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"Don't Ask the Questions You've Been Taught by Science": Rebecca Elson's Astronomical Poetry

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Abstract
Rebecca Elson was a poet and an observational astronomer studying globular clusters and stellar evolution. Her only poetry collection, *A Responsibility to Awe*, was published posthumously in 2001 and offers a glimpse into the intersections and relationships between her poetry and her science. In cosmological and astronomical research, invisible and often highly mathematical and abstract objects like dark matter, gravity, and dark energy require similes and metaphors before even specialists can understand and begin to study them. This article argues that Elson used her poetry as a creative ground to explore such metaphors: in her short and condensed poems she tried out and developed various images or models for cosmological phenomena. In particular, her poems challenge conventional models of dark matter, as this article demonstrates through close readings of some of her poems.

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In an *American Scientist* article on the roles of analogies in science, poet, chemist, and Nobel prize laureate Roald Hoffmann writes: "These thought mappings (let's loosely call them metaphors) also pulse deep in the heart of science. By this I mean they exist in the daily practice of doing research – in the way scientists generate hypotheses, theories and experiments" (406). In this article, Hoffmann explains the benefits of writing for scientists: writing for popular audiences or readerships encourages the use of narrative, metaphor, and analogy, which, in turn, helps the scientific researcher to better understand his or her research domain. This didactic approach is also discernible in Hoffmann's poetry, which often employs analogies for chemical processes in order to explain them to his non-scientific readership (Small 32). He emphasizes the pedagogic uses of analogies, but does not go into much detail about how comparisons to different systems can help to generate new hypotheses and further scientific research in general. The fecundity of analogies for scientific researchers has, however, been demonstrated by philosopher of science Mary Hesse. In her influential work on the roles of analogy in science, Hesse explains that analogies are potentially very useful for a scientist:

> one of the main functions of an analogy or model is to suggest extensions of the theory by considering extensions of the analogy, since more is known about the analogy than is known about the subject matter of the theory itself. ("Operational Definition" 291)

So, Hesse argues that analogies are valuable not only for the popular science writer but also for the researcher because an analogy can help to develop a theory and help the researcher to gain a better understanding of his or her domain by comparing it to a different system. Hesse's claims about metaphors in science are thus helpful to understand what exactly metaphors and imagery in poetry can contribute to scientific research.

Others, following Hesse, have written about the usefulness of metaphors in science: Ernan McMullin (1984) makes a case for the importance of metaphors in science in an article in which he defends scientific realism against the antirealism of philosophers like Bas van Fraassen, who postulates that scientific theories are only useful in that they help to make predictions about the observable world, not in the way that they explain structure as it really exists. McMullin points out the benefits of believing in and taking seriously the ontological status of scientific theories such as black holes, because it allows scientists to treat these models as metaphors. Metaphors in science work similarly to metaphors in poetry, according to McMullin, in that they make tentative suggestions.

The use of models and analogies is especially important in sciences like astronomy or astrophysics, which largely deal with invisible objects and forces, or with phenomena that, in their abstractness, defy our understanding, such as the big bang, dark matter, or dark energy. Such abstract and highly mathematical objects require similes and metaphors before even specialists can visualize or comprehend them. My argument is that Elson does exactly this in her poetry: she uses her short and condensed poems to try out and develop various metaphors, images, and similes for cosmological phenomena. Her poetry offers a creative ground where she plays with different conceptualizations of dark matter, in particular, challenging conventional models of this cosmological mystery. Elson was an observational astronomer at the University of Cambridge during her PhD in the late 1980s, and again from 1991 until her premature death from Non-Hodgkins lymphoma in 1999, when she was only thirty-nine. Using the Hubble Space Telescope, she conducted research on globular clusters in both our own galaxy and in very distant galaxies. She studied star formation and evolution as well as dark matter. At the same time, Elson wrote a significant number of poems, which were published posthumously by her husband Angelo di Cintio and her friend Anne Berkeley in 2001. *A Responsibility to Awe* contains fifty-two meditative and at times personal poems, the subject matter of which ranges from her childhood memories to her disease, as well as journal extracts and an autobiographical essay. About one third of her poems muse upon the cosmos and the different forces governing it.

These astronomical poems are where Elson could conceptualize some of the hard-to-understand findings from her astronomical research. Through a series of close readings of a selection of Elson's astronomical poems, this article will demonstrate that, through the use of metaphors, analogies, and imagery, Elson's poems serve to reflect on and in fact complement her astronomical research. A number of critics, such as Rachel Crossland, Jocelyn Bell Burnell, and Peter Howard, have read Elson's poetry as a type of popular science meant for non-scientific readers. Astronomer Jocelyn Bell Burnell has not written much on Elson herself, though she does mention her in an essay on poetry and astronomy. In this essay, she explains that she likes to start her talks about the universe to lay audiences with poems like Elson's (125). She found that opening her lecture with a poem "should help the non-scientists in the audience relate to the topic, may woo those who are suspicious of science or scientists, and demonstrate that astronomy is part of our cultural heritage" (126). So, Burnell is generally of the opinion that poetry complements astronomy in that it helps to communicate the science to popular audiences. Elson's collection was also widely reviewed with both *The Economist* and *The Observer* naming it book of the year. In his review of the collection, Peter Howard argues that Elson conveys her fascination by and passion for astronomy through her poetry. In his book on poet-scientists, which came out earlier this year, science communication scholar Sam Illingworth

presents valuable biographical information on Elson and argues that her poetry demonstrates her optimistic pragmatism (170).

This article builds on these interpretations of the poet-astronomer's work: Elson's poetry and her scientific practice should be seen further as closely intertwined, in that her poems visualize her astronomical research. Across four sections, the article discusses the ways in which Elson made her poetry integral to her scientific research. The first section sheds a light on the work of astronomers and the importance of visual metaphor in their profession in order to explain in what ways astronomy and poetry might be similar. The second and the third sections offer close readings of a few of Elson's poems in which the poet's use of metaphors to speculate about celestial phenomena such as dark matter and gravity is analyzed. In the concluding fourth section, Elson's scientific poetry is briefly discussed in relation to the views of Miroslav Holub, another poet-scientist in whose work science and poetry intersect.

1. The Death Star: Astronomers and the Importance of Analogies

When approaching the work of a poet-astronomer, one question that arises is how the two seemingly opposed activities could be put into dialogue with each other. How exactly does the literary occupation of poetry-writing fit into the daily routine of an astronomer? And what does this routine look like? In his helpful study of what modern astronomers actually do, for which he interviewed 478 U.S. astronomers, Timothy Spuck reveals that, contrary to popular belief, astronomers spend just ten to twenty hours a year collecting data at a telescope on average. By contrast, the majority of their time is spent interpreting the gathered data, reading new publications in their fields, discussing the research with colleagues, and doing administrative work (55-56). Even though Elson practised astronomy in the 1990s, around twenty years before Spuck's study, it is safe to assume that she also spent a considerable portion of her time working with computer software and programmes, as indicated by her scientific publications.

We know from the editors of *A Responsibility to Awe* that Elson handwrote her poems in journals, at least at a first stage (65). The switch in medium – from the computer screen to the pencil, and from abstract mathematical data to poetic play – probably encouraged her to reflect on her astronomical work, which might have set the stage for poetic thought experiments. Furthermore, astrophysicist Poshak Gandhi, who worked with Elson during his postgraduate thesis, explains that there has been a tendency in modern astronomy towards ever larger teams because the research has become more complex and the telescopes and other astronomical instruments more powerful and expensive to fund (personal interview). Although individual work is still required of an astronomer, that kind of occupation – the romantic trope of the lone astronomer observing the heavens – is disappearing. In this context, it is little surprise that Elson, again and again throughout her career, sought refuge and inspiration in the solitary writing of poetry, which allowed her to reflect on her profession independently of her colleagues' views and away from administrative and technological distractions. In a notebook entry from September 1993, she writes:

> If one day you are ~~out~~ riding in the forest
> And the universe ~~reveals itself shows~~ appears to you
> . . . . . .
> Don't ask the questions you've been taught by science
> Ask it everything ~~in your heart~~ you ever wanted. (*ARTA* 83)

These lines suggest Elson found that a turn away from scientific training – which in its rigorous adherence to logical and mathematical truths can be limiting – was sometimes welcome in her research about the cosmos. The crossed-out "in your heart" even suggests an antithesis between matters of the mind, such as mathematical and logical reasoning, and matters of the heart, which connotes her more creative, intuitive, and emotional faculties. Her poetry offers a creative ground that encourages her to ask the universe "everything [she] ever wanted".

Another area where astronomy and poetry intersect is in the use of metaphors. In the article quoted above, Hoffmann writes about the fecundity of analogies for scientists not only when they write for lay audiences, but also for their own research processes. He explains how, in order fully to understand a chemical process, he usually employs an analogy to visualize his area of research (406). Poshak Gandhi, whose main field of interest is black holes, uses the same method. Along with his team at the University of Southampton, he studied a type of jet plasma that is ejected by black holes. In order to better visualize and understand this phenomenon, the group of astrophysicists likened it to laser beams shot by the Death Star in *Star Wars*. This analogy was also used in the press release by the University of Southampton, which targeted a wider, non-astronomical audience. However, Gandhi's account of the use of the *Star Wars* analogy made it clear that this pop-culture image was not merely chosen for its popular explanation, but also for the astronomers themselves because the visual image helped them to grasp this highly theoretical concept (personal interview).

Both Gandhi and Hoffmann point out one other useful feature of using models that are analogous to the object being studied. Hoffmann writes about how insightful the limitations of a metaphor can be: "A naked metaphor clearly shows the analogy's limitations, its capacity for misinterpretation and its productive extensions. It aids its creator as well as its audience" (407). Gandhi is likewise interested in those aspects where the analogy breaks down:

> But the physics of black hole jets has nothing to do with lasers or the fictional Kyber crystals that power the Death Star. Nature has found other ways to power jets. . . . Gravity and magnetic fields play the key roles here, and this is the mechanism we are trying to unravel. (Gandhi, Southampton University)

Both scientists describe what Hesse called the benefits of a "neutral analogy". The philosopher distinguishes between three different analogies or aspects of an analogy: "positive", "negative", and "neutral" analogies. The first two describe similarities or dissimilarities between two models that are being compared to each other. A "neutral analogy", the most useful kind of analogy for Hesse, describes those "properties of the model about which we do not yet know whether they are positive or negative analogies; these are the interesting properties, because . . . they allow us to make new predictions" (*Models and Analogies* 8). The philosopher uses the analogy of billiard balls to visualize the behaviour of gas molecules: some parts of the analogy are described as negative (for example, the colours of the billiard balls), while others – motion and impact of gas molecules and billiard balls – are called positive aspects. The useful parts of this analogy are what she terms neutral aspects: the comparison between billiard balls and gas molecules invites the researchers to make predictions about the expected behaviour of gas molecules (8-9).

In other words, the imperfect fit between the analogy and the scientific phenomenon can actually further scientific investigation. This imperfect fit that Hesse describes is closer to how a metaphorical explanation of science works. Metaphors are different from analogies in that they do not necessarily compare two systems that are analogous or similar to each other. Philosopher Max Black distinguishes between analogy and metaphor by explaining that "metaphor *creates* the similarity" rather than "formulat[ing] some similarity antecedently existing" (285). In addition, while it has long been established that scientists recurrently think along metaphors and analogies, the metaphors and imagery Elson, or any poet, uses in her poetic compositions do slightly different work: whereas scientists employ mainly visual analogies, such as Gandhi's Death Star image and Hesse's billiard balls, the linguistic metaphors found in poetry establish more complex relationships between the two models through the use of semantics, grammar, syntax, wordplay, and lineation, as I will demonstrate below. Poetry, through its playfulness and experimentation, is a medium that can take these metaphors further by suggesting connections between the two models that a more straightforward scientific thought experiment or visualization would not. It is in this sense that poetry can be credibly employed as a tool of investigation.

Writing poetry is beneficial to Elson the astronomer because it gives her a licence to free speculation. The poetry she writes, with its vivid imagery and speculative metaphors, encourages her to train her scientific mind. Her poetry fosters a freeing up of imagery, which encourages her to think outside the box. Employing different metaphors and thinking through their implications means that she disrupts her own thinking habits as a scientist, which is necessary to perform good science. Translating astrophysical phenomena from one symbolic language – mathematics – into another – poetry – is an exercise of moving ideas from one medium to another, inevitable to which is a broadened or cross-pollinated understanding. Furthermore, her science, astronomy, is concerned with vast distances and conceptually very challenging phenomena. The science deals with objects that cannot easily be controlled or reduced. In her poetry, Elson parallels this vastness and mystery of the universe with exuberant imagery such as dancers and spider-webs, analogies far less available in her more rigorous scientific practice. The image of the spider-web plays a central role in a poem that will be analyzed in the next section, which is devoted to Elson's questions around the cosmological phenomenon of dark matter.

2. Dark Matter: Traps, Spiders, and Hyperobjects

Elson worked at a time when the biggest unknown in astronomy and cosmology – the study of the cosmos as a whole – was dark matter, the mysterious missing ingredient in the universe. Dark matter captured the poet-astronomer's imagination and figured extensively in her poetry and, to a lesser extent, in her research. While she returned again and again to the visual representation of dark matter in her notebooks, she only has one finished poem about this scientific phenomenon. The haiku-like poem presents a still-life in nature:

> Above a pond,
> An unseen filament
> Of spider's floss
> Suspends a slowly
> Spinning leaf. (*ARTA* 15)

What does this serene nature scene of a leaf stuck in a spider's web near a pond have to do with the title, "Dark Matter"? Upon a closer look, Elson's poem metaphorically incorporates the various functions of dark matter. In order to fully appreciate the metaphor in the poem, a short introduction to this cosmological phenomenon is needed.

The discovery of dark matter is generally credited to Fritz Zwicky. In the 1930s, Zwicky conducted research on galaxies and galaxy clusters. During his work, which consisted in cataloguing numerous galaxies, the Swiss astronomer attempted to understand what held those clusters together. He also observed, contrary to the orbital velocities in our solar system, that the stars in the outer arms in spiral galaxies revolve much faster than the stars at the centre of the galaxy. He wondered why those stars in the outer reaches of the galaxies were not dispersed and flung away into space due to their high velocities. He concluded that there had to be much more mass for gravity to act on and to keep the stars in place. From his observations and measurements of the Coma Cluster, he obtained a mass that was about ten times larger than could be accounted for by the light emanating from it. It was Zwicky also who invented the term "dunkle Materie" ("dark matter"). Despite these baffling results, this research area lay dormant for several decades until the 1970s, when renewed interest in the structure and evolution of the universe led to a revival of interest in dark matter.

In the 1970s, Jeremiah Ostriker and Jim Peebles studied our own galaxy and found that the high velocity of stars in the outer arms of the galaxy meant that the Milky Way should be unstable and that, as a result, it must be embedded in a halo of dark matter that stabilizes it. Following the publication of their findings in a paper called "The Size and Mass of Galaxies, and the Mass of the Universe" in 1974, there was sustained interest in studying this mysterious component of space especially because it played a crucial role in predicting the fate of the universe. Knowing the quantity of dark matter would allow scientists to determine the percentage that dark matter and baryonic (or ordinary) matter constitute of the critical density. The critical density describes the point at which the universe would be in balance and at which gravity would slow down and eventually stop expansion. By measuring the gravitational force that galaxies exert on other objects, through microlensing for example, scientists concluded that dark matter was six times as abundant as baryonic matter. As astronomers assume that we are living in a critical density universe – a universe that will eventually stop growing – and as this critical density can be calculated, they found that visible matter and invisible (dark) matter only constitute around twenty-six per cent of the critical density. However, during Elson's time, it was believed that dark matter constituted up to ninety-five per cent of the matter in the universe, which explains why astronomers were so fascinated with it at this time (Bell Burnell 136). It was very perplexing indeed that almost all of the universe consisted of something that kept eluding astronomers and cosmologists.[1]

Returning to Elson's poem, the different parts of the metaphor that compares two different systems can now be identified. The pond stands for the flat disc of our galaxy, while the spider's floss above it represents the invisible halo of dark matter encircling the Milky Way, gravitationally suspending stars or star clusters, or in the poem's case a leaf. The metaphor is further sustained by the words "unseen" and "filament". "Unseen" is an obvious hint at the invisible matter. "Filament" becomes a more obvious allusion when one considers the role that dark matter plays with regards to structure in the universe. A photograph capturing the universe from a distance would reveal that matter is organized in a sponge-like fashion; or, in other words, that galaxies are grouped together in clusters, which form part of filaments (Gott 166).

This behaviour is attributed to the workings of dark matter. The orthographical similarity between "filament" and the biblical "firmament" suggests a new visualization of the night sky. Furthermore, the haiku-like format that the poet chose here is well suited to conveying a single strong metaphor. While haikus traditionally contain a juxtaposition of two images or fleeting moments in nature, the juxtaposition in "Dark Matter" resides in the title and the body of the poem. The analogy of the spider's web and its implications raise a few questions about the purpose of dark matter. What was dark matter designed to catch? And, as the leaf in this imagined model for dark matter is not the spider's prey, what does that suggest about the universe? Are galaxies (and indeed life) merely side effects of dark matter?

These neutral parts of the analogy – where the similarities between the two models stop – are what drives Elson's poetry. This becomes clear in a poem entitled "Some Thoughts about the Ocean and the Universe", in which, as the title indicates, the universe is compared to the ocean:

> If the ocean is like the universe
> Then waves are stars.
>
> If space is like the ocean,
> Then matter is the waves,
> Dictating the rise and fall
> Of floating things.
>
> If being is like ocean
> We are waves,
> Swelling, travelling, breaking
> On some shore.
>
> If ocean is like universe then waves
> Are the dark wells of gravity
> Where stars will grow.
>
> All waves run shorewards
> But there is no centre to the ocean
> Where they all arise. (*ARTA* 25)

Throughout the short poem, Elson draws comparisons between the behaviour of waves in the sea and the behaviour of matter in space. The imperfect fit between these models raises questions about the extensions of the analogy. Can matter and energy in fact be compared to the movements of waves? Is their origin similar to the origins of waves? In this poem, Elson thinks through the implications and the extensions of the oft-used and somewhat trite comparison between the universe and an ocean. By setting the cliché into the context of scientific research, she allows the poem to raise questions that encourage her to conceptualize the objects of her research in different ways.

In "Dark Matter", it is also the gaps in the metaphor of a spider-web for a galaxy that raise useful questions. Especially the notion of a spider's web casts doubts on conventional views of the universe. In popular science accounts authors often write from a purely anthropocentric viewpoint. The narrative of our world, our solar system, and our galaxy, is embedded in teleological language that suggests that dark

matter exists to attract ordinary matter, and Jupiter exists to prevent asteroids from crashing into our planet, and the Earth is the perfect distance from the sun so as to enable humankind to prosper. Thus, Richard Gott describes the formation of matter in the early universe in these terms: "This allows the density fluctuations due to cold dark matter to get a big head start on growth*, a feature of the model that is very helpful in making galaxies*" (101, emphasis mine). Narratives of the story of the universe, such as this one, typically use vocabulary that depicts the different stages of the universe as conducive to the emergence of life, especially human life. This is the anthropic principle, according to which the universe is believed to have the qualities it has in order to allow human existence. Thinking about cosmology according to the anthropic principle, then, presents a skewed perspective as it is limited to the human point of view. Highly trained astronomers, like Elson, are probably not in need of a reminder, in poetic form, of the idea that humanity and our solar system do not constitute the centre of the universe, as, ever since the Copernican revolution, astronomers have had to learn that we are not in any particularly privileged place. The metaphor of the spider-web, hence, is not only able to resist an anthropocentric mentality; it also gestures at the notion that dark matter could be something ominous or threatening to human conceptions.

The effect of such a distortion of reality is a central theme in Timothy Morton's object-oriented ontology, whose quest to find new ways of representing the invisible or massive objects that defy comprehension and conventional pictorial representation shares similarities with Elson's project of thinking through new models of dark matter. Morton's book, *Hyperobjects*, offers guidance for the conceptualization of an "object" like dark matter from a non-anthropocentric viewpoint. Morton starts his book by providing a few examples of what he terms "hyperobjects" and cites a black hole among the first ones (1). On the same page, he explains that:

> [hyperobjects] are *viscous*, which means that they "stick" to beings that are involved with them. They are *nonlocal*; in other words, any "local manifestation" of a hyperobject is not directly the hyperobject. They involve profoundly different temporalities than the human-scale ones we are used to. In particular, some very large hyperobjects, such as planets, have genuinely *Gaussian* temporality: they generate spacetime vortices, due to general relativity. Hyperobjects occupy a high-dimensional phase space that results in their being invisible to humans for stretches of time. And they exhibit their effects *interobjectively*; that is, they can be detected in a space that consists of interrelationships between aesthetic properties of objects. (1)

While Morton never mentions dark matter as an example of a hyperobject, his description suggests that the invisible matter does fall under its definition: dark matter can only be detected through its interaction with other objects, an interaction which only affords a glimpse of the hyperobject dark matter. Moreover, dark matter has a temporality that humans can hardly comprehend. Elsewhere, Morton describes hyperobjects as pertaining to a higher dimension "that makes them impossible to see as a whole on a regular three-dimensional human-scale basis" (70). It is because of all these obstacles to human perception that hyperobjects force us to reconceptualize our ways of thinking about them. Morton cites as examples global warming, planets, plutonium, or the cosmic microwave background radiation: "Like the image in a

Magic Eye picture, global warming is real, but it involves a massive, counterintuitive perspective shift to see it" (49).

Morton further argues that the perspectival shift can and should be effected through the arts. He calls for an art that creates a link between the human and the non-human, and which helps us to deal with hyperobjects. Art should attune its audience to this new reality which is governed by hyperobjects and other non-human entities. He calls the work that art necessarily has to do "demonic" because it alienates us from a once-familiar reality. He concludes his section on the discussion of the roles of art by claiming that art "in these conditions is grief-work. We are losing a fantasy – the fantasy of being immersed in a neutral or benevolent Mother Nature" (196). It is the recognition that we are merely objects among other objects that art is supposed to help us to face. While his views about art and reality are not exactly innovative – many of his ideas about defamiliarization were already expressed in Modernist texts and theorized by Czech and Russian formalists – his efforts to develop similes and metaphors to talk about objects and events that challenge our comprehension can be compared to Elson's use of strange metaphors, such as a spider's web to refer to dark matter.

The refusal to subscribe to the anthropocentric narrative of the universe in Elson's "Dark Matter" also anticipates some ideas expounded in *Hyperobjects*. In fact, her short poem is an exercise in defamiliarization by turning the popular anthropic principle on its head: instead of showing dark matter as attracting and fostering the growth of galaxies and galaxy clusters when the universe was young, she imagines dark matter as a trap – the spider-web – in which galaxies like ours accidentally got caught. The fact that the "unseen filament / Of spider's floss" is the subject of the sentence further contributes to the reversal of points of view. Most popular accounts of dark matter would cast our galaxy as the subject and describe dark matter's behaviour in passive syntactical structures. For example, in his account of the discovery of dark matter, Gott writes: "[Jeremiah Ostriker and Jim Peebles] proposed that [our Galaxy] must be stabilized by a spherical halo of invisible dark matter", not that "a spherical halo of invisible dark matter stabilizes our galaxy" (32). Furthermore, not only is dark matter likened to a hunting tool, but the thing that gets stuck in it – the leaf – is only a side effect of the hunting technique. The notion of the leaf, which happened to get caught in a spider's web, which, in turn, has the purpose of catching flies and other edible insects, underlines the fundamental roles that chance and accident play in the cosmos. Visualizing dark matter as a trap and assigning it (grammatical) agency introduces new ways of thinking about this missing ingredient: for example, the notion that dark matter "suspends" the entire cosmos implies that it plays an even greater role in cosmology than had been assumed until then. In fact, Elson's analogy of the spider-web is not far off later analogies for structure in the universe: as mentioned above, Gott imagines matter to be organized like a sponge or Swiss cheese, with dark matter determining higher and lower density areas (125-130).

The short imagistic poem also reveals a close attention to regularity and form. The poem is written in an iambic metre – the last two lines are in fact an iambic tetrameter split in two, as by caesura. The only irregular line is the second line, containing a series of spondees, thus forcing the reader to slow down and pause on the words "unseen" and "filament", two of the most important words in the poem. Moreover, the repetitive sound effects of /sp/ in "spider", "suspends", and "spinning", as well as the alliterations in /s/, draw the poem together. Lastly, the visual form of the poem on the page is equally striking, lending it an almost perfectly square shape. This close attention to form, making the poem very regular in rhythm, sound patterns,

and typographic shape, stands in contrast to the chaos and whims of chance, which are the subject of the poem. The simplicity and elegance of the poetic form of "Dark Matter" mirror the striving for simplicity and elegance in physics and astrophysics. Astrophysicists have been searching for a simple formula, a Theory of Everything, that encapsulates all known physical laws in one equation. So far, such an attempt has been unsuccessful because the theory of relativity cannot be satisfactorily combined with quantum mechanics.

Elson's short poem, which represents the chaos of a universe ruled by the mysterious dark matter and chance in an elegant, haiku-like poem of only five lines, raises the question as to whether natural and cosmological phenomena can even be accurately represented through a human-made language, be it poetry or mathematics. It could thus be seen as a provocatively ironic comment on mathematics, which forces order onto natural occurrences. Historically, poems about the universe and our place in it have often taken the form of epics, such as Dante's *The Divine Comedy* and Milton's *Paradise Lost*. The condensed "Dark Matter" stands in stark contrast to such texts. It is the author's training in the concise and elegant language of mathematics that might explain the brevity and elegance of the poem, while simultaneously passing judgment on the possibility of embodying the chaos and inscrutability of the cosmos in mathematics.

As mentioned above, while she only has one finished poem on dark matter, Elson grappled more with this mystery in her notebooks. In other notebook entries, which look like poem fragments or draft poems, Elson imagines dark matter as a dark meadow that can only be inferred from the presence of fireflies, the force governing human relationships, and a fish that creates ripples on the surface of a pond (71, 108, 107). One journal entry from October 1993 includes a poem also entitled "Dark Matter". The poem plays with the idea that parts of our world are invisible but can be inferred from the behaviour and properties of visible things:

> Seeing, like that, only purple
> You would understand your world
> From a few iris,
> A few bolts of silk,
> And emptiness.
>
> And knowing the gravity of iris
> You might postulate stems,
> Though green were unimaginable
> And seeing the silk fall in folds,
> A body, though flesh could not be thought.
>
> And speaking in purple
> You might acknowledge still
> The universe outside of sound. (*ARTA* 86)

Here, the search for dark matter is compared to a type of visual impairment which renders all colours except purple invisible. The limited state of perception she describes here is reminiscent of Plato's allegory of the cave, in which chained-up prisoners mistake the moving shadows in front of them for reality, as they have never seen the world outside the cave. In Elson's poem, the person she addresses lives in a limited reality that renders the perception of touch ("silk" and "flesh") and other

colours impossible. While the prisoners in Plato's allegory are oblivious to the larger world outside the cave, the addressee in Elson's poem at least "acknowledge[s]" the "universe outside".

While the imagery in this poem is less ominous or threatening than the image of the spider's web, it still contains a slightly disconcerting thought: rather than dark matter turning out to be merely a concentration of particles possibly already known to astrophysicists (which many instruments for the detection of the mysterious matter take it to be), Elson's image of the extremely restricted vision suggests that the detection of dark matter would open doors to a reality so different as to be utterly disorienting. The detection of dark matter, Elson suggests in her poems, could thoroughly challenge astronomers' view of the universe and our place in it, forcing them to completely rewrite textbooks. Further, not only might dark matter turn out to reframe our understanding of the universe, but her imagery also hints at a certain menace that lurks in dark matter. Elson seems to believe that it has the potential possibly to bring about another revolution in astronomy, one like the Copernican revolution, whose repercussions affected every realm of cultural and intellectual life. The next section studies how others of Elson's poems add, to a universe constituted by spider-webs and iris, a cosmos made up of dancers. It then addresses how these poetic metaphors help to reconceptualize astronomical research and the way we think about the universe.

3. A Cosmic Dance

Elson's astronomy poems also cleverly use puns. Apart from analogies and metaphors serving to represent visually astronomical or cosmological phenomena, puns, as a poetic trope, can also be a tool for scientific investigation. Janine Rogers, in her book about the similarities between science and literary form, includes a short discussion on the fertility of puns in poems, which produce "linguistic instability" (95). She argues that wordplay is a "balance between singularity and multiplicity" and "produce[s] multiple realities", which she compares to the infinite quantum realities of the atom (95). However, while she acknowledges the pun's potency to create new meanings, she does not explore this potency as a mode of scientific investigation. Daniel Brown, on the other hand, in his study of the poetic writings of nineteenth-century scientists, offers useful insights into exactly that. Somewhat like metaphors, puns are playful ways of creating links between seemingly unrelated ideas, but unlike metaphors the links reside in often nonsensical and merely semantic or even just phonetic similarities (88). Thus, in a certain sense, puns follow a similar principle as analogies, but they are more liberating in that they create links between areas of knowledge that do not appear to be connected. He argues that puns "teeter on the brink of nonsense, as . . . the relation between their . . . twin terms, understood literally, is unmeaning" (40). This leads him to point to the fecundity of language: "Truth is seen as relational and latent in language, intrinsic to the riddling phenomena of puns and analogies, which accordingly require an act of mind to bring them to consciousness" (80).

Elson's poem "Constellations" excellently illustrates the hermeneutic possibilities of puns. The short poem challenges the ancient view of the night sky as representing the images of different gods and creatures by likening this view to the rather sinister image of cases displaying dead beetles and butterflies:

> Imagine they were not minor gods
> Mounted in eternal *in memoriam*

> Or even animals, however savage,
> Pinned like specimens upon the sky. (*ARTA* 22; italics in original)

In this first stanza, the night sky with its stars is presented as a dead, two-dimensional display of objects meant for scientific analysis. Quite morbidly, the twinkling stars here become the shiny pins with which insects are held in place in their cases. The second stanza moves away from this sinister image and introduces an alternative way of thinking about the night sky:

> Imagine they were lambada dancers
> Practising their slow seductions
> On the manifolds of space.

Instead of picturing minor gods and mythological animals, Elson invites the reader to think of them as "lambada dancers". "Lambada" is a Brazilian dance that became internationally known and popular in the late 1980s and 1990s, presumably thanks to a widely successful song with the same title by the French group Kaoma, who covered earlier Brazilian and Bolivian versions of the same song. The *OED* defines the lambada as "a fast erotic Brazilian dance which couples perform in close physical contact". In that regard, the "lambada" fits very well with the theme of the rest of this second stanza: based on the definition above, lambada dancers can certainly be described as seductive. Portraying the constellations as erotic dancers for those who study the heavens changes the dynamic between scientific object and scientific observer: no longer merely a passive object subjected to scientific scrutiny, the night sky dazzles and seduces the astronomer. In this new picture, Elson conceives of the cosmos as having a certain power over the astronomer, who cannot help but be attracted by the sensual dance of the stars.

The metaphor of lambada dancers for constellations is strengthened by a pun in "lambada". The choice of the lambada seems peculiar when the salsa or the merengue are much more famous and similarly erotic Latin dances. What motivated Elson to use the word "lambada" here? The word "lambada" may well have been chosen for its similarity to the word "lambda" and for the useful associations that this near-miss pun opens up. In cosmology, the Greek letter lambda (Λ) represents the cosmological constant, which Einstein introduced into his field equations in order to stabilize them and to counter-balance gravity. Then, after Edwin Hubble discovered, in the 1920s, that space is expanding, Einstein's cosmological constant became obsolete and was discarded; the expansion (initiated by the big bang), in fact, worked as a counter-balance to gravity.[2]

The Greek symbol implied in the word "lambada" and its cosmological signification become especially relevant in the third stanza. The double meaning of "lambada / lambda" is sustained throughout the remaining poem, whose sexual overtones are explicit:

> Then in the name of science
> We might ride their studded thighs
> To the edge of our hypotheses,
> Discover there the real constants
> Of the universe:
>
> The quick pulse,

> The long look,
> The one natural law. (*ARTA* 22)

The remainder of this poem depicts a universe that is ultimately knowable but that also seems to tease the astronomer with hidden or false truths. In order to arrive at "the real constants", the astronomer has to think beyond her hypotheses. The allusion to lambda is repeated here: Einstein's cosmological constant, designated by lambda (Λ), turned out to be unnecessary. In fact, astrophysicist George Gamow recorded Einstein as saying that the cosmological constant was "the greatest blunder" of his life (qtd. Gott 27). The adjective "real" to describe the "constants / Of the universe" possibly alludes to the mistaken lambda in early twentieth-century physics. The "real constants" are yet to be discovered and existing hypotheses might need to be discarded. The last line of the poem even suggests the greatest ambition of contemporary physics, also mentioned above: a Theory of Everything. "The one natural law", which Stephen Hawking, in *A Brief History of Time*, promised was at physicists' fingertips, would encapsulate the entire universe in one elegant all-encompassing theory (193).

Like the poem "Dark Matter", the notion of the lambada dancers also invests the night sky (or the constellations) with an agency that it rarely possesses in popular accounts of cosmology. Just as dark matter is cast as the grammatical subject of the sentence in the previous poem, the night sky, far from being a passive research object, is here actually responsible for making itself understood. It is relevant to quote Morton again: "The more we know about radiation, global warming, and the other massive objects that show up on our radar, the more enmeshed in them we realize we are" (160). Like Bruno Latour's Actor network theory (ANT), Morton's object-oriented ontology imagines a network or a mesh in which humans are just some among many objects. The dichotomy between subject and object, or astronomer and night sky, is broken down and reconfigured. So, in Elson's case, thinking of the universe in terms of lambada dancers seducing astronomers is an exercise of the imagination that seeks to redefine the relationship between scientist and research: "If . . . the universe ~~reveals itself shows~~ appears to you" (*ARTA* 83).

What new light, then, does the pun in "lambada" throw on "lambda", or the cosmological constant, or constellations? One of the main connotations of dancing is movement, and in the case of the lambada, rapid movement. This image of a dynamic or energetic night sky full of movement ties in with the new cosmology: since Edwin Hubble's discovery of the expansion of the universe in the 1920s, the notion of a static, eternal, and fixed universe has disappeared and the opposite view of the cosmos has been strengthened with every new theory. Thus, the discovery of the cosmic microwave background radiation in the mid-1960s, the inflationary theory proposed by Alan Guth in the 1970s, according to which the early universe experienced a period of exponential growth, and, most recently, the discovery of the accelerated rate of expansion in the 1990s, which is designated by the updated cosmological constant, or dark energy, have further contributed to a vision of a lively cosmos, not filled with ancient gods and dead animals ("pinned like specimens upon the sky"), but rather with "lambada dancers".

The idea of an ever more complex universe is also discernible in Elson's poem "Girl With a Balloon":

> From this, the universe
> In its industrial age,

With all the stars lit up
Roaring, banging, spitting,
Their black ash settling
Into every form of life,

You might look back with longing
To the weightlessness, the elemental,
Of the early years.

As leaning out the window
You might see a child
Going down the road,
A red balloon,
A little bit of pure Big Bang,
Bobbing at the end of her string. (*ARTA* 12)

Here, the current age of the universe, which is commonly called the age of the stars, is described as the industrial era. Indeed, the onomatopoeia in the fourth line and the image of "black ash" suggest images of a noisy and dirty factory and heavy machinery. The stars, in contrast to the elegant lambada dancers in "Constellations", are here depicted as polluting space with "black ash". The romantic notion that we are made of star dust – carbon, a necessary element to life, is in fact created in stars – is undermined here: we are made of "black ash" instead. In fact, the poem reveals a certain nostalgia for an earlier and simpler age of the universe, an era before even the first stars appeared. The loud industrial age of the stars is compared to a past and calmer stage of "weightlessness". The first chemical elements in the universe were helium and hydrogen (Kragh 181). Heavier elements, such as carbon and metals, were only created when the first stars exploded. Although helium is not directly mentioned in the poem, it is evoked in the last lines, which describe a girl holding a balloon – the word 'bobbing' suggests that the balloon is filled with helium.

The contrast between the first stanza, with its unpleasant images of a loud and dirty factory, and the last lines of the poem, which connote simplicity and elegance, as well as an image of childhood and play, suggests a sense of frustration with the current cosmos. While "Constellations" is more celebratory in its tone, "Girl With a Balloon", to some extent, expresses the struggles of stellar astronomy: not only has structure in the universe become much more complex, but astronomers' understanding of the cosmos has also become vastly more complex, making the science ever more intricate. Studying the earlier stages of the universe, by contrast, is – perhaps unfairly – represented as a more straight-forward task.

Katherine Hayles, in *The Cosmic Web*, analyzes the interactions between literature and science and starts her study by observing that different epochs conceived of the cosmos utterly differently. Thus, while the universe has been thought of by the Deists in terms of clockwork and by romantic pantheists as an animated organism, Hayles identifies the predominant image of the modern cosmos as one of a dance. She draws parallels between the Romantic notion of an organism and the twentieth-century one of a cosmic dance based on the common idea of the "dynamic, fluid nature of reality" and that the "whole cannot adequately be represented as the sum of its parts" (17). If this notion of fluidity, instability, and change was based on the belief in a living force in the Romantic era, these features are nowadays due to the "breakdown of universal objectivity" (18). It is doubtless this uncertain apprehension

of reality and the belief in a dynamic and changing cosmos that led Hayles to adopt the phrase "cosmic dance" to describe our current conception of the universe. One of the most distinct features of twentieth-century thinking – the blurring of the lines between subject and object and the limits to our knowledge this entails – is in line with a Romantic philosophy, which was marked by a belief that reality could not be apprehended by rational thought alone and that the imagination played an important role in the study of the world as well (Hayles 18).

Thus, Elson's lambada dancers conform to Hayles' conception of the twentieth-century cosmos as a dance: not only do the lambada dancers suggest that the imagination is as important a tool in scientific investigation as rational thought; the way the lambada dancers and the astronomers are played with in the poem also suggests that there is no strict separation between object and subject. The notion of the dance also underlines the idea of the "dynamic, fluid nature of reality" (Hayles 17). So, poetry and a science like Elson's can, to a certain extent, be seen as generically complementary. In fact, both poetry and astrophysics are concerned with identifying patterns and organizing information. As noted earlier in this article, astronomers spend much of their time sorting through the data they received from the telescope or other instruments of observation. In that regard, Elson was trained in looking for relations and proportions between phenomena, an activity that poets are well-versed in, too. In her poetry, as in her science, Elson seeks patterns, analogies, models, and parallelisms in the world.

4. Conclusion: The Investigatory Properties of Poetry

The group of poet-scientists writing and working in the second half of the twentieth century is small, and so it is helpful that one of them voiced his views on the relationship between science and poetry. In fact, while the Czech immunologist and poet Miroslav Holub generally agrees with Elson in that the two disciplines can inform each other, he diverges from Elson in his belief that his scientific training is of advantage to his poetry. Here is Holub writing in 1998 about how poetry is enriched by a scientific mentality:

> My argument is that there may be something like a scientific approach incorporated into something which may still be poetry, but not vice versa. Science in poetry may be represented by the hard-centred scientific thinking, by the elegance or incisiveness of scientific questions, and temporary solutions, but not by interpretations or versifications of scientific data of the sort seen in many learned magazines where biochemists may publish verses on the action of prostaglandins or physicists on quarks. (11-12)

Holub believes that it is the "hard-centred scientific" attitude, rather than scientific content, that enriches poetry. In this account, poetry seems to learn from the sciences a certain focus and rationality. Contrary to Roald Hoffmann, who claims that the composition of poetry trains the researcher's scientific writing skills, Holub sees the influence as running the other way: the scientific attitude improves poetry (Hoffmann 406). The rather dismissive description of what sounds like the kind of poetry Elson wrote – "interpretations or versifications of scientific data" – makes it clear that Holub has little patience for poetry that explains scientific content. Later in his essay, Holub adds that "scientific allusions in a poem . . . are some kind of anchors in the high seas of feelings, sympathies, hates, impressions, and memories" (23). Holub's

reductive description of what sounds like romantic poetry would indeed benefit from the contrast that a scientifically-minded poet would bring to it. Thus, while Holub and Elson agree that science in poetry is recommendable, they have divergent opinions on which of the two disciplines is improved by the other one.

Holub finds his poetry augmented by his scientific mind because he sees an opposition between poetry and science. This assessment of the intersections between poetry and science are not applicable to Elson's work because she does not conceive of the two as opposed to each other, but rather as complementary. My close readings of Elson's astronomical poems have shown that rather than astronomy acting as an "anchor" to her poems, her poems have unmoored her astronomical investigation. By turning the popular scientific narrative on its head and by giving celestial phenomena like dark matter and constellations agency, by imagining lambada dancers and traps in the night sky, the poet-astronomer uses the medium of poetry to shake up her astronomical research, to look at her work from a different viewpoint.

As Elson's science precludes the possibility of creating controlled experiments in a laboratory, she conducts thought experiments in her poetry instead. Her thought experiments, however, are more creative and involve more elements than merely thinking through the implications of a given situation, which, for example, is the purpose of a thought experiment like Schrödinger's Cat. Elson's poems are not merely exercises of her deductive reasoning skills, but offer her a space where she can rely on her intuition and imagination and experiment with perspectival shifts and different visualizations of cosmic forces and phenomena.

Elson's poems help her astronomical work by raising difficult, elusive questions, which emerge through the new relationships that she imagines between humans and the cosmos and astronomy and astronomers. What if galaxies are the by-product of dark matter, which fulfils a different role entirely? What instruments should be designed to detect dark matter? What if observers of the night sky are being duped by the constellations? In the opening poem of Elson's collection, the poet writes about how easily she can get lost in the innumerable data about the universe, "[a]nd I forget to ask questions, / And only count things" (9). In fact, her poems serve Elson as a space where she can ask the right questions and where she can reflect on her at times mechanical astronomical investigation, which, unfortunately too often consists of many hours of making sense of and sorting through data on a computer. What Elson's example demonstrates, then, is the investigatory properties that poetry can have. Instead of viewing poetry and science as two disparate activities, I have suggested that, in the case of Rebecca Elson at least, poetry and scientific research can both interact fruitfully and perfect one another.

Notes

1. The information presented in this introduction to dark matter is taken from a few different popular astronomy books. My sources are Richard Gott's *The Cosmic Web* (2016), Jeremiah Ostriker and Simon Mitton's *Heart of Darkness* (2013), Iain Nicolson's *The Dark Side of the Universe*, and Simon Singh's *Big Bang*.

2. A new development in the 1990s complicated the matter of the cosmological constant: thanks to the observation of type Ia supernovae, whose specific luminosity allows them to be used as standard candles for extragalactic distances, astronomers discovered that the universe is in fact expanding at an accelerating rate. The cosmological constant, or rather dark energy, as astronomers came to call the mysterious force tearing the universe apart, was studied again.

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