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Deconstructing Durin's Day: Science, Scientific Fan Fiction, and the Fan-Scholar

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Cover Page Footnote

Many thanks to Robin Reid for her thoughtful suggestions. They greatly improved this work.

> *You have at any rate paid me the compliment of taking me seriously; though I cannot avoid wondering whether it is not 'too seriously,' or in the wrong directions….That the device adopted, that of giving its setting an historical air or feeling… is successful, seems shown by the fact that several correspondents have treated it in the same way…. i.e. as if it were a report of 'real' times and places….* - J.R.R. Tolkien (Carpenter 2000: 188)

Science and the Secondary World

J.R.R. Tolkien defined a successful "Secondary World" as one into which "your mind can enter." Once immersed inside this world, any event is considered true by the reader because it "accords with the laws of that world. You therefore believe it, while you are, as it were, inside" (Flieger and Anderson 2008: 52). In order to hold the readers' attention and keep them from wandering off the map a believable Secondary World requires the creation of not only languages, family trees, histories, and mythologies, but details concerning the natural environment, including species of flora and fauna, stars and constellations (Wolf 2012). Given the fact that many scientists and science writers were self-admitted science fiction and fantasy (SF/F) geeks from a tender age, it is not surprising that as adults they may couple their love for these imaginary worlds with their scholarly pursuits.

One means of doing this is to pay homage to their favorite SF/F works through the naming of real-world species, celestial bodies, or geological features after fictional characters, locations, or objects (Larsen 2007). For example, the International Astronomical Union (n.d.) has approved names for features on Saturn's largest moon, Titan, that derive from planets in Frank Herbert's *Dune* series (e.g. Arrakis Planitia and Anbus Labyrinthus) and mountains and characters in Middle-earth (e.g. Arwen Colles and Doom Mons). Unofficial (pending IAU approval) names of features on Pluto's largest moon, Charon, currently include Tardis Chasma, Vulcan Planum, Ripley Crater, and Mordor Macula (Jet Propulsion Laboratory 2015). Another example is a 1978 article in *Chemical and Engineering News* that favorably discussed adopting Tolkien's logical and consistent Shire calendar in our Primary World (Reese 1978).

Elsewhere (Larsen 2017) I coined the term "scientific fan fiction"[1] to describe works in which scientists (or other science-interested fans) immerse themselves into a Secondary World and apply scientific concepts while ignoring

[1] Colleagues have suggested "scientifiction" or "fan science" as perhaps better terms, but I have elected to remain with the term I used elsewhere for consistency.

to some degree the fact that the Secondary World is not real (in the Primary World sense). Extending Henry Jenkins' analysis of fan activity, such scientists not only muddy the boundary between literary canon and popular culture, but scientific and popular literature (1992). In the words of Jenkins, these scientist-fans draw upon their personal knowledge to "become active participants in the construction and circulation of textual meaning" (1992: 24). Reasons for engaging in such activities are highly personal and range from the theoretical to the practical. As a result, the scope of these activities is wide, varying from simply identifying real world science in the subcreated world to penning pseudoscientific works in which the subcreation is considered to be "real" for the purpose of discussing its scientific properties, whether or not they align with our Primary World (a so-called *thought experiment*, in the vernacular of theoretical physics).

A common example of the former is popular science monographs that entertain members of the wider fandom (Beck, 2015; Whipple, 2014). These include physicist Lawrence M. Krauss's *The Physics of* Star Trek (2007); *The Science of Middle-earth* (2004), written by Henry Gee, an evolutionary biologist and senior editor at the austere science journal *Nature*; chemist and science writer Roger Highfield's *The Science of Harry Potter* (2002; and *The Science of Philip Pullman's His Dark Materials* (2005), co-authored by children's science writer Mary Gribbin and her husband, astrophysicist John Gribbin. One of the most recent additions to the genre is Helen Keen's *The Science of Game of Thrones* (2016). While Keen is a comedian by trade, she has written a number of highly successful and award-winning popular science radio programs, demonstrating that one need not be a professional scientist to engage in this type of activity An example of the second type of scientific fan fiction is Skye Rosetti and Krisho Manaharan's calculation of the minimum number of lembas required for the Fellowship to complete their journey, based on the approximate caloric content of Elvish waybread and the nutritional requirements of the different species represented in the Fellowship (2015).

As I will argue, such scientific fan fiction has value beyond its obvious creativity. First of all, it is important to recognize that it is not only professional scientists and engineers who engage in this fannish activity, but fans from other vocations who are nonetheless motivated by their love for Westeros, Hogwarts or Middle-earth to attempt to connect the science of the Secondary World with the laws of nature in our Primary reality. In order to accomplish this, fans need to educate themselves in real world science before they can educate their peers. In sharing this work with the larger fan community, these fan-scholars can lead others to a greater appreciation of the depth and breadth of their favorite Secondary reality. As a result, interested fans may engage more deeply with both the original works and the science involved, educating themselves in order to engage in a critical dialogue with other fans. Lastly, once these scientific

connections and examples are identified and discussed in the larger fandom, educators can integrate them into their K-12 or college curricula. In this essay I will take as my primary example attempts by Tolkien fans to identify the real-world date of the Dwarvish holiday Durin's Day, either within the timeline of *The Hobbit* itself, or relative to our current time. I will examine the overall processes involved, identify common pitfalls, and argue for the potential for this type of work to generate wider public interest in and appreciation for Tolkien and his works.

Here Be Dragons: Inherent Difficulties in Applying Real World Science to Durin's Day

On Midsummer's Eve, Lord Elrond of Rivendell held up the dwarf lord Thorin Oakenshield's heirloom map, and when the light of a "broad silver crescent" moon (several days after new moon) passed through it, once-invisible letters were seen (Tolkien 2007: 50). The moon-letters revealed that a secret keyhole would be illuminated in the side of the Lonely Mountain if the map's reader stood by a "grey stone when the thrush knocks" at the exact moment that the final ray of the setting sun on Durin's Day shined upon the rock. Thorin was concerned that he and his companions would fail in their quest to enter Erebor, because he admitted that "it passes our skill in these days" to calculate the timing of Durin's Day, as the Dwarves' New Year is termed when it is not merely the "first day of the last moon of Autumn," but in addition the sun and moon are visible together in the sky (Tolkien 2007: 50-1).

Why did the Dwarves have a holiday that was so difficult to determine? The answer is that (as is so typical of Tolkien's work), this important aspect of the plotline grew and changed in the telling. According to John Rateliff's *The History of The Hobbit*, Durin's Day was originally a far simpler affair and became decidedly more complicated over the period of *The Hobbit's* construction (1930-33). Originally Durin's Day had no connection to the moon, as it was simply stated that the Dwarves needed to "Stand by the grey stone when the crow knocks and the rising sun [will>] at the moment of dawn on Durin's Day will shine upon the keyhole" (Rateliff 2007: 22). This was later crossed out and replaced with the "setting sun on the last light of Durin's Day" (Rateliff 2007: 23), a change that was necessitated, as Hunnewell (2014) pointed out, because the secret entrance was consistently depicted as being on the west side of Erebor.

A detailed discussion of the evolution of Durin's Day is beyond the focus of this paper but can be found in Rateliff (2007). In summary, the moon first came into play during the Second Phase of Tolkien's work on *The Hobbit*, where the

moon-letters revealed that the keyhole would be illuminated by "the [rising>] setting sun on the last light of Durin's Day" (Rateliff 2007: 116). The first definition of Durin's Day appeared at this phase, as Gandalf noted that the Dwarves' New Year was "the day of the first moon of autumn," and that Durin's Day (which was not said to be difficult to predict) was the "day when the first moon of autumn and the sun are in the sky together" (Rateliff 2007: 116). During the Third Phase (no later than December 1932-January 1933), Tolkien shifted Durin's Day from the first to last moon of autumn and inserted a statement from Thorin that "it passes our skill in these days to guess when such a time will come again" (Tolkien 2007: 51). As Tolkien later realized, this seemingly innocuous change added a chronology problem to Bilbo's journey, as there would be insufficient time for the company to travel the entire distance between Rivendell and Laketown, slay the dragon, fight the Battle of Five Armies, and make it back to Beorn's for Yule.

There were also a number of serious errors in Tolkien's moon phases throughout the novel, for example in the scene with Bilbo and the three trolls. Working backwards from the moon-letters scene in Rivendell, it was impossible for the phase of the moon to be waning (after full). The famous scene at Laketown where Bard spied the gap in Smaug's jewel-encrusted armor by the light of a rising moon in the east late at night (similar to a moon after full) was also astronomically incorrect. Since the death of Smaug took place soon after Durin's Day, the moon must have been a waxing crescent, setting in the west within a few hours of sunset. As explained in detail in *The History of The Hobbit*, Tolkien tried valiantly to correct all these problems in his post *Lord of the Rings* updates to *The Hobbit*, but with very limited success, either because the changes would create a chain reaction of other difficulties in the text or because the changes would remove important dramatic elements from the text, such as Bard's role in the death of Smaug (Rateliff 2007).

It is important to realize that the intermediate designation of Durin's Day as the *first* new moon of autumn made it similar to Rosh Hashanah, the Jewish New Year. This was probably not a coincidence, as in both a 1955 letter to Naomi Mitchison (Carpenter 2000) and 1965 BBC interview (Rateliff 2007) Tolkien stated that the Dwarves and Jews have much in common. In the case of any new moon-based holiday, a culture (whether in the Primary or Secondary World) could either calculate the timing of the event or rely on actual observations. But since by definition the new moon cannot be seen, the sighting of the very slender, less than 24-hour-old waxing crescent moon, would have to be used. While the date of the Dwarves' New Year was eventually shifted to the last new moon of autumn, it apparently remained a holiday determined by the direct observation of the young crescent moon within 24 hours of new (the "first day"). As I suggested

elsewhere (Larsen 2014a), the original impetus for the construction of Durin's Tower on the peak of Zirakzigil above Moria might have been such an observation.

Predicting the visibility of a slender crescent moon from a particular geographical location ahead of time is difficult, and depends on a number of factors, including the location of the moon relative to the sun and the horizon (itself dependent on factors such as the time of year, the time since actual new moon, distance between the earth and moon, and the observer's latitude, longitude, and altitude), weather and other atmospheric conditions, and the individual's experience and visual acuity. It is generally considered impossible to see a slender crescent that appears less than 5 degrees from the sun, or about ten times the moon's apparent diameter (Hasanzadeh 2012). All of these factors would explain why Thorin and company were apprehensive about their ability to predict Durin's Day. A number of mathematical algorithms have been developed to attempt to predict the visibility of a newborn crescent moon at a given location (e.g. Fotheringham 1910; Doggett and Schaefer 1994), but actual observations continue to be used to refine such algorithms to this day.

Given these inherent difficulties, one might wonder why fans continue to attempt to date Durin's Day using scientific means and real-world calendars. Simply put, because they can, because they want to, and in doing so potentially improve their understanding of both Tolkien's works and real-world astronomy. However, as we analyze specific examples of fan interpretations of Durin's Day there are several facts that should be kept in mind:

1) Tolkien's astronomy was at times impressively accurate, but as previously described, at others woefully atrocious, in some cases simply because it fit the story. A famous example is found in *The Silmarillion*, where Venus (Eärendil sailing the skies in his winged ship Vingilot bearing aloft one of the silmarils) was visible in the western sky as a beacon all night long as the Faithful of the Edain first sailed to Númenor (Tolkien 2001), a physical impossibility in our Primary World. Therefore, there are times when Tolkien's astronomy is unequivocally at odds with Primary World astronomy, despite the creativity of scholars in attempting to align the two.

2) Tolkien clearly understood that the phases of the moon are a powerful way to measure and keep track of the passage of time. This is most famously demonstrated in the well-known care he took with his lunar chronology of *The Lord of the Rings*, timing the parallel journeys of the main characters to the phases of the moon. Descriptions of the moon's phases within the text provide the astute reader with an

internal timeline for the action without undue intrusion. Christopher Tolkien explained how his father first aligned the lunar chronology to the actual moon phases of 1941-2 during the drafting of the post-Moria adventures (Tolkien 1989), while John Rateliff described how the final novel-wide consistency was only achieved through the construction of "many-columned sheets listing where each character was on each day of the story," a cheat-sheet that is now housed in the Tolkien archive at Marquette (Rateliff 2007: 827). There was no corresponding chart for *The Hobbit*, as the main characters remained in close proximity for most of the tale (with the exception of Gandalf). Such a chart would have presumably helped Tolkien avoid some of the obvious inconsistencies with his lunar phases.

3) As previously noted, Tolkien himself was aware that his usage of lunar phases in *The Hobbit* was problematic at best, and clearly inconsistent. Compounding this was the fact that, as I have shown elsewhere (Larsen 2011a), when he wasn't using the real-world calendar as a basis (as he was in *The Lord of the Rings*), Tolkien was erroneously using a 28-day cycle instead of 29.5 days (a common misconception concerning lunar phases).

4) The scene at the Lonely Mountain clearly described a slender newborn crescent moon being visible at the same time as the setting sun. After the last sunbeam illuminated the secret keyhole, "the sun sank, the moon was gone, and evening sprang into the sky" (Tolkien 2007: 194). However, in our Primary World the newborn crescent moon cannot be seen with the unaided eye before the sun has actually set because the sky is too bright and the slender moon is too dim. Durin's Day is therefore technically not possible to observe, at least as described in *The Hobbit*.

5) Given the above realities, John Rateliff warned that we risk frustration whenever we try to use the same rigid scholarly lens to view *The Hobbit* as is commonly used to analyze *The Lord of the Rings*. For in the end, *The Hobbit* was a story told using the "tradition of long ago and far away, where details are only included when dramatically relevant or aesthetically effective." Again, some of the astronomically impossible observations occur in *The Hobbit* simply "because that's how Tolkien envisioned the scene" (Rateliff 2007: 836-7).

6) Finally, while Tolkien was capable of doing basic arithmetic calculations – as demonstrated by his scientifically accurate Númenórean calendar (Carpenter 2000: 229) – he also had an aversion for arithmetic from an early age, noting in different versions of his essay "On Fairy-stories" that "I did not like arithmetic at all" and was "stupid at arithmetic" (Flieger and Anderson 2008: 235; 287). Therefore, we should avoid assuming that Tolkien would have been able (or had the inclination) to make detailed mathematical computations, especially in an age before electronic calculators.

There are also two important parameters that any detailed analysis of Durin's Day needs to define, the calendar date for the end of autumn (or, as most authors phrase it, the beginning of winter) in Middle-earth, and what it means to have the sun and moon visible in the sky together. For example, is this to be taken literally (which means that either Middle-earth operates differently than our Primary World, or that the moon is other than a slender crescent) or figuratively (for example, having the moon being visible in twilight right after sunset). Some authors simply equate the Dwarves' New Year and Durin's Day, and just attempt to compute the date of the last new moon of autumn, either in the timeline of *The Hobbit*, or our Primary World. However, attempts to connect both calendar systems must be done with caution, as the Shire calendar of Appendix D in *The Lord of the Rings* was not used in the original writing of *The Hobbit*, although Tolkien did attempt to use it in his later abandoned revisions (Rateliff 2007). With this operational scaffolding defined, I will now examine several specific examples of scientific fan fiction focused on solving the mystery of Durin's Day.

Where Angels Fear to Tread: Specific Attempts to Unravel the Mystery of Durin's Day

One of the first attempts to quantify the timeline of Bilbo's entire adventure appeared in *The Atlas of Middle-earth*, where cartographer Karen Wynn Fonstad struggled to reconstruct the chronology using clues from the book (for example, the ripening of seasonal berries) and her own calculations for the approximate distances between the various locations. As she explained of Durin's Day,

> Calculating backwards, with time allowed for the armies' march, the siege, the battle, and Bilbo's return to Beorn's before Yule, Durin's Day would not have been later than October 30. That was the estimate shown, but if precise calculation of Durin's Day was beyond the skill of the Dwarves, it certainly was beyond mine. (Fonstad 1991: 98)

Note that there is no attempt to connect Durin's Day to the phases of the moon, or their observability, in this analysis.

One of the more recent algorithms for predicting the visibility of the young crescent moon was devised by astronomer Bradley Schaefer. In a 1994 article in the Los Angeles Griffith Planetarium's *Griffith Observer*, Schaefer utilized his algorithm for the visibility of the newborn crescent moon to estimate when Durin's Day (which he equated with the Dwarves' New Year) would occur in our Primary World in 1994. In doing so, he chose to ignore the problem of the crescent moon and sun being seen simultaneously in the sky, although he did note Tolkien's error in the phase of the moon at the death of Smaug. He also disregarded the inconsistencies in the phases in the novel in general, as his goal was merely to calculate the real-world date of the visibility of the last newborn crescent moon of autumn.

His methodology initially followed that of Fonstad by interpolating between Bilbo's recollection that he arrived in Laketown on his birthday (September 22) and the company's respite at Beorn's house on their return trip at Yule-tide. Schaefer determined the original Durin's Day to be on November 3 on the real-world Gregorian calendar, in contrast to Fonstad's preferred date of October 30. Schaefer then noted that an exact Dwarvish definition of winter was never clearly stated but reasoned that Yule-tide or midwinter was identified with the winter solstice in Appendix D of *The Lord of the Rings* (Tolkien 1993), as opposed to our astronomical definition of the solstice as the start of winter. Therefore, he argued, winter must begin 1.5 months before the winter solstice in Middle-earth, or approximately on November 7. He then used his computer algorithm to produce a table of "Durin's Days" for the years 1994-2004 for Cambridge, England, Washington, D.C., and southern California, dates prior to November 7 on which the very young crescent moon might first be briefly glimpsed after sunset from these locations. Given the limited focus of Schaefer's analysis, and the fact that he was not claiming that Tolkien himself did any particularly precise or complex computations, it can be said that Schaefer's work stands as a solid, albeit limited, piece of self-consistent scientific fan fiction, because its central purpose appears to simply be to draw attention to the author's moon phase visibility algorithm.

In an article first appearing in *Special Mythcon* 30/ *Bree Moot* 4 in 1999 and revised for inclusion in the 2014 volume *The Hobbit and Tolkien's Mythology*, Tolkien fandom scholar Sumner Gary Hunnewell noted that it was unrealistic to believe that all of the events from the entry into Erebor to the return to Beorn's house could be accomplished if winter was defined to begin with the solstice on December 21. He instead argued that Tolkien was using what he refers to as a Celtic seasonal calendar (with an equinox or solstice at the appropriate season's center), which he estimated would put the first day of winter in early

November, either seven weeks before the winter solstice (on November 2/3), or on what he refers to as the "modern Celtic calendar" holiday of Samhain, November 1 (2014: 60).

Hunnewell next attempted to tackle the thorny issue of how the detailed description of Durin's Day in the published *Hobbit* – as a special case of the New Year in which the newborn crescent moon was seen in the sky together with the setting sun – might possibly refer to an actual astronomical observation. Hunnewell summarized personal communications with Schaefer concerning the ability to view a young crescent moon before sunset and reported that a minimum angular distance of 35 degrees between the moon and sun was required. However, such a moon would be nearly three days past new and hardly the "thin new moon" described by Tolkien (2007: 193). Regardless, Hunnewell described his personal attempts to sight a young crescent moon and the sun together in the sky the day after new moon (when the moon was more than 24 hours old) or more than a day *before* new moon, and as a result came to the correct scientific conclusion that what Tolkien was describing in *The Hobbit* was not physically possible in our Primary World. While his observations were doomed by the laws of physics, Hunnewell is to be commended for trying, as it is clear from his essay that he increased his own scientific understanding through the experience, and perhaps unintentionally inspired some of his readers to attempt a similar experiment on their own.

Despite the inability to actually observe the sun and moon together in the sky, Hunnewell was able to narrow down a hypothetical calendar date for Durin's Day by using Gandalf's statement that Thrain had disappeared one hundred years before Bilbo's adventure, on Thursday, April 21, and Thorin's statement on the night before they opened the door to Erebor that "Tomorrow begins the last week of October" (Tolkien 2007: 192). If April 21 falls on a Thursday, Hunnewell argued, then the Gregorian calendar demands that (outside of a leap year) the last week of October begins on Sunday, October 30, which he called Durin's Day (2014: 63). This computation is consistent with the evidence in the novel, and as it did not rely on the phases of the moon but merely assumed that the phase was correct on that date, it was not subject to the inconsistencies of Tolkien's moon phases in *The Hobbit*. His analysis also did not assume any advanced computations on the part of Tolkien. In its acceptance and acknowledgement of the scientific limitations of Tolkien's description of Durin's Day, Hunnewell's analysis is perhaps the most honest of all those attempted. While he did not acknowledge the erroneous 28-day lunar phase cycle used by Tolkien, he had no direct need to, given his strategy.

Douglas Harder, lecturer in the Electrical and Computer Engineering Department of the University of Waterloo, Canada, tried to align the chronology of *The Hobbit* to the phases of the moon. He first challenged Fonstad's date of

October 30 as Durin's Day by noting that the moon phase at Rivendell on Midsummers Eve would not be correct, based on the 29.5-day lunar phase cycle. However, as previously noted, Tolkien used an erroneous 28-day cycle for his phases in *The Hobbit* (when he actually made calculations). Harder was apparently unaware of this fact; instead he reasoned forward starting from the phase of the moon as a broad waxing crescent in Rivendell and tried to compute the date of the original Durin's Day that would best fit the moon phase using a 29.5-day cycle. Like Schaefer he took the winter solstice to be the date of mid-winter, and thus placed the start of winter between November 5-10. Due to the problem of the resulting compressed timeline between Laketown and the return to Beorn's home, he decided to change the phase of the moon seen in Rivendell to a broad *waning* crescent, or a day or two *after* third quarter phase, which would necessitate the map reading episode to have been in the hours before dawn, because this phase rises after midnight. He demonstrated that this revision does work, albeit in order to make the timing of the troll scene work he noted somewhat humorously that "wet dwarves may be slower" when walking to Rivendell (n.d.). In this scenario the original Durin's Day would fall on the date of the new moon, October 24.

While Harder's analysis was certainly creative (and featured a detailed calendar for Bilbo's entire adventure, including presumed lunar phases), it was based on the incorrect assumption that Tolkien utilized a 29.5-day lunar cycle. In order for it to be consistent, Harder mandated making changes in the primary text (substituting a waning crescent for a waxing one in Rivendell), therefore his scientific fan fiction might be best described as occurring in an alternative universe (or AU).

Fan Iduna's 2013 essay on Durin's Day (hosted on thorinoakenshield.net) used the astronomical definition of the seasons (with winter starting on December 21) and looked to the last lunar cycle before that date in order to estimate the date of Durin's Day. Unlike Harder and Schaefer, Iduna keyed in on the fact that in the novel the moon and sun are said to be visible in the sky together, but unlike Hunnewell allowed that fact to dictate the actual phase of the moon. While Schaefer offered that the moon and sun can be observed together in the sky when the angular separation between them is at least 35 degrees, this observation is easier (and more obvious) at larger angles. Iduna therefore suggested that the moon phase was between first quarter (rising about noon, with a separation angle of 90 degrees) and full (rising at sunset, and therefore opposite the sun in the sky). Iduna noted that for 2013 this would occur between December 9th and 17th.

I must debate this interpretation for several reasons. Firstly, it would not be difficult for the Dwarves (or Tolkien) to calculate the visibility of the first quarter moon, as it would be obvious to any observer in any sky that is relatively free of clouds. Next, Iduna assumed the standard 29.5-day cycle for the moon

phases, which was not what was used by Tolkien. Most importantly, not only does the text of *The Hobbit* describe the moon as a slender crescent, but the dust jacket of *The Hobbit* drawn by Tolkien clearly featured a crescent moon as well. Therefore, as in the case of Harder, Iduna's analysis is, like all conscientious fan fiction, creative and to an extent based on the primary text, but also openly challenged the written canon and therefore inhabits an AU.

While the essay was obviously of benefit to Iduna, allowing her to increase her understanding of both the text and the astronomy, the discussion posted in the comments section to her essay also afforded other fans the opportunity to compare the analysis of Iduna to those of Hunnewell and Schaefer, as well as offer interpretations of their own (citing both scholarly sources as well as Tolkien's primary texts). Likewise, Iduna's essay motivated The Dwarrow Scholar (TDS) to analyze the issue of Durin's Day. TDS approached the problem in terms of calendars, arguing that the start of winter in the Shire (as well as Dale) was consistent with the Anglo-Saxon calendar, as "recorded by the Venerable Bede" (2013), thus bringing another cultural and literary source into the mix. TDS paraphrased Rateliff's recounting of Tolkien's later attempts to revise and make consistent the timeline of *The Hobbit* (unfortunately without citations), specifically the suggestion that the new moon occurred on October 19. But as noted by Hunnewell, in his attempts to revise *The Hobbit* Tolkien proposed another timeline that listed a potential date of October 17 (Rateliff 2007: 830; 826). TDS also did not clearly distinguish between the Shire calendar (which was referenced by Tolkien in this particular calculation) and the Gregorian calendar, the dates on the two calendars differing by approximately ten days (Rateliff 2007). In addition, the analysis ended with a suggestion that since "Tolkien considered the waxing crescent (a thin new moon) as still being a new moon, we must add our 1.5/2 days to this calculation" (The Dwarrow Scholar 2013). Nowhere is this specific assumption further explained. It is my opinion that the lack of references/citations and unsupported assumptions both detract from TDS's analysis, as they hinder other interested fans' attempts to engage in an informed discussion/debate on the merits of this model.

Freelance writer Andreas Moehn (writing under the pen name Lalaith) took a particularly original approach in attempting to solve the problem of the inconsistent phases in *The Hobbit,* by simply ignoring Tolkien's self-admitted inconsistency and instead using the problematic phase timing as evidence of real-world science at work in Middle-earth. First, he utilized his own interpretation of often vague lines from the text, such as "the moon was up and was shining into the clearing" (Tolkien 2007: 92) to construct a detailed chronology for Bilbo's adventures, claiming that Durin's Day unambiguously fell on the 22 day of the tenth month (October 22), two days after the actual new moon. Given the lack of detail given in the essay it is not possible to further analyze his claim for the date

of Durin's Day, except to state that his choice of it falling two days after the new moon seems at odds with the description of the moon disappearing (presumably setting) so quickly after the sun, but interestingly is aligned with The Dwarrow Scholar's analysis. Perhaps Moehn's essay was the (unattributed) source of TDS's assumption. Regardless, Moehn's analysis is worthy of discussion due to a rather curious extension to his timeline. Based on his evaluation of the timing of the phases of the moon in *The Hobbit* versus that in *The Lord of the Rings*, he comes to the conclusion that the lunar cycle of Middle-earth in the Third Age was twenty minutes shorter than its current real word value. He noted (correctly) that the length of the lunar cycle in our Primary World is increasing due to tidal effects as the moon slowly recedes from the earth (the so-called secular acceleration, although Moehn himself did not use this term), and suggested that this difference between the *Hobbit* lunar cycle and ours today might allow us to scientifically date just how long ago in the past the events in the novel took place in our real world's history.

While certainly creative, I would argue that such an analysis cannot be supported from either a scientific or Tolkienian viewpoint. Firstly, while the basic concept of the moon receding from the earth (and the slowing of earth's rotation, which also needs to be taken into account in such an analysis) was certainly well-known by the time of the writing of *The Hobbit* (including important work on the concept published by George Darwin, son of Charles Darwin, in the late 1800s), according to former NASA scientist and eclipse expert Fred Espenak, the size of the "secular acceleration of the Moon is very poorly known and may not be constant" (2007). So while I myself have argued elsewhere (Larsen 2008) that Tolkien would have known of this concept and Darwin's popular hypothesis that the moon was formed when it spun off the molten young earth, the inherent well-known problems with the phases of the moon in *The Hobbit* (not the least being that he used a 28-day cycle, not a 29.5-day cycle) and his self-described aversion to mathematics suggest that he did not take secular acceleration into account.

Secondly, Moehn was apparently also ignoring that there are normal short-term variations in the lunar phase (also termed the synodic) cycle due to various factors, such as the eccentricity (non-circularity) of the moon's orbit. While the current average value of the synodic cycle is precisely known (29.53059 days or 29d 12h 44m 03s), in any given month the actual length of the synodic cycle can vary from this value by as much as seven hours (Espenak 2013), a fact that was apparently ignored by Moehn. An overview of the complexity of secular acceleration and the various factors that can affect the average length of the synodic cycle can be found in Bromberg (2016). Note that the analysis contained in this source as well as the work of Espenak (2007; 2013) involve computer modeling, something that was not available to Tolkien.

Finally, the cycle for the phases of the moon in *The Lord of the Rings* is the correct 29.5-day real world average cycle, since, as previously stated, Tolkien was actually using the real world dates of various moon phases in his careful lunar phase "cheat sheet," while he was using a 28-day cycle in *The Hobbit* (when he was actually taking care to use any cycle at all). Therefore Moehn's assertion that he can discern a 20 minute evolution in the length of the synodic cycle in Middle-earth as compared to our current Primary World value (and that such a value can be used to "compute the geological period to which the Third Age belongs") is, in my view, an example of serious scientific fan fiction overreach.

Despite these problems with Moehn's essay, I would argue that it appears to have been a worthwhile intellectual exercise, in that it obviously caused the author to closely read the source material in search of references to lunar phases, search for chronological connections between them, and research (although to what level is unclear) the astronomical concept of the secular acceleration of the moon. To the extent that any one of his readers reviews the primary texts in order to find the context of his quotations or further explores on their own the natural changes in the moon's synodic period, the interested fellow fan will also reap some intellectual benefit.

In an essay (like Iduna's) hosted on thorinoakenshield.net, DarkJackal (2013) attempted to summarize a number of fan computations of Durin's Day, including many of those described here. As the author glibly noted, "My approach is two-fold: First – take Excedrin for the headache this issue is causing. Second – quote John D. Rateliff's *The History of The Hobbit* until things begin to make sense." DarkJackal summarized the debate as to whether winter in Middle-earth begins on the winter solstice or reaches its midpoint around this date and recapped the various stages in Tolkien's development of Durin's Day as described in Rateliff (2007), clearly citing the various primary and secondary sources. DarkJackal ultimately admitted, "there are too many contradictions to make any estimate 100%. If Tolkien was having trouble with it years after publication, then I believe we can be forgiven for not resolving the matter ourselves." While the author made no original contribution to the debate, it was a thoughtful and detailed summary of some of the main issues with Durin's Day (ignoring the basic problem of trying to view the waxing crescent moon and the sun simultaneously in the sky), and therefore has educational value as an introduction to the problem of Durin's Day written *by* a fan *for* other fans.

As noted by Rateliffe (2007), Tolkien himself made a tentative estimation of October 17 or 19 for Durin's Day on the Shire calendar during his attempts to revise *The Hobbit* in the 1960's. But as Rateliff (2007) explained in his analysis of Tolkien's largely aborted revisions, using the Shire calendar led to a number of internal problems of its own, and retrofitting the story to account for a Durin's Day of October 17/19 would have required a number of changes to the story,

including distances and timelines. It is therefore accurate to state that even Tolkien was unable to pin down an unambiguous, internally consistent date for Durin's Day within his own legendarium.

We are ultimately led to the perhaps disappointing conclusion that there is no completely self-consistent scientific date for Durin's Day, not only because the described observation is astronomically impossible, but again because we know from Tolkien's notes as published by Rateliff that Tolkien used a 28-day lunar cycle (when he was being consistent), not 29.5 days. In theory one could devise a consistent Secondary World description of Durin's Day by assuming a 28-day lunar phase cycle as normal in Middle-earth, and that the ability to see the newborn crescent moon and the sun in the sky at the same time is somehow due to the moon's driver, Tilion, being "wayward" and holding "not to his appointed path" (Tolkien 2001: 100). However, the internal inconsistencies with the lunar phases in *The Hobbit* as published make it impossible to devise a completely consistent lunar calendar for Bilbo's adventures in general, and Durin's Day in particular.

Having said this, I, too, am guilty of a bit of Durin's Day speculation of my own, having argued (Larsen 2014a) that Tolkien's final changes to Durin's Day (especially making it difficult to predict) may have been inspired by the work of John Knight Fotheringham, a controversial fellow Oxford scholar. In particular I suggest that Fotheringham's work on an algorithm to predict the visibility of the young crescent moon and attempts to use the phases of the moon to date historical events (including the crucifixion) could have piqued Tolkien's interest and influenced the final evolution of Durin's Day in *The Hobbit*. I leave it to other fan-scholars to judge my specific piece of scientific fan fiction.

"The compliment of taking me seriously": The Real-World Impact of Scientific Fan Fiction

As in the case of fan activities at large, the reasons why individual scientists or science-minded fans apply their scientific knowledge to popular culture are legion. On the philosophical side, Harm Schelhaas (2017) reflected during a particularly spirited Tolkien Society Facebook thread concerning the geology of Middle-earth's mountains that although Middle-earth (or any successful subcreation) "is not our reality, it has its own secondary reality that is knowable and analyseable [sic] by us… the secondary world can be investigated by its sources (the Fantastic or mythological texts), and it is possible to deduce to what extent it functions as the primary world and to what extent it functions differently."

More concretely, scientific fan fiction is often used as a vehicle through which to either interest other fans (or the general public at large) more deeply in SF/F literature, science, or both. For example, Henry Gee noted in *The Science of Middle-earth* that his "reason for writing this book is to show how the application of scientific knowledge can add new and exciting perspectives to our understanding of Tolkien's work as *literature*, deepening our understanding of the complexities of the plot and the motivations of the characters" (2004: 24). On the other hand, Lawrence Krauss used *Star Trek's* role as a "natural vehicle for many people's curiosity about the universe… to introduce some of the more remarkable ideas at the forefront of today's physics" (2007: xvi). The American Chemical Society likewise capitalized on people's fascination with the science of *Game of Thrones* through videos in their *Reactions* series, including an analysis by chemist Raychelle Burks of the poison that killed King Joffrey (American Chemical Society, 2014a). In an accompanying piece, Burks explained that both poisons and pop culture "are a good way to get people talking and thinking about science" (American Chemical Society, 2014b). Retired botany professor Walter Judd similarly hoped that his analysis of 141 plant series in Middle-earth would

> increase respect for and understanding of the plants that grow in the environments that exist around us. In a small way, we hope that the book will increase the visibility of and love for plants in our modern culture (which is rather plant-blind)! We think that Tolkien would agree. (Dillon 2017)

In contrast, some of the reasons for writing such works are strikingly personal rather than public in nature, as Henry Gee reflected:

> Scientists love to discover and to explain, and when one comes across an invented world as detailed and more importantly as internally consistent as Tolkien's Middle Earth, it's tempting to dig in, try and work out what might be happening behind the scenes. The key thing is this – if the invented world is self-consistent, all the things one might explain about it after the fact are already in it, even if the original author only implied them or didn't mention them at all in his published writing. Mithril exists – so what would it be made of? Balrogs exist – but could they fly?... In my view these are legitimate questions and asking them will (at least in my view) only enrich one's experience of the invented world. (Personal communication)

It is not only fans and scholars who directly benefit from such scientific fan fiction, but educators of all levels and their students. C. Renee James pointed

out that "J.K. Rowling might not have known it, but she provided a vast new avenue for astronomy outreach by doing some good research into mythology and naming plenty of characters after things you can find in the night sky" (2007: 22). As a result, numerous *Harry Potter* themed planetarium shows, star parties, and hands-on astronomy activities have been created to capitalize on this synergy between the Potterverse and astronomy (Larsen 2008; Larsen and Archer 2012). In reflecting upon teaching a traveling class of 18 undergraduate non-science majors that included both time in Australia and viewing a total solar eclipse in Wyoming, James noted that of all the talks the students heard the two that resonated most with them were those on the astronomy in *Harry Potter* and the celestial navigation found in *Moana*. In her words, these two talks

> generated the most discussion, the most excitement. It showed them that science was not some "other" subject being done in a vacuum, but was very much a human endeavor. Astronomy reached into the stories they already loved, stories they already were connected to. There was no common bond between the students when we learned about supermassive black holes, so it was a cool talk, but detached from their lives. But most of them had seen *Moana*. There's something intensely personal about the times that scientists can reach into the things you love and show you something you didn't know before. The stories take on a richer meaning, and the science becomes less alien. (Personal communication)

Similarly, I have personally been able to utilize not only my own Tolkien-based scientific fan fiction in astronomical outreach and teaching (Larsen 2004; 2012; 2015), but similar work in *Doctor Who* (Larsen 2013), *The Walking Dead* (Larsen 2011b), and the *Resident Evil* film series (Larsen 2014b), among others. In addition, I have given presentations at professional astronomy and education conferences on how to use the astronomy of *The Hobbit*, including Durin's Day, in K-12 and college science curricula.

As demonstrated throughout this essay, authors who engage in these types of activities can increase their personal understanding of both science and their favorite Secondary Worlds. For example, as astronomer Kevin Krisciunas (2003) explained in a letter to the editor of *Sky and Telescope* magazine, while he, like most seasoned observers of the night sky, assumed that J.K. Rowling had made a mistake in having the students of Hogwarts view Venus near midnight, he found that it is actually possible to make such an observation from the middle of the UK, but only in certain years. In taking part in such scientific fan fiction science-minded fans therefore provide supporting evidence to Tolkien's assertion in "On Fairy-Stories" that fantasy "does not destroy or even insult Reason; and it does not either blunt the appetite for, nor obscure the perception of scientific verity. On

the contrary. The keener and clearer the reason, the better the fantasy it will make" (Flieger and Anderson 2008: 65). If the scientific fan fiction created to explain the science of Durin's Day is any indication, the Professor's works have keenly whetted the appetite for "scientific verity" on the part of numerous readers.

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