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Chasing Light: The Experience of Riding a Beam through Imagination and Physics

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Abstract

As Einstein grew up to be sixteen, he asked himself what the path of a beam of light would be if he could run along it at the same speed. This mental exercise was a private one which, decades later, he recalled in his own recollections, and has developed into one of the most recounted stories in contemporary culture, a story that serves as the foundation for the special theory of relativity. The present paper does not look at this "chase" just as a historical chapter in the life of physics, but as a kind of literary event: a story of desire, movement, point of view and wonder, a story of the writing of physics about light that has a much longer history than the game it describes. The paper is informed by literary criticism, the philosophy of thought experiments (Brown, and by the history of science and literature, and draws on the imagination of poets from the Book of Genesis through Dante and Milton to Vaughan, Pope, Blake, Wordsworth, Keats, Shelley, Whitman, Dickinson and Hopkins, envisioning the nature of light, as a god, as measurable, and as a mystery that is not measurable. It then returns to Einstein's beam and to contemporary stories like Gamow's Mr Tompkins in Wonderland (1940) and Lightman's Einstein's Dreams (1993) to demonstrate how the imaginative ride on the beam has been made accessible to the common reader. The paper proposes that the pursuit of light is part of a common practice of imagination that began since the Romantic era (Snow, 4), in which poetry and physics collide. It ends with the statement that the beam of light is a threshold image, a boundary that limits human perception and inspires the mind to go beyond it.

Keywords: light, imagination, thought experiment, Einstein, relativity, Romantic poetry, literature and science, wonder, metaphor

There are few images as international as the beam of light. In the sciences it is a phenomenon to be measured, refracted, polarised and timed; in literature, one of the oldest metaphors for knowledge, divinity, truth and hope. "Chasing light" thus means two things. It can talk about the lab pursuits of the speed of light as they were conducted in the seventeenth century by Ole Rømer, or in the nineteenth by Michelson and Morley, and it can talk about the spiritual and aesthetic yearnings of poets over the centuries (Zajonc, 5). My aim in this paper is to explore the intersection of those two senses, the time when a young physicist envisioned himself alongside a beam, and the extended history of literature that made that conception possible.

As happens so often, the narrative has been repeated a million times. In his Autobiographical Notes, Einstein remembered that at age sixteen he had encountered a paradox: if he could run toward a beam of light at the speed of light, he would see the light as an electromagnetic field at rest, oscillating in space, but moving nowhere (Einstein, 53). But no frozen wave of this kind

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seemed to have ever been found, either in the experience, or in Maxwell's equations. This puzzle was later presented as the seed from which the special theory of relativity developed, which Einstein published under the mild banner "On the Electrodynamics of Moving Bodies", in 1905. The anecdote has been recounted so many times that it has become a sort of origin myth for modern physics (Pais, 131).

The literary scholar is not only asking whether the anecdote is historically accurate—a question to which historians of science have devoted attention (Norton, 50), but what the form of the story is. It tells a story and has a protagonist, a quest, a vehicle and a revelation. It asks the reader to be at a place, feel a speed, turn a corner to see a wave sideways, and to be surprised when the picture he/she is expecting doesn't show up. That is, it operates in exactly the same manner as literature, which operates through imagined experience. Arthur I. Miller has suggested that visual imagery was at the heart of Einstein's imagination and has questioned the distinction between "scientific" and "artistic" imagination, arguing that it is not as clear-cut as one might assume from disciplinary habits. In a similar vein, Max Wertheimer, who spoke to Einstein about the development of relativity, referred to the fact that the theory was not an entirely formal deduction, but rather a reconstruction of a mental picture (Wertheimer, 171).

If the beam chase is a tale of imagination, it's part of the long string of stories about light. The Hebrew Bible opens with the creation of the light, and light is one of the predominant symbols of Western and Indian literature. The poets did not measure light, they theorized it through images, and in so doing, they set expectations for future readers, including scientists. The classic study by M. H. Abrams demonstrates how the Romantic poets adopted a new image of the mind as a lamp rather than the older image of the mind as a mirror, and how the mind is an active source that illuminates the world (Abrams, 60). In a sense, Einstein's thought experiment is the ultimate version of this Romantic idea: The mind is not just a reflection of the beam; it is riding it.

Literature and science have been said to be at loggerheads. C. P. Snow spoke of a division between "two cultures" who could no longer converse with one another. However, recent scholarship has focused on exchange and not separation. Gillian Beer revealed links between Victorian fiction and science, Marjorie Hope Nicolson illustrated how poets and scientists were developing ideas in the same circles in the eighteenth century, and Richard Holmes labelled the Romantic period as an "age of wonder" in which "poets and experimenters were in the same circles." This paper extends that work, taking a single, shared image as its point of departure.

Thought experiment: An experiment carried out by thinking instead of doing it in the lab. The pioneer of systematic naming of such experiments, Ernst Mach, claimed that they rely on a memory bank of experience and reactivate it for use in testing the implications of an idea. Some later philosophers have been very critical regarding the way knowledge is gained from a thought experiment. James Robert Brown has claimed that certain thought experiments provide a sort of direct knowledge of the laws of nature; a "laboratory of the mind" where reason is a way of seeing. By contrast, John D. Norton has claimed that all thought experiments can be "reconstructed" as ordinary arguments with "picture talk." The middle ground has been

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advocated by Tamar Szabó Gendler, who proposes that the imaginative particulars of a thought experiment have real cognitive work doing their work, which is that of reorganizing what we already know. In his expansive study, Roy Sorensen considers thought experiments to be a family of practices, ranging from physics to ethics to fiction (Sorensen, 6).

To any reader of literature this is a conversation that rings very true. It is like the old debate about the conferring of knowledge or the mere enjoyment of pleasure in poetry which started with Plato's doubt about the poets and continued with Sidney and Shelley's arguments for poets. Poets are "the unacknowledged legislators of the world," Shelley suggested, because poets are able to view relations that could not be assembled by reason (535). Coleridge made a difference between fancy, which can only shuffle around fixed images, and imagination, which "dissolves, diffuses, dissipates, in order to re-create". Einstein's beam chase is an instance of Coleridge's conception of imagination: not only does it take a boy by the hand and place him beside a wave, it also dissolves the old image of absolute space and absolute time and sets the stage for a new one.

Close reading of details of the chase reward. The elements that Einstein recalls are: a pursuer moving at the speed of light, a beam that should be stationary for him, and a feeling that there is something wrong with this picture (Einstein, 53). The third is the most significant, the most literary. Einstein is not saying that he worked out a contradiction, rather, in effect, the frozen wave was too difficult to believe, too much a challenge to intuition. According to Norton, the exact logical structure of the thought experiment is hard to reconstruct, and Einstein might have attributed its significance to it later in retrospect (Norton, 134). However, as a story, the thought experiment is effective because of a defamiliarisation, to use the terminology of literary critics; it throws an unremarkable premise, the possibility of ever 'catching up with' anything that is moving ahead of you, into a spotlight and makes it look different.

The scene's imaginative economy, likening it to William Blake's famous declaration that great truths may be revealed in small facts, is the subject of this section's exploration. This section explores the economy of the imagination in the scene, as Blake states, vast truths may be seen in minute particulars. In "Auguries of Innocence", Blake invites the reader to consider a possible scenario of perception:

To see a World in a Grain of Sand
And a Heaven in a Wild Flower
Hold Infinity in the palm of your hand
And Eternity in an hour
(Blake, 490)

Blake's juxtaposition of infinite and finite, eternity and hour, is turned upside down. Einstein's chase does something similar to an inversion. The mostspeedy of all things in the universe is light, which is thought to be stopped, and that impossibility means that time and space must stretch and shrink. Both texts teach to treat own habitual measures as provisional. The second element of the chase is point of view. At the heart of Relativity is the theory of observers: one observer's observation of simultaneity can be different from another's (Einstein, 895). Peter Galison has demonstrated that Einstein's concept of simultaneity's background was established

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by the real-life problem of synchronizing clocks on the railway and telegraph lines, in a world of signals sent and received (235). The novel had addressed the same issue as a human problem for long. According to narrative theory, the same story can be seen from different perspectives, and there is no one who sees the entire picture. When Einstein rode along on the train, he was also an observer who could only see what he traveled at speed. The moral of the story is that there is no privileged seat in the universe as modern fiction implies there is no privileged seat in a story.

The third feature is wonder. These are concepts Einstein often expressed, and he referred to the experience of the mysterious as the source for all true art and science (Einstein, 11). The philosophical tradition of wonder dates back to Plato and Aristotle, who took it as the starting point of philosophy, down to the Romantic poets who tried to safeguard it against the stifling rigor of analysis (Holmes, 310). The thought experiment creates wonder through the "edge of the known" technique. The beam-chase has become a favourite in the classroom, and a popular book; it provides a novice with a chance to experience, for a time, the thought of the discoverer. Lastly, the chase is about failure that eventually becomes success. The pursuer never catches up with the beam; light cannot be slowed down by any material body. It is an old literary form, perhaps the oldest, in which the quester's goal moves away as he moves toward it, from the medieval Grail romances to Romantic poems of frustrated desires. The scientific mind moves forward, Bachelard noticed, in the struggle with the images it encounters, by the identification of the barriers that these images put in the way of knowledge (Bachelard, 26). This is the problem with Einstein's frozen wave: It's a clear picture that needs to be set aside. But it was a thing to be imagined first before it could be conquered. The thought experiment is thus an exercise in imagination double-shocked, that is, creating a picture, then tearing it apart.

Long before light was a quantity, there was light with a meaning. Light is first created in Genesis 1.1 - it is created by the spoken word: "Let there be light: and there was light". The sentence is notable for its conciseness. The light exists before creation of the sun and the stars, which are created on the 4th day; therefore, it does not seem to be a property of objects but a precondition of all seeing. Arthur Zajonc has proposed that this division of light from its sources plagued Western thought for centuries, and that light became a natural symbol for mind and spirit (Zajonc, 15).

Illumination is a metaphor for knowledge and liberation in Indian traditions, too, and the Upanishadic prayer to be led from darkness to light reflects this intuition. The symbolic interpretation transcends the limits of Dante's Divine Comedy. The Paradiso is composed almost entirely of light: the souls of the blessed seem to be fire and sparks, and the pilgrim's journey is conducted by the degree to which he is able to carry brightness. At the end of the canto, Dante tries to describe the vision of God itself as a light that blinds and fulfils:

O grace abundant, by which I presumed
To fix my sight upon the Light Eternal,
So that the seeing I consumed therein!
(Dante, 658)

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It is a problem that Einstein would face in a very different register: the approacher of the light source who discovers that "ordinary seeing" is changed. The gaze is “consumed” for Dante because it is not possible to capture the infinite with a finite gaze. The young Einstein’s imagined gaze is unsuccessful, for no observer can be in the frame of light. In both, it is the extent of vision that reveals the nature of reality. This does not imply any historical influence—only that the way of light is also the way of the limits of the self (Abrams, 380).

Invocation to the Holy Trinity is one of the most famous in English poetry, from the third book of Paradise Lost by John Milton written in the seventeenth century when optics was emerging as a mathematical science. Light is the subject of Milton's direct discussion in the epic:

Hail holy Light, offspring of Heav’n first-born,
Or of th’ Eternal Coeternal beam
May I express thee unblam’d? since God is light,
And never but in unapproached light
Dwelt from eternity, dwelt then in thee,
Bright effluence of bright essence increate.
(Milton, 56)

Milton's lines are theologically circumspect, he queries whether he can even mention light without sinning. But they are also very contemporary in their interest in the nature of light. Is it a “beam” of God's coeternal nature, or an “effluence”, that is, something that pours out? The question reminds me of the controversies among scientists of Milton's own century in the 19th that questioned whether light was a substance, a motion, or a pressure transmitted through a medium (Zajonc, 86). The term, “unapproached light”, taken from the New Testament, is particularly poignant to the current investigation. Milton's light cannot be approached, Einstein's light cannot be caught. In both, the beam is a line that humans can think about, but never cross.

The poet's blindness imbues the invocation with a personal touch. In the same text he bemoans the fact that “light revisit'st not these eyes,” requesting an “inner illumination,” to make the world of darkness out of it seem bright. The poem thus shifts from the physical to mental light, from the eyes to the imagination. The movement is anticipatory of the logic of the thought experiment where inner vision takes the place of observation. It has been pointed out that Milton's universe, both its distances and its movements through chaos, echo Galileo's universe which opened up through his telescope, and which Milton does mention in the poem (Nicolson, 7). In Milton's epic, imagination is a means to traverse places that no human body could traverse.

Light had been treated more intimately and paradoxically by the Metaphysical poets of the same century. The first vision in Henry Vaughan's “The World” is an image of light that is a condensation of all time:

I saw Eternity the other night,
Like a great ring of pure and endless light,
All calm, as it was bright;
And round beneath it, Time in hours, days, years,

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Driv'n by the spheres
Like a vast shadow mov'd; in which the world
And all her train were hurl'd.
(Vaughan, 227)

Vaughan's stanza is a beautiful poetic illustration of the connection between light and time. Time is a shadow moving under a ring of light, calm, untroubled, in which everything hangs motionless and unperturbed, and the turning spheres move. In the poem the vantage point allows one to see time as a whole, as it was given to an ideal observer by classical physics, but as it would be denied by relativity. In Einstein, Vaughan's vision highlights the long cultural history of believing in an absolute frame. The poet is not subject to time, and knows the whole of it. In Relativity, by contrast, all the observers are in time, and move with their own clocks (Einstein, 893; Galison, 255).

There is also the Metaphysical habit of the "conceit", which is a lengthy comparison, sometimes quite surprising, which also has associations with the thought experiment. In Metaphysical poetry "the most heterogeneous ideas are joined by violence" is the well-known complaint of Samuel Johnson. But the yoking is part and parcel of a thought experiment when it attaches a boy to a bicycle or a passenger to a train and rides with electromagnetic waves. Both modes of imagination rely on the boldness of the unlikely likeness, and both delight the reader with an unexpected likeness (Miller, 258). In this respect, the poetry of the 17th century trained just the imagination needed by the physicist of the 20th century.

In 1704, Isaac Newton published his Opticks, a work which transformed the poet's conception of light. White light is made up of colours which can be spread apart using a prism and then brought together again, Newton showed, and the refraction of each colour is a fixed amount and can be measured. In the eighteenth century, poets and writers eagerly embraced these innovations, incorporating the prism, the spectrum, and the seven colours of the rainbow into their poetry (Nicolson, 33). Newton was elevated to the status of a quasi god and Alexander Pope's proposed epitaph for him reflects the spirit of the time:

Nature and Nature's laws lay hid in night:
God said, Let Newton be! and all was light.
(Pope, 808)

The first two lines are specifically a reference to Genesis. Newton's achievement is explained as a second creation, where God created light, Newton created intelligible light. The brilliance of the epigram is its double meaning of light: not only the physical light but also the mental light, the enlightenment as the one that illuminates itself. To the imagination of the Augustans, there was, of course, no difference between measurement and wonder; to measure light was to celebrate its creator (Nicolson, 135).

This harmony was starting to disintegrate by the end of the century. William Blake saw Newton as the symbol of a mechanistic perspective which deified the material and abstract particles of the living world. In one of his notebook poems he compares the atomic theories of Democritus and Newton to the vision of the spirit:

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The Atoms of Democritus
And Newton's Particles of light
Are sands upon the Red sea shore
Where Israel's tents do shine so bright.
(Blake, 477)

Blake refuses to acknowledge that there are not particles, and he puts them in a bigger context and sees them as the pebbles in the path, a shining tent in the firmament of a spiritual people. The poem is an anti-genre statement against one way of looking at things. Blake's well known prayer "keep me from single vision and Newton's sleep" reveals the same. (Blake, 722) It was not science per se but physics being identified as the whole world that Blake took exception to. It is ironic that Einstein's later work should also challenge the Newtonian notion of absolute space and time, but not in the way that Blake did, but more carefully.

William Wordsworth was more ambivalent. In the Prelude, he remembers his school days at Cambridge, from the window of his room where he saw the statue of Newton in the chapel of Trinity College:

And from my pillow, looking forth by light
Of moon or favouring stars, I could behold
The antechapel where the statue stood
Of Newton with his prism and silent face,
The marble index of a mind for ever
Voyaging through strange seas of Thought, alone.
(Wordsworth, 95)

The lines were inserted in the later version of the poem and depict Newton as a lonely traveler, an explorer of the mind. The expression "voyaging through strange seas of Thought" is very close to the nature of a thought experiment. The scientist moves down without moving his feet, just like Einstein later traversed with a beam as he sat in a classroom in Aarau. While Wordsworth was concerned about the applications of science, he was also able to see in the scientist a like mind in his imagination. (Holmes, 318) The prism in Newton's hand is a symbol of the power of the mind to divide light, and to look into it and find an order he did not expect.

John Keats is the most acerbic of the Romantic complaints. Keats and Charles Lamb are said to have met at the "immortal dinner" in December 1817 that was given in honour of the painter Benjamin Robert Haydon in which they concluded that Newton had destroyed the poetry of the rainbow by reducing it to the prismatic colours (Hughes-Hallett, 158). "Keats revisited the notion in his narrative poem Lamia:

Do not all charms fly
At the mere touch of cold philosophy?
There was an awful rainbow once in heaven:
We know her woof, her texture; she is given
In the dull catalogue of common things.
(Keats, 473)

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The term “philosophy” is used in this place as a term for natural philosophy, the earlier name for physics. The complaint is that the world of the rainbow is emptied of awe, when it has become known as "refraction": it becomes "the dull catalogue of common things". Keats' phrase was later picked up by Richard Dawkins, who used it as the title of a book debating the opposite side of the argument—that science actually enhances rather than undermines wonder. This controversy lives on. Although a miracle is not a word that Einstein ever used, his own testimony is closer to Dawkins than to Keats: he wrote that the world's 'wonders' are its own 'comprehensibility,' and that the scientist's 'emotional reaction to the mysterious is the root of all serious research' (Einstein, 39).

At the end of the nineteenth century, poets were still debating the benefits of scientific looking. The poet Walt Whitman’s short poem, “When I Heard the Learn'd Astronomer,” sets the Keatsian complaint in an American context. The speaker is seated in a lecture hall filled with “proofs” and “figures”, charts and diagrams, until he is no longer able to take them:

How soon unaccountable I became tired and sick,
Till rising and gliding out I wander’d off by myself,
In the mystical moist night-air, and from time to time,
Look’d up in perfect silence at the stars.
(Whitman, 228)

Whitman's poem is frequently thought to be anti-scientific, but his last gesture is more a shift in mode than a rejection of knowledge. The speaker departs the lecture, enters the stars in silence, as light comes from vast distances. The poem chooses to seek out feelings rather than calculation, a preference that is also that of Einstein, who writes that he thinks mainly in pictures and emotions, not in words and concepts (Miller, 243). Lecture hall and night air don't have to be at odds; the thought experiment brings the night air into the lecture hall.

Emily Dickinson, gave to light an unusual weight and texture. The spirit is burdened by the winter light in one of her most highly praised poems.

There’s a certain Slant of light,
Winter Afternoons –
That oppresses, like the Heft
Of Cathedral Tunes –
(Dickinson, 118)

There is such heft in Dickinson's poem to light; it is not abstractly medium, but physical and emotional weight. The angle of its “slant” is what's important. This focus on the angle of light, the angle of relation between the beam and the observer, makes the poem an unlikely contender for affinity with relativistic thinking, where what is perceived is dependent on the frame of the perceiver. Dickinson's light does not just shine on the world, it changes the person who receives the light. The observer is a part of the phenomenon being observed.

Conclusion

This paper has journeyed with a beam of light across scripture, poetry, philosophy and physics. It originated with Einstein's young idea of riding on a light wave, rejected for its own reason and accepted for its own reason, and it revolutionized modern science. As a literary work, that

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thought experiment has elements of a narrative: there's a protagonist, there's a quest, there's a point of view, there's a moment of surprise, there's a revelation. It relies on the power of imagination as he described it, the ability to break down old pictures and recreate new ones. This ability has been developed over many centuries as witnessed in the poetic tradition. The word of creation was light, which Genesis made light; which Dante made the goal of vision; which Milton questioned, and called "unapproached"; which Vaughan saw as a ring of light above the moving shadow of time. During Newton's time, Pope praised the scientist as the second creator of light, Blake was against the vision of particles and Keats lamented the unwoven raindrop. But Wordsworth saw in Newton another traveller through the weird seas of thought, and Shelley made the prism's lesson a symbol of life's staining the white radiance of eternity. Whitman, Dickinson, Hopkins and Tagore continued the dialogue in the modern era with a focus on the subjective connection between the observer and light.

From this study three conclusions can be drawn. First, the dividing line between the scientific imagination and the literary imagination is not as rigid as the "two cultures" would have it. The thought experiment is a narrative format, and literature is a protracted rehearsal of the practice of imaginative experience. Secondly, the image of light has been a threshold over and over again; it is the limit of human sight in the poets Dante and Milton, the limit of absolute time in Vaughan, and the limit of attainable speed in Einstein. In each case the limit gives rise to an understanding and not to a blockage. Thirdly, Keats' and Whitman's fear—that explanation kills wonder—is not substantiated by the history of light. The more light has been understood, the morestrange and marvellous it appeared. The beam chase is an enriching interdisciplinary dialogue between students and teachers of English. It can be used to demonstrate the way metaphor, perspective and narrative work beyond literature and how scientific discovery relies upon imagination, which the humanities hold and develop. Today, a series of writers, including Gamow and Lightman, have already shown how to make the most bizarre of physics ideas emotionally understandable through fiction. A more thorough investigation could be carried out to explore the image of light in literature in India (Hindi and Sanskrit and other languages) and how this could be useful to the international dialogue between poetry and physics. Finally, to chase light is to know that one will never be able to catch it. This is the law of relativity and this is also the teaching of the poets. The pursuit remains out of reach, unattainable, and knowledge is gained through the pursuit itself. Imagination goes to the end of the journey, imagination makes the journey possible.

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