Arda Remade (and Remade, and Remade...); or, Entropy, Einstein’s Blackboard, and $R = c e^{a(t-t_0)/3} [\sin \left[ \frac{\beta}{2} (t-t_0) \right] } \right]^{(2/3)}$, being an Exploration of Overlapping Themes in the Venn Diagram of the History of Middle-earth, the History of Middle-earth, and the History of Twentieth Century Cosmology

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Arda Remade (and Remade, and Remade...); or, Entropy, Einstein’s Blackboard, and

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being an Exploration of Overlapping Themes in the Venn Diagram of the History of Middle-earth, the *History of Middle-earth*, and the History of Twentieth Century Cosmology

*Expanded from a combination of two conference presentations, the keynote of the April 2, 2022 Tolkien in Vermont Conference (University of Vermont) and the June 24, 2022 Myth, Imagination, Literature: 6th Tolkien Conference in Budapest (Virtual)*

With his dying breath, Thorin Oakenshield tantalizingly announces “I go now, to the halls of waiting to sit beside my fathers, until the world is renewed” (*H* 262). Tom Bombadil warns the barrow wight that it will be “Lost and forgotten… till the world is mended” (*FR* 154), banning the wight until the end (and vaguely referenced restoration) of the world. In contrast, the world’s beginning is described in some detail from the earliest versions of the legendarium. In “The Music of the Ainur,” the deity Ilúvatar “propounded a mighty design of his heart” to the Ainur, the offspring of his thoughts, revealing an outline of history. He directed them to “make a great and glorious music and a singing of this theme” (*LT* I 53), however, one of their brethren, Melko (later named Melkor or Morgoth) began to “interweave matters of his own vain imagining,” introducing discord and disorder into the blueprint of the cosmos (*LT* I 53).

Tolkien’s richest depiction of the End Times of Middle-earth is found in the Second Prophecy of Mandos, dating to the 1930s, prior to his writing of *The Lord of the Rings*. Specifically, at the end of *The Quenta* it is said that “when the world is old and the Powers grow weary, then Morgoth shall come back through the Door out of the Timeless Night; and he shall destroy the Sun and the Moon,” although the forces of the Valar will ultimately defeat the Great Enemy (*Shaping* 165). In the aftermath, the luminous Two Trees of Valinor – of which the later sun and moon were inferior derivative lights – would be restored (*Letters* 148).

Verlyn Flieger (*Interrupted* 121) and Marjorie Burns (219) have clearly demonstrated that Tolkien was heavily influenced by Norse mythology, including the concept of the apocalyptic Ragnarök, the “fate of the Powers” or “doom of the Gods” (*S&G* 26). Indeed, the Norse tradition includes both the death of the sun and moon and the restoration of the sun and creation of a new world, Gímlé, after the destruction of the old (Davidson 38). As John Davenport (213) and Ralph Wood (75) have noted, the concept of Arda Remade or Healed also owes a great deal to
Tolkien’s own Christian beliefs about the End Times and the eventual triumph of good over evil – the ultimate eucatastrophe. Interestingly, during the 1930s Tolkien was also composing two of his non-legendarium works of epic poetry, his “New Lays” of the Völsungs and of Gudrún (published in The Legend of Sigurd and Gudrún) including his own poetic rendering of the Ragnarök legend, and The Fall of Arthur, which also makes repeated references to the End Times. For some reason, eschatology was apparently on Tolkien’s radar at this specific time (Larsen, “While”).

As noted by Elizabeth Whittingham (184), in the last stage of Tolkien’s tinkerings with the legendarium (post-LOTR), he downplayed the Last Battle and the so-called Second Music (the playing “aright” of the song of creation without the stain of Melkor [LT I 53]), instead focusing on “the philosophical elements of his world… [and] how the world might be healed.” Why the revisiting of his eschatological thinking after writing The Lord of the Rings? Clearly, these ideas were still important, as reflected in numerous references to the End Times in The Lord of the Rings itself and its appendices (e.g., RK 246, 248, 340, 343).

I argue that Tolkien’s cosmological creativity drew upon (perhaps quite unconsciously) the science of his day, in particular the eschatological ramifications of the concept of entropy, the natural inclination of closed systems to move from a state of order into disorder, or what is colloquially (but not accurately) called chaos.1 More specifically, it was realized in the mid-19th century that the second law of thermodynamics predicts that “in a closed system, energy always moves from an available to an unavailable state. So the total amount of energy remains constant, but the amount of fuel, or useable energy, decreases” (MacDuffie 6). The classical laws of physics predict that the entropy of the entire universe increases over time, such that in the far distant future “no further change could evermore take place, and the universe would be in a state of unchanging death,” an eventuality termed the “heat death” of the universe (Clausius 419; MacDuffie 6). It is important to note that the earth is not a closed system, for example constantly receiving sunlight. The solar system as a whole approximates a closed system, being mainly dependent on the light from a single star with an expected lifespan of 10-11 billion years (defined by its ability to continuously convert some of its mass into energy by fusing hydrogen into helium). While even the vast majority of college-educated persons avoids taking a formal course in thermodynamics, the concept of entropy is widely known. This was particularly true in the late 19th and early 20th centuries,

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1 Mathematical chaos theory explains that there is “spontaneous emergence of… self-organization” in some systems (order from chaos), while there is a “hidden order that exists within chaotic systems” [emphasis original] (Hayles 9-10). As counterintuitive as it seems, “Chaotic systems are both deterministic and unpredictable” – they do follow defined laws of nature, but are so sensitive to small changes in their initial conditions that tiny causes can generate large effects over time (Hayles 14).
including the decades of Tolkien’s education and early crafting of the legendarium, thanks to best-selling popular level books by physicists such as Sir James Jeans and Sir Arthur Eddington. Speaking of these works, Dean of St. Paul’s Cathedral William Inge (himself the author of God and the Astronomers [1934]), opined “It is safe to assume that almost all intelligent people have read and thought about them” (1-2).

While the possible heat death of the universe in the far distant future (long after the deaths of all stars) is perhaps comfortably remote (both temporally and intellectually), the death of our sun appears more urgent and personal. It is therefore not surprising that the eventual death of the sun was widely referenced in popular literature of the late 19th and early 20th centuries, including the opening paragraph of Charles Dickens Bleak House and letters, essays, and novels penned by Joseph Conrad (MacDuffie 198). For example, in a 1905 essay on Henry James, Conrad remarks “When the last aqueduct shall have crumbled to pieces, the last airship fallen to the ground, the last blade of grass have died upon a dying earth, man, indomitable by his training in resistance to misery and pain, shall set this undiminished light of his eyes against the feeble glow of the sun” (84). This “feeble glow” of the dying sun reflects an erroneous model of stellar evolution popular in the late 1800s and early 1900s, in which stars are born large, hot, and blue-white, and shrink and cool over their lives, ultimately dying as a red dwarf (Eddington, Stars 106). This model was later extended to include an initial collapse of a red giant into a hot blue-white star and at the end from a red dwarf to a white dwarf, an initially hot yet low luminosity object roughly the mass of the sun but the diameter of the earth. These would cool over billions of years to form black dwarfs.

This outdated model of star formation is reflected in H.G. Wells’ The Time Machine, when the narrator travels millions of years into the future to witness the death of our planet. The sun is described as a “huge, red-hot dome” that “had come to obscure nearly a tenth part of the darkling heavens” (84), a rather accurate depiction of the sun having cooled to a red dwarf, with the earth having spiraled into a much closer orbit, the result being the larger apparent size of our star. In Olaf Stapledon’s 1930 novel Last and First Men it is said that the sun would ultimately die by “shrinking to a minute, dense grain with feeble radiation… a typical ‘white dwarf’” (240), while in his Star Maker (1937) it is noted that during its youth, a star “is what human astronomers call a ‘red giant’,” and afterwards the star shrinks to the smaller “state in which our sun now is” (143). Stapledon’s work is known to have been influential on both Tolkien and C.S. Lewis (Larsen, “Lessons” 178; Larsen, “Strange” 206).

The correct evolutionary path of the sun (greatly simplified for the sake of this discussion) is that it spends the vast majority of its estimated 10–11-billion-
year life as a relatively stable, medium temperature G-class main sequence star\(^2\) before using up the hydrogen fuel in its core. Afterwards it will expand into a bloated red giant, its surface temperature nearly cut in half as its radius balloons to two hundred times its current size, swallowing Mercury, Venus, and perhaps the earth itself. After an interlude of relative stability fusing helium into carbon and a second expansion into a red giant, it will shed its outer layers of gas into space as the core collapses down to the size of the earth, creating a white dwarf (Schröder and Smith 155). We see the correct evolutionary ordering of red giants as old, dying stars (DeVorkin 429) in C.S. Lewis’ *The Magician’s Nephew* (1955), in the star of the dying world of Charn (29-30).

As described elsewhere (Larsen, “Carry On” 1-2), there are numerous instances within the various versions of the legendarium in which the sun is disordered or killed, usually at the hand of Melkor. Such celestial violence is to be expected in pseudo-mythological writings, given the numerous real-world traditions connected with the death and rebirth of the sun, especially those related to the quite noticeable seasonal “weakening” of sunlight in the winter (Hadingham 50). There are also the numerous literary references to the eventual death of the sun in Victorian and Edwardian literature. Gillian Beer argues that Max Müller’s solar mythology (famously panned in Tolkien’s essay “On Fairy-stories” [41]) owes much of its popularity during this time period to its ability to give “expression to covert dreads then current: it cast itself as past enquiry but expressed current fears” (225).

Indeed, the sun’s death, and that of the universe as a whole, can be summarized as “a grand narrative of decline: a story about the cosmos moving from abundance to exhaustion” (MacDuffie 71). Likewise, the concept of the “long defeat” (*Letters* 255) is a constant refrain throughout Tolkien’s writings. As noted by Sas and Weyant (1) and Stewart (n.p.), this leitmotif reflects a knowledge of entropy on Tolkien’s part. Recall that disorder is interwoven into the very fabric of Tolkien’s universe from the original song of the Ainur, through the themes of Melkor. Indeed, as noted by blogger Actualmairon, “From the very beginning, and at every turn, Melkor tried his very best to make things as evil, corrupt, and disorganized as possible. In this way he is the exact personification of entropy, as he is increasing the amount of disorder in Arda.” This includes destroying the great light-giving artifices of the Valar, the Two Lamps and the Two Trees. In Tolkien’s post-*LOTR* revisions of the cosmology the connection between between Melkor and entropy is even more apparent: like entropy, “Evil is fissiparous. But itself barren. Melkor could not 'beget’” (*Morgoth* 405-6). Tolkien’s statement that “The whole of 'Middle-earth' was Morgoth's Ring” is perhaps clearer when viewed through the lens of entropy (*Morgoth* 400), namely that Melkor’s “marring could

\(^2\) Astro-speak for a happy, healthy, stable adult star.
not now be wholly undone… for power had gone forth from him and could not be recalled, but would continue to work according to the will that had set it in motion” (Morgoth 258-9).

Victorian scientists pictured the early universe as a timeless, formless cloud of particles, without order or structure. The true beginning of the universe was marked by “the first unwinding of the cosmic clock, not the creation of the clock. As to where the clock – the matter and motion of the original universe – had come from, this question was considered outside science” (Kragh, Entropic 46). Similarly, before the universe existed Eru, the one, who lived in the Timeless Void, and “Time indeed began with the beginning of Êä, and in that beginning the Valar came into the World” (Morgoth 50). Furthermore, Tolkien appears to be cognizant of the centrality of entropy to closed systems. As noted in Manuscript B of the Ainulindalë, the Ainur who descended into the world were constrained such that “their power should thenceforth be contained and bounded by the world, and fail with it” (Lost Road 161). Jenny Coombs and Marc Read asked the reasonable question “Whence do the Valar derive their energy?” noting that in the early days of Arda the Valar “perform physical work on a massive scale, raising mountains and rearranging continents, which necessitates the ‘expenditure’ of tremendous amounts of energy,” energy that they posit was drawn from some “extraterrestrial source” (29). Indeed, one directly comes to mind, the “Flame Imperishable” with which Eru kindled the Ainur (Morgoth 8).

If the Valar cannot replenish this energy, it perhaps explains the “fading” of the Valar and Elves (Morgoth 219, 401), in particular the fact that the “Valar ‘fade’ and become more impotent, precisely in proportion as the shape and constitution of things becomes more defined and settled. The longer the Past, the more nearly defined the Future, and the less room for important change” (Morgoth 401). Note the close parallel with Clausius’ description of the heat death of the universe as a state in which “no future change could evermore take place” (419). Indeed, in his popular book The Universe Around Us (1930), Sir James Jeans noted

Energy cannot run downhill for ever, and, like the clock-weight, it must touch bottom at last. And so the universe cannot go on for ever; sooner or later the time must come when its last erg of energy has reached the lowest rung on the ladder of descending availability, and at this moment the active life of the universe must cease. The energy is still there, but it has lost all capacity for change (329).

It is therefore particularly interesting that the main power of the three great Elven-rings of power was to “ward off the decays of time and postpone the weariness of the world” (S 288), “the power of preservation” (Letters 177), and “the prevention or slowing of decay (i.e. ‘change’ viewed as a regrettable thing)” (emphasis
original; *Letters* 152), in other words, to hold back the march of entropy for as long as possible.

In his post-*LOTR* writings Tolkien attempts to differentiate between Arda, the solar system, and the greater universe, Eä, although he is far from consistent (*e.g.*, *Morgoth* 7, 337-8, 375, 378; *Nature* 227). He also distinguishes between the end of Arda and the end of Eä (*Morgoth* 338-9, 342-3; *Nature* 301). In particular, the Elves “appear to have held that the physical universe, Eä, had a beginning and would have an end: that it was limited and finite in all dimensions,” although it is interesting that the “Elvish conception of the End was in fact catastrophic. They did not think that Arda (or at any rate Imbar [Earth]) would just run down into lifeless inanition” (*Morgoth* 338-9). In other words, the Elves rejected the idea of a “heat death” for the world. This view parallels that of physicist Hermann von Helmholtz, who opined in an 1854 lecture “the same forces of air and water, and of the volcanic interior, which produced former geological revolutions…. More probably will bring about the last day of the human race than those distant cosmical alterations” including the death of the sun (171).

As science historian Helge Kragh reflects, “Many scientists as well as non-scientists felt it unbearable that life in the universe shall one day cease to exist, and they came up with a variety of suggestions to avoid the heat death” (*Entropic* 40). Among these was famed science fiction writer and popularizer of science Isaac Asimov, whose famous 1956 short story “The Last Question” centers on the possibility of reversing the heat death of the universe. Asimov’s work was read and appreciated by Tolkien (*Letters* 377). Janet Brennan Croft (169) also notes that the ongoing battle between the Valar and Morgoth in the legendarium can be read in “an allegorical way to symbolize our vain little attempts to delay the inevitable heat death of the universe—the ultimate ‘long defeat’,” drawing a direct parallel with the famous Asimov tale. Asimov’s short story ends on a decidedly theological note; it is therefore interesting that beginning in the late 1800s, the second law of thermodynamics was sometimes used to argue for a beginning of the universe, a creation in the Biblical sense and hence a Creator. Kragh explains that this “entropic creation argument” was “discussed by scientists and other authors in Britain, Germany and France” and especially “among Catholic circles in Germany” (Kragh, *Entropic* 72, 47).

In addition, many Christian writers were not disturbed by the prediction of a universal heat death. For example, William Inge explained in *God and the Astronomers* that “Christian theism has always contemplated the final dissolution of the material universe. It is not Christianity but modern pantheism, and the myth of unending progress, which are undermined by the degradation of energy” (ix). While we do not have direct evidence that Tolkien read Inge’s work, Lewis called Inge’s *Personal Religion and the Life of Devotion* (1924) “one of the best books of the kind I have yet struck” (*Collected Letters* 904). Indeed, in *God in the Dock*
(1943), Lewis made an argument quite similar to Inge’s, noting that “In one respect, as many Christians have noticed, contemporary science has recently come into line with Christian doctrine, and parted company with the classical forms of materialism. If anything emerges clearly from modern physics, it is that nature is not everlasting. The universe had a beginning and will have an end” (Lewis, Dock 38-9). Furthermore, Lewis argued,

It is not Christianity which need fear the giant universe. It is those systems which place the whole meaning of existence in biological or social evolution on our own planet. It is the creative evolutionist… the inevitable downward trend in the universe as a whole, the trend to low temperatures and irrevocable disorganization. For entropy is the real cosmic wave, and evolution only a momentary tellurian ripple within it. (Dock 44)

Kragh attributes the “most explicit use of the entropic creation argument as… valid proof for God’s existence” to theoretical physicist and University of Edinburgh professor Edmund Taylor Whittaker, a 1930 convert to Catholicism and later member of the Pontifical Academy of Sciences (Entropic 211). Whittaker is not only quoted by Lewis in God in the Dock (39), but was mentioned by name in Pope Pius XII’s 1951 address to the Pontifical Academy of Sciences. The pontiff’s lengthy speech, which openly invoked a number of scientific advances as well as the names and even direct words of several scientists, was considered controversial by many scientists due to its opinion that “the more it advances, the more it discovers God, as if He were watching and waiting behind every door that science opens” (Pius XII n.p.). For example, after describing the law of entropy, the pontiff observed that that “if the scientist turns his gaze from the present state of the universe to the future, albeit very far away, he is forced to see the aging of the world,” while looking in the other direction, he glimpses and recognizes the work of creative omnipotence, whose virtue, stirred by the powerful ‘fiat’ pronounced billions of years ago by the creator Spirit, unfolded in the universe, calling the exuberant matter of energy into existence with a generous gesture of love. It really seems that today's science, suddenly going back millions of centuries, has managed to bear witness to that primordial ‘Fiat lux’” (Pius XII n.p.).

Here the pontiff was referring to the cosmological model now known as the Big Bang, in 1951 still in its scientific infancy, having been initially proposed by

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3 Interestingly, the name ‘Big Bang’ was not penned by Lemaître or George Gamow, who in the 1940s further fleshed out the model by including detailed calculations from nuclear physics, but rather by controversial British astrophysicist Fred Hoyle (an unabashed and
astrophysicist and priest Georges Lemaître in 1931. I argue that it is quite reasonable to assume that the well-read Catholic polymath and Inkling Tolkien would have also been aware of authors such as Whittaker and Inge and their cosmological arguments, and the relevant scientific investigations and discoveries that were widely reported in the popular press.

Among these was the work of Albert Einstein. In 1917 Einstein considered the cosmological ramifications of his General Theory of Relativity, a novel formulation of gravity as the result of the warping of space and time by the presence of matter and energy. To his surprise, his calculations predicted that the universe would either be expanding or contracting, and in response he added another mathematical term to his equations, a ‘cosmological constant’ that would keep the universe static and unchanging. However, in 1922 Russian mathematician Alexander Friedmann demonstrated that model universes still evolved in the presence of the cosmological constant; more generally, Friedmann published mathematical descriptions of both universes that expanded forever (what we now call an ‘open’ universe model) and those that ceased expanding at some point in the future and would afterwards contract (a ‘closed’ universe model). While mathematically consistent, there was, at that time, no observational evidence of an evolving space-time, and Friedmann’s original paper and a follow-up two years later were largely ignored in the astronomical community (Kragh, “Cyclic” 3-4).

In 1927, Belgian astrophysicist and Catholic priest Abbé Georges Lemaître published (in French) his discovery of evidence for the expansion of the universe, rather vocal atheist) in his BBC radio broadcasts and resulting book, The Nature of the Universe (1950), and was meant as a term of derision. See Larsen, “Strange Bedfellows: C.S. Lewis and Fred Hoyle,” for a detailed description of Lewis’ fascinating inconsistency regarding Hoyle, in particular publicly attacking Hoyle’s science in his essays while simultaneously utilizing Hoyle’s scientific work on red giants in his description of Charn’s star in The Magician’s Nephew.

After the 1951 Pontifical Address, Lemaître requested an audience with the pope, and although there are no written notes concerning the meeting, it is interesting that Pius’ subsequent speech to the International Astronomical Union was “much shorter than the previous one” and omitted any “textual quotations from men of science” (Tanzella-Nitti n.p.). It is generally assumed that Lemaître asked the pontiff to refrain from trying to use science to ‘prove’ theology, in alignment with Lemaître’s widely reported personal philosophy that science and religion, while not contradictory, were also distinct endeavors (Aikman 3).

See O’Raifeartaigh et al. for more details.

Not to be confused with a ‘closed’ system in the sense of entropy; an ‘open’ universe model is also ‘closed’ in the sense of entropy. Welcome the wonderfully frustrating world of scientific terminology.

The discussion included here is vastly over-simplified and streamlined. For more information see Kragh, “Cyclic Models.”
a paper that unfortunately went largely ignored by the astronomical community until American astronomer Edwin Hubble’s announcement of the same discovery in papers in 1929 and 1931.\(^8\)

It was against this backdrop that Albert Einstein made the first of three annual, month-long visits to Christ Church College, Oxford. The internationally famous physicist delivered three Rhodes Memorial Lectures during that first visit (May 1931) that reflected changes in his thinking about the nature and evolution of the universe in the wake of Hubble’s publication of evidence of its expansion. While the lectures were highly mathematical and delivered in German without a translator or notes, they drew large interdisciplinary audiences at Oxford as well as local press attention (Fox 293). For example, articles on the first two lectures (on May 9 and 16) penned by physicist (and later President of Magdalen College) James Griffiths appeared in *The Oxford Magazine*. Speaking of the second lecture, which directly addressed Einstein’s new thinking on an expanding model of the universe similar to Friedmann’s that grew to a maximum size before shrinking once again. Griffiths noted that Einstein used two blackboards “previously prepared with the relevant equations” (719). Both blackboards were saved intact after the lecture, although one was later accidentally wiped clean. The other can be seen in the History of Science Museum in Oxford, as shown in Figure 1 (Robinson n.p.). Again, while there is no evidence that Tolkien attended any of these lectures, it would have been nearly impossible for him not to have been aware of the lectures and the general topics covered.

It is instructional to now revisit Tolkien’s author’s note to the *Athrabeth Finrod ah Andrath*, which Christopher Tolkien dated to approximately 1959 (*Morgoth* 304). Recall that the Elves believed the universe to be “limited and finite in all dimensions” (*Morgoth* 338); so, too, was Einstein’s closed universe. It was, as Sir James Jeans had described space-time in *The Mysterious Universe*, like “the surface of the soap-bubble,” albeit in more dimensions (135). In having a beginning and an end, Einstein’s universe was finite in time; in expanding to a maximum size before eventually recollapsing it was also finite in space. As Einstein himself noted of this model in his popularization *Relativity: The Special and General Theory* (published in its expanded 15\(^{th}\) edition in 1952) “if matter is distributed uniformly, the universe would necessarily be spherical” (in the sense of curving back on itself

\(^8\) For decades this discovery was known as “Hubble’s Law.” In 2018 the International Astronomical Union (the same body that reclassified Pluto to the status of dwarf planet) voted to adopt the name Hubble-Lemaître law (https://www.iau.org/static/archives/announcements/pdf/ann18029e.pdf). Those interested in the details of the controversy surrounding the original attribution of the discovery are directed to Livio, “Mystery of the Missing Text Solved.”
like the surface of a sphere); even if the material were not evenly distributed but more clumped together, the universe “will be necessarily finite” (114).9

1931 was a seminal year in the application of thermodynamics (in particular the concept of entropy) to cosmology. American physicist Richard Tolman found that general relativity predicted a slightly different behavior for entropy when applied to the space-time of the universe as a whole. In particular, a ‘closed’ universe could expand and contract numerous times (an oscillating or so-called ‘phoenix’ model). As noted in the formula included in the title10 of this paper (and graphically represented in Figure 2), each succeeding cycle of expansion would expand to a larger size than the one before it, and therefore take longer to complete one cycle; when extended into the distant future it was possible to demonstrate that such a universe would avoid “coming to that dreadful final state of quiescence predicted by the classical thermodynamics” – it would avoid heat death (Tolman, “Models” 372).

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9 For the sake of completion, note that Einstein’s original static model was also finite in the geometric sense, in that space also curved back in on itself like the surface of a sphere. An intergalactic rocket would eventually return to its starting point, given sufficient time.

10 I reproduce the equation here as an image in case the pdf text editor has difficulties:

$$\frac{Dt}{c} = \frac{1}{c} \frac{dP}{\rho \cdot \gamma}$$

$$D^2 = \frac{1}{P^2} \frac{P_{\rho} - P_{\rho}}{P_{\rho}} \sim \frac{1}{P^2}$$  (1a)

$$D^2 = \frac{1}{3} \frac{P_{\rho} - P_{\rho}}{P_{\rho}} \sim \frac{1}{k \rho}$$  (2a)

$$D^2 \sim 10^0$$

$$c \sim 10^{-26}$$

$$P \sim 10^8$$

$$t \sim 10^6 (10^{10})$$

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Figure 1. The “Einstein blackboard.” Image by author.
In his 1934 textbook *Relativity, Thermodynamics and Cosmology* (published by Oxford University Press), Tolman was a bit more careful to state that it “would of course not be safe to conclude therefrom that the actual universe will never reach a state of maximum entropy, where further change would be impossible” but only that the existence of such models must be allowed to exert some liberalizing action on our general thermodynamic thinking. At the very least it would seem wisest, if we no longer dogmatically assert that the principles of thermodynamics necessarily require a universe which was created at a finite time in the past and which is fated for stagnation and death in the future. (Tolman, *Relativity* 444)

Tolman’s connection of a creation of the universe at a specific point in the finite past with dogmatic assertions is quite interesting. Near the end of his book he more emphatically returns to his rejection of the necessity of a definitive creation of the universe, noting that in his model no definiteness could now be attached to any idea as to the beginning of the physical universe. Indeed, it is difficult to escape the feeling that the time span for the phenomena of the universe might be most appropriately taken

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*Figure 2. Tolman’s illustration of two expansion cycles (Relativity 443)*

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11 Tolman’s model avoided describing the exact moment of transition between cycles, instead assuming that it would be a state of high density that nonetheless still followed the known laws of nature. See Heller and Szydlowski, “Tolman’s Cosmological Models,” for a more complete analysis of his oscillating model, which “although mostly qualitative, has proved to be essentially correct” (328).
as extending from minus infinity in the past to plus infinity in the future. (emphasis original, *Relativity* 486)\(^{12}\)

He further ends the work with the caution that no cosmological model should be taken as evidence either for or against religious interpretations:

we must be specially careful to keep our judgements uninfected by the demands of theology and unswerved by human hopes and fears. The discovery of models… which could expand and contract irreversibly without ever coming to a final state of maximum entropy and rest, must not be confused with a proof that the actual universe will always provide a stage for the future role of man…. They must be treated, however, by the detailed, critical, and dispassionate methods of the scientist. (*Relativity* 488)

Tolman’s scientific papers and textbook are certainly too technical to have been light reading by the philologist, but again, it would have been impossible for someone as widely read and having a self-attested scientific interest as Tolkien to have been unaware of Tolman’s model, especially given some of the rather sensational coverage of it. For example, an article in the *Science News-letter* pronounced “The universe may be immortal” (“Death” 389), while another explained that “Like a toy balloon that a child blows up and deflates, the universe may be expanding and contracting in cycles of many millions of years without running the risk of a death from reaching a dead-still level of energy” (“Universe” 341).

Cyclical universe models of various varieties were not original to Tolman, of course, nor even to modern science, seen, for example, in seasonal solar rebirth rituals and legends. Verlyn Flieger (*Question* 23) observes that Tolkien makes good use of the obvious cycles of time in his writings, from the repeating seasons and phases of the moon to the daily repetition of sunrise and sunset. She points out that the names of the three Norns – commonly translated as Past, Present, and Future –

\(^{12}\) As noted by Tolman, a classical heat death of the universe is avoided in general relativity. However, as explained in a seminal 1997 paper by physicists Fred Adams and Gregory Laughlin “the universe can still become a dull and lifeless place with no ability to do physical work,” a possibility they designated “cosmological heat death” (369). For example, the creation of new stars becomes impossible, and the already existing stars will all burn out, by the time the universe reaches an age of \(10^{14}\) (100 trillion) years (367). If the Standard Model of particle physics and Stephen Hawking’s model of the entropy of black holes are reasonably correct, in the far distant future (\(t \sim 10^{100}\) years) matter itself and even black holes will decay, leaving the universe a cold, dark wasteland with no watchmaker in sight to rewind the cosmos (Adams and Laughlin 369).
philologically are more verb than noun, as at least two of them derive from the “Old Norse vertha (Old English weorthan) ‘to happen, to occur,’” and “conveys a sense of process… continuous and continuing activities” (Question 24). She argues that “Tolkien’s close familiarity with Old English and Old Norse would have made him aware of such a perception of time,” and thus “the idea of time as not just a linear progression but as a cycle, a ‘turning’ or ‘return,’ was a philosophical concept with which Tolkien was comfortable on mythic as well as on purely philological grounds” (Question 25). Flieger also draws attention to the popularity of Friedrich Nietzsche’s theory of Recurrence and Giambattista Vico concept of idea of ricorso “both of which posited the perpetual return and repetition of the same events or configurations at intervals throughout human history” and comes to the conclusion that

Tolkien was not alone in responding imaginatively to this intellectual rediscovery, nor in seeing, through its lens, myth and philology as deeply interconnected…. History blends into myth in what Mircea Eliade has called the Eternal Return, the concept whereby the same event can – indeed must – cycle and recycle through mythic time, although in actual historical time the event as already passed. (Question 25)

Indeed, Tolkien’s incomplete time-travel stories The Lost Road and The Notion Club Papers can be considered as treating past and present as forming a circle that one travels upon.

Katarzyna Ferdynus also reflects that

The history of Tolkien’s universe consists of a number of repeating cycles, each beginning with the false assumption… that Evil was ultimately defeated. This … allows Evil to be reborn. Each time Evil is defeated, it may reappear as being weaker; however, the powers of Good also dwindle. As a result, over its long history, the world is continually decaying, sliding into greyness and mediocrity, with each cycle losing a part of its former glory. (38)

This is certainly reminiscent of Tolman’s model, with cycles of ever-increasing entropy. Also consider a 1969 note on Elvish life-cycles published in The Nature of Middle-earth which described how “Elvish lives should go in cycles. They achieved longevity by a series of renewals. After birth and coming to maturity and beginning to show age, they began a period of quiet in which when possible they ‘retired’ for a while, and issued from it renewed again in physical health to approximately the vigour of early maturity” (Nature 154). This model explained the “fading” of the Elves as “the periods of activity and full vigour became
progressively shorter” and the “renewal was not so complete; they were a little older at each renewal than at the previous renewal” (*Nature* 155). In a related text he adds “at each new ‘cycle’ the vigour of the Eldar waned a little. Before the end of the Second Age youth-renewals … were becoming rare,” again, analogous to the eventual running down of the Phoenix universe in the longer and longer delays between collapses and renewals (*Nature* 155-6).

Sir James Jeans explained the popularity of the idea of a cyclic universe as due to a human viewpoint of “the final dissolution of the universe as distasteful a thought as the dissolution of their own personality, and man’s strivings after personal immortality have their macroscopic counterpart in these more sophisticated strivings after the imperishable universe” (*Mysterious* 181). Similarly, in a 1933 paper Lemaître noted that “Those solutions where the universe expands and contracts successively while periodically reducing itself to an atomic mass of the dimensions of the solar system, have an indisputable charm and make one think of the Phoenix of legend” (qtd. in Kragh, “Cyclic” 12). William Inge draws a connection to “the old theory of cosmic cycles, which has long attracted me” (50). However not all scientists embraced the possibility of the universe returning from the ashes like the mythological phoenix. Sir Arthur Eddington emphatically opined in his 1928 popular-level work *The Nature of the Physical World* (based on his 1927 Gifford Lectures delivered at the University of Edinburgh)

I have no great desire that it should succeed in averting the final running-down of the universe. I am no Phoenix worshipper…. I would feel more content that the universe should accomplish some great scheme of evolution and, having achieved whatever may be achieved, lapse back into chaotic changelessness, than that its purpose should be banalised by continual repetition. I am an Evolutionist, not a Multiplicationist. It seems rather stupid to keep doing the same thing over and over again. (86)

Describing time in general opens the door to all manner of complications, both in terms of the physics and the linguistic aspects. Tolkien seemed aware of this in his own writings. In a late 1960s note on his invented languages titled “Elvish Time,” Tolkien muses that in our Primary World we use confusing language when describing time, for example, “using *after* or *before* both (in certain circumstances)” in describing the future (*Nature* 161). In contrast, he explains, the Eldar more carefully distinguished between *before* and *after* in describing space versus time. However, he added that “In Elvish sentiment the future was not one of hope or desire, but a decay and retrogression from former bliss and power” (*Nature* 161-2).

Time was clearly a topic that Tolkien thought a great deal about, not only in crafting Middle-earth, but also in famously starting – and abandoning – two time-
travel tales, “The Lost Road” (in the 1930s) and “The Notion Club Papers” a decade later. Tolkien’s contemplations concerning the nature of time echoed both the work of physicists and philosophers, and, as Verlyn Flieger has explored (“Tolkien’s Experiment;” Question), speculations by aeronautical engineer J.W. Dunne. Introduced in his 1927 work An Experiment with Time and expanded in three subsequent books, Dunne’s concept of time, called serialism, is based on the idea that what we call the present is a window through which we view the entirety of reality, similar to a train rider viewing a landscape. Like the train, our present moves along a track, in the dimension we call time T1. Dunne argued that there must exist a higher dimension, a more ultimate time T2, in which we measure the rate of motion of our journey along time’s track. There exists a higher dimensional observer in this T2 who has the freedom to observe all events in our time in whatever order they wish. Dunne argued that there exists an infinite regression of these higher times and observers, leading to some Ultimate Time and an Ultimate Observer which Dunne calls the “Super-Mind” (Dunne 146). Through dreams we can access these higher dimensions and thus experience both the past and future at will. Verlyn Flieger notes that Tolkien read An Experiment with Time in 1934, only three years before submitting the incomplete draft of ‘The Lost Road’ to publishers Allen and Unwin, in which a father-son pair travel through time via serial identities that could access each other in dreams (“Tolkien’s Experiment” 39).

Fast-forward to the late 1950s, and Tolkien was dealing with a different type of time travel. As explained in The Nature of Middle-earth, Tolkien had decided that the exchange rate between sun-years and years of the trees (Valian years) should be “greatly increased” from the previous rate of 10 to 1 to a new rate of 144 to 1, necessitating many tedious calculations of how this would impact the timeline of Middle-earth and the ageing of Elves (Nature 3). Around the same time, Tolkien stated in the 1959 essay “Aman” that the Valar “could move backward or forward in thought…. All that was past they could fully perceive; … the future they could only perceive or explore in so far as its design was made clear to them in the Music, or as each one of them was specially concerned with this or that part of Eru’s design… they could foresee none of the acts of the Children, Elves and Men, in whose conceiving and introduction into Eä none of the Valar had played any part at all” (Morgoth 425). We see an echo of Dunne’s concept of time, albeit with an interesting limitation, or asymmetry that distinguishes past from future.

Clearly, when Sam is confused by the experience of time in Lothlórien, he is only scratching the surface (FR 404-5). In the 1959 essay “Time and its perception” Tolkien mused “The question of ‘perception of Time’ is more difficult to deal with, since it varies with persons, circumstances, and kinds of persons, and it is difficult also to express or communicate” (Nature 159). In the essay “Aman” Tolkien offers “as for the Valar themselves… they could live at any speed of thought or motion which they chose or desired” (Morgoth 425). Indeed, as Einstein
proved in his 1905 Special Theory of Relativity, the literal physical passage of time is dependent on the relative motion of two observers. But reality gets even stranger. Most of the primary laws of physics, including Newton’s laws of motion, Einstein’s relativity, and quantum mechanics, work equally well with time running backward or forward. If this is so, why do we, like the Valar, recognize a difference between past and future?

In *The Nature of the Physical World* Eddington spends numerous pages explaining what he terms “time’s arrow,” a “one-way property of time which has no analogue in space” that is “vividly recognized by consciousness” as we experience the past, present, and future in a linear manner (*Nature* 69). This *psychological arrow of time* is actually one of three such arrows, the others being the *cosmological arrow of time* (defined by the expansion of the universe) and the *thermodynamic arrow of time* (defined by the law of entropy) (Hawking 145). In our current universe, all three point in the same direction; however, during the contracting phase of a closed or oscillating universe the arrow of expansion will point in the opposite direction from the other two. Is it possible that the psychological arrow, or even the entropic arrow, could reverse direction during a contracting phase as well? Tolkien includes such a possibility at the end of the “Sketch of the Mythology” (c. 1926-30), explaining that after the ultimate defeat of Melkor and the rekindling of the Two Trees through the aid of the Silmarils (a de facto “fiat lux” in Biblical terms) the “Gods [Valar] and Elves and Men shall grow young again, and all their dead awake” (*Shaping* 40-1). In *The Quenta* (circa 1930) this is slightly amended to “the Gods will again grow young, and the Elves awake and all their dead arise” (*Shaping* 165), which remains intact in the c.1937 *Quenta Silmarillion* (*Lost Road* 333). In Tolman’s 1931 model only the arrow of time defined by the expansion of the universe would reverse, although decades later Stephen Hawking originally considered of his so-called “no boundary” cosmological model that its contracting phase would be like the time reverse of the expanding phase. People in the contracting phase would live their lives backwards: they would die before they were born and get younger as the universe contracted. This idea is attractive because it would mean a nice symmetry between the expanding and contracting phases (Hawking 150).

Perhaps Tolkien was likewise drawn by the aesthetics of symmetry to experiment with the possibility of aging backwards while the universe was remade and healed of its Melkor-imposed disorder – its entropy. However, we now know that in a closed universe entropy increases throughout the contraction phase, and, it is reasoned, the psychological one continues to evolve in a fixed direction as well. So much for growing younger (Hawking 150).
The question of entropy was also central to the birth of what became the Big Bang model. Georges Lemaître explained in his 1946 book on *L'Hypothèse de l'Atome Primitif*, translated into English as *The Primeval Atom Hypothesis* in 1950, that he was initially led to his hypothesis in 1931 “from thermodynamic considerations while trying to interpret the law of degradation of energy in the frame of quantum theory” (“The Primeval Atom” 339). In a brief letter to the journal *Nature* he first suggested that “we could conceive the beginning of the universe in the form of a unique atom, the atomic weight of which is the total mass of the universe. This highly unstable atom would divide in smaller and smaller atoms by a kind of super-radioactive process” (Lemaître, “Beginning” 706). Further details soon followed in a paper in the *Monthly Notices of the Royal Astronomical Society*. The doubly dramatic nature of a scientific model for the “creation” of the universe devised by a Catholic priest and cosmologist led to considerable interest in the popular press. For example, a 1932 article in *Popular Science* framed it as follows:

Out of a single, bursting atom came all the suns and planets of our universe! That is the sensational theory advanced by the famous Abbe G. Lemaître, Belgian mathematician…. Then, like a sky-rocket touched off on the Fourth of July after having remained quietly for months on a store shelf, the atom burst, its far-flung fragments forming the stars of which our universe is built. (Menzel 28)

Similarly, a 1933 *New York Times magazine* article openly marveled that

Here is a man who believes firmly in the Bible as a revelation from on high, but who developed a theory of the universe without the slightest regard for the teachings of revealed religion on Genesis. And there is no conflict…. Lemaître believes that if discussions could be carried on in a friendly, objective way, the church and the laboratory would find themselves closer together than they believe they are…. “Once you realize that the Bible does not purport to be a textbook of science, the old controversy between religion and science vanishes.” (Aikman 3)

Again, while it is unreasonable to assume that Tolkien read Lemaître’s scientific papers, it is likewise unrealistic to suggest that he was unaware of the basic concepts of the model.

Finally, consider the statement by Sir James Jeans in his 1932 popular-level work *The Mysterious Universe* that “Modern scientific theory compels us to think of the creator as working outside time and space, which are part of his creation, just as the artist is outside his canvas” (182). A similar point of view is reflected in certain actions of Eru, who, as Tolkien notes in a 1956 letter draft, “remains remote,
outside the World, and only directly accessible to the Valar or Rulers.” However, Tolkien makes the additional point that

the One retains all ultimate authority, and (or so it seems as viewed in serial time) reserves the right to intrude the finger of God into the story: that is to produce realities which could not be deduced even from a complete knowledge of the previous past, but which being real become part of the effective past for all subsequent time. (Letters 235-6)

Similarly, in a late 1950s musing Tolkien further elaborated that

since Eru is not bound by the Theme, nor by the Ainulindalë (as made by the Ainur), it would be rash to assert that He is or will be bound by Eä realized; since He is outside Eä but holds the whole of Eä in thought (by which he coheres). Some of those things that appear suddenly in History… may indeed be due directly to Eru. (Nature 289)

For example, one of these events may be the relatively late entrance of Tulkas into the world, in Year 1500 of the Valar, in order to help in the struggle against Melkor (Morgoth 52).

But also compare this with Georges Lemaître’s explanation that the primordial atom – the Big Bang –

could not conceal in itself the whole course of evolution; but, according to the principle of indeterminacy, that is not necessary. Our world is now understood to be a world where something really happens; the whole story of the world need not have been written down in the first quantum like a song on the disc of a phonograph. The whole matter of the world must have been present at the beginning, but the story it has to tell may be written step by step. (“Beginning” 706)

Likewise, in discussing the unforeseen death of Fëanor’s mother, Míriel, Aulë points out to his fellow Valar in a post-LOTR essay, “this we know to be true, and as the ages pass it shall often be manifest (in small matters and in great) that all the Tale of Arda was not in the Great Theme, and that things shall come to pass in that Tale which cannot be foreseen, for they are new and are not begotten by the past that preceded them” (Morgoth 240). Whether this is unconscious borrowing, or simply a case of two brilliant scientific Catholic minds thinking alike, is beyond this astrophysicist’s ability to demonstrate.

In a 1969 letter to Camilla Unwin, Tolkien opined that “Those who believe in a personal God, Creator, do not think the Universe is in itself worshipful, though
devoted study of it may be one of the ways of honouring Him” (Letters 400). Sir James Jeans further reflected in the early 1930s that as scientists continue to explore the cosmos, they “discover that the universe shews evidence of a designing or controlling power that has something in common with our own individual minds” (Mysterious 187). Jeans’ rather theological views are at odds with mainstream 21st century cosmology, in which the universe itself may possibly have begun as a quantum fluctuation of space-time, nothing more than a statistical accident. However, the numerous theology-tinged interpretations, arguments, and counterarguments of early 20th century cosmology (especially in the 1930s) provide us with yet another lens through which to view the complex cosmological history of Middle-earth, as well as Tolkien’s history of the writing of the mythology of Middle-earth, and his eschatological lays of the same decade.

In the end it appears that the laws of nature were set in the song of creation, both in our universe and Eä, and as we bear witness to the great cosmic unfolding the most important of the arrows of time, that of entropy, permanently points in a single direction. The ultimate scientific determination of the possibility of a rebirth, for the universe, rather than ourselves, must wait for cosmologists to determine the exact properties of the dark – dark energy rather than a dark lord in this case, the mysterious substance that makes up about two-thirds of our universe (Brout et al. 1). It is an intriguing thought that Tolkien would have been fascinated with this discovery, with pen ready to integrate its properties into his cosmology – mythologically of course.

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