicable mechanical laws, giving rise to the reassurances of the *mechanistic universe* (Harrison, 2003, p. 101).

Visual displays again precipitated imaginative visions of a god’s eye view on the world, re-awakening what Denis Cosgrove (2001) calls the “cosmographic dream” (p. 49). Visions of “flying sufficiently high to allow a panoptic view” (p. 49) of the Earth and cosmos had echoed through the European imaginative and scientific literature since the ancient Greeks, only this time it was to reflect back on humanity’s corner of a seemingly infinite cosmos (Figure 43). The revival of the ancient craft of designing devices for imagining an ‘Archimedean point’ once again played a central role in rhetorically demonstrating the possibility of achieving totalizing knowledge

about the world. Armillary spheres, heavenly globes, orreries, and other “planetary machines” (Brewster, 1830; King, 1978, p. 90) served as essential philosophical instruments for imagining the configuration of the heliocentric solar system.

3.18 Planetary Machining

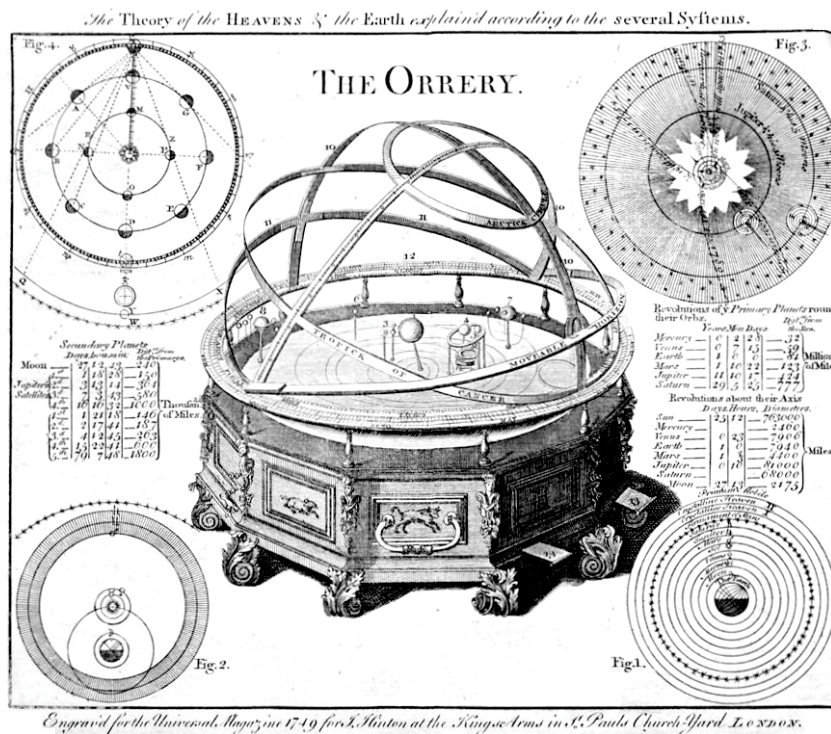


Figure 44. Engraving of an orrery displaying different models of the cosmos (Rowley, 1749).

The mechanical orrery—invented nearly two centuries before the recovery of the Antikythera mechanism—was particularly significant in establishing the veracity of the mechanistic model of the universe (Figure 44). The clockwork precision of planetary movements provided an indispensable tool for experientially demonstrating the logic of the Copernican world model, and, by extension, the capabilities of the rational intellect for discerning an underlying cosmic order.⁴⁹ Once again, these visual technologies of space and time functioned as *tools for thinking*, enactively shaping

⁴⁹ Henry King (1978) exhaustively catalogues these devices in his *Geared to the Stars: The Evolution of Planetariums, Orreries, and Astronomical Clocks*, situating orreries within the extensive European lineage of machines for quantifying space and time.

and reinforcing conceptions based on their particular material configuration (2.05 Tools for Thinking). In the case of the orrery, it helped to visually transfer concepts of temporal quantification of clocks to the spatial control of planetary movements.

Michael Punt (2008) describes how the “three-dimensional schematic” of the Early of Orrery’s original device—and its subsequent replications—placed its early eighteenth century observers “in a very special position outside the universe” (p. 269). By effectively “reinstall(ing) man as the pivot of the universe, after having been so ignominiously dislodged from the center of God’s eye” (p. 269), the omniscient view and reassuring precision of the orrery—like Greek *sphairopoia*—provided an experience of omnipotence and eccentric separation from the world. In so doing, it further reinforced the epistemological and ontological bifurcation of the mind and body, creating a “clockwork expression of a new anthropocentrism; one which places the observer outside of the solar system and in the realm of the aerolites and comets” (p. 270). “It supported a mechanical philosophy,” Punt writes, “that was nothing short of a metaphysics which separated matter from life” (p. 271)—but that simultaneously “acknowledged the possibility of purposive agency in the universe” (p. 272).

By the mid eighteenth-century, the designs of these European cosmographic devices were shaping conceptions in America, used extensively “in public lectures on science and in college courses as part of the demonstration of Newtonian principles” (Cohen, 1997, p. 80). Describing his own orrery, clockmaker David Rittenhouse (as cited in Ponder, 2010) wrote, “an Easy Motion of the hand [. . .] will in the space of a few Minutes, point out the times of all remarkable phenomena of the Heavenly Bodies for years to come” (p. 211). Thomas Jefferson (1853) was so taken by Rittenhouse’s instrument that he claimed it “exhibited as great a proof of mechanical

genius as the world has ever produced" (p. 71). Jefferson, echoing Cicero's praise of Archimedes, concluded that in constructing the miniature solar system, Rittenhouse "has not indeed made a world; but he has by imitation approached nearer its Maker than any man who has lived from the creation to this day"⁵⁰ (p. 71).

Like previous *cognitive cosmographic models*, these new philosophical instruments materially provided cognitive scaffolding for making imaginary flights through the cosmos tangible. They rhetorically demonstrated the efficacy of mechanistic cosmological speculations, appearing to bridge the presumed chasm between the limitations of sensory experience and the physical universe via the ingenuity of disembodied rationality. These demonstrations also embodied literary tales of "grand tours" and "cosmic voyages" (Nicolson, 1940), popular forms of "mind-traveling" designed to imagine the unimaginable by narratively illuminating the perspective of the god's eye view. In conjunction with the Neoplatonic metaphor of the infinite universe, these planetary machines revived ancient tropes, reconfiguring the what Ladina Lambert (2002) calls the "finite structure of relations" of the geocentric cosmos to confirm the potential predictability of the new, uncanny universe of "infinite relativity" (p. 145). They helped to increase faith in the intellect's ability to fill the void left by the dissolution of the *heavenly spheres*—functioning as cognitive extensions that seemingly liberated the imagination from the limitations of the unaided senses. As philosophical divisions estranged the 'internal'

⁵⁰ As a *cognitive cosmographic model*, Rittenhouse's orrery may even have, like its predecessor the Pantheon, helped to instigate a famous revolution. Benjamin Ponder (2010) argues that the temporal sensibility it imparted as a "space and time machine" (pp. 171–229)—along with other of Rittenhouse's devices—played an instrumental role in establishing the urgency of the American Revolution.

metaphysical world of thought from the 'external' world of nature, material engagement with these devices helped to enact tantalizingly omniscient visions of the cosmos, further reifying conditions necessary for the establishment of a *mechanistic universe*.

3.19 Blurring the Boundaries

However, as Punt (2008) writes, the paradox and instability of the point of view of “observing oneself outside of the system” (p. 273) formed key questions throughout the nineteenth century concerning relationships between observers, the human perceptual apparatus, external stimuli, and instrumental observations. In particular, the invention of photography—with its “aura of unselective partiality” (Daston & Galison, 2010, p. 35)—established new “epistemic virtues” of “objectivity” (p. 18). Dependence on sophisticated devices firmly secured instrumental materialism as the dominant scientific path to knowledge, partitioning natural philosophy into increasingly specialized disciplines. The quest for impartial perspectives on the world accompanied a concomitant suppression of the ambiguities of ‘subjective’ aspects of experience. The paradox of the orrery, however, demonstrated this was hardly a straightforward task. In the tradition of orreries and magic lantern shows of previous centuries, new visual technologies were employed within philosophical toys and public amusements that exploited ambiguities between ‘subjectivity’ and ‘objectivity,’ further blurring the already unstable boundaries between science, spirituality, art, technology, and entertainment (Crary, 1990; Nekes, 2004a, 2004b; Punt, 2000; Wade, 2004).

Conclusion

This chapter considered how visualization devices, immersive environments, and spherical metaphors contributed to the emergence of cosmological ideas central to the *mental-rational worldview* and the *geometric* and *mechanistic universes*. Greek *sphairopoia*, Pantheon, planetary machines, and other artifacts of cosmographic practices functioned—like their archaic predecessors—as *cognitive cosmographic models*. They both demonstrated and reinforced the shifting metaphors of *heavenly*, *infinite*, and *terrestrial* spheres, provoking questions concerning not only humanity's place in the cosmos but also the relationship between notions of mind and body, human and nature, and subjectivity and objectivity. As materialist sciences became increasingly dependent on instrumentally mediated perception, they also attempted to isolate, separate, and even suppress all-too-human desires and spiritual longings. As these found outlets within popular amusements, they demonstrated the difficulties of clearly defining boundaries between the ambiguous domains of human experience. The next chapter examines how these ambiguities were amplified in the twentieth century as the ability to project cinematic visions of 'inner' and 'outer' worlds within domed theaters blurred boundaries between art, science, education, spirituality, and propaganda.

Chapter 4: Cosmological Cinema

“Mind is perpetual motion. Its symbol is the sphere.”

(Eddy, 1875, p. 85)

Introduction

Building on previous chapters, this chapter examines of the enactive role of tools and techniques for visualizing the *heavenly sphere* in the twentieth century. It considers how immersive vision theaters shaped conceptions of the cosmos in both novel and archaic ways. A brief history of the medium reviews seminal efforts to project astronomical visualizations within hemispherical screens. I discuss how these efforts to simulate and stimulate the spherical gestalt of vision emerged from a diverse range of influences and motivations, resulting in applications of the medium as pedagogical environments, art installations, and entertainment attractions. I then examine the Hayden Planetarium’s contemporary efforts to push the dream of cosmic flight to its virtual extreme. I review the script of the Hayden’s production *Passport to the Universe* and describe the visualization software that enabled its creation. Finally, I discuss this effort within the broader context of immersive environments, as well as the implications of its producers’ efforts to blur the boundaries between science and science fiction.

4.01 Bifurcations and Projections

By the first half of the twentieth century, visions of a mechanistic universe had fragmented the once broad philosophical study of nature into increasingly specialized scientific disciplines. Attempts to dissociate and clarify methodological, metaphysical, and moral aspects of cosmological theories resulted in the bifurcation of cosmology into *physical cosmology*, primarily the domain of astrophysics, and *cultural or religious cosmology*, generally categorized as a subset of anthropology (Iwaniszewski, 2009). Defining physical cosmology as a ‘hard’ science was—and continues to be—justified by citing the increasing precision of instrumentation and mathematics of positivist science, appearing to enable ever more finite and objective quantification of phenomena.⁵¹

However, these emerging capabilities and insights also created serious complications for the epistemological and ontological dualism that underpinned nineteenth century scientific assumptions. Evidence of quantum indeterminacy, relativistic space-time, and non-local entanglements revealed a highly complex and relational cosmos—quite different than the picture of a mechanically determinate universe painted by materialist reductionism (Longair, 2004; Roszak, 2000). The ability of new instruments to peer into previously inaccessible spatiotemporal scales disclosed the seemingly paradoxical behavior of light, which had long served as the primary metaphor for truth (Blumenberg, 1993).

⁵¹ Lorraine Daston's (1992) *Objectivity and the Escape from Perspective* and Lorraine Daston's and Peter Gallison's (2010) *Objectivity* address the complicated and contingent history of the notion of “objectivity” (3.16 Entraining Objectivity and 6.11 Fabricating Meditations).

In spite of—or more likely because of—the ambiguous implications of these discoveries, domed structures once again emerged as the quintessential environments within which to collectively imagine a discernible heavenly order. Over the course of the twentieth century, hemispherical projection theaters were embraced for immersing audiences within large-scale scientific visualizations and other moving imagery. Combining elements of sacred caves, temples, orreries, camera obscuras, painted panoramas, and celestial globes, dome theaters displayed the orderly motions of the night sky and visualized fantastic journeys to inner and outer space. By radially extending thought experiments onto vaulted screens using projections of light, they perpetuated the ancient practice of visualizing flights between worlds. Though the recondite findings of some branches of physics appeared to reveal a paradoxical cosmos, the spectacular allure the dome's archetypal architecture was used to convince public audiences that the universe was not only sublime but also—thanks to physical cosmology—perhaps ultimately intelligible.

4.02 Opto-Mechanical Universe



Figure 45. The Zeiss projection dome (1924).

Domed projection theaters began with the first Zeiss planetarium, unveiled in 1923 by the Carl Zeiss Optical Company of Jena, Germany. Jointly conceived by the Deutsches museum director, Oskar von Miller, and Zeiss engineer, Walther Bauersfeld, it was designed to teach astronomical concepts in a direct, experiential way. Miller's goal was to create an exhibit that would clarify "the underlying *theories*" of science while conveying "the variety and excitement of a world's fair" (Alexander, 1983, p. 353). The system used two revolutionary innovations: a highly accurate opto-mechanical projector and a sixteen-meter thin-shell concrete dome supported by a lightweight iron rod framework (Figure 45), both patterned on the twenty-sided icosahedron. The projector, named the Zeiss Mark I, provided a means by which high fidelity simulations of the night sky could be projected onto the dome surface and controlled by a single operator. Together, the projector and hemispherical screen created the impression of a controllable night sky, immersing participants

within the illusion of an animated starry vault. Celestial positioning and mechanics could be interactively animated, which simulated the patterns and movements of the stars as they would appear at different times and locations on Earth.

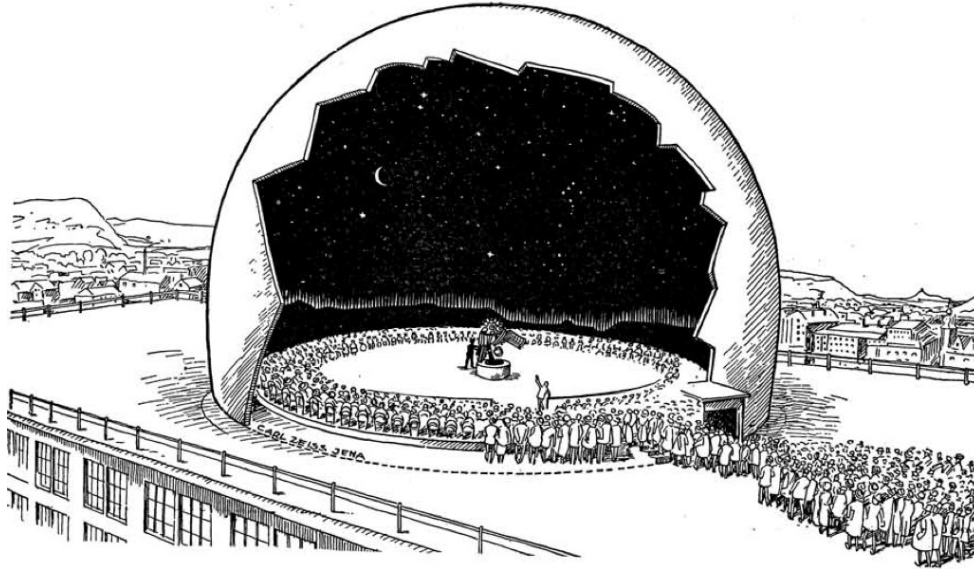


Figure 46. Illustration of the *Zeiss Ptolemaic Planetarium* (Todd, 1925, p. 447).

The Zeiss Planetarium made its public premiere on October 21, 1923 at the Deutsches Museum in Munich, shortly after initial demonstrations at Zeiss, where Bauersfeld gave the first public demonstrations in the museum's newly constructed nine-meter dome (Figure 46). After witnessing one of the initial presentations, the director of the Copenhagen Observatory proclaimed that it was “a school, a theater, a cinema in one; a schoolroom under the vault of heaven, a drama with the celestial bodies as actors” (as cited in Marché, 2005, p. 19). David Todd (1925), the first American astronomer to report on the planetarium, was so impressed by its ability to “compress the cosmic happenings of many years into a few minutes” (p. 455) that he suggested it would not only arouse interest in astronomy, but also broaden audiences perspectives “intellectually, ethically, and esthetically” by enabling them to directly

experience the “influence of vision” (p. 456). He was so taken by the experience that he claimed the planetarium provided a means to, quoting William Blake, “hold Infinity in the palm of your hand and Eternity in an hour” (p. 446).

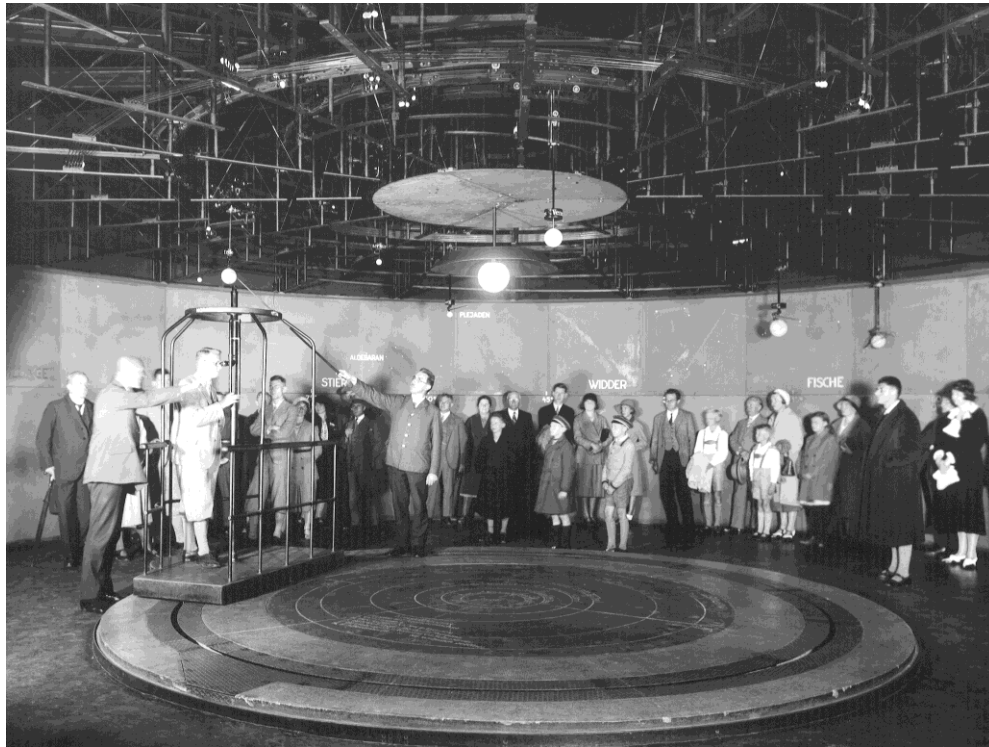


Figure 47. The Zeiss *Copernican Planetarium* (Deutsches Museum, 1924).

Though its inventors adopted the term “planetarium” from previous devices designed to mechanically replicate the movements of planetary bodies,⁵² Miller recognized the extraordinary irony of teaching modern science within an environment that depended on—and reinforced—an illusory sense of the Ptolemaic model of rotating celestial spheres. As a counterbalance to this geocentric perspective, he designed an adjacent room-sized “Copernican planetarium” (Figure 47) using a large-

⁵² As noted in the previous chapter, orreries were often called planetariums, and are considered the primary instrumental predecessors of the modern planetarium. However, the discovery of the Antikythera mechanism proves that similar devices existed in antiquity.

scale mechanical orrery to demonstrate the “true motions of the planets around the sun” (Marché, 2005, p. 14). By experiencing successive demonstrations of the geocentric and heliocentric views of solar system dynamics, Miller hoped audiences would intuitively grasp the complementary nature of these representations. However, the emotional impact of the night sky simulation within the domed planetarium was so powerful that it dramatically overshadowed its Copernican counterpart. As the popularity of planetariums grew internationally, the additional cost and complexity of the secondary exhibit prohibited its installation in all but a few museums. These constraints thus limited the full realization of Miller’s pedagogical vision of a multi-perspectival learning environment.

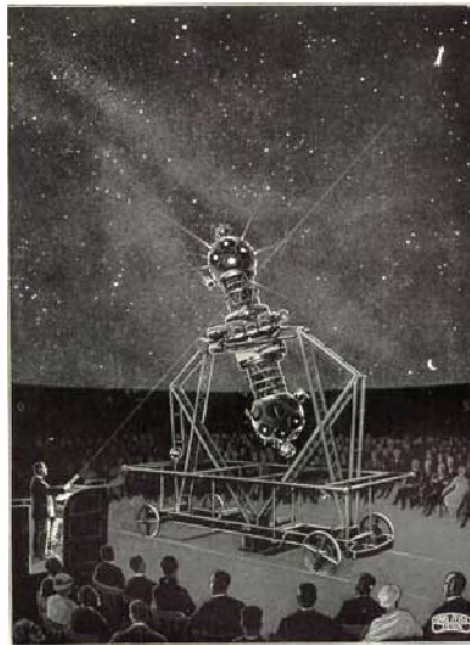


Figure 48. Zeiss Mark II (The Carl Zeiss Company, 1929).

Zeiss concentrated on the refinement of their Ptolemaic design, and introduced the improved Zeiss Mark II in 1926 (Figure 48). As word spread of the “Wonder of Jena,” orders came in from other European and Russian cities. By the end

of the 1920s, Zeiss had constructed planetarium theaters in a dozen German municipalities, which were made possible by the support of local and federal government funding. Zeiss was also commissioned to build theaters in Vienna, Rome, Moscow, and Sweden. Attendance steadily grew throughout the decade, and records reveal that millions of visitors had experienced the simulated heavens in Germany alone (Marché, 2005, p. 20).



Figure 49. Adler Planetarium and Science Museum (1930).

It was not until 1930 that the first planetarium in the United States, the Adler Planetarium, opened its doors to the public in Chicago (Figure 49). Four additional Zeiss theaters were constructed throughout the decade at museums in Philadelphia, Los Angeles, New York, and Pittsburgh. Lack of federal funding for education delayed earlier entry into the United States, necessitating the support of wealthy private donors and prohibiting the installation in all but some of the largest cities.

Regardless, attendance at American planetariums, and by extension popular interest in astronomy, increased throughout the decade as audiences sought to escape the economic realities of the Great Depression. The planetariums provided a vicarious experience of the heavens rarely experienced within urban environments.

Many of the donors and proponents who helped finance planetariums in America believed the metaphysical experience of these celestial simulators could affect cultural and social evolution by increasing social equality, spiritual epiphanies, and even environmental awareness. Concerned with the rise of anti-Semitism, Sears and Roebuck vice president Max Adler (as cited in Kaempffert, 1928) hoped that his namesake would show that “all man kind, rich and poor, here and abroad constitute part of one universe,” and that “under the vast firmament, there is no division or cleavage but rather interdependence and unity” (p. 21). Similarly, stockbroker Charles Hayden, backer of the American Museum of Natural History’s planetarium in New York explicitly stated his religious intentions for the new installations. Hayden hoped that the “artificial heaven” would give visitors a “more lively and sincere appreciation of the magnitude of the Universe and of the belief that there must be a very much greater power than man which is responsible for the wonderful things which are daily occurring in the universe” (“\$150,000 by Hayden for planetarium,” 1934, p. 23).

John D. Rockefeller Jr. (as cited in Marché, 2005) was unambiguous in his praise for Hayden’s motives, arguing, “people must realize more and more that spiritual values are the only ones that offer a solid foundation for the development of civilization if the world is to go on and mankind to become in any sense worthy of the Creator” (p. 35). At the dedication of the Hayden Planetarium in 1935, one presenter

took a decidedly more secular perspective, foreshadowing modern environmental awareness by expressing his hope the new theater would impart a “geographical planetary consciousness” and visitors might better comprehend “the common fate of the human race in one spherical boat out upon the boundless ethereal sea” (Laurence, 1935, p. 21).



Figure 50. The Rosicrucian Planetarium (AMORC, 1936).

The first planetarium created by an American embodied the spiritual and mystical appeal echoed by many visitors to early domed theaters. Harvey Spencer Lewis, founder and Imperator of the Ancient and Mystical Order of the Rosae Crucis, installed in 1936 the Moorish-influenced Rosicrucian Planetarium in 1936 in San Jose, CA. Known as the *Theater of the Sky*, the device consisted of multiple optical projectors emanating from a centrally mounted sphere that projected onto a 40-foot diameter dome (Figure 50). In addition to the celestial vault, it simulated the daytime sky, the rising and setting of the sun, and clouds of fog to “show how in the beginning

of the creation of the universe moisture preceded the creation of everything else” (AMORC, 2010, pp. 292–293). Additionally, it was claimed that visitors could witness “the mysteries of the ancient mythologies demonstrated in a surprising manner” (p. 14). Other eccentric inventions developed by Lewis were also on display including the *Luxatone* color organ, the *Cosmic Ray Coincidence Counter* radioactivity tracker, and *Sympathetic Vibration Harp* (Nowicki, 2001). Not surprisingly, the Zeiss-based planetarium community that represented the institutional status quo of scientific outreach and education largely ignored the Rosicrucian Planetarium.

By perceptually opening the frontiers of space and time, these early planetarium theaters provided a means by which the general public could vicariously experience the movements of the celestial sphere. In an era of intense political, economic, and scientific upheaval and uncertainty, the Zeiss planetariums provided awe-inspiring and mechanized reassurance of the underlying order of a clockwork universe. Their expansion throughout the United States was attributable to both metaphysical and scientific appeal—as indicated by funders’ religious motivations and media rhetoric. For example, the *New York Times*’ described of the Hayden Planetarium opening as a “make-believe world shorn of space and time” (Laurence, 1935). Though this ambiguity reached its early pinnacle in the Rosicrucian Planetarium, Harvey Spencer Lewis’ investigations into multi-sensory metaphysical knowledge spaces served as a harbinger of the spiritual, artistic, and technological experimentation of later decades.

4.03 Transcending the Firmament

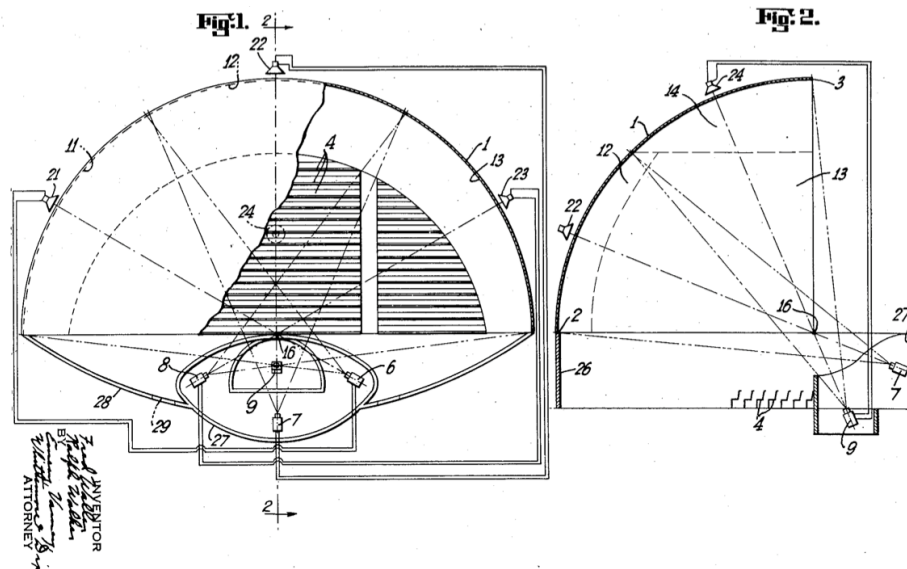


Figure 51. Plan and section view of Fred Waller's *Motion Picture Theater* (Waller, 1942).

While planetarium projectors were limited to simulating the night sky, a series of lesser-known experiments with cinematic projection began laying the foundation for transcending the firmament within dome theaters. These started when special effects artist Fred Waller (1953) tried to mediate the complete panoramic field of human vision in the 1930s. Through a series of experiments, he realized how strongly humans rely on peripheral vision for a sense of presence noting that “A sphere [. . .] does not arbitrarily limit the field of vision, and it actually corresponds to the way we see normally” (p. 120). He developed a concept for a multi-projector dome-based motion picture theater to display panoramic moving images (Figure 51), which Waller’s (1942) patent application described as producing the “effect or illusion that the spectator is actually in and surrounded by the environment depicted” (p. 1).



Figure 52. *Theater of Time and Space* at the 1939 New York World's Fair. Photograph by American Museum of Natural History (Fyfe, 1939, p. 4).

Waller had the opportunity to realize his invention when invited by the Longines Watch Company to participate in the creation of their *Theater of Time and Space* (Figure 52) for the 1939 New York World's Fair. The exhibit consisted of multiple motion picture projectors illuminating a 44' high vertical domed screen whose contours blended into the floor and side walls to provide the illusion of a limitless projection surface. With scientific guidance from the chief curator of the American Museum of Natural History's Hayden Planetarium, the creators of the production touted it as "a cosmic spectacle of incredible scope and awe-inspiring wonders" (Fyfe, 1939, p. 3).

Upon entering, up to 350 visitors at a time were informed they were about to "leave this earth for a journey of tremendous distance" to "see for ourselves with our

own eyes some of the myriad wonders of the heavens" (Fyfe, 1939, p. 3). Beginning at the skyline of New York City, the film began by simulating a voyage rising through the sky, penetrating the clouds, and traveling millions of miles through deep space to witness the Sun's fiery rim. Flying back towards the Earth time accelerated to reveal the phases of the moon. Cruising towards Mars, the audience witnessed clouds and dark bands of vegetation lining riverbanks emanating from its polar ice caps, reflecting the belief in the red planet's capacity to sustain life. Finally, leaving the solar system, the audience flew out of the spiral arms of the Milky Way, eventually returning home to land back at a scale model of the World's Fair. The Hayden Planetarium's special publication for the fair extolled that the 15-minute journey "of thousands of billions of miles" was both "miraculous" and "almost unbelievable" (p. 4).

4.04 Race to Space

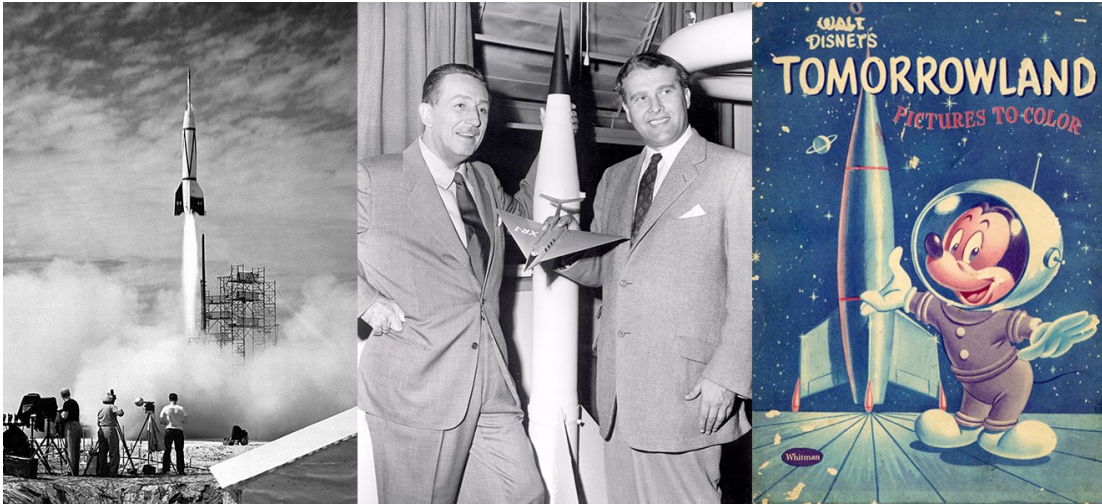


Figure 53. US Army launch of V2 rocket (NASA, 1950); Walt Disney and Werner von Braun (NACA, 1954); Walt Disney *Tomorrowland* coloring book (Whitman, 1955) .

By the end of the 1930s, the construction of new Zeiss planetariums came to a halt with the onset of World War II. The final installation was Pittsburgh's Buhl Planetarium, which opened its doors to the public less than two months after Hitler's invasion of Poland. At the dedication ceremony, the city's mayor acknowledged the irony of the situation, commenting, "The skilled hands and brains, which made this very Planetarium possible, are today forging weapons of destruction for a war of conquest and subjugation, a war to spread the divine right of dictators" (Scully, 1939). Indeed, the Jena factory was converted to manufacture bombsights for Nazi aircraft during the war. However, just as German engineering had allowed Americans conceptually to 'reach for the stars' in the previous decade, it also provided the foundation for more literal attempts after the war.

In 1951, the Hayden Planetarium hosted the *First Symposium on Space Flight* (McCurdy, 2011, p. 41), detailing the technologies and plans brought to the United States by German rocket scientists after the war. Led by Wernher von Braun, who

later became chief architect of the US space program, the symposium popularized many concepts of space flight that to most Americans seemed like science fiction. Topics covered at the symposium, including manned orbiting space stations, lunar space ventures, and questions of international law and sovereignty in space (Newkirk & Ertel, 1977, p. 5), were further elaborated by a series of widely read Collier's magazine articles the next year. Soon thereafter, a fruitful art/science collaboration between Walt Disney and von Braun produced a series of Disney television shows on the theme of space travel (Kimball, 1955) as well as the *Trip to the Moon* theme park ride in Disneyland's newly opened *Tomorrowland* (Wright, 1993, pp. 151–160) (Figure 53).⁵³

⁵³ In the same way that homegrown renditions of the European Orrery structured American temporal sensibilities two hundred years earlier (3.18 Planetary Machining), the collaboration between von Braun and Disney would shape American notions of “outer space” for decades to come.



Figure 54. Spitz Model A1 planetarium projector (1955).

As interest in astronomy and space-related subjects continued to grow in the first decade of the post-war America, over a hundred new planetariums were installed nationwide. Made possible by the development of an inexpensive planetarium projector by Armand Spitz of Pennsylvania, many of these systems were for the first time installed at schools and universities instead of major museums (Marché, 2005, p. 88) (Figure 54).

The Russian launch of Sputnik I, in conjunction with the 1957 International Geophysical Year, fully catalyzed the ‘Space Race.’ American scientists and politicians were caught off guard, assuming that the US had superior technology and would be the first to launch a manufactured Earth-orbiting satellite. Within four months, the US successfully launched Explorer I, followed by Congress’ passage of

the Space Act for the creation of the National Aeronautics and Space Administration (Wysession & Rowan, 2013, p. 173).

Widespread public anxiety after Sputnik's launch also caused the U.S. government to embrace fully science education as a vital component of cultivating a national defense-oriented *weltanschauung* among the public. Citing the need to remedy "existing imbalances in our educational programs [. . .] as rapidly as possible" (Marché, 2005, pp. 123–124) to compete in a cold scientific war with the Soviets, the US Congress enacted dramatic changes in federal policy to direct federal funds to support local education. The National Defense Education Act (NDEA) of 1958 included provisions to match funds for the construction of planetariums in schools. Prior to Sputnik, relatively few schools could afford their own star theaters, but the passing of the NDEA enabled them to become the primary sites of planetariums in America. Additionally, educators reintroduced astronomy into school curricula for the first time in nearly 60 years.

Film-based dome theaters were also integral to the cold war efforts to engage the American public. At the outbreak of World War II, Fred Waller had adapted the camera and projection system of *Theater of Time and Space* for use as gunnery trainers by the US and British military (Crist, 1943). After the war, he continued to refine the panoramic theater technology by establishing the Cinerama Camera Corporation, which had the opportunity to pioneer another form of domed cinema when hired to create an exhibit for the 1962 World's Fair in Seattle. Part of the "World of Science" funded by the US Department of Defense, the National Science Foundation, and Boeing Aerospace, it was intended to "awaken the US public to the significance of the general scientific effort and the importance of supporting it"

(Gilbert, 1997, p. 301) during the infancy of the space race. Designed specifically for middle-class Americans skeptical or indifferent about the importance of science, they determined that *Century 21* could offer “the first opportunity” to “illustrate our attitude of moral responsibility in international relations that go along with scientific progress” (p. 302).

To simplify the projector configuration of the earlier cosmic voyager, Cinerama developed what Scot (1963) described as a “totally new concept of motion picture presentation” (p. 528). Dubbed *Cinerama 360*, it employed a custom fisheye lens for photographing and projecting using 70mm film, which enabled the imagery to appear undistorted when displayed on the dome screen. Fine Arts Productions was hired to “explore new frontiers in three-dimension stop-motion photography and animation,” creating a 10-foot fiberglass domed set to simulate a “black sky ablaze with stars” (p. 528) within which the modeled elements were recorded.



Figure 55. Map of the space route travelled by ‘passengers’ at the Boeing *Spacearium*, Seattle World's Fair (Unknown, 1962).

The result was *Journey to the Stars*, a 12-minute cosmic journey simulating “an imaginary, but vividly realistic, spaceship flight through our own solar system and two billion light years beyond” (“Around outer space in 12 minutes,” 1962, p. 75) within a 70-foot diameter horizontal dome. Up to 750 standing “passengers” were informed by a narrator that the journey would require accelerating “up to ten trillion times the speed of light,” and that “because such extreme velocity violates all the laws of nature, this trip is possible only in our imagination” (Newlan, 1961, p. 2). Paralleling the earlier flight trajectory of the *Theater of Time and Space*, the film depicted a departure from Earth, views of constellations, a fly-by of the Moon and the Sun, as well as a flight past Mars and the outer planets. The flight eventually departed the Milky Way on the way towards Andromeda (Figure 55) and finally headed back home—visualizing a supernova explosion along the way for good measure.

Approximately 7 million visitors the *Boeing Spacearium Theater* during the Seattle World's Fair (Cinerama, 1961), making it one of the most widely visited exhibits in the ongoing attempts to increase public interest in the US space effort.



Figure 56. *To the Moon and Beyond* exhibit at the NY World's Fair (1964).

The *Cinerama 360* system was once again deployed at the 1964 New York World's Fair for *To the Moon and Beyond* (Figure 56), an exhibit for the Travel and Transportation Pavilion sponsored by KLM Royal Dutch Airlines. One account from *Business Screen Magazine* (Reevesound, 1964) reported that visitors entering the darkened 80-foot dome were freed “from conventional ideas of size and time” as a narrator prepared the audience to be “propelled on the most fantastic, incredible voyage through billions of miles of space [. . .] from its utmost outer reaches [. . .] back to the Earth itself, and into the center of the minutest atom” (para. 3). Following a plotted trajectory, audiences took a cosmic journey through the solar system and out of the galaxy, revealing time-lapse animations of galaxy simulations forming out of

groups of gas clouds. Upon returning to the Earth, audiences flew through the middle of a forest and to the bottom of the sea, concluding with a journey into a single cell.

Through its presence at the World's Fair, *To the Moon and Beyond* played a significant role in bridging science fiction and science fact. The producer, Graphic Films Corporation, whose founder had worked as an animator on Disney's *Snow White*, *Bambi*, and *Fantasia*, specialized in the development of simulation films for "training and scientific purposes" to show "senators and appropriations committees in order to stimulate the necessary flow of cash," with clients including NASA and Jet Propulsion Laboratories (Finch, 1984, pp. 103–104). The film was narrated by Rod Serling of *Twilight Zone* fame, and illustrated by special effects artist Douglas Trumbull who supervised effects for *Close Encounters*, *Star Trek: The Motion Picture*, and *Blade Runner*. Director Stanley Kubrick was so impressed after visiting the pavilion film that he tracked down Graphics Films to solicit their technical assistance with his *2001: A Space Odyssey*.

Though the *Cinerama 360* format was short-lived, it was the precursor of later and more popular large format dome theaters such as *Omnimax* and *Astrovision*. Furthermore, in moving beyond space travel and rocket science, the subject matter of *To the Moon and Beyond* foreshadowed other influential attempts to take audiences on imaginary trips through micro as well as macro scales, including the science fiction film (and later television series) *Fantastic Voyage* (1966), Monsanto's *Adventure Through Inner Space* ride at Disneyland's *Tomorrowland* (1967), and Charles and Ray Eames' (1968) classic film *Powers of Ten*.

A novel mixture of art, science, education, and propaganda shaped the aesthetics, technologies, and messages of the space race. New planetarium

technologies and unprecedented federal funding for education dramatically increased the number of planetariums throughout the 1950s and 60s, increasing fascination with outer space among generations of Americans. After the absorption of the Third Reich's rocket program into the US space program, fruitful collaborations between Walt Disney and Wernher von Braun (Wright, 1993) not only influenced public perspectives about the importance and goals of space travel, but also the design of the first large format film dome theaters. These early experiments in immersive cinema propelled audiences into new cosmic and molecular frontiers while simultaneously launching the careers of some of the primary forces behind science fiction filmmaking for decades to come.

4.05 Pedagogical Yearnings

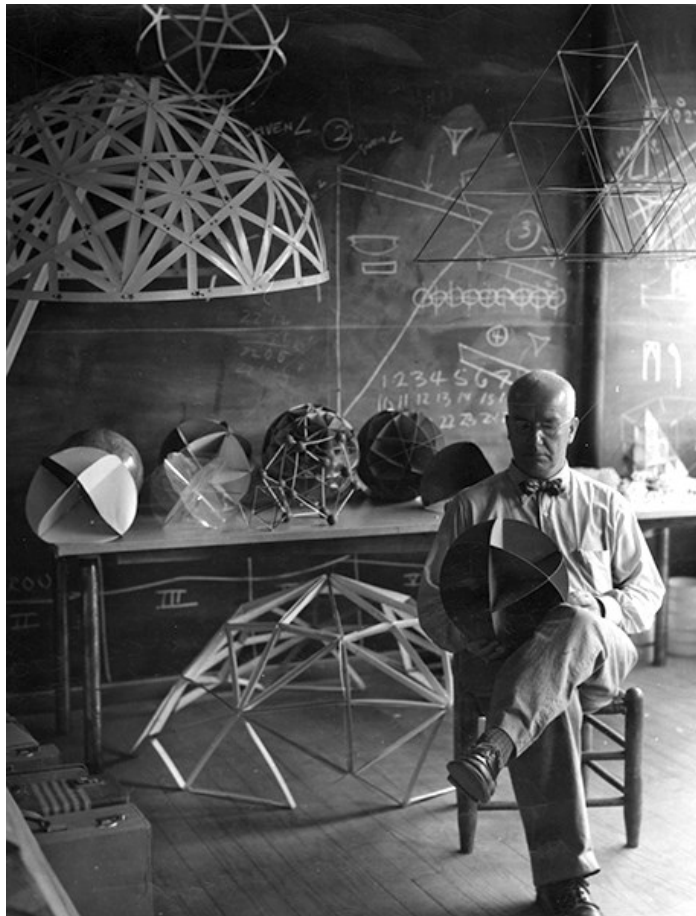


Figure 57. R. Buckminster Fuller at Black Mountain College (Larsen, 1948).

While dome theaters were primarily being used to focus audiences on astronomy, some pioneering educators were conceptualizing other applications that could leverage the pedagogical advantages of domed immersion. Believing that direct communication of spatialized multi-sensory input would enhance the capacity and speed of human cognition, they elaborated detailed visions that were often decades ahead of what the technology of the day would allow.

R. Buckminster Fuller (Figure 57), the American polymath best known for his icosahedron-based geodesic dome, envisioned ways in which his structures could be

used to dynamically visualize data. Ironically, the invention for which Fuller was most famous was almost identical to the design patented by Zeiss engineers a quarter century before. First fully realized at the experimental Black Mountain College in 1949, Fuller's 'geodesic' dome, like the Zeiss dome, was conceived and engineered as a highly efficient structure to enclose a very large volume with the least amount of possible structural weight. Hundreds of thousands of these structures have since been built worldwide—the most famous of which was the Montreal *Biosphere* constructed for the US pavilion at Expo 67.

Fuller's (1975) structural understanding of 'geodesic' domes and spheres emerged from his efforts to model the "geometry of thinking" through what he called "epistemography of synergetics" (325.22), a transdisciplinary system of inquiry integrating mathematics, design, philosophy, chemistry, physics, cosmology, cosmography, poetry, and other fields. He insisted on the importance of building models to physically demonstrate interconnections between human cognition, energetic structures, and evolutionary patternings. Spherical forms became a recurring theme within his efforts to operationally, experientially, and experimentally identify and model cosmic principles operating across microcosmic and macrocosmic scales (Krausse, 1993).

Like Fred Waller (4.03 Transcending the Firmament), Fuller (1975) recognized the significance of the spherical field of human vision, referring to it as "omnidirectional TV set" (801.20) that could be augmented using spherical displays (1.02 Cosmological Metaphorics, 1.03 Spherical Container). Like the Zeiss engineers, Fuller imagined that his structurally efficient designs could serve as highly effective immersive display environments. In 1961, he presented a lecture at Southern Illinois

University laying out his vision for transforming education. Later published as *Education Automation* (1962), it contained a description of what he called the *Geoscope*, a 200-foot diameter miniature Earth that would visualize time-series datasets of global phenomena. He proposed that the interior and exterior of the massive spherical geodesic display be covered with miniature light bulbs to be controlled by a computer, enabling the real-time display of world data.

Fuller (1962) predicted the necessity of the *Geoscope* to address many global problems, which he insisted stem from humanity's inability to comprehend critical phenomena with our unaided senses. By bringing extra-sensory phenomena into the realm of conscious understanding through these visualizations, he believed that observers on the inside and outside of the *Geoscope* would be able to "recognize formerly invisible patterns and thereby to forecast and plan in vastly greater magnitude than heretofore" (p. 49). Though never fully realized in his lifetime, Fuller believed the *Geoscope* would perceptualize "phenomena that are not at present communicable to man's conceptual understanding" (p. 48), such as natural resource consumption, world hunger, and weather patterns. Through a network of *Geoscopes*, he hoped that people of all nations could intuitively understand humanity's interconnectedness and the global repercussions of individual and collective actions.



Figure 58. Cloud time-lapse sequence for the *Atmospherium* (Norton, 1967).

Another attempt to use visuospatial immersion for educational purposes was initiated in 1960 by planetarian O. Richard Norton (1967). Calling it the *Atmospherium*, Norton incorporated a 35mm dome projection system into the planetarium at the Desert Research Institute at the University of Nevada-Reno. He wanted to open the possibilities of dome-based learning environments and to extend the available subject matter to include numerous non-astronomical topics. Though his experiments with fisheye filming were limited to the natural phenomena he could capture, including time-lapse cloud sequences (Figure 58) and underwater photography, he understood the potential of the medium to explore topics that would be good at “attracting current interest or raising controversy” (p. 145). Reflecting numerous emerging interests of the day, his suggestions for program topics included

“Space Travel, Quasi-Stellar Radio Sources, Stonehenge, UFOs, Life in the Universe, Theories of Cosmology” (p. 143) and “experimental art programs” (p. 143).

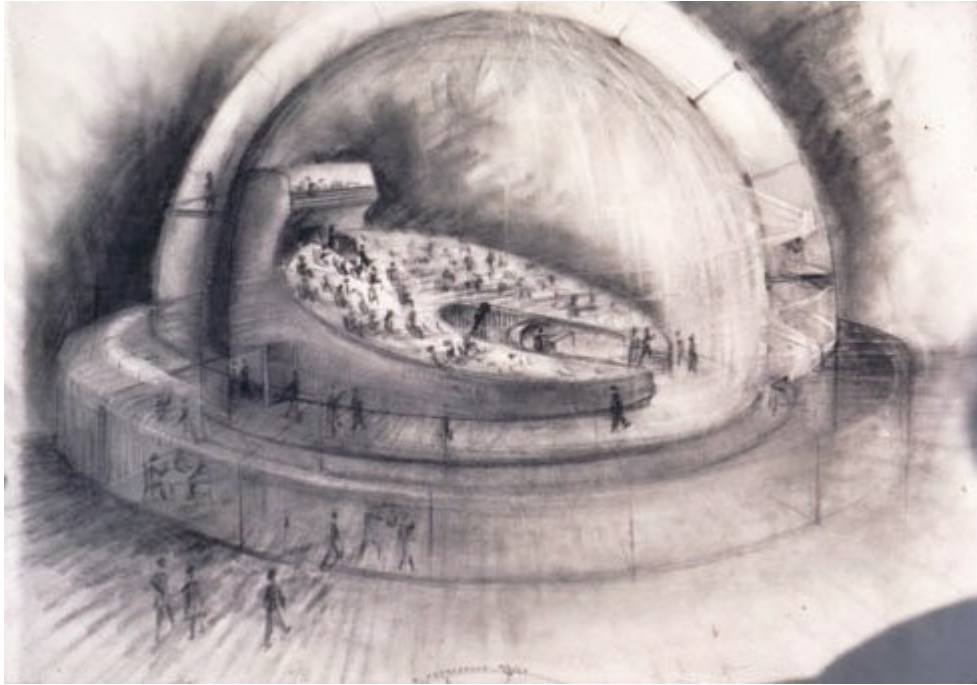


Figure 59. Sketch of the *Total Environment Learning Lab Sensorium* (Ferragallo, 1967).

Artist and community college professor Roger Ferragallo proposed a more complex hybrid system in 1967. Influenced by virtual reality pioneer Morton Heilig’s (1955/1992) essay “EI Cine del Futuro: The Cinema of the Future,” Ferragallo developed numerous drawings, models, and descriptions of his ideas to extend the concept of Heilig’s pioneering single-user multi-sensory simulator, the *Sensorama Machine*, to a large, multi-user environment. The result was his *Total Environment Learning Laboratory (TELL) Sensorium* (1967), an elaborate vision for a highly controllable, multi-sensory, and fully immersive domed theater (Figure 59). Designed for the Laney College campus in Oakland, CA, Ferragallo’s primary objective was to demonstrate that “learning at the adult level is substantially enhanced by the

simultaneous stimulation of several sensory receptors at the time of presentation of specific subject matter” (para. 1).

The ambitious *TELL Sensorium* proposal (1967) incorporated numerous types of visual projections (hemispheric, planar, stereoscopic, cinematic, and television), spatialized surround sound, atmospheric effects, an olfactory delivery system, and a fully controllable light and color environment. Enclosed in a 60-foot geodesic dome screen, the audience was to sit on a “revolving, tilting, lifting, vibrating hydraulic platform and floor” (sec. 7). Though the community college enthusiastically received his ideas and provided initial concept development funding, Ferragallo never realized his “perceptual learning center” due to monetary and technical constraints as well as political upheavals.

4.06 Perturbing the Gestalt



Figure 60. Henry Jacobs and Jordan Belson at the Morrison Planetarium for the *Vortex Concerts* in 1959 (Youngblood, 1970, p. 388).

In response to the cultural and technological climate of the US in the 1950s and 60s, numerous avant-garde media artists and engineers were experimenting with electronic and multi-media technologies and environments. Collectively known as the “expanded cinema” movement (Youngblood, 1970), they initiated a broad array of explorations into various aspects of consciousness, aesthetics, and communication. In contradistinction to the entertainment-focused science fiction themes of the day, they critically explored a variety of avant-garde topics and media, integrating cybernetics, kinetics, interaction, improvisation, computer graphics, multiple projection techniques, and multi-channel audio to produce a synesthetic gestalt.

One of the earliest expanded cinema experiments, initiated months before the launching of Sputnik I, was *Vortex: Experiments in Sound and Light*. Orchestrated and performed by audio composer/engineer Henry Jacobs and filmmaker Jordan Belson (1958) (Figure 60), this series of immersive performances was presented at San Francisco's Morrison Planetarium from 1957 to 1959. Purportedly experienced by over 10,000 people during its run, *Vortex* was conceived as a "new form of theater based on the combination of electronics, optics and architecture [. . .] a pure theater appealing directly to the senses" (para 21).

In addition to featuring the custom planetarium projector developed for the Morrison by the California Academy of Sciences after the war, the live performances incorporated "all known systems of projection" (Jacobs & Belson, 1959, para. 7), including 16mm film, slides, and custom optical instruments. Belson projected and manipulated the works of fellow abstract filmmakers and early computer graphics pioneers, including Hy Hirsh and James Whitney, as well as his own abstract mandalic films that he viewed as extensions of his own consciousness. Jacobs mixed and panned effects and music through a custom-built rotary console, controlling one of the first surround sound systems ever developed, which was composed of multiple loudspeakers around the dome's perimeter and apex. The audio source materials, including mix tape collages, electronic music, and ethnic field recordings, featured his own work as well as pieces by John Cage, Karlheinz Stockhausen, Vladimir Ussachevsky, Tōru Takemitsu, Luciano Berio, and others.

Though the program broke attendance records at the planetarium and was invited to participate in the 1958 Brussels World's Fair, the planetarium management did not appreciate the types of clientele it attracted and cancelled the event after

thirteen performances (Jacobs, 2006). Jacobs, a self-proclaimed Zen surrealist, was unapologetic. In the liner notes to the *Vortex* LP (1959), he claimed the improvisatory and evolving nature of the performances were a necessary and self-justified provocation in the context of “pre-fabricated dreams, pre-fabricated houses, and indeed pre-fabricated lives.” In contrast to the planetarium’s usual fare, he acknowledged the “non-intellectual, non-educational and non-reformatory” nature of the experiments, ascribing their value instead to the “purely accidental aesthetic experience which is so overpowering that even memory is obliterated by the dominance of that moment.”

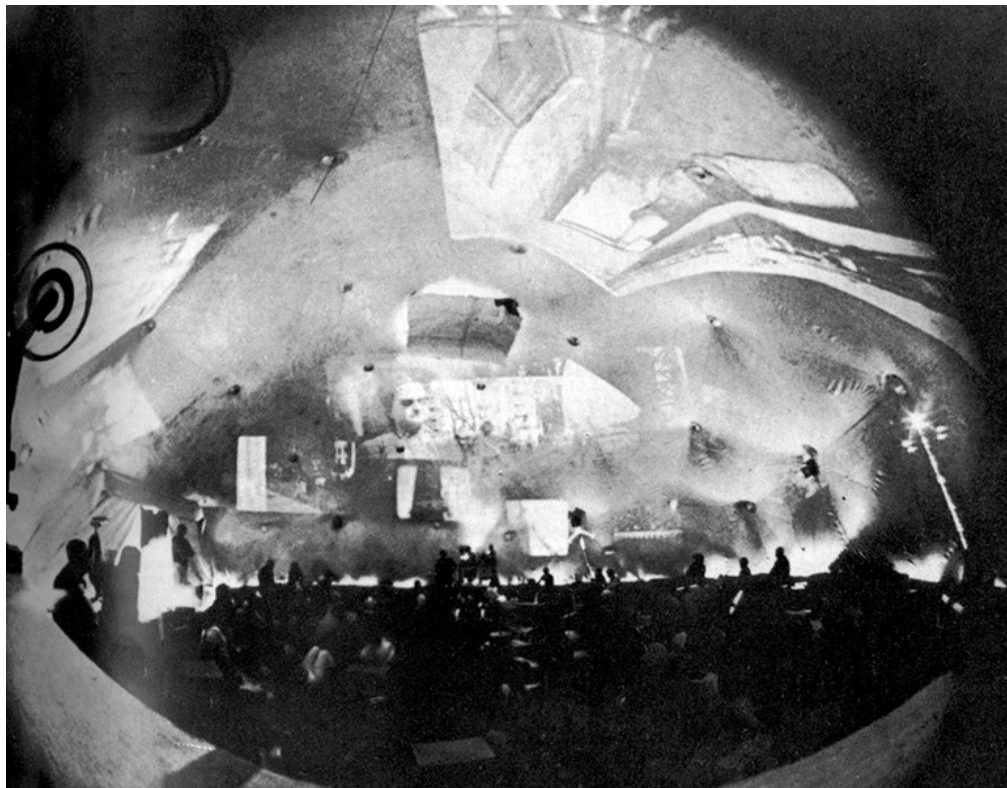


Figure 61. Stan Vanderbeek's *Movie-Drome* (1965).

Filmmaker and animator Stan Vanderbeek, also intrigued by the ability to communicate non-verbally within immersive environments, later explored approaches

similar to those of the *Vortex* performances. After meeting Buckminster Fuller at Black Mountain College in the late 1940s, Vanderbeek became interested in concepts of social consciousness and was intrigued by the idea of using domes for surround projection. In 1957, Vanderbeek began creating materials for his evolving concept of a *Movie-Drome*, the prototype of which he finally built in 1965 in Stony Point, NY (Figure 61).

The home-built hemispheric theater was constructed from a metal silo cap. Audience members would enter through a trap door in the center and lie on the floor (Ditto, 2007). Inside, 16mm film and slide projectors on wheeled carts and turntables projected computer-generated animations, collage films, found footage, contemporary newsreels, and appropriated advertisements combined with the reverberant audio from a quadraphonic sound system playing pre-recorded soundtracks (Sutton, 2003). Vanderbeek (1966) described this cacophonous gestalt as a “newsreel of ideas, of dreams, a movie-mural, a kinetic-library, a culture de-compression chamber, a culture inter-com” (p. 48).

Vanderbeek (1966) was anxious that “technological research, development, and involvement have almost completely outdistanced our emotional and socio-‘logical’ comprehension,” calling for “quickly find[ing] some way for the level of world understanding to rise to a new human scale” (p. 39). He viewed the *Movie-Drome* as a rudimentary prototype to address these concerns, functioning as networked audio-visual research centers for the development of a new non-verbal international picture-language. The goal of these proposed research centers was to encourage international dialogue and cultural understanding through the direct

transmission of this new visual language, with each dome receiving its images “by satellite from a worldwide library source” (p. 47).

Anticipating the eventuality of networked and interactive computing capabilities, Vanderbeek (1966) further envisioned a real-time programmable communication network in which “Cinema would become a ‘performing’ art and image library” (p. 48). Like Belson and Jacobs, Vanderbeek felt that these “movie-murals [. . .] penetrate[d] to unconscious levels,” reaching for the “emotional denominator of all men, the nonverbal basis of human life” (p. 47). Though technological and financial limitations prohibited Vanderbeek’s dream of realizing a network of *Movie-Dromes* in his lifetime, he continued to explore networked and electronic communication during later residencies at NASA, Bell Labs, and elsewhere.



Figure 62. The interior of E.A.T.'s *Pepsi Pavilion* from Expo '70 in Osaka. (Shunk & Kender, 1970).

The art/engineering collective Experiments in Art and Technology (E.A.T.) pushed the concept of an experiential domed environment to reflexive extremes. Approached by the Pepsi Corporation to develop a pavilion for Expo '70 in Osaka, the collective, spearheaded by Bell Lab engineer Billy Klüver and artist Robert Rauschenberg, worked with over 60 American and Japanese artists to develop what Klüver (1972) called a “theater of the future,” and a “living responsive environment” (p. x). Klüver envisioned it as a “total instrument” to be played by the participants, providing them with “choice, responsibility, freedom, and participation” (p. ix). The resultant *Pepsi Pavilion* (Figure 62) was composed of a 210-degree spherical mirror made of aluminized Mylar enclosed within a 90-foot diameter geodesic frame. The improvisatory actions of the audience and performers were reflected on the spherical surface as a 37-speaker surround sound system; audience-held handsets emitted pre-

recorded sounds. Numerous other kinetic and tactile elements combined to create chaotic multi-sensory experiences and encourage maximum audience interaction.

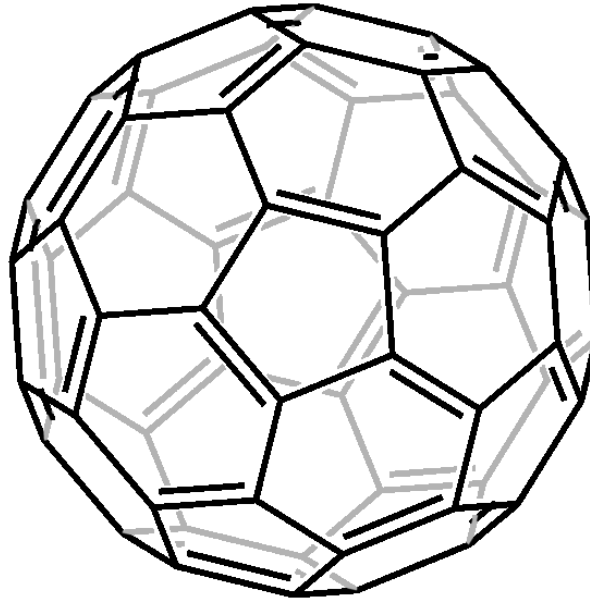


Figure 63. The truncated icosahedron geometry of Carbon 60, the *buckminsterfullerene* (Mills, 2007).

Enclosed within a geodesic dome and enshrouded in a vapor cloud, the *Pepsi Pavilion* was a hybrid of efficiency and ephemerality. Its psycho-cosmological significance, as well as those of numerous Zeiss planetariums and Fuller's *Geoscope*, went well beyond the imagery displayed within them. In 1985, the truncated icosahedron ("geodesic") structure was discovered to mirror the molecular structure of Carbon 60 (named "buckminsterfullerenes") (Figure 63), which was thought to be the strongest molecular structure and became the foundation for the new science of nanotechnology. Like the encoded geometric of mosques and stupas, the geometric configuration of these constructions echoed the architectural designs of nature.

As diverse technologies, influences, and intentions intermingled within these quests for mediated immersion over the course of the twentieth century, they expanded to include broader creative visions. In this regard, these efforts can be seen as making many philosophical, ontological, and epistemological issues explicit, visualizing them through—in the language of extended cognition—processes of “enactive signification” (Malafouris, 2007a, p. 294). Ideas, cosmovisions, and visualizations were “structurally coupled” (Varela et al., 1991, p. 204) within ongoing networks of interactions between projection instruments, display environments, media productions, audiences, and their creators. Abstract notions were actively embodied and visualized through participation in material engagements. Like ancient paintings on cave walls, the displayed worlds were not simply representations of a pre-given reality, but emerged in the process of their creation, blurring the boundaries between image and imagination.

This brief history of dome-based projection theaters is intended to demonstrate how the archetypal desire to transcend the boundaries of the mundane world continued to be closely associated with embodiments of the *heavenly sphere* throughout the twentieth century. However, just as the underlying motivations for image making within Paleolithic caves cannot be effectively reduced to any single factor (2.04 Complexity of the Caves), these early experiments with dome theaters emerged from a diverse range of desires, technologies, funding streams, and beliefs. The introduction of projection techniques within planetaria and World’s Fair exhibits provided new ways of manifesting ancient dreams of visualizing ‘flights’ through the heavens.

Additionally, the creators of the *Geoscope*, *Atmospherium*, and *Total Environment Learning Laboratory* saw them as new forms of multimedia education, designed to make previously invisible and inaccessible phenomena intuitively understandable. The *Vortex* performances were meant to serve as an antidote to the perceived superficiality of ‘space age’ American consumer culture, using new media technologies and improvisatory processes to explore the effects of spatialized, synesthetic, and omnidirectional gestalt on audience perceptions. With the *Movie-Drome*, Vanderbeek hoped to extend the application of these environments to include networked interaction and a combination of abstract and representational imagery for exploring the emergence of an international visual language. The *Pepsi Pavilion*’s metaphorical and literal self-reflexivity, as well as its yet-to-be discovered structural significance, symbolized a chaotic and paradoxical apex of a complex era, one defined by ideological conflicts, techno-utopianism, technological determinism, new media experimentation, and consciousness exploration. As a result, these efforts embodied a multitude of motivations and ideas within the cultural zeitgeist that were often cultivated under the watchful eye and active participation of the American military-industrial-entertainment complex.

4.07 Digitizing the Cosmos



Figure 64. Rose Center for Earth and Space (Finnin & AMNH, 2000).

By the turn of the twenty-first century, many of the themes present within these earlier experiments with spherical imaging converged within a new generation of immersive vision theaters. The integration of digital computing and display technologies enabled exploration of a wide array of subject areas, continuing to blur the boundaries between art, science, education, entertainment, and propaganda. Alternately referred to as *fulldome*, *digital planetariums*, *digital dome theaters*, the creators of these IVTs have revitalized earlier aspirations concerning the pedagogical and transcendent potential of dome-based immersion.⁵⁴ A special issue of the

⁵⁴ I initiated the “fulldome” Wikipedia article (McConville, 2006b) to solicit input from the Fulldome mailing list (Wyatt, 2000) to begin establishing a history of this medium. At the time there were very few resources chronicling the use of digital projection within dome theaters. I’d previously created the fulldome.org web site (McConville, 2004b) as a platform for the dome production user community. I have published and presented reviews of IVTs and their predecessors under the rubric of *Cosmological Cinema* (McConville, 2007a, 2007b, 2007c, 2007d, 2009a) (also see Chapter 4: Cosmological Cinema). Ed Lantz’s (2007) “A survey of large-scale immersive displays” provides an additional overview of contemporary dome-based display technologies. Simone Schnall, Craig Hedge, and Ruth

Planetarian journal devoted to the ongoing transition from analog to digital systems summarized the hopes of many, suggesting that, “the planetariums of the future will likely touch upon deeper metaphysical issues that have plagued philosophers for millennia while remaining firmly grounded in scientific rigor” (Lantz, 2009, p. 12).

The Hayden Planetarium once again played a central role in the development of the medium. In 1997, a team of scientists, artists, educators, and engineers initiated the *Digital Galaxy Project* to push the perennial trope of the cosmic journey to a new extreme. The project sought to transform planetariums through the integration of supercomputer simulations with immersive projections to fly audiences through scientifically accurate models of the universe. Initial funding from the US government—the largest museum grant in NASA’s history—enabled the project to begin assembling scientific datasets from around the world into a navigable three-dimensional virtual atlas based on a Cartesian coordinate system (Emmart, 2005).⁵⁵ This coincided with a \$210 million renovation of the Hayden Planetarium designed to project the virtual atlas of cosmographic imagery to simulate voyages beyond the dome of the sky (Wilford, 2000). Dennis Davidson, the *Digital Galaxy Project*’s artistic director, summarized his ambitious vision as creating an experience “that met cinema standards, but also had a high level of scientific accuracy that could bring the scientific data to the peer level of universities” (Quan, 2000).

Weaver (2012) review research into the psychological factors contributing to the efficacy of immersive vision theaters, including studies of both immersion and interaction. Loch Ness Productions’ (2013) *Fulldome Theater Compendium Online* maintains a database of installations worldwide, including over 1200 entries at the time of this writing.

⁵⁵ The \$2.272,000 *Digital Galaxy Project* grant was a subset of the *National Center for Science Literacy, Education, and Technology*, a cooperative agreement between the American Museum of Natural History and NASA funded by \$7,999,250 from an earmark grant from the US Congress (Davidson, 2014; NASA, 2002).

The new theater opened in 2000 under the auspices of the *Rose Center for Earth and Space* (Figure 64) with the premier of *Passport to the Universe*, its first production based on the *Digital Galaxy* simulations. Described as an “unforgettable exploration of our ‘cosmic address’” that enabled “viewers to understand the true structure and enormity of our universe” (AMNH, 2000, p. 1), the show expanded on the motifs developed by its analog planetarium predecessors by emphasizing the power of modern astronomy and astrophysics to provide new insights into perennial existential questions.

Narrated by actor Tom Hanks, the production’s script (Druyen & Soter, 1999) draws heavily on many themes associated with the “great Copernican cliché” (Danielson, 2001) . Before audiences entered the theater, expectations were set within a pre-show waiting area through a mythic narrative suggesting that scientific cosmology not only ‘dethroned’ humanity but also has the potential to emancipate it:

There comes a time in each of our lives when it first dawns on us that we are not the center of the universe . . . that we are part of something larger than ourselves. As it happens to each of us, so it is happening to our civilization . . . right now. We are living in the golden age of astronomy. We are completing the spacecraft reconnaissance of our solar system . . . We are using other kinds of light to observe the life cycles of stars and galaxies, revealing wonders never before visible . . . We are mapping the grand structure of the universe, tracing its ancient past, finding our place in its great story. We are becoming citizens of the cosmos. (p. 1)

Upon entering the “great sphere” (p.1), the audience was informed of the significance of shift from analogue to digital projection, assuring them of the technical and scientific authority—and ontological certainty—of what they were about to witness:

Rising into view is the most advanced star projector in the world, capable of reproducing a perfect night sky as seen from Earth. But our journey will take us far beyond Earth. To explore the universe in three dimensions, we will use a powerful computer, loaded with real astronomical data from the great observatories on Earth and in space. What you are about to see is not an artist’s fantasy, but a three-dimensional map of the *real* universe, carefully calculated and drawn from the best astronomical observations and data. (pp. 1-2)

The hemispherical screen was then used to rhetorically recollect the naïveté of pre-scientific perceptions of the heavens:

For a thousand generations, our ancestors looked at the night sky and wondered what it was. The sky looked like the inside of an enormous bowl, slowly turning around an Earth believed to be at its center. The stars were like tiny points of light stuck to the inside of the bowl, and not so very far away. The ancient sky seemed two dimensional. (p. 2)

Then the role of technology in liberating both the senses and the imagination was recounted:

But for every star we can see with the unaided eye, the night hides fifty million others, in our Milky Way Galaxy alone. To see what’s really out there,

we need telescopes. Using telescopes, we discovered that the sky has a third dimension – depth – and that the universe is far grander than anyone could have imagined.” (p. 2)

As the central opto-mechanical projection apparatus lowered into the floor, the dome was illuminated with virtual stars from the *Digital Galaxy* emanating from video projectors concealed along the perimeter of the dome.

The bulk of the presentation followed the familiar narrative arc of the cosmic journey, closely resembling *Theater of Time and Space* (Fyfe, 1939), *Journey to the Stars* (Newlan, 1961), and *To the Moon and Beyond* (Reevesound, 1964).⁵⁶ The simulated flight began by transcending the view from Earth, flying past other planets of our solar system, and then refocusing on the “pale blue dot”:

We’ve come a long way. Can you find the Earth? It’s so small we can hardly see it from here. It’s that one -- the pale blue dot. That’s home. Everyone you ever knew -- or ever heard of -- came from that tiny spot. Seeing it like that always gets to me. (p. 4)

The trajectory continued past the Orion Nebula, beyond the Milky Way, and into the intergalactic space of the Virgo supercluster. Upon arriving at the ‘large scale structure’ of galactic surveys at the distant reaches of the dataset, the script describes the narrator as speaking softly, then “losing himself in reverie”:

⁵⁶ At the time of the creation of *Passport to the Universe*, its creators were unaware of *Theater of Time and Space* or the Hayden Planetarium’s involvement with it (Emmart, 2007).

We may just be little guys, living on a speck of dust. But we don't think small. We managed to figure this much out. And we're still figuring . . . there are about a hundred billion galaxies in the universe we can see. But there are parts we can't see. And—who knows?—it may be that all this, the entire observable universe, is one tiny bubble in an infinite universe hidden beyond our cosmic horizon. (p. 8)

The journey came full circle with a dramatic plunge through “trumpet-shaped tunnel” of an imaginary black hole, admittedly dissolving observational facts into science fiction. Upon “emerging abruptly in our solar neighborhood, into a peaceful silence,” the audience was returned to Earth and welcomed home:

Next time you look up at the clear night sky, remember . . . you, me, and everybody—we are starstuff. We are in the universe, and the universe is in us. In the deepest sense, we are citizens of the cosmos. (p. 9)

As with the premiere of the original Hayden Planetarium, the *New York Times* heralded the re-opening as signaling a new era in technical achievements for the purposes of scientific outreach to the public. In “Bringing the Universe Inside” (Wilford, 2000), the “grand tour” of the Universe was praised for initiating a “new era in showmanship that dramatize[s] new knowledge of the cosmos through the technology of virtual reality” (para 5). In contrast to the description of a “make-believe world shorn of space and time” (Laurence, 1935) 60 years earlier, the *Times*’ emphasized the digital production’s ability to suspend disbelief by using “the latest in cinematic special effects for a display of cosmic vistas churned out in supercomputer simulations based on cosmology’s newest theoretical models” (para 8). Claims

concerning the *Digital Galaxy Project*'s scientific veracity were consistently repeated, exemplified by assertions that *Passport to the Universe* displayed “the Universe as it really is” and that “science has finally caught up with science fiction” (Boxer, 2000)—a quote widely reprinted within the Hayden’s own promotional materials. The scientific visualization of the cosmos also was praised for its ability to induce feelings of sublime ambivalence, contrasting the sense of mediocrity presumably induced by the Copernican ‘dethroning’ with a pride in scientific accomplishment:

At the end of the Hayden's new space show, indeed, audiences may feel thoroughly humbled to see Earth put in its place as a small planet around an ordinary star in an ordinary galaxy, one of perhaps 100 billion galaxies. Or they may feel a swelling of pride to think—as the earlier nobility did with the celestial globes and orreries in their libraries—that human beings have the power to take the measure of the universe in all its vastness and summon it indoors. (Wilford, 2000, para. 24)

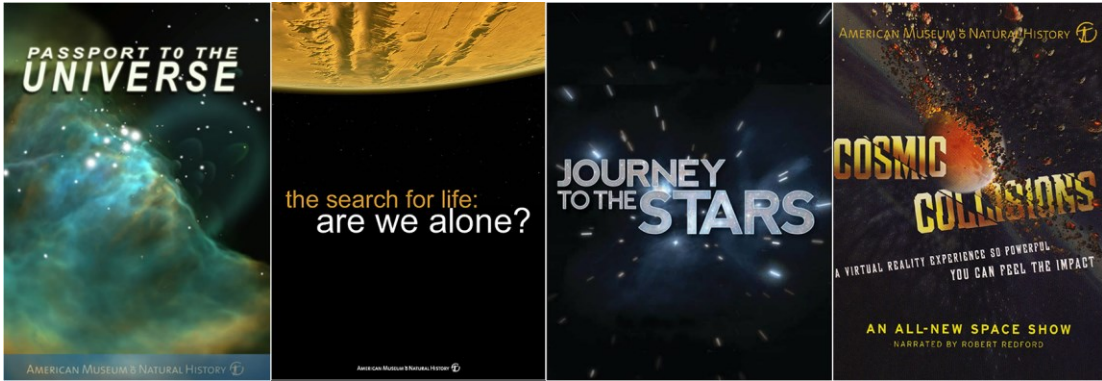


Figure 65. Posters for dome theater productions for the Hayden Planetarium (AMNH, 2011b).

After its premiere, the new Hayden Planetarium continued to expand the *Digital Galaxy Project*, integrating additional academically published surveys of galaxies, quasars, and other phenomena beyond the Milky Way. Renamed the *Digital Universe Atlas*, the ongoing project is described as "the most complete and accurate 3D atlas of the Universe from the local solar neighborhood out to the edge of the observable Universe" (AMNH, 2011c, para. 1). The Hayden's director of special projects estimates that the data collected within the *Atlas* represents approximately US\$10 billion in expenditures from international space missions and astronomical research programs (Sweitzer, 2010). It has provided the visualized cosmic context for a series of Hayden Planetarium productions but also featured in digital planetariums worldwide, including *Search for Life: Are We Alone?* (Druyan & Soter, 2002), *Cosmic Collisions* (Abrams, 2006), and *Journey to the Stars* (Gikow, 2009) (Figure 65). The ambitious effort appears to have paid off, with the Hayden Planetarium attracting over a million visitors a year since its opening (Tyson, 2009).

4.08 Expanding Virtual Horizons

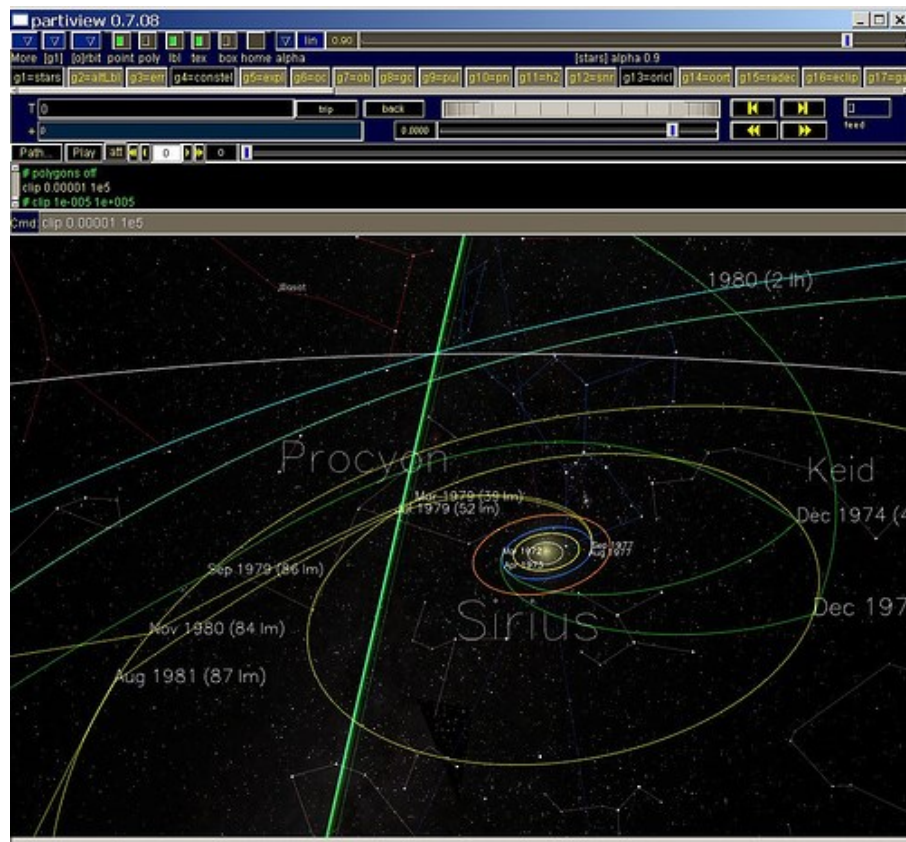


Figure 66. *Digital Universe Atlas* as seen within the *Partiview* software interface.

However, one of the most significant aspects of the project has received relatively little attention. Creating the *Digital Universe Atlas* required the development of new tools and techniques to curate, aggregate, and interactively visualize astronomical surveys from around the world. To accomplish this, the Hayden Planetarium developers worked with the National Center for Supercomputing Applications to create *Virtual Director*, a software application enabling local and remote teams to collaborate on determining flight paths through the *Atlas* (Emmart, 2005) (Figure 66). As *Virtual Director* was used extensively during pre-production for *Passport to the Universe*, its creators realized its value as a general visualization

tool. Components of the platform were modified and released as *Partiview*, a free, open source software platform for interactively visualizing static and animated 2D imagery and 3D datasets (AMNH, 2013e). However, the sheer scale of the cosmographic datasets presented significant technical challenges, requiring further refinement to fluidly traverse the simulated orders of magnitude. Carter Emmart (2005), the Hayden's Director of Astrovisualization, worked with his interns to develop a new tool based on *Partiview* and inspired by the "long zoom" (Johnson, 2006) of Charles and Ray Eames' (1968) classic short film *Powers of Ten*. The final result was *Uniview* (AMNH, 2013d) (Figure 67), an interactive software platform for interactively modeling, visualizing, and modifying cosmographic data within a virtual world across unbounded spectral, spatial, and temporal scales.

In his descriptively titled essay "The Powers of Ten with a Steering Wheel on the Global Visualization Superhighway," Emmart (2005) explains the motivations behind the creation of these tools. He envisions the new digital tools as a continuation of attempts to extend imagination through visual aids, similar to the earlier discussion of *tools for thinking* as "continuous and interactive parts of an extended cognitive system" (Malafouris, 2007b, p. 9) (2.05 Tools for Thinking). Emmart contends that the human ability to project ourselves through space and time are "part of our species' survival skills," helping humanity to better understand relationships and "frame our sense of presence within the perceived external reality" (p. 20). By providing techniques for accommodating the "flood of new information," he argues that these new tools can help to bring humanity "to a new level of consciousness of our surroundings" (p. 21), much like the orienting function of previous cosmographic practices.

However, beyond the need for practical orientations to celestial and terrestrial phenomena, Emmart expressed the existential desire to visualize the “holy grail of unbounded scale” and experience the “real size and scale relationships of the universe” (p. 23). He hopes that the spread of these technologies will spark a revolution, with planetariums becoming the “locations to show humanity a view of itself, alone, afloat in space around one dim star in a vastness that shrinks before us as we fly away from it, spanning the knowledge worked out by our fellow human beings” (p. 26).⁵⁷

⁵⁷ Donna Cox (2008), director of the Advanced Visualization Laboratory (AVL) at the National Center for Supercomputing Applications, provides a detailed account of the development of *Virtual Director* in her PhD dissertation “Astral Projection: Theories of Metaphor, Philosophies of Science, and the Art of Scientific Visualization” (also through the *Planetary Collegium*). Cox develops an approach to contemporary scientific visualization practices closely related to the current study with her ‘visaphor’ theory of visual metaphors. She describes how “visaphors enact for audiences a vital, sensory experience that they then incorporate into their embodied selves and manifest in the systems of which they are a part—including our highly situated and partial reality that is ever subject to vision and revision” (pp. 7-8). Similar to Emmart’s assertions concerning the cognitive benefits of visualization, Cox believes that the “most valuable aspect of the new visaphor aesthetic” is its “power to awaken our cognitively and intuitively enlightened selves, granting us insight into our as yet unsuspected capacities” (p. 58).

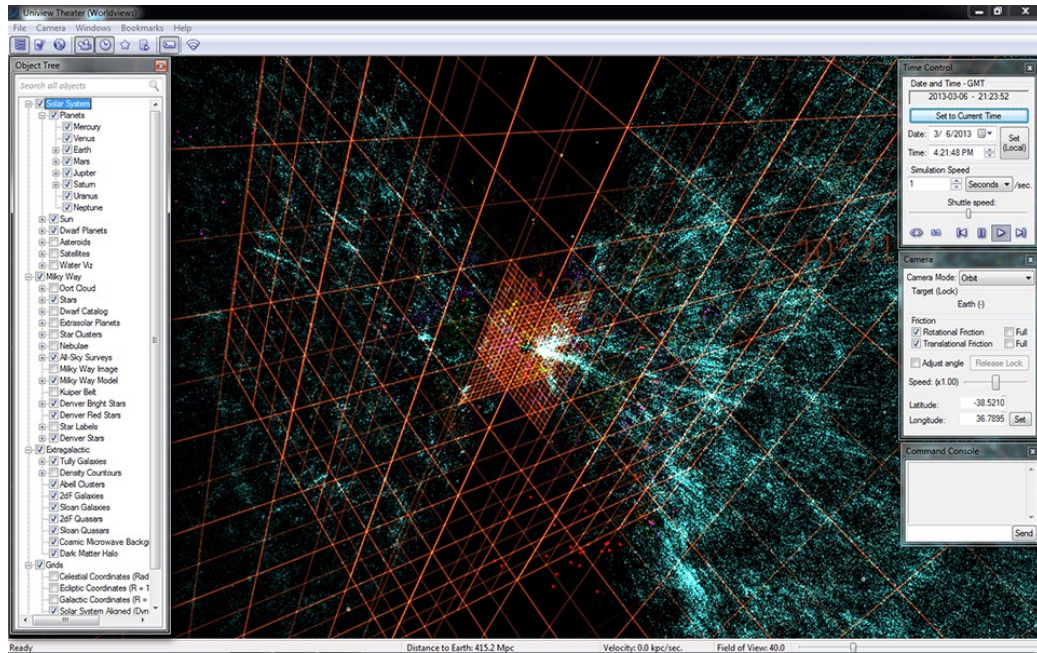


Figure 67. *Uniview* visualization software interface displaying galactic surveys and the virtual world’s 3D Cartesian grid.

In the past decade, *Uniview* (SCISS, 2013) has been adopted by numerous digital planetaria seeking to break from the fixed storylines of pre-rendered movies. Additional commercial software platforms have emulated these capabilities in the past few years (AMNH, 2013b, 2013c), enabling interactive presentations inspired by Emmart’s “Grand Tour of the Universe” (AMNH, 2012b) to become increasingly common. Hundreds of permanent and portable dome theaters now have the ability to visualize these interactive cosmic journeys across vast orders of magnitude—from the local solar system to the cosmic microwave background radiation that forms humanity’s ‘cosmic horizon.’ As a result, the *Digital Universe Atlas* has become the *de facto* cosmic model within immersive vision theaters around the world.

4.09 Making Sense of the Real Sky

Emmart (2005) insists that the “illusion of a full-dome display *with* a digital atlas of the universe” provides a way to understand astronomical data within its “proper three dimensional context” (p. 21), but he also acknowledges the challenges they pose for educators and audiences accustomed to views of the night sky as seen from Earth. He points out that much of the traditional planetarium field is “struggling to grapple with our three dimensional knowledge of the cosmos,” and that describing the spatial, temporal, and spectral aspects of astrophysical datasets requires quite a different vocabulary and knowledge base than those developed for Ptolemaic projections. Additionally, he recognizes that using dome screens to transcend the illusion of a celestial vault can appear paradoxical, suggesting that the “mere fact we use a dome to model the night sky authoritatively may confuse children more than we might care to admit in their attempts to make sense of the real sky” (p. 21). However, children are not the only ones confused by this latest effort to literally and figuratively “make sense of the real sky.” My participation in Emmart’s presentations during *Bok Globule* raised more questions than they answered, instigating in this current investigation (see the Prologue).

Emmart’s virtual tours continued the functional lineage of *cognitive cosmographic models* (2.03 Cognitive Cosmographic Models). Like sacred caves, Buddhist Stupas, Islamic Mosques, Christian Cathedrals, Roman Mithraea, and the Pantheon, projections of the visualized *Atlas* within the mediated dome of the sky induced imaginary flights to upper worlds. Narrative interpretations of the datasets shaped my understanding of the ‘exosphere’ and ‘endosphere’ of current cosmological understanding, enacting a strong sense of domesticating unknown

macrocosmic realms into an orderly home. Like sphairopoia and planetary machines, its high fidelity 3D digital simulations appeared to demonstrate the possibility of achieving the revered ‘Archimedean point’ (3.17 Cosmographic Dreaming).

This virtual cosmic voyager can also be situated within a long tradition of environments designed to induce “perceptual immersion” (Biocca & Delaney, 1995, p. 57), traced within media art history through the development of frescos, cathedrals, museum dioramas, painted panoramas, large-format cinemas, and virtual reality displays (Comment, 2000; Grau, 2004; Griffiths, 2008; Manovich, 2001; Oettermann, 1997; Packer & Jordan, 2001; Rheingold, 1992; Shaw & Weibel, 2003). Grau (2004) describes these as “diminishing critical distance to what is shown and increasing emotional involvement in what is happening” (p. 13). By fusing observers with the image medium, he claims they experientially “organize and structure perception and cognition” (p. 13) by affecting sensory impressions and awareness. Grau also identifies the ability of virtual worlds to integrate the functions of previous immersive environments, classifying them “as extreme variants of image media that, on account of their totality, offer a completely alternative reality” (p. 13).

Perceptual immersion within IVTs primarily derives from the combination of spherical projections surrounding audiences’ visual fields and the strong sense of forward locomotion afforded by moving images. Gibson (1979) describes this physiological effect as the “optical flow of the ambient array,” contending that it is “almost never perceived as motion,” just “simply experienced as kinesthesia” (p. 123). This sense of “ego-motion” (Bertin & Berthoz, 2004, p. 1) was key to achieving the visceral illusion of transcending the dome of the sky within numerous twentieth century World Fair exhibits (as previously discussed within this chapter). This

powerful perceptual effect continues be exploited within visualized flights through the *Atlas*.

This heightened illusionistic verisimilitude of these cosmic journeys also recalls Alison Griffiths' (2008) notion of the "revered gaze" (p. 22). She defines this as the much sought-after quasi-religious "sublime contemplation" (p. 261) associated with spectacular immersive spaces. This call for reverence was made explicit within the *Passport to the Universe* script, which described the narrator as "losing himself in a reverie" (Druyen & Soter, 1999, p. 8) when contemplating the sublime possibilities that the universe may be infinite.

4.10 Poetic Faith

The seamless integration of perceptual immersion, ego-motion, and the revered gaze appeared to achieve the stated goal of the Hayden's artistic director to provide entertainment that was both scientifically accurate and met cinematic standards. Samuel Taylor Coleridge (1817) called these the "two cardinal points of poetry," namely "the power of exciting the sympathy of the reader by a faithful adherence to the *truth of nature*, and the power of giving the interest of novelty, by the *modifying colours of imagination*" (p. 3) [emphasis added]. The "three-dimensional map of the *real universe*" (Druyen & Soter, 1999, p. 2) was presented as the ultimate glimpse into nature's truth, colorfully visualized within an awe-inspiring technological gestalt. Faster-than-light-speed cosmic journeys enacted imaginative visions, sowing Coleridge's 'poetic faith' in scientific cosmology's 'Archimedean point' on the cosmos (3.16 Entraining Objectivity).⁵⁸

Shortly after the premiere of the new Hayden Planetarium, the *New York Times* testified to the rhetorical potency of technoscientific flights through the heavens. In "Bringing the Universe Inside" (Wilford, 2000), one reporter's newfound faith was exhibited by his proclamation, "The new projectors and computer simulations have at last enabled planetariums to fully adopt in their shows the Copernicus and Galileo perspective, which long ago removed Earth from the center

⁵⁸ Cox (2008) acknowledges the poetic intentions of the *Atlas*' creators in her description of visual metaphors as "reflect[ing] our evolving collective consciousness," calling them "tangible artifacts of our meaning making that serve to both suspend our disbelief as well as generate new meaning, novel faith" (p. 58). She also addresses the challenges facing the production team in dealing with the "contingency of data" and the "construction of scientific 'truth'" (p. 134). I first became aware of the complexities of visualizing cosmographic data when I attended *Visualizing the Cosmos: Smoke or Mirrors*, a discussion panel moderated by Cox (2000) with other members of the *Digital Galaxy Project* at SIGGRAPH 2000. This was shortly after my participation in Mariko Mori's *Dream Temple* installation (see the Prologue) and piqued my curiosity in connections between the two projects.

of the universe” (para 23). Though *Passport to the Universe* had succeeded in cultivating Coleridge’s (1817) “willing suspension of disbelief” (p. 4) that “science has finally caught up with science fiction” (Boxer, 2000, para. 14), its carefully crafted flight path concealed a considerably more complex situation.

However, as I discovered at *Burning Man*, the ability to interactively navigate beyond pre-rendered trajectories provided a radically different perspectives on the *Atlas*. As Emmart moved beyond the *Atlas*’ outer boundary of the cosmic microwave background survey, my own poetic faith in the ability of modern cosmology to achieve an objective ‘Archimedean point’ was disrupted. Witnessing its spherical, geocentric configuration enacted quite a different imaginative vision. I realized the profound incongruity of the claim within the *Passport to the Universe* script (Druyen & Soter, 1999) that, “There comes a time in each of our lives when it first dawns on us that we are not the center of the universe” (p. 1). To the contrary, the configuration of the *Digital Universe Atlas* appeared to indicate just the opposite.

Conclusion

As immersive projection environments pushed the ‘Archimedean point’ to its extreme over the course of the twentieth century, they embodied and exacerbated the complications of separating ‘subjective’ and ‘objective’ interpretations of the universe. Early attempts by Zeiss to create a ‘Copernican’ planetarium were overshadowed by the sublime attraction of its ‘Ptolemaic’ counterpart. As science educators embraced the Earth-centric simulations of the celestial vault to demonstrate the elegance and predictability of a clockwork universe, their backers sought to increase public appreciation of interdependence and the importance of spiritual values. The integration of cinema technologies within dome theaters afforded opportunities to explore new horizons by transcending the firmament, which governments and corporations enthusiastically funded to justify military expenditures by promoting dreams of space colonization.

At the same time, artists and educators began experimenting with these novel modes of immersion and interactivity, seeking to expand pedagogical and phenomenological possibilities beyond astronomy and science fiction. By the end of the century, the integration of computer graphics and video projection within domed theaters enabled digitally mediated variations on the ancient trope of the cosmic journey. Though these were heralded as spectacular demonstrations of the physical cosmology’s ability to achieve the Archimedean/Copernican/Cartesian view from nowhere, the coincident creation of a new cosmic atlas also exacerbated ambiguities between ‘subjectivity and ‘objectivity.’ The latest technological attempt to push the objective view from nowhere to its cosmographic extreme revived a spherical, geocentric world model, which—when acknowledged—significantly complicates the

Copernican cliché. The next chapter explores the implications of the *Atlas*' configuration, including how the return of the *heavenly sphere* has enacted tensions that have exposed philosophical assumptions underlying its dominant interpretations.

Chapter 5: Eternal Return

“We think the question is not whether the theory of the cosmos affects matters, but whether, in the long run, anything else affects them.”

(Chesterton, 1909, p. 41)

Introduction

This chapter examines interpretive tensions enacted by the return of the *heavenly sphere* and their implications for the ‘Archimedean point’ and the ‘Copernican cliché.’ I begin by investigating disagreements among the *Digital Universe Atlas*’ creators concerning how the spherical model of the cosmic microwave background radiation should be presented to the public. I analyze production scripts and exhibits from the Hayden Planetarium within the context of these debates to highlight the difficulties of interpreting and visualizing scientific cosmology. I then use these disagreements to examine how philosophical assumptions shape current efforts to mythologize the cosmological theories upon which the *Atlas* is based, including ways in which habituated objectifying tendencies occlude the process-oriented insights of modern science.

This chapter recalls the findings of previous chapters to draw correlations between historic cosmographic practices and their contemporary successors, from ancient caves to modern planetaria. This chapter concludes by considering the consequences of perpetuating the ‘mediocrity principle’ within the Copernican cliché, particularly its role in promoting the dream of human spaceflight and the search for extraterrestrial intelligence. I argue that by conflating *anthropocentrism* with *geocentrism*, the progressive narrative of modernity replaces the Christian doctrine of

salvation with faith in science and technology as the means to achieve the Platonic ideal of a transcendent escape from a corruptible Earth.

5.01 Observational Center

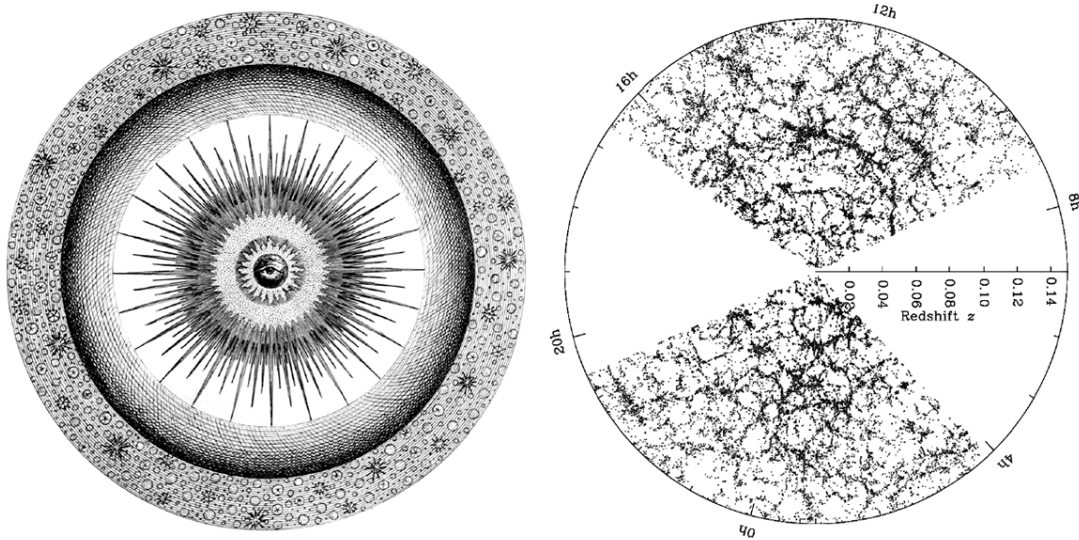


Figure 68. *The eye of Providences seated in the centre, as in the virtual agent of creation* (Wright, 1750) and *The large-scale structure of the local universe* (SDSS, 2011).

At the premier of the new Hayden Planetarium, the ‘Archimedean point’ reached a dazzling virtual pinnacle within *Passport to the Universe*. Skillful visualizations of scientific datasets within a state-of-the-art immersive vision theater blurred distinctions between empirical observations, mathematical models, technological mediations, and aesthetic decisions—successfully cultivating ‘poetic faith’ that the revered Copernican perspective had finally been achieved. It appeared that the *fin de siècle* zenith of twentieth century efforts to domesticate the universe had, at long last, realized Descartes’ dream of a firm scientific foundation within the “most complete and accurate 3D atlas of the Universe” (AMNH, 2011c) ever created.

At *Burning Man*, however, Carter Emmart’s interactive interpretations of the *Digital Universe Atlas* exposed the cosmic conundrum concealed in *Passport to the Universe*: the *heavenly sphere* had returned. He attributed this kōan-like paradox to

the finite speed of light, which, when factored into astronomical measurements, yielded a spherical visual horizon surrounding humanity's 'observational center' (Figure 68). The relativistic observations centrally projected from the center of the *Atlas*' 3D virtual world seemed to visualize a macrocosmic demonstration of Alan Watts' assertion in my short film *Optical Nervous System* (McConville, 2004a) also showing during *Bok Globule*: "All that you see is a state of affairs inside your head." Their parallels were as uncanny as they were conspicuous, with each presentation appearing to illustrate the ambiguous relationship between 'inner' and 'outer' worlds at radically different scales.

The interactive capabilities of *Uniview* afforded new opportunities to move beyond prescribed flight paths, enabling the revelation of the *Atlas*' observer-centric configuration. I suspected that this re-emergence of a *heavenly sphere* had been skillfully concealed within the Hayden's productions due to concerns that it would be too difficult to scientifically explain to general audiences in the short period of the planetarium shows. But, I realized, it posed significant complications to the Copernican cliché while also casting doubt on 'poetic faith' in the ability to scientifically visualize an idealized 'Archimedean point.'

The paradoxical appearance of the archetypal *heavenly sphere* within the "most complete and accurate 3D atlas of the Universe" (AMNH, 2011c) provoked many questions, setting the trajectory of the current investigation: What does it infer about commonalities between the creation of the *Atlas* and historic cosmographic practices? Doesn't the notion of an *observational center* necessitate accounting for the observer when describing observations? Wouldn't this significantly complicate the ideal of a purely 'objective' cosmic model? If relativistic effects shape all views

of the universe, are there other factors we need to take into account? And what motivated the Hayden's producers to conceal the CMB sphere and the 'observational center' from the public?

5.02 Cosmic Tensions

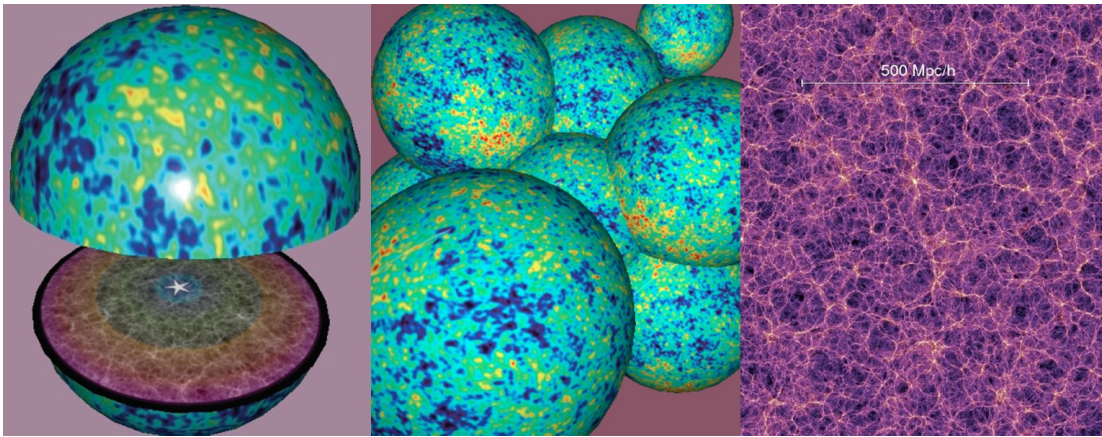


Figure 69. Cosmic Picture inside the WMAP CMB Sphere, CMB Spheres for Different Observers, and a Cosmic Map of the Universe from the *Millennium Simulation* (Sweitzer, 2006).

Two years after my perplexing encounter with the *Atlas*, astrophysicist James Sweitzer (2006) published an article in the *Planetarian* journal that seemed to justify my befuddlement. In “The Mystery at the Edge of the Universe,” he provides scientific explanations for the *Atlas*’ spherical configuration. It was written to avoid “misconceptions that can arise from the problem of displaying the cosmic microwave background (CMB)” (p. 7)—directly addressing some of the questions with which I had been struggling since *Burning Man*. In the process, however, his explanation also reveals significant conflicts between Hayden producers concerning appropriate strategies for presenting this new cosmic model to the public.

Sweitzer cautions that when planetariums depict the CMB sphere “as the ultimate data set after flying past stars, galaxies and clusters of galaxies,” it can “engender problems when the models contradict relativity” (p. 7). Since “we rely on light for celestial information,” he explains, “we are constrained to live in a relativistic universe where images of distant objects are actually images of past

events” (p. 8). Though this is true for observations at every scale, the delay becomes noticeably pronounced at the vast cosmological distances modeled within the *Atlas*. His proposed solution is to distinguish between “cosmic pictures” and “cosmic maps,” defining the former as “literally what we see with our telescopes” and the latter as “our common sense understanding of large-scale spatial information” (p. 8). By this denotation, we should classify the majority of the *Atlas* as a cosmic picture, since its datasets are primarily derived from astronomical observations. The only way to generate a ‘cosmic map,’ Sweitzer insists, is by computationally generating models based on mathematical theories, citing the example of the Virgo Consortium’s (2009) *Millennium Simulation* of the formation and evolution of large-scale cosmic structures (Figure 69).⁵⁹

None of the Hayden’s previous productions, however, distinguished between theoretical maps and observable pictures. To the contrary, the *Passport to the Universe* script (Druyen & Soter, 1999) script unambiguously states that its astronomical renderings are based on a “three-dimensional map of the *real* universe” (p. 2). Sweitzer (2006) bluntly contradicts this assertion, insisting, “The fact is, however, we cannot actually observe a map of the real universe, since we must rely on light from the galaxies for their positions to be known” (p. 11). The contrast between these two statements is striking—particularly considering Sweitzer’s unique position and qualifications. At the time of the article’s publication, he was the

⁵⁹ At the time of Sweitzer’s article, the *Millennium Simulation* (Virgo Consortium, 2009) was the “largest N-Body Simulation ever carried out, containing over 10 billion particles.” This has since been computationally eclipsed by its successor, the Millennium-XXL Simulation (Max Planck Institute for Astrophysics, 2013), as well as the University of California’s High-Performance Computing Center’s *Bolshoi Simulation* (UC-HiPACC, 2013).

Director of Astrophysics Education at the Hayden Planetarium—where he'd been initially hired as a principal investigator on the NASA *Digital Galaxy* grant (NASA, 2002).

Sweitzer (2006) ambivalently addresses the “opportunities and challenges” afforded by the interactive capabilities of digital planetarium systems to visualize “cosmological-scale models” (p. 7). As the title of the article suggests, he seeks to address the “mystery at the edge of the universe” and clarify issues he felt were “concealed by the problematic WMAP Sphere” (p. 8).⁶⁰ In addition to suggesting the map/picture distinction, he also recommends limiting the use of the CMB visualization due to its potential to obfuscate “several important scientific concepts” (p. 8), including distinctions between different types of cosmic horizons, the fact that different observers have different horizons (Figure 69), the expansion of the universe, and the challenges of visualizing the distances of deep space data using cosmological redshifts.

Sweitzer (2006) is not only concerned about concepts the CMB sphere might conceal, but also about misconceptions that could result from revealing the what he refers to as a “misleading baby picture” (p. 7) of the early universe. These included the impression that “there is an ‘outside’ to the universe,” that “there is a center to the universe,” and that “the Big Bang was like a bomb” (p. 9). Yet he acknowledges the difficulty of avoiding “the public’s questions about the edge of the universe” when

⁶⁰ WMAP refers to the cosmic microwave background data acquired from NASA’s (2001) Wilkinson Microwave Anisotropy Probe launched in 2001. The WMAP sphere has since been replaced by imagery from the European Space Agency’s (2013) Planck mission in the *Digital Universe Atlas*. Sweitzer’s comments about the WMAP sphere remain applicable to the Planck sphere, both of which are referred to throughout this dissertation as the CMB sphere.

the CMB sphere is revealed. He calls this “a boundary question” with “deep meaning for both novices and experts” (p. 9) that addresses “knowledge at its limits,” relating it to questions regarding what happened before the beginning of time, the existence of extraterrestrial life, and “life, the universe, and everything” (p. 15).

Recognizing the existential significance of these questions, Sweitzer (2006) concludes with recommendations for how to interpret the CMB sphere. The first, which he admits is “a bit of a cop out,” is for planetarians to “limit the scope” of audience questions concerning CMB-related boundaries by only discussing the cosmological model of observable phenomena. Acknowledging the challenge of constraining boundary questions, he instead encourages planetarians instead to “understand the limits of common sense,” writing:

Asking about what’s outside the universe is really an inadmissible question—a question outside of the rules of our scientific model for the universe. We simply can’t take our everyday concepts and language and hope that they apply to the extremes of space-time. Everyday concepts don’t apply in the quantum world of the atom, so why should common sense work for cosmology? (p. 13)

In his final consideration of these conundrums, Sweitzer (2006) concludes that explaining the “esoteric cosmological concept” of the CMB sphere is important “if we wish to continue to stay enlightened in our scientific age.” He suggests that instead of naïvely interpreting or concealing it, planetarians should use it to cultivate an “understanding of the use of scientific models” by demonstrating the “limits of common sense” at the cosmological scale. “In the end we may not make everyone

think like a cosmologist,” he writes, “but at least we might help them understand a more accurate model and help them critically discuss its implications and limitations” (p. 13).⁶¹

Sweitzer (2006) directs his comments towards “educators who form the front lines of astronomical education,” for whom he insists “a sound background in aspects of modern cosmology” is crucial “if the public understanding of contemporary science is to progress” (p. 7). However, the article contains no references to the *Digital Universe Atlas*, the Hayden Planetarium, or the occlusion of the CMB sphere within the Hayden’s productions—a notable omission considering his position at the time. However, many readers of the specialized *Planetarian* journal likely understood the subtext of his ambivalence, as his position and work were well known among the professional community.

These connections are not made explicit, however, and to this day no publications have addressed the Hayden’s decision to conceal the CMB or the interpretive conflicts among its producers concerning the distinctions between ‘cosmic maps’ and ‘cosmic pictures.’ There are no references to these disagreements within the current technical documentation about the *Atlas* (AMNH, 2013a) or materials promoting the Hayden’s productions (AMNH, 2013f). Consequently, the implications of these production decisions or the role of these interpretive

⁶¹ John Gilbert (2005) similarly calls for the cultivation of what he calls “metavisualization” skills within science education. He writes, “Visualization is central to learning, especially in the sciences, for students have to learn to navigate within and between the modes of representation” (p. 9), contending that this approach can enhance metacognition, memory, and the ability to think through images (2.05 Tools for Thinking).

inconsistencies within the public presentation of modern cosmology have yet to be formally addressed.

5.03 Relativistic Effects

It is reasonable to assume that the CMB sphere had been concealed within the Hayden's productions in an attempt to avoid the misconceptions cited in Sweitzer's article. However, the presentation of astronomical surveys as a "three-dimensional map of the *real* universe" (Druyen & Soter, 1999, p. 2) perpetuate an objectified perspective on the *Atlas*, failing to explain fundamental theoretical considerations of modern scientific cosmology. Sweitzer (2006) recognizes the perils of this approach, warning that presenting the CMB sphere "as the ultimate data set" (p. 7) falls prey to the "common-sense depiction of space" (p. 9). He relates this to a Newtonian classical view that is "more like a static map with stars and planets represented as tiny balls arrayed in empty space" (p. 9), insisting that conflicts can arise "when using everyday experience to understand cosmological models" (p. 9).

Sweitzer's description echoes long-standing philosophical critiques of the theory of perception known as *naïve realism* or *common sense realism*. Francisco Varela et al (1991) describe this as the attitude that "consists in the conviction that not only that the world is independent of mind or cognition but that things generally are the way they appear" (p. 16). John Gilbert (2005) draws a connection between this naïve realist view and the belief scientific visualizations represent a reality that is "out there," and, by extension, that visualizations "must have the same impact on all brains." "However," he contends, "'phenomena' are not ready-made: we impose our ideas of what might be important on the complexity of the natural world" (p. 10). In short, interpretations of datasets constructed from observational models as the '*real* universe' exhibit a theory of perception considered by many to be naïvely anachronistic.

Sweitzer (2006) acknowledges that navigating past the outer boundary of the *Atlas* and abruptly complicates these naïve interpretations by revealing the complexity of cosmographic practices. Since the CMB survey is modeled using techniques that factor in spatiotemporal relationships between observers and their observations, it appears as a spherical horizon around an observational center. Explaining this, however, requires acknowledging relativistic effects that dispel “common-sense” interpretations of the *Atlas*’ datasets ignoring lookback time—the time elapsed between light radiating and its observation.

Since the Hayden’s virtual flight paths hide the spherical shape of the CMB survey, these relativistic effects were not immediately apparent and acknowledgement of them could be avoided. This also enabled sidestepping distinctions between ‘cosmic pictures’ and ‘cosmic maps,’ which enabled naïve claims the datasets represented ‘*real* universe’ without apparent contradiction. The introduction of interactive visualization software, however, has enabled operators to move beyond the Hayden’s trajectories through the *Atlas*, complicating the naïve real stance tacitly assumed within the pre-rendered productions. “Because a digital planetarium can display a model based upon 3-D databases,” Sweitzer (2006) writes, attempts to ignore the consequences of the speed of light “can engender problems when the models contradict relativity” (p. 7).

As discussed in previous chapters, relativistic speculations were central in the development of modern cosmology. Nicolas of Cusa’s (1440/1981) transference of the Hermetic ‘infinite sphere whose center is everywhere and circumference is nowhere’ from theology to cosmology provided a critical thought experiment that undermined the idea of natural center (3.11 Infinite Sphere). As Harries (2001)

points out, this not only undercut “the geocentric cosmology of the Middle Ages,” but also the “heliocentric cosmology of Copernicus and Kepler that was to replace it” (p. 33). Bruno, Pascal, and others cited the metaphor of the infinite sphere in their attempts grapple with a relativistic universe (see Appendix II: Metaphors of the Sphere). Galileo (1632) substituted the infinite sphere’s horizon with inertial frames of reference to demonstrate the relativity of uniform motion. And Einstein (1905) formulated the “special theory of relativity” to extend Galileo’s mechanical relativity to include electromagnetic radiation, toppling beliefs in the absolute space and time of classical Newtonian physics. In an Einsteinian universe, all astronomical measurements must be described in relationship to the spatiotemporal reference frame of the observer. So, like Cusa’s center that is imagined everywhere, special relativity implied an infinite number of theoretical observational centers, each with its own visual horizon.

This relativistic understanding is embodied within the structure of the *Atlas*, with objects positioned in the 3D Cartesian virtual world relative to the central coordinates representing humanity’s observational center. These positions are calculated by factoring in the finite speed of light and other considerations, such as cosmological redshifts used to determine the locations of intergalactic objects (Abbott, 2012, p. 204). As Sweitzer (2006) points out, “Because c [the speed of light] is finite, we need to deal with many issues in interpreting what astronomers observe with telescopes as well as what we can display in visual models,” (p. 7) such as the ways in which “images of distant objects are actually images of past events” (p. 8). Referring to the need to move beyond naïve interpretations of the *Atlas*, he writes, “Now it is time to put the universe in that [relativistic] perspective and understand

that our view of space is entangled with time” (p. 13). Considering the significance of these ideas, the Hayden’s lack of acknowledgement of their implications within its high profile public productions was quite a pronounced oversight.

5.04 Return of the Spheres

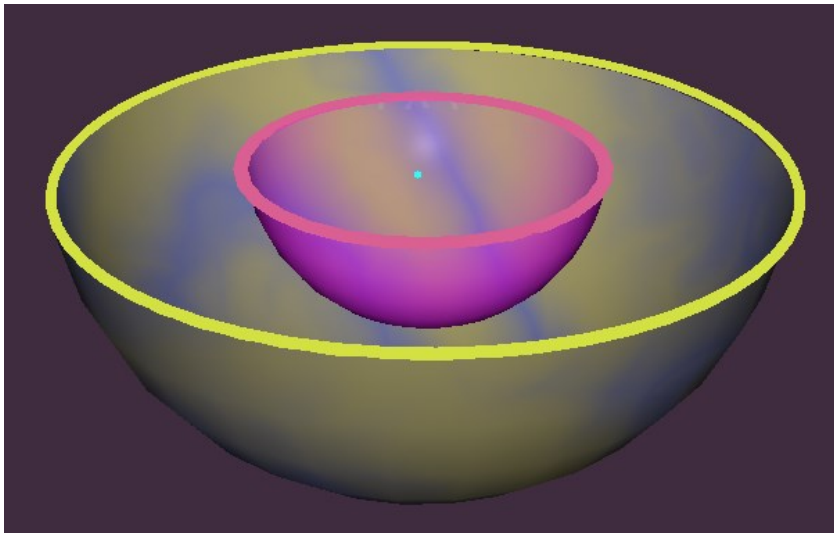


Figure 70. Sweitzer's (2006, p. 13) *Three Horizons: Visual Horizon* (blue), *Hubble Horizon* (pink), and *Particle Horizon* (yellow).

The spherical shape of the CMB makes the consequences of ignoring relativity particularly conspicuous. Sweitzer's (2006) attempt to clarify the CMB's radius, however, also indicates the complexity of determining its proper location. He specifies three different spherical "horizons" (Figure 61). Sweitzer contends that the CMB sphere "should be properly referred to as our *visual* horizon" or the "proper distance at which the WMAP light was released upon its journey to us" that is "40 million light years in radius."⁶² Next, he delineates the "Hubble horizon" or the "Speed of Light Sphere," which is "20.6 billion light years in radius or the total

⁶² In describing the illustrate of the three horizons, Sweitzer (2006) noted that the "proper distance at which the CMB was emitted" could not be depicted to scale. It is, he notes, "really only about 1/340th of 13.7 billion light years," requiring that its size be increased tenfold to be visible as the small blue dot in the center of the illustrated horizons. He calculated this "Visual Horizon" to have a radius of 40 million light years from Earth, writing, "Rather than being from the current edge of the universe, the light that makes up the WMAP Sphere started on its journey from a distance far less than the present proper distance of Virgo Cluster of Galaxies!" (p. 12).

proper distance light has been able to travel in the expanding universe since the Big Bang.” The outer sphere, he suggests, should be called the “Particle Horizon,” which “represents the current proper distance of the particles that originally last scattered the WMAP light” whose radius is “two times that of the Speed of Light Sphere, or 41.1 billion light years distant” (p. 13). He describes this as the “actual set of particles (mostly hydrogen, helium and electrons) that last scattered the CMB light” (p. 9).

However, only one spherical horizon—not three—is included in the *Atlas*. The rationale for the positioning of the CMB sphere is described in the *Digital Universe Guide*, written by Brian Abbot (2012), the Hayden Planetarium’s Digital Universe Manager:

The WMAP all-sky image is a two-dimensional image taken from a space telescope in orbit around Earth. We place the image on a sphere whose radius represents the furthest extent of light from the recombination era. This is a bit deceiving, since the CMBR is everywhere in the Universe; however, the sphere marks the farthest reaches of the Universe as seen from Earth, where hydrogen formed 379,000 years after the Big Bang. Currently, this places our horizon at about 42 billion light-years in all directions. Beyond this distance, the Universe will forever be opaque to us. (p. 203)

In defining the location of the CMB sphere, Abbot’s description attests to conflicts concerning the appropriate way to represent what Sweitzer’s (2006) article called “the edge of the universe.” Sweitzer’s insistence that the CMB sphere “should be properly referred to as our *visual* horizon” places its radius at 40 billion light

years, more than one thousand times less than the 42 billion light-year radius of the CMB sphere within the *Atlas*—a truly astronomical disparity.

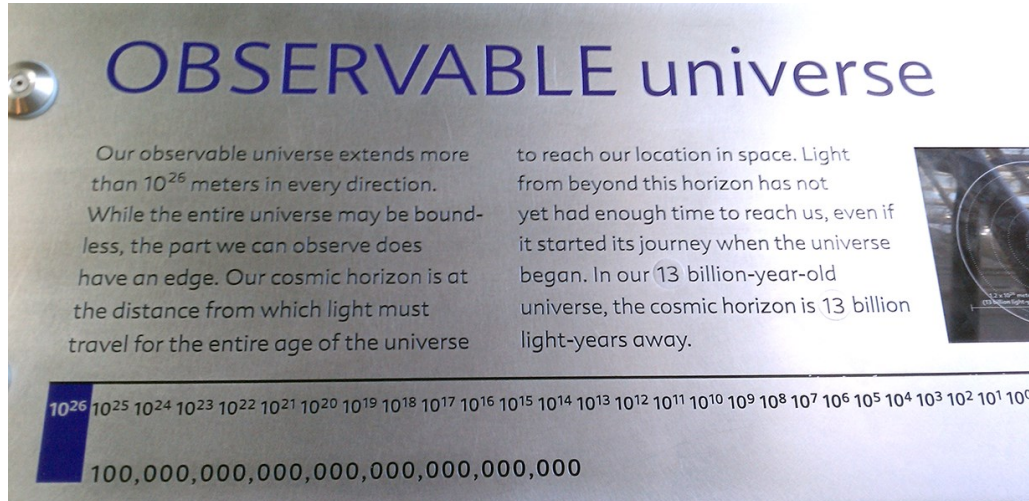


Figure 71. *Observable Universe* plaque from the Rose Center for Earth & Space (AMNH, 2011a).

Furthermore, a plaque located within the *Rose Center for Earth and Space* during its opening evidences further confusion surrounding spherical horizons. Called “The Observable Universe” (Figure 71), it reads:

Our observable universe extends more than 10^{26} meters in every direction. While the entire universe may be boundless, the part we can observe does have an edge. Our cosmic horizon is at the distance from which light must travel for the entire age of the universe to reach our location in space. Light from beyond this horizon has not yet had enough time to reach us, even if it started its journey when the universe began. In our 13 billion-year-old universe, the cosmic horizon is 13 billion light-years away.

The plaque’s claim that the radius of the “observable universe” is located at 13 billion light years conflicted with both Sweitzer’s opinion and Abbott’s

description. If it was meant to explain the position of the CMB sphere within the *Atlas*, it failed to take into account the expansion of the universe—a critical consideration within the standard Lambda-Cold Dark Matter cosmological model upon which the *Atlas* is based. Since the expansion rate is factored in to Abbot’s placement of the CMB sphere at the 42 billion light-years—what Sweitzer called the “Particle Horizon”—the plaque’s inscription miscalculates the overall diameter of the observable universe by 58 billion light years.



Figure 72. The ceiling of the Grand Central Terminal in New York City (Arnoldius, 2008).

The Hayden Planetarium, however, is not the first New York City landmark to prominently display confusing perspectives on the universe. At the end of Sweitzer’s (2006) article, he thanks Neil de Grasse Tyson, the Director of the Hayden

Planetarium, for a picture of the ceiling of Grand Central Terminal (Figure 72). Sweitzer uses it to illustrate a “cautionary tale” of the “egregious error” of constellations painted backwards—a consequence of the artist basing the design of the constellatory mural on a celestial globe. “If only the creator of the terminal’s ceiling had understood the solar system model,” Sweitzer laments, “this would have been avoided.” He insightfully warns that a “celestial globe is another fictional perspective, just like that of the WMAP Sphere” (p. 14).

Sweitzer (2006) concludes, “Let’s hope that our depictions of the modern cosmological models are free of excuses” (p. 14). Still, it appears that a similar cautionary tale is necessary to warn of confusion emerging from the complexities of contemporary cosmological speculations, evidence of which ironically remains engraved in a plaque outside of the new Hayden Planetarium.

5.05 Age of Endarkenment

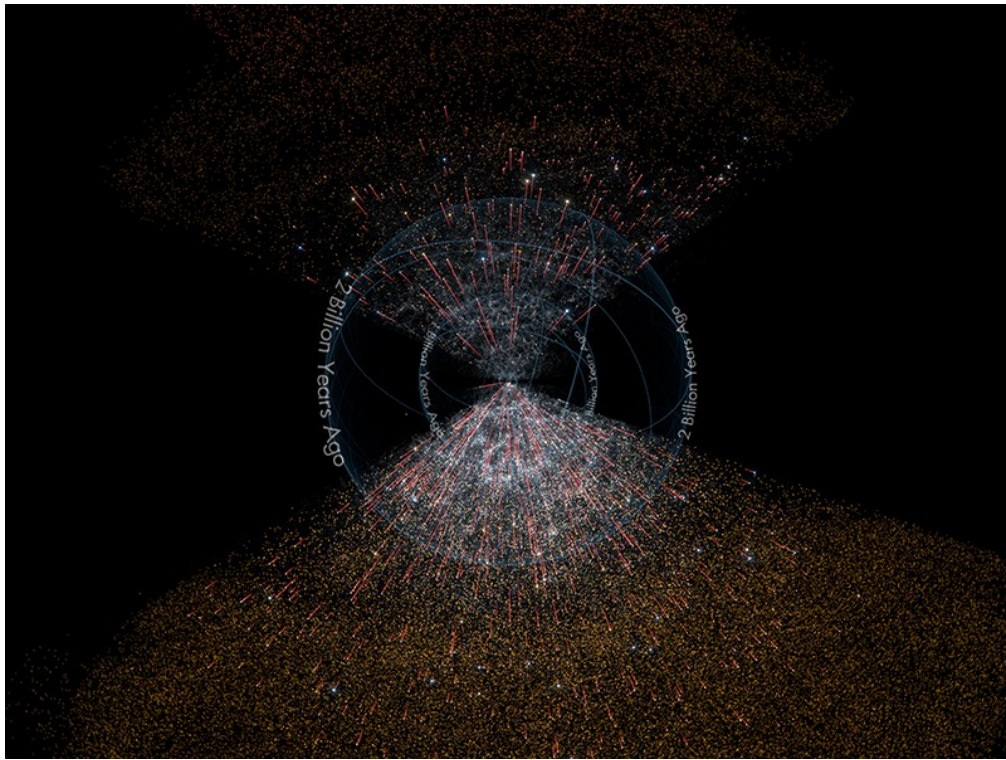


Figure 73. Lookback time indicators within the large-scale structure of galactic surveys in the Hayden Planetarium's *Dark Universe* (Emmart, 2013).

The relevance of these inconsistencies has become pronounced within the Hayden's most recent production. Released in the final months of writing this dissertation, *Dark Universe* (Emmart, 2013) presents contemporary theories concerning the origins, evolution, and structure of the cosmos. For the first time, the relativistic implications of lookback time were made explicit. As the script (Ferris, 2013) explains, “everything we see in the sky belongs to the past” because “it takes time for the light from distant objects to reach Earth” (p. 4). A series of animated spheres whose radii are placed at different light years away from the observational center of the *Atlas* visualizes these relative distances (Figure 73).

However, the script (Ferris, 2013) also introduces conflicting accounts concerning the source of the displayed data. The production’s visualizations are accompanied by claims that astronomers have been able to “map the visible universe well enough to chart an accurate course all the way back home” (p. 2) from virtual intergalactic space, though this seemingly contradicts the later statement that “everything we see in the sky belongs to the past” (p.4). This ambiguous interpretation implies that the production’s visualizations are simultaneously “the ultimate data set after flying past stars, galaxies and clusters of galaxies” (p. 7) and a model of relativistic observations. The naïve “*real universe*” (Druyen & Soter, 1999, p. 2) of *Passport to the Universe* and the *Atlas*’ relativistic “space-time universe” (Sweitzer, 2006, p. 13) are presented as one and the same.

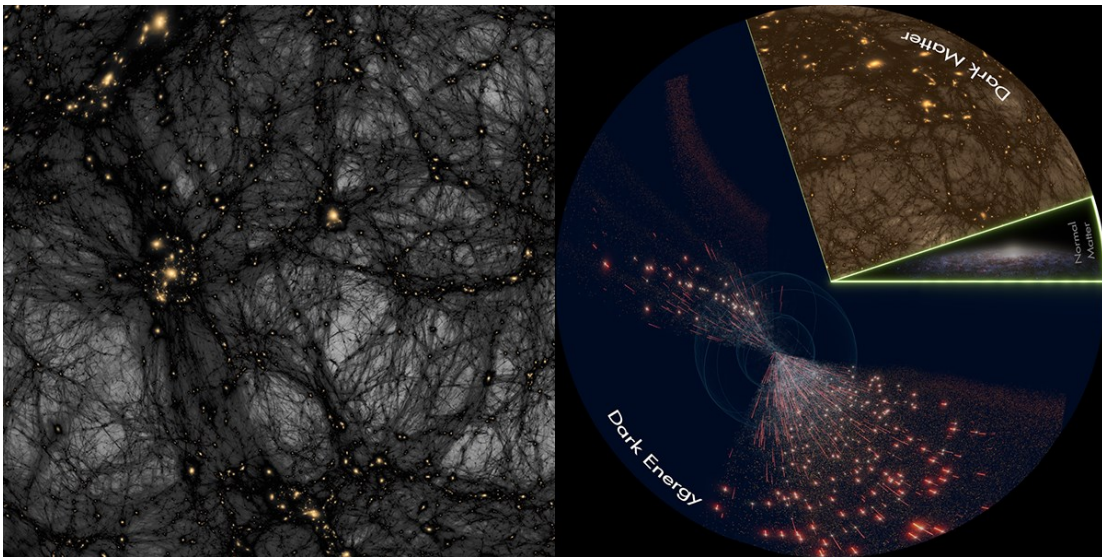


Figure 74. Dark matter visualization from the *Millennium-XXL* simulation and a pie chart illustrating theoretical cosmic density in the Hayden Planetarium’s *Dark Universe* (Emmart, 2013).

These ambiguities are further exacerbated as the *Digital Universe Atlas* is visualized alongside a computational model. The *Millennium-XLL* simulation (Max

Planck Institute for Astrophysics, 2013)—the updated version of the ‘cosmic map’ referenced in Sweitzer’s article—integrates within the production to visualize theoretical dark matter and dark energy (Figure 74). However, no indication is given when the observed data seamlessly fades into the theoretical simulation, thereby giving the impression of a coherently modeled virtual universe. As the title of the show suggests, the highly speculative nature of the primary subject matter lends itself to such creative ambiguities. In the process of explaining the mysteries of theoretical dark matter and dark energy, the script (Ferris, 2013) acknowledges the astonishing conclusion of contemporary cosmology: “Normal matter—all that we are, all that we’ve ever seen or touched—amounts to less than five percent of the known universe” (p. 8).

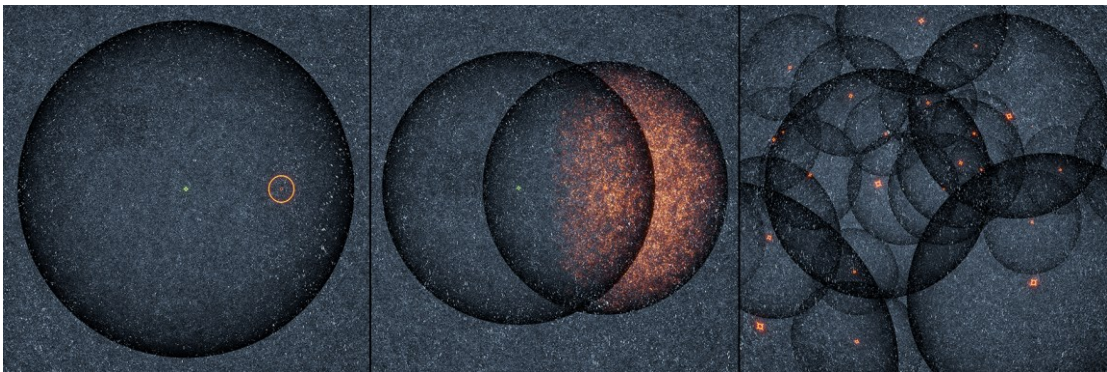


Figure 75. Simulation of particle horizons for multiple observational centers in the Hayden Planetarium’s *Dark Universe* (Emmart, 2013).

When the virtual camera path finally moves beyond the *Atlas*’ boundary towards the end of the show, the CMB sphere appears for the first time in a Hayden production. Instead of addressing the implications of visualizing this view that Sweitzer (2006) calls a “fictional perspective” (p. 14), the scene is swiftly populated with other spheres to accompany the script’s (Ferris, 2013) caveat, “every galaxy

occupies the center of its *own* observable universe” (p. 8) (Figure 75). This ‘outside’ view of humanity’s cosmic horizon fades from the Planck CMB survey into a generic sphere, which is duplicated to approximate the theoretical observational horizons of other galaxies—replicating the approach demonstrated by Sweitzer (2006) to illustrate his explanation, “Cosmic pictures are centered on observers, cosmic maps are not” (p. 8) (Figure 69). But the script also disregards Sweitzer’s plea to distinguish between observational ‘cosmic pictures’ and simulated ‘cosmic maps,’ continuing the Hayden’s tradition of cultivating the suspension of disbelief in the ability to ‘objectively’ model the universe.

5.06 Viewing from Nowhere

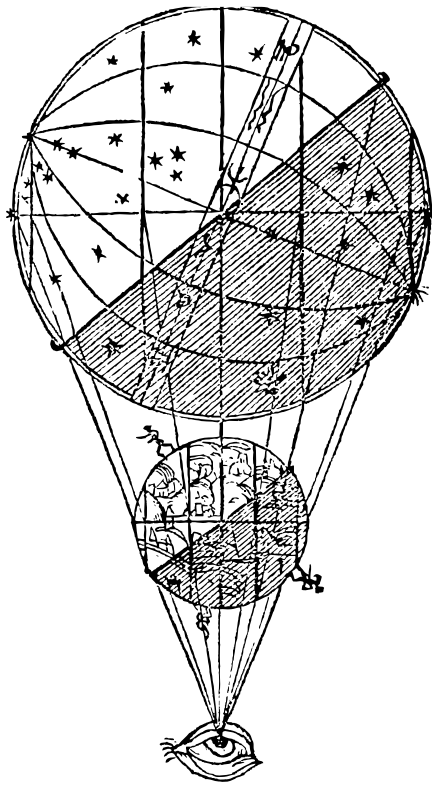


Figure 76. Peter Apian's *Cosmographiae* (1545).

Whereas previous Hayden productions simply avoided these issues by occluding the CMB sphere, its revelation in *Dark Universe* necessitates a series of increasingly complex maneuvers to convey the impression of a scientifically constructed ‘Archimedean point.’ It does not address the relationship between observational and theoretical data—nor the substantial disagreements concerning the distances of various horizons. These omissions suggest that, in their pursuit of a compelling narrative, the Hayden’s producers decided to leave out critical details in order to sustain the illusion of a purely objective perspective. This raises significant questions concerning the motivations and assumptions underlying these decisions,

particularly why they felt it was necessary to convince the public that achieving an omniscient view of the *real* universe is even possible.

The belief in the transcendent ideal of scientific objectivity has received increased academic scrutiny in recent decades. Numerous scholars have examined the origins and consequences of this imaginary omniscient view on the world, alternately referring to it as an “escape from perspective” (Daston, 1992), a “disembodied eye” (Klatzky, Wu, & Stetten, 2010), a “view from nowhere” (Nagel, 1986), and a “god’s eye view” (Snell, 2006) (Figure 76). Donna Haraway (1988) calls it the “god-trick of seeing everything from nowhere” (p. 581), describing it as a mythologized representation of the “perfectly known” (p. 589) within “Western cultural narratives about objectivity” (p. 583).⁶³

The contemporary return of a spherical, geocentric cosmic model complicates these narratives, particularly the conflation of scientific progress with humanity’s “dethroning” from its central position. If, as Emmart (2005) suggests, “using a dome to model the night sky authoritatively may confuse children more than we might care to admit” (p. 21), the need to explain the overall configuration of the *Atlas* presents a cosmic conundrum at a different order of magnitude.

The solution in *Passport to the Universe* was to disregard these contemporary issues, referring to the sphere only in reference to previous generations’ naïve

⁶³ Muriel Spark (1952/2004) foreshadows later critiques in her poem “Against the Transcendentalists”:
And what good’s a God’s-eye-view of
Anyone to anyone
But God? In the Abstraction
Many angels make sweet moan
But never write a stanza down.
Poets are few and they are better
Equipped to love and animate the letter. (p. 58)

perception of being “inside of an enormous bowl, slowly turning around an Earth believed to be at its center” (Druyen & Soter, 1999, p. 2). The themes addressed within *Dark Universe*, however, finally force acknowledgement that perceptual spheres persist within modern cosmology. For the first time, the Hayden’s scriptwriters concede that relativistic astronomical measurements necessarily surround a central point of observation.

The attitude towards the re-emergence of the archetypal *heavenly sphere* is understandably ambivalent, particularly in light of its association with credulous cosmologies. Sweitzer indicates the general sense of uneasiness with his characterization—if not outright dismissal—of the CMB sphere as a “misleading baby picture” (p. 7). When modeled within a virtual world, he explains, the CMB is “necessarily centered on our location” (p. 9). He expresses concern that this will plant or reinforce misconceptions that “there is a center to the universe” (p. 9), suggesting that planetarians explain that its appearance is “merely due to the finite nature of c [the speed of light]...not due to any Ptolemaic point of view” (p. 9).

We may interpret Sweitzer’s conceptual bifurcation between ‘subjective’ perception and ‘objective’ simulations as a strategy to rescue the revered ‘Archimedean point.’ In offering an alternative to the *Atlas*’ use of empirical observations, he implies that a truly objective “view from nowhere” of the “*real* universe” can only be generated by theoretical computer simulations (like the *Millennium-XXL*). However, this strategy introduces assertions that, when taken to their logical extreme, have profound consequences. The primary implication of his proposed distinction between ‘cosmic pictures’ and ‘cosmic maps’ is that *all* observations are misleading due to relativistic effects. In expressing his concern that

the spherical appearance of the CMB might reinforce naïve misconceptions, Sweitzer also discloses his own faith in the ability of computer simulations to produce ‘cosmic maps’ of the “perfectly known” (Haraway, 1988, p. 589).

This situation bears an uncanny resemblance to Plato’s challenge to his students at the Academy to ‘save the appearances,’ with the desire to sustain the ideal of an ‘Archimedean point’ replacing the ancient existential need for uniform and orderly planetary movements (3.05 Saving the Appearances). Just as Ptolemy attempted to save the appearances of the celestial motions through a complex system of epicycles, the Hayden’s producers have adopted an increasingly complex strategy of integrating observational data and computer simulations to save the appearance of an ‘objective’ model of the cosmos.

The *Dark Universe* script (Ferris, 2013) addresses Sweitzer’s concern by asserting that “there’s no center to the universe” (p. 3) after the CMB sphere is revealed. But this statement also presumes an ideal panoptic perspective independent of any observer from which to answer the question of spatial centrality. This requires ‘poetic faith’ in an imaginary view beyond the inherently situated perspectives of a relativistic space-time universe. Assuming this position contradicts Sweitzer’s (2006) stark warning, “Asking about what’s outside the universe is really an inadmissible question” (p. 13). Just as presenting the “cosmic microwave background data as a sphere seen from the outside” (p. 6) may reinforce popular misconceptions, so too does the Hayden’s continued use of the “god-trick of seeing everything from nowhere” (Haraway, 1988, p. 581). The central pretense of this disembodied view presumes the ability to transcend the observational constraints described by Einstein’s relativity over a century ago.

Though *Dark Universe* begins to address relativistic effects, its narrative doesn't fully account for the broader logical, ontological, and epistemological consequences of Sweitzer's (2006) insistence that educators "cannot rely on naïve notions of a Newtonian universe with its absolute concepts of space and time" (p. 9). The script's (Ferris, 2013) acknowledgement at the end of the show that, "every galaxy occupies the center of its *own* observable universe" (p. 8) testifies to the continued metaphorical relevance of Cusa's infinite sphere whose center is everywhere. The assertion that "there's no center to the universe" disregards the relativistic insight that the center of the universe is situated everywhere there is an 'observer.' A more sensible claim would be that Earth—and the complex of 'observing systems' it enables—is the center of humanity's universe. This is implied by the explanation that the *Atlas*' configuration results from humanity's observational center, but the insistence that there is no center at all is predicated on the dubious Archimedean perspective of absolute space-time within a theoretical, non-relativistic cosmos.

5.07 Sphere of Cognition

While objectified interpretations of the *Atlas* in the Hayden's early productions relied on 'poetic faith' in their naïve real presentations, Sweitzer's proposed corrective discloses his own philosophical stance. The modern roots of his Platonic distinction between 'cosmic pictures' and 'cosmic maps' can be traced to Cartesian dualism and Kantian idealism (3.15 Quantifying the Uncanny). Descartes (1641/1901) famously described a similar bifurcation between the *internal* world of mental substances (*res cogitans* or 'mental thing') and the *external* world of corporeal substances (*res extensa* or 'extended thing') to justify his quest for an 'Archimedean point.' Similarly, Kant's (1781/2010) "transcendental idealism" distinguished between the world of sense perception (*phenomena*) and the world of objects only accessible to thought (*noumena*) (p. 296). Kant even summoned the metaphor of the sphere to describe the limits of phenomenal sense perceptions:

For we come to the conclusion that our faculty of cognition is unable to transcend the limits of possible experience; and yet this is precisely the most essential object of this science. The estimate of our rational cognition a priori at which we arrive is that it has only to do with phenomena, and that things in themselves, while possessing a real existence, *lie beyond its sphere*. [emphasis added] (p. 15)

The *cosmic picture* of the CMB effectively visualizes Kant's metaphorical sphere of sensory perception. Scientific efforts to map the spatial, temporal, and spectral extremes of mediated perceptions have produced a virtual sphere that embodies the inevitable centrality consequences of a relativistic universe. In the same

way explaining this sphere forces acknowledgement of the consequences of relativity, it also illuminates the dualistic paradigmatic assumptions underlying “precision cosmology” in the ontological primacy of theoretical models (Cardoso, 2010; Guth, 2002; Primack, 2004). Like Kant’s claim that his division between *a priori* and *a posteriori* worlds was “the key to the solution” of the “pure cosmological dialectic,” (p. 296), a theoretical universe of computer simulated ‘things in themselves’ are presumed to be the solution to the conundrum of what lies beyond telescopically assisted sense perception.

Sweitzer’s (2006) contention that “we cannot actually observe a map of the real universe” (p. 11) confesses this belief, continuing the Platonic tradition of emphasizing the ontological veracity of a transcendental, theoretical universe over the universe of the senses. Computer simulations, he suggests, can give the mind’s eye a glimpse of the *real* universe by visualizing what “we might see ... when we looked into space ... if the speed of light were infinite” (p. 8). However, discounting the constant speed of light and the inherent non-simultaneity of observations violates key postulates of special relativity. Even with the help of computer models, imagining an *a priori* view from nowhere requires suspending disbelief in speculations that disregard fundamental relativistic precepts of the standard model of scientific cosmology. This is a particularly ironic thought experiment, considering Sweitzer’s proposed map/picture distinction was instigated by the need to acknowledge the role of relativistic effects when visualizing the CMB sphere. Nevertheless, transitioning between different *real* universes—as *Dark Universe* does with the *Digital Universe Atlas* and the *Millennium-XXL* simulation—does not require much of an imaginative leap. It simply builds on the already-established *suspension of disbelief* in the

scientific ability to escape the relativistic perspectives of an embodied space-time universe.

5.08 Myth-Conceptions

The Hayden's use of "real science and cutting-edge technology" to create an "unprecedented virtual tour that takes audiences to the limits of the universe and back again" (AMNH, 2013g) also mythologizes the accomplishments of modern science. Beyond attempting to "make sense of the real sky" (Emmart, 2005, p. 21), the Hayden's productions perpetuate "Copernican myths" (Singham, 2007, p. 48) of humanity's dethroning from the center of the "*real* universe" (Druyen & Soter, 1999, p. 2). By occluding disagreements concerning how the epistemological and ontological complexities of the *Atlas* should be interpreted for the public, they also perpetuate misconceptions about the scientific ability to visualize Descartes' (1641/1901) "certain and indubitable" (p. 225) 'Archimedean point' (3.15 Quantifying the Uncanny). Instead of acknowledging the ways in which the attempts to model the cosmos complicates naïve real and dualistic assumptions, these productions continue to employ the trope of the cosmic journey to mythologize the "perfectly known" (Haraway, 1988, p. 583), seemingly separating subject from object, mind from body, and cognition from cosmos through the rhetorical power of perceptual immersion.

This mythologizing approach is by no means unique to the Hayden. Recent examinations of the culture of scientific research and popular science communication have addressed the problems arising from unacknowledged philosophical beliefs that reinforce misconceptions about the nature and capabilities of science (Midgley, 2003; Schrempf, 2012; Sheldrake, 2012; Wood, 2007). Douglas Allchin (2003) warns that the re-telling of "popular histories of science" for the sake of "telling a good story" have resulted in a number of "myth-conceptions" (p. 329). He contends that these

“share a rhetorical architecture of myth” but can mislead “students about how science derives its authority” (p. 330). Cautioning against narratives that “romanticize scientists, inflate the drama of their discoveries, and cast scientists and the process of science in monumental proportion” (p. 329), he suggests the need for more realistic approaches.⁶⁴ Acknowledging uncertainties, contingency, controversy, and complexity, he argues, can more accurately portray “both the foundations and limits of scientific authority and foster deep understanding of the nature of science” (p. 348).

⁶⁴ According to Sydney Ross’ (1962) “Scientist: The Story of a Word,” the invention of the term ‘scientist’ did not occur until the 1830s. Like the contemporary definitions of ‘objective’ and ‘subjective,’ the coining of ‘scientist’ was due in part due to the philological provocations of Samuel Taylor Coleridge.

5.09 Viewing from the Center

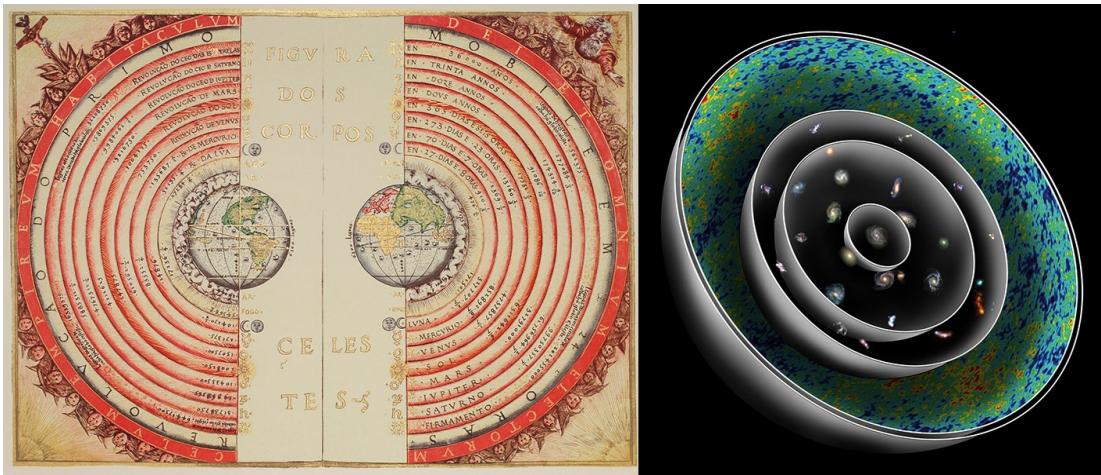


Figure 77. *Figura dos corpos celestes* by Bartolomeu Velho (1568) and *Cosmic Spheres of Time - Our Visible Universe* by Nicolle Rager Fuller (Primack & Abrams, 2011, p. 74).

Some scientists, however, have intentionally embraced the mythic possibilities of the ‘observational center’ and the return of the *heavenly spheres* as evidence of humanity’s special place in the cosmos. Physicist Joel Primack and science historian Nancy Abrams not only acknowledge the anthropomorphic centrality of human observations, but also attempt to elevate this centrality to the foundation of a new mythology in *The View from the Center of the Universe: Discovering Our Extraordinary Place in the Cosmos* (2006) and *The New Universe and the Human Future: How a Shared Cosmology Could Transform the World* (2011). Primack and Abrams (2006) write:

The classic image of the heavenly sphere remains useful. It expresses a truth not only about the universe but also about how people *experience* the universe. We do experience it surrounding us, and indeed we *can* accurately say that we are surrounded by nesting spheres, but in modern cosmology they

are not hard crystal objects or orbits of celestial bodies. They are what we will call “Cosmic Spheres of Time” (Figure 77), and we truly are at the center in a sense never imagined in the Middle Ages. Since looking into space is looking back in time each concentric sphere [. . .] moving outward from today, represents an earlier epoch in the evolution of the universe. The farther away from us a sphere is, the farther back in time are the objects that we observe in that sphere. (p. 133-134)

Primack and Abrams (2006) express concern over the perils of anachronistic beliefs about scientific paradigms (as discussed in Chapter 5), attributing “humanity’s most dangerous problems” (p. 4) to that prevailing popular understanding of the “seventeenth-century Newtonian picture that replaced the medieval one—a universe in which space is as a shapeless, endless, cold, and empty except for scatter stars and other celestial bodies” (p. 73).

Their proposed solution, however, stands in stark contrast to Douglas Allchin’s (2003) suggestion that “myth-conceptions” be addressed by making explicit “both the foundations and limits of scientific authority” (p. 330). Instead, Primack and Abrams (2006) attempt to construct a new mythology based on scientific cosmology, asserting that the “faith of active research cosmologists—a faith shared with the ancients—is that human beings can personally connect in a meaningful way with the real cosmos” (p. 19). Far from advocating for humility and transcendence through *learned ignorance*, they claim the “copious data on the early universe coming in from new instruments” (p. 83) is providing “humanity’s first picture of the universe as a whole *that might actually be true*” (p. 4). Though “there have been countless

myths of the origin of the universe,” they suggest, “this is the first one that no storyteller made up” (pp. 4-5), citing the observational confirmation of mathematically based cosmological predictions as proof. They argue that “traditional cultures’ cosmologies were not factually correct,” but that ancient mythologies “offered guidance about how to live with a sense of belonging in the world,” while “modern scientific cosmology says nothing about human beings or how we should live” (p. 16).

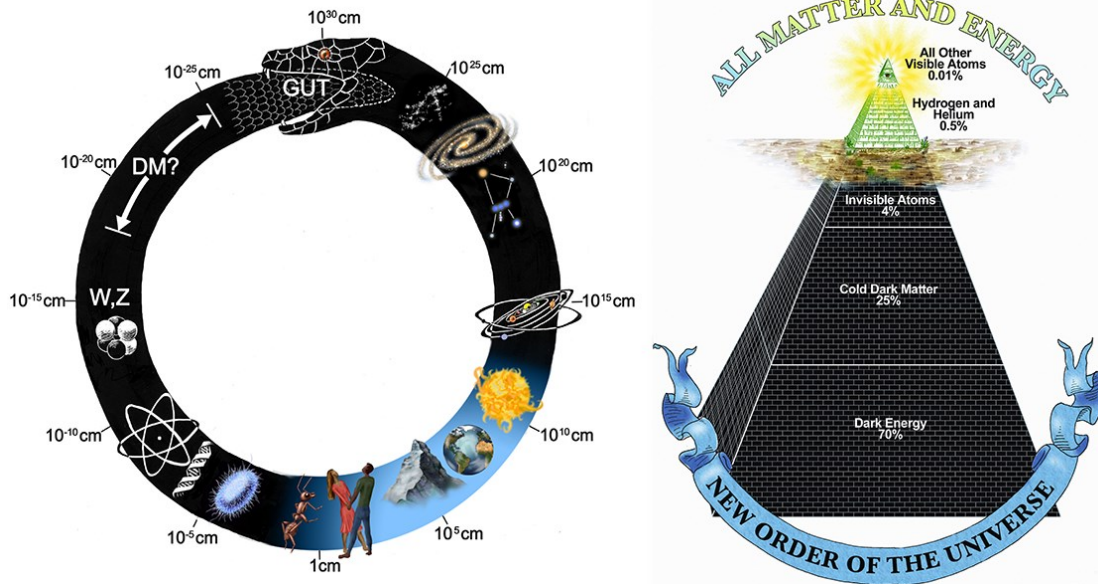


Figure 78. *Cosmic Uroboros* by Nicolle Rager Fuller (Primack & Abrams, 2011, p. 30) and *The Cosmic Density Pyramid* by Nicolle Rager Fuller (Primack & Abrams, 2011, p. 49).

Primack and Abrams (2006) propose a strategy for re-constructing a sense of meaning by fusing theories of modern astrophysics with appropriated mythological tropes to “represent the mythic power of the new cosmology” (p. 10). Drawing on ancient Egyptian, Hebrew, Greek, Alexandrian, and medieval imagery and techniques, they develop a series of symbols and cosmographic illustrations (Figure 78) designed to “offer a science-based explanation of our human place in the universe” (p. 16) that purport to illustrate humanity’s privileged, extraordinary position at the central point of the observed scales of reality.

Though they appropriate the language and imagery of traditional mythologies, Primack and Abrams (2006) assert that only modern science has the authority to yield “answers to big questions” (p. 4) capable of providing “a satisfying picture of the universe” (p. 23) for all of humanity. They insist that the “experience of connection across mythic time [. . .] serves a crucial purpose in expanding human consciousness

beyond the deadly narrowness of the everyday” (p. 46), hoping that their narrative of scientific cosmology can fill a universal void of spiritual longing.⁶⁵

When I first discovered Primack and Abrams (2006) *The View from the Center of the Universe* midway through the current study, I was intrigued by their efforts to explain the consequences of modeling the cosmos from an ‘observational center’ through the lens of mythology. As I studied their proposals, however, I found their “invitation to take part in the creation of the next myth” (p. 36) problematic. Their de-emphasis on the complications of ‘big bang’ cosmology⁶⁶—combined with what may be the first copyrighted images explicitly designed as mythical symbols—calls into question their willingness to admit the limits of scientific knowledge as well as the collaborative spirit of their intentions. They claim to “try to make clear where science gives way to the kind of speculative theory that verges on metaphysics” (p. 23), but imply that a “true” mythology can only be predicated on the standard Lambda-Cold Dark Matter model of cosmology—which, by Primack’s own calculations (p. 105), fails to account for over ninety-five percent of cosmic density (Figure 78). Like the return of an Earth-centered cosmic model, their descriptions of invisible non-atomic (‘non-baryonic’) matter and inexplicable ‘dark’ energetic

⁶⁵ Brian Eno (2001) similarly remarks on the dangers of myopic perspectives in his essay “The Big Here and Long Now,” referring to the “studied disregard of the future” as a “peculiar form of selfishness” (para 8). He insists that we must “reach a frame of mind where it comes to seem unacceptable—gauche, uncivilised—to act in disregard of our descendants” (para 10). To achieve this, he suggests that humans actively use their “unique trick” of “creating realities by first imagining them” and “experiencing them in their minds” (para 14), suggesting that our shared visions become the reality against which currently reality is measured and modified towards. By way of examples, he cites the “ways in which artists and designers since the beginning of the twentieth century have been moving away from an idea of art as something finished, perfect, definitive and unchanging towards of view of artworks as processes or the seeds for processes—things that exist and change in time, things that are never finished” (para 15).

⁶⁶ For an accessible and nuanced discussion of the current state of scientific cosmogonies, see Adam Frank’s (2011) *About Time: Cosmology and Culture at the Twilight of the Big Bang*.

forces—also prominently featured in the Hayden’s *Dark Universe*—bear a suspicious resemblance to aspects of the Aristotelian world system that required a quintessential ‘aether’ and an ‘unmoved mover’ to account for the substance and movements of the *heavenly spheres*.

Though they don’t address these quintessential parallels, they do recognize the uncanny historic significance of the notion of the observational center. In contradistinction to the claim in *Dark Universe* (Ferris, 2013) that “there’s no center to the universe” (p. 3), Primack and Abrams (2011) celebrate its antithesis, stating, “We are not using this ‘center of the universe’ language ironically, but there is perhaps some irony in the fact that after centuries of believing that science has pushed us out of the center of the universe, we discover that we’re central after all” (pp. 195-196).

5.10 Cosmogonic Cycling

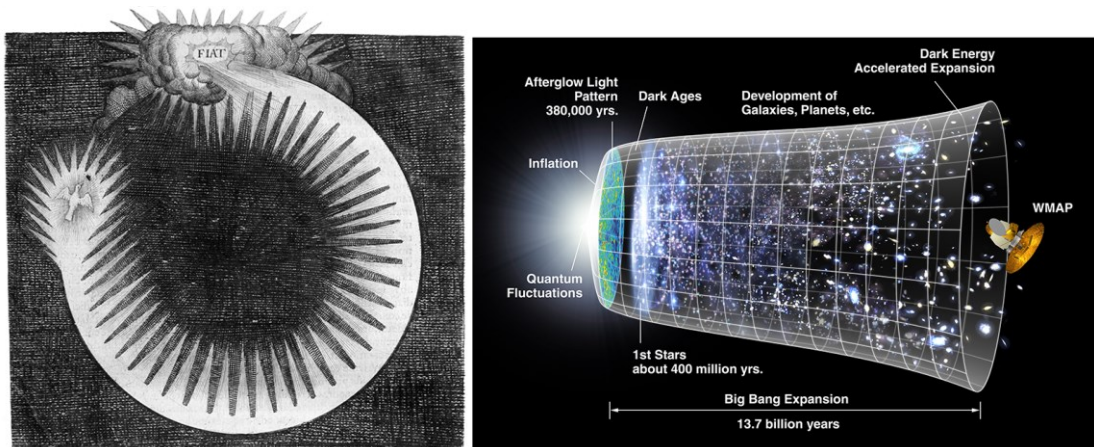


Figure 79. Robert Fludd's *Let There Be Light* (1617) and NASA's *Timeline of the Universe* (2009).

It seems appropriate, then, that Primack and Abrams (2011) justify their proposals by citing Joseph Campbell, interpreting his work to suggest, “what the modern world needs more than anything else is a story that unifies” (p. 120). Though he never made this claim directly, Campbell (1988) does recall Nietzsche’s madman, writing, “The old gods are dead or dying and people everywhere are searching, asking: what is the new mythology to be, the mythology of this unified earth as of one harmonious being?” (p. xix). Primack and Abrams (2011) respond with their version of a “transcendent origin story” (p. 139), which they assert “comes closer than any other to helping us fulfill” the spiritual longing to “experience our true connection to all that exists” (p. 142).

Though they don’t acknowledge the relationship, their mythic elevation of the return of a geocentric world system—surrounded by the “cosmic spheres of time” (p. 74) and dependent on mysterious, quintessential substances—bears a striking relationship to Campbell’s (1949/2004) “cosmogonic cycle” (p. 217). In *The Hero*

with a Thousand Faces, Campbell describes a “great vision(s) of the creation and destruction of the world” that “is vouchsafed as revelation to the successful hero” (p. 36). This epic tale, he claims, is structured around the basic formulaic process of separation, initiation, and return, “a hero ventures forth from the world of common day into a region of supernatural wonder: fabulous forces are there encountered and a decisive victory is won: the hero comes back from this mysterious adventure with the power to bestow boons on his fellow man” (p. 28). Campbell finds variations of this monomyth “presented with astonishing consistency in the sacred writings of all the continents” (p. 30). Considering the uncanny parallels between medieval and contemporary scientific cosmological speculations (Figure 79), the scientific mythological narrative offered by Primack and Abrams appears to be no exception.

Some scientists are less anxious to cast the achievements of modern cosmology in such an unambiguously triumphalist light. In “The Case Against Cosmology,” astrophysicist Michael Disney (2000) strongly cautions against insinuating that “the solution to some of the great problems” of cosmology, such as the origin of the Universe, “lie[s] just around the corner” (p. 1). Citing a series of challenges facing attempts to characterize modern cosmology as a science—as well as tacit assumptions underlying beliefs it can definitively answer grandiose questions—he asserts that a more humble approach is essential to place cosmological pursuits within their necessarily limited perspective. He goes as far to suggest that scientists offer pragmatic caveats to the general public:

It is not likely that we primates gazing through bits of glass for a century or two will dissemble the architecture and history of infinity. But if we don't try we won't get anywhere. Therefore we professionals do the best we can to fit

the odd clues we have into some kind of plausible story. That is how science works, and that is the spirit in which our cosmological speculations should be treated. Don't be impressed by our complex machines or our arcane mathematics. They have been used to build plausible cosmic stories before—which we had to discard afterwards in the face of improving evidence. The likelihood must be that such revisions will have to occur again and again and again. (p. 9)

Instead of “trying to answer grandiose questions which may, in all probability, be unanswerable” (p. 8), Disney argues that astronomical research should be understood within its limited context. In his (2007) more recent *American Scientist* article “Modern Cosmology: Science or Folktale?,” he quotes historian of science Daniel Boorstin:

The great obstacle to discovering the shape of the Earth, the continents and the oceans was not ignorance but the illusion of knowledge. Imagination drew in bold strokes, instantly serving hopes and fears, while knowledge advanced by slow increments and contradictory witnesses. (para 19)

Disney (2007) points out that while the Lambda-CDM ‘concordance’ model has made three successful predictions (“the apparent flatness of space, the abundances of the light elements and the maximum ages of the oldest star clusters”), there have been “at least half a dozen unpredicted surprises...including dark matter and dark energy” and that “there is no sign of a systematic improvement in the net significance

of cosmological theories over time” (para 15).⁶⁷ In the tradition of *learned ignorance*, he cautions attempts to overstate the certitude of scientific knowledge by dogmatically mythologizing current astrophysical speculations threaten to “hold up progress in cosmology for generations to come” (para 19).

The pronounced differences between Primack and Abrams’s mythological project and Disney’s decidedly more cautious approach demonstrate that perennial cosmological conundrums are alive and well. Given the extraordinary complexity of both historical and contemporary attempts to make sense of humanity’s place in the universe, it’s little surprise that differing opinions result in significant disagreements about fundamental existential questions. It is also understandable why cosmological speculations continue to exert significant influence on beliefs about the ultimate meaning and purpose of existence, even if the ability to interpret and predict the perceived patterns and motions of the heavens may no longer be seen as essential for daily life.

⁶⁷ Joel Primack (2004) addresses the successes and potential problems with the Lambda-CDM model in his article “Precision Cosmology.”

5.11 Pluralistic Worldviews

By turning to cosmology for answers to big questions, scientists and non-scientists alike echo variations on Primack and Abrams' (2011) belief that a “potentially empowering, transcendent origin story” can “unify so many around the world who may not see eye to eye on many other things” (p. 142), though their specific motivations and proposed strategies vary considerably. Some attempt to develop ‘satisfying stories’ by constructing grand historical scientific narratives (Brown, 2008; Christian, 2005; Duncan & Tyler, 2008; Guth, 1997; Halpern, 2012; Sagan, 2011; Spier, 2010). Others seek to explicate the relevance of specific topics as they relate to cosmology, including living systems (Brown, 1994; Grange, 1997; Sahtouris, 2000; Swimme & Berry, 1994; Ward & Brownlee, 2000), the nature of time (Frank, 2011; Penrose, 2011), religion (Berry & Tucker, 2009; Frank, 2009; Tucker, 1994), phenomenology (Abram, 2009; Rosen, 2008), esoteric philosophy (Lachman, 2013), design strategies (Fuller, 1975), embodied consciousness (Edelman & Tononi, 2001; Lanza, 2009), complexity (Chaisson, 2002; Kauffman, 1995), evolution (Chaisson, 2005; Dowd, 2008; Liebes, Sahtouris, & Swimme, 1998), theoretical universes (Barrow, 2011; Kaku, 2006; Krauss, 2012; Rees, 1997), and indigenous beliefs (Chamberlain, Carlson, & Young, 2005; Grim, 2001; Roepstorff, Bubandt, & Kalevi, 2004).

The breadth of these different approaches, and the passion with which they are proposed, attests to both the mythologizing power and remarkable complexity of contemporary efforts to make sense of the universe. The presence of so many interpretative lenses for discerning a cosmic order is a testament not only to the continued cultural significance of cosmology, but also that the presence of concurrent

perspectives that, when recognized, contribute to what Combs' (2009) calls the *pluralistic worldview* (p. 142) (1.06 Worldviews and Universes). The ability to shift between these interpretive lenses provides an opportunity to explore what Edward Harrison (1981/2000) calls the different “mask[s] fitted on the face of the unknown Universe” (p. 1).

These interpretive possibilities draw attention to the challenges faced by high-profile efforts to communicate scientific cosmology and cosmographic datasets to the public. In particular, the shifting narratives of the Hayden's productions attest to the different intonations of interpretative strategies. Whereas *Passport to the Universe* assured audiences of scientific certainty, *Dark Universe* takes a more ambivalent stance towards the “perfectly known” (Haraway, 1988, p. 583). The script (Ferris, 2013) finally concedes that, “with new instruments on Earth and in space, we've begun to glimpse how much we still *don't* know about the cosmos” (p. 2). Still, it continues to affirm of the mythic power of modern cosmology to instigate, if not answer, life's big questions: “Peering into the dark, we stand on the threshold of great discoveries—and we always will, as long as we keep exploring” (p. 8).

5.12 World Picture

The phrasing of Primack and Abrams' (2006) quest for "a satisfying picture of the universe" (p. 23) and Sweitzer's (2006) "cosmic picture" draw further attention to the tacit philosophical beliefs of modern cosmology. Sweitzer writes that the use of the term "cosmic picture" was derived from "world picture" (p. 10), a notion first introduced within scientific literature by astrophysicist E. A. Milne (1935, p. 290). Shortly thereafter, this same term became the central motif in phenomenologist Martin Heidegger's (1938/1977) essay "The Age of the World Picture," though there is no indication that the philosopher borrowed the concept from the scientist. In this frequently quoted essay, Heidegger asserts, "The fundamental event of the modern age is the conquest of the world as picture," defining "picture" as a "structured image that is the creature of man's producing which represents and sets before." Through this quest, he writes, "man contends for the position in which he can be that particular being who gives the measure and draws up the guidelines for everything that is" (p. 134). He traces this insistence on the need to quantify an external reality to a familiar source, writing, "Through Descartes, realism is first put in the position of having to prove the reality of the outer world" (p. 139) (3.15 Quantifying the Uncanny).

In examining the consequences of this Cartesian split, Heidegger points to the scientific tendency to pursue extremes in search of certainty. Seemingly in anticipation of Primack and Abrams' (2006) faith in the Lambda-CDM model to produce a "satisfying picture" (p. 23) through the microcosmic and macrocosmic alignment of particle physics and precision cosmology, Heidegger (1938/1977) writes,

The gigantic is rather that through which the quantitative becomes a special quality and thus a remarkable kind of greatness. Each historical age is not only great in a distinctive way in contrast to others; it also has, in each instance, its own concept of greatness. But as soon as the gigantic in planning and calculating and adjusting and making secure shifts over out of the quantitative and becomes a special quality, then what is gigantic, and what can seemingly always be calculated completely, becomes, precisely through this, incalculable. This becoming incalculable remains the invisible shadow that is cast around all things everywhere when man has been transformed into *subjectum* and the world into picture (p. 135).

It is difficult to imagine a more unequivocal example of this qualitative shift brought about by gigantic calculable incalculability than the search for dark matter and dark energy. Both *Dark Universe* and Primack and Abrams' books endeavor to relate awe-inspiring narratives centered around this "remarkable kind of greatness," asserting the importance of multi-billion dollar scientific research projects as keys to comprehending the mysterious "invisible shadow"—in the form of dark substances and forces—supporting the speculative frame of the contemporary cosmological world picture. By attempting to solicit qualitative and emotional responses, they further dissolve dividing lines between poetic, philosophical, mythical, scientific, and even religious impulses by exalting the mystery of the seemingly quantifiable unknown.

5.13 Cartesian Anxiety

Heidegger (1938/1977) points to the Cartesian split as the seminal point at which “truth has been transformed into the certainty of representation,” enabling the “objectification” (p. 127) of the world that was central to the metaphysics of modern science. Descartes’ (1641/1901) *Meditations* was unambiguous about his intention of accomplishing this, stating that he was “convinced of the necessity” of ridding himself “of all the opinions” he had adopted and of “commencing anew the work of building from the foundation” to “establish a firm and abiding superstructure in the sciences” (p. 219).

As disagreements concerning the process of creating and interpreting a scientifically valid “world picture” demonstrate, this “certainty of representation” has been complicated by the ambiguities of visualizing astronomical observations. In particular, the CMB sphere forces a confrontation with both naïve real and dualistic assumptions, indicated by Sweitzer’s (2006) “Mystery at the Edge of the Universe.” Instead of providing an idealized view from nowhere, pushing the desire for an objectified world picture to its extreme, the *Digital Universe Atlas* visualizes the situated, relational nature of all perspectives. In the context of the inevitable centrality of the observer, the *Atlas* visualizes the macrocosmic equivalent of what quantum physicists (Bohr, 1958; Heisenberg, 1958) encountered on the microcosmic scale: the ambiguous boundaries between notions of ‘subjectivity’ and ‘objectivity.’

Ambivalence towards this provocative topic not only permeates debates concerning the epistemological and ontological status of quantum phenomena (Beller, 1999), but also continues to percolate through the contentious disputes between the “two cultures” (Snow, 1959/1993). Yet the Hayden productions’ attempts to sustain the

illusion of an objective ‘Archimedean point’ exemplify how these ambiguities remain unacknowledged within science education and public outreach.

The resultant complications arising from these dualistic stances point to what Richard Bernstein (1983) calls “Cartesian anxiety.” He cites “the problems, metaphors, and questions that [Descartes] bequeathed to us” (p. 16) as the primary constructs permeating modern (and postmodern) science and philosophy, though he acknowledges this did not begin with Descartes. “At the heart of the objectivist’s vision,” he writes, “and what makes sense of his or her passion, is the belief that there are or must be some fixed, permanent constraints to which we can appeal and which are secure and stable” (p. 19).

At the same time, Bernstein (1983) argues, relativists insist on the opposite, that, “no such basic constraints except those that we invent or temporally (and temporarily) accept” (p. 19). From the perspective of Cartesian metaphysics, the empirical observations represented within the *Atlas* cannot be considered the “*real* universe” (Druyen & Soter, 1999, p. 2)—reinforcing the uncanny sense that the actual world of things-in-themselves is forever beyond the grasp of even instrumentally assisted experience. Instead, faith in the firm foundation is placed in the promise of mathematics and computer simulations to represent a true ‘cosmic map.’

Francisco Varela et al (1991) similarly point out that this anxiety affects both objectivist and subjectivist stances. Recalling Heidegger, Varela and his colleagues link these stances through the concept of representation, in which the processes of cognition are seen “either as the ‘projection’ (subjectivism) or ‘recovery’ (objectivism) of the world” (p. 241). They ask:

Why should it be threatening to question the idea that the world has pregiven properties that we represent? Why do we become nervous when we call into question the idea that there is some way that the world is “out there,” independent of our cognition, and that cognition is a re-presentation of that independent world? (p. 133)

Varela et al (1991) challenge the belief that the idea that the world is simply a “projection” of the mind (p. 172)—a tendency, they point out, has continued within “cognitivist” theories of mind derived from computational metaphors (p. 52). The notion of “projections,” as well as the commitment “representationalism,” shows the continued influence of John Locke’s (1706/1856) metaphorical use of the *camera obscura*—with the senses seen as “windows” onto the pregiven external world, projected in the “dark room” of the mind (p. 109) (3.16 Entraining Objectivity).

Examinations of the process by which Descartes arrived at his philosophical insistence on a bifurcation between the inner world of the mind (*res cogitans*) and the outer, physical world (*res extensa*) cast doubt on the presumption that his skepticism derived from a purely rational methodology. James Hill (2006) draws comparisons between Descartes’ first-person meditational form to previous scholastic devotional practices, while Antonio Damasio (1994) argues that Descartes’ imaginings were invariably entangled with somatically-grounded emotions.

Similarly, Bernstein (1983) argues that *Meditations* should properly be read as a “journey of the soul,” a phrase recalling the long history of spiritual and religious practices for imagining ‘flights’ to other worlds (see Chapter 2: Domesticating the Universe and Chapter 3: Globalizing the World). He contends that Descartes’ “search

for a foundation or Archimedean point is more than a device to solve metaphysical and epistemological problems,” but that it “is the quest for some fixed point, some stable rock upon which we can secure our lives against the vicissitudes that constantly threaten us.”

Descartes’ anxiety, Bernstein (1983) argues, stems from his insistence dualistic absolutes. Bernstein calls this insistence the “apparent and ineluctable necessity” to choose between a “grand and seductive Either/Or,” that, “Either there is some support for our being, a fixed foundation for our knowledge, or we cannot escape the forces of darkness that envelop us with madness, with intellectual and moral chaos” (p. 18). In choosing this meditational form, Bernstein suggests, “It is less clear what is the Archimedean point in Descartes’ philosophy—whether it is the cogito or God himself” (p. 16). Considering the embodied and spiritual scaffolding of *Meditations*, it becomes clear that Descartes’ (1641/1901) effort to create a “firm and abiding superstructure in the sciences” (p. 219) was, from its genesis, always a view from somewhere.

Primack and Abrams also challenge Cartesian dualism in their promotion of the mythic possibilities of a geocentric, spherical “view from the center”—but on ethical instead of ontological grounds. Echoing what Koyré (1968) called “the divorce of the world of value and the world of facts” (p. 2) (3.13 Mythologizing Revolutions). Primack and Abrams (2011) credit Descartes with establishing the scientific tendency to “make no claims to authority over anything but the material world” and to “defer to religion in all questions of meaning, value, and spirit.” This “Cartesian Bargain,” they claim, established a “policy of noninterference with religion,” which was “helpful in allowing science to flourish, especially in past

centuries” (p. xiv). They insist, however, that the modern world “can no longer afford to maintain this historical fiction and see fact and meaning as automatically separate” due to the “enormous and pressing global issues that confront us.” Their proposed solution is to “reconnect the two different understandings of the word cosmology—the scientific and the mythic—into one” (p. xiv).

By mythologizing science, however, Primack and Abrams (2011) practically canonize the orthodox Cartesian belief in the rational intellect’s ability to establish a secure ‘Archimedean point’ for the sciences. While their “view from the center” refers to empirical observations, their claim to “humanity’s first picture of the universe as a whole *that might actually be true*” (p. 4) is predicated on correlating theoretical simulations with astronomical observations. These models push cognitivism to its computational extreme, integrating speculations about the behavior of dark matter and dark energy to predict the outcome of cosmic evolutionary processes. Their faith derives from apparent agreements between the computationally augmented *res cogitans* and the technologically mediated *res extensa* of to provide a “lasting foundation for cosmology” (Primack, 2004, p. 1). Like Sweitzer, their philosophical commitment to the ontological split between observational ‘cosmic pictures’ and theoretical ‘cosmic maps’ attests to the continued influence of Descartes’ radical dualism, as rigid distinctions between sensorial and conceptual worlds remain at the philosophical foundation of the “tacit infrastructure of scientific ideas” (Bohm & Peat, 1987/2011, p. 6).

5.14 Objectifying Processes

The Lambda-CDM model quantifies over 95% of cosmic density as unobservable mass and energy, effectively domesticating the universe by objectifying theoretical speculations. So Primack and Abrams (2006) predicate their confidence in the potential of the elusive mystery of these “dark” forces to become a “satisfying world picture” (p. 23) on their faith in the ultimate reality of a transcendent, Platonic world of mathematically quantifiable phenomena. By mythologizing the findings of scientific cosmology, they seek to provide assurances that a true picture of the universe can finally assuage “Cartesian anxiety.” Their effort to definitively quantify uncertainty definitively, however, shares noticeable commonalities with the Hayden’s attempts to convince audiences of the objectivity of the *Digital Universe Atlas*. Both approaches downplay the relativistic contingency and influence of observational systems in favor of mythologizing the objectifying absolutism of an ideal ‘Archimedean point.’

These objectifying tendencies overshadow what Xian Chen (2010) argues was the true “revolutionarily change” of the scientific revolution: the “transformation from object to process concepts” (p. 189). Chen identifies the cognitive ability to understand process concepts as the truly disruptive development of the past few centuries, in contrast to Thomas Kuhn’s (1964) emphasis on abrupt and all-at-once taxonomic shifts of the ‘gestalt switch’ triggered by new object-oriented classifications.

While Kuhn originally claimed that paradigmatic shifts—like moving from a geocentric to heliocentric world system— were “incommensurable” (p. 111-135), Chen (2010) disagrees, arguing “individuals who embrace a system built around a

process concept are able to go back to the system built around an object concept” (p. 190). From this perspective, Chen proposes that the true revolutionary concept of the ‘Copernican revolution’ was Kepler’s move from orbs to orbits, dissolving the ontological certitude of *heavenly spheres* into a view of planetary orbits as dynamic processes. Chen also points to more recent examples, like the nineteenth century replacement of the particle theory to the wave theory of light and the evolutionary insights of the Darwinian revolution (p. 189). Similarly, many of the cognitive techniques discussed previous chapters, including Cusa’s metaphor of the infinite sphere and Galilean and Einsteinian frames of reference, have functioned as thinking tools for shifting away from the “object bias” (p. 182).

Instead of viewing competing paradigms as locked in a battle of incommensurate binary polemics, Chen’s (2010) approach acknowledges that "the world that we live in consists not only in a variety of objects such as planets, molecules and swans, but also in a variety of processes such as orbits, waves, and evolution" (p. 183). Consequently, the arts, sciences, and humanities have explored the implications of the shift to process-oriented sensibilities for over a century. New understandings of dynamic relationality and emergence spawned and transformed many fields of study, including ecology, cybernetics, synergetics, systems theory, complexity science, and evolutionary cosmology (Natural Genesis, 2014). Philosophers have reconsidered fundamental notions of time, novelty, creativity, signification, evolution, consciousness, and the habits, patterns, and cycles of ‘nature’ in light of process-oriented awareness (Rescher, 2000).

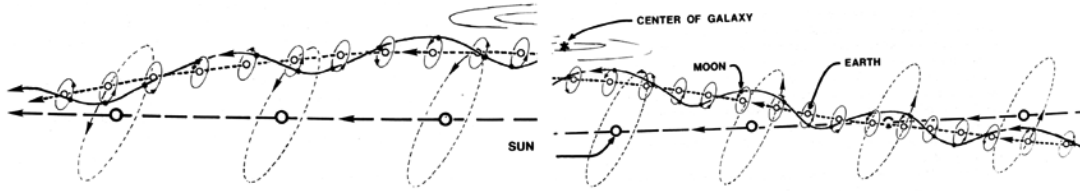


Figure 80 Illustration of spiro-orbital dynamics of the Earth, moon, sun, and galaxy (Fuller, 1975, sec. 1130.24).

R. Buckminster Fuller calls attention to the relevance of process-oriented perspectives for basic conceptions of humanity’s cosmic environment. Fuller (1975) points out that orbital trajectories “are precessionally modulated by remotely operative forces” (sec. 1130.24). In the case of Earth, this is largely due to the gravity of the sun, moon, and galaxy that produce spiralinear paths relative to one another (Figure 80). Fuller argued that it was critical to realize this relational dynamism, extending this awareness to reflexive considerations of his own being:

I live on Earth at present, and I don't know what I am. I know that I am not a category. I am not a thing—a noun. I seem to be a verb, an evolutionary process—an integral function of the universe. (Fuller, Agel, & Fiore, 1970, p. 1)

This is particularly relevant to the current study, since planetary orbits within our local solar system are almost always rendered relative to the Copernican vision of a static sun (3.08 Visible God). Though the sun’s motion was scientifically discovered over two centuries ago, even the *Digital Universe Atlas* continues to visualize this anachronistic view of our local cosmos (Figure 81).

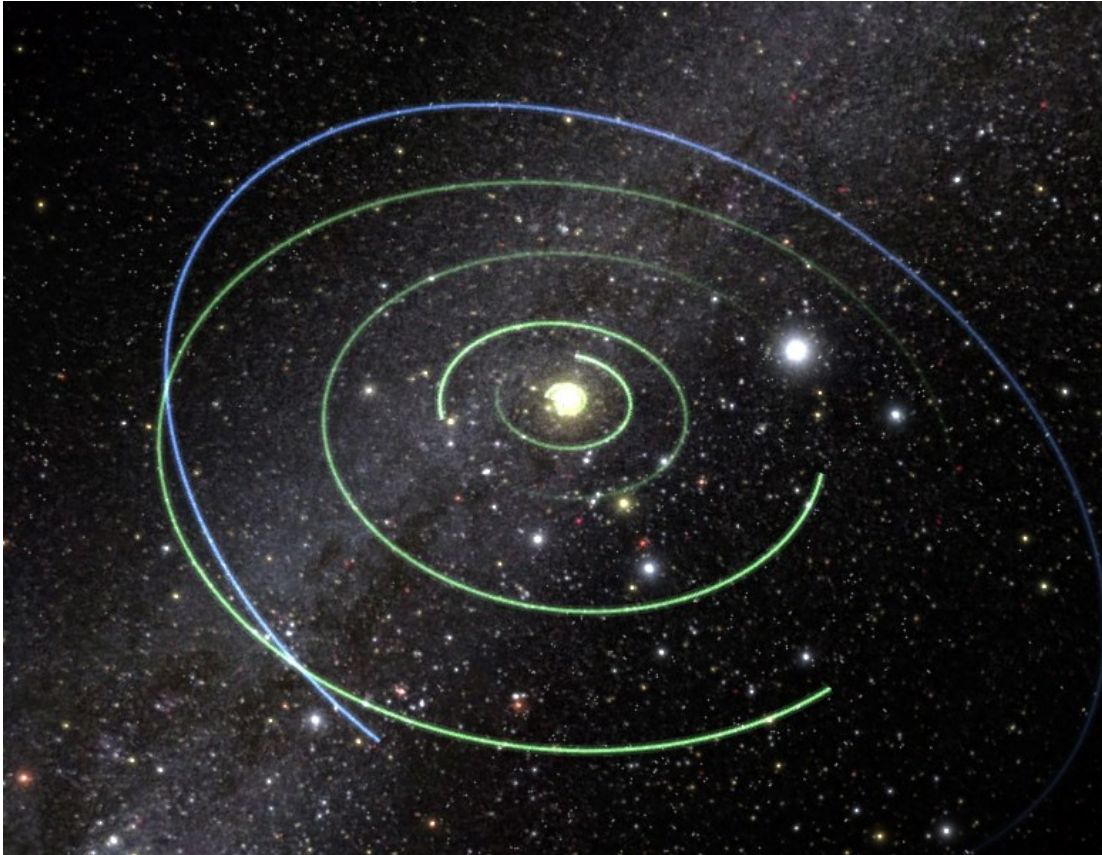


Figure 81. Orbital trajectories relative to a static sun in the *Digital Universe Atlas*. Rendered in Uniview.

Though temporal and relational considerations are central to modern cosmology, the *Atlas*' visualizations are susceptible to overly objectified interpretations. Their apparent stasis can tacitly encourage naïve real views of phenomena—particularly, as Sweitzer warns, the CMB sphere—that are inherently dynamic and relational. In the same way, presenting computer simulations as ‘cosmic maps’ of the ‘perfectly known’ can reinforce popular ‘myth-conceptions’ (see 5.08 Myth-Conceptions) and conceal significant speculative assumptions underlying their creation. This is not to suggest that the Hayden's producers are not fully cognizant of the inherent relationality, dynamism, and speculative nature of their models, but to

point out the potential perils of perpetuating the pretense of a purely ‘objective’ god’s eye view from nowhere (5.06 Viewing from Nowhere).

As Donna Haraway (1988) contends, very few scientists actually believe in the “ideological doctrines of disembodied scientific objectivity,” but these ideals continue to be “enshrined in elementary textbooks and technoscience booster literature” (p. 576). Efforts to paint a “a satisfying picture of the universe” (Primack & Abrams, 2006, p. 23) from an ‘Archimedean point’ undoubtedly stem from worthy intentions to convince the public of science’s ability to secure a foundation of reliable knowledge. However, it can also obscure new—and even centuries-old—scientific insights as well as conceal the inherently situated and process-oriented nature of all perspectives.

5.15 Revisiting the Caves

The Hayden's ongoing objectification of the *Digital Universe Atlas* suggests that the progression of cosmographic practices seem to be more circular than linear. Though video projectors have replaced torches and paint, the perennial impulse to project visions of the heavens within immersive spaces has yielded familiar themes within modern planetariums. These uncanny parallels are not lost on Michael Rappenglück (2007), who argues that ancient sacred caves served even more complex and integrating functions than their modern counterparts:

Because of its archaic and archetypal character some of the ancient ideas are still actual: Planetaria e.g. are multifunctional "dark caves", which map the dome of the sky above the landscape of the location (often other planets—so to speak "other worlds") and permit a view into the universe (at different levels). Among their sky vault magical picture shows and animations, including musical presentations, or meditation sessions and philosophical recitations are performed. They however represent only a profane version of an original sacred world-cave, because they are not regarded anymore as a cosmic womb, a place of initiation and transformation. (p. 247)

However, the narratives of the Hayden's productions—and the writings of Primack and Abrams—suggest otherwise. In mythologizing science, they blur the boundaries between the sacred and profane by promising transformative experiences through connections to the 'real universe.' Within these modern-day 'dark caves,' audiences are initiated into the 'poetic faith' of contemporary astrophysics in a transcendent 'view from nowhere.' The origins and consequences of this belief within

the “tacit infrastructure of scientific ideas” (Bohm & Peat, 1987/2011, p. 6), however, are rarely critically examined or discussed, remaining occluded under the authority of science and the rhetorical power of perceptual immersion.

Pushing the Platonic ideal of transcendence to its perceptual extreme also illuminates its contradictions. The return of the *heavenly sphere* problematizes this ideal by highlighting the paradox of visualizing the “god-trick” (Haraway, 1988, p. 581). In their attempts to explain the CMB sphere, the Hayden’s producers have stumbled upon philosophical conundrums that have troubled the *mental-rational worldview* (Combs, 2009, p. 69) and the *geometric universe* (Harrison, 2003, p. 45) for centuries: the ambiguous relationship between the ideal world of thought and the sensory world of perception.

This situation has come about largely because of the decision to base the *Atlas* on observational data instead of theoretical models. Unlike Plato’s allegorical cave—representing the perils of illusory sense perceptions—the Hayden’s modern cave harnesses the veracity of empirical evidence to enhance verisimilitude of the immersive experience. And when the consequences of this decision are situated within the history of *cognitive cosmographic models*, the Hayden appears to have as much in common with embodied archaic and Hermetic traditions as it does with Platonic abstractions.

In his study of the origins of Western thought, James Luchte (2009) contends nondual integration of ecstatic practices and rational theories were once central to Pre-Socratic cave rituals. He writes that early students of Pythagoras often used caves to “gather together in a community of praxis, cultivating an attunement with the *Kosmos*, as the orchestration of an indigenous unity in the world of the body” (p. 4)

through poetry, song, and mathematics. Dualistic distinctions were only later inserted by Plato's revisions of philosophical history, Luchte argues, reflecting Plato's own "desire to flee from the embodied world of flux, from the unity of opposites." Luchte asserts that Plato's writings embedded "aesthetic prejudices against the body and the sensible world" (p. 3) within Western philosophy, the influence of which continues to the present day.⁶⁸

Peter Kingsley (2003) relates a similar tale in his study of the shamanistic influences on early Greek thought and practices. He argues that Parmenides, widely considered the founder of Western logic prior to Aristotle, has been profoundly misunderstood as a purely abstract thinker. Kingsley contends that Parmenides was in fact an *iatromantis*—a 'healer-prophet' and practicing priest of Apollo—who cultivated the nondual awareness of *mêtis* by consciously using the senses to access the divine—often through transformative rituals within caves.⁶⁹ This embodied wisdom tradition, Kingsley argues, "has nothing to do with ... modern notions of philosophy" (p. 324) and science which continue to be dominated by Platonic ideals about the transcendent rationality of the intellect. Commenting on the lack of transparency concerning this philosophical position, Kingsley writes, "We pride

⁶⁸ Luchte (2009) contends that the effects of Plato's epistemological bifurcation continue to resonate within contemporary 'object-oriented' philosophy. He cites how the 'new' philosophical school of 'speculative realism' subscribes to rigid dualistic assumptions, primarily concerned "a quasi-platonistic, mathematicized methodology as the predominant way to discover truth ('thing without me') within the labyrinth of utter flux and subjectivism in the sensible or apparent world" (p. 4).

⁶⁹ Kingsley (2003) writes, "*Mêtis* was the Greek term for cunning, skillfulness, practical intelligence; and especially for trickery. It was what could make humans, at the most basic and down-to-earth level, equal to the gods...It meant a particular kind of awareness that always manages to stay focused on the whole: on the lookout for hints, however subtle, for guidance in whatever form it happens to take, for signs of the route to follow however quickly they might appear or disappear" (p. 90). In this nondual realization, he contends, "you discover that nothing exists apart from you. There is nothing outside you any more: nothing out there at all. You are everybody, everywhere." (p. 256)

ourselves on being able to separate fact from fiction, science from myth, but don't see that our science itself is what it always has been: a fragile mythology of the moment" (p. 254).

The Hayden's efforts to demonstrate that "science has finally caught up with science fiction" (Boxer, 2000, para. 14) have spectacularly demonstrated how fragile the mythology of the 'Archimedean point' actually is. Through the fusion of immersive virtual environments, observational data, and computer simulations, its productions further blur the already ambiguous boundaries between the real and the ideal, all under the auspices of scientific objectivity. The hybrid physical and virtual immersive environment collapses Plato's "divided line" (trans. 1892, sec. 509d–510a) (3.04 Ambivalence of World Consciousness), integrating the theoretically separate realms of empirical vision, intelligible phenomena, mathematical reasoning, and philosophical theories. The result is an epistemological and ontological amalgam, combining the experiential aspects of archaic and Hermetic cave rituals with the theoretical convictions of Platonic idealism and Cartesian dualism.

The Hayden's Director, Neil deGrasse Tyson, even assumes the role of a modern day priest of Apollo. He regularly performs the function of scientist-shaman by actively promoting the union of science and the senses, advocating scientific understanding as a vehicle for accessing a divine cosmic unity. In addition to guiding initiates through the cosmic mysteries of Lambda-CDM cosmology in *Dark Universe*, he increasingly promotes the transformative potential of attunement to the

scientifically known cosmos across multiple media.⁷⁰ In an interview with *TIME* magazine, he echoes his mentor Carl Sagan's (2011) oft-repeated comment that we are "starstuff pondering the stars" (p. 286), jubilantly proclaiming:

The most astounding fact, is the knowledge that the atoms that comprise life on earth, the atoms that make up the human body, are traceable to the crucible that cooked light elements into heavy elements in their core under extreme temperatures and pressures. So that when I look up at the night sky, I know that we are part of this universe; we are in this universe, but perhaps more important than both of those facts, is that the universe is in us. When I reflect on that fact, I look up . . . many people feel small because they're small and the universe is so big . . . but I feel big, because my atoms came from those stars. There is a level of connectivity. That's really what you want in life you want to feel connected, you want to feel relevant, want to feel like you are a participant in the goings on of activity of events of life around you. That is precisely what we are, just by being alive.⁷¹ (Tyson, 2008)

Like Rappenglück's (1998) descriptions of sacred caves enabling shamans to commune with the potentiality behind phenomena by "travel[ing] to the spheres of the space-time" and communicating with "relatives in the sky" (para. 6), Tyson's

⁷⁰ Tyson's reach extends far beyond the Hayden Planetarium. In addition to his hosting the public television series *NOVA* scienceNOW (PBS, 2005), a video remix of the quote above entitled *The Most Astounding Fact* (Schlickemeyer, 2012) recently went viral, garnishing over 6 million views on YouTube. More recently, he starred in a remake of Sagan's *Cosmos* TV series. The premiere episode was viewed by almost ten million people worldwide.

⁷¹ The similarities of these statements from Sagan and Tyson to Alan Watts' (2000) meditative insight that "you are an aperture through which the Universe is looking at itself and exploring itself" (p. 90) further connect the *Digital Universe Atlas* to *Optical Nervous System*.

cosmic voyager is the platform through which he can visualize processes of cosmic evolution. Nevertheless, his homily of cosmic connection is also fraught with ambivalence. Like Sagan's insistence that the Copernican shift was the first of "great demotions [. . .] delivered to human pride," (Sagan & Druyan, 1997, p. 26), Tyson also perpetuates the Copernican cliché of humanity's 'dethroning' by science. Tyson (2007) writes, "Once Earth no longer occupied a unique place in the cosmos, the Copernican revolution, *based on the principle that we are not special*, had officially begun" (p. 42) [emphasis added]. Though he acknowledges, "the Copernican principle comes with no guarantees that it will forever guide us to cosmic truths" (p. 230), he consistently calls upon the cliché as an existential rhetorical device.⁷² *Dark Universe* (Ferris, 2013) continues to reinforce this trope of cosmic mediocrity, reminding audiences that they are "inhabitants of a small planet" orbiting an "unexceptional star" (p. 2).

Additional historical incongruities of Tyson's narrative emerged in his testimony before the US Senate Committee on Commerce, Science and Transportation. In a speech and written statement, Tyson (2012) insisted that additional funding for NASA was essential for transforming the United States "from a sullen, dispirited nation, weary of economic struggle, to one where it has reclaimed its twentieth century birthright to dream of tomorrow" (para. 28). Attributing the success

⁷² In *Death By Black Hole*, Tyson (2007) continues to insinuate the connotations of geocentrism and anthropocentrism, writing, "While the Copernican principle comes with no guarantees that it will forever guide us to cosmic truths, it's worked quite well so far: not only is Earth not in the center of the solar system, but the solar system is not in the center of the Milky Way galaxy, the Milky Way galaxy is not in the center of the universe, and it may come to pass that our universe is just one of many that comprise a multiverse. And in case you're one of those people who think that the edge may be a special place, we are not at the edge of anything either" (p. 230).

of American dominance to government funding for the Apollo era space program, he argued, “When a nation permits itself to dream big, those dreams pervade its citizens’ ambitions.” But, he warned, without reaching for the stars, the country will “move back to the caves because that is where we are going to end up anyway as the rest of the world passes us by.”

Tyson’s testimony continues the Hayden’s decades-old tradition of promoting human spaceflight as key to the American “idea of progress” (Fay, 1947) (4.04 Race to Space). However, the believability of his narrative relies on the derogatory characterization of Plato’s allegorical cave and the insinuation that primitive cave dwellers are the antiheros of the modern, space-faring human. Yet the parallels between ritualistic caves and contemporary planetariums suggest that the “cave” has long been used as a place for visualizing dreams of transcendence, particularly the Mithraic sanctuaries of ancient Rome (3.06 Hypercosmic Sun). Like the Hayden, these served as *cognitive cosmographic models*, helping to establish and sustain an imperial cosmology by promoting Platonic visions of synoptic command of the world. While the Mithraea were used to unite its members’ souls with Sol Invictus and the stars, the Hayden serves to substantiate the accomplishments of American science and technology to “pervade its citizens’ ambitions” with dreams of infinite expansion.

Throughout its decades of collaborating with the US military-entertainment complex, the Hayden has promoted what Donna Haraway (1988) calls “dreams of the perfectly known in high-technology permanently militarized scientific productions and positionings” (p. 589). Yet, as Haraway cautions, mythologizing this “Star Wars paradigm of rational knowledge” (pp. 589-590) comes at a price. In converging

“science, science fantasy and science fiction,” (p. 596), this “ideology of direct, devouring, generative, and unrestricted vision” (p. 582) occludes the situated complexities of knowledge production (5.06 Viewing from Nowhere). Ironically, this ideology often overshadows the most critical scientific findings about humanity’s cosmic home that emerged from the Space Race of the twentieth century.

5.16 Inverting Heaven



Figure 82. *Earthrise* from Apollo 8 (NASA, 1968) and *Blue Marble* from Apollo 17 (NASA, 1972).

Tyson's (2012) testimony before the US Congress celebrated the successes of the US space program, recounting how they inspired the American public by increasing faith in the power of science and technology. Indeed, the aptly named Apollo missions—honoring the Greek god identified with flight and the sun—were made possible by significant efforts on the part of the US government and the Hayden Planetarium to encourage public interest in space exploration. The Hayden Planetarium's *Symposium on Space Flight*, the collaboration of Walt Disney and Wernher von Braun, the immersive cosmic voyagers at the 1962 and 1964 World's Fairs, and numerous other factors (Launius & McCurdy, 2001; Prelinger, 2010) not only insured public support of necessary funding, but also set the stage for what would become the *de facto* visions of 'outer space' that would come to dominate the public's imagination (4.04 Race to Space).

The resulting accomplishments not only served as inspiring examples of human achievement, but have also provided unprecedented insights into our cosmic and planetary environment. Some of the most significant consequences of the ‘space age’ were largely unintended, made possible by materializing ancient dreams of transcendence. Photographs taken by the Apollo astronauts—particularly the *Earthrise* (NASA, 1968) and *Blue Marble* (NASA, 1972) images (Figure 82)—are widely credited with expanding global environmental awareness.⁷³ Additionally, the launch of Earth-orbiting satellites—instigated by the Cold War provocation of Sputnik—have radically changed perceptions of the world.

Since the launch of Explorer 1 in 1958 to study cosmic radiation, Earth observing systems have enabled scientists to investigate the complex relationships between human activities and Earth’s ecosystems. The expanding global network of satellites has played a crucial role in studying previously invisible interconnections by enabling new forms of “planetary proprioception” (Barasch & Fedorova, 2011). The views from these instrumentally mediated eyes in the sky have contributed to the dawning realization that the health of the planet’s biosphere is inseparable from humanity’s physical, social, and economic well-being. The more the metabolic flows of the planet have been studied from a bird’s eye view, the more apparent the dangers of degrading planetary ecosystems have become.

⁷³ Sheila Jasanoff’s (2001) “Image and Imagination: The Formation of Global Environmental Consciousness,” Denis Cosgrove’s (2001, pp. 257–264) *Apollo’s eye: A cartographic genealogy of the Earth in the western imagination*, and Robert Poole’s (2008) *Earthrise* investigate the history and impact of Earth photographs from the Apollo missions on ‘whole Earth’ discourses.

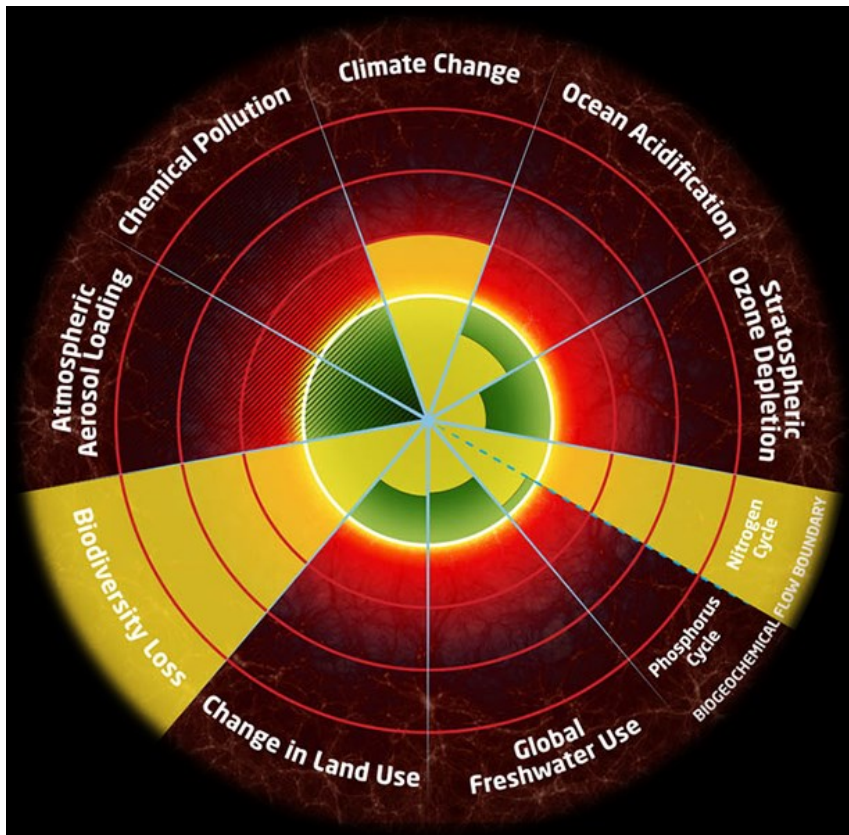


Figure 83. *Planetary Boundaries* framework (Rockström et al., 2009). Illustration by Ingenious Designs.

The recent “planetary boundaries” framework (Rockström et al., 2009) (Figure 83) have recently brought the urgency of this situation to light. Primarily made possible by satellite observations, it quantifies the dynamic relationships between various conditions necessary to support adequately the needs of human civilization. Examining interconnections between land use, freshwater availability, chemical pollutants, biodiversity loss, climate change, and other factors, its authors warn that we are collectively tipping towards the unknown, engaged in a high stakes game of unwittingly crossing the boundaries of social-ecological systems that define the “safe operating space for humanity” (p. 1). Human activities have so significantly impacted the Earth’s biosphere that the current geologic era has been dubbed the *Anthropocene* (Crutzen & Schwägerl, 2011; Crutzen & Stoermer, 2000). Yet the

global neoliberal economic system continues to be predicated on “externalities” and “perpetual growth” (Wijkman & Rockström, 2012, pp. 134, 162), ensuring the consumption of resources faster than planetary systems can regenerate them.⁷⁴



Figure 84. Promotional photograph of Virgin Galactic's *SpaceShipTwo* in a test glide flight (Rose, 2013).

Given the daunting nature of these and related findings, it is little surprise to find so much renewed interest in the possibility of escaping Earth. Numerous billionaire entrepreneurs have taken up this cause, investing heavily in privatized

⁷⁴ According to calculations by the Global Footprint Network (2013), “humanity uses the equivalent of 1.5 planets to provide the resources we use and absorb our waste” (para 1), though consumption rates vary between countries. If the entire planet consumed as much as Americans, humanity would use the equivalent of over 4 planets worth of resources.

space programs that promise a renaissance of human spaceflight (Wall, 2012) (Figure 84). Calls for interplanetary settlements and interstellar travel have also been echoed by scientists (Chang, 2013; Hawking, 2010), journalists (Austen, 2011; Newitz, 2013), science fiction authors (Stephenson, 2011), not-for-profit organizations (SFF, 2014), and federal projects (100YSS, 2014), insisting on the necessity, if not the inevitability, of escaping Earth.

For a generation raised on fantastic visions of conquering space, the logical step after the successful moon landings and the ongoing robotic exploration of Mars appears to be the establishment of human colonies on other worlds. The discovery of planets outside our solar system, which has reached a fevered pitch in recent years, has bolstered the prospects of space colonization. Space-based telescopes have enabled the identification of nearly 1000 ‘exoplanets’ since 1995, which are increasingly portrayed as potential “Goldilocks planets” and “Earth 2.0” (Brownell, 2014; Connor, 2014; Kasting, 2010; O’Neill, 2011). The detection of exoplanets within their solar system’s “habitable zones”—the region around a star with the necessary temperature for liquid water—has fed widespread speculation that there may be “billions of Earth-like planets near Earth” (Speigel, 2013).

Reporting that exoplanets are “near Earth” fails to distinguish between years and millennia or miles and light years. Tacitly implying the possibility of humans traveling to these remote destinations has resulted in significant confusion—what I call the “scalar fallacy”—within the public imagination concerning the practical implications of these findings. This was recently exemplified by a nationally televised American news program reporting on the discovery of a “Goldilocks planet,” during

which the reporter reassured the audience, “It’s just nice to know that if we screw this place up badly enough there is some place we can all go” (Williams, 2010).⁷⁵

In reality, the prospects of actually reaching other habitable worlds in the foreseeable future have diminished beyond the horizon of believability. Reports that “Earth-like planets are much closer than ever before imagined” (Speigel, 2013, para. 2) egregiously misrepresent both historical facts and scientific findings. If anything, stars and exoplanets are infinitely more remote than previously imagined. By way of comparison, the widely accepted distance of the outer *heavenly sphere* in Middle Ages was 73 million miles from Earth (Hetherington, 1993, p. 195), about twice the now-known distance of Mars at its closest point to Earth (Cain, 2013). But the closest possible exoplanets to Earth may be orbiting our sun’s nearest celestial neighbor, Alpha Centauri B. In relating its distance, *Universe Today* (Hall, 2014) recently reported this neighboring star to be “a mere 4.3 light years away...almost close enough to touch” (para. 1) and “likely to be teeming with life” (para. 12). The author doesn’t clarify, however, that a light year is almost 5.9 trillion miles. This places Alpha Centauri B at over 25 trillion miles away from Earth, or the equivalent to 200 thousand times more distant than Mars. Traveling at the speed of the fastest human spaceflight mission thus far (Wall, 2011), it would take over a million years to travel there—over five times longer than *Homo sapiens* have been a species (NSF, 2005).

⁷⁵ NBC Night News’ Brian Williams (2010) reported: “Well you may have heard the news—astronomers are excited because they think they've found a place that could be a lot like home. It's a rocky planet, they say it's about 20 light years away, but that's practically nothing in astronomer terms. And it's more like Earth than anything else found thus far outside our own solar system. That's why this discovery has planet watchers so excited.” After an interview with Neil deGrasse Tyson, Williams continued, “Now astronomers are calling their discovery a Goldilocks planet—not too cold, not too hot, possibly just right to sustain water and perhaps life. And it’s just nice to know that if we screw this place up badly enough there is some place we can all go.” Neither Williams, nor Tyson, clarified the scientific feasibility of humans travelling the distance of 20 light years.

Similarly, claims that exoplanets are “Earth-like” because they might be a similar size or contain liquid water occlude the unexpectedly complex conditions for life discovered since the dawn of the ‘space age.’ For centuries, it was widely assumed that the “plurality of worlds” would be habitable and likely even host other lifeforms (Crowe, 2008). The potential of finding life on Mars was a central motivation in the development of space programs in the twentieth century, a prospect portrayed as all but inevitable by Walt Disney, the Hayden Planetarium, and many others.⁷⁶ But the field astrobiology has since identified numerous contingencies of Earth’s evolution and cosmic ecosystem that were previously unrecognized and requiring far more than a “habitable zone” to support a life-sustaining biosphere (Chyba, 2005; Lovelock & Margulis, 1974; Margulis, 2000; Ward & Brownlee, 2000). Even though the “Drake Equation” (SETI Institute, 2013) is frequently referenced to argue for the theoretical existence of other “technological civilizations that might be among the stars” (para 2), no discernible radio signals indicating ‘extraterrestrial intelligence’ have been detected after decades of scanning the electromagnetic spectrum (Webb, 2002).

⁷⁶ In the introduction to Disney’s *Mars and Beyond* (Kimball, 1957), part of the *Tomorrowland* television series, Walt Disney suggests that, at the minimum, vegetable life would be found on Mars: “In this exciting age when everyone seems to be talking about the future possibilities of space travel, there is much speculation on what we will discover when we visit other worlds. Will we find planets with only a low form of vegetable life? Or will there be mechanical robots controlled by super-intelligent beings? One of the most fascinating fields of modern science deals with the possibilities of life on other planets. This is our story.” This was not an uncommon assumption at the time, as evidenced by visualizations of Martian vegetation and rivers in the *Theater of Time and Space* (Fyfe, 1939) (4.03 Transcending the Firmament). Writing in the journal *Science*, Nobel laureate Harold Urey, one of the founders of modern planetary science, and his student Stanley Miller (1959) wrote, “Surely one of the most marvelous feats of the twentieth century would be the firm proof that life exists on another planet. All the projected space flights and the high costs of such developments would be fully justified if they were able to establish the existence of life on either Mars or Venus” (p. 251).

Hopes of finding life elsewhere are intimately tied to aspirations of escaping Earth. Some scholars have compared these ‘space age’ ideologies to a secular religion, tracing its origins to both the Enlightenment and the culturally dominant force of American evangelicalism (Wilson, 1984, p. 210). Roger Launius (2013), NASA’s former chief historian, refers to human spaceflight as the “incarnation of a new religious tradition” (p. 49) imbued with the “salvation doctrine” that if “humanity does not become multi-planetary, it will not survive” (p. 50). As Launius points out, these aspirations are by no means limited to the United States. Commenting on the religion of spaceflight in the Soviet Union, the Dutch ambassador to Moscow commented, “It is significant that a regime which preaches atheism above all else, cannot do without heaven, in a way” (p. 47).

5.17 Externalizing Epiphanies



Figure 85. Installation of a prototype model of Virgin Galactic’s spaceplane at the AMNH exhibit *Beyond Planet Earth: The Future of Space Exploration* (Redlinski, 2011).

The religious overtones of human spaceflight, as well the continued significance of ancient dreams of transcendence, have been made explicit by the testimonies of astronauts. From the Apollo missions onward, reports of profound psychological and even spiritual transformation have accompanied the descriptions of physically viewing Earth from space.⁷⁷ Dubbed the “overview effect” by Frank White

⁷⁷ Astronaut Edgar Mitchell (2012) was so impacted that he founded the *Institute of Noetic Sciences* (2013) to facilitate research that could help him to understand his experience. The mission of IONS is to support “individual and collective transformation through consciousness research, educational outreach, and engaging a global learning community in the realization of our human potential” (para 1). In the tradition of Parmenides, Mitchell’s epiphanic realization of oneness within the stillness of space can be interpreted his true initiation into the modern priesthood of Apollo. The short film *OVERVIEW* (Planetary Collective, 2012) documents “astronauts’ life-changing stories of seeing the Earth from the outside—a perspective-altering experience often described as the Overview Effect.”

(2012), he describes this experience as a “*cognitive shift in awareness* with a new understanding of humanity and our place in the universe” (para. 3). In his book *The Overview Effect: Space Exploration and Human Evolution*, he (1998) relates these experiences to “spiritual technologies” that “maintain a link to the spiritual experience of the universe, generating a relationship with God, an ultimate oneness, ‘the Universe,’ or ‘System of Systems’” (p. 78).

As a literal and mythical realization of the Apollonian perspective, this god’s eye view has recently become a central selling point of efforts to promote the nascent space tourism industry. Calling it “enlightenment from the final frontier,” White (2012) contends that space tourism could have a potentially “transformational impact worldwide” by inducing a sense of oneness and cultivating holistic, environmental awareness (para. 16). Comparing this to religious and spiritual experiences, he promises that suborbital flights will help humanity “enter a new era in which a renewed faith in the future takes its rightful place alongside more traditional forms of belief” (para 20).

The American Museum of Natural History is once again playing a significant role in promoting this new brand of human spaceflight. A recent exhibit entitled *Beyond Planet Earth: The Future of Space Tourism* (AMNH, 2011d)—sponsored by defense contractor Lockheed Martin—features scale models of private spaceplanes (Figure 85) alongside interactive exhibits that enable visitors to terraform a model of Mars. In “Oh, the Places We Could Go,” *New York Times* reporter Dennis Overbye (2011) praises the exhibit’s revitalization of space-faring visions, writing, “The world sorely needs some kind of cosmic blueprint going forward, if indeed we are to go

forward and outward, and though one can quibble with many details, this one is as good as any” (para. 7).

Both White and the AMNH exhibit, however, fail to address the dark side of these high hopes for rocket-propelled consciousness transformation. The US\$250K price tag isn’t the only expense for a few minute suborbital joyride in simulated microgravity (Virgin Galactic, 2014). To achieve its peak altitude of 68 miles (DVICE, 2010), Virgin Galactic’s SpaceShipTwo burns a rubber-based ‘hybrid’ rocket fuel of nitrous oxide and a solid synthetic rubber that emits black carbon pollutants when combusted. Due to the lack of wind currents and precipitation at this height, these flights would create a persistent layer of particulate matter in the stratosphere. Global atmospheric simulations suggest that if the industry hits its goal of a 1000 flights a year using this type of fuel, it could double the current greenhouse effect contributed by the entire current subsonic aviation industry. These computer models imply that the success of Virgin Galactic would radically alter ozone abundances and increase polar surface temperatures by 1°C within a decade (Ross, Mills, & Toohey, 2010).⁷⁸

By seeking the thrill of the Apollonian perspective, ‘space tourists’ threaten to become a significant exacerbating factor in transgressing the “safe operating space for humanity” (Rockström et al., 2009, p. 1)—an understanding that has been made

⁷⁸ The article *Space Tourism to Accelerate Climate Change* (Mann, 2010) in the journal *Nature* summarizes a report from *Geophysical Research Letters*: “[E]missions from 1,000 private rocket launches a year (using “hybrid” fuels) would persist high in the stratosphere, potentially altering global atmospheric circulation and distributions of ozone. The simulations show that the changes to Earth’s climate could increase polar surface temperatures by 1°C, and reduce polar sea ice by 5–15%” (para 2). Companies other than Virgin Galactic use liquid hydrogen and oxygen as a propellant, emitting mainly water and some nitric oxide, though studies of their potential impact have yet to be published in peer-reviewed journals (Toohey, 2010).

possible by ‘space age’ science. Promoting the “overview effect” as a means to cultivate environmental awareness may, ironically, be one of the quickest paths to destabilize planetary life support systems (Babones, 2012). At this rate, dreams of colonizing ‘outer space’ predicated on the “salvation doctrine” that humanity’s only prospects for survival involves abandoning Earth could rapidly become a self-fulfilling prophecy (Austen, 2011; Chang, 2013; Hawking, 2010).

The failure of an exhibit at a natural history museum to acknowledge the ecological consequences of space tourism, in addition to the glaring miscalculations in the presumptions of inhabited worlds, attests to the persistent power of the mythologized ‘flights’ to outer space. Dreams of transcendence and escape—whether driven by yearnings for epiphanic unity or doctrines of salvation—continue to materialize within an ambiguous realm between science and science fiction, militarization and mythologization. The American Museum of Natural History’s progressive “cosmic blueprint” for traveling “forward and outward” serves as a particularly poignant example of the dangers of uncritically promoting fantasies fueled by the fumes of twentieth century heroic visions of human spaceflight.⁷⁹

⁷⁹ Billionaire engineer Elon Musk (2013) states that the desire to start a self-sustaining human civilization on Mars was the inspiration for founding his rocket company SpaceX. He cites his disappointment in the lack of progress since the Apollo space program, but that America is a “nation of explorers” that has not lost the will to move beyond the moon. He states, “We don’t just want to have flags and footprints and then never go to Mars again. If we just have one mission...it’s not going to fundamentally change the future of humanity.” Though he states that living on Mars is “the relatively easier thing” to getting there, he doesn’t mention how self-contained biospheres will work or how many people he anticipates living there. *Life Under Glass: Inside Story of Biosphere 2* details the challenges of creating and living within a self-contained environment (Nelson & Alling, 1993). Additional publications about closed biospheres are available from the *Institute of Ecotechnics* (2014).

5.18 Marketing Mediocrity

The desire to escape to other worlds—and the concomitant faith in extraterrestrial life—are often assumed to be a universal human trait. They seem, however, to have emerged from the contingent—and primarily European—histories. Jean Schneider (2009) traces the origins of beliefs in other habitable worlds and the question “Are we alone?” to ancient Greece, which seeded subsequent developments in Europe that produced an ever-increasing sense of separation (see Chapter 3: Globalizing the World), or what he calls “distantiation” (p. 12). Like Remi Brague’s contention that the notion of the *kosmos* emerged from the distanced position of Plato’s demiurge, Schneider identifies strands within Greek philosophy enabling the conceptual abstraction of “life” away from “the living beings with which we have personal relationships” (p. 12).⁸⁰ Euclid’s geometrical homogenization of space enabled further distance, which laid the conceptual foundations for later Renaissance rationalizations of linear perspective. It was from this critical distance of this imaginary god’s eye view—perhaps assisted by the Pantheon—that Copernicus could envision a new cosmic order in which the sun became the central “lantern of the universe” (3.08 Visible God).

The consequences of elevating Earth to the status of a planet, combined with Cusa’s infinite sphere, Kepler’s orbits, Galileo’s telescope, and other factors gradually dissolved the ontological boundary between the heavens and Earth of the Aristotelian cosmos in the European imagination. As the “immune system”

⁸⁰ See 2.03 Cognitive Cosmographic Models for a discussion of Rappenglück’s (2009a) writings about the lack of separation between living systems and the human lifeworld within early cosmovisions.

(Sloterdijk, 2011, p. 23) of the *heavenly spheres* disappeared, the elemental corruptibility of Earth spread throughout a seemingly infinite universe. But this new sense of “psychic homelessness” (Chowers, 2004, p. 106) (3.15 Quantifying the Uncanny) was assuaged by an ever-increasing faith in the inevitability of the “plurality of inhabited worlds” (Grinspoon, 2003, p. 19). If Earth was just another planet, the reasoning went, why wouldn’t there be life everywhere?

The so-called “Copernican principle” gradually took hold, based on the idea that “the Earth is not in a central, specially favored position” (Bondi, 1952/2011, p. 13). It is predicated on the discovery that the universe appears to be physically isotropic and homogenous—natural laws and elemental distribution are the same everywhere, in all directions—in contrast to the Aristotelian distinction between the corruptible Earth and eternal heavens. This principle should more rightly be attributed to Nicolas of Cusa (3.11 Infinite Sphere), who deduced the possibility of a plurality of worlds based on his intuition of an isotropic cosmos. In contrast to Copernican objectification of centrality, the more nuanced Cusan perspective acknowledges the paradox of a relative center within notion that the center is everywhere and nowhere simultaneously. This view aligns more with the contemporary understanding of relativity (5.03 Relativistic Effects), acknowledged within the *Dark Universe* (Ferris, 2013) as “every galaxy occupies the center of its *own* observable universe” (p 8).

Variations on this principle are sometimes simply called the “cosmological principle,” frequently cited as *the* foundational insight of modern science and the most significant outcome of the scientific revolution. This is sometimes used to justify the so-called “mediocrity principle,” a central philosophical assumption of the Copernican cliché that “you aren’t special” and “the universe does not revolve around

you” (Myers, 2012). This philosophical stance, along with the tropes of “decentering” and “dethroning,” are habitually called upon as counterpoints to perceived religious naïveté and hubris that continue to be associated with beliefs in an Aristotelian, geocentric cosmos.⁸¹

The spherical, geocentric appearance of the *Digital Universe Atlas* from a virtual ‘Archimedean point,’ however, conspicuously problematizes this simplistic narrative. Its “observational center” demonstrates that, from a relativistic perspective, Earth actually *is* the center of humanity’s universe. But it can also be considered a different—and in every respect, more urgent—kind of center. The quest for extraterrestrial life and inhabited worlds produced a radically refined scientific appreciation for the requirements necessary to support the evolution and persistence of a robust planetary biosphere. When we take these findings into account, the most unanticipated—and existentially profound—scientific discoveries of the ‘space age’ pertain to the complexity of synergistic interactions required for the evolution of complex living systems. Far from mediocre, these conditions can’t be taken for granted. From this perspective, Earth should be recognized not just as the

⁸¹ In *This Will Make You Smarter: New Scientific Concepts to Improve Your Thinking*, PZ Myers (2012) writes that the mediocrity principle is “fundamental to science” and is “also one of the most contentious, difficult concepts for many people to grasp.” He claims that, “opposition to the mediocrity principle is one of the major linchpins of religion and creationism and jingoism and failed social policies,” and that acceptance of it would dispose of many “cognitive ills.” Myers continues, “The mediocrity principle simply states that you aren’t special. The universe does not revolve around you; this planet isn’t privileged in any unique way; your country is not the perfect product of divine destiny; your existence isn’t the product of directed, intentional fate; and that tuna sandwich you had for lunch was not plotting to give you indigestion. Most of what happens in the world is just a consequence of natural, universal laws—laws that apply everywhere and to everything, with no special exemptions or amplifications for your benefit—given variety by the input of chance. Everything that you as a human being consider cosmically important is an accident” (p. 6-7). This is more subtly referenced in the line from *Passport to the Universe* (Druyen & Soter, 1999): “There comes a time in each of our lives when it first dawns on us that we are not the center of the universe” (p. 1).

observational center, but also the *ecological center* of humanity's cosmos since it is the only known place that supports life.

Nevertheless, the continued uncritical conflation of *geocentrism* with *anthropocentrism* remains a tacit fixture within popular science communication, occluding the most significant findings of twentieth century science. Ironically, however, an examination of the transference of a quantitative hypothesis (isotropy) to a qualitative judgment (mediocrity) reveals a peculiar, and telling, inversion. In reviewing the actual consequences of the dissolution of the *heavenly spheres*, it was heaven—not Earth—that lost its specially favored position in the European imagination (3.14 Promoting Demotion).

The most pronounced anthropocentrism was not the medieval belief in an Earth-centered universe, but the hubristic presumption that the human intellect—whether Descartes' *res cogitans* or Kant's *noumena*—is independent of its embodied, symbiotic relationship with Earth's biosphere. Dreams of dominating nature and colonizing space too often disregard the significance of Earth as the elemental ground of being for human and more-than-human life. As the Copernican shift has been mythologized as 'dethroning' Earth and humanity to support the progressive narrative of a radical break between pre-modern and modern worlds, it has produced a significant historical irony. Faith in the promise of science and technology has replaced the salvation of Christianity as the epiphanic vehicle for Platonic transcendence to the heavens and escape from the 'cave' of a corruptible, mediocre Earth.

Conclusion

As the Hayden Planetarium pushed the Western dream of the ‘Archimedean point’ to its logical extreme, it has also demonstrated the inherently situated nature of all perspectives. The return of the *heavenly sphere* in the form of a cosmic microwave background survey has enacted tensions among the *Digital Universe Atlas*’ creators. An analysis of its interpretations reveals the complexity of attempts to visualize contemporary cosmological theories, including conflicting messages concerning the ability of scientific cosmography to visualize the *real* universe. Attempts to increase ‘poetic faith’ in the objectivity of the *Atlas* are contradicted by the dualistic distinction between ‘cosmic maps’ and ‘cosmic pictures’ that cast doubt on the *Atlas*’ ontological validity. Though these disagreements have arisen from the objectification of dynamic and relativistic processes, the Hayden’s *Dark Universe* begins to address issues of lookback time, visible horizons, and the centrality of observations. However, this process also necessitated a series of increasingly complex maneuvers to perpetuate the impression of a god’s eye view from nowhere, collapsing the distinction between observational data and theoretical simulations.

Furthermore, when these efforts are situated within the history of *cognitive cosmographic models*, many commonalities between this modern planetarium and its ancient predecessors come to light. Just as ancient caves facilitated imaginative ‘flights’ to other worlds, the Hayden Planetarium fuses science and science fiction to create rituals of cosmological indoctrination. Yet the persistent influence of the Copernican cliché, conflating *anthropocentrism* with *geocentrism*—including tropes of ‘dethroning,’ ‘decentering,’ and ‘mediocrity’—tacitly perpetuate intellectual and physical ‘distantiation’ of humans from Earth’s biosphere. The configuration of the

Digital Universe Atlas complicates this modern mythology, providing a reflexive reminder that Earth is not only the *observational center* of humanity's universe but also its *ecological center*.

Though the search for habitable planets has demonstrated that the conditions for life are far more complex than previously assumed, this realization is frequently occluded by progressive narratives perpetuating the Platonic ideal of transcendence to the heavens from the 'cave' of a corruptible, mediocre world. The next chapter develops an alternate interpretive approach, expanding beyond naïve real and dualistic interpretations to examine the complex knowledge production processes from which the *Atlas* emerged.

Chapter 6: Visualizing World Views

*“If you’d look at nature truly
One as all examine duly!
No thing’s inside, outside neither:
In is out and both are either.
Grasp it quick, let nought confound you,
Sacred secret all around you.”
(Goethe, 1819/1998, p. 127)*

Introduction

This chapter describes the motivations, practical strategy, and theoretical frameworks informing my efforts to expand interpretations of the *Digital Universe Atlas* beyond naïve real and dualistic perspectives. It details findings that have emerged from an iterative research process, integrating multiple methodologies that transcend disciplinary boundaries (see Motivation, Aims, and Methods in the Introduction). This has required becoming familiar with scientific, technical, and artistic aspects of the *Atlas*’ construction as well as the cultural beliefs and material practices that shaped its creation. Whereas previous chapters provided historic and theoretical reviews to demonstrate the significance of the different intonations given *heavenly spheres* across time, the strategies described here have been developed as practical interpretive heuristics to guide my *cosmotroping* practice. I first review philosophies and fields of study developing complex, paradoxical, and multi-perspectival epistemologies. I then discuss the rationale for using immersive visualization environments as postphenomenological ‘third spaces’ within which they can be applied in examinations of the *Atlas*. This chapter concludes with a description

of *cosmographic hermeneutics*, the system of visual heuristics used during my *cosmotroping* performances to facilitate interactive interpretations of cosmic models from transdisciplinary *world views*.

6.01 Looking In from the Outside



Figure 86. *The Treachery of Cosmography* (McConville, 2009b).

Throughout this investigation, I have endeavored to demonstrate how the interpretations of the *heavenly spheres* have enacted and shaped visions of the cosmos. Though domes and spheres have been a lifelong fascination, it wasn't until I saw the spherical *Digital Universe Atlas* from the 'outside' during *Bok Globule* (see the Prologue) that it dawned on me to investigate this elusive trope (Figure 86). The description of the CMB sphere as a consequence of measuring the finite speed of light from humanity's 'observational center' raised many questions, particularly concerning the nature of the boundary between the 'internal' world of observers and the 'external' world of their observations. In this way, this virtual cosmic model

seemed to scientifically visualize to the central motif of my film *Optical Nervous System* (McConville, 2004a)—in the words of Alan Watts, “all that you see is a state of affairs inside your head.”

The ambiguous configuration of the *Atlas* intimated an ambiguous situation that defied dualistic ‘objective’ and ‘subjective’ interpretations. Though it had been rigorously assembled from peer-reviewed datasets generated by empirical astronomical surveys, these were invariably shaped by the time, place, and configuration of the observing systems. The *Atlas* not only visualized data from a worldwide scientific research community, it also virtually embodied aesthetic decisions, cultural influences, and the limits of observation. The extent and complexity of these converging influences, however, only became apparent from the perspective beyond the outer boundary of the CMB sphere.

My previous work with different cultural cosmologies and epistemologies (see the Prologue) drew my attention to the intriguing recursivity and historic irony of viewing the observer-centric *Atlas* from the ‘outside.’ From the perch of the virtual ‘Archimedean point,’ the “most complete and accurate 3D atlas of the Universe” (AMNH, 2011c) provided a macrocosmic demonstration of the inherently situated nature of all observations—this “view from nowhere” (Nagel, 1986) showed that “every view is a view from somewhere” (McPherson, Rabb, & Weaver, 2011, p. 20). I regard this encounter as my personal ‘gestalt switch’ (1.04 Gestalt Switching), during which my experience of this “mystery at the edge of the universe” instigated the many “boundary questions” (Sweitzer, 2006, p. 15) at the heart of this investigation. Though I was quite taken with the awe-inspiring elegance of Emmart’s expert guided tours, I became convinced of the need to develop a transdisciplinary

strategy for expanding interpretations of the *Atlas*. I found out later that this intuition was resonant with Sweitzer's recommendation that the CMB sphere be used to demonstrate the "limits of common sense" and to "develop an understanding of the use of scientific models" (p. 13).

This experience also shed light on another respect in which I was looking in from the outside. Primarily educated in the liberal arts, I was witnessing Emmart's tours as a scientific neophyte. With limited knowledge of astrophysics and scientific cosmology, I was largely unfamiliar with the theories and practices that had given rise to the CMB sphere and the observational center. At the same time, however, I was also a literal and figurative 'insider.' By participating in the installation as both an artist and technologist, I was partly responsible for the development of the environment within which we were immersed. I was paradoxically 'outside' and 'inside' at the same time, a position that paralleled the conundrum of the CMB sphere and further piqued my interest in engaging the questions provoked by the experience.

6.02 Starting with Universe

Witnessing the *Atlas*' remarkable configuration during *Bok Globule* triggered my curiosity concerning why it had previously been concealed within the Hayden Planetarium's pre-rendered productions—and by extension, many questions concerning the unexamined assumptions of modern scientific cosmology. After *Burning Man*, I discovered that the relationship between cosmological visions and paradigmatic beliefs is a key topic within sociological and anthropological studies on the history of science (Blumenberg, 1989; Harrison, 2003; Koestler, 1959; Koyré, 1968; Kuhn, 1957, 1964; Roepstorff et al., 2004; Toulmin, 1982; Toulmin & Goodfield, 1962). Primack and Abrams (2006) go so far as to refer to cosmologies as “thought-control systems that can have a dark side of limiting both imagination and membership” (p. 71). However, literature within the highly specialized field of ‘precision cosmology’ rarely explicates or reflexively examines the tacit philosophical beliefs from which the *Atlas* emerged.

When I encountered Primack and Abrams' (2006) acknowledgement of the “view from the center” and “cosmic spheres of time” (p. 133), their proposed synthesis of scientific and mythological aspects of cosmology appeared to offer a promising strategy for examining these beliefs. Their dream of unification—and their expressed desire to re-integrate facts and meaning—seemed to be in alignment with my own goals. Yet upon closer inspection, I realized their proposals were predicated on distinctions similar to Sweitzer's ‘cosmic maps’ and ‘cosmic pictures’ (5.02 Cosmic Tensions). In their attempts mythologize the findings of scientific cosmology, they retain a dualistic faith in the ‘Archimedean point’ to yield an objective view of the cosmos “*that might actually be true*” (p. 4). In the process, they also fail to

address how “a satisfying picture of the universe” (p. 23) might functionally tackle what many consider to be *the* central challenge facing efforts to deal with complex problems: the extreme fragmentation of knowledge resulting from disciplinary specialization.⁸²

As the scale and scope of seemingly intractable “wicked problems” (Kolko, 2012; Rittel & Webber, 1973) have become increasingly apparent in recent decades (5.16 Inverting Heaven), so too has acknowledgement of the need to develop comprehensive strategies for understanding interconnected issues within a cosmological context. Efforts to re-consider the ‘big picture’ context informing educational paradigms have occurred under the rubrics of *transdisciplinary research* (Brown, Harris, & Russell, 2010; Hadorn et al., 2008; Hodgson, 2012; Nicolescu, 2002) and *transformative learning* (Mezirow, 2012; O’Sullivan, 1999; Sterling, 2003, 2011; Taylor & Cranton, 2012). These fields seek to explicitly illuminate the paradigmatic assumptions operating within academia to determine their origins, efficacy, utility, and limitations in hopes of identifying strategies to address the root causes of planetary challenges.

I also found that these concerns directly intersect with my research into the history of domes and spheres within the work of R. Buckminster Fuller (4.05

⁸² The severity of this problem became evident when I was invited to the Hayden Planetarium in November of 2011 to meet with the producers of a new production about the history of cosmology (later released as *Dark Universe*). When I asked how far back they were tracing this history, I found they considered its origins to be in the 1920s—i.e. referring exclusively to birth of “precision cosmology” (Guth, 2002; Primack, 2004). As I probed further, I also discovered that none of the producers were familiar with Thomas Kuhn’s (1964) *Structure of Scientific Revolutions*. Considering the seminal importance of this book within scholarly studies of the history of science and Western cosmology, this was a particularly relevant example of the perils of extreme disciplinary specialization. Though admittedly anecdotal, this situation spoke volumes about the urgent need to facilitate transdisciplinary collaborations for connecting pertinent ideas that may be missed due to knowledge fragmentation.

Pedagogical Yearnings).⁸³ Fuller (1969a) was a prolific advocate of situating problem solving within a cosmic context, asserting, “If we could start with Universe, we would automatically avoid leaving out any strategically critical variables” (p. 60).⁸⁴ Fuller (1975) arrived at his geodesic dome design as a practical application of principles operating within what he called “eternally regenerative Universe” (sec. 304.00), an understanding of which he claims is key to optimizing the conditions for life on Earth. He exhaustively details the necessity of designing for emergent and synergistic interactions of cosmic and planetary ecologies, the consequences of which, he argues, entail no less than prospects for humanity’s survival (Fuller, 1969b).

Fuller argues that the tendency towards disciplinary hyperspecialization precludes comprehensive understanding of critical cosmic and evolutionary contexts. In the aptly named *Cosmography: A Posthumous Scenario for Humanity*, Fuller (1992) writes that “institutionalized catering to want and suffering gives us a sense of the almost certainly fatal dilemma we are in” (p. 249). Citing “world education systems’ deliberate cultivation of specialization,” (p. 249), he contends that the “self-perpetuating...disease of specialization” stems from “interdepartmental battling for

⁸³ I discovered connections to my own work when preparing the presentation “Making the Invisible Visible: Buckminster Fuller and Immersive Media Environments” (McConville, 2005). This catalyzed an interest in Fuller that led to my joining the Board of the Buckminster Fuller Institute in 2008. I have served as President and Chairman since 2011.

⁸⁴ In his *Synergetics: Explorations in the Geometry of Thinking*, Fuller (1975) defines “Universe” as “the aggregate of all humanity’s consciously apprehended and communicated nonsimultaneous and only partially overlapping experiences” (sec. 301.10). In contrast to the Platonic and dualistic traditions ontologically prioritizing transcendence and mathematical abstraction, Fuller envisioned the universe as an integrated whole. He summarized this with his pithy generalization $U=MP$, “standing for an eternally regenerative Universe of M times P, where M stands for the metaphysical and P stands for the physical” (sec. 162.00), indicating the complex unity of the weightless “metaphysical” human intellect and the “physical” material world.

educational funds and the concomitant jealous guarding of the various specializations assigned to a department's salaried experts on each subject in any university” (p. 251). The “narrow professionalism” fostered by these institutions, “together with the “power structures of big money, big religion, and big politics,” Fuller argues, continue to frustrate human comprehension of synergistic design strategies based on “millions of years of trial-and-error striving” (p. 103). Through his numerous artifacts and initiatives, Fuller consistently demonstrated the utility of transdisciplinary approaches to intellectually and experientially “ascertain and comprehend the generalized design principles” (p. 249) functioning within the evolutionary patternings of the cosmos.

6.03 Transcending Dualities

Throughout this research, I have consistently encountered the challenge of overcoming the perceived limitations and divisions imposed by habituated dualistic ways of thinking—a concern I have discovered is shared by many researchers developing interdisciplinary, transdisciplinary, and mixed methodological approaches (Foshay, 2012; Johnson, 2009; Nicolescu, 2002). Many of these efforts to transcend disciplinary boundaries draw attention to the necessity of addressing entrained habits of linear and dualistic thought. Though Kuhn (1964) insisted that different paradigms represent “incommensurable ways of seeing the world” (p. 4), these efforts advocate for a more process-oriented understanding to cultivate alternatives to dominant logical, epistemological, and ontological assumptions (5.14 Objectifying Processes).⁸⁵

Stephen Toulmin (1972) challenges Kuhn’s assertion, contending that paradigmatic change is more evolutionary than revolutionary (p. 105) (3.13 Mythologizing Revolutions). Toulmin also echoes Fuller’s concerns, arguing that a transdisciplinary approach to cosmology could yield fruitful discourses that have been largely precluded from science and academia since the mid-nineteenth century. In

⁸⁵ As John van Breda (2008) summarizes in “Overcoming the Disciplinary Divide: Towards the Possibility of a Transdisciplinary Hermeneutics”: “[I]f the overcoming of disciplinary boundaries is a necessary prerequisite for finding sustainable solutions to complex planetary problems, then we cannot merely assume that a trans-disciplinary dialogue will emerge when the different disciplines come together to look for solutions. On the contrary, after centuries of epistemological, methodological and institutional fragmentation it becomes increasingly important to explicate the hermeneutical possibility of such a trans-disciplinary dialogue between the different disciplines. In other words, gaining conceptual and theoretical clarity on how shared understanding between the disciplines may emerge can play an important role in actually achieving this common ground. It is then in this sense of a dynamic interplay between theory and praxis that the hermeneutics of a trans-disciplinary dialogue between the different disciplines should be seen as a *sine qua non* for the conceptualisation of a ‘sustainability science’. Without understanding how the different disciplines are to communicate and develop a shared understanding of the complex world and its complex problems, it remains highly improbable, if not impossible, to imagine the meaning and establishment of a ‘sustainability science’” (pp. 92-93).

contrast to Primack & Abrams' faith in the power of a science-based mythology, Toulmin (1982) seeks to understand "the preconditions on which a science-based cosmology [is] *possible at all*," calling for the creation of a "middle way" (p. 12) between skepticism and credulity as well as science and theology. "We cannot afford to embrace the results of all the specialized scientific disciplines naïvely and uncritically," Toulmin writes, "but neither can we dismiss them as completely irrelevant, in principle, to the whole cosmological project" (p. 12).

Toulmin's notion of a 'middle way' has deeply informed this current study as I have sought to identify philosophies and methodologies working to transcend habituated dichotomies. For instance, I have integrated the "antidualistic and syncretic philosophy" (Johnson, 2009, p. 449) of mixed methods research, which seeks to transcend the "either/or logic" to "advocate thinking in terms of continua on multiple philosophical and methodological dimensions" (p. 451) (see Motivation, Aims, and Methods in the Introduction). Tensions arising from presumed dichotomies continue to permeate academic discourse and methodological approaches, made evident by ongoing debates between materialism and idealism, empiricism and rationalism, naturalism and humanism, objectivism and relativism, theory and practice, and quality and quantity (B. Johnson & Gray, 2010, p. 71). I have explored this 'middle way' through my performative practice to cultivate a more dialectical than divisive approach when interpreting the *Atlas*.

Alfred North Whitehead (1933/1967) points to the deep philosophical roots of these entrained thinking habits, asserting that, "modern scholarship and modern science reproduce the same limitations as dominated the bygone Hellenistic epoch, and the bygone Scholastic epoch." He insists that these unexamined conventions

“canalize thought and observation within predetermined limits, based upon inadequate metaphysical assumptions dogmatically assumed” (p. 122). Similarly, Graham Priest (2006a) similarly traces the habituated dualistic assumptions to the denial of contradictions within Aristotle’s system of logic:

It is fair to say that, at least since the Middle Ages, Aristotle’s views concerning contradiction have been orthodoxy. (This is so obvious, that it is hardly worth documenting.) They are taken for granted so much that, as far as I know, there is no sustained defence of the LNC [Law of Non-Contradiction] in Western philosophy other than Aristotle’s. Why? I really don’t know. It is certainly not because of the rational persuasiveness of Aristotle’s arguments. I suspect (unhappily) that the view was accepted simply on the basis of the magisterial authority of Aristotle’s texts in the Middle Ages. In general, that authority disappeared long ago, of course. In logic it hung on till the twentieth century; most of it there has been swept out since then, but the views about contradiction have hung on doggedly (p. 121)

As this ‘classical’ logic has continued to inform the foundations of both modern and postmodern Western thought, its practical limits and methodological consequences of this have been the subject of considerable analysis (Korzybski, 1933; McNiff, 2013; Priest, 2006b). Numerous authors express deep concern that rigidly dualistic epistemologies tend toward knowledge fragmentation through attempts to reduce the complexity of the world by seeking categorization instead of relational understanding. Basarab Nicolescu (2002) identifies the quest to resolve contradictions as the central enabler of the “disciplinary big bang” in the twentieth century, resulting

from strategies to segment knowledge into ever-increasingly siloed disciplines. He contends that dualistic logic reinforces unsustainable “rigid norms of truth,” enabling individual disciplines “to pretend to entirely contain all knowledge within its own field” (p. 33). As a result, he asserts, the “relentless specialization” (p. 41) of academic knowledge systems often occlude the “multi-dimensional complexity” (p. 37) of challenges facing humanity.

To overcome these reductionist tendencies, Nicolescu (2002) proposes what he calls the logic of the “included middle” (p. 28) that, like Toulmin’s ‘middle way,’ acknowledges paradoxes that emerge when considering problems and phenomena from multiple perspectives instead of assuming rigid polarities. Similar to Chen’s emphasis on the ability of process-oriented paradigms to integrate object-based understanding, Nicolescu contends that the transdisciplinary frameworks can use classical logic while also recognizing its limitations (p. 44). In this context, the emergence of ‘unity’ is not contingent on a shared origin story or belief in a common cosmology, but derives from an awareness of the inherent interconnectedness and complexity of recursive relationships between presumed dichotomies. Notions of subject and object, observer and observed, order and disorder, parts and wholes, thinking and doing, mind and body, and culture and nature enter into dialectical relationship instead of mutually exclusive opposition (van Breda, 2008, p. 94)—what Nicolescu (2002) metaphorically refers to as “two ends of a stick” (pp. 23-26) that can never be separated.

6.04 Thinking the Complex

Edgar Morin (2008) similarly acknowledges the value of classical logic while also stressing the urgency of taking into account its *de facto* limitations (p. 6). He asserts the necessity of ‘thinking the complex’ by moving beyond binary distinctions to recognize the importance of pluralistic perspectives. Unlike the presumed incommensurability of the Kuhnian notion of paradigms, Morin’s (2008) “paradigm of complexity” seeks to dialogically conceptualize the recursive and “polyrelational” (p. 102) interdependencies among seemingly contradictory perspectives and points of view. He contends that it is necessary to integrate the findings of both holism and reductionism to recognize the complex relationships that support complex living systems. Like Fuller’s focus on synergistic principles, Morin argues that emergent properties of complex systems are inversely proportional to entropy and are often fundamentally unrecognized specialized and reductionist approaches (p. 14).

The continued influence of rigid dualistic assumptions has also been identified as a significant obstacle within efforts to develop ‘transformative’ educational strategies. In seeking to overcome excessive fragmentation and institutional myopia, these transdisciplinary approaches recognize the context-dependent and enactive nature of knowledge and the necessity of integrating the knower into the process of inquiry (Froese & Di Paolo, 2011; Montuori, 2008, 2012). They argue for the need to cultivate multiple perspectives by engaging diverse methodologies and ways of knowing (Andreotti, Ahenakew, & Cooper, 2011; Brown et al., 2010) and acknowledge the profound influence of cosmological beliefs on ethics and education (O’Sullivan, 1999). By focusing on inquiry-driven instead of discipline-driven questions—and moving from “matters of fact to matters of concern” (Latour, 2004)—

they seek to transcend the mutual exclusivity of Aristotelian logic that continues to reinforce and justify the rigidity of conventional disciplinary boundaries.

6.05 Re-Imagining the World

Contemporary planetarium productions have done little to acknowledge or examine these paradigmatic assumptions underlying contemporary cosmology. In many cases, they actively perpetuate the “Copernican myths” (Singham, 2007, p. 48) and “myth-conceptions” (Allchin, 2003, p. 329) (see Chapter 5: Eternal Return), tacitly reinforcing ideas that contribute to knowledge fragmentation and dissuade complex thinking. As previously discussed, naïve real interpretations of a “three-dimensional map of the *real* universe” (Druyen & Soter, 1999, p. 2) reinforce the impression of an ‘Archimedean point’ on Newtonian universe of absolute space and time. While the proposed distinction between ‘cosmic maps’ and ‘cosmic pictures’ begins to address misconceptions of naïve realism, it also perpetuates strictly dualistic philosophical beliefs that prioritize theoretical understanding over sensory perception. The “apparent and ineluctable necessity” to choose between Descartes’ “grand and seductive Either/Or” (Bernstein, 1983, p. 18) continues to inform biases and intuitions, limiting the heuristic availability (Tversky & Kahneman, 1973) of anything beyond ‘subjective’ and ‘objective’ perspectives.

In the absence of alternative interpretative heuristic or metaphors, these habituated approaches are understandable and perhaps even inevitable. Yet, as my experience during *Bok Globule* demonstrated, the return of a spherical, geocentric cosmic model complicates these overly simplified approaches, challenging their ability to sufficiently explain its features—to the degree that they had been concealed in most of the Hayden’s productions. Like many previous *cognitive cosmographic models*—including sacred caves, sphairopoia, and planetary machines—the visualization of the *Atlas*’ within a domed theater suggested that the sphere might

once again prove to be a useful visual metaphor for imaging how the ‘world’ comes into being.

The spherical, geocentric *Atlas* draws attention to the central role of the observer, much as I’d attempted to do with the deconstruction of visual phenomena within *Optical Nervous System* (see the Introduction: The Perennial Pursuit). In this way, both presentations during *Bok Globule* related—at least poetically—to the perplexing ‘observer effect’ (Bianchi, 2013) within quantum physics. For decades, efforts to make sense of intimate connections between observational systems on the behavior of light instigated the development of alternatives to dualistic logic (Birkhoff & Neumann, 1936). In my search for alternate interpretative possibilities, the insights of physicists grappling with quantum paradoxes have proven quite useful for informing the macrocosmic concerns addressed throughout this study.

Particularly relevant to the current study are considerations of the critical role of metaphors in shaping logic and scientific understanding. Physicists David Bohm and F. David Peat (1987/2011) argue that metaphors permeate the “tacit infrastructure of scientific ideas” (p. 6), much like Blumenberg’s “cosmological metaphors” (1.02 *Cosmological Metaphors*). Bohm and Peat correlate the function of metaphors with scientific discovery, suggesting, “For in perceiving a new idea in science, the mind is involved in a similar form of creative perception as when it engages a poetic metaphor” (p. 21). Bohm and Peat claim (1987/2011) that “new perceptions and novel ideas” can arise when metaphors enable “break[ing] out of old patterns of thought” (p. 19), arguing that metaphoric perception is “fundamental to all science and involves bringing together previously incompatible ideas in radically new ways”

(p. 23). This ability to synthesize previously incompatible ideas, they argue, is essential for creativity.

Physicist Karen Barad (2007) challenges ‘representationalist’ metaphors for thinking about observer/observed relationships in *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. She insists that metaphors of mirrors and reflection are the wrong approach for studying complex systems, whether scientific, social, or psychological. The radical interconnections of phenomena at the microcosmic scale, she argues, complicate efforts to split the ‘subject’ and ‘object’ into “separate individual agencies” that ontologically precede interactions. She contends that “‘distinct’ agencies are only distinct in a relational, not an absolute, sense, when she states “*agencies are only distinct in relation to their mutual entanglement; they don't exist as individual elements*” (p. 33). Coining the neologism *intra-action* to describe this mutual entanglement, Barad asserts that “distinct agencies do not precede, but rather emerge through, their intra-action” (p. 33). She claims that quantum physics “provides unambiguous empirical evidence for the existence of intra-acting (rather than interacting) agencies” (p. 408), though she insists that the notion of *intra-action* has broad applications since it “is completely general, and, in particular, is not limited in its applicability to microscopic objects” (p. 408).

Barad develops this nondual stance within her philosophical framework of “agential realism.” She argues that this approach “entails a rethinking of fundamental concepts” that support binary divisions between “human and non-human, material and discursive, and natural and cultural factors in scientific and other social-material practices” (p. 26). However, moving beyond “well-worn debates that pit

constructivism against realism, agency against structure, and idealism against materialism” (p. 26) requires “*a radical reworking of the traditional notion of causality* [emphasis in original]” (p. 33).

From this perspective, Barad (2007) insists, there is no “exterior position where the contemplation” of the universe makes any sense, echoing other critiques of the idealized ‘Archimedean point’ (5.06 Viewing from Nowhere). Similarly, her assertion, “We are of the universe—there is no inside, no outside” (p. 396) is directly applicable to the entangled complexity of ‘observer’ and ‘observed’ visualized within the observer-centric *Atlas*. Barad insists the findings of quantum physics, and particularly the interpretations of Neils Bohr, have profound significance beyond the microcosmic realm, though understanding its implications requires a reconsideration of fundamental paradigmatic beliefs:

[T]he traditional conception (of causality)—which presents only the binary options of free will and determinism—is flawed. But if causality is reworked, then power needs to be rethought. (Power relations cannot be understood as either determining or absent of constraints within a corral that merely limits the free choices of individuals.) Agency needs to be rethought. Ethics needs to be rethought. Science needs to be rethought. (p. 23)

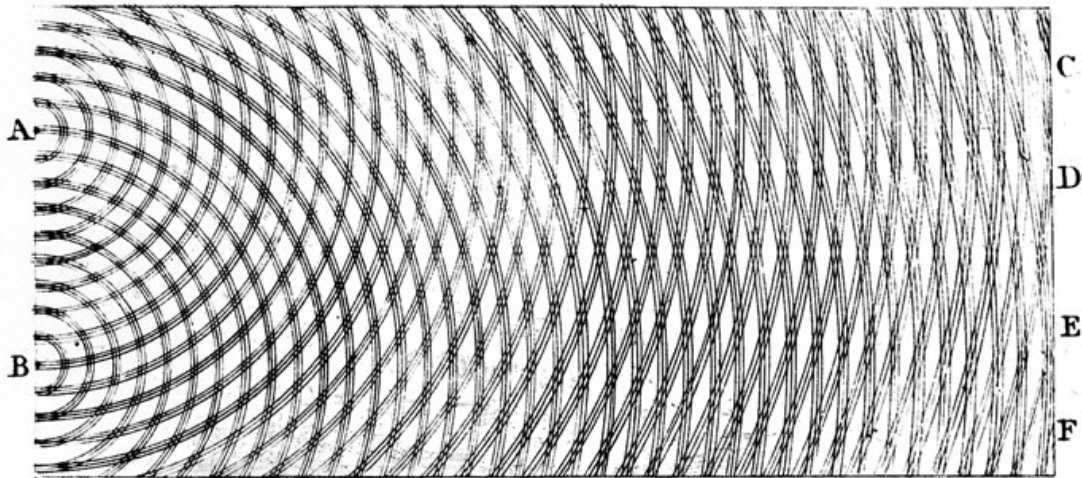


Figure 87. Thomas Young's sketch of two-slit diffraction of light (1804).

To assist with this radical rethinking, Barad (2007) adopts Donna Haraway's metaphorical use of "diffraction" to imagine how "[t]here is only intra-acting from within and as part of the world in its becoming" (p. 296) (Figure 87). Visualizing intra-actions as diffraction patterns, they suggest, encourages more critical forms of reflexivity by capturing the essence of difference patterns and the non-fixed fluidity of "subject" and "object" (p. 418). As will be discussed later in this chapter, I have followed their lead, adopting the metaphor of 'diffraction' instead of 'reflection' to examine the complex intra-actions among different perspectives within knowledge production processes.

While Barad arrived at her notion of "intra-action" through studying diffraction patterns at the quantum scale, her re-thinking of mutually causal relationships closely parallels the Buddhist doctrine of *paticca samuppāda*. Joanna Macy's (1991) *Mutual causality in Buddhism and general systems theory: The dharma of natural systems* describes this understanding of causality, alternately translated as *dependent origination* or *dependent co-arising*. She defines it as "a dynamic interaction of mutually conditioning events, posit[ing] no prime cause or

unconditioned absolute to which occurrences can be traced in a linear fashion” (p. 18). Like Barad, Macy maintains that adopting nondual logic and a nonlinear understanding of “mutual causality” is essential for recognizing the fundamentally “interdependent structure” of reality (p. 63).

6.06 Enacting Cognition

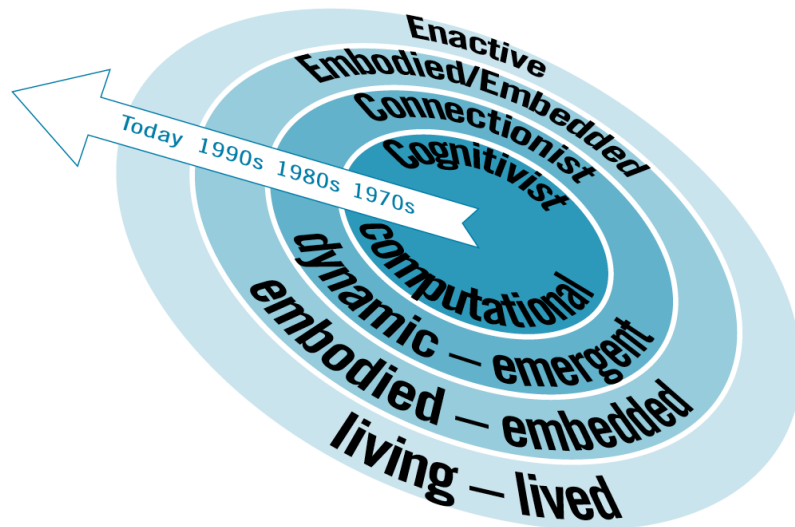


Figure 88. Emerging paradigms within cognitive science (Froese, 2010, p. 76).

Challenging accepted notions of linear causality has profound implications. Not only does it require rethinking agency, ethics, and science, but also the fundamental relationship between cognition and the cosmos. As Steven Rosen (2008) points out, the “common sense notion of a ‘universe out there’ developing on its own is so compelling that it seems absurd for us to think otherwise” (p. 242). But this view of mutually co-arising agencies complicates both naïve real and dualistic notions of a world ‘out there’ independent of intra-acting agencies.

The task of re-imagining these fundamental assumptions has been taken up within the nascent field of *enactive cognition* (Froese & Paolo, 2011; Thompson, 2010; Varela et al., 1991). This field has emerged from critiques of dominant ‘computationalist’ theories of cognitive science (Figure 88), calling into question the assumption that “cognition consists of the representation of a world that is independent of our perceptual and cognitive capacities by a cognitive system that

exists independent of the world” (Varela et al., 1991, p. xx).⁸⁶ Instead of assuming an ultimate foundation of conscious awareness, the enactive approach emphasizes that all experiences of phenomena are entangled within histories of embodiment.

Enactive theory explicitly challenges the philosophical assumptions of the so-called ‘mind-body problem’ inherited from Descartes’ split of *res extensa* and *res cogitans*—a problem that has remained prevalent within consciousness studies and cognitive science. Like modern cosmology, these dualist views draw heavily from the ‘representationalist’ metaphors—also critiqued by Barad—asserting that things-in-themselves have intrinsic properties and that the world is simply a ‘projection’ of the mind. These continue to employ John Locke’s (1706/1856) metaphors of the senses as “windows” onto the pregiven external world and the mind as the “dark room” (p. 109) of the internal world (3.16 Entraining Objectivity). Similar to my discussion of the problems with presenting visualizations of theoretical simulations as an ideal ‘view from nowhere’ in modern ‘precision cosmology’ (5.07 Sphere of Cognition), enactivists critique the ideal of representation as the “Archimedes point for cognitive science” (Varela et al., 1991, p. 8).

Instead, adherents to the enactive approach view cognitive processes from a non-dualistic perspective, asserting that all phenomenological experience occurs within a performative history of biological, social, cultural, and technological practices and beliefs. Examples of these types of ‘structurally coupled’ intra-actions were previously introduced in the discussion about cave art as active extension of

⁸⁶ Tom Froese’s (2010) *From Cybernetics to Second-Order Cybernetics: A Comparative Analysis of Their Central Ideas* provides a succinct overview of the history of the enactive paradigm of cognitive science, describing the diagram in Figure 88.

cognitive process (2.05 Tools for Thinking). Lambros Malafouris (2013) draws from these ideas within his theory of *enactive signification*, which he defines as “a process of embodied ‘conceptual integration’ responsible for the co-substantial symbiosis and simultaneous emergence of the signifier and the signified” that bring forth the world through the “meaningful engagement of cognition and matter” (p. 99). Though he develops this theory in his analysis of Paleolithic painting, it is equally applicable to the many cosmographic practices reviewed throughout this dissertation. In short, visualizing the cosmos always involves processes of embodied, material engagement, through which we humans think *through* our engagements with things and images, not just *about* them. We are not simply passive participants discovering a pre-given world from disembodied ‘Archimedean point,’ but active agents engaged within complex intra-actions and co-creative, structurally coupled processes.

6.07 Returning to the Senses

Relating the radical implications of complex thinking, transdisciplinarity, mutual causality, and enactive signification requires cultivating sensibilities that transcend presumed bifurcations between mind and body, subject and object, self and world. This can be difficult, however, when communication is limited to the use of language and abstract concepts. These challenges are compounded by the tendency of academic discourse to prioritize abstract and theoretical processes of knowledge production over other experiential “ways of knowing” (Abram, 1996, p. 270). The dominant emphasis on written language and mathematics can also exacerbate these difficulties by reinforcing dualistic assumptions that reinforce disciplinary boundaries and knowledge fragmentation.⁸⁷

Inquiring into the performative, embodied foundations of conceptual thought are central to the philosophy of phenomenology. Enactive cognitivists draw heavily on phenomenologist Maurice Merleau-Ponty (1968), whose work investigates the continuous circulation between the ‘inner’ and ‘outer’ aspects of embodiment encompassing what he called the “life world” (p. 18) of experience within the sensuous, corporeal world of social and physical existence. Merleau-Ponty elucidated the need for the philosophical foundations of modern science—particularly physics—

⁸⁷ In the words of Charles Hampden-Turner (1982), “because words come in bits and pieces many people have assumed that the world is in bits and pieces too...[w]ord maps have a fragmentary structure that derives from language itself, not necessarily from what language describes” (p. 8). In “Physics and Language—Science and Rhetoric: Reviewing the Parallel Evolution of Theory on Motion and Meaning in the Aftermath of the Sokal Hoax,” Gregory Deslilet (1999) addresses ways in which language reinforces Aristotelian logic and its role in the “two cultures” debate. Lilian Papin (1992) similarly describes the influence of the English language on dualistic assumptions in “This Is Not a Universe: Metaphor, Language, and Representation,” arguing that “attempts to escape metaphor often lead physicists and poets on parallel paths” (p. 1256). William Byers (2011) explores the ambiguity, self-referentiality, and lack of ultimate certitude within mathematics in *The Blind Spot: Science and the Crisis of Uncertainty*.

to be re-orientated away from the purely “objectivist ontology” of Cartesian dualisms and idealizations, which he claims, “undermines itself and collapses under analysis” (p. 10). Instead, he asserted, science needs to *situate* both the ‘subject’ (observers) and the ‘object’ (their observations) within their reciprocal intertwinings. Only by acknowledging the depths of these interconnections, he insists, can science begin to account for the non-linear and even paradoxical aspects of perception to study how these shape relations between scientific practices and the world.

While enactive cognition is informed by phenomenology, Francisco Varela and his colleagues (1991) seek to move beyond theoretical analyses of experience to develop pragmatic applications. Like Toulmin, Johnson, Morin, Barad, and others, they cite the need for a ‘middle way’ to move beyond habituated dualistic convictions. But instead of a purely theoretical approach, they describe the integration of mindfulness meditation and other techniques from Buddhist traditions into cognitive science. Their motivation is to experientially cultivate appreciation that “all phenomena are free of any absolute ground,” claiming that the “Cartesian anxiety” of modernist absolutism and postmodernist nihilism derives from the perpetual grasping to find a firm foundation of a stable ego-self (p. 144) (5.13 Cartesian Anxiety). Referring to the *paticca samuppāda* doctrine, they contend, “such ‘groundlessness’ is the very fabric of dependent coorigination” (p. 144).

6.08 Learning to See

Don Ihde (1998) proposes a different approach with similar aims, arguing that immersive virtual environments be used to illuminate the paradoxes of perception and examine their implications for logic, epistemology, and ontology.⁸⁸ He speculates that the gestalt of “‘whole body’ experiences” (p. 191) within virtual world simulators could function as a “counter-laboratory” (p. 131) to overcome the “technical opacity” (p. 130) of scientific texts. Referring to his study of the mediated structures of consciousness as “postphenomenology,” Ihde (2009) contends that audiovisual and tactile-kinesthetic engagements offer a pragmatic way to help audiences experientially understand the complex and multi-perspectival nature of scientific discovery. Ihde goes as far to speculate that a “new science” could emerge through novel “possibilities of investigation” (p. 195) afforded by the ability of virtual environments to extend the technical mediation of consciousness (2009, p. 23).

Echoing many of the concerns discussed throughout this chapter, Ihde (1998) argues that the nature and processes of science have often been misconstrued “because, in part, we have for so long ceded the interpretation of science to forms of positivism” (p. 3). Elucidating what he calls the “H-P Binary”—the “contestation between hermeneutics and positivism” (p. 3)—he insists that hermeneutics is largely divorced from the sciences. As a result, he contends that “most scientists’ self-understanding remains with the limits of modernism” (p.4), referring to the entrained

⁸⁸ My essay “Being (T)Here: A Syncretic Approach to Understanding Presence” (McConville, 2008) draws parallels between mindfulness practice and immersive virtual environments for cultivating “presence” and drawing attention to the mutually co-arising nature of phenomena. This is closely related to Ihde’s ideas about postphenomenology, though it was written prior to encountering his writings on this subject.

tendencies to disregard the value of multiple perspectives beyond dualistic logic—citing the contentious divisions between the ‘sciences’ and ‘humanities’ in the ‘Sokal affair’ as a prime example.⁸⁹ To emphasize these limits, Ihde (1998) employs the term *technoscience*, a concept that Donna Haraway (1997) writes, “extravagantly exceeds the distinction between science and technology as well as between nature and society, subjects and objects, and the natural and the artifactual that structured the imaginary time called modernity” (p. 3). Nicolescu (2002) also uses this term, calling disciplinary hyperspecialization “a response to the demands of a technoscience without brakes, without values, without any end other than utilitarianism” (p. 34).

⁸⁹ Mara Beller’s (1998) *The Sokal Hoax: At Whom Are We Laughing?* provides a reasoned account of the most infamous—and particularly heated—example of the sustained division between the “two cultures.” Beller astutely addresses how the lines between philosophy and science are often ambiguous when confronting inexplicable and paradoxical observations. Contentious and provocative posturing continues to the present day, recently demonstrated by physicist Lawrence Krauss’ (2012) boast to answer age-old philosophical and religious questions in his book *The Universe from Nothing*. After its publication, Krauss (as cited in Vacula, 2012) referred to well-informed critics of his ideas as “moronic philosophers” and asserting that “philosophy is the field that hasn’t progressed in two thousand years whereas science has” (para 6), even though at least one of these philosopher critics held a Ph.D. in physics. Coincidentally, the example of Sokal and Krauss both centered on interpretations of *quantum gravity*, or the theoretical attempts to unify the microcosm of quantum mechanics and the macrocosm of general relativity. This is held by some physicists to be the primary stumbling block to the development of the ultimate ‘Archimedean point’ of a ‘theory of everything’—a single theoretical framework that could “successfully predict or explain the value of any constant of Nature” (Barrow, 2007, p. 112) in purely mathematical terms.

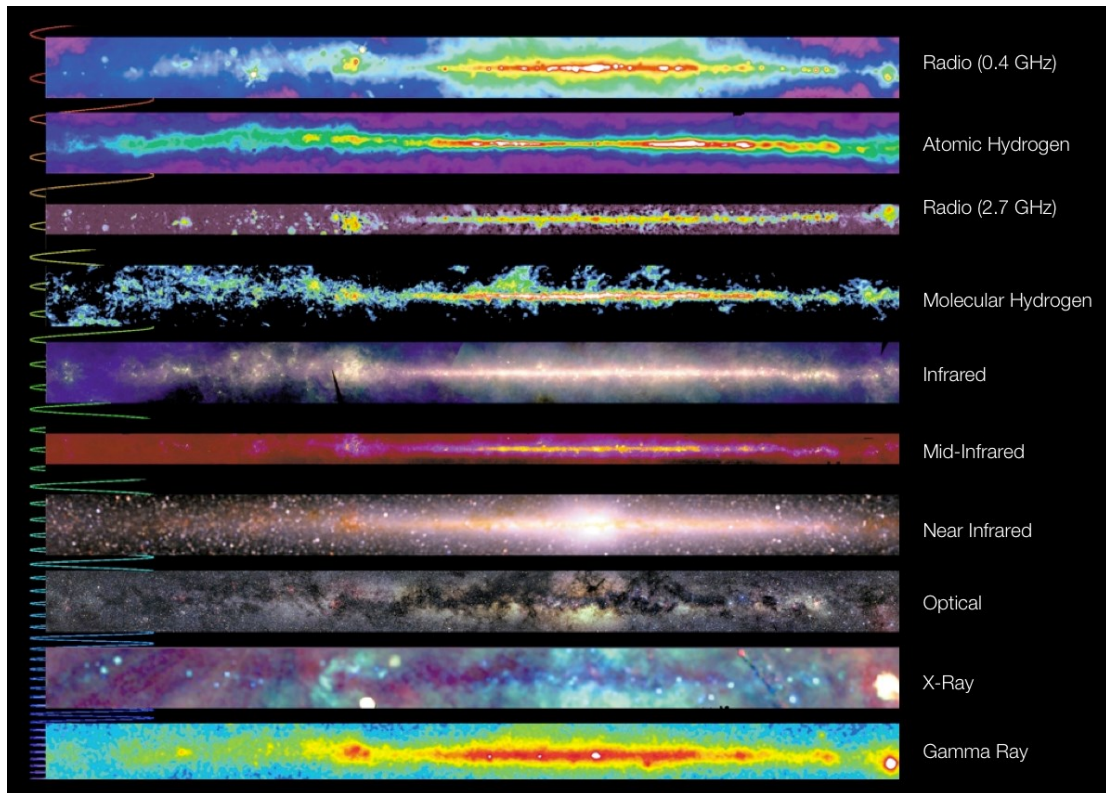


Figure 89. ‘False color’ astrophotography visualizing the electromagnetic spectrum (NASA, 2013a).

Ihde (1998) argues that hermeneutic approaches to technoscience require mediating instruments to allow bodily perception of otherwise imperceptible phenomena (p. 53) (Figure 89). However, instead of assuming the dualistic stance that these mediations are ‘representations’ of pre-existing phenomena, he interprets them—like the enactivists—as a “means by which our perceptions and our wider experience are modified and transformed” (p. 1). This *instrumental realism* sets the theoretical and philosophical stage for his *visual hermeneutics*—examining the practices of technoscience using its own devices and artifacts.

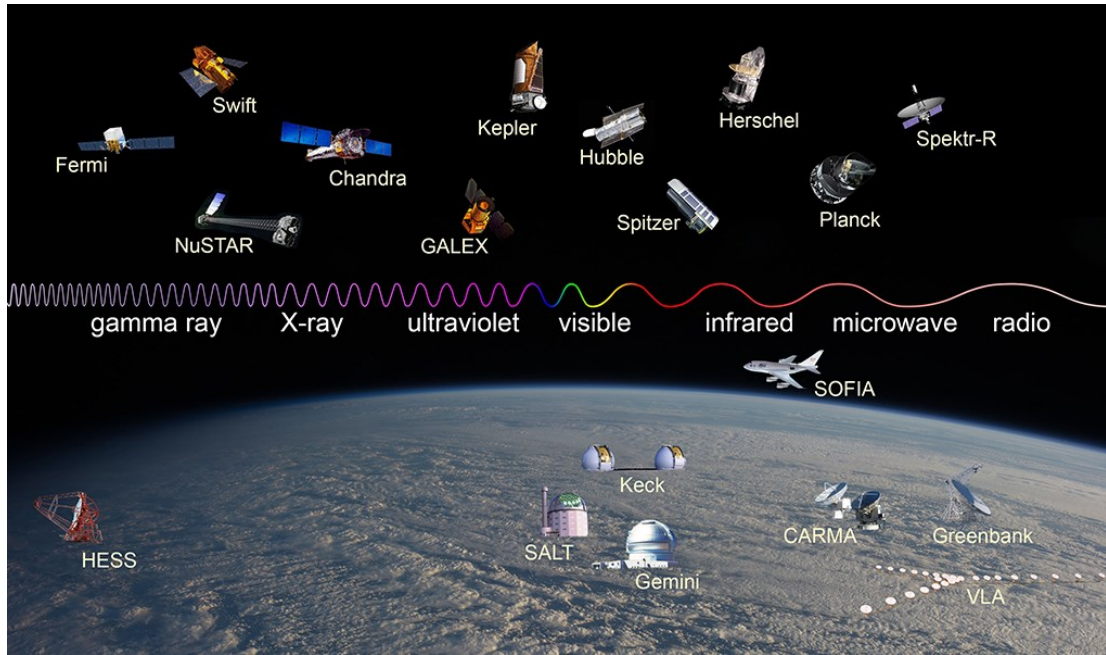


Figure 90. Astronomical observatories positioned along their primary operations within the electromagnetic spectrum (NASA, 2013b).

Ihde (1998) contends that the ever-increasing realism of contemporary technoscientific image making—that is, the ability of instruments to make visible previously invisible persistent effects—has expanded access to the “aha phenomenon” (p. 179) closely associated scientific insights and discoveries (Figure 90). By encouraging more reflexive hermeneutic “visual readings” of scientific artifacts, he intends for postphenomenology—like ‘enactive signification’—to facilitate learning to see both *with* and *through* these “perception-mediating and perception-transforming devices” (p. 185). Through postphenomenology, Ihde contends that the “Latoureaan laboratory” of science—whereby “instruments become the scriptorium of things” (p.187)—can experientially provide essential insights into the functionally hermeneutic nature of scientific praxis. These multi-perspectival and multi-sensory examinations of technoscientific artifacts, he argues, require transcending the limitations of tacit dualistic epistemologies. This, he believes, is

essential for moving beyond the contentious and ongoing “wars of interpretation” (p. 6) between the so-called two cultures.

In addition to his critiques of dualistic scientific assumptions, Ihde (1998) also calls out misconceptions originating with dualistic characterizations of science by philosophers. He specifically points to theories derived from “Cartesian” or “theory-weighted interpreters of science” (p. 53) that support rigid ontological dichotomies by characterizing all observations as *indirect*. He argues that while “science requires *measurement, quantification*, and the processes of *analysis* which occur in mathematization,” it “equally requires a *material* relation with ‘things in themselves’” that “occurs in actually embodied science” (p. 53). “That embodiment,” he suggests, “is *technological extension of primary perception through instrumentation*” (p. 53).

To illustrate the importance of sensory extensions, Ihde (1998) cites Galileo’s famous telescopic observations of planetary satellites, contending they are “*mediated and instrumentally real*” (p. 53) instead of simply mathematical, abstract, or idealized constructs. Ihde argues that seeing “by means of imaging technologies is not to ‘look at a picture’” but to “*look through the image*” (p. 57). This recognition, he insists, is essential to move beyond the limits of representational epistemologies tacitly dependent on “passive theories of perception” (p. 57-58)—whether informed by “naïve image realism” (p. 180) or Cartesian dualism. Instead of accepting the “objectifying’ gaze” (p. 193) of suspended disbelief, Ihde questions how acknowledging the “secret liaison between science and the visual” might expose the breach of a more “bodily ‘dance’” (p. 193) between observational instruments and things.

Ever since my personal “aha” epiphany triggered by the *Digital Universe Atlas*, I have attempted to discern the implications of the re-emergence of the *heavenly sphere* through this instrumentally mediated bodily dance. Ihde’s writings—and the many parallels with those of Toulmin, Johnson, Priest, Morin, Nicolescu, Barad, Haraway, Macy, Merleau-Ponty, Varela et al., and others—have provided essential philosophical and methodological contexts within which to situate this inquiry. Their collective insights into the constraints of binary logic have helped me to appreciate the significance of what I perceived to be a conspicuous paradox virtually embodied within the *Atlas* (7.02 Cubing the Sphere). Within my performative practice, I have employed postphenomenological visualization techniques to cultivate what I call the *transcalar imaginary* (see Chapter 7: Transcalar Imaginary). This a collective space of the imagination in which instrumentally real visualizations are used to illuminate the complexities of knowledge production and the necessity of *learning to see* beyond the limitations of rigidly dualistic interpretations.

6.09 Creating a Third Space



Figure 91. The Elumenati *GeoDome Theater* (Mann, 2011).

Pragmatically applying these ideas necessitated creating virtual, physical, and social spaces within which to experiment with the possibilities interpreting cosmic cartography from transdisciplinary perspectives. After *Bok Globule*, I worked with colleagues at the Elumenati to create a rapidly deployable portable visualization system, designed to facilitate ongoing experiments within a range of cultural contexts. This entailed developing and integrating custom optical projection and screen display technologies (see Patents in Appendix I) into an immersive environment that has since been commercialized as the *GeoDome* (Figure 91). This system included three primary components developed by the Elumenati (2009a): the *OmniFocus* fisheye projector, an inflatable *OpenDome* screen, and the *OmniMap* real-time geometry correction software library. Together, these simulated the natural spherical gestalt of human vision within an immersive space (1.03 Spherical Container). Incorporating

OmniMap into *Uniview* (SCISS, 2013) for the *Bok Globule* (Emmart & Villareal, 2004) installation enabled its eventual use in *GeoDomes*. This has given me the opportunity to explore the creative possibilities guiding postphenomenological, transdisciplinary renditions of the ancient trope of the ‘cosmic journey’—using interactive visualizations to enact imaginary ‘flights’ through the cosmos within immersive, dome-shaped environments.

My experimentation has been informed by various investigations into the use of visual and cartographic techniques and environments for examining notions of ‘space.’ These have been widely addressed in recent decades under the rubric of the “spatial turn” (Warf & Arias, 2008b) in the arts, sciences, and humanities, many of which share motivations similar to my own. Like my questioning of the situated aspects of the observer-centric *Atlas*, Denis Cosgrove (1999b) writes that the spatial turn corresponds to the recognition that “position and context are centrally and inescapably implicated in all constructions of knowledge” (p. 7). Edward Soja (2008) suggests this tactical shift has arisen from strategic awareness of the consequences of collectively created and shared spatiality, which he describes as “a vital part of making both theoretical and practical sense of our contemporary lifeworlds at all scales, from the most intimate to the most global” (p. 49).

Further connecting the spatial turn to this current inquiry, Barney Warf and Santa Arias (2008a) contend that placing “space and place at the center of the analytical agenda” has “played a major role in helping to facilitate interdisciplinary inquiry that offers a richer, more contextualized understanding of human experience, social relations and the production of culture” (p. 2). They cite the subordination of space to time within modern consciousness—and the resultant linearity of notions of

“temporal ‘stages’ of development”—as portraying “the past as the progressive, inexorable ascent from savagery to civilization, simplicity to complexity, primitiveness to civilization, and darkness to light” (p. 2). This recalls Peter Sloterdijk’s (2004b) use of spherical ‘thought-images’ to elucidate transhistorical interconnections across personal, social, and global domains (1.05 Polycentric Thought-Forms) as well as my use of the *heavenly sphere* to identify commonalities among cosmographic practices across time.

Increased interest in the geographical imagination and cartographic tools have also been accompanied by calls for the creation of a “third space” (Soja, 2008) to explore connections among seemingly contradictory ideas (Ikas & Wagner, 2008; Tambiah, 1990). David Turnbull (2000) describes this as “an interstitial space, a space that is created through negotiation between spaces, where contrasting rationalities can work together but without the notion of a single transcendent rationality” (p. 234). ‘Third spaces’ are envisioned as facilitating transdisciplinary and transcultural engagements through increasing a fluid sense of time and dynamic sense of space (Soja, 1996, p. 113) to show how embodied practices extend beyond the constraints by binary polemics, dualistic logic, and linear historicism. It is hoped that reflecting on the ambiguity of map/territory relationships—including visual-spatial metaphors, mapmaking practices, and cognitive processes (Cosgrove, 1999b; Ruitenberg, 2007)—can help to expose the agency behind acts of making and

mapping (Bhabha, 2008) and the potential complementarities of diverse perspectives.⁹⁰

Effectively designed ‘third spaces’ provide pathways for dialogues about the “performativity of cartographic representations” (Ruitenbergh, 2007, p. 7) by demonstrating how maps emerge from networks that “vary with local, cultural, and historical contingencies” (Turnbull, 2007, p. 147). Cosgrove (1999a) argues that examining decisions made about scale, framing, selection, and coding (p. 9) can increase appreciation of the complexity of the entangled “semiotic connection[s] between sign and signified” (p. 10) and their influence “on questions of representation and reality” (p. 9). Throughout this thesis, I have considered how cosmographic artifacts provide clues to the context of their “various circuits of use, exchange and meaning” (Cosgrove, 1999a, p. 9) as well as the practices and beliefs within which their creators are engaged and enmeshed.⁹¹

The possible configurations of ‘third spaces’ are potentially as diverse as interpretations of the notion of ‘space’ itself. In this context, Tim Recuber (2007) suggests that “immersion cinema” could help to creatively synthesize and extend

⁹⁰ The notion of ‘map/territory relationships’ derives from Alfred Korzybski’s (1933/1994) comment, “Two important characteristics of maps should be noticed. A map is *not* the territory it represents, but, if correct, it has a *similar structure* to the territory, which accounts for its usefulness. If the map could be ideally correct, it would include, in a reduced scale, the map of the map; the map of the map of the map; and so on, endlessly...” (p. 58). A variation on this idea was famously expressed by René Magritte’s (1929) painting *La trahison des images*, to which I pay homage in *The Treachery of Cosmography* (Figure 86).

⁹¹ In her PhD dissertation “Landscapes of Ephemeral Embrace: A Painter's Exploration of Immersive Virtual Space as a Medium for Transforming Perception” (also through the *Planetary Collegium*), Char Davies (2005, pp. 44–68) reviews key concepts of ‘space,’ ‘place,’ ‘landscape,’ and ‘boundaries’ as they relate to the creative possibilities of using immersive virtual artworks for epistemological and ontological re-orientation. Davies draws from Anne Spirn’s (1998) notion of first, second, and third nature, in which “first nature” (*natura/naturans*) is unaltered by human labour, “second nature” (*natura/naturata*), is modified reworked by human hands, and “third nature” is a designed garden—an “artful interpretation”—a “self-conscious re-presentation of first and second natures” (p. 32).

perceptions of the material world and “‘imagined’ interpretations and representations of that reality” (p. 326). He theorizes that, if mindfully applied, the liminal, virtual aspects of immersion cinema could possibly allow for the “openness, flexibility, and multiplicity that mental and physical space alone forestall” (p. 326). Recuber contends, however, that the novelty and intensity of “high-fidelity audiovisual technologies” (p. 327) often places paramount importance on the physical and kinesthetic experience of the spectators, and that these developments often harm the artistic quality and social relevance of their applications (p. 315). To realize more fully their potential for encouraging “human intimacy and meaningful interactivity” (p. 327) through contemplation and discussion, he argues for the deployment of immersion cinema “in a way that does more than simply absorb spectators as a single mass” to move beyond the passive experience of “hyperreal simulations and empty thrills” (p. 328). This critique is applicable to the claim that the Hayden’s productions are constructed from datasets of the “*real* universe” (Druyen & Soter, 1999, p. 2). Pushing the quest for ‘realism’ to its logical, technological, and cosmological extremes has revealed the paradoxes of attempting to achieve what Andre Bazin (1946/2004) characterized in the *Myth of Total Cinema* (p. 22) as “a recreation of the world in its own image, an image unburdened by the freedom of interpretation of the artist or the irreversibility of time” (p. 21). Addressing these shortcomings, Recuber (2007) suggests, requires increasing the integration of interactivity and immersion to

more fluidly enable the “celebration of art, difference, and clandestine imaginings”
(p. 328).⁹²

⁹² Recuber (2007) also finds fault with academic cinema studies, contending that their “discourse on spectatorship and the apparatus” should move “away from psychoanalytic themes and toward an approach more grounded in spatial and bodily experience” to “remain relevant while also encouraging further analysis of and possible corrections to the imbalances of immersion cinema” (p. 328).

6.10 Suspending Belief

Throughout this investigation, I have developed the practice of *cosmotroping* to create a ‘third space’ for cultivating “clandestine imaginings” (Recuber, 2007, p. 328) to examine the presumed “transcendent rationality” (D. Turnbull, 2000, p. 234) of the ideal ‘Archimedean point.’ This has required remaining skeptical about fundamental assumptions, an approach informed by both Buddhist philosophy and the techniques of modern science. Zen master Hakuin Ekaku (1971, p. 144) writes that at the “bottom of the great doubt lies the great awakening”—that doubting fully is the key to awakening fully. Similarly, Neal deGrasse Tyson (2004) echoes Descartes’ famous philosophical insistence on the importance of systematically questioning one’s own beliefs, describing science as “organized skepticism” that depends on “continual, methodical doubting” (p. 17). Carl Sagan emphasizes the critical importance of this approach in the original *Cosmos* series, famously declaring that “extraordinary claims require extraordinary evidence” (Haines-Stiles & Malone, 1980).

Yet, in *Passport to the Universe*, the claim is made that, “What you are about to see is not an artist’s fantasy, but a three-dimensional map of the *real* universe, carefully calculated and drawn from the best astronomical observations and data” (Druyen & Soter, 1999, p. 2). This unambiguous assertion implies that the Hayden Planetarium—and, by extension, modern cosmology—has successfully quantified the cosmos, securing Descartes’ dream of an ‘Archimedean point’ by visualizing the “god-trick of seeing everything from nowhere” (Haraway, 1988, p. 581). The *Atlas* is described as a “hyperrealistic view of the planets, star clusters, nebulae, and galaxies”

(AMNH, 2012a) that portray the universe in its “proper three-dimensional context” (Emmart, 2005, p. 21).

Upon closer skeptical examination, however, a decidedly more complex situation has become apparent (5.02 Cosmic Tensions). Claims to ontological verisimilitude are directly contradicted by the Hayden’s Director of Astrophysics Education, who insists, “we cannot actually observe a map of the real universe” (Sweitzer, 2006, p. 11). These rigidly ‘subjective’ or ‘objective’ interpretations appear to have induced a kind of schizophrenic “double bind” (Bateson et al., 1956, p. 251). The “mutually contradictory demands” of describing the astronomical observations as *either* a ‘cosmic map’ *or* ‘cosmic picture’ have created an “impossibly problematic situation” (Tarnas, 1991, p. 419), yielding radically divergent descriptions of the consequences of the Hayden’s cosmographic efforts.

Perhaps this is why *Passport to the Universe* is promoted as spectacular proof that “science has finally caught up with science fiction” (Boxer, 2000, para. 14) (4.07 Digitizing the Cosmos). This rhetorical strategy depends on audiences’ ‘poetic faith’ (4.10 Poetic Faith) in the scientific ability to objectively map the *real* universe—even if the Hayden’s producers do not naïvely share the same confidence due to their understanding of the ontological complexity of their efforts. Concealing the appearance of the CMB sphere was necessary in earlier production to sustain the ‘willing suspension of disbelief’ in the ‘Archimedean point’ and avoid acknowledgement of the situated and relativistic nature of all observations. When the spherical horizon is finally revealed in *Dark Universe*—almost fifteen years after the premier of *Passport to the Universe*—the pretense of a purely objective ‘cosmic map’ requires ambiguously merging the observational data with theoretical simulations.

As I witnessed the configuration of the *Atlas* from ‘outside’ the sphere during *Bok Globule* (see the Prologue), my own ‘poetic faith’ in its naïve interpretation dissolved. I became intrigued by possibilities of studying the perceptual paradoxes, scientific complexities, cultural contingencies, paradigmatic assumptions, and ecological synergies this latest *heavenly sphere* seemed to embody. Instead of concealing the CMB sphere to enhance the suspension of *disbelief*, Emmart’s exposition of the *Atlas*’ configuration inspired me to investigate techniques for encouraging the suspension of *belief* in dominant logical, epistemological, ontological, and cosmological assumptions.

Through this research project, I have worked to develop techniques for interactively visualizing the *Atlas* to examine the inherent performativity of cosmographic practices and artifacts. Instead of trying to force the *Atlas*’ into the map/picture distinction, I have approached it as a kōan-like paradox that is both “*mediated and instrumentally real*” (Ihde, 1998, p. 53), emerging as a diffraction pattern from complex intra-actions (6.05 Re-Imagining the World). It has not only been necessary to transcend disciplinary boundaries during the interpretive process, but also to suspend belief in the “grand and seductive Either/Or” (Bernstein, 1983, p. 18) of ‘classical’ dualistic logic and dominant notions of linear causality. Though these thinking habits are deeply ingrained within the modern scientific paradigm, examining the *Atlas* within a ‘third space’ provides a critical opportunity to mediate transdisciplinary meditations concerning the schizophrenic ‘double bind’ enacted by the return of a spherical, geocentric cosmic model.

6.11 Fabricating Meditations

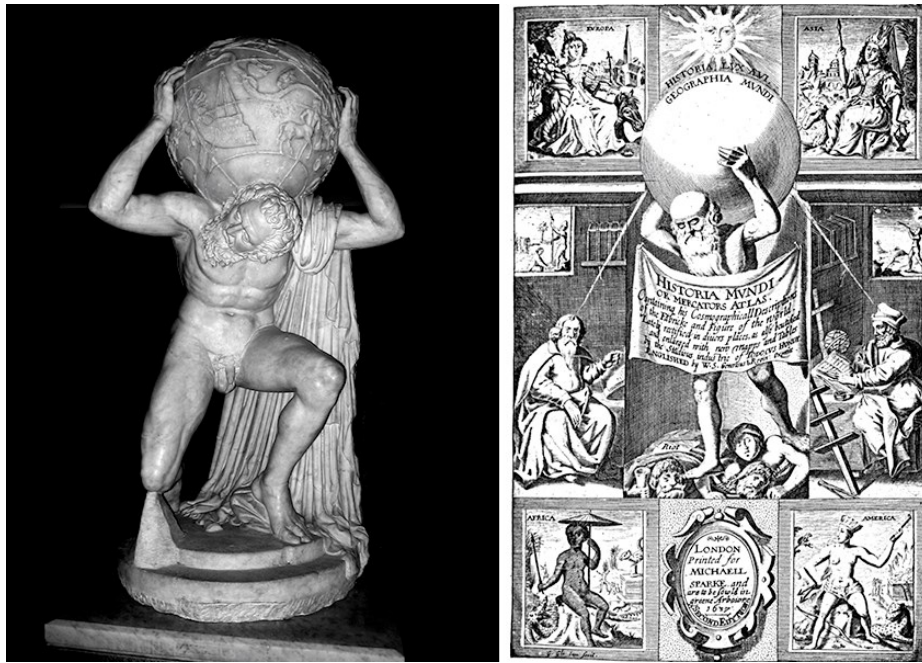


Figure 92. *Farnese Atlas* [Italy, c. 150 C.E.] and *Atlas, or Cosmographical Meditations on the Fabric of the World and the Figure of the Fabrick'd* (Gerardus Mercator, 1595).

Using the *Digital Universe Atlas* to examine of the consequences of complex knowledge production processes can also be justified in the context of the historical use of cosmographic image collections. Since their inception five centuries ago, ‘atlases’ have been designed to facilitate meditations on the nature of the world. The title of the original atlas, Gerard Mercator's (1595/2000) *Atlas sive cosmographicae meditationes de fabrica mvndi et fabricate figvra*, intimated the reflexive nature of his intentions. Though rarely quoted in full, its translated title reads *Atlas, or Cosmographical Meditations on the Fabric of the World and the Figure of the Fabrick'd*, distinguishing the world’s fabric (the territory) from its figure (the map). The use of the name ‘atlas’ indicates the weighty ambitions of these imagery collections, alluding to the mythical Greek Titan condemned by Zeus to carry the

heavenly sphere on his shoulders (Figure 92). A poetic epitaph to Mercator in his posthumously published work further testifies to the mythical status of his cosmographic accomplishment, praising him for having “joined the stars to the earth and added the sacred to the profane, rectifying both at once” (p. 73).

In their aptly named book *Objectivity*, Lorraine Daston and Peter Galison (2010) document how, by the mid-nineteenth century, the use of the term ‘atlas’ had expanded to include geography, astronomy, and anatomy. The term proliferated throughout the empirical sciences. Through an extensive analysis of drawings, maps, and photographs within printed atlases, Daston and Galison describe these as “dictionaries of the sciences of the eye” (p. 22) that “aim to ‘map’ the territory of the sciences they serve” (p. 23). These “systematic compilations of working objects,” they argue, perform a functionally enactive role: “Not only do images make the atlas; atlas images make the science” (p. 22). They find “epistemic virtues” (p. 18) permeating “scientific practice as well as precepts,” and that “scientific atlases have been central to scientific practice across disciplines and periods” by setting “standards for how phenomena are to be seen and depicted” (p. 19). By consulting atlases, Daston and Galison contend, practitioners “find out what is worth looking at, how it looks, and, perhaps most important of all, how it should be looked at” (p. 23).

The *Digital Universe Atlas* extends this tradition into the postphenomenological realm, virtually embodying epistemic virtues of contemporary cosmography within its spatial, temporal, and spectral visualizations. Like the exposition of imagery within printed atlases, it is a systematic compilation designed to make explanations of basic scientific concepts accessible and appealing. When interpreted solely from ‘subjective’ and ‘objective’ perspectives, however, its true

utility can be overlooked, as these conceal these the complex consequences of attempting to model a god's eye view of the "known universe" (Emmart, 2009). This approach also illuminates the enactive function of mediation, recalling Malafouris' (2007b) suggestion that "if there was a single special element in the process of human becoming then it has to be 'mediation' rather than 'meditation'" (p. 7) (2.06 Cave as a Cosmos).

6.12 Cosmographic Hermeneutics

Developing a “middle way” (Toulmin, 1982, p. 12) beyond dualistic readings of the *Atlas*—that often perpetuate the “great Copernican cliché” (Danielson, 2001, p. 1029) and other “myth-conceptions” (Allchin, 2003)—requires a more nuanced, multi-perspectival approach. I have been motivated not only to demonstrate the “limits of common sense” and to “develop an understanding of the use of scientific models” (Sweitzer, 2006, p. 13), but to also explicate the intricate consequences of attempting to visualize an objective ‘Archimedean point.’ Through exploratory iterations within my *cosmotroping* performances, I have developed the transdisciplinary strategy of *cosmographic hermeneutics*, interactively visualizing and interpreting this latest *Atlas* to explicate complex, intra-acting epistemic virtues and situated processes of knowledge production.

Expanding hermeneutic possibilities required identifying appropriate lenses through which the *Atlas* could be viewed. I reviewed numerous integrative *theories of theories*—sometimes called “metatheories” (Molz, 2010; Wallis, 2010)—that offer alternatives to discipline-specific perspectives and dualistic epistemologies. These metatheories are generally designed to provide alternate pathways to “hyper-specialized discourses that dominate the academy” and “over-simplified discourses that dominate the mass media and the political arena” (Benedikter & Molz, 2011, p. 49). They commonly seek to “reconnect the increasingly error-prone and in some cases even life-threatening dissociations between whole and part, centre and periphery, theory and practice,” as well as define relationships “between facts and values, effects and intentions, and more generally, between matter, mind and spirit” (Benedikter & Molz, 2011, p. 49).

These diverse proposals emerge from and attempt to cover a vast array of topic areas, including cosmology (Harrison, 2003), cultural history (Gebser, 1984), systems theory and cybernetics (Brier, 2009), developmental psychology (Combs, 2009; Wilber, 2000), ecology (Esbjörn-Hargens & Zimmerman, 2009), evolutionary psychology (Ploeger, 2010), developmental theory (Antley, 2010), nondual philosophy (Poonamallee, 2010), creativity studies (De Bono, 1985), and traditional knowledge (Apgar et al., 2009; Armstrong, 2005; Houde, 2007), among others. Many of these cite the need to build bridges among specific disciplines (Stafford, 2011), while others present methodologies for overcoming long-standing divides among the natural sciences, social sciences, and humanities (Nicolescu, 2002; van Breda, 2008). These approaches represent impressive theoretical syntheses, painting synoptic views over vast fields of inquiry. They have proven very useful in the development of transdisciplinary heuristics for *cosmographic hermeneutics*.

Though these metatheories are theoretically inclusive of many perspectives, their conceptual density, ideological idiosyncrasies, and/or cultural specificity often limit their adoption beyond specific applications or communities of practice. This is understandable considering the depth and complexity of the intellectual ground they cover in their attempts to offer “integrative, emancipatory alternatives” (Benedikter & Molz, 2011, p. 62) to dualistic metaphysics. While some of these approaches are more well known than others (De Bono, 1985; Wilber, 2000), their relative obscurity—including their “insufficient impact on society”—has been attributed to the difficulty of competing within the gestalt of ideas within the “multimedia attention economy” in which these multi-perspectival methodologies often “remain scattered, weak and unnoticed” (Benedikter & Molz, 2011, p. 62).

To address these challenges, I have explored how the central themes of this investigation can be used to expand the “heuristic availability” (Tversky & Kahneman, 1973) of epistemic virtues beyond ‘subjectivity’ and objectivity.’⁹³ Appropriately, the term *heuristic* derives from the Greek *heuriskein*, meaning to “discover or to find” (Moustakas, 1990, p. 9). It derives from the term *eureka*—first purportedly used by Archimedes to express his ‘aha moment’ upon discovering the principle of buoyancy. As demonstrated throughout this thesis, both metaphors and visualizations of the archetypal form of the sphere have performed critical heuristic functions as they have enactively shaped the history of ideas.

⁹³ Clark Moustakas (1990) defines heuristic inquiry as “process that begins with a question or problem which the researcher seeks to illuminate an answer” to “understand one’s self and the world in which one lives.” This form of “exploratory, open-ended inquiry,” he claims, aims to discover “underlying meanings of important human experiences” and requires remaining with a question intensely and continuously until it is illuminated or answered” (p. 15).

6.13 Inciting Sight

I have remained mindful of suspicions towards “ocularcentrism” (Levin, 1993) that permeated twentieth century philosophy as a response to the privileging of vision over other senses in previous centuries. Heidegger’s (1938/1977) famous proclamation that the “fundamental event of the modern age is the conquest of the world as picture” (p. 134) famously attests to this mistrust (5.12 World Picture). Heidegger (1953/1996) also addresses, however, the pre-theoretical origins of philosophy in his discussion of the “hermeneutic circle,” writing, “This circle of understanding is not a circle in which any random kind of knowledge operates, but it is rather the expression of the existential *fore-structure* of Da-sein itself” (p. 153). This “fore-structure” relates to Blumenberg’s (2010) nonconceptual realm that gives structure to metaphorical models that are “*foundational elements* of philosophical language” (pp. 3-4) (1.01 Archaic Stratum, 1.02 Cosmological Metaphorics).

I have traced this “fore-structure” to the morphology of image schemas shaped by the spherical perspective of human vision. I contend that the archetypal significance of the sphere derives from shared human experiences of the CONTAINER of visuospatial consciousness (1.03 Spherical Container). Peter Sloterdijk (2004b) also uses the lens of the sphere within his philosophy of *spherology*, examining the importance of “thought-images” for navigating different “world pictures” (Jongen, 2011, p. 199) (1.05 Polycentric Thought-Forms). Like the current study, Sloterdijk contends that visual metaphors should not—and cannot—be dismissed given their pervasiveness, instead advocating that they be taken to their extremes to expose their limits,

Others have similarly acknowledged that visuospatial imagery is not only inescapable but can also be quite useful for understanding philosophy. Like Toulmin, Donncha Kavanagh (2004) proposes a ‘middle way’ between skepticism and enthusiasm, suggesting that “it is just as inappropriate to dismiss the vision metaphor (which would be impossible anyway) as to be transfixed by it” (p. 459). Similarly, Gilles Deleuze (1995) recognizes the immanence and primacy of visual experience, borrowing the term “noology” from Immanuel Kant to describe the study of “images of thought” as the “prolegomena to philosophy” (p. 149).⁹⁴ As Deleuze contends, “It’s the image of thought that guides the creation of concepts” (p. 148). Visual modeling and diagrammatic reasoning have even been called the “secret weapons” of natural philosophy during the scientific revolution (Franklin, 1999, p. 53).⁹⁵

I find spherical visual metaphors intuitively useful for clarifying philosophical concepts and recalling a broad range of possible interpretive perspectives. To guide my *cosmotroping* practice, I have created a series of diagrams distilled from aspects of integrative metatheories I find most germane, understandable, and pragmatically functional. I use the noological lens of the sphere to syncretize and visualize these

⁹⁴ In *The Critique of Pure Reason*, Kant (1781/2010) writes, “In relation to the origin of the pure cognitions of reason, we find one school maintaining that they are derived entirely from experience, and another that they have their origin in reason alone. Aristotle may be regarded as the head of the empiricists, and Plato of the noologists. Locke, the follower of Aristotle in modern times, and Leibnitz of Plato (although he cannot be said to have imitated him in his mysticism), have not been able to bring this question to a settled conclusion” (p. 475).

⁹⁵ For examples, see Simeon Heninger’s (2004) *The cosmographical glass: Renaissance Diagrams of the Universe* as well as *Picturing Knowledge: Historical and Philosophical Problems Concerning the Use of Art in Science* (Baigrie, 1996). For a general discussion of the role of the enactive role of diagrams and diagrammatic reasoning, see *Diagrammatic Representation and Reasoning* (Anderson, Meyer, & Olivier, 2002) and Michael Hoffman’s (2004) *How to Get It: Diagrammatic Reasoning as a Tool of Knowledge Development and its Pragmatic Dimension*. For further discussion of the scientific, artistic, religious, and cognitive function of imagery, see Bruno Latour’s (2002) *What is iconoclasm? Or Is There a World Beyond the Image Wars?* and Barbara Maria Stafford’s (2009) *Echo Objects: The Cognitive Work of Images*.

metatheories, using illustrations as mnemonic devices to recall and connect different ‘worlds’ from transdisciplinary perspectives. These diagrams epitomize the double meanings of metaphors like *perspective*, *lens*, *insight*, and *illuminate*, drawing attention to the role of embodied experience within processes of enactive signification.

I refer to these diagrams as *world views* in reference to ambiguities between sensorimotor experience, cognitive scaffolding, and conceptual thought exemplified by the philosophical term *weltanschauung*. Though it is commonly translated as *worldview*, the more literal interpretation of *weltanschauung* is ‘world intuition’ or ‘world perception.’ First introduced by Immanuel Kant, it has been widely used as a totalizing concept to designate a kind of philosophical or cognitive scaffolding—often referring to the “ultimate nature and meaning of being and value of the universe, and especially of human life, as a whole” (Seifert, 1998, p. 2).⁹⁶ However, analyses of this term in the context of philosophical efforts to disentangle concepts from percepts have shed light on tensions concerning its ambiguous meaning since its inception.⁹⁷

⁹⁶ Kant (1790/1987) introduced the term in the *Critique of Judgment*, only using it once within all of his writings: “If the human mind is nonetheless *to be able even to think* the given infinite without contradiction, it must have within itself a power that is supersensible, whose idea of the noumenon cannot be intuited but can yet be regarded as the substrate underlying what is mere appearance, namely, our intuition of the world [*Weltanschauung*]. For only by means of this power and its idea do we, in a pure intellectual estimation of magnitude, comprehend the infinite in the world of sense *entirely under* a concept, even though in a mathematical estimation of magnitude *by means of numerical concepts* we can never think it in its entirety” (pp. 111-112).

⁹⁷ These different approaches are epitomized by the contrasting positions of Kant and Johann Wolfgang von Goethe regarding the fundamental structure of *weltanschauung*. Kant insists on a duality while Goethe a unity of subject and object as well as mind and body. George Simmel (2007) addresses the implications of these tensions in “Kant and Goethe: On the History of the Modern *Weltanschauung*.” Thomas Naugle (2002) addresses the broader history in his “A Philological History of ‘Worldview’” section of *Worldview: The History of a Concept* (pp. 55-67).

6.14 World Views

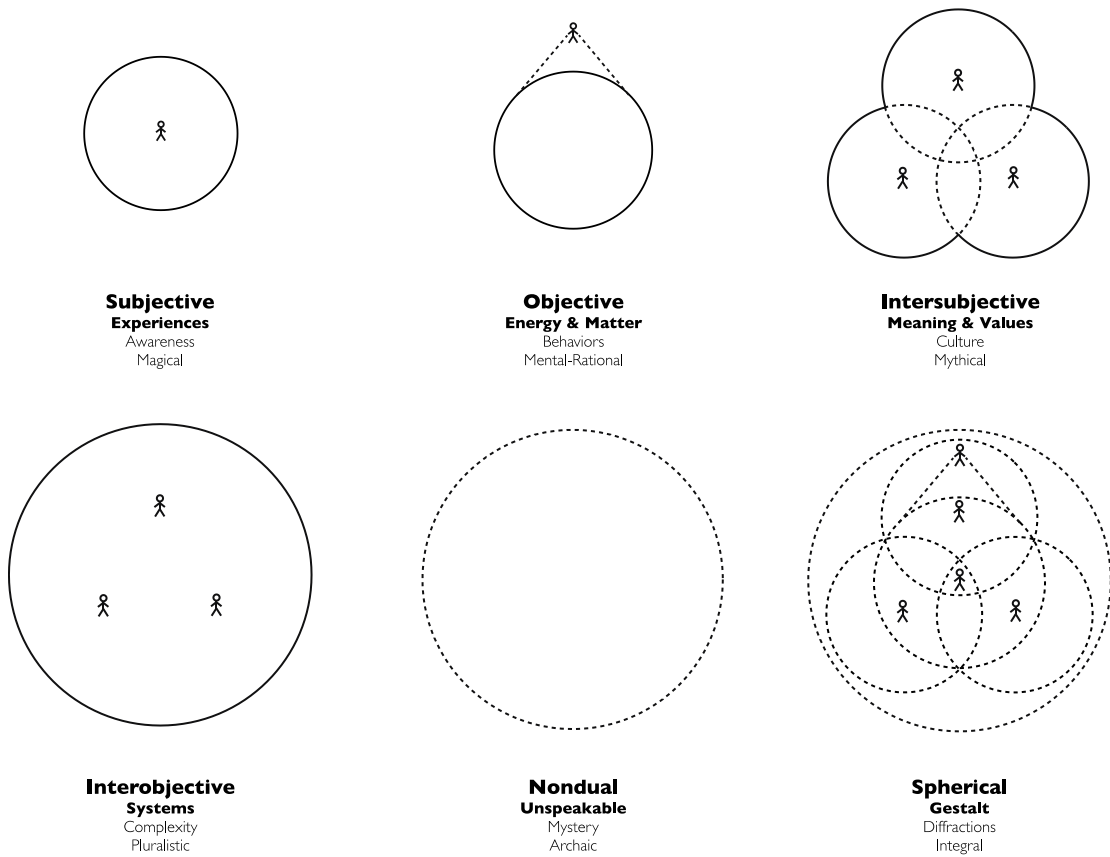


Figure 93. The spherical thinking *world views*.

To examine the ambiguities and complexities of the *Digital Universe Atlas* using the approach of *cosmographic hermeneutics*, I have created a visual logic model composed of transdisciplinary *world views*. These heuristic diagrams illustrate different ‘views’ (agents) on ‘worlds’ (circles), expanding the subject/object dichotomy to include intersubjective, interobjective, and nondual perspectives—culminating in what I call *spherical thinking* (Figure 93). These line drawings serve as noological lenses for interpreting cosmographic visualizations and examining the complex knowledge production processes from which they emerge.

These simple diagrams are designed as mnemonic devices to increase the heuristic availability of multiple epistemic virtues while *cosmotroping*. They help me to recall and explore different transdisciplinary perspectives—different ‘views’ of ‘worlds’—when navigating and narrating the *Atlas*. By diagrammatically illustrating what Edgar Morin (1992) refers to as the “complex unity” (p. 376) of systems, these *world views* help me to use cosmographic visualizations as enactive *tools for thinking* to cultivate *spherical thinking* (2.05 Tools for Thinking, 6.13 Inciting Sight).

In referring to these heuristics as *world views*, I split the compound word *worldview* to distinguish my approach from the colloquial use of the term. This term typically refers to a purely conceptual ‘point of view,’ whereas I use *world view* as a double entendre to integrate vision (percept/ontology) and imagination (concept/epistemology). This also highlights the ambiguous and interactive nature of the “hermeneutic circle” within *cosmographic hermeneutics*. As I move back and forth between individual perspectives and their attempted integration within *spherical thinking*, I also zoom in and out of the center and periphery of the ‘world’ of the *Atlas* to ‘view’ it from different virtual perspectives.

These heuristics are not meant to encompass the full depth and breadth of the pluralistic methodologies and transdisciplinary perspectives from which they draw but to introduce and invite further exploration of them. They were inspired by Tim Ingold’s (2000) diagrammatic illustrations of “views of the environment” that graphically depict his distinction between the Western “globe” and indigenous “lifeworld” (p. 209). The different *world views* also parallel Combs’ ‘worldviews’—based on Gebser’s ‘structures of consciousness’—to suggest that these structures are not linear or mutually exclusive but exist concurrently within human consciousness

(1.06 Worldviews and Universes). Additionally, Søren Brier's (2008) detailed elaboration of epistemological and ontological 'worlds' within his field of "cybersemiotics" informs categorization of disciplines within aspects the system. The *world views* taxonomy has also been inspired by "integral methodological pluralism" (Esbjörn-Hargens, 2009; Stein, 2007), a well-established metatheoretical framework that maps interrelationships among multiple 'perspectives.'

Though the *world views* diagrams are arranged in a linear progression, I use them nonlinearly to integrate them within *cosmographic hermeneutics*. It is important to emphasize their inherently heuristic function, as they are not intended to encompass the full range of interpretative possibilities. The descriptions below are intentionally succinct to retain their pragmatic simplicity. Countless volumes have been written addressing aspects of each of these perspectives, so this sketchy overview is meant solely to provide a general summary of how they inform my interpretive practice. They have proven valuable and sufficiently comprehensive within my *cosmotroping* practice, affording considerable interpretive depth and latitude for developing transdisciplinary interpretations of the *Atlas* (detailed in 7.01 Cosmotroping).

6.14.01 Subjective

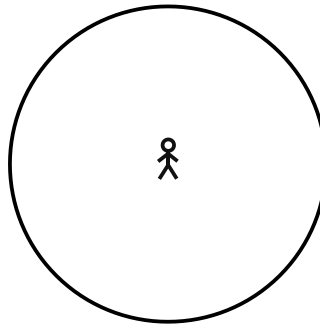


Figure 94. Subjective *world view*.

The *subjective world view* illustrates the spherical lifeworld “imagined from an experiential centre” (Ingold, 2000, p. 211) (Figure 94). I employ this lens to examine the first-person, experiential aspects of consciousness and knowledge production. This encompasses how different states of awareness structure and are structured by situated factors and complex interactions. For instance, I examine the influence of embodied physiology on perceptions, including how the spherical field of vision shapes visuospatial awareness—and, by extension, the ‘archaic stratum’ of pre-theoretical, non-dual experience (1.01 Archaic Stratum). I also include considerations of how humanity’s spatio-temporal location and the limited spectral range of visual perception affect attempts to understand the ‘real’ universe.

Through this heuristic, I primarily address cognitive, emotional, and existential aspects of the ‘inner’ world of cognition studied under the rubrics of psychology, phenomenology, constructivism, and structuralism (Brier, 2008; Esbjörn-Hargens, 2009). This depiction is also similar to the “microspheric units” Peter Sloterdijk (2011) refers to as “bubbles,” constituting “the intimate forms of the rounded being-in-form” (p. 62). Ingold associates this view with traditional and

indigenous cosmologies, which “place the person at the centre of an ordered universe of meaningful relations (p. 216). I correlate this *subjective* heuristic with the *magical worldview* (Combs, 2009, p. 63) and *magic universe* (Harrison, 2003, p. 15) to explore the ambiguous nature of boundaries between the ‘self’ and the ‘environment.’ Since beliefs in ‘supernatural’ phenomena—seeking causal links between thoughts and events—exemplify the magical view of the world, I also employ this heuristic to address how subjective experiences cognitively shape entanglements with and ‘views’ of our personal, social, planetary, and cosmic environments. (6.10 Suspending Belief). In this way, the *subjective world view* is not only limited to the personal but extends to the collective—which I demonstrate by visualizing humanity’s central location within the CMB sphere while *cosmotroping*.

6.14.02 Objective

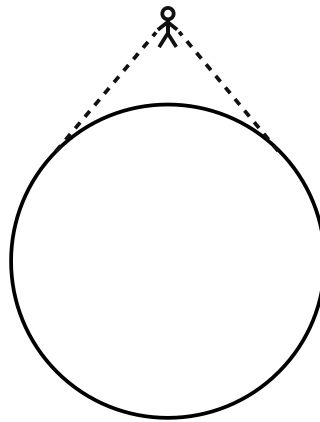


Figure 95. Objective *world view*.

The *objective world view* illustrates the imaginary exocentric perspective epitomized by the ‘Archimedean point’ (Figure 95). This perspective guides my interpretations of the visualized behaviors of energy and matter from the esteemed god’s eye view. I associate this with Gebser’s *mental*—and later *rational* or *perspectival*—structure of consciousness (Combs, 2009, p. 69), as well as the imaginary view of the world from the outside, the origins of which Remi Brague (2003) traces to Plato’s imaginary demiurge in *Timaeus*. Thomas Nagel (1986) describes this “view from nowhere” as thinking of reality as “a set of concentric spheres, progressively revealed as we detach gradually from the contingencies of the self” (p. 5). Echoing this analogy, Tim Ingold (2000, p. 211) likens this conception of the world to that of a globe as seen from the view of an astronaut or a schoolchild in a classroom. Ingold depicts a figure outside of and looking down on the sphere, symbolizing the culmination of a “process of separation” (p. 209) from the environment. In Western discourse, Ingold contends, “the world appears as an object of contemplation, detached from the domain of lived experience” (p. 210). This is

also closely related to the processes of “globalizing” the cosmos and Earth addressed by Peter Sloterdijk and others (see Chapter 3: Globalizing the World).

However, I don’t present this as the idealized disembodied view of Descartes that he hoped would serve as a firm and immovable foundation for his existential anxiety. Instead, this is more influenced by Sandra Harding’s (1991) notion of “strong objectivity.” Harding describes this as a counterpoint to the “weak conception of objectivity” (p. 143) associated with ‘objectivism,’ which she claims fails to take into account situated influences and historic contingencies of scientific beliefs. Strong objectivity acknowledges “all human beliefs—including our best scientific beliefs—are socially situated” and requires a “scientific account of the relationships between historically located beliefs and maximally objective belief” (p. 142). Joining calls for a ‘middle way’ by Toulmin (1982), Kavanagh (2004), and others (6.03 Transcending Dualities), Harding (1991) argues that it is necessary to move away from exclusively dualistic epistemic virtues, which she calls “the fruitless and depressing choice between value-neutral objectivity and judgmental relativism” (p. 142). In this spirit, I remain cognizant of the other intra-acting perspectives as I interpret the *Digital Universe Atlas* from this *objective world view*.

Lorraine Daston and Peter Galison (2010) further justify this position historically with their study of how ‘objectivity’—what they call the ideal of “blind sight, seeing without inference, interpretation, or intelligence” (p. 17)—has a significantly more recent and complex history than is commonly assumed. They demonstrate that this as a relatively recent invention emerging from the transformation of natural philosophy into modern science. Through this single perspective, I am guided by the four distinct “codes of epistemic virtue” (p. 18)

Daston and Galison identify within ‘objectivity’. The first code, *truth-to-nature*, is exemplified within images that portray the essential, universal, and ideal form of specific natural phenomena—which can be found within the *Atlas*’ visualization of the Milky Way galaxy (3.16 Entraining Objectivity). Their *mechanical objectivity* is an “attempt to capture nature with as little human intervention as possible” (p. 20), such as photographs of planets and stars within the visible range of the electromagnetic spectrum. And the third, *trained judgment*, is identified within images modified through ‘subjective’ interventions believed to be necessary to smooth data and remove instrumental artifacts. This encompasses the majority of observational datasets in the *Atlas*, often composed of hyperspectral imagery translated to be both visible and aesthetically attractive. Daston and Galison also point to a concurrent mistrust of images within some branches of science seeking the virtue of *structural objectivity*, resulting in what they call a “war on images” (p. 45). They describe how proponents of this last approach, “mostly mathematicians, physicists, and logicians [. . .] carried the self-denial of mechanical objectivity to new extremes” (p. 45). Nevertheless, common to all of these, Daston and Galison argue, are aspirations to achieve “knowledge that bears no trace of the knower—knowledge unmarked by prejudice or skill, fantasy or judgment, wishing or striving” (p. 17). *Structural objectivity* is exemplified by computer simulations based on theoretical, mathematical models.

6.14.03 Intersubjective

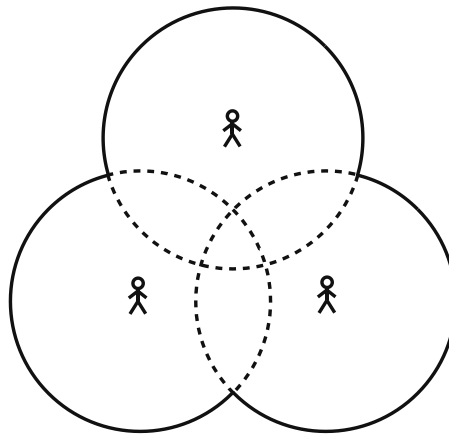


Figure 96. Intersubjective *world view*.

The *intersubjective world view* calls attention to significant influence of sociocultural factors in shaping ways of understanding and relating to existence. These emerge from relationships and shared experiences, which I depict as figures whose ‘lifeworlds’ are overlapping (Figure 96).⁹⁸ I associate this perspective with the experiential ‘first person collective’ aspects of experience, encompassing linguistic, philosophical, and religious aspects of shared culture. This “cultural world of language, meaning, symbols, brand, art, power and technology” (Brier, 2009, p. 35) is generally studied within the humanities, including the fields of anthropology, classical studies, literature, history, and philosophy (Esbjörn-Hargens & Zimmerman, 2009, p. 63).

⁹⁸ This is similar to Peter Sloterdijk’s (2004a) use of his “plural-spherology” notion of “foam” to “analyse the interlinked and connective relations between human spheres” (Elden & Mendieta, 2009, p. 6), which itself was partly inspired by the rhizomes of Deleuze and Guattari (Alliez & Sloterdijk, 2007, p. 317). Schinkel and Noordegraaf-Eelens (2012) describe “foam” as a “shared psycho-spatial immunological edifice,” containing elements of “Latourian actor-network chains [. . .] Deleuzian assemblages [. . .] [and] a Foucaultian dispositif in its mesh of discourse” as well as aspects of Luhmann’s sociological theory (p. 13). I interpret the overlapping and pluralistic perspectives of Sloterdijk’s “foam” to be a hybrid of this *intersubjective* (sociocultural) *world view* and the *interobjective* (socioecological) *world view* described below.

I have expanded Ingold's (2000) original illustrations to address critiques of his binary division between the cosmologies of the indigenous "lifeworld" and Western "globe" as useful but limiting. Andreas Roepstorff (2004) contends that this dualistic analysis "parallels one of the most powerful origin myths about modernity," namely that the world was once "full of meaning and coherence, cosmology, but then 'something' happened, the world lost its meaning and inner coherence, and it became the way we know it today: namely technological and modern" (p. 123). Echoing numerous calls for the need to move beyond binary polemics (Nicolescu, 2002; Pepperell & Punt, 2000; Pepperell, 2006; Priest, 2002), Roepstorff (2004) cautions against accepting simplified dualistic histories, suggesting that it may be most fruitful to find ways to move between subjective and objective views (p. 137). This also relates to the description of Sloterdijk's "spheres" strategy as able to "avoid both a naïve realist position and a 'post-modern' version of perspectivism" (Schinkel & Noordegraaf-Eelens, 2012, p. 213).

This heuristic provides an opportunity to address aspects of the *mythical worldview* (Combs, 2009, p. 140) and *mythic universe* (Harrison, 2003, p. 29) (2.11 Mythic Worldview). This includes the cultural influences of spiritual and religious perspectives, as well as what Carl Jung (1959/1981) calls the archetypal forces residing within a collective unconscious that, he writes, "does not develop individually but is inherited" (p. 43).

6.14.04 Interobjective

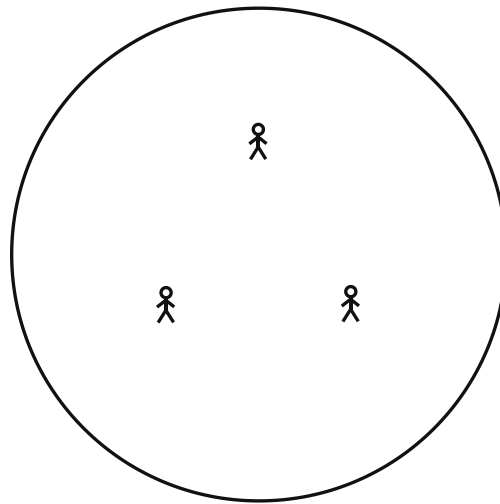


Figure 97. Interobjective *world view*.

The perspective of the *interobjective world view* provides a critical counterbalance to approaches that attempt to reduce the world through ever-increasing specialization and categorization. Broadly speaking, it provokes recognition of *systems* and *relationships* that give rise to synergistic properties emerging through the complex intra-actions across multiple scales. This diagram further extends the *intersubjective* heuristic, encompassing the figures within a common sphere symbolizing a shared environment (Figure 97).

Humberto Maturana (2000) writes that “interobjectivity is not a domain of objects that exist independently” but one in which objects arise and are constituted within the “flow of recursive coordinations of doings” (p. 463). He defines it as “the domain of explanations” in which “we see ourselves as constituting a larger system,” taking place “in the flow in which relations take place—it is the happening of that flow, not a commentary on it” (p. 465). Sally Gradle (2007) considers recognizing interobjectivity as essential for arts education, particularly within the creative

processes that give rise to “interrelational transformation(s)” and “connective actions” which “comprise, and thus alter, the creator-object relationships that transform the world” (p. 1509). She finds evidence of interobjective ideas within Gregory Bateson’s (1972) writings concerning ecological views on the processual nature of mind as well as Gregory Cajete’s (1994) thinking on creative strategies with indigenous education.

Through the *interobjective world view*, I examine many conventional concepts associated with reductionist and representationalist paradigms. I explore the fluidity of the existential continuum, focusing on the multitude of ways in which distinctions—between human and non-human (Latour, 1996), mental and physical (Clark, 2008), social and ecological (Berkes, Colding, & Folke, 2003), celestial and terrestrial (Berry & Tucker, 2009)—are ultimately constructs. Interobjective explorations expose deep interconnections and interdependencies with the “more-than human cosmos” (Abram, 1996, p. 71) to evoke new ways of understanding, participating in, and designing for living systems (Pourdehnad, Wexler, & Wilson, 2011; Skrbina, 2001; Wood, 2007).

6.14.05 Nondual

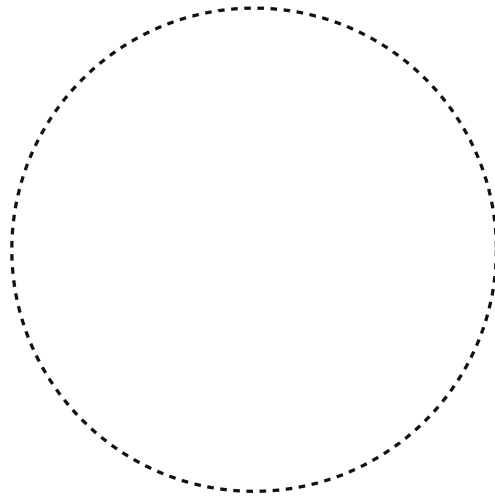


Figure 98. Nondual *world view*.

The *nondual world view* is an inherently elusive and ineffable sphere, though it paradoxically encompasses some of the most conspicuous aspects of *cosmographic hermeneutics*. The dashed circle of this diagram symbolizes the infinite sphere (Figure 98), with its center everywhere and circumference nowhere (Harries, 1975). By having “neither beginning nor end” (Brendel, 1977, p. 24), the infinite sphere serves as a reminder of the sublime encounter with mystery—sought by some, denied by others—that manifests as both illumination and ignorance. Its ineffability derives from the paradoxes of self-consciousness and the concomitant desire to describe the indescribable by quantifying the infinite within the finite.

Hans Blumenberg (2010) describes it as “self-transcending ‘explosive metaphors’, which operates with geometric figures even as it transforms them” (pp. 122-123). He traces the origins of its “metaphysically hypostasized” structure to Plotinus’ contemplation of the “One” and Mind’s relationship to itself, supplying “an ‘image’ in place of the concept and conceptual understanding” (p. 122). Emphasizing

its reflexive circularity, Blumenberg claims this “literally reproduce[d] the Mind, and its reproduction is at the same time a metaphor for what it reproduces and a metaphor for its failure to reach its goal” (p. 122). He relates this inability of the intellect to conceive of the infinite to the strategies of negative theology, particularly Nicolas of Cusa’s notion of *learned ignorance*. Blumenberg claims Cusa’s strategy does not “represent a body of knowledge,” but “is a path, a spiritual exercise, a method for cultivating a stance or attitude” (p. 123). The aim, he suggests, is to draw intuition into a process making “transcendence something that can be ‘experienced’ as the limit of theoretical apprehension [. . .] exploding what avails itself to the mind’s eye by adding the infinitum and withdrawing it from apperception” (p. 123) (3.12 Learning Ignorance). Similarly, Harrison (2003) asserts “*the ratio of learned ignorance to knowledge tends always to increase*,” but that “gaining conscious awareness of ignorance – is one of the main agents causing universes to evolve” (p. 306).

This perspective can be understood as pointing to the realm of paradox in which notions of ‘subject’ and ‘object’ are joined within a complex unity. It has been assigned countless names throughout the history ideas, the descriptions of which often transcend the boundaries between religion, science, psychology, and philosophy. David Loy’s (1997) *Nonduality: A Study in Comparative Philosophy* develops a “core doctrine” of nonduality through hermeneutical examinations of numerous philosophical systems, including Derrida’s deconstructionism. References to nondual ideas defying non-contradictory logic can be found throughout numerous traditions and disciplines, including the Greek *khôra* (Derrida, 1995; Plato, trans. 1892, sec. 48a, 52a), Buddhist *Śūnyatā* or *emptiness* (Loy, 1997, p. 20), the *ein Sof* of

Judaism (Michaelson, 2009, p. 1), Sri Aurobindo's (1985, p. 860) *Spirit*, and Taoism's namesake *The Tao* (Loy, 1997, p. 112). The Sanskrit word "advaita" literally translates as nondualism—"a=not or non; dvaita=two, dual, or dualism" (Jnaneshvara, 2005, p. 3). Carl Jung's term *collective unconscious* describes a "universal substrate present in the environment," correlated with the *Unus Mundus* (Latin for "one world") that is "coextensive with nature in its entirety" (Aziz, 1990, p. 177).

Quantum physicists refer to an *implicate order* (Bohm, 1980) and the *non-local universe* (Nadeau & Kafatos, 2001), while logicians and philosophers attempt to describe the *Monad* (de Quincey, 2010, p. 130), *Firstness* (Peirce, 1932, p. 183) and a world *beyond the limits of thought* (Priest, 2002). Parapsychologists and consciousness researchers describe a field of *nonlocal consciousness* (Targ & Ketra, 1999) and *nonlocal awareness* (Schwartz, 2007). Furthermore, mathematicians repeatedly encounter this perplexing realm when grappling with concepts of *infinity*—what the ancient Greeks call *apeiron* (Rosen, 2004)—producing seemingly paradoxical 'proofs' of uncertainty (Byers, 2011). Bringing awareness to nondual interpretations has helped me to appreciate that nonduality is not duality. Instead of being mutually exclusive of dichotomies, nonduality refers to the nonconceptual, archaic ground that includes, transcends, and generates conceptual polarities (1.01 Archaic Stratum, 1.02 Cosmological Metaphorics).

6.15 Spherical Thinking

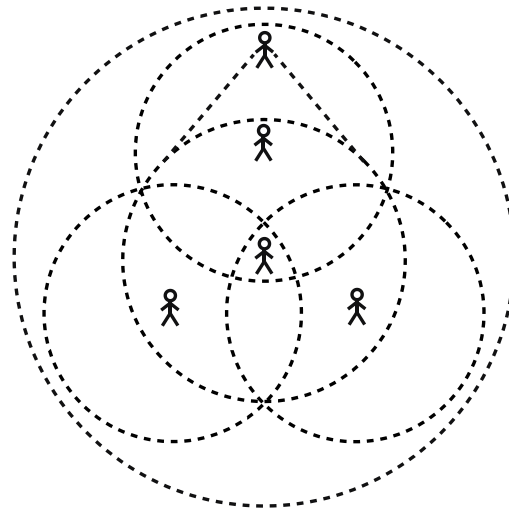


Figure 99. Spherical thinking.

The final perspective, what I call *spherical thinking*, culminates and integrates the other *world views*. Analogous to Karen Barad’s (2007) definition of intra-acting agencies, this heuristic emphasizes that the ‘perspectives’ and of the different *world views* are only distinct in relation to their mutual entanglement. Accordingly, all of the spheres within this diagram are dashed (Figure 99), indicating the interdependence and permeability of all of the ‘worlds.’ This serves as a reminder that *subjectivity*, *objectivity*, *intersubjectivity*, *interobjectivity*, and *nonduality* can be seen as epistemic virtues, constantly intra-acting and never fully independently of one another. Instead of absolute or isolated views, they provide imaginative lenses to examine complex diffraction patterns emerging from processes of knowledge production.

Similar ideas can be found within Native American Indian philosophies. Dennis McPherson et al. (2011) refer to their “polycentric perspective,” describing a way of knowing that “recognizes that we finite human beings can never obtain a

God's-eye view, a non-perspectival view, of reality, of philosophical truth” (p. 20). They cite examples from what they call “ethno-metaphysics that recognize the inherently situated nature of all perspectives—that ‘every view is a view from somewhere’” (p. 20). In contrast to the ‘incommensurability’ of Kuhn’s paradigms, they explain that no perspective is privileged, but that each “contributes something to the total picture, a picture which is not yet and may never be wholly complete” (p. 20). They contrast this position with the absolute relativism of certain strands of postmodern philosophy. Instead of overly deconstructive or theoretic approaches, they advocate for a *balanced philosophy*. Rupert C. Lodge (1951) describes this as flexibly applying idealism, realism, and pragmatism that “retains the divergent characteristics of all three philosophic attitudes, but holds them in balance against one another” (p. 19).

Related ideas can also be found in Asian philosophical traditions. Joanna Macy (1991) elucidates connections between central Buddhist concept of “dependent origination” or “dependent co-arising” (*paticca samuppāda*) and general systems theory. This describes the fundamentally “interdependent structure” of reality (p. 63), which challenges the conventional viewing of things as having autonomous, independent existence. Like Rappenglück (2007, p. 241) and Sloterdijk (2011, p. 275), Macy invokes a womb metaphor to connote the generation and the arising of phenomena from within a matrix or web of interdependence.⁹⁹ Perceiving this

⁹⁹ Rappenglück (2004b, p. 10) describes the cave as a “cosmic womb,” and a “place of creation and transformation” (p. 241) (2.06 Cave as a Cosmos). Sloterdijk (2011) connects the womb to the cave to suggest the circularity of the quest for wisdom, asking “Who is the hero with a thousand faces if not the seeker who journeys out into the wide world in order to return home to his ownmost cave? The tales of heroic truth-seekers celebrate the womb-immanence of all being. Wisdom is the realization that even the open world is encompassed by the cave of all caves” (p. 270). Plato (trans. 1892) also

“mutual causality,” Macy (1991) contends, is “not a dissecting or categorizing exercise of the intellect,” but involves a “synthetic rather than analytic ... awareness of wholeness” to behold interrelationships (p. 63). Like Barad’s (2007) intra-action, Macy regards this view on causality diverging from the linear perspective characteristic of the West. It is, Macy (1991) writes, “both relative and objective: Objectively inhering in the nature of things, it is relative, not as a subjective opinion but by virtue of the interdependence of phenomena” (p. 64) (6.05 Re-Imagining the World).¹⁰⁰

John Koller (2000) describes the similar Jain metaphysics of non-absolutism (*anekāntavāda*), exemplified by the tale of the blind monks each detailing a different part of an elephant. Unlike mutually exclusive logic, this tradition recognizes multiple co-existing perspectives, “illustrat[ing] a way of thinking about existence as simultaneously both being and becoming” (p. 400). Instead of succumbing to binary polemics, knowledge claims within this system use qualifications to clarify the perspective from which they are being made. For instance, the definitive statement "X is Y" would be modified to, "From a certain perspective, X is Y" (p. 401).

suggests this womb metaphor in his description of the primordial *khôra* as “the receptacle, and in a manner the nurse, of all generation” (sec. 48a).

¹⁰⁰ David Gray (2006) summarizes the doctrine of interdependent origination as holding “that all entities are deeply interdependent, collectively constituting a vast network of interrelationality” (p. 297). Paul Williams (2000) describes the Buddhist view that this doctrine extends to both consciousness and phenomena: “Consciousness comes about in dependence upon some condition or another. ‘Consciousness’ is just the name we give to e.g. sensory experience, as happens when an unhindered eye meets (as it were) a visual object. Then we speak of ‘visual consciousness’. There is a flow of such experiences, and if experiences actually take place no really existing additional subject as consciousness itself, over and above conscious experiences, is needed” (pp. 62-63). He contends that this is the essential teaching of the Buddhist “Middle Way,” writing, “Thus instead of identity and difference, and instead of eternalism and annihilationism, the Buddha substitutes dependent origination, in the sense of causal dependence” (p. 70).

Many different names have been given to systems of logic that acknowledge seemingly contradictory or paradoxical concurrent perspectives, including paraconsistent logic (Weber, 2010), non-Aristotelian logic (Korzybski, 1933), dialetheism (Garfield & Priest, 2003; Pepperell, 2006; Priest, 2002, 2008), maybe logic (Bauscher, 2003), the logic of myth (Lévi-Strauss, 1955), the logic of ambivalence (Pregadio, 2004; Smelser, 1998), the logic of laughter (Koestler, 1964), the logic of the included middle (Nicolescu, 2002), a logic of the ambiguous, of the equivocal, of polarity (Vernant, 1990, p. 260), and the ‘middle way’ (Toulmin, 1982). Each of these opens potential paths beyond Aristotelian non-contradictory logic and Cartesian dualistic metaphysics—“not the binary logic of yes or no but a logic different from that of the *logos*” (Vernant, 1990, p. 260)—recognizing the utility of binary logic and linear causality as well as their limitations (6.03 Transcending Dualities). The ability to shift fluidly between multiple perspectives has been assigned an array of designations. Jean Gebser (1984) calls this complex unity the integral-aperspectival structure of consciousness, marked by the ability to “assimilate the entirety of our human existence into our awareness” (p. 4).¹⁰¹ Similarly, Alan Combs’ (2009) integral worldview, Robert Kegan’s (1994) self-transforming mind; Jürgen Habermas’ (1984, 1985) domination free discourse; and Ken Wilber’s (2000) vision-logic all describe variations on the theme of this *spherical thinking* encompassing trans-paradigmatic, multi-perspectival, and paradoxical thinking.

¹⁰¹ Gebser (1984) clarifies that his use of the term “aperspectival” is not the negation or antithesis of “perspectival” but designates the culmination and integration of perspectives (p.2). In contrast, Lorraine Daston (1992) uses the term to describe the dominant epistemological assumption of the possibility of achieving an ultimate “view from nowhere” (p. 599). She defines aperspectival objectivity as “eliminating individual (or occasionally group) idiosyncracies” (p. 597).

The five *world views* comprising *spherical thinking* are by no means meant to be exhaustive in their descriptions since it impossible to encompass the full range of possible interpretive lenses. They function as a pragmatic heuristic framework for recalling an array of transdisciplinary interpretations during the process of *cosmographic hermeneutics*. As visual metaphors, the spherical diagrams provide mnemonic shortcuts for recalling diverse *perspectives, worldviews, structures of consciousness, and universes* during my interactive *cosmotrope* performances.

Given the depth, breadth, and complexity of the information referenced by these *world views*, it is useful to explain their utility in simple terms. I describe these heuristics as tools for cultivating *spherical thinking*, which includes, expands, and transcends to the “masculine ideal of objective, rational, logical, linear thinking” and the “reductionist approach to studying nature” (Shepherd, 1993, p. 21). The need to shift from *linear thinking* to *spherical thinking* provides a succinct, poetic narrative to describe why domes and spheres are useful *tools for thinking* to enact different ways of knowing (2.05 Tools for Thinking).

Others have also employed spherical metaphors in ways resonant with the spirit of this current project. Bonnie DeVarco (1997) writes that “the basic concepts surrounding a spherical world view often merged in the intersection between seemingly disparate bodies of experience, the sciences and the humanities,” connecting Buckminster Fuller’s efforts to move beyond the cubic frame of reference to the lineage of the Pythagorean philosophy of divine geometry (4.05 Pedagogical Yearnings). Within a spherical frame of reference, DeVarco writes, “music, philosophy, art and the imagination no longer need to be seen in opposition to a scientific, abstract world of fixed rules” (para. 2). Lauren Ewing (2010) also calls for

spherical thinking within contemporary arts education. She describes the need for “remixing the hive” (p. 162) to cultivate multidimensional, multi-sensorial, interdisciplinary, and holistic learning that transcends ideas about progress and historical ideologies.

In his thesis about the potential of virtual worlds to shift conventional ways of thinking, Joseph Nechvatal (1999) similarly argues that “immersive spherical thinking, as stimulated by the immersive spherical perspective, opens up a territory of signification and possibility for the creation of hybrid and deterritorialised meanings” (p. 7). He contends that this advances meaning within art and life “by seeing more clearly the underlying assumptions of excess inherent in the immersive outlook, by facing up to the radical implications of those assumptions, and by purging itself from conventional ways of thinking” (p. 7). And foreshadowing the *kōan*-like encounter during *Bok Globule* that initiated this dissertation, Michiko Yusa (1987/2005) describes paradoxes as a form of expression that are “baffling, striking, surprising, or nonsensical to linear thinking.” He contends that their “free, creative, and playful” elements are also conducive to “spherical thinking” that “expands and contracts freely across terminal and categorical boundaries” (p. 6991). This fluid expansion and contraction across boundaries is evident within the consequences of my own encounter with the contemporary return of the paradoxical *heavenly sphere*.

Conclusion

As the provocative conundrum of the *heavenly sphere*'s return has complicated efforts to make sense of the *Digital Universe Atlas* from either 'subjective' or 'objective' perspectives, I have sought to develop a pragmatic strategy for interpreting cosmographic models from multiple perspectives. Though dualistic logic and mythologized narratives of the Copernican cliché continue to influence interpretations of the history of science and its artifacts, numerous artists, scientists, and philosophers have called for transdisciplinary approaches that transcend entrained habits of linear thought. They have re-imagined fundamental epistemological, ontological, and cosmological assumptions, elucidating new possibilities for tackling the interconnected and seemingly intractable problems from transdisciplinary perspectives.

In reviewing these proposals, this chapter has described numerous strategies informing my creation of *cosmographic hermeneutics*. I have integrated these ideas into a system of visual heuristics metaphorically embodying multiple *world views*, which I use to guide transdisciplinary 'tours' through the *Atlas*. Designing a 'third space' within which to facilitate interactive examinations of historic and contemporary cosmographic models has enabled me to iteratively develop these ideas within immersive visualization environments. The next chapter describes how I apply these heuristics during my performative practice of *cosmotroping*. This demonstrates a practical approach for explicating complex processes of knowledge production to cultivate capacities for multi-perspectival and paradoxical *spherical thinking*.

Chapter 7: Transcalar Imaginary

*“When we try to pick out anything by itself,
we find it hitched to everything else in the universe.”*

(Muir, 1911, p. 211)

Introduction

This chapter describes my explorations of the *transcalar imaginary*. I use this term to describe the hybrid ‘third space’ (6.09 Creating a Third Space) emerging through the integration of immersive environments, scientific visualizations, social interactions, and collective imaginings. Postphenomenological mediation techniques (6.08 Learning to See) cultivate this third space and enable examination of contemporary and historic efforts to visualize a cosmic order across multiple scales of spatial, temporal, and spectral scales.

I begin with an account of *cosmotroping* through the *transcalar imaginary*. A narrative compiled from multiple performances provides an example transcription of my performative practice. The transcription is accompanied by a reflexive commentary explaining how the findings of the previous chapters are integrated into the narrative. I describe how I apply the *world views* heuristics to the *Digital Universe Atlas* during the process of *cosmographic hermeneutics*. The heuristics function as mnemonic keys to navigate a range of possible interpretive trajectories through the curated collection of cosmographic models. The *Atlas* is an ideal experimental candidate since—as a virtual artifact of complex technoscientific processes—it visually and structurally embodies the *mediated* and *instrumentally real* intra-acting *diffraction patterns* of the multiple *world views* (6.10 Suspending Belief).

Next, I describe the consequences of my efforts to re-imagine the trope of the cosmic journey. I recount how this mixed research methods research project has transformed my interpretations and use of historic and contemporary cosmographic models, particularly how I approach the ‘centric’ and ‘eccentric’ aspects of the *Atlas*. I contend that the Hayden Planetarium’s efforts to push the ‘Archimedean point’ to its cosmographic extreme have encountered the perennial paradox of ‘squaring the circle,’ continuing in the paradoxical tradition of *cognitive cosmographic models*. I also consider the implications of the return of an Earth-centered cosmic model within the context of ongoing appeals for *neo-geocentrism*—the human re-orientation to the more-than-human lifeworld of Earth. I next describe how this research catalyzed the *Worldviews Network*, a collaboration of artists, scientists, and educators in science centers across the US. This chapter concludes with a summary of how the findings of this dissertation are informing current and future projects.

7.01 Cosmotroping



Figure 100. Invitation to *The Transcalar Imaginary* cosmotroping performance at Stanford University's *MediaX: Collaborative Visualization for Collective, Connective, and Distributed Intelligence* (McConville, 2009c).

Cosmotroping is the performative practice of enacting *cosmographic hermeneutics* (6.12 Cosmographic Hermeneutics) to convene 'tours' of contemporary and historic cosmic models from transdisciplinary perspectives. I interactively navigate and interpret perceptually immersive projections of the *Digital Universe Atlas* within the *GeoDome*. Narrating and navigating flight paths through visualized datasets during these performances, I examine relationships between presumed dichotomies, such as image and imagination, mediation and meditation, the physical and metaphysical, subject and object, body and mind, as well as cognition and the cosmos. I refer to the hybrid 'third space' created through this practice as the *transcalar imaginary*, using postphenomenological visualizations to traverse multiple

orders of simulated spatial, temporal, and spectral magnitude (Figure 100) (6.08 Learning to See, 6.09 Creating a Third Space).

I have iteratively refined this approach over the course of this research project, informed by ongoing exchanges with participants from a diverse range of backgrounds and perspectives within many locations and settings. These include informal science institutions, universities, academic symposia, art/science/film festivals, not-for-profit organizations, community gatherings, government agencies, and corporations. I have explored the *transcalar imaginary* with participants representing the arts, sciences, humanities, and indigenous traditions in over 100 invited performances (see Select Cosmotrope Performances in Appendix I).

I have developed this practice to experientially demonstrate how cosmographic practices can illuminate intra-acting epistemic virtues. I apply the *world views* heuristics to improvise interpretations of the *Atlas* (6.14 World Views), highlighting what Ihde (1998) calls the “functionally hermeneutic” (p. 4) nature of scientific praxis. Instead of presenting datasets as the ‘real’ universe, I seek to *suspend belief* (6.10 Suspending Belief) in the clichés and tacit expectations of the cosmic journey by integrating narratives about the influences of contingent and situated cultural, technological, and ecological factors within knowledge production processes.

Though the *world view* diagrams circumscribe considerable theoretical and historical depth, their visual metaphors optimize my ability to traverse multiple perspectives during the performances. The various positions and configurations of the symbolic ‘views’ of the agents (symbolized as stick figures) in relation to the ‘worlds’ (symbolized by the root metaphor of the sphere) mnemonically guide my

transdisciplinary interpretations of the *Atlas*. Though each performance combines these heuristics in differing variations, the overall system helps me recall and interweave theoretical, historical, and scientific narrative threads.

When *cosmotrope* through the *transcalar imaginary*, I attempt to illuminate the shortcomings of interpreting visualizations from naïve real or dualistic philosophical perspectives. Instead, I interpret the cosmic models as diffraction patterns emerging through the dynamic interplay of intra-acting *world views*. The *instrumentally real* datasets of the *Atlas* emerged from technoscientific ‘objective’ observations, providing the overarching structure of the three-dimensional virtual cosmos. ‘Subjective’ artistic and technical decisions shaped the modeling of observational data, the appearance of which is partially determined by situated spatiotemporal perspectives of the observing systems. ‘Intersubjective’ cultural narratives and assumptions concerning the nature of reality significantly influenced the structure of the observing systems and the decisions of how to visualize their findings. ‘Interobjective’ ecological contexts provide the elemental, synergistic ground of existence that produced and sustain the living and technoscientific systems responsible for these creations. ‘Nondual’ entanglements between perceived dichotomies also gave rise to the complex unity of the *Atlas*, contributing to numerous mysteries, paradoxes, and uncertainties. I integrate these multiple perspectives into a *spherical world view*, which I use to reflexively examine how the *transcalar imaginary* visualizes diffraction patterns of the ‘universe’ emerging from complex and transdisciplinary processes of knowledge production.

This section provides a basic overview of how these heuristics inform my interpretative process of *cosmographic hermeneutics*. Since *cosmotrope* sessions

are always live and improvised, I have resisted recording the sessions. My desired effect for myself and other participants depends on both social and technological interactions within the immersive spherical environment. To give a general sense of how these sessions unfold, I have transcribed and edited the following narrative from audio recordings of numerous performances. Since I frequently tailor these presentations for general audiences from diverse and often non-academic backgrounds, I have maintained a vernacular and colloquial style to illustrate how I interpret and relate transdisciplinary topics while *cosmotroping*.

The subject areas addressed within this example narrative are by no means exhaustive. I always adapt the flow and trajectory of the performances to integrate audience interaction and current events. However, the narrative includes many of the general topics and key points I attempt to cover in these sessions as well as the general narrative arc of the performances. The scientific and technical descriptions of the *Atlas*' modules primarily derive from the *Digital Universe Guide* (Abbott, 2012), so I do not describe them in detail here. The flight trajectory and models being visualized are described in brackets. Reflexive and descriptive commentaries are interspersed throughout the narrative to provide additional context. These comments describe how the results of this mixed methods investigation informed each section as well as how I apply the *world views* heuristics. Commentary text is in standard format and the narrative is indented as an inline quote. All images are rendered using the *Uniview* visualization platform (SCISS, 2013) unless otherwise noted.

7.01.01 Points of Orientation

I begin each performance by greeting the participants, explaining the interactive nature of the session, and expressing my gratitude for their participation. To give everyone's vision a chance to adjust to the low light of the simulated star field, I inform them that, in the course of the next hour or so, we'll be taking a virtual journey within our collective imagination, guided by scientific visualizations primarily constructed from astronomical observations. This, I suggest, is a unique moment and opportunity within the evolution of human consciousness, as we're the first generation with the ability to interactively visualize and examine the consequences of a three-dimensional scientific model of the observable cosmos. I then pose the central existential questions that have driven this inquiry: Why do we want or need to know our place in the cosmos? What does the creation of this model suggest about the capabilities and ambitions of scientific endeavors? What are the consequences of this effort? And how do interpretations of this larger cosmological context inform our understanding of—and actions in—the world?



Figure 101. *Digital Universe Atlas* visualized within *Uniview*, projected in the *GeoDome* (Foley, 2012b).

[Scrolling around to look at the simulated starfield]

Let's start by considering how we know where we are in the universe (Figure 101). For countless generations, our ancestors turned to the dome of the sky seeking answers to their deepest questions. They imagined all kinds of stories and constellations to keep track of the movements of the stars and make sense of their worldly existence. But in this age of streetlights and global positioning

systems, many of us find ourselves too rarely turning to the sky to contemplate a cosmic order.

7.01.02 The Black Marble

From the outset of the presentation, I encourage the type of *suspension of belief* I experienced during *Bok Globule* (6.10 Suspending Belief). I work to establish transparency by pointing out the technological apparatus—including the projector, dome screen, and software—to illuminate the apparatus and processes through which the experience is generated. Standing towards the center of the dome and directing attention to the fisheye projector, I explain how the system mimics the spherical field of human vision. I also point out that the visualized data has been estimated to represent around US\$10 billion of expenditures on astronomical surveys around the world (Sweitzer, 2010). I then discuss my own position within the system, explaining that I am not a scientist but that I became interested in these topics through my professional and artistic work designing visualization environments. I also invite the participants to examine the interactive game controller I'm holding—sometimes passing it around the room—to demonstrate that I will be interactively navigating through the datasets and determining which visualizations are displayed.

As I move towards the back of the dome, I bring a model of Earth into view, asking who recognizes the image. I recount the importance of the ability to see this perspective, recalling the collective impact on humanity of the 'whole Earth' and 'Blue Marble' images taken by NASA Apollo astronauts almost half a century ago (5.16 Inverting Heaven). Even though this view of the world, I suggest, is largely taken for granted in the era of *Google Earth*, the Apollonian perspective has in many ways transformed how humanity's home planet is perceived and understood.

People used to come to planetariums to learn about the night sky. But today we're going to start off by leaving the surface of our home planet to see a much more familiar view.



Figure 102. NASA's *Black Marble* satellite imagery composite of Earth at night.

[Scrolling around and zooming out to reveal the model of Earth]

Many people first saw this perspective of ourselves in 1968, thanks to the Earthrise photograph taken by Apollo 8 astronauts. This image of Earth from outer space had a profound impact on the global imagination. It was credited with inspiring the first Earth Day as well as the birth of the environmental movement. Today, we can also see the impacts of human civilization from

space where our lights are illuminating the night sky (Figure 102). As beautiful as these views are, however, we can easily take once novel perspectives for granted since they regularly appear in advertising campaigns, science fiction movies, and of course *Google Earth*.

But where exactly is Earth?

[Zooming further out from the Earth model, keeping it at the center]

As we begin to zoom out, we'll start to see that when it comes to understanding our relationship to the cosmos, context is everything.

7.01.03 The Milky River

Pointing to the image of the Milky Way plane, I ask how many of the participants have seen it recently—or ever. I have found that many participants in urban areas have never experienced this view due to light pollution. I sometimes discuss the significance of this view of the galactic river to cultures across time, pointing out that the word “galactic” derives from “lactation” and was used to refer to a “milky circle” (Harper, 2012a).

Yet achieving this perspective is just the latest within a long history of attempts of our species to understand its home in the cosmos. Today, we understand the Milky Way is a barred spiral galaxy containing hundreds of billions of stars. However, varying mythological interpretations of the nature and purpose of this “river of milk” have played an important role in informing how cultures understand the overarching context of existence.



Figure 103. Milky Way all-sky survey (ESO & Brunier, 2009).

[Scrolling around to view the Milky Way image from various perspectives]

The Milky Way's apparent brightness and position shifts throughout the year due to a rotating Earth (Figure 103). The summertime view appears brighter because we're facing inward towards the galactic core, composed of billions of stars orbiting what is thought to be a black hole at the Milky Way's center. As we face the outward in the winter, the spiral arm is dimmer but the individual stars in the sky appear brighter.

7.01.04 Ancestral Visions

To explore of *intersubjective* factors that have shaped different *worldviews* and *universes* across time, I integrate custom modules of historical imagery alongside the *Atlas*' scientific visualizations. Inspired by Aby Warburg's use of cosmological imagery within his *Mnemosyne Atlas* (Johnson, 2012), I use this series of images to address the historical antecedents of contemporary cosmographic practices and artifacts (see Chapter 2: Domesticating the Universe).

Understanding this apparent rotation of what looks like a sphere of stars—and the position of the sun and moon—has been essential for humanity's survival. Knowledge of these celestial phenomena enabled our ancestors to synchronize with the cycles of life, helping them to develop techniques for hunting, gathering, navigation, and other skills requiring orientation to local and cosmic environments. The heavenly patterns and rotations were a shared experience guiding the evolution of diverse human cultures. The development of techniques for recognizing and keeping track of these phenomena shaped humanity's collective imagination for countless millennia. The ability to 'read' the stars was a fundamental survival skill—a connection that's difficult for us to appreciate in this age of streetlights and modern conveniences.

In other words, our species has been visualizing these patterns for a very long time. We have become quite proficient in developing creative techniques for making sense of a cosmic order across generations. It's actually believed that a number of ancient etchings and cave paintings may be visualizations of patterns in the sky.



Figure 104. Inverted outlines of the ‘birdman’ panel from the Lascaux cave, mapped onto the summer triangle. Based on research by Michael Rappenglück (1999a, 2004b).

[Turning on the Cave of Lascaux ‘birdman’ panel constellation]

For example, this painting from the Cave of Lascaux in southern France may be a 17,000 years old constellation (Figure 104). An extensive analysis has suggested it that the cave—like the dome we’re in now—may have served as a proxy for the dome of the sky. The eyes of the little bird on a stick, the bird-man, and the bison may symbolize the primary stars of what we call the “summer triangle.” This constellation appears to frame a portal the Milky Way. It’s likely that as we sit here visualizing the heavens today, we’re continuing a tradition that’s tens of thousands of years old.

Many cultures envision the milky river as an important part of the upper world. The birdman may symbolize the flight of a shaman or psychopomp that helps to guide souls through the afterlife. Remnants of this practice are still evident today in the tradition of using feathers within headdresses or hats. And we even can still see the constellation Cygnus the swan in approximately the same place as the birdman.

The integration of this cave painting within my performances took an unexpectedly personal turn in 2011. After discovering the research of Michael Rappenglück (2.06 Cave as a Cosmos) and creating the Lascaux constellation module within *Uniview* (4.08 Expanding Virtual Horizons), I became increasingly interested in connections to archaic cosmographic practices. I spent considerable time when *cosmotrope* speculating about the complexity of the cave rituals, the relevance of the *axis mundi*, and the significance of bird symbolism. After a year of these explorations, I conducted a DNA test to trace my own paternal lineage. The results (ancestry.com, 2011) indicated that I'm a member of the haplogroup R1b, known as "The Artisans." This group—who "first arrived in Europe from west Asia about 35,000-40,000 years ago at the dawning of the Aurignacian culture" (p. 2)—is claimed to have possibly "been responsible for the first cave paintings" (p. 1). I interpreted these results a sign that I'd chosen an auspiciously synchronistic dissertation research topic.

7.01.05 Copernican Shifting

In my solo performances, I augment the *Atlas*' scientific visualizations within historical images, but only from the lineage of European traditions. In addition to the Lascaux painting, I use illustrations of Ptolemaic and Copernican world models to highlight the influence they have had on shaping the conceptions of religion, science, and modern cosmology (see Chapter 3: Globalizing the World). On occasion, I have integrated cosmographic imagery from other cultural traditions into performances, but only when collaborating with other presenters from those cultures (7.04 Worldviews Network). Associating these visual artifacts with the *intersubjective world view* (6.14.03 Intersubjective) and the *mythical structure of consciousness* (2.11 Mythic Worldview), I highlight the commonalities among various cultural techniques for creating experiential tools to make sense of the heavens (Magli, 2009; Turnbull, 2007).

Instead of caves and paint, today we use immersive virtual reality environments and interactive 3D computer graphics to visualize the cosmos. Though we call this astronomy or cosmology—or even cosmography—in many ways we're continuing an ancient tradition of using our imaginations to visualize the heavens within immersive environments.



Figure 105. *The Transcalar Imaginary*, live presentation by David McConville in the GeoDome Theater (2010). Interactive visualization of NASA's *Blue Marble Next Generation* (2004) and Andreas Cellarius' *Ptolemaic Planisphere* from *Harmonia Macrocosmica* (1660) (Pohl, 2010).

[Turning on the Ptolemaic Planisphere]

Of course, the ways in which cultures have envisioned the cosmic order have changed over time. The ancient Greeks, for instance, widely believed that our world was at the center of the universe. Since the stars seem to rotate around us, they imagined that the Earth was static, surrounded by a series of rotating celestial spheres (Figure 105). The Catholic Church later adopted this geocentric model, helping it to dominate the Western view of the cosmos for over a thousand years. Contrary to the common tale that being in the center of this geocentric universe was a point of pride, it was actually the place furthest away from Heaven. As Dante reminds us, Hell was believed at the center of

Earth. In a *diabolocentric* universe, this would have been one of the worst places to be.

Eternal Heaven was believed to be outside of the crystalline spheres, far away from the corruptible Earth. Aristotle attributed the apparent rotations of these spheres to the ‘unmoved mover,’ an idea later modified by the Church to describe the hand of God moving the *heavenly spheres*.

The circles within this image look like orbits, but you can see the inscription actually reads *orbes*. These circles represented spheres, not orbits. Everything inside of the white circle was believed to be within the sublunary sphere below the moon—the realm of the physical world composed of the four corruptible elements *Earth, Air, Fire, and Water*. This realm thought to be the realm of impermanence—where things change and die. Everything above the moon was believed to be eternal—composed of heavenly *quintessence* or *aether*.



Figure 106. Andreas Cellarius' *Copernican Planisphere* from *Harmonia Macrocosmica* (1660).

[Zooming out, with the virtual camera locked to the model of Earth as the central axis, turning on the Copernican Planisphere]

Almost five hundred years ago, Nicolas Copernicus published *On the Revolutions of the Heavenly Spheres*, arguing that the sun, not Earth, was at the center of the universe (Figure 106). This move is widely credited with instigating the original ‘paradigm shift’ of the ‘scientific revolution.’ However, as the title of the book suggests, Copernicus didn't challenge the dominant belief in the existence of *heavenly spheres*. It took over a century more for the invention of the telescope and new mathematics to reveal that the planets and stars weren't supported by invisible, crystalline orbs.

This had quite a traumatic effect on the European imagination. The immune system of the *heavenly spheres* disappeared.

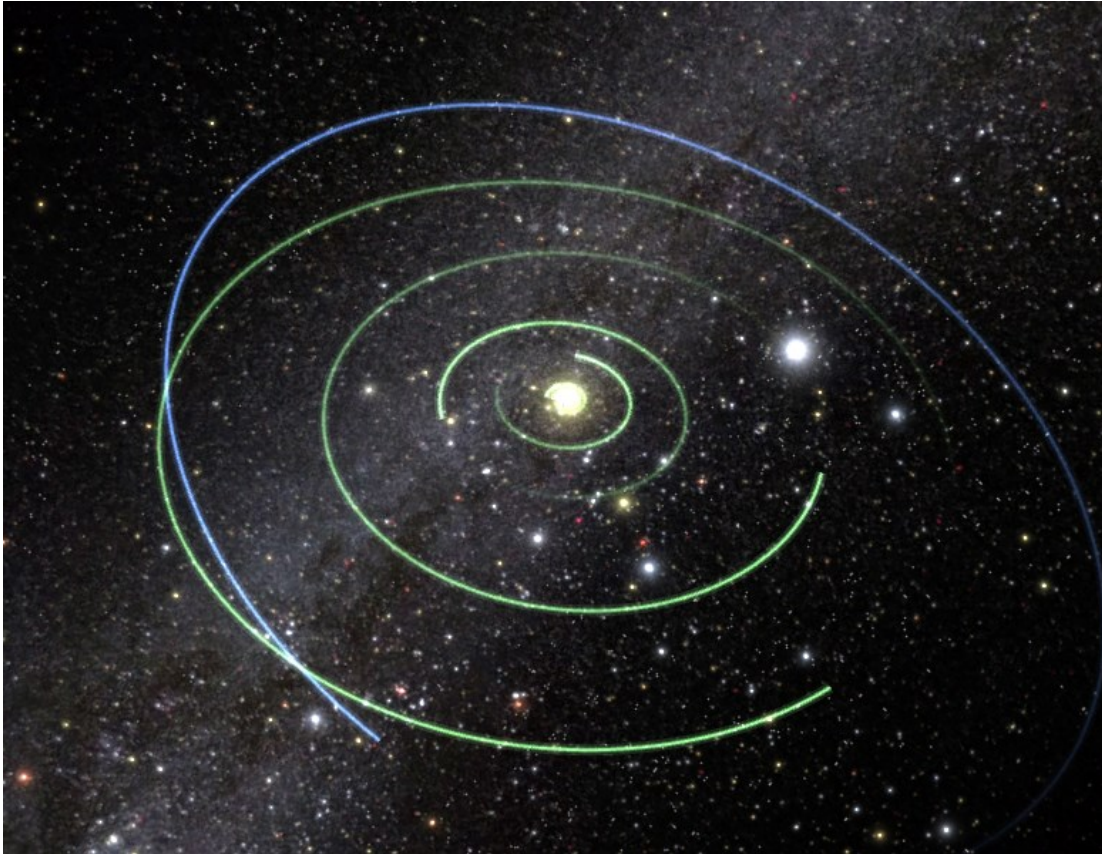


Figure 107. Local solar system in the *Digital Universe Atlas*.

[Turning off the Copernican Planisphere]

Visions of the eternal heavens gradually dissolved into an infinite physical cosmos. Friedrich Nietzsche's Madman summed up the collective anxiety, proclaiming, "God is dead. God remains dead. And we have killed him. Who gave us the sponge to wipe away the entire horizon? What did we do when we unchained the earth from its sun?"

It wasn't a sponge, or even just Copernicus, that wiped away the heavens. It was the culmination of many things—including Galileo's telescope, and the philosophy and mathematics of Descartes, Kepler, and Newton. Over time, it appeared that the entire cosmos was governed by the same laws and composed of the same elements as the corruptible Earth. The once-eternal transcendent heavens transformed into what seemed like a mechanical, clockwork universe (Figure 107). And in the process, the Copernican or mediocrity principle took hold, based on the assumption that Earth is nowhere special.

At the same time, new tools for observing and manipulating the physical world led to an explosion of scientific knowledge and technical skills of observation, measurement, and calculation. Not surprisingly, the human mind—the rational intellect—appeared to become increasingly god-like, separated from our bodies and even the world. This newfound power not only reinforced a sense that humanity was separate from nature, but also that nature was something to be conquered and controlled.

[Zooming in to Earth]

7.01.06 Planetary Proprioception

Since the majority of public presentations of the *Digital Universe Atlas* are already informed by objective epistemic virtues, I use the *objective world view* (6.14.02 Objective) to draw attention to the ways in which visualizations are constructed from a range of techniques and practices. I contrast the different epistemic virtues within ‘objectivity’ derive from a combination of instrumental measurements, aesthetic decisions, and mathematical models, demonstrating how varying emphases on *truth-to-nature*, *mechanical objectivity*, *trained judgment*, and *structural objectivity* (Daston & Galison, 2010) intermingle under the rubric of ‘objectivity.’ As discussed throughout this dissertation—and unfolds over the course of the performance—these ambiguous relationships can easily produce seemingly contradictory and even paradoxical results. This highlights the ongoing ambivalent tensions between naked eye, instrumental, and theoretical approaches that have permeated the *mental-rational structure of consciousness* since antiquity, exemplified by Sweitzer’s distinction between ‘cosmic maps’ and ‘cosmic pictures’ (5.12 World Picture).

Instead of over-emphasizing or critiquing the notion of *objectivity*, I address the centrality of objectifying processes within contemporary scientific endeavors. To demonstrate the ways in which these instruments function as sensory extensions that expanding human perception, I visualize Earth-orbiting satellite trajectories while discussing how we use postphenomenological instruments to map our home planet and cosmic environment.

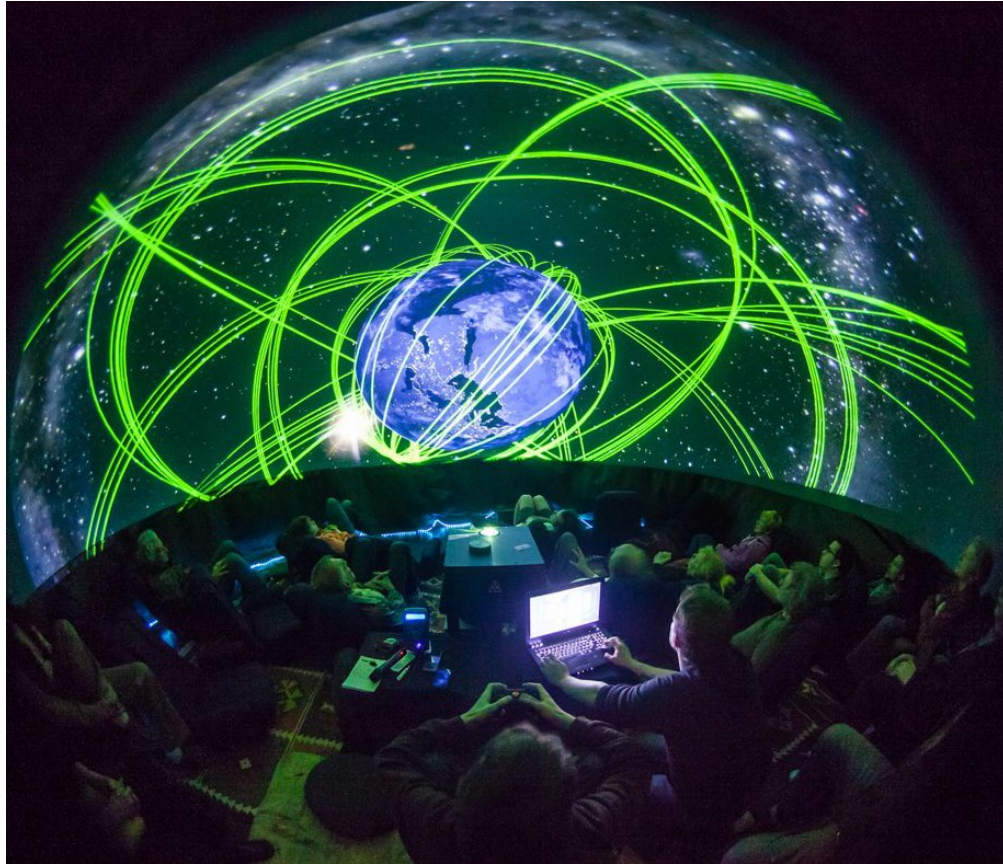


Figure 108. Earth satellite trajectories visualized within *Uniview*, projected in the *GeoDome* (Foley, 2012a).

[Turning on 100 brightest satellites]

Today, new technologies have radically expanded our views of the heavens and Earth. There are currently over 3000 satellites in Earth's orbit—these are the 100 brightest. These eyes in the sky are monitoring the planet's vital signs and allowing us to communicate at the speed of light (Figure 108). These techniques enable us expand our collective imagination by looking back on ourselves from this god's-eye view.

[Orbiting Earth to reveal the lights at night]

These new views help us to consider the positive and negative consequences of the scientific revolution. The rapid expansion of modern industrial society has resulted in unprecedented conveniences, like this map of lights at night showing how the power grid has spread across the world.

But this view of Earth doesn't tell the whole story. Satellites and telescopes act as sensory prosthetics, helping us expand our perceptions by translating wavelengths of the electromagnetic spectrum that are normally invisible to us.

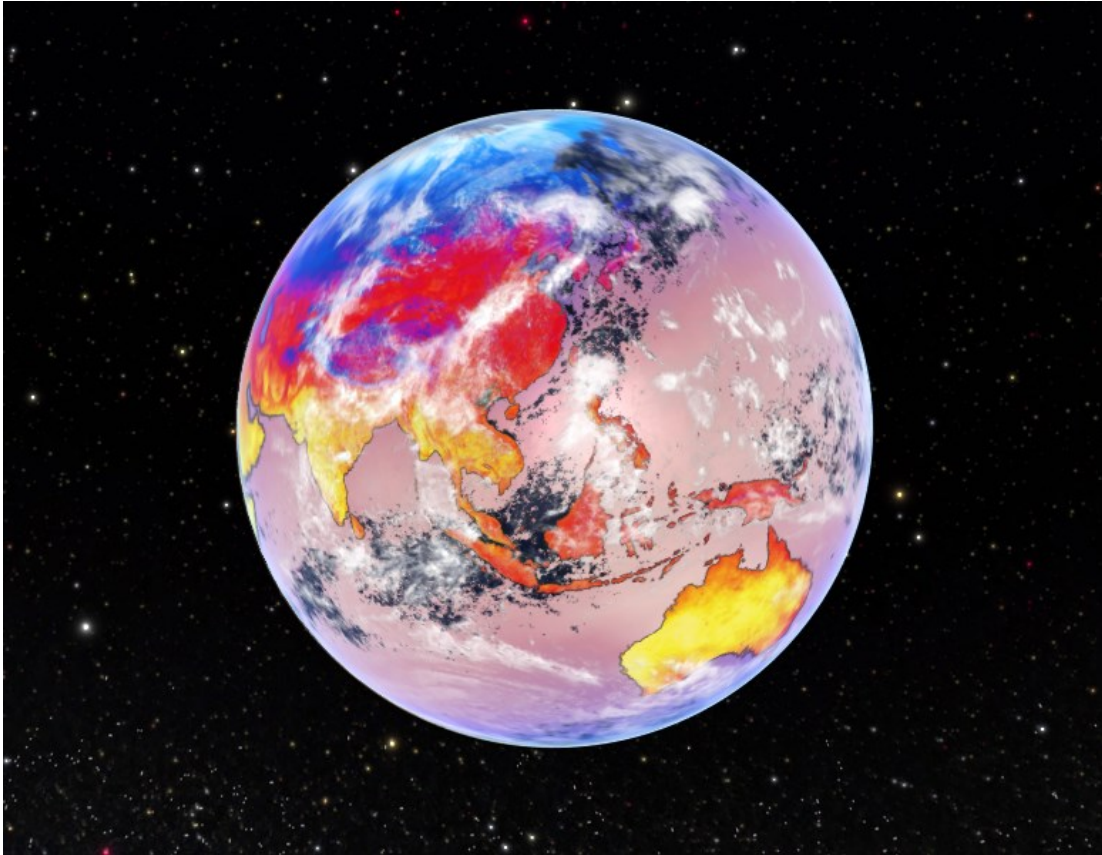


Figure 109. Land and sea surface temperature from NASA Earth Observatory.

[Turn on the sea and land surface temperature maps]

For instance, these colorful maps represent land and sea surface temperatures around the world (Figure 109). We use these ‘false-color’ images of the oceans, land, and atmosphere to study the impact of human activities. They are revealing serious unintended consequences of our current economic system, which justifies profits by ignoring so-called ‘externalities’ – or the damage to social and ecological systems. However, the health of the human and natural world are inseparable, and the global economy is a wholly owned subsidiary of the biosphere.

7.01.07 Sensorial Tunability

I next turn on a series of all-sky surveys as to continue with the examination of the *Atlas* from the *objective world view*. I also draw attention to the *subjective world view* (6.14.01 Subjective) by using these surveys to describe how most frequencies from the electromagnetic spectrum are imperceptible to unaided human vision. Astronomical artists create these ‘false color’ images by transposing hyperspectral frequencies of astrophotography into visible spectrum. Recalling Harrison’s distinction between *the Universe* and *universes* (1.06 Worldviews and Universes), these visualizations illustrate how the contemporary scientific universe is made possible by instrumentally-assisted cosmic cartography techniques. I use this to highlight importance of these of post-phenomenological “translation technologies” (Ihde, 1998, p. 181) in capturing and displaying selective and otherwise invisible aspects of the cosmos. I describe how these instruments assist in determining the positions of supernova remnants, stars, galaxies, and quasars, as well as visualizing the chemical compositions and metabolic flows of various systems.

We can also use these same techniques to study cosmic temperatures and interactions, such as the formation and movements of stars and galaxies. Some wavelengths correspond to specific elements, revealing otherwise invisible phenomena. Chemical elements resonate at different frequencies, so astronomers have developed a range of techniques for studying our cosmic environment. Because of these capabilities, we now understand that space is not an empty void, but a vast continuum of interacting fields, particles, and radiation.

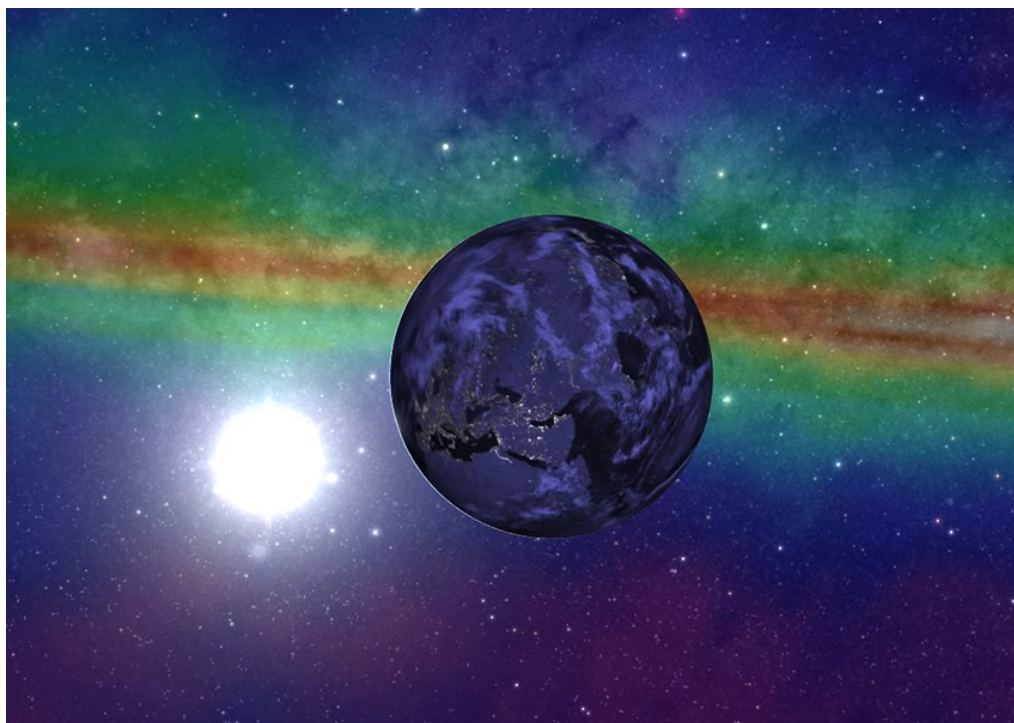


Figure 110. All-sky survey of the 21cm band of the electromagnetic spectrum, transposed into ‘false color’ to visualize neutral hydrogen within the plane of the Milky Way.

[Turning on 21cm band all-sky survey]

For instance, this is a map of the twenty-one centimeter band of the electromagnetic spectrum. This visualizes gas clouds that are glowing with the light of ionized hydrogen (Figure 110). The brightest, most colorful area is the plane of the Milky Way because there’s a tremendous amount of energy and matter emitting from celestial neighbors—the other stars in the band of our galaxy.

7.01.08 Cartesian Dreaming

Next, I revisit the *intersubjective world view* to point out cultural influences on scientific conceptions of space, particularly how these have been shaped by the history of philosophy and technology. I turn on the *Atlas*' three-dimensional Cartesian grid to discuss the *xyz* coordinates, how the curated datasets are modeled, and how the grid's origin point coincides with the central point of observation. I also draw attention to the scale markers that indicate the simulated orders of spatiotemporal magnitude within the virtual world, mirroring the logarithmic techniques used in Charles and Ray Eames' (1968) *Powers of Ten*. This trope the “long zoom” (S. Johnson, 2006)—the distinct way of imagining and seeing across vast scales of phenomena—has become one of the defining characteristics of the contemporary era.

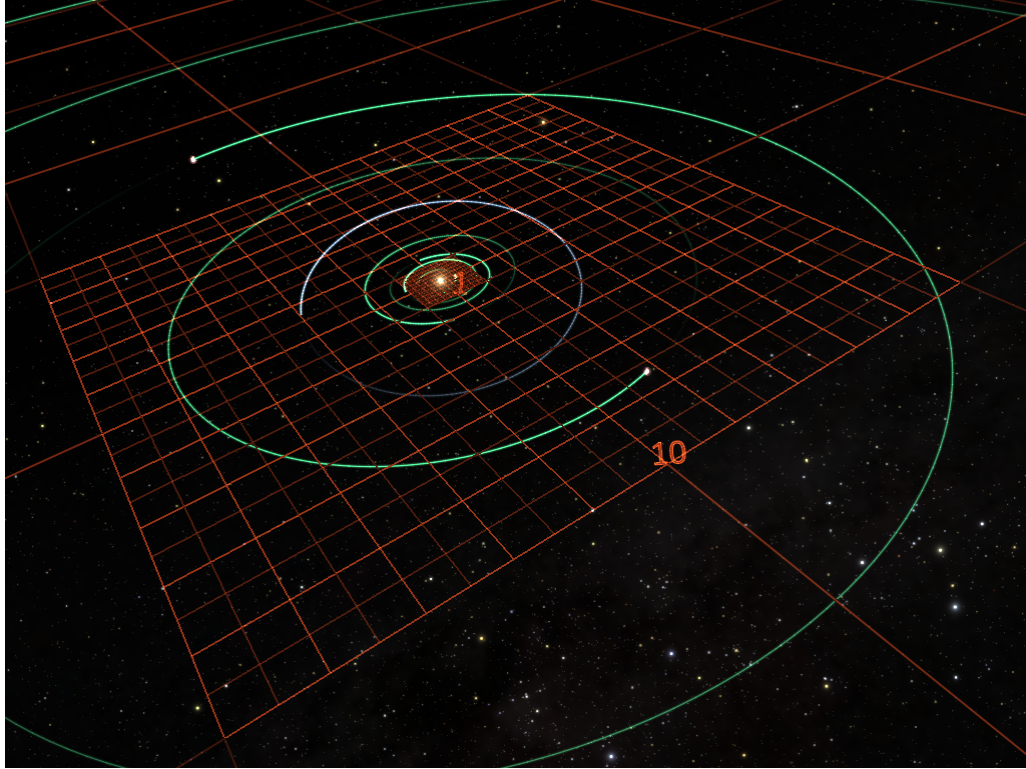


Figure 111. Three-dimensional Cartesian grid and planetary trajectories seen from the scale of Earth's solar system.

[Turning on the Earth-centered Cartesian grid]

When I turn on this Cartesian grid, we can see how the objects are positioned within the *Digital Universe Atlas* (Figure 111). Astronomers develop distance calculations of observed phenomena based on a wide range of parameters, which astronomical artists use to place images within a 3D virtual world.

But this grid also illustrates that these virtual distances aren't linear. Our simulated speed is exponentially increasing as we move out, indicated by orders of magnitude—you can see 10^9 , 10^8 —a technique inspired by the classic film *Powers of Ten* by Charles and Ray Eames. This trick of simulating travel speeds much faster than the speed of light gives us an

opportunity to imagine and intuitively grasp a big-picture overview of astronomical observations. This logarithmic scale allows us to traverse many orders of magnitude. Otherwise, it would take a very, very long time to visualize a journey to our cosmic horizon, even in this virtual world. So as we zoom out, keep in mind that we're moving out faster and faster—and seeing objects that are further and further away in time relative to us.

[Turning off the Cartesian grid].

7.01.09 Emergent Properties

A considerable amount of *cosmotrope* involves addressing ecological aspects of Earth's planetary and cosmic environment from the *interobjective world view* (6.14.04 Interobjective). This perspective, which I associate with complex interactions and emergent properties of systems, provides a counterpoint to the assumption that cosmic value solely based on spatial, chemical, or physical homogeneity (Ward & Brownlee, 2000)—a belief long associated with the Copernican or mediocrity principle that Earth “does not occupy a special position in the cosmos” (Trefil, 2003, p. 93). This view engenders acknowledgement of the interdependent and interconnected synergistic systems within which lifeforms are inexorably entangled (Sahtouris, 2000; Swimme & Berry, 1994). Acknowledging the complex and self-organizing aspects of our planetary system sets the stage for a later description of Earth as the *ecological center* of humanity's universe.

When the first US satellite Explorer 1 was launched in 1958, it probed the inner Van Allen belt—the doughnut of charged particles trapped by the Earth's magnetic field.

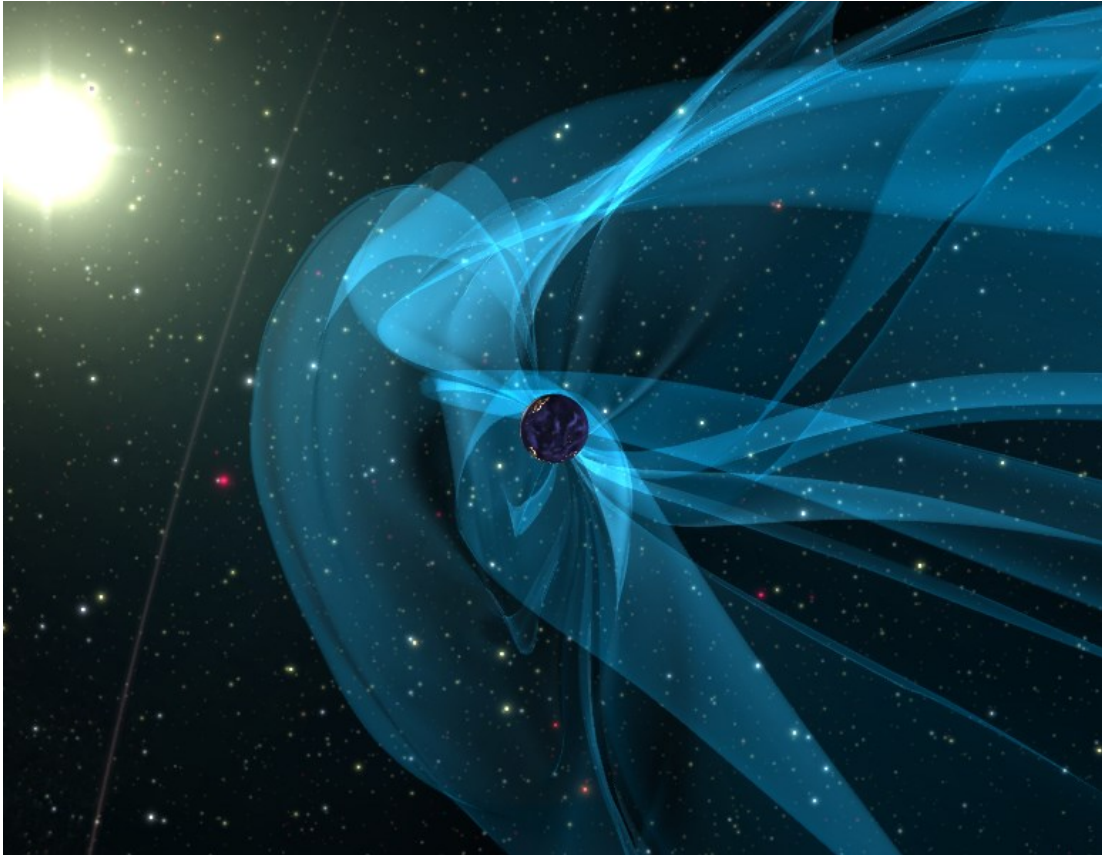


Figure 112. A ‘false color’ simulation of Earth's magnetosphere.

[Turning on Earth’s magnetosphere]

Scientists discovered that the solar winds of our local star are actually blowing back this magnetic field (Figure 112). We know that birds and other animals have evolved the ability to tune into the magnetic field to navigate, while we humans have used magnetic compasses for over two thousand years. But before Explorer I, scientists didn’t know about the bombardment of solar winds. This realization brought awareness to the importance of the Earth's magnetosphere in protecting us from dangerous levels of solar radiation. If it weren't for this protective field, the Earth's atmosphere and oceans would have

likely escaped into space long ago, resulting in very different conditions on this planet.

The magnetosphere exists because Earth cooled down during its formation over four billion years ago to maintain a molten core and a solid outer shell. And this protective field has been an essential condition for the evolution of life here.



Figure 113. Simulated Rayleigh scattering of Earth's atmosphere.

[Zooming in to show Earth's simulated atmosphere]

This thin blue line surrounding the outer edge of Earth is a scale model of the thickness of the atmosphere (Figure 113). The magnetic field protects the atmosphere—and the Earth's biosphere—from the violent bombardment of solar winds. But as the atmosphere's air pressure and density decrease with altitude, it eventually dissipates completely.

In addition to the magnetosphere, the presence of air and water on our planet is also due in part to its mass and gravity. It turns out that Earth's size has played an important role in it maintaining its oceans and atmosphere, and

hence how hospitable it is to life. If the Earth were much larger or smaller, the amount of water and air would have likely been different, and the Earth would have evolved differently. Life on our planet, if it existed at all, would probably look quite different.

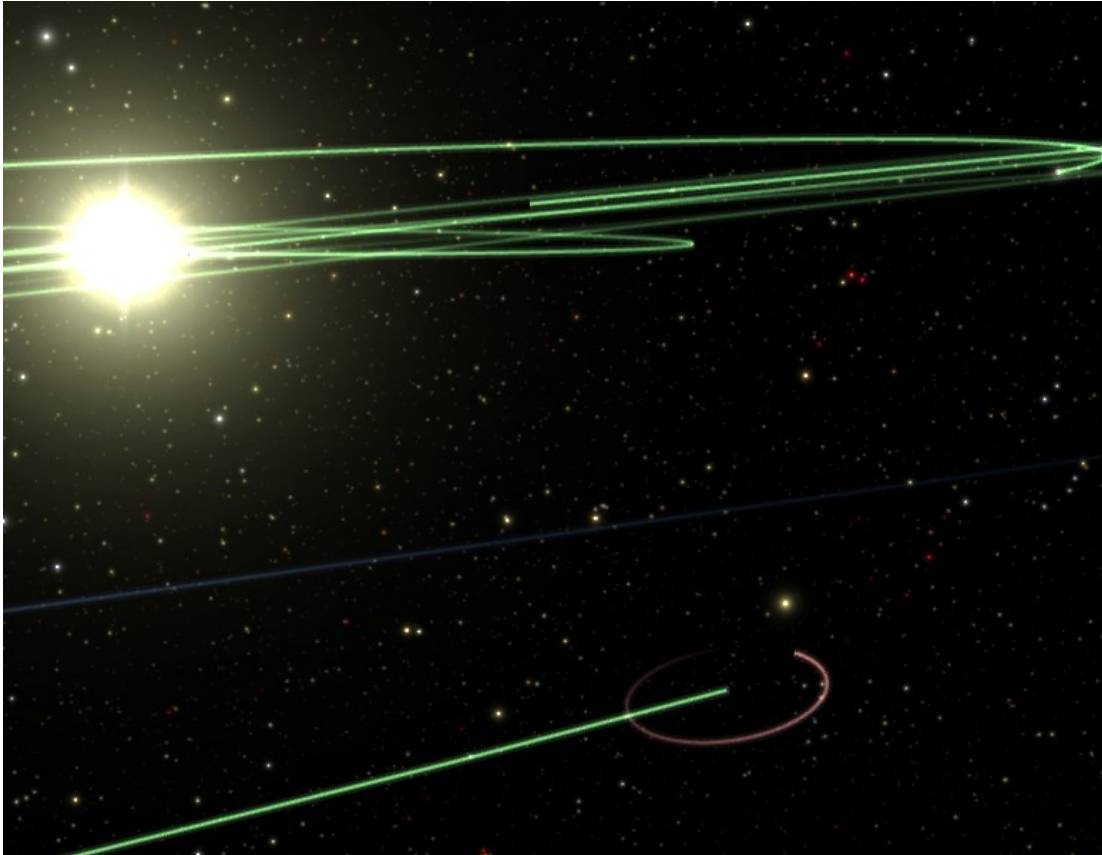


Figure 114. Orbital trajectories of Earth's moon and planets.

[Zooming back out to reveal the moon's orbital trajectory]

Additionally, the gravity and distance of our moon has played an important role in stabilizing Earth's tilt that regulates the seasons. The moon's gravitational pull also creates the tidal dynamics in our oceans, which generate over half of the Earth's oxygen (Figure 114).

We can easily overlook the significance of these emergent properties. Over the past few decades, however, scientists have gained an increasing appreciation of the previously unknown synergies that support life on our home planet. These complex cosmic and planetary interactions increase order,

making the behavior of the whole system unpredictable by the sum of its parts taken separately.

For instance, we live on the only planet in the solar system that's the right distance from the sun for liquid water to exist on its surface.

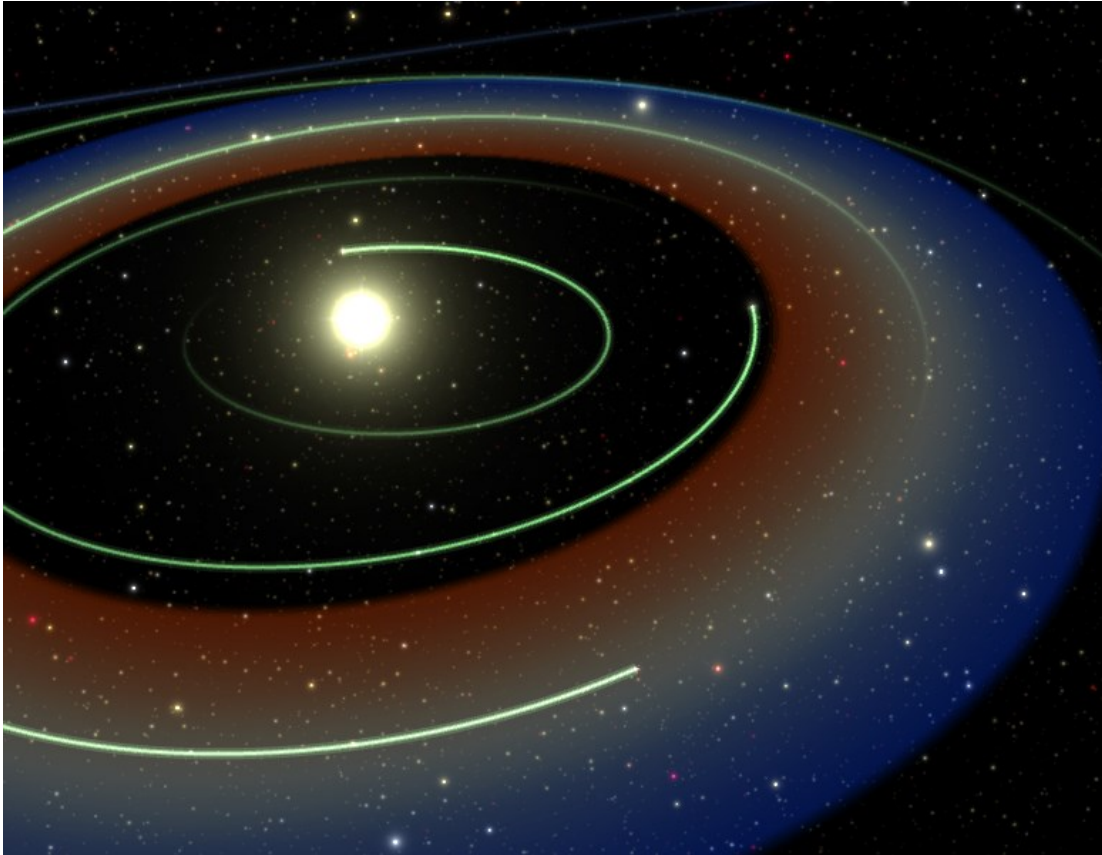


Figure 115. The local solar system habitable zone.

[Turning on the Solar System Habitable Zone]

Here we see a map of the habitable zone (Figure 115) of our solar system. Sometimes called the Goldilocks zone—where it's not too hot and it's not too cold—the surface temperatures are just right for liquid water. Combined with the magnetosphere and a mild greenhouse effect, this enables surface water on Earth to neither permanently freeze nor evaporate. And as far as we know, this is a primary requirement for life. We also know that the Sun has become warmer over billions of years, and this habitable zone is very slowly migrating outward. But with the right conditions of carbon dioxide in the atmosphere,

ocean dynamics, and recycling of rocks into the mantle, Earth can remain habitable for quite some time.

The idea of a habitable zone wasn't conceived until the 1950s, when it was widely assumed we'd find water and life on Mars. Since then, however, scientists have continued to discover the unique emergent properties made possible by Earth's cosmic ecosystem. We're learning that we can't take these conditions for granted.

7.01.10 Searching for Life

Combining the *objective* and *interobjective world views*, I next address a series of visualizations related to the search for planets and life beyond our solar system—as well as to clarify the vast distances of these planets. Many of these insights have emerged through the search extraterrestrial life as astrobiologists looked for similar conditions elsewhere.

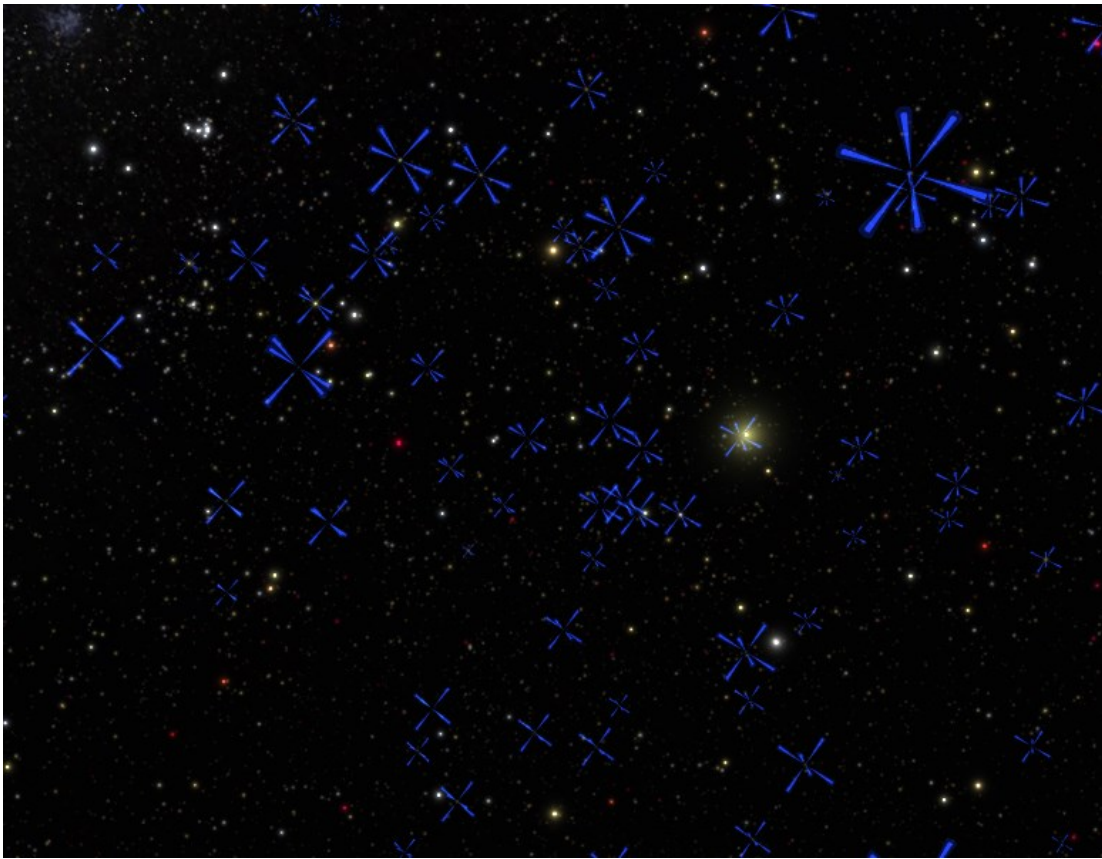


Figure 116. Extrasolar planetary system markers.

[Turning on exoplanet markers]

In 1995, astronomers finally found indications of exosolar planets—or exoplanets—and today over a thousand have now been found. Each of these crosshairs marks a star that has at least one planet in its orbit (Figure 116). They have recently detected exoplanets that may be within the habitable zones of their own solar systems. But these are many light years away and traveling there would take thousands if not millions of years. Nevertheless, the prospects of these distant worlds having the conditions necessary to support any forms of life has become a matter of considerable popular speculation.

Some scientists propose that that best way to detect life may be to listen for radio signals.

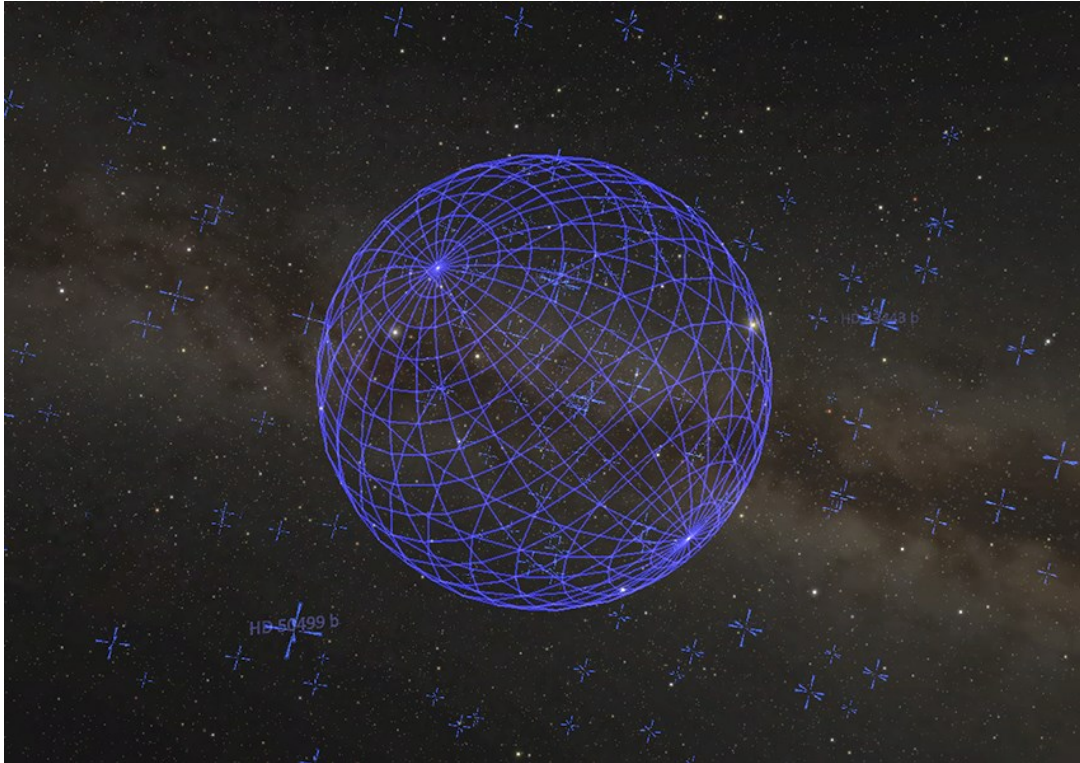


Figure 117. The extent of the distance theoretically travelled by humanity's radio transmission (the 'radio sphere') visualized as a spherical grid against the backdrop of the Milky Way and exoplanet markers (Abbott, 2012, p. 42).

[Turning on Earth's radiosphere]

In the early twentieth century, humanity began transmitting radio signals strong enough to travel into the interstellar space at the speed of light—our species became *radio bright*. This gridded radiosphere approximates how far humanity's radio transmission will have reached by 2050, washing over other solar systems with exoplanets (Figure 117). And it's these kinds of signals that *SETI*—the *Search for Extraterrestrial Intelligence* project—is trying to detect from alien civilizations. But after decades of listening, none have been detected. As far as we know, Earth's ability to support complex life is still unique in the Universe.

7.01.11 Cosmic Ecosystems

I explain that the quest for other habitable worlds has catalyzed much understanding about the conditions for life on Earth. I activate the simulated Oort cloud and supernova regions to demonstrate the spatiotemporal vastness of our cosmic ecosystem.

And even at this distance, we find connections to water on our home planet.

The Earth's oceans are believed to have come from comets and asteroids bombarding the young planet some four billion years ago.



Figure 118. Oort cloud simulation in the *Digital Universe Atlas*.

[Turning on the Oort Cloud simulation]

If we could travel to the far reaches of our solar system, astronomers speculate we would encounter the Oort cloud—a massive debris field composed of trillions of icy comets left over from the very early formation of our solar system (Figure 118).

We believe the solar system to have formed from heavy elements created within the hearts of stars, which compress hydrogen and helium in the process of nucleosynthesis.

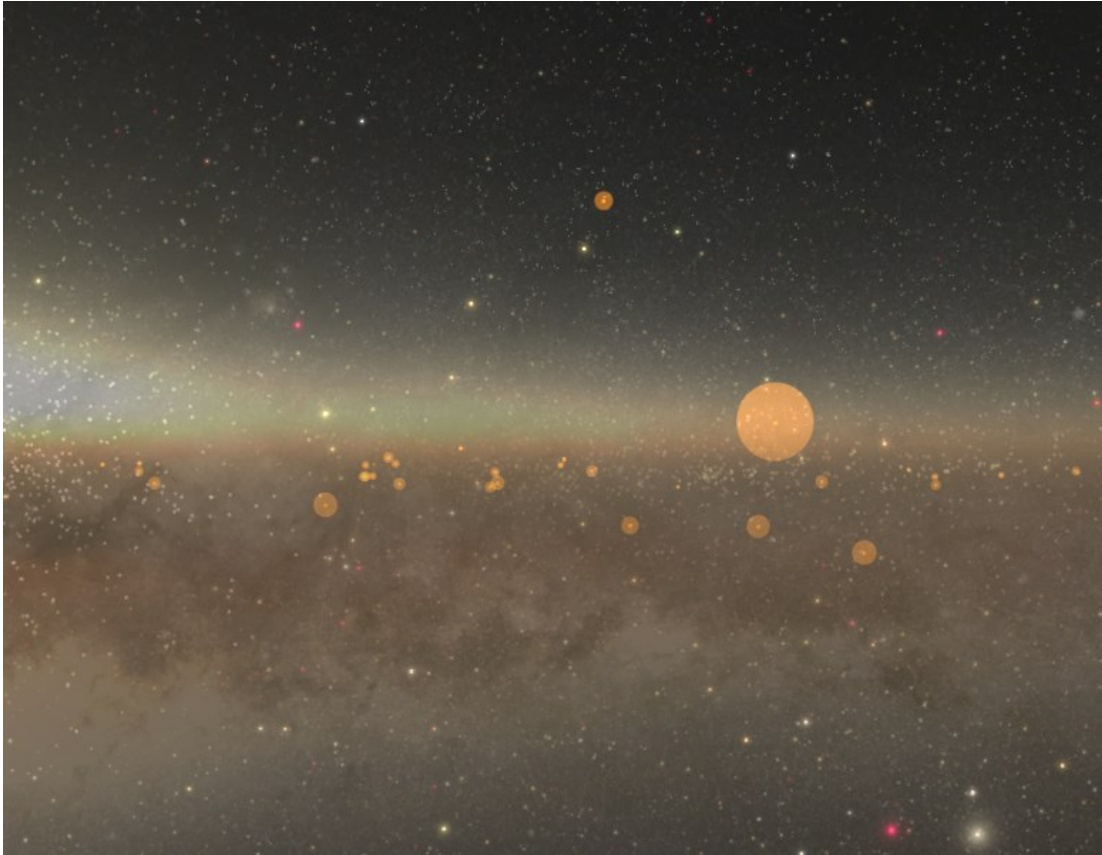


Figure 119. Type 1A supernova regions in the *Digital Universe Atlas*.

[Turning on Type 1A Supernova visualizations]

When some stars explode, they become supernovas, spewing heavy elements throughout space. These orange markers indicate the regions where we have detected remnants of supernovas (Figure 119). Over the course of billions of years, the gravitational mass of these elements created larger and larger objects in our solar system. Buckminster Fuller once said love is metaphysical gravity, so I like to think of gravity as a kind of physical loving embrace. As elements attract each other over vast periods of time and space, they enable increasingly complex conditions to arise.

7.01.12 Constellatory Patterning

I once again return to the *subjective world view* to describe the consequences of viewing constellatory patterns from perspectives different than Earth-bound observations. This also assists with illustrating the apparent spherical shape of the firmament and its *intersubjective* consequences on cultural assumptions, which I revisit later in the presentation in the discussion of the cosmic microwave background.

Now, this is where things get weird. Keep in mind that this imaginary cosmic journey has been increasing in speed and distance as we zoom out. Light from our sun would take over a year to get to the distance this represents, and it would take a space probe many thousands of years.

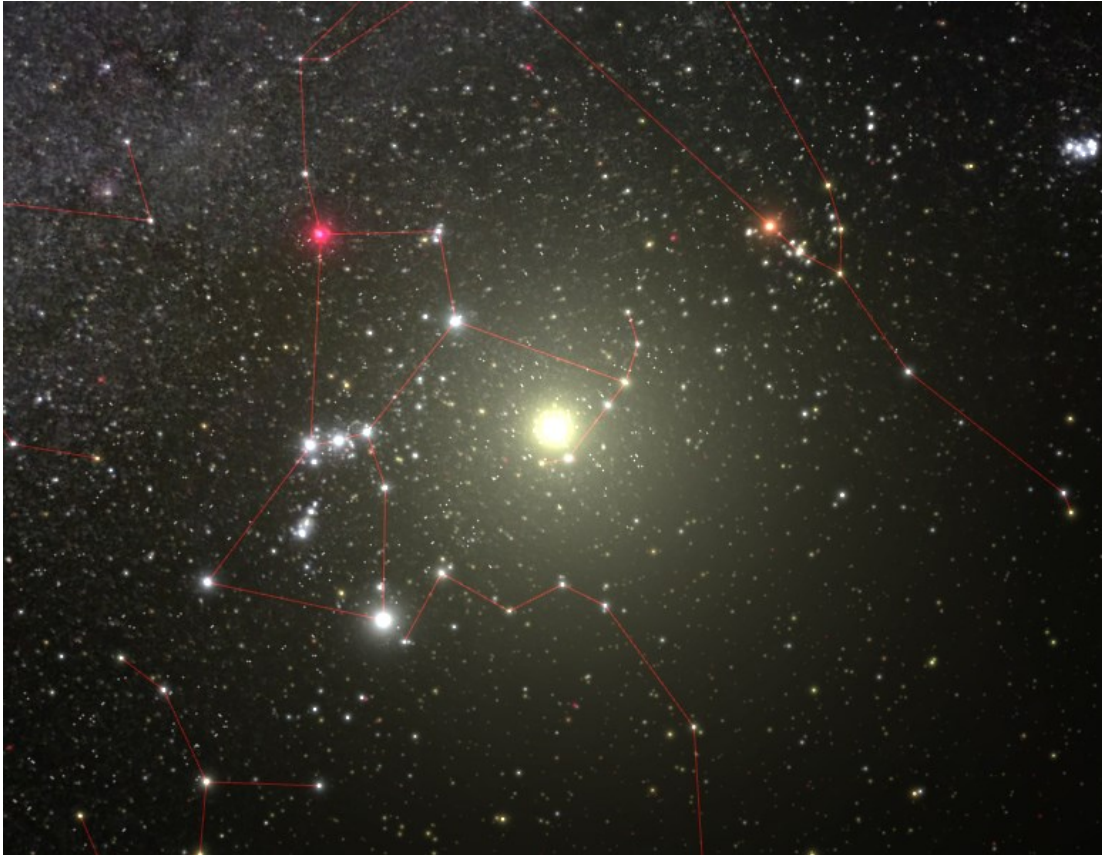


Figure 120. Greco-Roman constellation lines in the *Digital Universe Atlas*.

[Turning on the constellation lines]

Even at this simulated distance, we still see the constellation lines as we do from Earth (Figure 120). But as we continue to move out, we visualize what it might look like to view our constellations from a different perspective.



Figure 121. Greco-Roman constellation lines visualized from a simulated view outside Earth's solar system.

[Zooming out to reveal depth of the constellation lines]

Since this is a 3D model of the stars, look what happens as we start to pull out further (Figure 121). Everybody got that? Even though they appear to be the same distance within the dome of the sky, leaving these lines connected indicates how they vary in brightness and distance from Earth. Whereas many of our ancestors imagined a spherically contained cosmos, we're now attempting to map and model the observable universe in infinite three dimensions. From the perspective of these exoplanets, we see quite different celestial patterns.

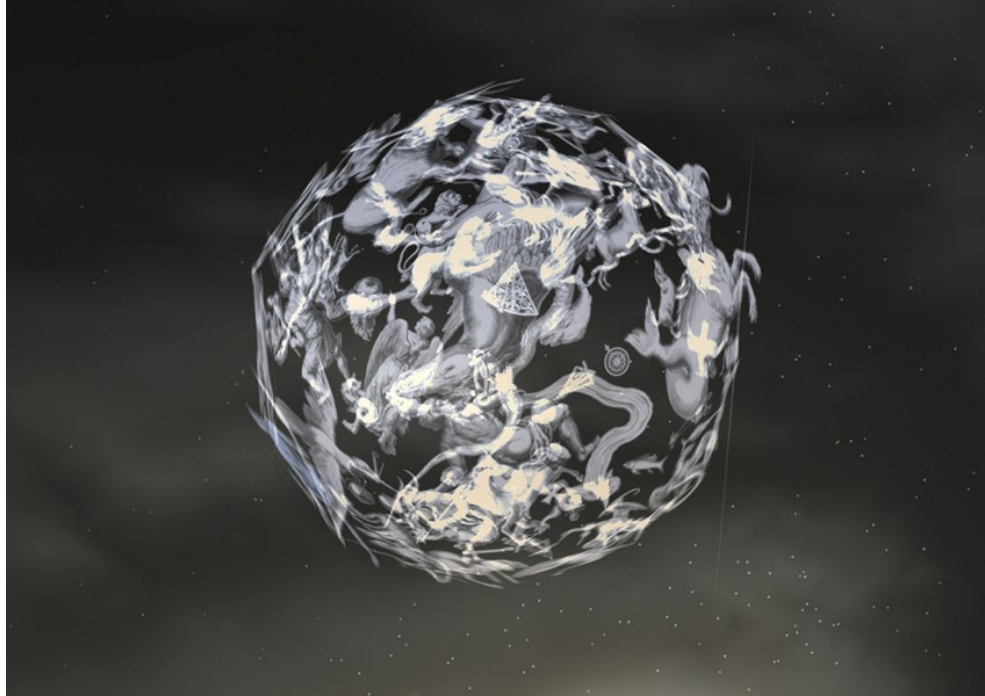


Figure 122. ‘Outside’ view of the Johannes Hevelius’ (1690) drawings of Greco-Roman constellations modeled within the *Digital Universe Atlas*, modeled to simulate the perspective of a celestial globe. Constellation module created by the Denver Museum of Nature & Science.

[Turning on Greco-Roman constellations]

When I turn on the Greco-Roman constellations at this simulated distance away from the Earthly view of the night sky, we can also see why the cosmos was once widely believed to be spherical. These seventeenth century engravings are mapped in a way to retain the basic relationships we see from the perspective of Earth. As the virtual camera pulls ‘out’ into simulated interstellar space, we move ‘outside’ to simulate a god’s eye view of the *heavenly sphere* (Figure 122). This demonstrates the kind of celestial globe the mythical figure *Atlas* is depicted as holding on his back.

This significance of this perspective can't be emphasized enough. The birth of modern science was intimately connected to this ability to imagine the universe from beyond this *heavenly sphere*.

7.01.13 Home Galaxy

At the scale of the Milky Way galaxy simulation, I revisit the *interobjective world view* to accentuate the possible connection between our solar system's positioning within the galactic ecosystem and the evolution of life on Earth.

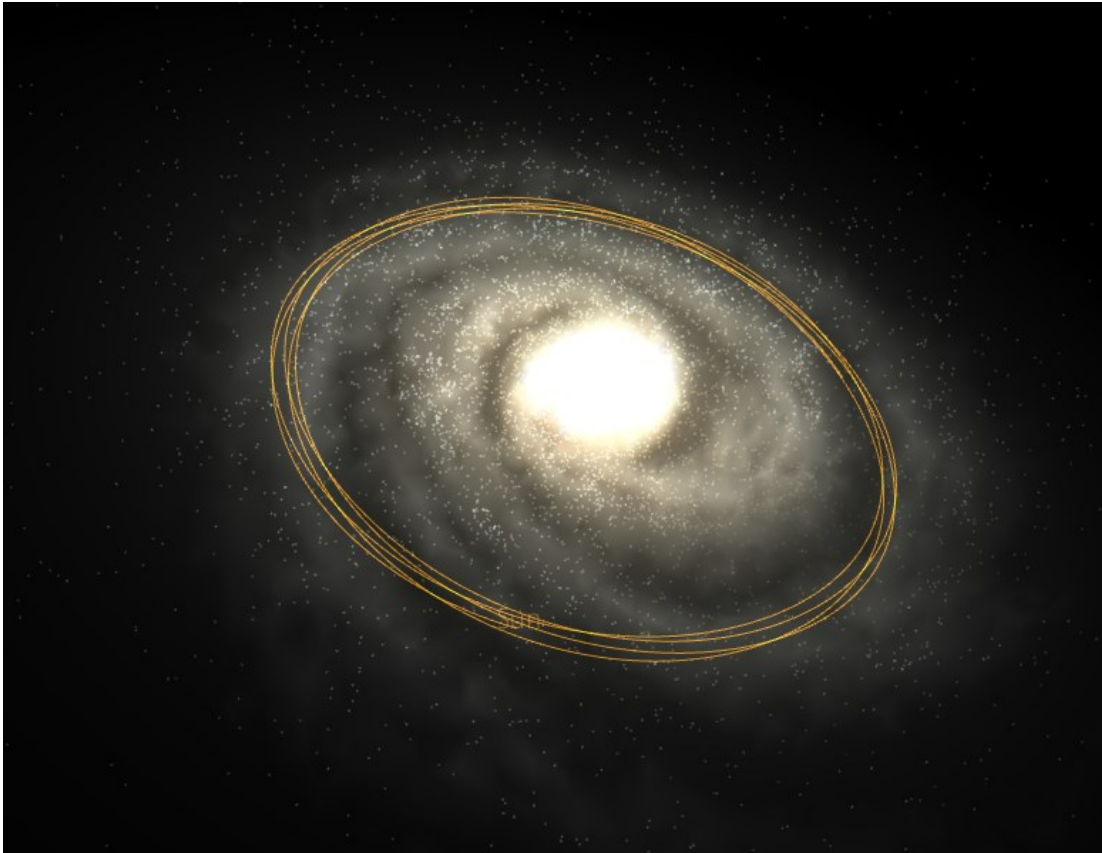


Figure 123. Simulation of the sun's orbit around the Milky Way galaxy in the *Digital Universe Atlas*.

As we pull out even further, a simulation of the Milky Way enters into view. Of course, we can't observe this outside perspective on our galaxy, so this is an approximation of what it might look like. It's believed that our sun is one of over a hundred billions stars orbiting this hundred-thousand light-years diameter galaxy. Unlike many other stars, however, our sun's orbit—indicated by the yellow line—seems to maintain a relatively steady distance from the

galactic core (Figure 123). It is estimated that the sun is traveling at a staggering half a million miles an hour, with us in tow. But even so, the Milky Way is so large that it takes almost 250 million years for Earth to make a full rotation around the galaxy—the length of a galactic year. This means that the last time our sun was in this area of the galaxy, dinosaurs were just beginning to walk on Earth.

The sun may even be within the habitable zone of the galaxy. If we were further in, there may be too much radiation from other stars for life as we know it to exist. If we were further out, there may not be enough elements from exploded stars to create a solid planet. So the sun's galactic location and steady orbital trajectory may represent more synergistic conditions playing a role in the evolution of life on Earth.

7.01.14 Surveying the Sublime

As the virtual camera zooms out to the scale of galactic surveys, I use the sublime gestalt of thousands of data points to address the immense scale of the observable cosmos. I emphasize the difficulty of imagining the astronomical numbers involved within this effort to create the *Atlas*.

Less than a century ago, astronomers believed the Milky Way contained all of the stars in the universe. But in the 1920s, it was determined that some objects—thought to be interstellar dust clouds—were actually other galaxies. Since then, it's been calculated that there are actually hundreds of billions of other galaxies, each containing hundreds of billions of stars. These may seem like impossibly large numbers to imagine, so think of it this way: there may be 10 times more stars in the visible Universe than all of the grains of sand on Earth. In recent decades, surveys of these galaxies have detected a small fraction of them.



Figure 124. Galactic surveys in the *Digital Universe Atlas*.

[Zooming out to reveal galactic surveys beyond the Milky Way]

Here we see some of the ones recorded so far—mapped in three dimensions and color-coded according to their galactic groupings (Figure 124). The surveys of our so-called ‘local group’ of over 50 galaxies are colored green, though this is a relative definition of ‘local’ since they are millions of light years apart.

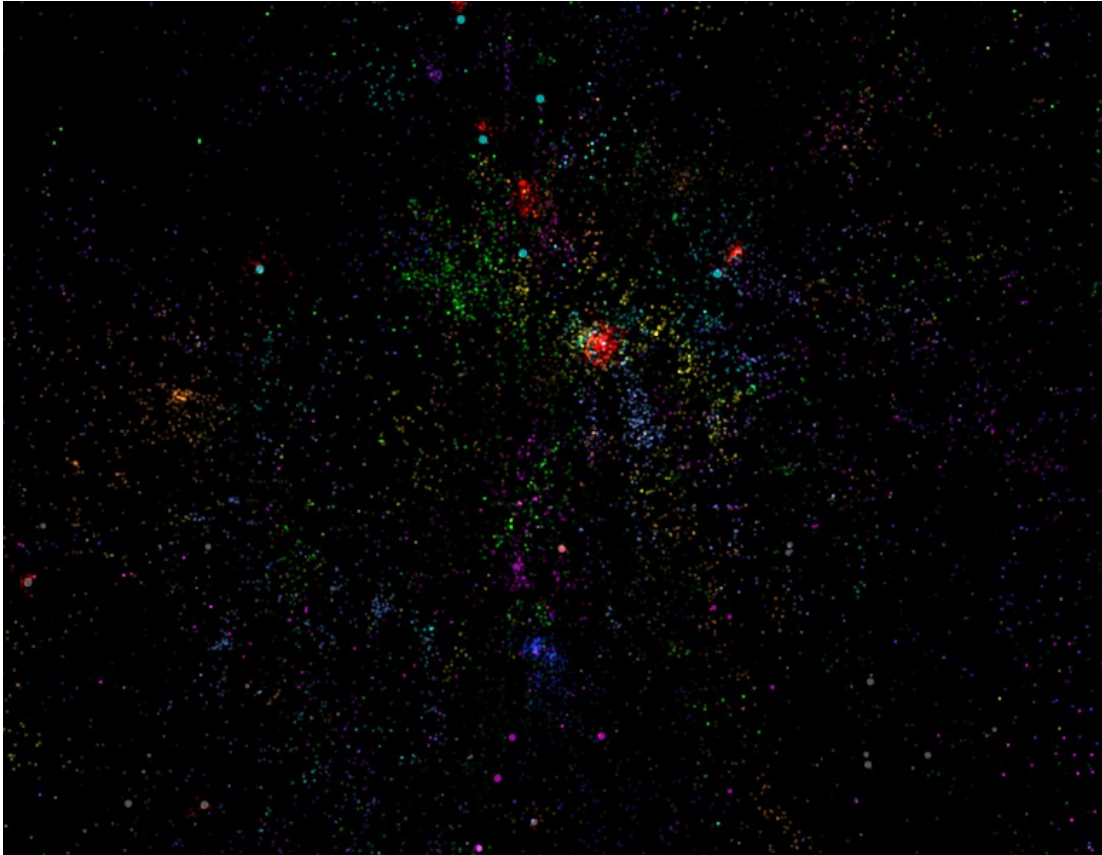


Figure 125. Galactic surveys revealing the ‘large scale structure’ in the *Digital Universe Atlas*.

[Zooming out even further to reveal additional galactic surveys]

As we pull out even further, we begin to see many more surveys that make up what astronomers call the ‘large-scale structure’ of the universe (Figure 125).

These are assembled from photographic surveys of galaxies.

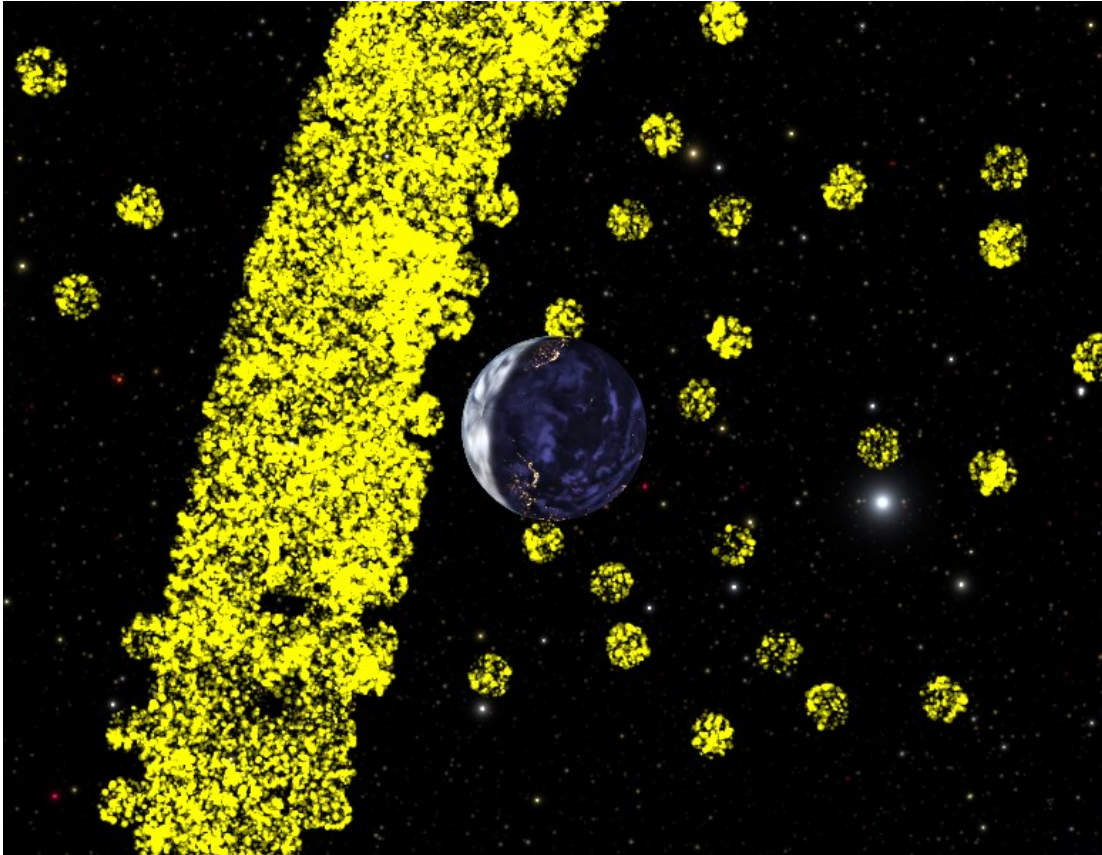


Figure 126. 2DF Galaxy Redshift Survey in the *Digital Universe Atlas*.

[Zooming in to the Milky Way, turning on the 2DF Galaxy Redshift Survey]

If I turn on the 2DF Redshift Survey so it won't fade away as we pull in, we can see what it looks like from where these data points were collected on Earth (Figure 126). Redshift refers to one of the techniques astronomers use to determine the distance of these galaxies. The shifting of light's color indicates movement towards or away from our point of observations—much like the frequency of a siren shifting as it speeds by on an ambulance.

[Zooming out to reveal multiple galactic surveys]

So these redshifts are used to determine each galaxy's distance from Earth and placed within the 3D coordinate system of this virtual cosmic atlas.

7.01.15 Zones of Avoidance

The simulated intergalactic view explicitly visualizes the necessity of interpreting the *Atlas*' datasets from the *subjective world view*. When viewed from a virtual distance of billions of light years from Earth, the points represent galactic surveys—extruded into three dimensions—converging on the central frame of reference from which they were mapped. A spherical map of the cosmic microwave background radiation encloses the model as an outer boundary, positioned at humanity's particle horizon.

These features graphically illustrate how attempts to map and model the observable universe are dependent on where, when, and how measurements are made. In this regard, the utility of the *Digital Universe Atlas* derives not only from its 3D portrayal of scientific datasets, but also from its validation of the inherently situated and contingent nature of perspectives arising from the intimate relationship between intra-acting *world views*. Visualizations of the 'observational center' and 'cosmic horizon' illustrate the inexorably entangled nature of these perspectives, showing that "every view is a view from somewhere" (McPherson et al., 2011, p. 20). I also describe the aptly named "zones of avoidance" (Moore, 2002a, p. 446) to emphasize this point further.

This provides a way to challenge the naïve real interpretation that the *Atlas* represents an objective snapshot of the (capital U) "Universe" in Harrison's totalizing sense. Because the light from distant phenomena requires time to reach the telescopes that record them, photographs of distant stars, galaxies, quasars, and other phenomena represent cosmic processes as they appeared in the past relative to humanity's technologically mediated perspective. Consequently, the phenomena represented by

photographs and omnidirectional ‘all sky’ maps within the 3D virtual world invariably surround the central point from which they were modeled.

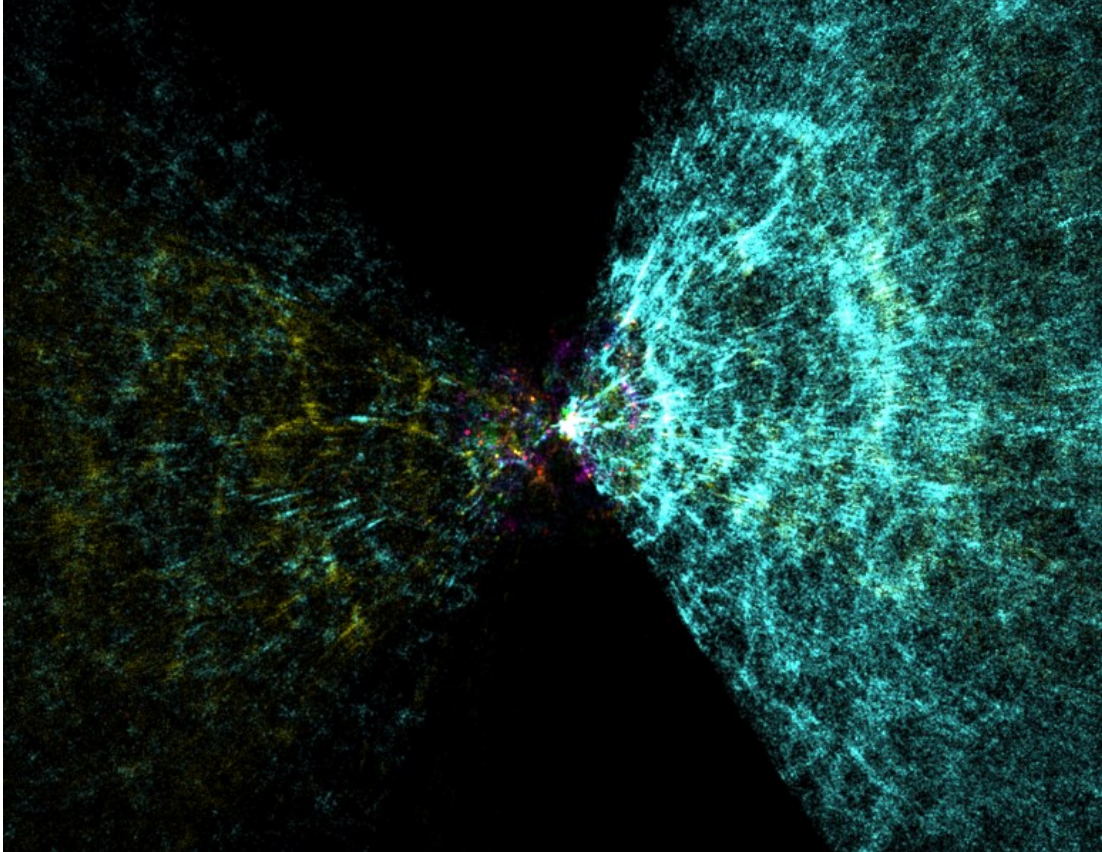


Figure 127. Visualizations of galactic surveys and ‘zones of avoidance’ in the *Digital Universe Atlas*.

[Zooming out to reveal zones of avoidance]

As we continue to zoom out, intriguing patterns begin to emerge. We’re now seeing what astronomers call the ‘large-scale structure’ of the cosmos (Figure 127). But I like to think of it as a picture of what we happen to see right now from our unique vantage point on Earth. As a result, these cumulative surveys of galaxies and quasars form a pattern emanating from the central point—looking like a bow tie or the wings of a psychedelic butterfly.

But this structure can be visually deceptive. The large empty spaces are primarily areas where our view is obstructed by our own galaxy. Astronomers call these areas “zones of avoidance”—our intergalactic blind spots.

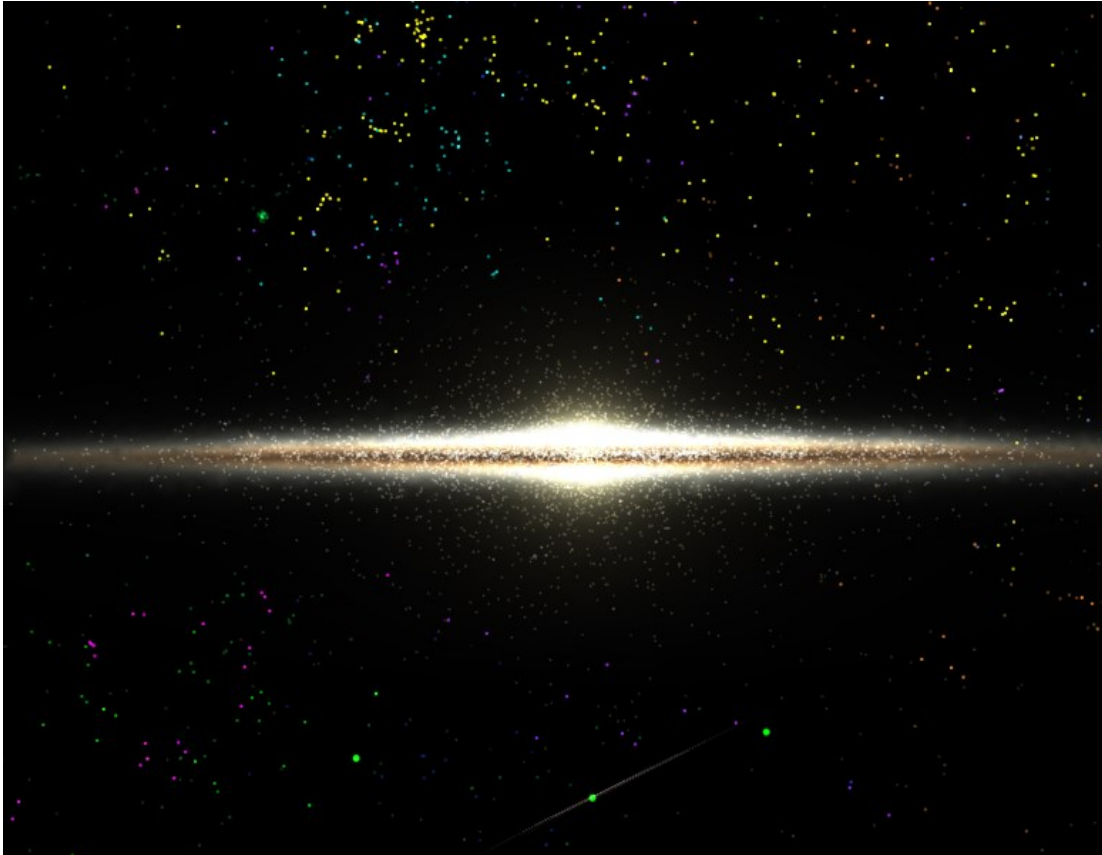


Figure 128. Milky Way simulation in the *Digital Universe Atlas*.

[Zooming in towards the center]

The gas, dust, and stars of the Milky Way make it difficult to collect data from areas parallel to the plane of the galaxy. When we zoom back in, we can see simulations of these obstructions (Figure 128). New infrared satellites will enhance our ability to see beyond these areas in the future, but for now they’re

blind spots. It's the cosmic equivalent of taking a panoramic photograph when you can't see the full sky because of the clouds above you.

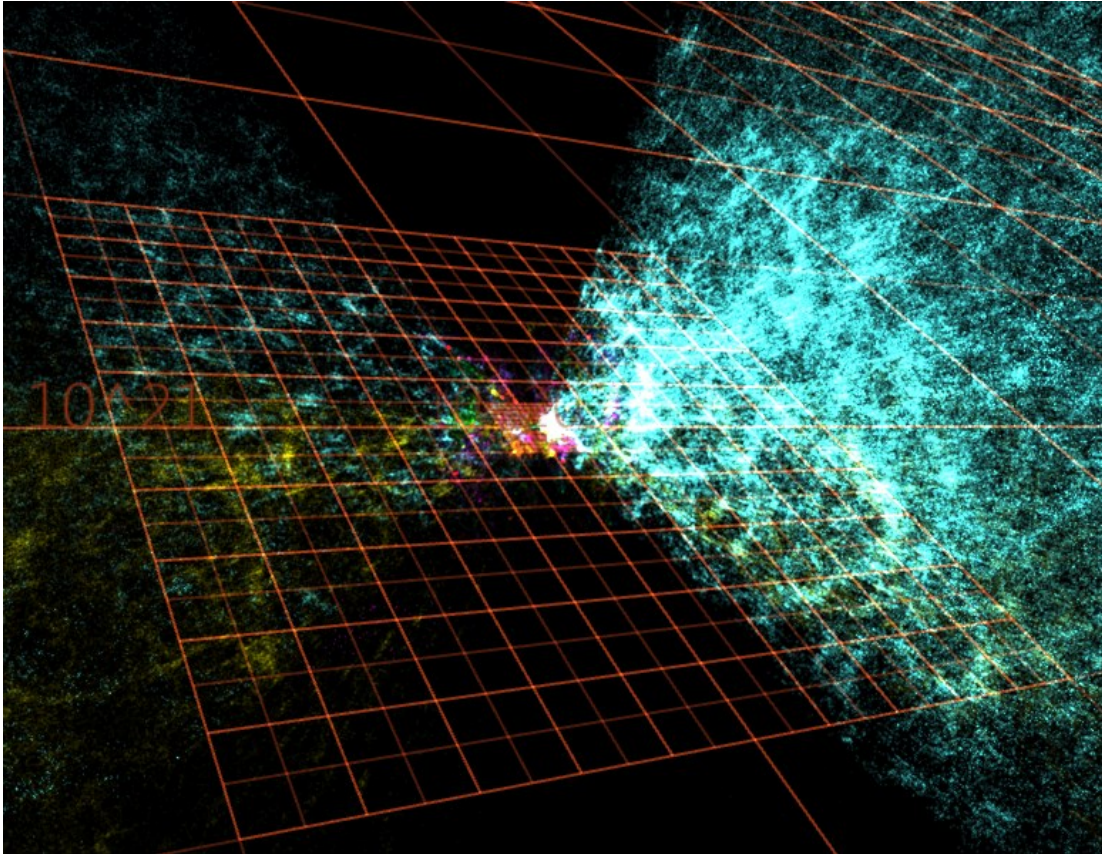


Figure 129. Visualizations of galactic surveys and 'zones of avoidance' in the *Digital Universe Atlas*.

[Zooming out to the intergalactic scale, turning on Cartesian grid]

As we scroll around, we can also see there are many places that have yet to be surveyed (Figure 129). This is a *perpetually* incomplete data set.

This dataset can easily be mistaken as a map of the Universe as it appears *right now* from this intergalactic perspective. However, these surveys were

taken from or around Earth, so like the blind spots, they are all registered to our unique view.

We attribute the configuration of this three-dimensional structure to the finite speed of light—understood to be approximately 186,000 miles per second relative to us. The more distant a radiating source is from Earth, the longer it takes for its light to reach out telescopes. Which means this is not only a snapshot of the apparent distance of galaxies from Earth, but also their position in time relative to us. According to this understanding, the further phenomena are from us, the more removed from us in time they are. Though our instruments are said to be looking ‘out’ into space, they can more precisely be said to be collecting photons that have made it to Earth.

Consequently, the further ‘out’ we look, the further ‘back’ we see. So while this is a snapshot of galaxies based on recent telescopic pictures, it’s also a composite of cosmic events occurring over the course of billions of years. The closer these galactic points are to the center of this model, the closer they are in time relative to Earth. While they appear to be ancient in the sense of their distance in time from us, they can also be described as phenomena from the younger universe.

If similar observations were made from other galaxies, they would be subject to different occluding factors. And since the light reaching remote observers would have traveled different distances than it would have travelled to

observers on Earth, the light would also register phenomena at different stages of their cosmic evolution.

In this respect, the *Digital Universe Atlas* not only shows the inseparability of space and time, but also how all observations are unique to their observers—dependent on where, when, and how the observations are made.

7.01.16 Illuminating Darkness

After discussing the galactic surveys, I zoom back in to reveal a custom module simulating the ‘dark matter halo’ between the Milky Way and Andromeda galaxies. This module is based on the speculations of the dominant Lambda-CDM “big bang” model of cosmology (Diemand et al., 2008), which employs the enigmatic notions of ‘dark’ matter, energy, and flow to account for over ninety-five percent of the cosmos (Disney, 2007; Frank, 2011; Horvath, 2008). The module highlights the significant unknowns within modern cosmology. Visualizing some of this ‘missing’ mass within the *Atlas* affords the opportunity to discuss the nature of science and how mysteries and paradoxes perennially emerge through human attempts to make sense of a cosmic order. From the perspective of the *nondual world view* (6.14.05 Nondual), I address the limits of both discursive reasoning and scientific certainty, sometimes describing the value of Nicolas of Cusa’s notion of ‘learned ignorance.’ This provides an opportunity to catalyze discussions about commonalities among nondual conceptions across different spiritual, philosophical, religious, and scientific traditions. I point out that even within the standard concordance model of cosmology, the dominance of these speculative dark forces serve as a humbling reminder that we are invariably implicated within purportedly ‘objective’ conceptualizations of space, time, and the physical structure of reality—regardless of how technically impressive contemporary efforts to ‘save the appearances’ might be (3.05 Saving the Appearances).

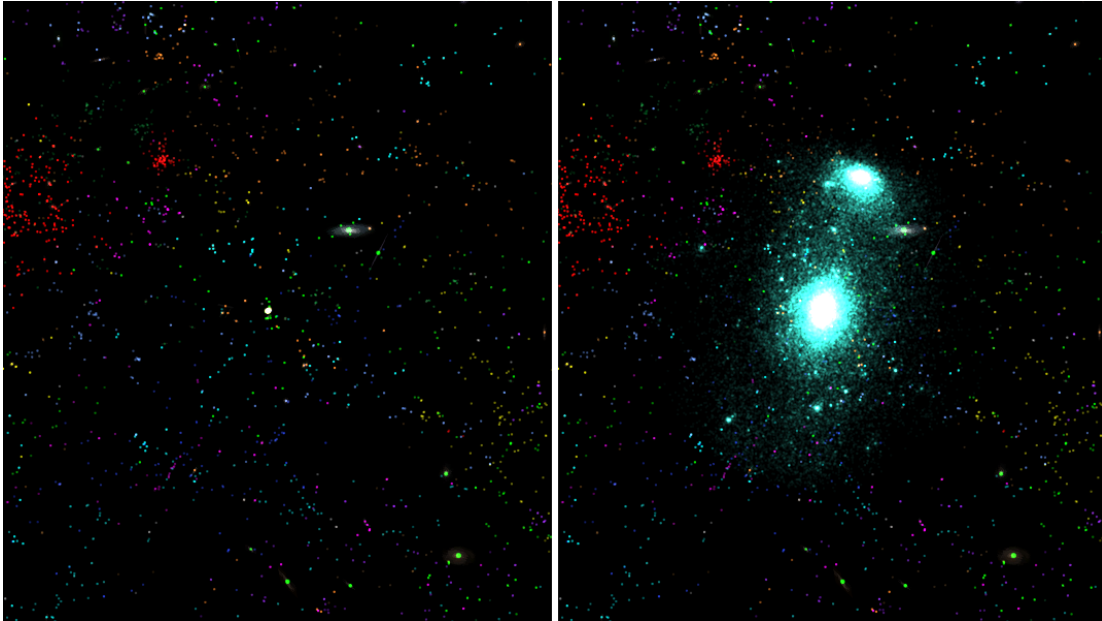


Figure 130. Comparison of the *Tully Galaxy Catalog* (Abbott, 2012, p. 180) within the *Digital Universe Atlas* (left panel) and the same dataset with a simulation of missing ‘dark matter’ between the Milky Way and Andromeda galaxies (right panel).
Dark matter module by Denver Museum of Nature and Science.

[Zooming back in to view the Milky Way and Andromeda, turning on the dark matter halo]

As we more closely study galaxies, significant mysteries emerge. Just as the ‘scientific revolution’ shattered the celestial spheres of the Middle Ages, today we’re being challenged to expand our notions about the nature of the cosmos. In the twentieth century, increasingly precise observations indicated that there’s much more gravity holding galaxies together than could be explained by the dominant understanding of physics. These blue areas visualize the amount of matter that should be present between the Milky Way and our neighboring galaxy Andromeda according to current understanding mass, energy, and gravity (Figure 130).

At the same time, the universe also seems to be expanding at an accelerating rate. To account for these mysteries, astrophysicists have theorized the existence of what they call ‘dark matter’ and ‘dark energy’—suggesting that a vast majority of the material and forces in the universe are invisible and unknown to us. Consequently, they suggest, we can only observe less than five percent of the stuff that makes up the density of the cosmos.

Because our Newtonian and Einsteinian understanding physics is good enough to predict planetary movements and successfully navigate spacecraft, these large-scale behaviors were completely unanticipated. In an ironic twist, scientists even refer to ‘dark energy’ as *quintessence*, the same name given the mysterious fifth element in the Middle Ages to describe the composition of the heavenly bodies.

7.01.17 Cosmic Horizon

I call attention to the ‘inside’ of the CMB sphere to address how astrophysicists attempt to confirm theoretical predictions with instrumental observations. I also expand this to include transdisciplinary considerations of relativistic effects, the ecological significance of cosmic evolutionary processes, and the paradoxes of light. This necessarily requires speaking from the multiple perspectives of *spherical thinking* (6.15 Spherical Thinking), moving between—and integrating aspects of—*subjectivity, objectivity, intersubjectivity, interobjectivity, and non-duality* for the remainder of the performance.

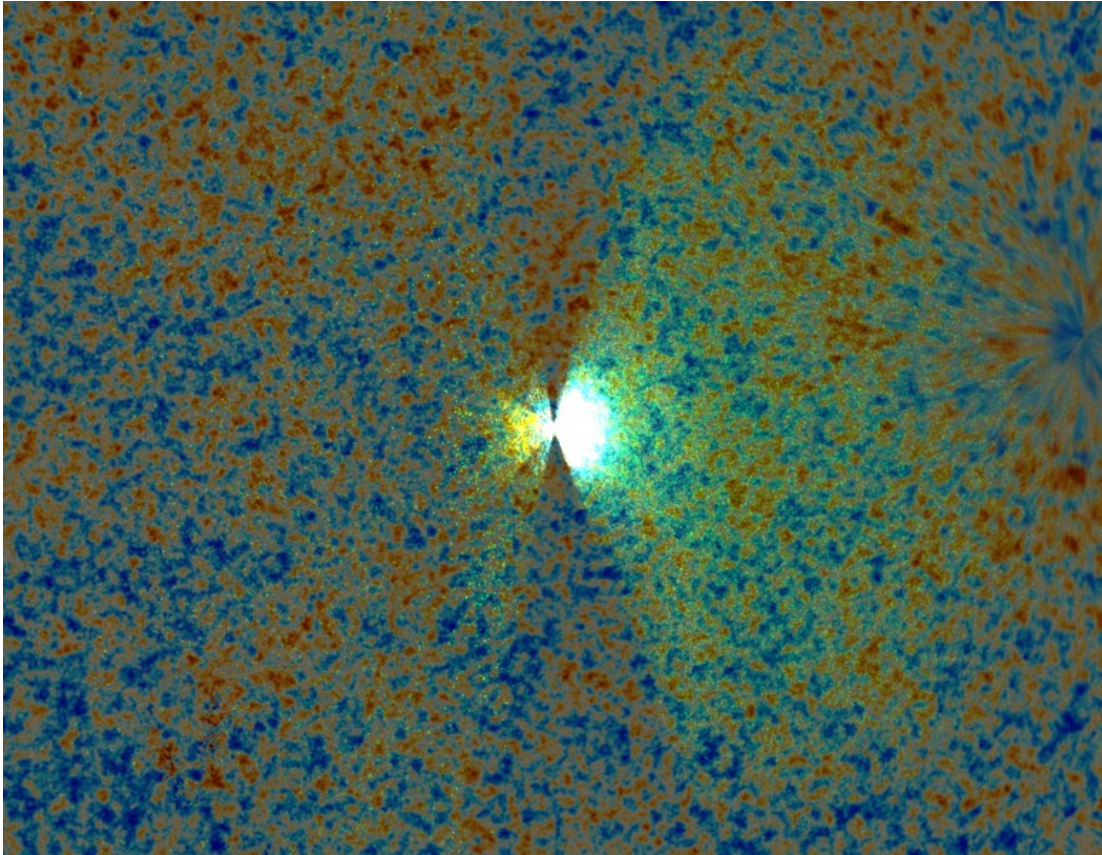


Figure 131. Visualizations of galactic surveys and the Planck CMB survey in the *Digital Universe Atlas*.

[Zooming back out to the intergalactic scale to reveal large-scale galactic surveys and the cosmic microwave background]

Nevertheless, astronomers appear to have empirically verified many cosmological predictions. One of the most famous predicted that faint signals from the beginning of time—so-called “Big Bang”—would be detectable all around us. In the 1960s, a couple of engineers started detecting low-level radiation evenly filling the sky. They initially assumed it was a malfunction of their telescope. It was eventually confirmed, however, that they’d seemingly identified the predicted cosmic microwave background radiation. This is thought to be very faint glow emanating from shortly after the massive

creation event. Astrophysicists believe this was when protons and electrons recombined to form hydrogen—the most abundant element in the universe—some 13.8 billion years ago relative to us. We can still detect these ancient signals as static on ‘in between’ channels of analog television sets.

I qualify this statement with ‘relative to us’ because of Einstein’s special relativity. According to this theory, we must make all space-time measurements relative to an observer’s frame of reference. But this has strange implications. According to this understanding, at the speed of light there is no time. Paradoxically, this implies the moment of creation is both timeless and within time. Our experience of space-time within this timelessness is shaped by our unique cosmic circumstances and particular forms of embodiment—made possible by all the emergent properties supporting life on Earth.

The Planck satellite mission released this cosmic microwave background survey in 2013 (Figure 131). Its different colors indicate very subtle temperature variations. The blue areas are cooler regions believed to be the dense areas that seeded stars, galaxies, and the rest of the material world. From this perspective, we’re looking at the traces our earliest elemental ancestors within this cycle of cosmic evolution.

This image is believed to be the oldest and furthest thing we can see—our cosmological horizon—so it is used as the outer boundary of the *Atlas*. But its radius has been modeled at a point even further than the measured age of the

universe to account for the theorized rapid expansion of space-time. Instead of 13.8 billion years from us, this map is placed at 42 billion light years in all directions. Basically, we can't detect anything beyond this boundary because light further away hasn't had enough time reach us.

7.01.18 Heavenly Sphere

At the pinnacle of the cosmic journey, the revelation of the ‘outside’ view of the CMB sphere functions like the self-transcending ‘explosive metaphors’ of Cusa’s infinite sphere (3.11 Infinite Sphere). I point out its ouroboric significance, recalling the importance of the shift *away* from a spherical, geocentric world model within the dominant narrative of the ‘scientific revolution.’ I continue to integrate the previous perspectives through the *spherical world view*, drawing attention to the complex intra-actions and processes of knowledge production from which the *Digital Universe Atlas* emerged. Its ‘observer-centric’ configuration arises from the *subjective* view that results in blind spots, the *intersubjective* consequences of postphenomenological Cartesian mapping, the *interobjective* ‘ecological center’ that has birthed life and self-consciousness, and the *nondual* co-arising of phenomena conspicuously demonstrated by the spherical diffraction pattern of the CMB survey.

I often use these transdisciplinary interpretations to once again highlight the importance of *learned ignorance* by acknowledging the profound mysteries that persistently permeate cosmological speculations. Like *Dark Universe*, I use the CMB sphere to encourage participants to imagine an infinite number of ‘observational centers’ and ‘cosmic horizons.’ This visualization provides cognitive scaffolding for envisioning the paradoxical infinite sphere whose center is everywhere and circumference nowhere. This facilitates the imaginative ‘explosion’ of the *heavenly sphere* metaphor, which is already recursively enhanced by the spherical immersive display and participants’ embodied familiarity with CONTAINER image schema (1.03 Spherical Container).

This tactic is informed by Sweitzer's (2006) proposal to use the CMB sphere to demonstrate the "limits of common sense" and to "develop an understanding of the use of scientific models" (p. 13)(6.01 Looking In from the Outside). I use the appearance of the CMB sphere a conspicuous macrocosmic demonstration of the situated, relativistic nature of all perspectives. This metacognitive view from 'outside' the edge of the universe appears to signal the return of the *heavenly sphere*. I often discuss how my initial encounter with the CMB sphere complicated my 'poetic faith' in naïve real and dualistic interpretations of the universe, but helped me gain an appreciation of the complexities and paradoxes of attempting to map *the* Universe in any totalizing sense.

And this is where things get funny. Because this is image mapped within this 3D virtual world, we can fly beyond our own virtual horizon to look at it from the 'outside.'

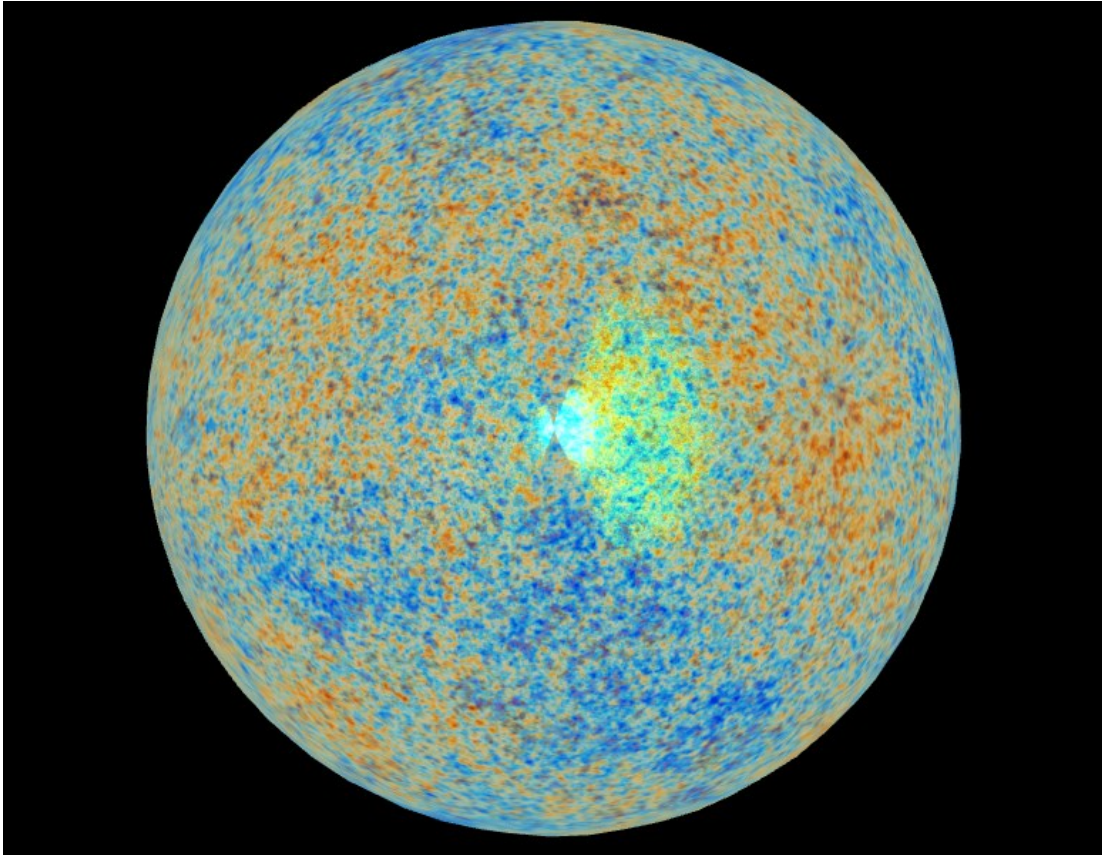


Figure 132. Visualizations of all-sky surveys and the Planck CMB survey in the *Digital Universe Atlas*.

[Pulling out to reveal the Planck CMB sphere]

Notice anything peculiar? After spending many years and billions of dollars to map the observable universe, we once again find ourselves at the center of a cosmic model surrounded by a *heavenly sphere* (Figure 132).

Astronomers attribute this configuration to our ‘observational center.’ This is because when we map and model a universe based on light with a finite speed, the measurements are inevitably centered on us. This also implies that if we’re mapping from another galaxy, it would appear to be the center as well, though with a different cosmological horizon. But we are at the center of this universe

because we're the ones taking the measurements from here, on Earth, in the Milky Way.

I'm always tempted to suggest that this return of a spherical, geocentric cosmic model implies that the 'Copernican revolution' has finally come full circle. But I actually think that it poetically visualizes our arrival at a higher order of complexity. When we study these consequences of this modern scientific dream from this perspective of a god's eye view from nowhere, we encounter a profound paradox. This *Digital Universe Atlas* isn't simply a 'subjective' or 'objective' map, but a kind of complex diffraction pattern enacted through scientific attempts to make sense of the world. The center of the universe seems to be everywhere there's a conscious observer. But its boundary also seems to be nowhere, since the cosmological horizon would always be relative to the point of observation.

But even more importantly, embodied, self-conscious observers *aren't* everywhere. They only exist in places with the right conditions and emergent properties. This implies that Earth isn't simply humanity's observational center—it's also the *ecological center* of our universe. Though it's sometimes imagined as mediocre and no place special, so far it's the only place we've found that supports life. And fortunately for us, it provides the elemental ground of being for our particular form of complex life. Because of this, we have the luxury of asking big questions about our place in the cosmos.

So, as a consequence, Earth's physical density and synergistic conditions also make it the relativistic frame of reference of the *Digital Universe Atlas*. That's why it appears as the central axis—the *axis mundi*—of this new cosmic model.

7.01.19 Long Zooming

After examining the gestalt switch of the CMB sphere, the presentation generally concludes by reversing the trajectory and zooming back to the center of the model. I use visualizations of star-forming regions and supernovae remnants within the Milky Way to describe the nucleosynthetic formation of heavy elements in the heart of stars—as well as the subsequent explosive spewing forth of supernovae into the surrounding interstellar medium. Simulated stars, comets, and meteors illustrate how gravitational accretion increased the elemental complexity over the course of billions of years. Throughout the journey, I recount the systems, relationships, and emergent properties of cosmic evolution to suggest that each of us are, in the words of Alan Watts (2000), “aperture[s] through which the universe is looking at itself and exploring itself” (p. 90).¹⁰²

So my question for all of us is: What exactly is this thing?

I’ve found that it helps to not think of this as a model of the ‘universe’ as it is right now. I consider it a *tool for thinking* that enables us to examine the complex intra-actions and diffraction patterns that emerge when we try to map and model of the cosmos. Visualizing these datasets not only expands our

¹⁰² Like Neil deGrasse Tyson and Carl Sagan (5.15 Revisiting the Caves), Watts (2000) insists that, “We are no less than the universe.” He explains, “When you take a scientific point of view, your organism is inseparable from its environment, and so you really are the organism/environment. In other words, you are no less than the universe, and each one of you is the universe expressed in the particular place that you feel is here and now. You are an aperture through which the universe is looking at itself and exploring itself” (p. 90).

imaginations, but it also helps us to view the complexity of the world from new perspectives.

[Gradually zooming from the CMB sphere back to Earth]

Just like our ancestors in the caves, we're using this environment to orient ourselves to the cosmos. This can help us to imagine the creation story of modern science. The photons of this cosmic microwave background were emitted shortly after the Big Bang, traveling at 186,000 miles per second and journeying through the formation of stars, quasars, and galaxies. As nucleosynthesis compressed hydrogen and helium into heavier elements, stars exploded in supernovas to seed the cosmos with matter that eventually gave birth to solar systems and planets.

[Zooming into the simulations of the Milky Way simulation and the local solar system]

That light eventually arrived at a barred spiral galaxy containing at least one star around which a planet was orbiting at just the right distance to have the necessary conditions for the emergence of complex life.



Figure 133. Earth model displaying the *Blue Marble Next Generation* composite satellite image from NASA.

[The model of Earth comes into view]

And on this planet, at least one species emerged around 200,000 years ago that become self-aware enough to turn to the skies to inquire about its cosmic origins (Figure 133). By creating techniques for studying the heavens, this species could survive by anticipating and synchronizing with the cycles of life. These techniques evolved from cave paintings to telescopes and satellites, which eventually registered those photons emitting from the early universe. We used the satellite data of archaic light to create the map of the cosmic microwave radiation. As that spherical image was projected here as a *heavenly sphere*, photons bounced off the screen of this dome and were absorbed into your eyes. So as you sit here, imagining all of this, you are, in this story, the

Universe becoming aware of itself after a 13.8 billion year process of cosmic evolution. Give yourselves a hand.

7.01.20 Universe Mattering

Once we've returned to the center of the *Atlas*, I emphasize humanity's role in shaping the metabolism and evolutionary trajectory of Earth. Far from passive observers, I suggest we are, as Carl Sagan (1980/2011) famously stated, "the local embodiment of a Cosmos grown to self-awareness [. . .] organized assemblages of ten billion billion billion atoms consider the evolution of atoms [. . .] starstuff pondering the stars" (p. 286). But this realization, I argue, comes with a great responsibility.

From the perspective of modern science, we are all evolutionary functions of the cosmos. Every single one of us is something the entire universe is doing right now. The universe matters because we are the universe mattering.

After decades of searching our cosmic environment for signs of life elsewhere, Earth is still the only planet we've found with a biosphere. Far from being alone in the universe, we're enmeshed within the more-than-human world of our planetary biosphere. And our relationships to other living beings may be the greatest gift the universe has to offer. Since the dawn of the 'space age,' we've realized the ancient dream of traveling through the heavens in new ways, only to find ourselves already living in the only heaven that we may ever know.

By scanning our omnidirectional horizons, we've realized that our *ecological center* provides the elemental ground of being that animates our embodied consciousness, enabling and enacting our self-awareness. As we've continued to study the dynamics of this planetary ecosystem, we've realized that we take its conditions for granted at our own peril. The systems of Earth are deeply

interconnected and interdependent, and our current actions have consequences far beyond what we can imagine.

If we want our species to stick around for a while, it's up to each of us to take on the responsibility this realization implies. Though we're facing some wicked challenges, we also have extraordinary opportunities to re-imagine and re-design our planetary civilization. These new perspectives on Earth and the cosmos have helped us to appreciate the extraordinary planet we call home. And they can also help us to once again synchronize with the remarkable structures, flows, and cycles of life that make our cosmic journey possible. Thanks for joining me in cosmotroping...

7.02 Cubing the Sphere

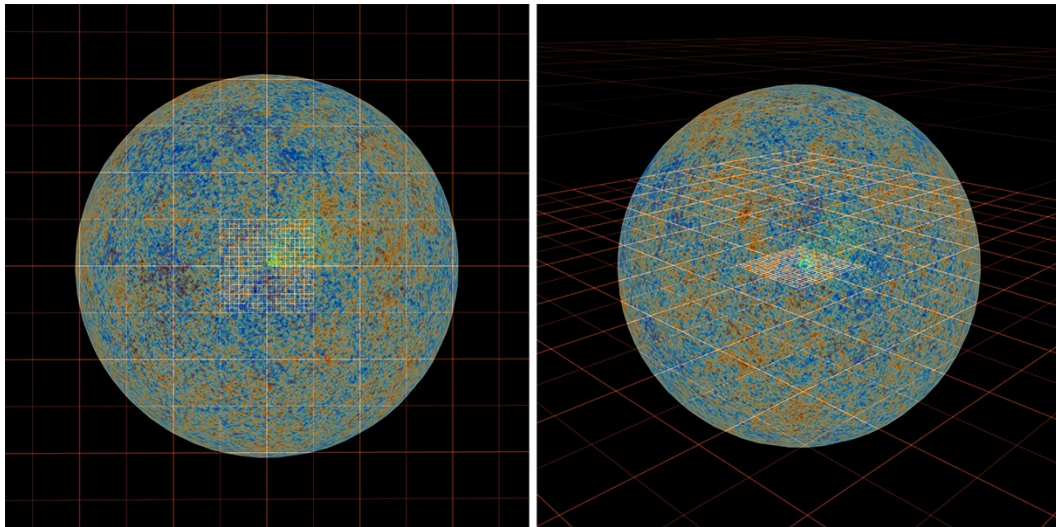


Figure 134. Different views of the *Digital Universe Atlas* enclosed by the Planck survey of the cosmic microwave background with the Cartesian coordinate grid turned on. Rendered in *Uniview*.

By exploring the *transcalar imaginary* within my *cosmotrope* performances, I have recognized that the *Digital Universe Atlas* embodies the inherent tensions that arise from self-consciousness. By simultaneously visualizing ‘centric’ and ‘eccentric’ perspectives (1.03 Spherical Container), this latest model of the observable universe connects to *cognitive cosmographic models* across time. Cosmographic practices are once again being used to turn chaos into a cosmos by “substituting the unknown with the well-known” (Rappenglück, 2009a, p. 24) (2.03 Cognitive Cosmographic Models).

Since encountering the *kōan*-like paradox of the *Digital Universe Atlas* at *Burning Man*, I have used its spherical, geocentric configuration to address how it complicates the dualistic logic of Aristotle and Descartes (see the Prologue). Attempting to interpret the CMB sphere—and, consequently, the *Atlas* as a whole—from *either* a ‘subjective’ or ‘objective’ perspective generates a schizophrenic

“double bind—in which a situation in which no matter what a person does, he ‘can't win’”(Bateson et al., 1956, p. 251). The extent of this “double bind” is apparent within disagreements among the Hayden producers concerning whether or not their visualizations can be considered a map of the *real* universe (5.02 Cosmic Tensions).

Through the integration of mixed methods research with my performative practice (see Motivation, Aims, and Methods in the Introduction), I have come to consider the *Atlas* a contemporary manifestation of a perennial cosmic conundrum. By modeling the observable universe within a scalable 3D virtual world, the Hayden Planetarium has exoterically visualized the consequences of attempting to conjoin the finite realm of sense perception and the infinite realm of mathematical abstractions. When the Cartesian grid is visualized and the omnidirectional CMB survey is viewed from beyond its outer boundary, this technoscientific cosmographic atlas appears to be a macrocosmic rendition of ‘squaring the circle’ (Figure 134). This ancient riddle results from the geometric paradox of attempting to “construct circles and squares of equal areas or perimeters precisely” (Fletcher, 2007, p. 119) —with the irrationality of the former and the rationality of the latter appearing to be irreconcilable.¹⁰³ Combining the finitude of empirical observations within the infinitude of mathematical conceptions generates a postphenomenological ‘sphere of cognition’

¹⁰³ Rachel Fletcher (2007) cites numerous physical and mathematical embodiments of this riddle, including the Great Pyramid of Khufu, Buddhist stupas, the Roman Pantheon, the Vesica Piscus, the Golden Section, Leonardo’s Vitruvian Man, she contends they commonly visualize efforts to realize “the union of opposing eternal and finite qualities, symbolizing the fusion of matter and spirit and the marriage of heaven and earth” (p. 119). Chang Hong Liu (1997) demonstrates that “referents of circle and square as symbols” are also “referents of other forms that share many properties with a circle and a square-forms such as a sphere and a cube” (p. 135) and concludes that “different forms with the same key shape features can operate as similar kinds of symbolic forms” (p. 145). This correlations also relates to Erwin Panofsky’s (1924/1991) work on how visual and mathematical perspectival systems function as symbolic forms that shape notions of the finitude and infinitude of space.

(5.07 Sphere of Cognition) within the *heavenly sphere* of humanity's cosmic horizon. By pushing the ideal 'Archimedean point' to its virtual extreme, the objectification of the CMB sphere has instigated a crisis of interpretation similar the metaphoric explosions enacted by the infinite sphere centuries ago (3.11 Infinite Sphere).¹⁰⁴

Acknowledging these paradoxes has significant consequences for explaining scientific conceptions of the cosmos. For instance, according to Einstein's theory of special relativity, there is no time at the speed of light. This implies that from the frame of reference of photons, the radiation of the cosmic microwave background is timeless. But from the relative, situated, and contingent perspective of human observations, this universe—or at least this cycle of it—appears to have been evolving for nearly 13.8 billion years. So the universe can be viewed as still 'banging'—within an "ever-present origin" (Gebser, 1984)—while simultaneously evolving based on the contingent measurements and embodied experiences of living organisms. As the *heavenly sphere* has reappeared through humanity's postphenomenological "view from the center" (Primack & Abrams, 2006), it can be poetically interpreted as bringing both the scientific and mythological understanding of the cosmos full circle—a spectacular reminder of the complex unity inherent within the art of creating worlds.¹⁰⁵

¹⁰⁴ Elizabeth Briant (1999) claims that the "coincidence of unity and plurality, of minimum and maximum, of inner and outer, of immanence and transcendence" are "explicitly thematized" (p. 580) in Cusa's infinite sphere. She also relates this to the riddle of squaring the circle, writing, "Cusanus makes an analogy [...] between the attempt of a finite intellect to attain the truth about things by means of concepts and comparisons, and the attempt to 'square the circle,' i.e., to approximate the circumference of a circle by an inscribed polygon. The more angles the inscribed polygon has the more similar it is to the circle. However, even if the number of its angles is increased ad infinitum, the polygon never becomes equal [to the circle] unless it is resolved into an identity with the circle" (p. 598).

¹⁰⁵ My visual essay "Cosmopoiesis: The Art of Worldmaking" (McConville, 2011) documents parallels between cosmographic imagery across time.

Describing the innermost point of the *Digital Universe Atlas* only as an ‘observational center’ occludes the interconnected totality and complexity of the model—and, by extension, of the entire cosmos. The CMB map appears spherical because it represents a panoramic snapshot of the visible horizon of the macrocosm taken from humanity’s *relative* perspective. But its positioning and scale within the abstract—*absolute*—three-dimensional virtual space has been calculated using conventional scientific understanding of correlations between relative distance and the speed of light. This is further complicated by the tenet within the ‘concordance model’ of Lambda-CDM cosmology that ‘space’ is expanding at an accelerating rate under the influence of ‘dark energy’ (Peebles & Ratra, 2003). Yet, by modeling it—and other astronomical surveys—within the static confines of an absolute 3D coordinate system, its temporality is frozen, resulting in a ‘timeless’ map of the structure of the observable cosmos. Instead of “cosmic spheres of time” (Primack & Abrams, 2006, p. 133), these dynamic temporal processes are mapped as static objects, whose placement, appearance, and overall configuration are derived from situated cosmographic practices. By objectifying processes of finite sense perception within an infinite 3D space, the *Digital Universe Atlas* visualizes the truly mythical proportions of the ‘Archimedean point’ by virtually embodying a paradoxical ‘timeless time.’

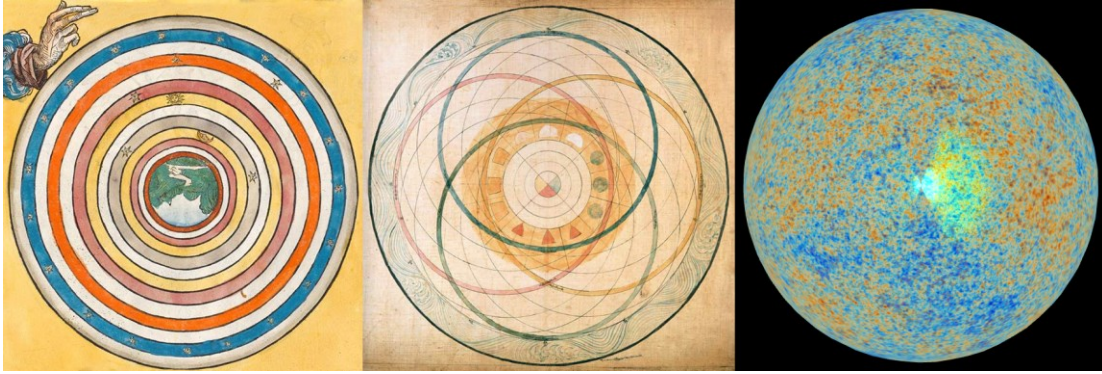


Figure 135. *The Fourth Day of Creation* (Schedel, 1493), Kalachakra mandala (Rubin Museum of Art, 2010), *Digital Universe Atlas* (AMNH, 2013a).

Furthermore, the observer-centric spherical model recalls the recurring archetypal configuration of the mandala (Figure 135). Carl Jung (1959/1981) explains innumerable variants of the mandala—a term derived from the word ‘circle’—“are all based on the squaring of a circle” (p. 357). The basic motif of mandalas, he writes, “is the premonition of a centre of personality, a kind of central point within the psyche, to which everything is related, by which everything is arranged... surrounded by a periphery containing everything that belongs to the self—the paired opposites that make up the total personality” (p. 357). He describes the totality of the mandala as comprising “consciousness first of all, then the personal unconscious, and finally an indefinitely large segment of the collective unconscious whose archetypes are common to all mankind” (p. 357).¹⁰⁶

Susan Walcott’s description of Buddhist practices draws further connections to the “double bind” (Bateson et al., 1956, p. 251) induced by the CMB sphere—

¹⁰⁶ Appropriately, *The Known Universe* (Emmart, 2009), a rendering of a flight through the *Digital Universe Atlas*, was originally created for an exhibition at the Rubin Museum of Art (2009) entitled *Visions of the Cosmos: From the Milky Ocean to an Evolving Universe*, presented alongside medieval cosmic models and Tibetan Buddhist mandalas.

particularly its challenge to dualistic separation between consciousness and the cosmos. Walcott (2006) writes:

As portrayed in mandalas, cosmograms (depictions of the universe as an ordered and harmonious system) employ a spatial visualization that falls into a different category from the currently contentious cartographic camps of positivists, realists, postmodernists, social theorists, and others. By directing visualization to the interior spaces of the observer's mind, this device contributes a non-Western perspective on the two-dimensional mapping of physical space with its portrayal of metaphysical, multidimensional experiential space." (p. 72-73)

Walcott (2006) goes on to compare directly the “interactive nature” of “mentally envisioned, guru guided mandala navigation” of Tibetan Buddhism with “the three dimensional computer-generated projection of a fly-through terrain” within flight simulators, geographic information systems, and video games (p. 79). While the former entails participants following “guided paths to encounter the lessons depicted and embodied in the imaginary three-dimensional palace-mazes,” the latter involves “navigational prowess of human-map interactions through queried terrain in cartographic depictions in a Geographic Information System (GIS) environment of simulated space based on material landscapes” (p. 79). The primary differences are in approach and intention, since mandalic practices are designed to reveal “aspects of the mind, providing a metaphor to help transcend the perspective of ordinarily perceived existence” (p. 82). Through this “heightened awareness” of the conditioning of enactive cognition, mandala practitioners seek to “take significant

strides in their understanding of the world outside and their inner nature” (p. 82).

Similarly, the visualizations within the *Digital Universe Atlas* diffract as much about the ‘inner nature’ of our ‘observing systems’ as they do about ‘outside’ world.

Walcott’s correlations situate the *Digital Universe Atlas* project squarely—and spherically—within a lineage of paradoxical techniques directly connecting ‘scientific’ with ‘traditional’ cosmographic practices.¹⁰⁷

¹⁰⁷ Char Davies (2005) similarly addresses the potential of immersive virtual artworks for exploring the paradoxical nature of self-consciousness, including ways in which they can be used to enact both the reinforcement and transcendence of subject-object dualisms associated with Cartesian ontology. She also draws parallels between experiences within immersive virtual worlds and pre-Socratic practices, Buddhist meditation, and phenomenology (pp. 68-84). Niranjan Rajah (1999) also considers how the “integrative, immersive, interactive and holistic nature” of virtual worlds might “engender a rapprochement of sacred and scientific theories of knowledge” (p. 1) through new cosmographic practices.

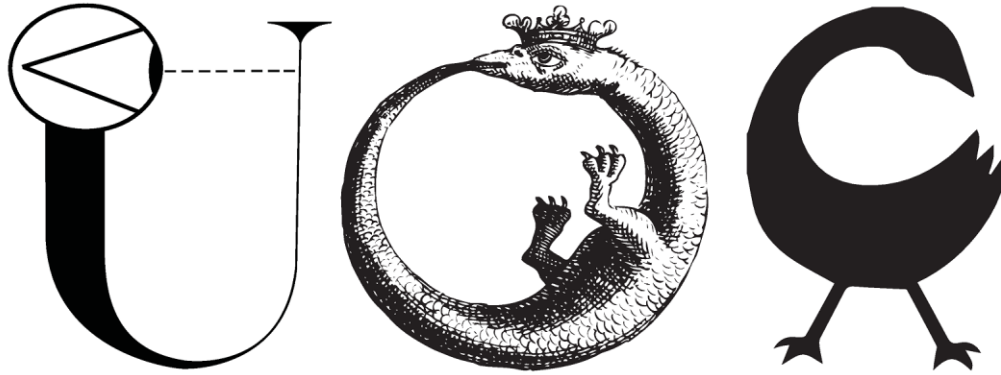


Figure 136. *The Universe as self-excited circuit* (Wheeler, 1980), *Ouroboros* (Eleazar, Baruch, & Gervasius, 1760), and the Adinkra *Sankofa* bird (MacDonald, 2004).

The integration of observable phenomena within a mathematized virtual world also meets Jung Huh’s (2010) definition of a mandala as an “archetype of empirical and synthetic design...through which the universe and human beings—and consciousness and matter—interconnect” (p. 19-20). Simultaneously empirical and synthetic, mandalas visualize the eternally recurring consequences of the encounter between a microcosmic ‘self’ and a macrocosmic ‘other’—embodying their complex unity. In effect, by objectifying space to model temporal processes statically, the creators of the *Atlas* have generated a postphenomenological cosmic mandala. Its consciousness-centered configuration recalls the self-referential paradoxes arising from what John Wheeler (1980) calls the “self-excited circuit” of a “participatory universe” (p. 361), alchemically symbolized by the autosarcophagic Ouroboros (Figure 136). In doing so, the *Atlas* confounds attempts to account for its complexity solely through the limited interpretations of dualistic logic, notions of linear causality, and the “great Copernican cliché” (Danielson, 2001, p. 1029).

These kōan-like paradoxes of the CMB sphere provided a gestalt switch (1.04 Gestalt Switching) that triggered my own intuition concerning the ‘double bind’

presented by the *Atlas*. The occlusion of the CMB sphere in dominant interpretations of the *Atlas* appear to arise from “metacognitive dissonance,” which Brent Turvey (2012) describes as “believing oneself completely objective despite the persistence of observer effects” (p. 63). To address this, I have developed the practice of *cosmotroping* through the *transcalar imaginary* to examine the implications of the return of *heavenly sphere*. Through this, I explore how we are more than ‘observers’ or even ‘observing systems,’ but embodied, self-conscious agents actively participating within an ongoing process of cosmogenesis. Instead of attempting to sustain the illusion of an objectified model of the Universe, I interpret the CMB sphere as mandala of diffraction patterns emerging from intra-acting *world views*.

Developing *cosmographic hermeneutics* has influenced more than my *cosmotroping* practice. It has shifted my own perspectives on the world, transforming my understanding of science, religion, art, philosophy, history, and the cosmos in many ways. Tracing the origins and influence of the ideals of Platonic transcendence and Aristotelian metaphysics (6.03 Transcending Dualities) has required examining my own paradigmatic assumptions and elucidating my own philosophical positions. I have gained a greater appreciation of the importance of *learned ignorance* (3.12 Learning Ignorance), particularly in the light of the ambiguity of conceptual boundaries between mind and body, self and other, immanence and transcendence, physical and metaphysical, matter and meaning, and cosmos and consciousness. In relaxing my own ‘object bias’ to study the complex artifacts of cosmographic practices (5.14 Objectifying Processes), my awareness of the fluid boundaries between my ‘self’ and Earth’s celestial and terrestrial cosmic processes has also deepened. This has led me appreciate the significance of *Sankofa*, a term from the

Ghanan Akan language that roughly translates as "go back and fetch it," "return to your past," or "it is not taboo to go back and retrieve what you have forgotten or lost" (Temple, 2010, p. 127). This idea is symbolized within the Asante Adinkra symbol resembling a combination of the ancient 'bird-man' and Ouroboros archetypes (Figure 136). *Sankofa* draws attention to the importance of learning and applying lessons from the past to take responsibility for the future. Combining this idea with the notion of the universe as "self-excited circuit," we can describe humans as the latest generation in a long lineage of species increasing in complexity and cosmic self-awareness. This combination of the theoretical and the practical not only implies an irreducibly paradoxical processes of being while becoming, but also highlights the regenerative potential of our individual and collective agency within guiding the evolutionary trajectory of Earth's living systems.¹⁰⁸

¹⁰⁸ Describing this process, Steven Rosen draws on Jung's (1962) notion of Individuation—the "transformational process of integrating the conscious with the personal and collective unconscious" (p. 301) through the *coincidence of opposites*. Asserting that the cosmos the recursive, self-similar, and holographic, Rosen (2008) contends that "full-fledged participation in cosmogony means realizing cosmic Individuations as self Individuation" (p. 244). By connecting ontogeny with cosmogony, he echoes the perennial theme of linking the microcosm and macrocosm as essential for consciously realizing the dynamic and paradoxical unity-in-diversity of nature.

7.03 Neo-Geocentrism



Figure 137. *Blue Marble 2012* (NASA, NOAA, GSFC, Suomi NPP, & Kuring, 2012).

Just as I draw attention to the peripheral boundary of the CMB sphere to rhetorically demonstrate the situated nature of all perspectives, I also draw attention to the ‘observational center’ to expand the notion of ‘geocentrism’ while *cosmotroping*. Within the *cognitive cosmographic model* of the *Atlas*, this serves as a ‘centric’ complement to the ‘eccentric’ periphery of the cosmic horizon (2.03 Cognitive Cosmographic Models). When viewed as a regenerative mandala, the

central ecological and relativistic reference frame also functions as “a kind of central point within the psyche, to which everything is related, by which everything is arranged” (Jung, 1959/1981, p. 357). I re-interpret the ancient notion of the *axis mundi* by addressing the significance of this Earthly ‘central axis’ from transdisciplinary perspectives. I draw particular attention to the complex, synergistic interactions supporting living systems that have yet to be found on any other planet, a decidedly unexpected finding of the ‘space age’ (Figure 137). I also work to clarify common ‘scalar fallacies’ concerning the distance from the ‘endosphere’ of Earth’s biosphere to the ‘exosphere’ of outer space by explaining the actual distance of exoplanets (2.03 Cognitive Cosmographic Models, 5.16 Inverting Heaven). As I have grappled with mythologized Copernican conflation of significance with perceived spatial centrality—of *anthropocentrism* with *geocentrism*—I have employed the notion of an *ecological center* to describe the *neo-geocentric* consequences of empirically mapping the observable cosmos. This has proven useful for addressing the profound implications of acknowledging the *Atlas*’—and humanity’s—*axis mundi*.

Others have made similar observations concerning Earth’s essential centrality, critiquing the ontological detachment of Copernicanism for its incompleteness and its role in reinforcing the ideal of scientific ‘objectivity’ (3.14 Promoting Demotion). In her essay “The Conquest of Space and the Stature of Man,” Hannah Arendt (1963/2007) contends that the narrative of Copernican dethroning leads to an “objective” dissociation and contributes to a “carelessness” (p. 51) that becomes a point of pride and glory. In particular, she identifies the hyper-specialization of some scientists as problematic, suggesting that they are trained not care about their own

stature in the universe or their positions in “the evolutionary ladder of animal life” (p. 51). Citing the known destructive potential of splitting the atom, she asserts that some scientists do “not even care about the survival of the human race on earth or, for that matter, about the survival of the planet itself” (p. 51).

Arendt (1963/2007) argues that the pursuit of pure objectivity can go on *ad infinitum*, threatening to lose its adherents “in the immensity of the universe.” She foreshadows the central theme of this thesis, presciently proclaiming, “the only true Archimedean point would be the absolute void behind the universe” (p. 53). She also cites the discovery of ‘observer effects,’ presaging Karen Barad’s insights into the implications of intra-acting quantum-scale diffraction patterns (6.05 Re-Imagining the World). Like quantum entanglement, Arendt speculates that a realization of humanity’s inextricable social-ecological entanglement with Earth will eventually become apparent by pushing the quest for the ultimate ‘Archimedean point’ to its logical extreme—a process virtually and spectacularly embodied within *Digital Universe Atlas*:

[O]nce the limit [of the observed “territory” of space] is reached and the limitations established, the new world view that may conceivably grow out of it is likely to be once more geocentric and anthropomorphic, although not in the old sense of the earth being the center of the universe and of man being the highest being there is. It would be geocentric in the sense that the earth, and not the universe, is the center and the home of mortal men, and it would be anthropomorphic in the sense that man would count his own factual mortality among the elementary conditions under which his scientific efforts are possible at all. (p. 53)

Similarly, Peter Sloterdijk (2013) writes of a “return to Earth,” appealing for a “radically altered sense of human localization” (p. 23). Identifying the development of cosmography in Europe as elevating visions of encounters with Earth from ‘outside’ to the norm (3.17 Cosmographic Dreaming), he insists that these dreams gained a physical verticality with the advent of flight, unlike the previous metaphysical age:

Notions of flying replaced the ancient and medieval ones of ‘ascending’; the airport earth, where one starts and lands, replaced the ascension earth, from which one propels oneself and which at some point, after a final flight is left for good. The view from the outside results not from a transcendence of the noetic soul into the extra- and supra-terrestrial, but rather from the development of the physical-technical, aero- and aeronautical imagination—whose literary and cartographical manifestations, furthermore, were always ahead of the technological ones. (p. 24)

Recalling the instability of transcendent fantasies of escape, Sloterdijk calls Earth the transcendental star “to which one now returns—no matter how distant one has become” (p. 23). Over the course of the gradual shift from the shattering of the *heavenly spheres* to the realization that Earth is teeming with life, Earth has become, he insists, “the locational condition for all self-reflections” (p. 25) (5.18 Marketing Mediocrity).

David Abram (2009) also traces the rift between “our sensing bodies and our thinking minds” to the insights associated with the Copernican revolution (3.13 Mythologizing Revolutions). He insists, however, that it is time to complete the

revolution by rejoining sensory experience and intellectual apprehension, “bringing its insights, at long last, back down to earth” (p. 306). Elucidating the central importance of humanity’s ground of being, Abram points out that we are held in orbit around the sun through Earth’s center of gravity deep within the heart of the planet. From this perspective, the Pythagorean/Hermetic/Copernican ideal of the ‘central fire’ shifts to the ground beneath our feet (3.08 Visible God). Thanks to Newton’s discovery of the universal mutual attraction of gravity, he argues, “we know that our most direct material engagement with the sun is through the gravitational center of our planet” (p. 305).

Abram (2009) also insists that relativistic understanding requires a radical reconceptualization of ‘centrality’ (5.03 Relativistic Effects). The Copernican myth of a sun-centered universe was scientifically dethroned more than two centuries ago when William Herschel recognized that the sun orbits around the galaxy (5.14 Objectifying Processes). But if we are in a cosmos where everything is in motion, and all motion must be measured relative to something else, how should a center be chosen? Abram answers:

In truth, any cluster or galaxy or star may be chosen as the stable reference, in relation to which every other body is seen to be in slow or rapid motion. In such an unbounded and dizzying pluriverse as ours, teeming with uncountable galaxies, *every* sphere enacts a center around which all the rest arrays itself.

Why not, then, our own sphere, our own wild-flowering Earth? (p. 308)

Returning to our felt experience, Abram (2009) contends, is crucial for reconnecting to the trustworthiness of our animal senses and to “recover our

attunement without abandoning intellectual rigor” (p. 307). Only then, he maintains, can we integrate with the “living land” and “more-than-human world” (p. 307) of our biospheric surroundings.

Similarly, Anne Primavesi (2003) insists that awareness of “Gaia’s gift” of life creates a “revolution within ourselves.” It means, she writes, “living as if we understand and give priority to the complex range of interdependent relationships on which all life here depends and in which we are totally involved” (p. 70). In the same vein, Thomas Berry (1992) insists that a “mutually enhancing relationship of the human to the Earth” will be the identifying feature of the emerging epoch—calling it the ‘Eozoic era’ instead of the ‘Anthropocene.’ Relevant to the current study, he maintains that artists are “integral to this larger process,’ since they “become vulnerable in the range and magic of their work to the extent that the natural world itself has become vulnerable” (p. 48). But, Berry warns, “If art becomes limited to human processes, or to human imagination, lacking an intimate relationship with the larger natural world, the art field will lose much of its vigor and purpose.” He expresses ominous hope that as we become aware of the extinction of species, the destruction of the rainforests, and the devastation of marine life, we also become attuned to the “isolation of humanity in an Epcot Planet” that is “leading us toward a disaster of untold dimension, both as individual artists and as citizens of the universe” (p. 19).

While each of these authors invariably arrived at their *neo-geocentric* positions through a variety of life experiences, my perceptions of the vulnerability of the human/Earth relationship have been significantly shaped by the modern gifts of the ‘space age.’ For instance, Abram’s (2009) route to his “Earthly cosmology” was

primarily through phenomenology (6.07 Returning to the Senses), but I have reached similar conclusions through postphenomenological artistic experiments (6.08 Learning to See). In exploring how our animal senses extend through technoscientific mediation, I have sought ways of enhancing attunement to the transcalar aspects of our cosmic and planetary ecosystems. My efforts have been inspired by many initiatives described throughout this dissertation (in particular, see Chapter 4: Cosmological Cinema) as well as pragmatic proposals concerning how scientific visualizations and theoretical scenarios can cultivate a sense of ‘planetcentric’ responsibility. Descriptions of the “overview effect” (F. White, 2012) testify to the transcendent appeal of this big picture, synoptic approach. The mythical and mystical attraction of the Apollonian perspective is *so* seductive that the dramatic ecological consequences of achieving it appear to be discounted as externalized costs by a space tourism industry promising consciousness expansion (5.17 Externalizing Epiphanies).

Anticipating the potential downside of dreams of escape to other worlds, Hans Blumenberg (1997a) proposes the interdisciplinary field of ‘astronoetics’ (p. 545) to examine spaceflight plans prior to takeoff. Karsten Harries (2001) describes astronoetics “not as an alternative to ‘astronautics’ [...] of actually traveling somewhere” but as a practice to give “thoughtful consideration of whether, and if so just what sense it would make, to travel there” (p. 320). Harries writes:

In Blumenberg’s astronoetics, centrifugal curiosity is balanced by centripetal care for the earth. And so understood astronoetics may well deserve funding after all: by occasionally pouring cold water on projects that would take many millions to realize, it might make an important contribution to human welfare. (p. 320).

Further connecting Earth to the heavens, Arendt (1963/2007) anticipates the “conquest of space” will result in the ability to apply the ‘Archimedean point’ to our own activities. She describes this synoptic satellite view of our movements as appearing “as no more than ‘overt behavior,’ which we can study with the same methods we use to study the behavior of rats” (p. 54). Fuller (1962) similarly describes his proposed *Geoscope* as visualizing planetary flows and interactions from this god’s eye view, which he insists will provide new insights into the impacts of human activities “that are not at present communicable to man’s conceptual understanding” (p. 48) (4.05 Pedagogical Yearnings).

In the same planetary spirit, Roy Ascott (2004) describes the field of “technoetics” as using “tools of mixed-reality technology as an extension of our own organic systems of perception and cognition” (p. 114). Foreshadowing my use of postphenomenological immersive environments, Ascott writes, “Computer-assisted technologies have allowed us to look deeper into matter and out into space, to recognize meaningful patterns, rhythms, cycles, correspondences, interrelationships and dependencies at all levels” (p. 112). Like Fuller (6.02 Starting with Universe), Ascott believes this enhanced understanding will necessarily lead to an increased focus on designing for the synergistic properties of whole systems, suggesting, “Computational systems have led us to a better understanding of how design might be an emergent process, replacing the old top-down approach with a bottom-up methodology” (p. 112).

Today, the prescient relevance of these proposals is made increasingly evident by the use of satellite-based Earth observations to visualize planetary metabolic flows (5.16 Inverting Heaven). These orbiting “technological prostheses” (Ascott,

1993/2003, p. 264) are enacting new forms of extended cognition, enabling reflexive examination of the impacts of human civilization from a virtual Apollonian view. By enhancing our “planetary proprioception” (Barasch & Fedorova, 2011, p. 89), these *instrumentally real* mediations have increasingly made visible the acute situational urgency facing both human and more-than-human astronauts aboard Spaceship Earth (Boulding, 1966; Fuller, 1969a; Höhler, 2008).

7.04 Worldviews Network

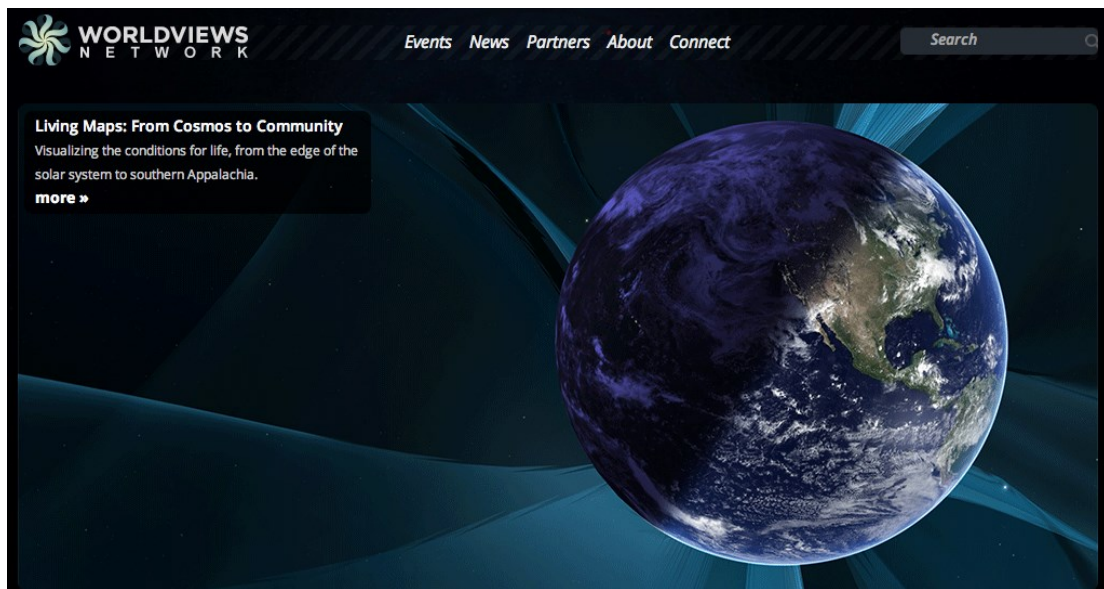


Figure 138. The *Worldviews Network* web site (McConville, 2013).

Since the dawn of the ‘space age,’ Earth-observing satellites have made explicit the impact of humanity’s individual and collective agency on interconnected systems. Within the *transcalar imaginary*, these instrumentally real datasets serve as tools visualizing previously invisible phenomena within humanity’s sphere of cognition. In considering how these tools should be applied, I have gained a deep appreciation for the importance of Karen Barad’s (2000) reconceptualization of “scientific literacy” as “agential literacy” (p. 221). Paralleling key aspects of *cosmographic hermeneutics*, she writes that within “agential literacy” science is understood not as an endeavor isolated from culture, but in “complex intra-action with other practices” (p. 238). Recognizing the consequences of our inextricable entangled diffractions with the universe requires “understanding the nature of our intra-actions within the world” (p. 237). But to “meet the universe halfway,” she insists, we must be “alive to the possibilities of becoming” and “take responsibility

for the role that we play” (p. 396) within its emergence (Barad, 2007, p. 396) (6.05 Re-Imagining the World). In other words, understanding scientific ‘facts’ alone is insufficient for comprehending the complexity of knowledge production or for adequately responding to interconnected, wicked problems.

To cultivate ‘agential literacy’ within my *cosmotroping* practice, I have integrated the findings and techniques described throughout this dissertation in my role as the Creative Director of the *Worldviews Network* (Figure 138). Catalyzed by this present study, the *Worldviews Network* began in 2009 when I worked with a team of scientists and educators to secure a multi-year environmental literacy grant.¹⁰⁹ We have since collaborated with informal science institutions, universities, non-governmental organizations, and federal agencies to address global change issues using immersive visualizations (McConville, 2013).

In the past three years, we have created and hosted numerous productions in science education centers across the US (see Worldviews Network Presentations in Appendix I). These are designed to help communities “reimagine the big picture” by visualizing transcalar connections and dependencies across local, planetary, and cosmic scales. We have sought to demonstrate how immersive vision theaters can facilitate transdisciplinary dialogues about how our collective actions are shaping the *Anthropocene* (5.16 Inverting Heaven).

¹⁰⁹ Funding for this project came from a US\$1,250,000 National Oceanic and Atmospheric Administration Environmental Literacy Grant (NA10SEC0080011 and NA10SEC0080017). Though the initial project—entitled *Worldviews Network: Ecological Literacy Programming for Digital Planetariums and Beyond*—was designed as a three-year project (2010-2013), we have applied for additional funding to expand the professional development components of the project to other planetariums and science centers. The original partners include the Elumenati, Denver Museum of Nature and Science, the California Academy of Sciences, WGBH/NOVA, and NOAA’s Climate Program Office. Production descriptions, storyboards and media assets from *Worldviews Network* presentations are available through <http://www.worldviews.net>.

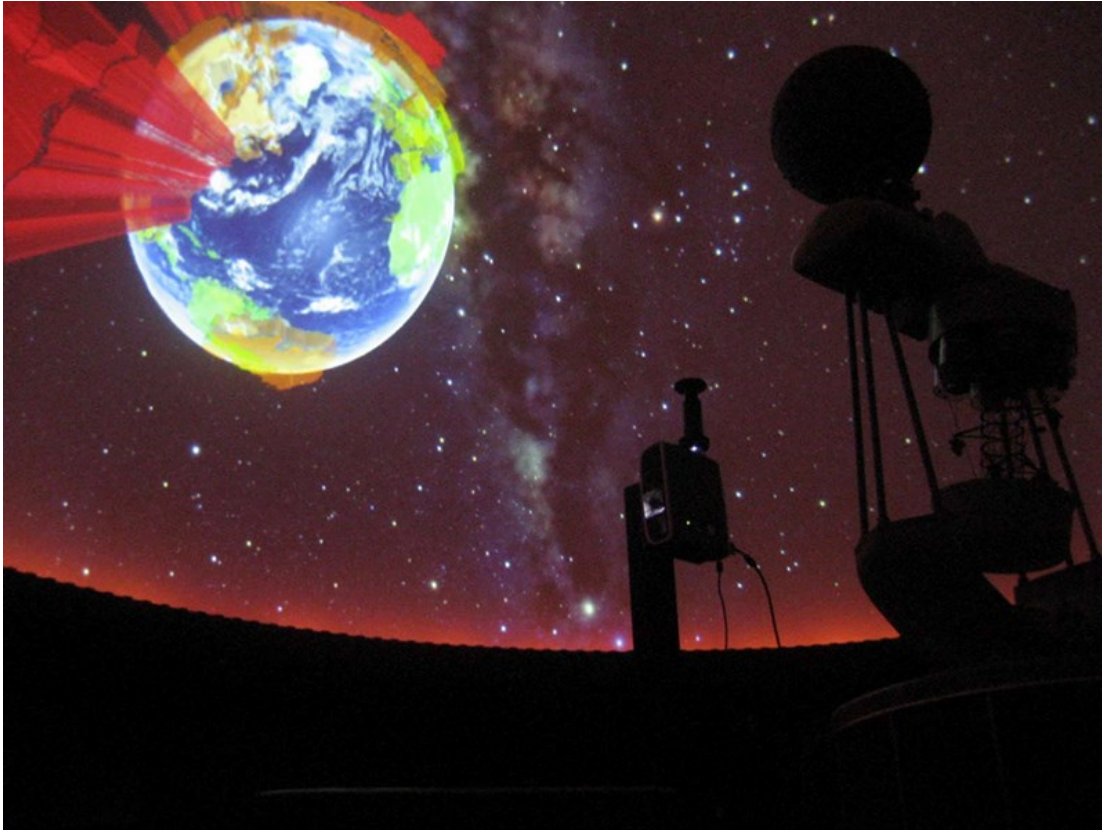


Figure 139. An Elumenati GeoDome Evolver digital planetarium retrofit projecting Earth data related to planetary boundaries (Colucci, 2008).

During the presentations, interactive visualizations of datasets across cosmic, global, and bioregional scales accompany live, narrated accounts of the interconnected conditions supporting life on Earth. These productions emerge from *cosmographic hermeneutic* techniques and narrative trajectories developed for my personal *cosmotroping* practice. However, they are tailored to address specific of the host communities and presented by the collaborating partner. Each presentation is framed within the context of one or more of the “planetary boundaries” (Rockström et al., 2009). Over the course of the project they have covered a wide range of topics, including water, drought, floods, climate, animal migrations, biodiversity, ocean dynamics, and land use.

I introduced the *world views* heuristics during the initial meeting of the *Worldviews Network* production team to facilitate acknowledgement and integration of intra-acting perspectives within the storyboards. Throughout the project, the heuristics have provided referents among the production team for developing transdisciplinary approaches, during which we've created narratives and data drawing from multiple disciplines, including geology, ecology, astrophysics, cosmology, anthropology, mythology, systems theory, and design. The visual simplicity of the diagrams has enhanced their comprehensibility and mnemonic utility, providing necessary scaffolding to support the heuristic availability of intra-acting epistemic and ontological perspectives. I also use them to contextualize different ways of knowing and collaborate with colleagues trained in diverse traditions, particularly for the purpose of synergizing 'western' and 'indigenous' knowledge (Agrawal, 1995). The heuristics have helped the productions teams to recognize the limits of dualistic logic and strictly disciplinarian perspectives to explore intra-acting matrices of scientific, cultural, ecological, and other factors that influence complex processes of knowledge production.

The *Worldviews Network* grant has provided the necessary funding and infrastructure for me to iteratively develop and apply the findings of this research project beyond my own *cosmotrope* performances. We are currently creating professional development materials that will be made available free of charge to the global network of digital planetarium operators, as well as finalizing participant evaluations for the final report on the outcomes of the project. It has enabled me to formally refine ways of engaging collaborators and participants in the process of "learning-to-see" (Ihde, 1998, p. 179) through the lens of *spherical thinking* using

technoscientific, postphenomenological, perceptually immersive environments (4.09 Making Sense of the Real Sky, 6.08 Learning to See, 6.15 Spherical Thinking).¹¹⁰

¹¹⁰ In addition to the *world views* visual heuristics, the *Worldviews Network* has used Stephen Sterling's (2003, p. 421) 'Seeing/Knowing/Doing' transformative learning model to integrate visual thinking, systems thinking, and design thinking. The narratives also been influenced by my participation with the *Buckminster Fuller Institute*. Many of the productions have integrated stories of projects submitted to the *Buckminster Fuller Challenge* (BFI, 2013), a yearly award program which seeks visionary, comprehensive, ecologically responsible, and replicable initiatives with the significant potential "to make the world work for 100% of humanity in the shortest possible time through spontaneous cooperation without ecological offence or disadvantage of anyone."

7.05 Future Directions

Though immersive vision theaters and digital planetariums have been integral to this current project, they also limit distribution of these research findings. In addition to *cosmotroping* and *Worldviews Network* presentations, I have participated in numerous symposia, workshops, and events to explore the *transcalar imaginary* and the *world views* heuristics with diverse audiences beyond immersive vision theaters (see Select Invited Lectures in Appendix I). These presentations primarily address the enactive role of cosmographic practices in shaping Western philosophy, religion, and science. I use the metaphor of the sphere as an optic for interpreting contemporary and historical visualizations from transdisciplinary perspectives. These build on the findings of this current research, through which I have established historical context, hermeneutic principles, and heuristic techniques to encourage *spherical thinking*. This research is ongoing, and I am currently developing practical applications to demonstrate the potential of *cosmographic hermeneutics* for understanding complex processes of knowledge production in non-immersive contexts. By visualizing the *transcalar imaginary* in new ways, I'm continuing to explore how postphenomenological techniques can illuminate interconnections between Earth and the heavens through the interpretive lenses of intra-acting *world views*.

Conclusion

Through my ongoing practice of *cosmotroping*, I have iteratively developed the *world views* heuristics (6.14 World Views) through *cosmographic hermeneutics* (6.12 Cosmographic Hermeneutics). I performatively applied these to visualizations of historic and contemporary cosmographic models within the *GeoDome* immersive visualization environment (2.06 Cave as a Cosmos). By artistically experimenting with creating the ‘third space’ of the *transcalar imaginary* using these postphenomenological *tools for thinking* (6.09 Creating a Third Space, 6.08 Learning to See, 2.05 Tools for Thinking), I have explored how processes of embodied conceptual integration bring about the co-substantial symbiosis and simultaneous emergence of the cosmos—the sign—and cognition—the signifier—to bring forth ‘views’ on the ‘world’ (6.06 Enacting Cognition). This practice has led me to conclude that when we reduce the artifacts of cosmographic practices to overly simplistic interpretations, we run the risk of obscuring the truly valuable lessons of our attempts to domesticate the universe (6.03 Transcending Dualities). By *learning to see* through the transdisciplinary lenses of the *world views* presented here, it is not only possible to illuminate the nuanced complexity of the factors informing the emergence of these macrocosmic diffraction patterns (6.05 Re-Imagining the World), but also to cultivate abilities to discern the complementarity of multiple, intra-acting perspectives (6.04 Thinking the Complex, 6.15 Spherical Thinking).

As I have continued to experiment with the techniques developed throughout this dissertation, my own understanding of the ‘Archimedean point,’ dualistic logic, linear causality, and the histories of philosophy, religion, and science have been radically transformed. Identifying and integrating critiques concerning tacit

paradigmatic assumptions have both shifted and expanded my own understanding of transdisciplinary approaches. This has entailed embodying and elucidating viable interpretive alternatives while guiding ‘tours’ through the *Digital Universe Atlas*. This practice has continued to catalyze the action research components of this project, through which I have engaged a broader community of practice through the *Worldviews Network*. In extending this research beyond my *cosmotroping* practice, I am continuing to develop additional tools and platforms for pragmatically cultivating complex and paradoxical perspectives through the enactive exploration of *spherical thinking*.

Conclusion: Spherical Leverage

“The sciences have two extremes, which meet.

The first is the pure natural ignorance in which all men find themselves at birth.

The other extreme is that reached by great intellects,

who, having run through all that men can know,

find they know nothing and come back again

to that same ignorance from which they set out;

but this is a learned ignorance which is conscious of itself.”

(Pascal, 1662/1910, p. 113)

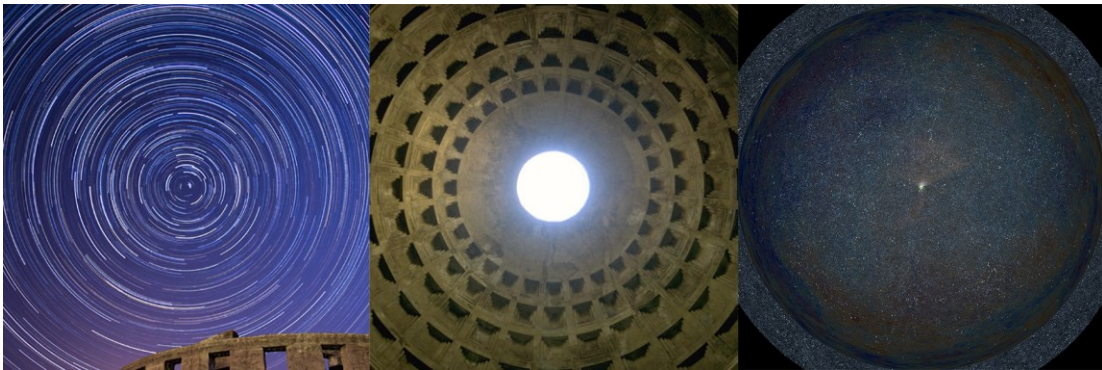


Figure 140. *Star Trails at Maryhill Stonehenge* (Stephen, 2011), *Pantheon Oculus* (Wackernagel, 1998), CMB sphere in *Dark Universe* (Emmart, 2013).

By developing an enactive approach to cosmography throughout this dissertation, I have demonstrated how interpretations of the *heavenly sphere* have profoundly influenced paradigmatic beliefs across time. From this perspective, *cosmographic hermeneutics* meets Donella Meadows’ (1999) definition of a ‘leverage point.’ She describes this as a place within a complex system “where a small shift in one thing can produce big changes in everything” (p. 1). Recalling Thomas Kuhn’s emphasis on the importance of ‘paradigm shifts,’ Meadows identifies the penultimate leverage point at the “mindset or paradigm out of which the system—its goals, power structure, rules, its culture—arises” (p. 3). But, Meadows insists,

there is a higher leverage point than changing a paradigm. Finding this ultimate leverage point, she contends, requires “throwing yourself into the humility of Not Knowing.” Counterintuitively, she identifies the *real* ‘Archimedean point’ as the ability to “remain unattached in the arena of paradigms” by realizing all of them provide a “tremendously limited understanding of an immense and amazing universe that is far beyond human comprehension.” In the spirit of learned ignorance, Meadows concludes, “In the end, it seems that power has less to do with pushing leverage points than it does with strategically, profoundly, madly letting go” (p. 19).

This process of creating *On the Evolution of the Heavenly Spheres* has taught me the importance of non-attachment, the value of recognizing the limits of my own knowledge, and the liberating potential of strategically, profoundly, and madly letting go of the quest for unambiguous answers. So it seems paradoxical to conclude with any definitive assertions about the outcomes of this research project. But this is precisely the point. Since this inquiry was instigated by my encounter with the kōan-like riddle of the *heavenly sphere*, I have come to appreciate intimately the value of paradoxes for teaching the humbling lessons of learned ignorance. Paradoxes help us transcend the conceptual mind by cultivating awareness of the limitations of trying to reduce the entangled, intra-acting complexity of the world to theories and words alone. Like a good kōan, attempting to understand this perennial cosmic conundrum led me to an encounter with the source and limits of my own discursive thought.

My effort to trace the ancient lineage of the *heavenly sphere* also took me on a personal cosmic journey—from the macrocosm of the heavens to the microcosm of human cognition. I traversed many fields of study to find that the spherical gestalt of the human visual field (1.03 Spherical Container) shapes the pre-theoretical archaic

stratum of phenomenological experience (1.01 Archaic Stratum). This visuo-morphology structures universal principles operating within individual cognition. As a result, archetypal spherical architecture continuously emerges from the ever-present origin of our shared ground of being and becoming. It embodies the paradoxes of self-consciousness, elusively yet conspicuously symbolizing the inherent tensions between the ‘centricity’ and eccentricity’ of human experience.

The persistent recurrence of spherical tropes serve as a profound reminder of the commonalities shared by human beings across time and cultures—as well our inextricable interconnections with the more-than-human lifeworld. We attempt to orient ourselves within a meaningful cosmos by materially engaging with culturally constructed ‘domesticating’ techniques. For the vast majority of our species’ history, however, the success of these cosmographic practices was contingent on their ability to help us synchronize with the celestial and terrestrial cycles of life. When Aristotle’s physics were overturned during the ‘scientific revolution,’ however, the *heavenly sphere* came to symbolize the naïve ignorance of credulous cosmologies. ‘Poetic faith’ in the ideal ‘Archimedean point replaced attunement to our intuitive senses. While this ‘objective’ view resulted in unprecedented capabilities to scientifically study and technologically manipulate the material world, it also produced ever-increasing estrangement and distantiation by fragmenting knowledge and prioritizing theoretical abstractions over our Earthly intuitions.

It is appropriate, then, that the latest attempt to push the Cartesian dream of the ‘Archimedean point’ to its cosmographic extreme has come full circle. Like the perspective of Archimedes as he moves the Earth (Figure 28), the metacognitive view of the *Digital Universe Atlas* confronts us with the centrality our Earthly being and

the significance of our individual and collective agency. Cosmographic practices should not distance us from the lifeworld with dreams of escape, but bring us into a more intimate relationship with it by illuminating the complexity of our entanglements. I have developed *cosmographic hermeneutics* as a practical strategy for examining this complex unity. I re-imagined the trope of the ‘cosmic journey’ to interpret cosmic models as diffraction patterns co-arising from complex intra-actions—not just objectified phenomena existing independently of lived experience.

This thesis has documented a practical strategy for empirically demonstrating the philosophical implications of shifting from single-point ‘linear perspective’ to the six-point ‘spherical’ perspective. By visualizing and interpreting *cognitive cosmographic models* (2.03 Cognitive Cosmographic Models) to create an immersive, postphenomenological ‘third space’ (6.08 Learning to See, 6.09 Creating a Third Space), I have explicated omnidirectional interconnections between cognition and cosmos (1.03 Spherical Container). I have created the *world views* heuristics (6.12 Cosmographic Hermeneutics, 6.14 World Views) to clarify the meaning of a shift from dualistic, *linear thinking* to complex, multi-perspectival, and paradoxical *spherical thinking* (6.03 Transcending Dualities, 6.04 Thinking the Complex, 6.05 Re-Imagining the World, 6.06 Enacting Cognition, 6.15 Spherical Thinking). By interpreting *heavenly spheres* through the noological lenses of *world views* while *cosmotroping* (7.01 Cosmotroping), I have demonstrated a practical, enactive approach for transforming ‘science literacy’ into ‘agential literacy’ (7.04 Worldviews Network). Through this exploration of the integrative potential of *learning to see* the ‘world’ from multiple ‘views,’ I have concluded that cultivating compassion for different perspectives may be the most secure, firm, and abiding foundation of all.

Epilogue

This study has detailed the findings of a transdisciplinary, mixed methods investigation into the origins and consequences of efforts to visualize the *heavenly sphere*. This thesis' contribution to new knowledge is the development of an enactive approach to cosmography that elucidates and integrates historical, theoretical, and practical considerations. The paradoxically elusive yet conspicuous *heavenly sphere* has provided a metaphorical and material optic through which I have examined the origins and consequences of cosmographic practices across time. To understand the complex knowledge production processes from which spherical tropes have emerged, I have outlined the process of *cosmographic hermeneutics* (6.12 Cosmographic Hermeneutics) to interpret cosmographic imagery through transdisciplinary *world views* (6.14 World Views). The practical applications of these techniques have been demonstrated in a reflexive account of my performative practice of *cosmotroping* (7.01 Cosmotroping), during which I interactively navigate and narrate visualizations of historic and contemporary cosmographic models within immersive vision theaters to cultivate *spherical thinking* (6.15 Spherical Thinking).

Examinations of the different intonations given the *heavenly sphere* have illuminated perennial cosmic conundrums emerging from the human desire to make sense of the overarching context of creation. Spherical symbolism within caves, burial tombs, temples, sphairopoia, armillary spheres, orreries, planetaria, immersive vision theaters, mandalas, and cosmological metaphors have shaped and been shaped by the perceived curvature of the firmament. These models emerged from complex 'domesticating' impulses and practices, functionally and existentially facilitating

orientation to social, spiritual, and ecological lifeworlds across generations (2.03 Cognitive Cosmographic Models). In so doing, they profoundly influenced conceptions of totalizing notions—like *god*, *cosmos*, *world*, and *nature*—used to model the diverse ways in which cultures have imagined, signified, and enacted their worlds. By structuring beliefs about the meaning and purpose of existence, interpretations of the *heavenly sphere* have guided the trajectories of civilization across time.

I have demonstrated the persistence—and significance—of the *heavenly sphere* by considering *cognitive cosmographic models* from transhistorical, transcultural, and transdisciplinary perspectives (2.01 Excavating Deep History). Its archetypal architecture emerges from complex intra-actions between numerous factors and influences, defying reduction to overly simple explanations. Nevertheless, I attributed the intuitive appeal and persistent appearance of the spherical form within notions of a cosmic order primarily to the common morphology of human vision that shape pre-linguistic bodily experiences. These gave rise to universal principles within individual and collective cognition that contributed to the logic of being ‘inside’ and ‘outside’ of a container (1.03 Spherical Container). The perennial association of the sphere with cosmographic practices and environments emerges from the spherical perspective of human vision and the existential need to make sense of celestial and terrestrial cycles (2.07 Circumpolar Rotations).

I asserted that the spherical visual field has long shaped perceptions of the celestial vault (3.03 Container of the Sky), giving rise to the embodied logic of cosmographic narratives, practices, artifacts, and environments (2.12 Embodying the Macrocosm). The paradox of self-consciousness—of being able to imagine the

‘endosphere and ‘exosphere’—experientially structured understanding of the pre-theoretical realm from which concepts of ‘mind’ and ‘world’ emerged (1.01 Archaic Stratum, 1.02 Cosmological Metaphorics, 6.13 Inciting Sight). I described the enactive significance of image-making processes through material engagement, showing how visuospatial *tools for thinking* guided efforts to make sense of an existential order (2.05 Tools for Thinking). Additionally, a review of the cultural contexts of these *cognitive cosmographic models* identified the persistent recurrence of spherical tropes within foundational elements of philosophy, religion, and science (Chapter 2: Domesticating the Universe, Chapter 3: Globalizing the World).

I gave particular focus to how *cognitive cosmographic models* enact visions of ‘flight’ through the heavens—from the bird’s eye view of the shaman to the Apollonian view of the astronaut. I recounted how this archetypal journey of transcendence has been pursued and epitomized by bird-men, psychopomps, philosophers, saviors, emperors, priests, scientists, and artists alike (2.08 Visions of Flight). This thesis examined the complex roles of cosmographic artifacts and immersive visualization environments in facilitating these cosmic journeys, identifying their integral function as structurally-coupled tools for thinking *through* things and images—not just *about* them. I asserted that cosmographic practices have long helped to enact and sustain complex ‘cosmovisions’ (2.03 Cognitive Cosmographic Models, 2.04 Complexity of the Caves).

Plato’s *Timaeus* broke with this tradition, distancing the intellect from the world by describing a living, spherical *kosmos* from the cosmically ‘eccentric’ perspective of the demiurge (3.01 Mental-Rational Worldview, 3.02 Cosmopoiesis, 3.03 Container of the Sky). The allegorical ‘cave’ from Plato’s *Republic* came to

symbolize the corruptible, deceptive, and imperfect terrestrial world of Becoming, while celestial knowledge became associated with the ideal ‘Archimedean point’ from the eternal, unchanging world of Being (3.04 Ambivalence of World Consciousness).

In his attempts to ‘save the appearances’ of celestial perfection, Plato’s student Aristotle developed a physical explanation of the *kosmos* predicated on the ontological bifurcations of the heavens and Earth (3.05 Saving the Appearances). When the medieval Church later appropriated his speculations as dogma, Christian scholastics influenced by the rediscovery of ancient Hermetic beliefs challenged his geocentric physics (3.06 Hypercosmic Sun, 3.10 Shifting Perspectives).

Nicholas of Cusa’s transference of the pseudo-Hermetic ‘infinite sphere’ from theology to cosmology helped to topple the dominant spherical, geocentric cosmic model by laying the metaphorical foundations for visions of a relativistic, infinite universe (3.11 Infinite Sphere, 3.12 Learning Ignorance). This paved the way for a series of developments commonly associated with the ‘scientific revolution’ (3.10 Shifting Perspectives), including Copernicus’ pursuit of heavenly perfection (3.09 Most Perfect Form), Kepler’s transition from orbs to orbits, and Galileo’s telescopically-assisted insights.

The resultant ‘paradigm shift’ named in Copernicus’ honor continues to be widely credited with ‘demoting’ Earth and humanity (3.14 Promoting Demotion). However, Copernicus and others asserted that heliocentrism elevated Earth to the status of a moving planet, away from the dregs of the cosmos (3.08 Visible God). As the *heavenly spheres* dissolved in the European imagination, it was heaven—not Earth—that was dethroned (3.13 Mythologizing Revolutions). Though Aristotle’s

physics were overturned, Descartes, Kant, and others philosophically fortified the dualistic logic of his metaphysics (5.13 Cartesian Anxiety). The sense of separation was cognitively enacted by visualization technologies that appeared to empirically confirm the ontological division of subject from object and mind from body (3.16 Entraining Objectivity). Additionally, planetary machines' seemingly accurate portrayal of celestial movements rhetorically reinforced theories about the predictable, clockwork-like nature of the universe (3.17 Cosmographic Dreaming). At the same time, the revelation of the illusory nature of the *heavenly spheres* seeded mistrust of intuitive perception and the unaided senses. An uncanny sense of homelessness in what appeared to be a vast, homogenous universe took hold (3.15 Quantifying the Uncanny). The resulting existential angst was mitigated by a growing 'poetic faith' in the theoretical possibility of achieving a scientifically objective 'Archimedean point' on the world (4.10 Poetic Faith).

By the early twentieth century, this faith was challenged when quantum scale observations blurred rigid distinctions between observers and their observations. Similar ambiguities emerged through efforts to impress the public with technical and scientific achievements (3.19 Blurring the Boundaries, 4.01 Bifurcations and Projections). The invention of opto-mechanical projection technologies and efficient dome structures produced a new generation of celestial simulators, but their immersive efficacy relied on a return to a geocentric perspective (4.02 Opto-Mechanical Universe). The integration of film projectors in dome theaters revived the ancient trope of the 'cosmic journey,' with the promise of Apollonian and Copernican transcendence beyond the firmament becoming a mainstay of dome-based cinema (4.03 Transcending the Firmament). The US government seized the opportunity to

promote new visions of ‘flights’ through the heavens (4.04 Race to Space). At the same time, artists, engineers, and educators began experimenting with the possibilities of perceptual immersion for exploring the vast reaches of inner space (4.05 Pedagogical Yearnings, 4.06 Perturbing the Gestalt).

By the turn of the twenty-first century, dome-based immersive vision theaters had embraced the rhetorical power of scientific visualizations (4.07 Digitizing the Cosmos). The Hayden Planetarium’s *Digital Universe Atlas* was promoted and praised as finally achieving a scientifically accurate Copernican perspective on the *real* three-dimensional Universe (4.09 Making Sense of the Real Sky, 4.10 Poetic Faith). As the *Atlas* became the de facto cosmic model in digital planetariums around the world, advancements in 3D computer graphics increasingly afforded the ability to navigate interactively through its curated collection of astronomical surveys (4.08 Expanding Virtual Horizons).

These interactive capabilities, however, complicated the narrative of the Copernican revolution. Viewing the *Atlas* in its totality revealed a paradox at the heart of the quest to push a scientific ‘god’s eye view’ to its cosmographic extremes. A geocentric cosmic model had returned, surrounded by a spherical survey of the cosmic microwave background (5.01 Observational Center). It wasn’t until fifteen years after the *Atlas*’ creation that *Dark Universe* became the first Hayden production to acknowledge the spherical, geocentric configuration of the new cosmic model (5.05 Age of Endarkenment). The Hayden’s producers attempt to sustain the illusion of a virtual ‘Archimedean point’ by artistically and ambiguously fusing empirical and theoretical scientific visualizations (5.06 Viewing from Nowhere). While *Dark Universe* begins to address paradoxes of relativity and mysterious aspects of modern

‘concordance’ cosmology (5.07 Sphere of Cognition), it also continues to mythologize the ideal of pure objectivity (5.08 Myth-Conceptions).

While earlier Hayden production concealed the *Atlas*’ configuration, others embraced the potential of a spherical, geocentric ‘new universe’ to mythologize the ‘big bang’ as the first true cosmogony (5.09 Viewing from the Center). But unlike many of its predecessors, this modern origin story was predicated on a cosmic theory admittedly composed of over 95% speculation (5.10 Cosmogonic Cycling). Though others have attempted to shift focus to different areas of cosmological concern (5.11 Pluralistic Worldviews), efforts to demonstrate the veracity of the Lambda-CDM model continue to dominate cosmological research and communication (5.12 World Picture).

Behind the scenes, the return of the *heavenly sphere* also enacted significant disagreements among the *Atlas*’ creators concerning how it should be interpreted and presented (5.02 Cosmic Tensions). These debates exposed significant disparities concerning the presumed distance of humanity’s cosmic horizon as well as fundamental philosophical assumptions regarding the nature of the *real* universe (5.04 Return of the Spheres). Examination of these disagreements exposed the ongoing tacit influence of Aristotelian metaphysics, Cartesian dualism, and Coleridge’s ‘poetic faith’ among Hayden Planetarium producers (5.13 Cartesian Anxiety). The complex implications of special relativity, process philosophy, and the sociology of scientific knowledge (5.03 Relativistic Effects, 5.14 Objectifying Processes) are often occluded in favor of a ‘satisfying story’ that convincingly demonstrates the ‘Archimedean Point’ (5.12 World Picture) within popular interpretations of the *Atlas*. Stemming from attempts to assuage ‘Cartesian anxiety’

(5.13 Cartesian Anxiety), these narratives are often predicated on the progressive narrative of Earth's and humanity's 'dethroning' of the 'Copernican revolution' (5.18 Marketing Mediocrity). Yet the process of visualizing astronomical observations in a virtual 3D world has created a 'double bind' of cosmic proportions, with some of the consequences bearing an uncanny—though often superficial—resemblance to ancient geocentric cosmic models and cosmographic practices (5.15 Revisiting the Caves).

The significance of these ironic developments, however, has been largely ignored, overshadowed by dreams of Apollonian 'flights' through the heavens (5.16 Inverting Heaven). These latest transcendent visions have physically and metaphysically taken off since the dawn of the 'space age.' Efforts funded by the US government and military contractors have increasingly blurred the boundaries between science education and science fiction (4.04 Race to Space, 4.07 Digitizing the Cosmos). The unintended consequences of these efforts have included increased awareness of the complexity and interconnectedness of challenges facing the 'whole Earth' (5.16 Inverting Heaven). The commercialization of 'space tourism,' however, is currently threatening to destabilize the 'safe operating space for humanity'—purportedly for the sake spiritual transcendence, ecological awareness, and shifting paradigms (5.17 Externalizing Epiphanies).

My own paradoxical position in the world of science education afforded me a unique opportunity to explore these issues from transdisciplinary perspectives (6.01 Looking In from the Outside). Beyond a 'satisfying story,' I attempted to identify the origins of paradigmatic assumptions contributing to the 'wicked problems' facing humanity. In my review of the diverse ways in which cosmological theories influence perspectives on the world (6.02 Starting with Universe), I found consistent references

to the dangers posed by the uncritical acceptance and tacit influence of Aristotelian logic (6.03 Transcending Dualities). These authors convincingly argue for a ‘middle way’ beyond rigid dualisms, calling for transdisciplinary, mixed methods, and pluralistic approaches to address the multi-dimensional complexity of the world (6.04 Thinking the Complex).

To find alternatives to dualistic logic and linear thinking, I reviewed theories from quantum physics, cognitive science, and Buddhist philosophy that elucidate nondual logic models and the ‘intra-acting’ nature of causality (6.05 Re-Imagining the World)—particularly the structural coupling of ‘mind’ and ‘world’ through ‘material engagement’ (2.05 Tools for Thinking, 6.06 Enacting Cognition). By considering the performative histories of biological, social, cultural, and technological practices and beliefs, these proposals emphasize the primacy of embodied experience over theoretical abstractions (6.07 Returning to the Senses).

I also identified ways in which these ideas can be applied using postphenomenological ‘space age’ visualization tools (6.08 Learning to See). I identified numerous proposals addressing the potential of virtually augmenting sensory perception. These not only provide new perspectives on previously invisible phenomena, but also assist in transcending contentious disciplinary divides through the re-integration of knowledge (6.09 Creating a Third Space).

The most significant challenge of this research involved the practical integration and demonstration of these ideas. Instead of simply critiquing linear thinking—predicated on tacit beliefs in the ‘Archimedean point,’ dualistic logic, and linear causality (6.10 Suspending Belief)—I needed to create a practical strategy to guide my *cosmotroping* practice. Discovering that cosmographic atlases have long

been used to establish, reinforce, and examine epistemic virtues (6.11 Fabricating Meditations), I developed techniques for interpreting the *Digital Universe Atlas* from multiple perspectives (6.12 Cosmographic Hermeneutics). Recognizing the potency of visuospatial cognition and diagrammatic reasoning (6.13 Inciting Sight), I constructed a system of visual heuristics illustrating transdisciplinary *world views* (6.14 World Views). These function as *tools for thinking* to enactively cultivate metacognitive abilities to shift between perspectives, appreciate paradox, and grapple with complexity—what I and others have referred to as *spherical thinking* (6.15 Spherical Thinking).

I then provided a reflexive account of how I apply these heuristics within my *cosmotroping* practice. This documented how I have re-imagined the trope of the ‘cosmic journey’ by examining the consequences of attempts to visualize a universal order (7.01 Cosmotroping). In the process of iterating this practice with diverse audiences (7.04 Worldviews Network), my understanding about the nature, purpose, and potential of cosmographic practices has been transformed. I have realized that acknowledging the ‘centric’ and ‘eccentric’ features and inherent self-referentiality of *Digital Universe Atlas* can help facilitate contemporary discourses about perennial cosmic conundrums (7.02 Cubing the Sphere). But even more importantly, I have found that illuminating these paradoxes can draw attention to the most significant—though largely unanticipated—findings of the ‘space age’: Earth is not only humanity’s relativistic center, it is also the *ecological center* of life in our universe (7.03 Neo-Geocentrism).



Figure 141. *Sankofa* bird from the Ashanti region of Ghana (Unknown, 1981).
Courtesy of the Seattle Art Museum. Photograph by Paul Macapia. Gift of Katherine
White and the Boeing Company.

From this perspective, I conclude in the way I began—though I have changed.

As I knocked on the sky and listened to the sound,
I discovered that the greatest lessons for our future
can be found by studying our ever-present past.

The bird's transcendent flight to the heavens always lands back on Earth.

“That bird is wise.

Look. Its beak, back turned, picks

For the present, what is best from ancient eyes,

Then steps forward, on ahead

to meet the future, undeterred.”

(Kayper-Mensah, 1976, p. 4)

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Appendix I: Creative and Performing Work

Publications

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- McConville, D. (2013d, August 25). *Cosmotroping: Visualizing Worldviews*. Presented at the California Institute of Integral Studies' Transformative Studies Intensive, Pacifica, California.
- McConville, D., & Gardiner, N. (2009a, May 9). *Water: A Transcalar Perspective*. Presented at the Communicating Climate Change, Arizona Science Center, Phoenix, AZ.
- McConville, D., & Gardiner, N. (2009b, October 17). *Kosmos, Oikos, and New Echoes*. Presented at the EcoFocus Film Festival, Athens, Georgia.
- McConville, D., & Gardiner, N. (2012, January 16). *#OCCUPY UNIVERSE*. Presented at Beloved Community: In Celebration of Martin Luther King, Jr., Warren Wilson College.
- McConville, D., Gardiner, N., & Hamilton, H. (2009, December 15). *Visualizing World Views: Shifting Perspectives on Global Change*. Presented at the COP 15 KlimaForum, Copenhagen, Denmark.
- McConville, D., & Lien, C. (2010, October 14). *Perceiving Home: An Ecological View of the Cosmos*. Presented at the Bioneers Conference, California Academy of Sciences Morrison Planetarium.

McConville, D., Lien, C., & Bagby, R. (2009, October 3). *Perceiving Home: An Ecological View of the Cosmos*. Presented at the West Coast Green After-Party, California Academy of Sciences Morrison Planetarium.

Select Invited Lectures

- Combs, A., & McConville, D. (2013, February). *The cosmological perspective: Metaphor, symbol, immersion, and action*. Lecture presented at the Consciencia de la Ciencia a la Espiritualidad, Puebla, Mexico.
- McConville, D. (2006b, December 2). *The Evolution of Domes: The Manifestation of Meaning from Celestial Screen to Virtual Environments*. Lecture presented at the F.A.q. <Questions about Art, Consciousness, Technology>, SESC, Sao Paulo, Brazil.
- McConville, D. (2007a, April 20). *Cosmological cinema: Pedagogy, propaganda, and perturbation in early dome theaters*. Lecture presented at the First International Planetary Collegium Summit, Université du Québec à Montréal, Montreal, Quebec.
- McConville, D. (2007b, August 8). *Absorbing the Big Picture: Immersion and Interactivity in Science Education*. Lecture presented at the NASA Education and Outreach Colloquium, NASA Goddard Space Flight Center, Silver Spring, MD. Retrieved from <http://esdepo.gsfc.nasa.gov/calendar/view.php?id=121&year=2007&month=08&day=08>
- McConville, D. (2007c, August 23). *Cosmological cinema: Pedagogy, propaganda, and perturbation in early dome theaters*. Lecture, Black Mountain College Museum + Arts Center, Asheville, NC.
- McConville, D. (2007d, October 22). *Cosmological cinema: Pedagogy, propaganda, and perturbation in early dome theaters*. Lecture presented at the Studio in Space and Time, Cornell University.

- McConville, D. (2007e, November 15). *Cosmological cinema: Metaphor, symbolism, and immersion*. Poster presented at the re:place 2007: on the histories of media, art, science, and technology, Berlin, Germany. Retrieved from <http://www.mediaarthistory.org/replace/>
- McConville, D. (2008a, March 26). *Why Dome?: Cosmos / Perception / Cognition*. Keynote lecture presented at the Workshop in Immersive Cinema, University of Plymouth, Plymouth, England.
- McConville, D. (2008b, April 4). *Shifting Perspectives: Explorations in the Process of Unframing*. Lecture presented at the ITP Live, Interactive Telecommunications Program, New York University, New York, NY. Retrieved from <http://itp.nyu.edu/itplive/archive.php?movieID=582>
- McConville, D. (2008c, April 20). *The Trickster and Transdisciplinarity*. Lecture presented at the Homo Ludens Ludens International Symposium, LABoral Centro de Arte y Creación Industrial, Gijón, Spain. Retrieved from <http://www.laboralcentrodearte.org/seminarios/proximos/3>
- McConville, D. (2008d, July 3). *Being (t)here: A syncretic approach to understanding presence*. Lecture presented at the The Planetary Collegium's IXth International Research Conference: Consciousness Reframed - New Realities: Being Syncretic. A transdisciplinary inquiry into art, science, technology and society, University of Applied Arts, Vienna, Austria.
- McConville, D. (2009a, April 24). *The Secret Guide to the Observable Cosmos*. Lecture presented at the Beyond Darwin: the co-evolutionary path of art, technology and consciousness, Sala Parpalló, Valencia, Spain. Retrieved from http://www.salaparpallo.com/en__ficha_nmmm.html?cnt_id=1712

- McConville, D. (2009b, May 3). *Visualizing Transcalar Worldviews: Connecting regional, global, and cosmic phenomena*. Lecture presented at the Visualizing Climate Change international workshop, Centre for Climate Science and Policy Research, Norrköping, Sweden. Retrieved from <http://www.cspr.se/vcc/network?l=en>
- McConville, D. (2009, July 17). *The Secret Guide to the Observable Cosmos*. Lecture presented at the Planetary Collegium Composite Session, Public Presentations, University of Plymouth, Plymouth, England.
- McConville, D. (2009d, September 24). *Visualizing world views: Explorations at the boundaries of perception*. Lecture, Black Mountain College Museum + Arts Center, Asheville, NC. Retrieved from <http://blackmountaincollege.org/content/view/123/60/>
- McConville, D. (2009e, November 20). *Worldmaking: Recentering on Earth*. Lecture presented at the Planetary Collegium's Xth International Research Conference: Consciousness Reframed – Experiencing design - Behaving media, Macromedia Hochschule für Medien und Kommunikation, Munich, Germany.
- McConville, D. (2009f, December 1). *Contextualizing Research: Beyond Disciplines and Across Scales*. Keynote lecture presented at the Fall Symposium on Undergraduate Research and Creativity, UNCA, Asheville, NC.
- McConville, D. (2010a, February 4). *Worldmaking: Recentering on Earth*. Lecture, Whidbey Institute, Whidbey Island, Washington.
- McConville, D. (2010c, June 17). *Beyond Disciplines: Liberal Arts as Transdisciplinary Research*. Lecture presented at the Council of Public

Liberal Arts College's Summer Faculty Institute on Liberal Learning in the Disciplines, University of North Carolina at Asheville. Retrieved from <http://www.coplac.org/>

McConville, D. (2010d, October 14). *Starting with Universe*. Workshop presented at the Architecting the Future: A World Design Science Decade 2010-2020 - Bioneers Conference 2010, San Rafael, California. Retrieved from <http://www.bioneers.org>

McConville, D. (2011a, February 9). *Visualizing Worldviews: Re-Imagining the Big Picture*. Lecture presented at the NISENet Anticipatory Governance Workshop, Arizona State University. Retrieved from <http://cns.asu.edu/>

McConville, D. (2011b, February 23). *Mnemonic Cosmos: An inquiry into cosmographic affordances*. Lecture presented at the Transtech Research Seminar: Reinstating the Visual: Aby Warburg's Mnemosyne Atlas, University of Plymouth, Plymouth, England. Retrieved from <http://transtechresearch.net/research/seminars>

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McConville, D. (2011d, March 29). *Re-imagining the Big Picture: Contextualizing the Ecologies of Immersive Environments*. Presentation presented at the Immersive Environments course, School of the Art Institute of Chicago.

- McConville, D. (2011e, April 9). *The Cosmotrope*. Immersive Interactive Presentation presented at the Re-Happening: Black Mountain College Museum + Arts Center & The Media Arts Project, Camp Rockmont, Black Mountain, NC. Retrieved from <http://rehappening.com>
- McConville, D. (2011f, June 11). *Starting with Universe*. Workshop presented at the Architecting the Future: Buckminster Fuller Challenge Conferring Ceremony, City University of New York, New York, NY. Retrieved from <http://bfi.org/news-events/architecting-future-june-8-10-new-york-city>
- McConville, D. (2011g, June 25). *Why the Universe Matters*. Lecture presented at the TEDx Education, The Wharton School of the University of Pennsylvania, Philadelphia, PA.
- McConville, D. (2011h, July 14). *Metagaming with SciVis*. Lecture presented at the Gordon Research Conference on Visualization in Science & Education: Transformation by Visualization: Radical Effects on Learning in Science and Across Education, Bryant University, Smithfield, RI. Retrieved from <http://www.grc.org/programs.aspx?year=2011&program=visualiz>
- McConville, D. (2011i, August 2). *World Game 2.0 Intro*. Lecture presented at the World Game 2.0 Workshop, Ogilvy Entertainment, New York, NY.
- McConville, D. (2011j, August 15). *Starting with Universe: Buckminster Fuller's Design Science Imperative*. Lecture presented at the 2011 NEH Landmarks Workshops - Black Mountain College: An Artistic and Educational Legacy, University of North Carolina at Asheville, Asheville, NC. Retrieved from <http://www.blackmountaincollege.org>

- McConville, D. (2011k, October 22). *Visualizing Cosmic Models: A Situated Approach*. Lecture presented at the Science & Nonduality, San Rafael, CA. Retrieved from <http://www.scienceandnonduality.com>
- McConville, D. (2012a, January 27). *Buckminster Fuller and Beyond: Starting with Universe*. Presentation presented at the Summit Basecamp, Resort at Squaw Creek, Lake Tahoe, NV. Retrieved from <http://www.summitseries.com>
- McConville, D. (2012b, April 20). *The Buckminster Fuller Challenge*. Lecture presented at the SwitchPoint, Haw River Ballroom, Saxapahaw, NC. Retrieved from <http://www.switchpointideas.com>
- McConville, D. (2012c, May 8). *Re-Imagining the Big Picture*. Keynote lecture presented at the Social Capital Markets' Designing the Future, Malmö University, Malmö, Sweden. Retrieved from <http://youtu.be/ykx4jzhjKOM>
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- McConville, D. (2013a, March 22). *Cosmomimicry: Why the Universe Matters*. Invited Talk presented at the CompostModern, San Francisco, CA. Retrieved from <http://compostmodern.org>
- McConville, D. (2013, April 26). *Domesticating the Universe*. Invited Talk presented at the Weltinnenraum. Das Planetarium als Medium kosmologischer Reflexion, Technical University of Berlin, Berlin, Germany. Retrieved from <http://www.tu-berlin.de/index.php?id=131759>
- McConville, D., Brooks, S., & Apablaza, M. (2012, May 10). *Designing for Resilience*. Workshop presented at the Social Capital Markets' Designing the

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Appendix II: Metaphors of the Sphere

Since, then, it has a furthest limit, it is complete on every side, like the mass of a rounded sphere, equally poised from the center in every direction; for it cannot be greater or smaller in one place than in another. For there is no nothing that could keep it from reaching out equally, nor can anything that is be more here and less there than what is, since it is all inviolable. For the point from which it is equal in every direction tends equally to the limits.

- Parmenides [early fifth century BCE] (1948/1983, frag. 8)

For two branches do not spring from his back, he has no feet, no swift knees, no organs of reproduction, but he is equal to himself in every direction, without any beginning or end, a rounded sphere, rejoicing in encircling stillness.

- Empedocles [c.490–430 BCE] (as cited in Garani, 2007)

And for shape he gave it that which is fitting and akin to its nature. For the living creature that was to embrace all living creatures within itself, the fitting shape would be the figure that comprehends in itself all the figures there are; accordingly, he turned its shape rounded and spherical, equidistant every way from centre to extremity—a figure the most perfect and uniform of all; for he judged uniformity to be immeasurably better than its opposite.

- *Timaeus* by Plato [c.424-c.348 BCE] (Plato, trans. 1935/1997, sec. 33b)

Deus est sphaera intelligibilis, cui us centrum ubique, circumferentia
nusquam. (God is an intelligible sphere, whose center is everywhere and
whose circumference nowhere.)

- Alan of Lille [c.1116– c.1203] quoting Hermes Trismegistus, also found in
Bonaventure, Alexander of Hales, and Thomas Aquinas, and others (Brient,
1999, p. 579)

I am the centre of a circle, to the which all parts of the circumference bear an
equal relation; but with thee it is not thus.

- *La Vita Nuova* by Dante Alighieri (1295, as cited in Otterspeer, 2010, p.
207)

With his whole being God is present whole and entire as much in the least thing as in the greatest. Thus the just person who loves God in all things would seek in vain for something more or greater when he has some little thing in which the God whom he loves alone to the exclusion of everything else is totally present. There is no 'greater' or 'less' in God nor in the One; they are below and outside God and the One. And thus someone who sees, seeks, and loves what is more or less is not as such divine. This is the meaning of the axiom in the *Book of Twenty-Four Philosophers*: 'God is the infinite intellectual sphere with as many circumferences as centers and whose center is everywhere and circumference nowhere. He is entire in his least part.

- "Commentary on Exodus" by Meister Eckhart (early 14th century / trans. 1986, p. 75)

Therefore, if with regard to what has now been said you want truly to understand something about the motion of the universe, you must merge the center and the poles, aiding yourself as best you can by your imagination. For example, if someone were on the earth but beneath the north pole [of the heavens] and someone else were at the north pole [of the heavens], then just as to the one on the earth it would appear that the pole is at the zenith, so to the one at the pole it would appear that the center is at the zenith. And just as antipodes have the sky above, as do we, so to those [persons] who are at either pole [of the heavens] the earth would appear to be at the zenith. And at whichever [of these] anyone would be, he would believe himself to be at the center. Therefore, merge these different imaginative pictures so that the center is the zenith and vice versa/ Thereupon you will see—through the intellect, to which only learned ignorance is of help—that the world and its motion and shape cannot be apprehended. For [the world] will appear as a wheel in a wheel and a sphere in a sphere—having its center and circumference nowhere, as was stated.

- *De docta ignorantia* by Nicolas Cusanus (1440/1981, p. 92)

The ancients did not attain unto the points already made, for they lacked learned ignorance. It has already become evident to us that the earth is indeed moved, even though we do not perceive this to be the case. For we apprehend motion only through a certain comparison with something fixed. For example, if someone did not know that a body of water was flowing and did not see the shore while he was on a ship in the middle of the water, how would he recognize that the ship was being moved? And because of the fact that it would always seem to each person (whether he were on the earth, on the sun, or on another star) that he was at the “immovable” center, so to speak, and that all other things were moved: assuredly, it would always be the case that if he were on the sun, he would fix a set of poles in relation to himself; if on the earth, another set; on the moon, another; on Mars, another; and so on. Hence, the world-machine will have its center everywhere and its circumference nowhere, so to speak; for God, who is everywhere and nowhere, is its circumference and center.

- *De docta ignorantia* by Nicolas Cusanus (1440/1981, pp. 92–93)

Even just so, when our Body is at Rest, that the Concoction is every-where accomplish'd, and that till it awake, it lacks for nothing, our Soul delighteth to disport it self, and is well pleased in that Frolick to take a Review of its Native Country, which is the Heavens, where it receiveth a most notable Participation of its first Beginning, with an Imbuement from its Divine Source, and in Contemplation of that Infinite and Intellectual Sphere, whereof the Centre is every-where, and the Circumference in no place of the universal World, to wit, God, according to the Doctrine of Hermes Trismegistus, to whom no new thing hap'neth, whom nothing that is past escapeth, and unto whom all things are alike present, remarketh not only what is preterit, and gone in the inferiour Course and Agitation of sublunary Matters, but withal taketh notice what is to come; then bringing a Relation of those future Events unto the Body by the outward Senses and exterior Organs, it is divulged abroad unto the hearing of others. Whereupon the Owner of that Soul deserveth to be termed a Vaticinator, or Prophet.

- *The Third Book of Pantagrue* by François Rabelais (1546/1900, pp. 70–71)

To a body of infinite size there can be ascribed neither center nor boundary. For he who speaketh of emptiness, the void or the infinite ether, ascribeth to it neither weight nor lightness, nor motion, nor upper, nor lower, nor intermediate regions; assuming moreover that there are in this space those countless bodies such as our earth and other earths, our sun and other suns, which all revolve within this infinite space, through finite and determined spaces or around their own centres. Thus we on the earth say that the earth is in the centre; and all the philosophers ancient and modern of whatever sect will proclaim without prejudice to their own principles that here is indeed the centre.

- *De l'infinito universo e mondi* by Giordano Bruno (1584, as cited in Koyré, 1968, p. 41)

Just as we say that we are at the centre of that [universally] equidistant circle, which is the great horizon and the limit of our own encircling ethereal region, so doubtlessly the inhabitants of the moon believe themselves at the centre [of a great horizon] that embraces the earth, the sun and the other stars, and is the boundary of the radii of their own horizon. Thus the earth no more than any other world is at the centre; moreover, no points constitute determined celestial poles for our earth, just as she herself is not a definite and determined pole to any other point of the ether, or of the world-space; and the same is true of all other bodies. From various points of view these may all be regarded either as centres, or as points on the circumference, as poles, or zeniths and so forth. Thus the earth is not in the centre of the Universe; it is central only to our surrounding space.

- *De l'infinito universo e mondi* by Giordano Bruno (1584, quoted in Koyré, 1968, pp. 41–42)

Let man then contemplate the whole of nature in her full and grand majesty, and turn his vision from the low objects which surround him. Let him gaze on that brilliant light, set like an eternal lamp to illumine the universe; let the earth appear to him a point in comparison with the vast circle described by the sun; and let him wonder at the fact that this vast circle is itself but a very fine point in comparison with that described by the stars in their revolution round the firmament. But if our view be arrested there, let our imagination pass beyond; it will sooner exhaust the power of conception than nature that of supplying material for conception. The whole visible world is only an imperceptible atom in the ample bosom of nature. No idea approaches it. We may enlarge our conceptions beyond all imaginable space; we only produce atoms in comparison with the reality of things. It is an infinite sphere, the centre of which is everywhere, the circumference nowhere. In short it is the greatest sensible mark of the almighty power of God, that imagination loses itself in that thought.

- *Thoughts*, by Blaise Pascal (1669/1910, p. 27)

Properly speaking, a mystery is an obviously absurd dogma which nevertheless conceals within itself a sublime truth. In itself, this truth is wholly unintelligible to the ordinary understanding of the crude and uncultured masses, who now accept it in this disguise on faith and trust, without allowing themselves to be led astray by the absurdity that is obvious even to them. In this way, they now participate in the kernel of the matter in so far as it is possible for them to do so. I may add by way of explanation that even in philosophy the attempt has been made to use a mystery, for example when Pascal, who was at the same time pietist, mathematician, and philosopher, says in this threefold capacity that God is everywhere center and nowhere periphery.

- *On Religion* by Arthur Schopenhauer (1851/1974, p. 334)

In like manner, in transcendental logic, infinite must be distinguished from affirmative judgments, although in general logic they are rightly enough classed under affirmative. General logic abstracts all content of the predicate (though it be negative), and only considers whether the said predicate be affirmed or denied of the subject. But transcendental logic considers also the worth or content of this logical affirmation — an affirmation by means of a merely negative predicate, and enquires how much the sum total of our cognition gains by this affirmation. For example, if I say of the soul, "It is not mortal," — by this negative judgment I should at least ward off error. Now, by the proposition, "The soul is not-mortal," I have, in respect of the logical form, really affirmed, inasmuch as I thereby place the soul in the unlimited sphere of immortal beings. Now, because, of the whole sphere of possible existences, the mortal occupies one part, and the immortal the other, neither more nor less is affirmed by the proposition, than that the soul is one among the infinite multitude of things which remain over, when I take away the whole mortal part. But by this proceeding we accomplish only this much, that the infinite sphere of all possible existences is in so far limited, that the mortal is excluded from it, and the soul is placed in the remaining part of the extent of this sphere. But this part remains, notwithstanding this exception, infinite, and more and more parts may be taken away from the whole sphere, without in the slightest degree thereby augmenting or affirmatively determining our conception of the soul. These judgments, therefore, infinite in respect of their logical extent, are, in respect of the content of their cognition, merely limitative; and are consequently entitled to a place in our transcendental table of all the momenta of thought in judgments, because the function of the understanding exercised by them may perhaps be of importance in the field of its pure a priori cognition.

- *Critique of Pure Reason* by Immanuel Kant (1781/2010, pp. 77–78)

Everything goes, everything comes back; eternally rolls the wheel of being.
Everything dies, everything blossoms again; eternally runs the year of being.
Everything breaks, everything is joined anew; eternally the same house of
being is built. Everything parts, everything greets every other thing again;
eternally the ring of being remains faithful to itself. In every Now, being
begins; round every Here rolls the sphere There. The center is everywhere.
Bent is the path of eternity.

- *Also Sprach Zarathustra, Part III* by Friedrich Nietzsche (1884/1977, p.
330)

In the order of Science, in which the Principle is above what it reflects, all is one grand concord. Change this statement, suppose Mind to be governed by matter or Soul in body, and you lose the keynote of being, and there is continual discord. Mind is perpetual motion. Its symbol is the sphere. The rotations and revolutions of the universe of Mind go on eternally.

- *Science and Health* by Mary Baker Eddy (1875, p. 85)

The “kingdom of God” is nothing that one expects; it has no yesterday and no day after tomorrow, it will not come in “a thousand years”—it is an experience of the heart; it is everywhere, it is nowhere.

- *The Antichrist* by Friedrich Nietzsche (1884/1977, p. 330)

The solitary ray dropping into the mother deep may be taken as meaning Divine Thought or Intelligence, impregnating chaos. This, however, occurs on the plane of metaphysical abstraction, or rather the plane whereon that which we call a metaphysical abstraction is a reality. The Virgin-egg being in one sense abstract Egg-ness, or the power of becoming developed through fecundation, is eternal and for ever the same. And just as the fecundation of an egg takes place before it is dropped; so the non-eternal periodical germ which becomes later-symbolism the mundane egg, contains in itself, when it emerges from the said symbol, "the promise and potency" of all the Universe. Though the idea per se is, of course, an abstraction, a symbolical mode of expression, it is a symbol truly, as it suggests the idea of infinity as an endless circle. It brings before the mind's eye the picture of Kosmos emerging from and in boundless space, a Universe as shoreless in magnitude if not as endless in its objective manifestation. The simile of an egg also expresses the fact taught in Occultism that the primordial form of everything manifested, from atom to globe, from man to angel, is spheroidal, the sphere having been with all nations the emblem of eternity and infinity — a serpent swallowing its tail. To realize the meaning, however, the sphere must be thought of as seen from its centre. The field of vision or of thought is like a sphere whose radii proceed from one's self in every direction, and extend out into space, opening up boundless vistas all around. It is the symbolical circle of Pascal and the Kabalists, "whose centre is everywhere and circumference nowhere," a conception which enters into the compound idea of this emblem.

- *The Secret Doctrine: Cosmogogenesis* by Madame Blavatsky (1888, pp. 64–65)

The eye is the first circle; the horizon which it forms is the second; and throughout nature this primary figure is repeated without end. It is the highest emblem in the cipher of the world. St. Augustine described the nature of God as a circle whose centre was everywhere, and its circumference nowhere. We are all our lifetime reading the copious sense of this first of forms. One moral we have already deduced in considering the circular or compensatory character of every human action. Another analogy we shall now trace; that every action admits of being outdone. Our life is an apprenticeship to the truth, that around every circle another can be drawn; that there is no end in nature, but every end is a beginning; that there is always another dawn risen on mid-noon, and under every deep a lower deep opens.

- "Circles" by Ralph Waldo Emerson (1888, p. 325)

You are a wheel whose substance alone exists, the diameter of the circle
without circumference creating a plane by its rotation around its median point.
The substance of your diameter is a Point.

- "Visions actuelles et future" by Alfred Jarry (1894, as cited in Parshall,
2002, p. 27)

I have seen a fog from hell...Oh ! I'm suffocating, oh ! how pretty it is . . . oh!
It holds together so well! O the center. And there, that's a molecule. The
center, it's marvellous. The center, oh! it's beautiful. Oh there! the center. O
the center of God. And its periphery. A periphery with only a center. There
are gardens. O how tiring to move. I feel a peripheraesthesia...Oh there.

- *Days and Nights* by Alfred Jarry (1897, as cited in Parshall, 2002, p. 29)

In the sphere I am everywhere the centre, as she, the circumference, is
nowhere found. Yet she shall be known & I never.

- *Book of the Law* by Aleister Crowley (1904)

Never in all their history have men been able truly to conceive of the world as one: a single sphere, a globe, having the qualities of a globe, a round earth in which all the directions eventually meet, in which there is no center because every point, or none, is center — an equal earth which all men occupy as equals. The airman's earth, if free men make it, will be truly round: a globe in practice, not in theory.

- “The Image of Victory” by Archibald MacLeish (1942)

Inasmuch as the kind of mathematics I had learned of in school required the use of the XYZ coordinate system and the necessity of placing π in calculating the spheres, I wondered, 'to how many decimal places does nature carry out π before she decides that the computation can't be concluded?' Next I wondered, 'to how many arbitrary decimal places does nature carry out the transcendental irrational before she decides to say it's a bad job and call it off?' If nature uses π she has to do what we call fudging of her design which means improvising, compromising. I thought sympathetically of nature's having to make all those myriad frustrated decisions each time she made a bubble. I didn't see how she managed to formulate the wake of every ship while managing the rest of the universe if she had to make all those decisions. So I said to myself, 'I don't think nature uses π . I think she has some other mathematical way of coordinating her undertakings.'

- *Conceptuality of Fundamental Structures* by R. Buckminster Fuller (1965, p. 71)

This new anticipatory science made large engineering projects possible, but it became known to, and then was employed by, only the world's richest schemers, monarchs, nations, and pirate enterprisers. No others could afford to buy great ships. With more powerfully engineered ships, humans emerged westward through Gibraltar to explore the Atlantic, to sail around Africa, to reach the Orient and the Pacific by water, and to circumnavigate the globe. Thus it became public knowledge that the old open-edged, infinite world system had closed back on itself in all circumferential directions to become a finite system: a closed sphere. The monarchs and merchants realized that, within that closed system, whoever commanded the line of most efficient high seas supply would become the masters of world wealth. Ships could carry cargoes that overland caravans could not.

- *Synergetics 2* by R. Buckminster Fuller (1979, sec. 000.105)

The first step to mystical realization is the leaving of such a defined god for an experience of transcendence, disengaging the ethnic from the elementary idea, *for any god who is not transparent to transcendence is an idol, and its worship is idolatry*. Also, the first step to participation in the destiny of humanity today, which is neither of this folk nor of that, but of the whole population of this globe, is to recognize every such local image of a god as but one of many thousands, millions, even perhaps billions, of locally useful symbolizations of that same mystery beyond sight or thought which our teachers have taught us to seek in their god alone. Black Elk's word, "The center is everywhere," is matched by a statement from a hermetic, early medieval text, *The Book of the Twenty-four Philosophers (Liber XXIV philosophorum)*: "God is an infinite sphere, whose center is everywhere and circumference nowhere."¹² The idea, it seems to me, is in a most appropriate way illustrated in that stunning photograph taken from the moon, and now frequently reproduced, of an earthrise, the earth rising as a radiant celestial orb, strewing light over a lunar landscape. Is the center the earth? Is the center the moon? The center is anywhere you like. Moreover, in that photograph from its own satellite, the rising earth shows none of those divisive territorial lines that on our maps are so conspicuous and important. The chosen center may be anywhere. The Holy Land is no special place. It is every place that has ever been recognized and mythologized by any people as home.

- "Cosmology and the Mythic Imagination" from *The Inner Reaches of Outer Space: Metaphor as Myth and as Religion* by Joseph Campbell (1988, p. 18)

Cosmology provides the guiding principles for human action within the world, technology provides the principles for human action upon it. Thus, as cosmology gives way to technology, the relation between people and the world is turned inside out, so that what was a cosmos or lifeworld becomes a world—a solid globe—externally presented to life. In short, the movement from spherical to global imagery corresponds to the undermining of cosmological certainties and the growing belief in, and indeed dependence upon, the technological fix. It is a movement from revelation to control, and from partial knowledge to the calculated risk.

- “Globes and Spheres” from *Perception of the Environment: Essays on Livelihood, Dwelling and Skill* by Tim Ingold (2000, p. 216)