

“The Countless Stars of Heaven's Field:”

Scientific Motifs in Middle-Earth

by Casey Lynn Brinkman-Traverse

Middle-Earth, a realm of fantasy and magic, lives and grows in the minds of those who read the works of J.R.R. Tolkien, and forms a place where modern readers can escape from the realities of their technological age. The works of Tolkien are rich with history, mythology, language, and religion—yet direct references to science and technology are sparse. Because of his anti-war and anti-industrial motifs, Tolkien often casts a dark shadow on the technology present in his works, most specifically the creations of Sauron and Saruman in *The Lord of the Rings*. Science, however, is both philosophy and utility: the quest for knowledge of the natural world exists alongside the technological products created using that knowledge. Tolkien valued science as the acquisition of knowledge, yet condemned the misuse of such knowledge as an instrument of power. Tolkien clearly understands many advanced scientific concepts, and many of his characters understand the physics, chemistry, biology, and geology—the natural philosophies—of Arda. Tolkien's elven culture, specifically, is very scientifically literate, and many of the puzzling pieces of “magic” in Middle-Earth can be unweaved using scientific analysis. Rather than a world in which science exists only for evil industrial purposes, I believe Middle-Earth is a world rich with science and technology, where the scientific pursuit of knowledge is as a noble endeavor.

One of the crowning scientific achievements of early civilization is the thorough mapping of the night sky: in the same way that ancient civilizations practiced observational astronomy, all of Tolkien's races, but particularly the Elves, have a detailed knowledge of the placement of stars and planets as constellations. Many of these constellations and stars, such as Remmirath, The Netted Stars, and Red Borgil correspond directly to our own constellations of Orion, The Pleiades, and Aldebaran (Larson, “Stars of Tolkien”). The Elves immortalize their mythologies—the battles of Inwe and Morgoth, Durin's Crown, and the Prophecy of Mandos—into the patterns of stars, just as humans have done throughout the centuries. The ancient civilizations of our Earth, however, did not simply diagram

the sky for the sake of art: they used the periodic evolution of the sky to record the seasons, and they used the phases of the moon to measure time. The races of Middle-Earth do this as well, applying their knowledge of the periodic motion and pattern of the sky for practical purposes: in this way forming a type of technology. Tolkien embraces this utility for astronomy, as it helps the Dwarves' quest for Erebor in *The Hobbit*, and allows the agrarian society of the halflings to prosper.

The science of the stars is not only represented through the utility of calendars and navigational maps, for the elves not only have catalogued the motion of the night sky, they seem to revere stars above all else. A cry of "*Gilthoniel! O Elbereth*"-- "Starkindler! O Queen of the Stars"-- greets the ears of Sam and Frodo at their first encounter with the elves, in a poem dedicated to the Elves' beloved Varda (Tolkien, "Lord of the Rings," p.79). Greater even than their worship of Iluvatar, the Stars seem to govern the spirituality of the elves. From the light of Earendil to the Evenstar, stars permeate the art and poetry of the elves, and symbolize the beauty of nature. In Peter Jackson's recent interpretation of *The Hobbit*, though stuffed with content that skews the original narrative and probably has Tolkien tossing and turning in his grave, the invented character Tauriel gives a speech about the Feast of Starlight that illuminates this idea and is ironically closer to the original Tolkien than the rest of the film: "All light is sacred to the Eldar. Wood elves love best the stars. It is memory, precious and pure." In referring to starlight as memory, Tauriel suggests that the elves know that the stars are very far away, and that they know it takes a very long time for their light to travel to Arda: the elves appear to be able to determine the distances of stars, possibly using techniques such as spectroscopic parallax, and their love of the stars kindles their desire to make the stars known through science.

Always the linguist, Tolkien chose his words very carefully; Tolkien's repetition of astronomical terms reveals the importance of the stars in the lives of many characters. He narrates the origin of Elves' love for starlight: "By the starlit mere...[the elves, the firstborn children of Iluvatar]...rose from sleep and beheld first of all things the stars of heaven. Therefore they have ever loved the starlight"(Tolkien, "Silmarillion", p.48). Similarly, and through their names, poetry, and

technology the elves demonstrate their deep connection with the stars beyond Arda. As Sam and Frodo sit, distraught and nearly without hope on the Plains of Gorgoroth, Sam beholds a twinkling star, and “the beauty of it smote his heart...and hope returned to him” for beyond the desolation of Mordor “there was a light and high beauty forever beyond it's reach” (Tolkien, “Lord the Rings” p.922). I believe that Astronomer Carl Sagan would feel quite at home among the Eldar, Children of the Stars, who acknowledge that we are star stuff, with a reverence for “the cosmos, ancient and vast from which we spring” (Sagan, “Who Speaks”). Tolkien uses the star motif to demonstrate our fundamental and profound connection with the cosmos, where the elves live harmoniously with the Earth of which they are an integral part, yet keep their eyes turned upward toward the heavens which instills both comfort and curiosity.

The philosophy and utility of science, however, are not so easily sundered, and this natural philosophy of the stars drives Elvish technology. The elves built things vastly more complex than star maps and so subtle that the Hobbits—and the reader—mistake it for nature or magic. The Hobbits, a simple agricultural people, “ooh” and “ahh” over Gandalf's fireworks at Bilbo's birthday party, viewing them as magical, while a reader might wonder about the magic of Gandalf's staff, the phial of Galadriel, the Palantiri, or the rings of power. We the readers, however, know exactly how the fireworks work. Mysticism, in Tolkien's universe, relies on a lack of knowledge, for in the words of Arthur C. Clarke “any sufficiently advanced technology is indistinguishable from magic.” Tolkien did not create a realm full of magic: he created a realm of such sophisticated science and technology that it appears as seamless, natural, and magical to the technologically ignorant. “A Hobbit visitor to a modern chemistry class would, no doubt, see it as sorcerous as a potions lesson at Hogwarts” while humans dub what we cannot readily understand as sorcerous as well (Gee, 179). Tolkien shows that he does not wholly deplore technology through the benevolent technology of the elves which aids Frodo and the Fellowship on their quest.

Upon departing Lothlorien, Galadriel gives to Frodo a phial shining with the light of Earendil's

Star—Venus, in our world. This piece of “magic” allows Frodo to ward off evil creatures, namely Shelob, with pure starlight. This invention of the elves shows the power in starlight, and the strength in the unmarred purity of nature, and it also demonstrates the profound scientific knowledge and technological capability of the elves. The Phial of Galadrial, filled with water from Galadriel's fountain, contains “trapped” light, an effect which could be attained using refraction of light waves: if the water from Galadriel's fountain had a high enough refractive index, than the light the enters the phial would take a very long time—in Frodo's case at least 39 days—to leave the phial again (Gee, 189). This is one possibility of how the elves constructed this elvish “weapon,” but we can only speculate based our current understanding of physics.

The Mirror of Galadriel, however, has not exhausted its magic, nor its potential for scientific investigation. When Frodo, Sam, and Gimli look into a lake along the Silverlode River—which runs through Lorien and could provide the source for Galadriel's fountain—they do not see their reflection. Instead, the company sees the reflection of an ancient sky: they see the stars of the Elder days before the sun and the moon, despite the daytime sun shining down directly above. Is this again a consequence of refraction, or does the water from the Silverlode warp time in more complex fashion? During the Fellowship's stay in Lothlorien, where “the connection with the general stream of time seems somewhat loose” they begin to forget how much time has passed (Gee, 192). Elvish technology appears to have the capability to distort time—something which Albert Einstein would have found particularly intriguing. Tolkien would have known that time is relative and can fluctuate based on acceleration, mass, and the curvature of space-time. The elves could have potentially taken this knowledge to an even further extreme, in establishing a singularity in the Mirror of Galadriel: if the elves understood the equations of general relativity well enough, they could provide the conditions necessary to open a wormhole (Gee 192). A wormhole could provide a glimpse into parallel universes, in which Frodo would have been able to view “things that were, things that are, and some things which have not yet come to pass.”

Not all elven technology has been entirely benevolent, however. Elven technology reached its peak in the First Age, in the “Laboratory of Feanor” (Gee, 139). The Noldor elves—Noldor meaning those with knowledge—crafted the Silmarils, the Palantiri, and the three rings of power. The Palantiri, forged in Valinor, were given to the men of Numenor and allowed those who possessed them to communicate with each other across vast distances. Instantaneous communication across large distances would require “magic” to the minds of the Hobbit, yet our modern world has become utterly dependent on nearly instantaneous communication across the globe. Rather than working like a computer or cell phone, bogged down and tainted with circuitry and electronics, Gee argues that the Palantiri could have been linked more fundamentally using a process called quantum entanglement (Gee, 140). Quantum mechanics says that two particles created together can be thought of as dual aspects of the same particle, and no matter how far apart in space they may travel, their quantum link will transmit information from one to the other instantaneously—faster than the speed of light. In this way, the exposure of one Palantir to thoughts and images would expose the other Palantir to those same thoughts and images if the Palantiri were crafted in the same quantum state. This explanation, provided by biologist Gee, skims over the fact that faster than light information travel is not possible according to our current understanding of physics, and quantum entanglement relies on the predetermined states of the entangled particles. Our study of quantum theory is young, however, and this strange understanding of matter could lead to an advanced society such as the Elves developing more complex collapsing wave equations that could transmit information in this fashion.

When the Saruman's Palantir falls from the top of Orthanc, it chips the tower stair upon which it lands—therefore made of an incredibly hard material, for the Ents who could easily destroy the rock surrounding Isengard could not even dent the Tower Orthanc. Henry Gee proposes that the Palantiri are composed of alternating layers of Beta Carbon Nitride—a theoretical substance harder than diamond, and Lithium Niobate—a material that can rearrange electrons to change its optical properties and reemit quantumly entangled photons (142). With these oscillating layers, just like a pearl, the elves

could have grown these palantiri organically—a form of technology harmoniously integrated with the natural world rather than a mark upon it.

The Palantiri may be prime examples of the remarkable engineering skills of Feanor and the Noldor, yet they represent the choices that a technologically advanced society must face: the Palantir could be used to spread diplomacy, art, poetry, and new scientific discoveries, or it could be used as Sauron and Saruman did to organize armies and assaults, to negotiate evil deals, and to instill terror into the minds of men. One could compare the Palantiri to atomic energy, for the theoretical knowledge of atomic structure and quantum mechanics allows us to better understand our world, yet the applied products of that technology have equal potential to bring about good and evil. For Tolkien, magic and technology in his text are “neither good nor bad (per se), but only by motive or purpose or use” (Tolkien, “Letters” p.199).

Tolkien acknowledged in his letter 155 that he “could hardly be burdened with a pseudo-philosophic disquisition...in any debate whether 'magic' in any sense is real or really possible in the world”, and he expresses ambiguity about what the hobbits refer to as elvish magic (Tolkien, “Letters” p. 199). If one takes the view that elvish magic is actually technology, one could conclude that the elves were well versed in both Relativity and Quantum Mechanics—the two main theories that govern the laws of physics from the very large to the very small. These two theories work beautifully in describing and predicting the vast majority of natural phenomena; however, they are two separate theories which cannot cooperate or coexist, leaving physicists perplexed in situations with incredibly high mass on the quantum scale. Relativity and Quantum Mechanics cannot both be true, and modern physicists hunt for a unified theory of everything. This paradox would allow the elves to construct both the Mirror of Galadriel and the Palantiri, yet not fundamentally understand the inner workings of their universe, something neither Tolkien nor the elves would be satisfied with. Despite Tolkien's strong focus on History and Language, he may have alluded to one of the leading ideas in Metaphysics that hopes to unify quantum gravity.

Natural philosophers have long described the universe using musical metaphors: “From the ancient Pythagorean music of the spheres to the harmonies of nature... we have collectively sought the song of nature in the gentle wanderings of celestial bodies and the riotous fulminations of subatomic particles” (Greene, 135). At the birth of Tolkien's universe:

“The voices of the Ainur, like unto harps and lutes, and popes and trumpets, and viols and organs, and like unto countless choirs singing with words, began to fashion the theme of Iluvatar to a great music and a sound arose of endless interchanging melodies woven in harmony that passed beyond hearing into the depths and into the heights, and the places of the dwelling of Iluvatar were filled to overflowing, and the music and the echo of the music went out into the void and it was not void” (Tolkien, *Silmarillion*, 15).

Tolkien's universe forms in a most poetic way: through song and music. These “musical metaphors take on a startling reality” writes physicist Brian Greene, “for [superstring] theory suggests that the microscopic landscape is suffused with tiny strings whose vibrational patterns orchestrate the evolution of the cosmos” (135). If tiny vibrating strings compose all matter—all of the quarks composing all of the atoms composing the universe—then the patterns of their vibration can account for their properties, including the ways in which they interact with all four forces of nature. Tolkien's creation myth, the *Ainulindale*, suggests that superstring theory governs the laws of physics in Arda: that physics is the harmony of stringed instruments, and all of Ilu is the melodies composed by Iluvatar using these harmonies. With this holistic and unifying theory in mind, the elves would have been able to develop their technologies by listening to the symphony of the cosmos.

“And the Mind of God would be cosmic music” writes physicist Michio Kaku, using the euphemism “mind of god” figuratively to wax poetic about the universe. Tolkien, a devout Catholic, clearly crafted Eru, or Iluvatar after the Judeo-Christian god and wrote the *Ainulindale* with his creation

beliefs in mind. However, as a master of languages, deeper meaning can be found by delving into the philology of his creation and translating from elvish. *Ilúvë* means allness, or all there is, in the elven tongue, and *Iluvatar* means all father, or the father of all. The elvish word for the Universe, *Ilu*, however, means absolutely everything—encompassing Eru and all of his creation (*Quettaparma Quenyallo*). If so, Eru is an intrinsic part of Tolkien's cosmos, woven into the tapestry of time and space, and not separated from it. I believe that by placing Eru so fundamentally entwined into the universe means that Tolkien intends for his God and Gods to be known, a very scientific and metaphysical prospect.

In order for a race such as the elves to practice science, Valinor and Middle-Earth must obey a set of rules called the Laws of Physics, and indeed “Tolkien was ever mindful of the inner consistency of his universe,” and even if those rules differ from the real universe, Arda is “not utterly exempt from the rules of the mundane world in which we live” (Larson, “Astronomy of Middle Earth”). That being said, Tolkien's universe, woven with gods, experiences sporadic changes in the laws of nature. The way in which Iluvatar composed his “cosmic symphony” indicates that he created the musical score, then let the universe unfold from there. The Valar, however, occasionally make decisions, intervene, and change the natural order: they violate the laws of physics, as established by Iluvatar's “string theory” song. When they do this, however, their changes nearly always echo modern astronomy in some fashion.

For instance, the moon and the sun were created from the flowers and fruit of the Two Trees of Valinor, placed in the sky by Varda. The moon we now understand probably formed from molten Earth material as an asteroid blasted it from our planet—similar to Tolkien's myth because the moon came from Earth and is ejected into orbit. Our sun did not come from the Earth; yet Tolkien's association that the Earth and the Sun are linked, that they came from the same matter, echoes astronomical realities in a beautiful way. The way in which Tolkien describes the behavior of *Tilion*—the Maia in charge of carrying the moon through the sky—even accounts for eccentricities in the moon's orbit, the dark side

of the moon, and solar eclipses (Larson, *Astronomy of Middle-Earth*). Before the sun and moon rose and set in Arda the world was lit with stars, possibly a nod from Tolkien that the stars far out in space existed before our sun and moon formed, and will be there long after.

Through Tolkien's deliberate choices regarding cosmology and physical consistency show how highly he valued knowledge of the natural world. While technology may have been both benevolent and harmful in his works, the quest for understanding and natural philosophy are unambiguously positive, and an integral part of Arda. One of Middle-Earth's largest mysteries, causing controversy among nearly every Tolkien scholar, may even take the form of science. Tolkien has described Tom Bombadil in a letter as:

“an allegory, or an exemplar, a particular embodying of pure (real) natural science: the spirit that desires knowledge of other things, their history and nature, *because they are ‘other’* and wholly independent of the enquiring mind, a spirit coeval with the rational mind, and entirely unconcerned with ‘doing’ anything with the knowledge” (Tolkien, “Letters” 192).

While Tolkien's overall distaste for technology echoes, his profound love and respect for science as a philosophy shines through. Many assign Tom Bombadil the embodiment of Middle-Earth, it's spiritual guardian, and if so this places the scientific enterprise at the heart of Middle-Earth and Tolkien's stories—just as important as language, art, and history.

In distinguishing Tom Bombadil as scientific philosophy, as separate from technology, I do not believe that Tolkien automatically dismisses all technology here. While the *Lord of the Rings* contains countless examples of characters choosing their fate—choosing to stand and fight, choosing selfless acts versus selfish ones, and choosing to invest hope in Middle-Earth—I believe that Tolkien also views technology as a choice. Both good and evil sides in each war of the ring used technology to achieve their ends. In creating the sharp divide between philosophy and utility, however, I believe that

Tolkien here establishes that no matter the evil ends for which technology is used, it will not mar scientific philosophy. The weapons of Mordor and Isengard, and the poor regard for natural world they showed in favor of technological progress, are unforgivable and morally abhorrent for Tolkien and for most readers. The argument in favor of science and progress does not condone these technologies in the slightest, but instead says that scientific philosophy is not the cause of this evil. Tom Bombadil and the elves can continue their noble search for understanding and their quest to know the music of Iluvatar, and the industrial forces of Mordor and Isengard have no moral impact upon that scientific quest.

Tolkien's stories burst with mysteries, mysticism and “magic”; yet “the most beautiful thing we can experience is the mysterious. It is the source of all true art, and all science” (Albert Einstein). For each mystery Tolkien posed, a curious reader can speculate on the scientific processes behind what seems like magic to replace mysticism with understanding. At the forefront of Tolkien's work, particularly the Lord of the Rings, is spirituality and religion, which many find incompatible with science. The spirituality of the stories is undeniable, yet I believe that the strong presence of science in Middle-Earth strengthens this spirituality, not diminishes it; I find beauty and exhilaration in understanding the natural world, and grasping our place in this cosmos, and that sensation is surely spiritual. I believe that the elves have tapped into a reservoir of spirituality in the stars that remains absent in those who choose not to see the scientific philosophy present in Tolkien's Ilu.

Works Cited:

Carl Sagan, and Ann Druyan. "Who Speaks for Earth?" *Cosmos*. PBS. 21 Dec. 1980. Television.

Gee, Henry. *The Science of Middle-earth*. Cold Spring Harbor, NY: Cold Spring, 2004. Print.

Greene, B. *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory*. New York: W.W. Norton, 1999. Print.

Larsen, Kristine. "The Astronomy of Middle-earth." RingCon, Bonn, Germany. November 23, 2002.

Larsen, Kristine. "The Stars of Tolkien." *Shooting Star* 54(12) 1990: 10

Tolkien, J.R.R.. *The Letters of J.R.R. Tolkien*. Ed. Humphrey Carpenter. New York: Houghton Mifflin, 2000. Print.

Tolkien, J.R.R..*The Lord of the Rings*. Great Britain: HarperCollinsPublishers, 2004. Print.

Tolkien, J.R.R..*The Silmarillion*. Ed. Christopher Tolkien. 2nd ed. New York: Houghton Mifflin, 2001. Print.