

Critiques and Contentions

Chasing the Light: What Happened to the Ancient Theories?

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Abstract: In the course of contemporary investigations into the history of optics, it is claimed that the study of light in antiquity was subordinated to the study of sight. Though previous scholarship allowed some conceptual space for an autonomous study of light, such an approach remains a largely unexplored possibility. This essay investigates further the possibility of a luminocentric as opposed to the oculo-centric approach to ancient optics. On the basis of evidence from the Platonic *Timaeus*, it argues for the existence of a proper physics of light in the ancient world. If the argument is correct, the ancient physics of light ought to be part of a comprehensive and systematic history of optics.

I
Light has captivated the human imagination since the dawn of civilization. Its nature and its properties have captured the interest of scientists, philosophers, theologians, and poets of old. In celebrated lines from his *Farbenlehre*, Goethe echoes something of the perennial human fascination with light and its sight:

Were not our eye another sun,
How could we contemplate the light?
Did God's own power not within us run,
How could we share in God's delight?¹

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¹ Johann Wolfgang von Goethe, *Farbenlehre*, quoted in Paul Kalligas, *The "Enneads" of Plotinus: A Commentary*, trans. Elizabeth Key Fowden and Nicolas Pilavachi, 3 vols., Vol. 1 (Princeton, N.J.: Princeton Univ. Press, 2014), p. 217. Fowden and Pilavachi's translation of the poem is notable for its sensitivity to the philosophical and metaphysical connotations.

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The luminocentrism of Western culture did not escape the attention of twentieth-century historians. In the words of David Lindberg, premodern thinkers

regarded light as a central feature of the world—at once a transcendental reality and a physical agent, one of the fundamental principles of cosmogony and epistemology, the source of life and movement, and a powerful theological symbol. This tradition goes back to antiquity, particularly to Plato, who made heavy use of light symbolism in his theory of knowledge and other aspects of his philosophy. Light metaphors also pervade the Bible and patristic literature, largely through Platonic influence.²

This fundamental role of light as a key element in deciphering the nature of the world might provoke a feeling of accord among some in the world of quantum and relativity physics. In his *Light: A Very Short Introduction* Ian Walmsley does indeed suggest some kind of familiarity—if not affinity—between pre- and postmodern concepts of light. Today we understand light in post-Einsteinian terms:

Einstein, by contrast [to Newton], places light at the centre of space. For him, it defines space and time by virtue of setting the speed limit for signals sent from one part of the universe to another. The fact that there is a finite maximum speed turns out to make space and time inseparable. Einstein's theory of relativity teaches us that we cannot think of the one without the other.³

But for medieval thinkers, too, understanding the nature of light was critical to understanding the world. A remarkable example is Robert Grosseteste's special treatise called *De luce*, which understands light as the limit of the physical world and defines it, famously, as “the first corporeal form”:

For Grosseteste, light defines space by its propagation instantly throughout the universe. Without light, there is no space, and therefore no forum in which events can take place. Matter, and thus the spatial extension of objects, are coupled to light, but cannot be separately defined. This intimate connection between light, space, and matter—in Grosseteste's hands amenable to quantifiable description—informed the development of ideas regarding cosmology in the subsequent centuries.⁴

Walmsley is not the first to notice the striking resemblance between Grosseteste's and Einstein's notions of light as limit. Scholars of Grosseteste have made similar observations.⁵ One may here prudently remark that we should not be too eager to stress similarities. But we cannot deny that Grosseteste's concept of light as a definiens of space is much closer to the post-Einsteinian view of light than, for example, Newton's was. And this is enough to open a bridge between pre- and postmodern physics—or, as regards light in particular, between pre-Keplerian and post-Einsteinian optics. For some of the best Grosseteste scholars have stressed that the core idea of the *De luce*—light as the first and most refined corporeal form, coextensive

² David Lindberg, “The Genesis of Kepler's Theory of Light: Light Metaphysics from Plotinus to Kepler,” *Osiris*, 1986, N.S., 2:4–42, on p. 9.

³ Ian Walmsley, *Light: A Very Short Introduction* (Oxford: Oxford Univ. Press, 2015), p. 84.

⁴ *Ibid.*, p. 83.

⁵ See Iain MacKenzie, *The Obscurism of Light: A Theological Study into the Nature of Light* (Norwich: Canterbury, 1996), pp. 1, 4.

with matter—has immediate roots in Arabic and Jewish thought, echoing the thought of Plotinus and Proclus. Others have highlighted the patristic context of Grosseteste's thought-world, laying particular emphasis on the hermeneutical tradition of the book of Genesis, especially Basil's *Hexaemeron*.⁶ If we look briefly into Basil's *Hexaemeron* and its immediate context, we will find clear antecedents of Grosseteste's fundamental insight about light as the first sensible form and as coextensive with matter.⁷ But the Jewish-Christian exegesis of the Genesis six-day Creation narrative, the so-called hexaemeral literature, of which Basil's work is but one celebrated example, did not emerge in a vacuum. It took up themes, ideas, and—crucially—the key cosmological and physical theories of the Greeks, which Christian thinkers grafted onto a biblical context.⁸ In an epoch-making study, David Runia showed how the beginnings of the hexaemeral tradition, as we know it through Philo's *De opificio*, received and transformed the physical and metaphysical insights of the Platonic *Timaeus*, mediated through Stoic, Aristotelian, and Neo-Pythagorean influences.⁹ Other seminal studies have shown how the ancient physics of light survived in late antiquity and was transformed by later Christian thinkers such as Philoponus, whose genius until recently was largely unrecognized.¹⁰ Their work was then transmitted to the Middle Ages through the Arab and Byzantine world.¹¹ Thus, for the contemporary thinker Grosseteste's *De luce* opens a window with a view to the premodern physical world. It is a view reaching back to early Greek speculation and fascination with light, but also one that offers a look at the first systematic attempts to give rational answers to one of the most fundamental questions of human civilization and culture: What is light?

II

The question of the nature of light takes center stage in contemporary history of science. Two significant milestones of twentieth-century historiography are the groundbreaking, but contested, work of Vasco Ronchi, *Storia della luce*, and David Lindberg's authoritative *Theories of Vision from Al-Kindi to Kepler*.¹² These works established the contours of the field that is now recognized as "history of optics." Both bequeathed to younger generations of scholars a hidden tension: on the one hand, they recognized the centrality of the question of light; on the other hand, they

⁶ For the idea that the *De luce* has roots in Arabic and Jewish thought see James McEvoy, *Robert Grosseteste* (Oxford: Oxford Univ. Press, 2000), p. 90. For emphasis on the patristic context see Clare Riedl, *Robert Grosseteste: On Light (De luce)* (Milwaukee: Marquette Univ. Press, 1942), p. 5; and MacKenzie, *Obscurism of Light*, pp. 7–24.

⁷ See Karl Gronau, *Poseidonios und die jüdisch-christliche Genesisexegese* (Berlin: Teubner, 1914), pp. 22–24; and Gregory of Nyssa, *Apologia in Hexaemeron* §10 (GNO IV 1 p. 20 = PG 44, 72C–73A).

⁸ See the comparative study of Charlotte Köckert, *Christliche Kosmologie und kaiserzeitliche Philosophie: Die Auslegung des Schöpfungsberichtes bei Origenes, Basilios und Gregor von Nyssa vor dem Hintergrund kaiserzeitlicher Timaeus-Interpretationen* (Tübingen: Mohr Siebeck, 2009).

⁹ See David Runia, *Philo of Alexandria and the "Timaeus" of Plato* (Leiden: Brill, 1986); and, more recently, Runia, *On the Creation of the Cosmos According to Moses* (Leiden: Brill, 2001).

¹⁰ Regarding the survival of the ancient physics of light in late antiquity and its transformation at the hands of later Christian thinkers see Werner Beierwaltes, *Lux intelligibilis: Untersuchung zur Lichtmetaphysik der Griechen* (Munich: Novotny & Sölnner, 1957); John Dillon, "Looking on the Light: Some Remarks on the Imagery of Light in the First Chapter of Origen's *Peri Archôn*," in *Origen of Alexandria: His World and His Legacy*, ed. Charles Kannengieser and William Petersen (Notre Dame, Ind.: Univ. Notre Dame Press, 1988), pp. 215–230; and Valentin Nikiprowetzky, "Thèmes et traditions de la lumière chez Philon d'Alexandrie," *Studia Philonica Annual*, 1989, 1:6–33. The assessment of Philoponus has changed since the landmark studies of Jean De Groot, *Aristotle and Philoponus on Light* (New York: Garland, 1991; rpt., Routledge, 2017); and Richard Sorabji, *Philoponus and the Rejection of Aristotelian Science*, 2nd ed. (London: Institute of Classical Studies, 2010).

¹¹ See Peter Adamson, "Vision, Light, and Color in al-Kindi, Ptolemy, and the Ancient Commentators," *Arabic Sciences and Philosophy*, 2006, 16:207–236; and David Whidden, *Christ the Light: The Theology of Light and Illumination in Thomas Aquinas* (Minneapolis: Fortress, 2015), pp. 47–68.

¹² Vasco Ronchi, *Storia della luce* (Bologna: Zanichelli, 1939), trans. into English by V. Barocas as *The Nature of Light: An Historical Survey* (London: Heinemann, 1970) (all citations are from the English translation); and David Lindberg, *Theories of Vision from Al-Kindi to Kepler* (Chicago: Univ. Chicago Press, 1976).

skewed the question by shifting the focus from light to sight. It is still instructive to recall how this shift occurred.

Ronchi began his historical survey with the biblical account of the creation of light (Genesis 1.3: “Let there be light”). Though he did not mention the great Jewish-Christian hexaemeral tradition, of which Philo, Basil, and Grosseteste are part, he came very close to its basic insight. The first verses of Genesis entail, for Ronchi, “a theory on the nature of light,” according to which light has “an existence of its own, independent of its source and of its receiver.” But the hexaemeral tradition remained elusive—indeed, likely unknown—to Ronchi, and he did not follow the Genesis lead further. In trying to unfold the story of light, Ronchi thus had only ancient Greek theories of light to work with. These prompted the following astonishing remark:

The Greek philosophers do not appear to have taken upon themselves the task of determining the nature of light. What interested them most was to explain the mechanism of vision. In those days the main goal of thinkers was to learn to understand man, his functions and his faculties. Vision was one of the important faculties of man, and hence the answer to the question “how do we see?” became fundamental. Every physical entity exists because it produces effects. At that time the only known effect of light was vision, and it was natural therefore, that the study of light should begin from this point.¹³

In Ronchi’s understanding—which has been influential for all subsequent discussions—Greek thought did not ask the question: What is light? Instead, it asked the question: What is sight? He held that this shift in the object of inquiry—sight instead of light—was empirically attested: that is what we get from the known sources. One may wonder whether Ronchi would have been willing to reconsider if he were shown different textual evidence. Be that as it may, he is the starting point in a process of assimilation between the history of light and of sight in modern historiography, a process through which the story of light became an integral part of the story of vision down to the seventeenth century.

Lindberg was one of Ronchi’s severest critics. He bemoaned, among other things, the fact that Ronchi emphasized light over sight. Given that, in the end, Ronchi did not follow the path of an independent inquiry into the nature of light but subordinated it to the study of visual theories, Lindberg’s critique might appear a bit overzealous. After all, he too acknowledged light as a possible field of independent historical study but ultimately followed, instead, the visual path inaugurated by Ronchi:

Before 1600 the science of optics tended to coalesce around two interrelated, yet distinguishable, problems—the nature and propagation of light, and the process of visual perception. Either problem could serve as an effective starting point for an investigation of early optics, but the second is clearly the broader and more representative. The problem of vision not only embraces the anatomy and physiology of the visual system, the mathematical principles of perspective, and the psychology of visual perception, but it also requires us at least to touch upon the nature of light and the mathematics and physics of its propagation.¹⁴

Ronchi and Lindberg understood the historian’s task of investigating light to be part of the history of vision. But that was the result of a *choice* or preference between two possible alter-

¹³ Ronchi, *Nature of Light*, trans. Barocas, pp. 2, 4.

¹⁴ See David Lindberg, “New Light on an Old Story” [rev. of Ronchi, *The Nature of Light: An Historical Survey*], *Isis*, 1971, 62:522–524, esp. p. 522 (criticizing the emphasis on light over sight); and Lindberg, *Theories of Vision from Al-Kindi to Kepler* (cit. n. 12), p. x (quotation).

natives, the way of light and the way of sight. If they opted for the way of sight, it was because they thought it fit better with how the source material treated the subject matter. An independent inquiry into the nature of light in the premodern world was still a viable option, at least theoretically. But it was left for others to undertake. Today we know that volunteers have been scarce. A survey of the existing literature betrays a steady preference for the visual approach.¹⁵

III

For Ronchi, Lindberg, and many other historians of optics, the inquiry into the nature of light was a theoretically valid enterprise, though not one that they could—or chose to—pursue in practice. That was not the case for another group of scholars, who contested the very *possibility* of a genuine inquiry into the nature of light in premodern thought. The new thesis was first argued by one of the most influential voices in Continental scholarship, that of Gérard Simon. Simon accused Ronchi and Lindberg of assimilating light (the light ray) to sight (the visual ray). He thereupon completely rejected their approach, dedicating a whole book to showing that “the center of the preoccupations of the Ancients is in no way the propagation of a ray but the positioning of an image, on account of the fact that they treat of vision and not like us of light.”¹⁶

Simon’s concern was that contemporary scholars, like Ronchi and Lindberg, read the sources anachronistically, probably without being aware of it (“victimes d’une illusion retrospective”): they force the ancient texts by unduly modernizing their meaning, assuming that premodern thinkers had the same interests as we do (“fausser indûment des centres d’intérêt qui ne sont plus les nôtres”), not realizing that ancient sources were asking radically different questions than ours (“questions radicalement différentes”).¹⁷ The reason is that there was no *physics* of light in the ancient world, only a concept of sight of which light was an auxiliary part: for the ancients, “it was impossible to pose the question of the physical nature of light independently of sensation, since the proprium of light was to stimulate the senses, whether by dazzling the eye or by making the blue, the red or the green visible.”¹⁸ Simon, therefore, firmly argued that the history of optics was not the history of light but, rather, the history of the transformation of a discipline and its subject matter: from sight to light (“du visible à la lumière”).¹⁹ In drawing the epistemological consequences of his position, Simon went perhaps a bit too far in contesting the intelligibility of ancient theories altogether: “we do not understand the purpose, nor the interests, nor the intrinsic limits of ancient optics. This is at least what this

¹⁵ See, from recent literature, Gábor Zemplén, *The History of Vision, Colour, and Light Theories: Introductions, Texts, Problems* (Bern: Bern Studies in the History of Science, 2005); Olivier Darrigol, *A History of Optics: From Greek Antiquity to the Nineteenth Century* (Oxford: Oxford Univ. Press, 2012); and Harald Siebert, “Transformation of Euclid’s *Optics* in Late Antiquity,” *Nuncius*, 2014, 29:88–126. But see the suggestions of Sylvia Beryman, “Euclid and the Sceptic: A Paper on Vision, Doubt, Geometry, Light, and Drunkenness,” *Phronesis*, 1998, 43:176–196, esp. pp. 194–196, that Euclid’s visual ray model is dependent on its underlying theory of light; and Colin Webster, “Euclid’s *Optics* and Geometrical Astronomy,” *Apeiron*, 2014, 47:526–551, that the Euclidean *Optics* is dependent on propositions and proofs from the astronomical tradition (celestial illumination).

¹⁶ See Gérard Simon, *Le regard, l’être et l’apparence dans l’Optique de l’antiquité* (Paris: Seuil, 1988), pp. 23–24, 25 (quotation) (all translations from Simon’s works are my own).

¹⁷ *Ibid.*, pp. 23, 25. See also Gérard Simon, “De la reconstitution du passé scientifique,” rpt. in *Sciences et savoirs aux XVIe et XVIIe siècles* (Villeneuve d’Ascq: Septentrion, 1996), pp. 11–29; the charge against Ronchi and Lindberg is on p. 16.

¹⁸ Simon, *Le regard, l’être et l’apparence dans l’optique de l’antiquité*, p. 14. See also Simon, “De la reconstitution du passé scientifique,” pp. 20–21: whichever ancient theory of light we take, “light always plays an auxiliary role [un rôle d’adjuvant], never that of a protagonist.”

¹⁹ Simon, *Le regard, l’être et l’apparence dans l’optique de l’antiquité*, pp. 11–20; see also p. 89 for the transformation thesis in the context of Simon’s work.

book aims to establish.” But this was consistent with his broader view on the archetypal function of vision in the ancient world.²⁰ For Simon, no transformation of optics was epistemologically innocuous; it was a transformation of our theory of knowledge (“transformation de la théorie de la connaissance”). In the end, the passage from sight to light signified not merely a change in the subject matter of a scientific discipline but a broader change in the way we understand the objects of knowledge (“objets du savoir”).²¹

Simon’s view gained currency in Continental scholarship, and the passage “from sight to light” became the quasi-motto of a certain way of understanding the history of optics: as a discontinuous narrative of the transformation of the concept of light, from an intrinsic feature of the mechanism of vision to an independent object of scientific inquiry.²² This view also found notable defenders in the English-speaking world. Perhaps the most eloquent example comes from a leading voice in Ptolemaic and Arabic optics, that of A. Mark Smith, who expounded the thesis in a series of publications. Smith famously contested Lindberg’s view that the medieval Perspectivist optical tradition was primarily concerned with the physics of light. Contrary to Kepler and his seventeenth-century successors, medieval Arabic and Latin thinkers “were far more concerned with making sense of sight than with understanding light.” “The proper and primary end of Perspectivist optics,” he repeatedly argued, *pace* Lindberg, “was to make full and coherent sense not of light but of sight.” Smith then generalized the thesis. In a recently published monumental monograph, he sought to capture the whole history of optics through the prism of a *paradigm shift*—namely, as the transition from the premodern to the modern optical paradigm: the celebrated passage “from sight to light.” In the opening paragraph of his book he summarizes his thesis as follows:

As currently understood, the science of optics is about light, about its fundamental properties and how they determine such physical behavior as reflection, refraction, and diffraction. But this understanding of optics and its appropriate purview is relatively new. For the vast majority of its history, the science of optics was aimed primarily at explaining not light and its physical manifestations, but sight in all its aspects from physical and physiological causes to perceptual and cognitive effects. Consequently, light theory was not only regarded as subsidiary to sight theory but was actually accommodated to it. And so it remained until the seventeenth century, when the analytic focus of optics shifted rather suddenly, and definitively, from sight to light. Marking the turn from ancient toward modern optics, this shift of focus evoked an equivalent shift in the order of analytic priority. Henceforth, sight theory would become increasingly subsidiary to light theory, the former now accommodated to the latter.²³

²⁰ *Ibid.*, pp. 11 (quotation), 16–17.

²¹ *Ibid.*, p. 17. See also Simon, “De la reconstitution du passé scientifique” (cit. n. 17), pp. 21–27. For ancient optics as part of Simon’s broader epistemological agenda see Maurice Caveing, “Savoirs et sciences selon Gérard Simon,” *Revue d’Histoire des Sciences*, 2007, 60:203–216, also available as “Knowledge and Science According to Gérard Simon,” https://www.cairn-int.info/article-E_RHS_601_0203-.htm (accessed Feb. 2018).

²² Simon is a standard reference point in French literature. See, e.g., Anca Vasiliu, “La parabole platonicienne du regard,” in *Lumière et vision dans les sciences et dans les arts: De l’antiquité au XVII^e siècle*, ed. Michel Hochmann and Danielle Jacquart (Geneva: Droz, 2010), pp. 1–44, esp. p. 6; and Muriel Pardon-Labonnelie, “Isis ‘Pupille de l’univers’: L’emprise de l’oculistique égyptienne sur l’oculistique gallo-romaine,” *ibid.*, pp. 45–64, esp. p. 45.

²³ A. Mark Smith, “What Is the History of Medieval Optics Really About?” *Proceedings of the American Philosophical Society*, 2004, 148:180–194, on p. 181 (“far more concerned”); Smith, “Bringing the Scientific Revolution into Focus: The Case of Optics,” in *Lumière et vision dans les sciences et dans les arts*, ed. Hochmann and Jacquart, pp. 163–186, on p. 165 (“proper and primary end”); and Smith, *From Sight to Light: The Passage from Ancient to Modern Optics* (Chicago: Univ. Chicago Press, 2015), p. ix.

It is not difficult to perceive that Smith comes close to the school of thought of Simon and the Continental agenda. For him, too, there is a discontinuity between premodern and modern optics.²⁴ According to the premodern optical paradigm, light was not the primary object of scientific inquiry. That role was reserved for sight, of which light was an enabler or a mediating factor. Only in that subsidiary sense was there conceptual space for an inquiry into light. To be clear, Smith does not go so far as to challenge the intelligibility of the ancient sources. But he does recognize the archetypical function of optics, acknowledging that the transformation of the visual model had “ramifications that extended well beyond its ostensibly narrow subject matter in light and sight.” Thus, for Smith, the passage from sight to light caused a tremendous shift in the way people conceived the world, signifying not a mere transformation of a scientific discipline (optics) but a real paradigm shift in the Kuhnian sense (a “Keplerian turn”). It was a change in worldview, with “ramifications in such apparently disparate fields as theology, literature, and art.”²⁵

To this point, I have sketched the contours of the modern historiography of light, following the narrative that was first laid out in the works of Ronchi and Lindberg and noting a subtle but crucial turn in this narrative suggested by Simon and recently exemplified by Smith. If I am right, there seems to be considerable agreement: the passage “from sight to light” becomes the signpost of a certain approach to the history of optics that studies light as part of sight in the ancient sources. Beyond this, there is room for dissent: according to some, a vision-independent inquiry into the nature of light in ancient sources is—theoretically, at least—a viable possibility (Ronchi and Lindberg); according to others, the “oculocentric” nature of ancient optics denies such a possibility. In its softer version (Smith), this latter view inquires into the nature of light in the premodern world as an integral, *auxiliary* part of the study of sight; the genuine inquiry into light as an “objective,” *physical* agent in the world will have to wait for the paradigm shift that occurred in the seventeenth century.²⁶ In its stronger version (Simon), the oculocentric narrative precludes all possibility of light being *knowable as such* in the ancient world; the ancients simply lacked any *independent* notion of light.²⁷

In the remainder of this essay, I want to pursue the insight of Ronchi and Lindberg that a vision-independent inquiry into physical light and its nature was possible in the ancient world. To do so, I want to focus on evidence that Ronchi and Lindberg did not take into account. My aim here is not to offer a comprehensive study of ancient theories of light. If, however, I succeed in showing that there was at least *some* inquiry into the nature of physical light independent of vision, I will have shown that a genuine *physics of light* was already accessible to the ancient world. My argument, then, has a programmatic character. In advancing the hypothesis of Ronchi and Lindberg, it aims to invite further research into ancient theories of light as such. In legitimizing the inquiry into the ancient physics of light, my argument also seeks to put the oculocentric narrative in the history of optics under deeper scrutiny.

²⁴ See also Smith, “What Is the History of Medieval Optics Really About?” pp. 180, 193–194; and Smith, “Bringing the Scientific Revolution into Focus,” p. 166.

²⁵ Smith, *From Sight to Light* (cit. n. 23), pp. x, 2, 277.

²⁶ According to Smith, “What Is the History of Medieval Optics Really About?” (cit. n. 23), p. 183, in the premodern optical paradigm of Alhacen and his Latin followers “pure light is a mere theoretical abstraction.” In a pre-Keplerian context, “the science of optics is not about light-radiation, reflection, or refraction, as we understand them in the modern, objective sense, but about how we perceive things directly or by mediation of reflective or refractive surfaces” (p. 191).

²⁷ See Jacques Blamont, “Du regard à la lumière,” in *Du visible à l’intelligible: Lumière et ténèbres de l’antiquité à la renaissance*, ed. Christian Trostmann and Anca Vasiliu (Paris: Champion, 2004), pp. 195–223, on p. 199: “We should not search in ancient science for anything of what we nowadays call the explanation of the phenomenon of light. In fact, as Gérard Simon writes, ancient optics is in the first place an *analytics of vision*. None of our concepts (ray, image, visible, visual field, binocular vision, object, subject, etc.) are transposable as they are into ancient and medieval texts” (my translation; italics in the original).

IV

The Platonic *Timaeus* has traditionally been studied by philosophers and theologians. Recently, a new group has been added to its readership. Historians of optics have discovered in it a valuable source of information for one of the most influential and long-standing ancient theories of vision and light. The optical discussion has mainly focused on the passage relevant to the eye and the mechanism of vision (45b–46a), to which is usually added the passage relevant to sensible qualities and colors (67c–68d).²⁸ But the *Timaeus* has much more to offer. For example, the theory of vision is followed by a short disquisition on catoptrics, discussing mirror images and reflection (46a–c), which, curiously, has escaped the attention of most textbooks on the history of optics. Even less noticed are several passages treating of elemental properties and particles (55d–58d), with direct relevance to Plato's notion of light. After a brief reminder of the Platonic theory of vision, I shall return to these passages.

The Timaeian theory of vision is well known.²⁹ It is based on the coalescence of two lights as an instance of the principle of like to like (ὅμοιον πρὸς ὅμοιον). When the *internal* light of the eyes (i.e., the visual ray) meets the *external* light of the Sun (i.e., the daylight), the two lights, being akin (ἀδελφόν, συγγενοῦς), form a single homogeneous body. As this body of light comes into contact with the surface of external objects it creates an affection, which is transmitted back to the soul, producing the sensation of vision (45b–46a). There are several such affections (παθήματα) as a further application of the principle of likeness. When the visual ray comes into contact with the surface of objects it encounters various streams of fire particles commensurate with it. The interaction produces the sensation of colors (67c–68d). Clearly, light is the key element in the Platonic theory of vision. Daylight, the visual current, and, eventually, colors are all described as different kinds of light. Francis Cornford provides the following taxonomy:

The mechanism of vision involves three kinds of “fire” or light. (Several varieties of fire will be enumerated at 58c.) These are: (1) Daylight, a body of pure fire diffused in the air by the Sun. This (like [2]) is “pure,” not admixed with other primary bodies. At 58c it is contrasted with flame (φλόξ) as “that which flows off from flame, and does not burn but gives light to the eyes.” (2) The visual current, a pure fire of the same kind as daylight, contained in the eyeball and capable of issuing out in a stream directed towards the object seen. At 67d it appears that the visual current or ray is not composed of the very smallest grade of fire. (3) The colour of the external object, defined at 67c as “a flame (φλόξ) streaming off from every body, having particles proportioned to those of the visual current, so as to yield sensation.”³⁰

Now, the question that both Ronchi and Lindberg encouraged us to ask—but that Simon insisted was not a valid question—was: What is the nature of light? Hence the challenge: if the *Timaeus* is able to provide an answer to this question, Ronchi and Lindberg will be justified. Moreover, if that answer is gained independently of the theory of vision, Simon's view will be under considerable pressure. With this challenge in mind, let us go back to Cornford's re-

²⁸ See Lindberg, *Theories of Vision from Al-Kindi to Kepler* (cit. n. 12), pp. 5–6; Darrigol, *History of Optics* (cit. n. 15), pp. 5–6; and Smith, *From Sight to Light* (cit. n. 23), pp. 29–30, 44–45.

²⁹ For a state-of-the-art discussion see Thomas Johansen, *Plato's Natural Philosophy* (Cambridge: Cambridge Univ. Press, 2004), pp. 110–114; and Andrea Nightingale, “Sight and the Philosophy of Vision in Classical Greece: Democritus, Plato, and Aristotle,” in *Sight and the Ancient Senses*, ed. Michael Squire (London: Routledge, 2016), pp. 54–67, esp. pp. 57–62.

³⁰ Francis Cornford, *Plato's Cosmology: The “Timaeus” of Plato* (London: Routledge, 1937; rpt., Indianapolis: Hackett, 1997), p. 152.

marks. We find there two insightful leads: that light and colors are kinds of fire and that the particular details of the relation between fire, light, and colors are dealt with in the second part of the treatise—namely, at 58c for light and at 67c for colors. Let us turn to the part of the *Timaeus* that explains further the relation between fire and light (58c), keeping colors (67c) in the background for the time being.

The theory of vision belongs to the first part of the Timaeian main discourse, the so-called “craftsmanship of intellect” (29d7–47e2). But 58c belongs to a different context: it is integrated in the second part of the main discourse dealing with mechanical causation, the so-called “effects of necessity” (47e3–69a5), and, more specifically, the part that describes the constitution, properties, and behavior of the four elemental bodies (fire, air, water, and earth). In 58c–60e the varieties of the four elemental bodies are defined and described, fire being treated first. Let me here briefly reproduce and compare two accounts of the relevant passage (58c). In A. E. Taylor’s interpretation:

Of fire *Timaeus* distinguishes three chief varieties (though he is careful to say that there are many others, γένη πολλά), (1) φλόξ, flame, (2) light, which he regards as an emanation from flame, which does not “burn” (τὸ ἀπὸ τῆς φλογὸς ἀπιὸν, ὃ κάει μὲν οὐ, φῶς δὲ τοῖς ὄμμασι παρέχει), (3) the red glow left behind in embers and red-hot bodies generally. The one point to be noted is that, like all the early φυσικοί, he regards light as a kind of body, just as they all regarded fire as a special kind of body.

Cornford writes the following:

Light, which Plato regards as a body given off by flame, has already been described at 45b. It is similar to the visual current of “pure fire” which is so fine that it alone can filter through the close texture of the eyeball. We may infer that it consists of particles of smaller grades than flame or glowing heat. It has the quality or “power” of brightness, but not that of heat, possessed by the other two varieties. We do not feel light as hot, presumably because of the extreme fineness of the pyramids; the pricking of their points would not disturb the coarser fabric of flesh. In the later account of colour (67d ff.), at least three grades of fire are invoked, corresponding to differences of colour.³¹

Taylor and Cornford, admittedly, did not read the *Timaeus* in the same way. As regards the relevant passage, however, they seemed to agree on two points at least: that light is the second species of fire; and that, because it is so, light shares all the characteristics of fire, like its bodily nature. In identifying the second species of fire with light, Taylor and Cornford stand in a long interpretative tradition.³² This identification is extremely important. It shows that, according to the *Timaeus*, light is simply a special case of fire. As such it shares in fire’s nature. If we now ask what kind of nature that is, the text gives us very specific answers: it is a body (53c) composed of particles with a certain (pyramidal) structure (56b) and with specific properties, like mobility, sharpness, acuteness, lightness (56a–b), and so forth. The *Timaeus* then *does* give us all the answers we need to the question: What is the nature of light? It is the nature of fire, which

³¹ A. E. Taylor, *A Commentary on Plato’s “Timaeus”* (Oxford: Clarendon, 1928), p. 410; and Cornford, *Plato’s Cosmology*, p. 247.

³² For ancient readers see Aristotle, *Topica* 134a26–135a8; Theophrastus, *De igne* 3.3–5; Philo, *De aeternitate mundi* §86; Galen, *In Timaeum*, fr. 18 (Larrain); Galen, *On the Doctrines of Hippocrates and Plato* VII.6.2 (= 629.2 de Lacy); Plotinus, *Enneads* II.1.7.20–30; and Proclus, *In Timaeum* II.8.22–25, 9.3–4, 9.15–20. For modern readers see R. D. Archer-Hind, *The “Timaeus” of Plato* (London: Macmillan, 1888), p. 211, who sets the tone for everybody else.

together with air, water, and earth is one of the constituent elements of Plato's physical world. Ronchi and Lindberg were right to suggest the possibility of a proper inquiry into the nature of light in the ancient world. At least as far as the *Timaeus* is concerned, the physics of light is a special case of the physics of fire. In the Timaean context, the agnostic epistemology of the (strong) oculocentric thesis is very difficult to uphold. The *Timaeus* thinks of light as a stream of the finest particles of fire—and hence the finest particles of Plato's universe. If we want to translate this into modern terms, we can say that we have here an early intimation of the particle theory of light. In a loose analogy, one may even suggest that Plato's light particles fulfill a function similar to our light quanta or photons. They mark the limits of the sensible, corporeal dimension.³³

V

If my analysis is right, the *Timaeus* confirms the hypothesis of Ronchi and Lindberg and puts pressure on the oculocentric thesis. First, it proves that the study of light as such was possible in the ancient world, against the opposite claim of strong oculocentrism. Second, it presents us with a luminocentric theory of vision, against the opposite suggestion of the soft oculocentric thesis. The latter's claim that light is "subordinated" to sight seems a bit out of tune with the vision-independent context of the Timaean physics of fire/light. And it seems to neglect the explanatory power of the physics of fire/light for the theory of vision. In the words of Sarah Broadie: "It is because of what *fire* contributes to vision that vision is possible. In general, we need to study the nature of fire, water, air, and earth to see what they in themselves contribute to the production of animals (including, of course, the cosmic animal) and their parts."³⁴

Indeed, the physics of fire/light refers to the theory of vision (φῶς δὲ τοῖς ὄμμασι παρέχει [58c]) precisely because fire functions as an *explanans* of sight: all the elements of vision (day-light, the visual current, and colors) and the processes that bring them together (their coalescence according to the principle of "like to like") are explained as interactions of different streams of particles of fire. In fact, one could see the Timaean theory of vision as a disquisition on the particle mechanics of fire, especially as suggested in 57c–d: vision is an exemplification of the mixture of different varieties of particles of the same primary body. If indeed the Timaean theory of vision can be seen as a special case of application of the Timaean physics of light, this is very difficult to reconcile with the oculocentric thesis, even in its soft version. At least as far as the *Timaeus* is concerned, it becomes clear that it is not light that is subordinated to sight, but sight that is subordinated to light. The mechanism of vision is entirely dependent on the physics of fire/light.³⁵

One must be aware, however, that mechanical causation—namely, the physics of light—is not the only *explanans* of vision. The *Timaeus* argues, against the materialist physicists, for a teleological rather than a purely mechanical explanation of the world.³⁶ In the words of Broadie again:

³³ So at least was Timaean light understood in the later tradition. See Proclus, *In Timaeum* II.8.23–25, 9.3–4, 9.12–16; and John Finamore, "Iamblichus on Light and the Transparent," in *The Divine Iamblichus: Philosopher and Man of Gods*, ed. Henry Blumenthal and Gillian Clark (Bristol: Classical, 1993), pp. 55–64, esp. pp. 57–59.

³⁴ Sarah Broadie, *Nature and Divinity in Plato's "Timaeus"* (Cambridge: Cambridge Univ. Press, 2012), p. 181 (italics in original).

³⁵ Galen, e.g., saw the Timaean theory of vision in this way; see Carlos Larrain, *Galen's Kommentar zu Platons "Timaios"* (Stuttgart: Teubner, 1992), fr. 18, p. 134 (with references).

³⁶ Mechanical causation is auxiliary causation: συννάτια (46d1), συμμενάτια (46e6). On the relation with primary, teleological causation see Johansen, *Plato's Natural Philosophy* (cit. n. 29), pp. 106–116; and David Sedley, *Creationism and Its Critics in Antiquity* (Berkeley: Univ. California Press, 2007), pp. 113–127.

Most thinkers, he [Timaeus] says, make the mistake of attributing causal status in the fullest sense to fire and air etc., factors that work by cooling and heating, condensing, dissolving, and so on. The fire that makes seeing possible is just such a factor. . . . Causes that come under the category of intelligence are the ones to be treated as primary, he states, whereas those that belong in the class of things “moved by other things and movers by yet others by necessity,” must be considered secondary. Both kinds must be discussed, but the distinction between the types of causality must be observed as fundamental (46c7–e6).³⁷

This is crucial. The oculocentric thesis, though difficult to maintain as such, contributes a valuable insight: there has been a paradigm shift (in the Kuhnian sense). Modern science gradually but decidedly downgraded teleological causation as a method of explaining the world. Moreover, there has been a subordination of the Timaeian theory of light: not to sight (hence no oculocentrism) but, rather, to divine intelligence, which was the ultimate *explanans* of the world, the regular properties of fire and light included (hence subordination indeed). Thus the underlying premises of the ocularist thesis (paradigm change and subordination) point in the right direction, though, in my view, with a different conclusion. If I am right, the crucial point of divergence between the Timaeian and the modern scientific paradigm is the emancipation of mechanical causality, including the physics of light, from Plato’s theistic teleology. This is not to deny other significant differences between modern and Timaeian optics, like the existence of the visual flux and its coalescence with external light. But these are all cases of pure, elemental, physical light. That means that, within the different scientific framework of Timaeian teleology, the proper inquiry into the physics of light was as indispensable for the ancient scientist as it is for the modern. With Broadie again: “on their own they [the elements] would still behave in quite determinate and possibly even predictable ways such as we often observe today, and would be in possession of their own definite natures. Only because they have their own natures are they able to make their important causal contribution to the cosmos, one requiring a distinct scientific study.”³⁸

In the Timaeian context it could not be otherwise. Even the explanation of perceptual experience requires the existence of objective properties that a thing has independently of any observer. This is, for example, the case for colors, which exist independently of vision. In the words of Katerina Ierodiakonou: “colours, according to Plato, are properties which bodies do actually have independently of the sentient beings which perceive them. Or, to be more precise, and to conclude, that bodies, according to Plato, have colours insofar as they emit effluences of a certain kind quite independently of the sentient beings which perceive them.”³⁹

But colors, as effluences of flame, belong to the same species of fire as light—that is, they are streams of fire particles commensurate with light. What is true for Timaeian colors must then also be true for Timaeian light. If so, light exists independently of vision and as such requires a distinct scientific study. It is this study of physical light and its properties that we find in the *Timaeus*.

VI

Modern optics, we are told, is the study of light and its properties. Ancient optics, we are also told, is the study of sight, as the etymology betrays (from *ὄψις*: view, sight, vision, aspect).⁴⁰ The

³⁷ Broadie, *Nature and Divinity in Plato’s “Timaeus”* (cit. n. 34), p. 174.

³⁸ *Ibid.*, pp. 182–183.

³⁹ Katerina Ierodiakonou, “Plato’s Theory of Colours in the *Timaeus*,” *Rhizai*, 2005, 2:219–233, on p. 232.

⁴⁰ See Smith, *From Sight to Light* (cit. n. 23), pp. ix, 25.

change in perspective creates a tension between modern and ancient optics in the sense that the same name denotes two different fields of scientific inquiry: now light, then sight. This raises a methodological question: What is the history of optics really about, the history of a name (“optics”) or the history of the inquiry into a specific subject matter (light)?

The oculocentric view understands optics as the history of a name and its definition. Since the definition changed, so too did the object of study. The history of optics aims to explain why and how the subject matter of optics “was transformed, as its definition was refined and modified over the course of some two millennia.”⁴¹ It is the history of the passage “from sight to light.” But perhaps there is room for a different approach. If modern optics is the study of light and its properties, it is legitimate, if not imperative, for a historian to inquire also into the past of the subject matter itself: *the history of the physics of light*. In this essay I have argued that such an inquiry is possible, and I have indicated a way of doing it. At least as far as the Platonic *Timaeus* is concerned, it is possible to reconstruct a proper theory of the nature of physical light and its fundamental properties. The question is: Should this be part of the curriculum of history of optics? My answer is affirmative. First, because if there were an ancient physics of light, as the *Timaeus* suggests, then we have clear antecedents of the subject matter of modern optics in the ancient world. Second, because even if ancient optics was (merely) about vision, we cannot properly understand the nature of vision, as far as the *Timaeus* is concerned, if we do not study the physics of light that underpins it. We thus have two possible approaches to the history of optics, an oculocentric approach that follows the path of sight and a luminocentric approach that follows the path of light. It is not clear why the history of optics should prioritize one approach (sight) over the other (light).

But perhaps we are confronting an artificial dichotomy. We have seen that in the *Timaeus* the visual current is conceived as a ray of light. What the oculocentric approach calls “sight” is not a different subject matter from modern optics but, instead, a different source of emanation of the same subject matter—namely, of the ray of light. The Timaeian theory of vision requires three sources of light (an internal, an external, and the surface of the thing seen), three streams of light (the visual current, the external light, and colors, as streams of fire particles commensurate with light), and their coalescence.⁴² That means that the subject matter of the Timaeian theory of vision is, strictly speaking, light. Thus, even if we follow the oculocentric approach to optics, the *Timaeus* leads us to a very “modern” outcome: the study of sight becomes unintelligible without the study of physical light, its nature and its properties. That is why, I suggest, a comprehensive and systematic history of optics needs to include the ancient physics of light in its scope.

I have focused on the Platonic *Timaeus* in order to support my argument. Though presented in isolation here, its evidence is not insignificant: it is well bolstered by the tradition in which it stands. The Timaeian theory of light, vision, and colors has, famously, important antecedents: it modifies and further develops basic insights of Empedocles, the Pythagoreans, and the Atomists.⁴³ It also has had a lasting influence in Western culture, echoing even as far as Goethe’s celebrated poem from the *Farbenlehre*.⁴⁴ The prehistory and the aftermath of the Pla-

⁴¹ *Ibid.*, p. 25.

⁴² So, too, Proclus, *In Timaeum* II.8.1–7; and Calcidius, *In Timaeum* §§244–245.

⁴³ See Kelli Rudolph, “Sight and the Presocratics: Approaches to Visual Perception in Early Greek Philosophy,” in *Sight and the Ancient Senses*, ed. Squire (cit. n. 29), pp. 36–53 (with references); and Nightingale, “Sight and the Philosophy of Vision in Classical Greece” (cit. n. 29) (with references).

⁴⁴ For the continuing echo of the Timaeian theory of vision in later theories see David Hahn, “Early Hellenistic Theories of Vision and the Perception of Color,” in *Studies in Perception: Interrelations in the History of Philosophy and Science*, ed. Peter Machamer and Robert Turnbull (Columbus: Ohio State Univ. Press, 1978), pp. 60–95; Robert Nelson, “To Say and to See: Ekphrasis and Vision in Byzantium,” in *Visuality Before and Beyond the Renaissance: Seeing as Others Saw*, ed. Nelson (Cam-

tonic theory of light suggest a wider presence of similar theories in the ancient world and invite further research. The aim of this essay has been to raise awareness of the existence of such theories and to give an indication of where and how to find them. If the ancient physics of light has not yet been the object of systematic study, this does not have to do with the fragmentary nature of the extant sources, which is a problem already known to the historian of optics. It has much more to do with a certain way of *reading* the sources—“from sight to light”—which has led historians to look aside or even look away from ancient theories of light. This essay is a call to look back and to look again.

bridge: Cambridge Univ. Press, 2000), pp. 143–168; and Roland Betancourt, “Why Sight Is Not Touch: Reconsidering the Tacitility of Vision in Byzantium,” *Dumbarton Oaks Papers*, 2016, 70:1–23.