

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. In what follows, I want to investigate further the possibility of a luminocentric as opposed to the oculocentric approach to ancient optics. Based on evidence from the Platonic *Timaeus*, I argue for the existence of a proper physics of light in the ancient world. If my argument is correct, the ancient physics of light ought to be part of a comprehensive and systematic history of optics.

Key words: History of optics – ancient physics – theories of light, vision & colours – *Timaeus*

I.

Light has captivated 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 the following 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

The luminocentrism of western culture did not escape the attention of twentieth-century historians. In the words of David Lindberg, pre-modern 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 raise a feeling of familiar accord amongst some in the world of quantum and relativity physics. In his *Short Introduction to Light*, Ian Walmsley does indeed suggest some kind of familiarity – if not affinity – between post- and pre-modern 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 Grosseteste's special treatise called *De*

Luce, which understands light as the limit of the physical world, defining light, 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 one to notice the striking resemblance between Grosseteste’s and Einstein’s notion of light as limit. Scholars of Grosseteste have made similar observations.⁵ One may here prudently remark that one should not be too eager to stress similarities. But one 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 post-modern 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, co-extensive with matter – has immediate roots in Arabic and Jewish thought, echoing the thought of Plotinus and Proclus.⁶ 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*.⁷ If we now look briefly into Basil’s *Hexaemeron* and its immediate context, we will find clear antecedents of Grosseteste’s fundamental insight of light as the first sensible form and its co-extensality with matter.⁸ 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.⁹ 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.¹⁰ Other seminal studies have shown how the ancient physics of light survived in late antiquity and were transformed by later Christian thinkers,¹¹ like the (until recently widely unrecognized) genius of Philoponus,¹² before they were transmitted to the Middle Ages through the Arab and Byzantine world.¹³ Thus, for the contemporary thinker Grosseteste’s *De Luce* opens a window with a view to the pre-modern physical world. It is a view reaching back to early Greek speculation and fascination with light, but also a view to the first *systematic* attempts to give *rational* answers to one of the most fundamental questions that occupy human civilization and culture: what is light?

II.

The question of the nature of light occupies the central stage in contemporary history of science. Significant milestones of twentieth-century historiography have been the groundbreaking, but contested, work of Vasco Ronchi, *Storia della luce*,¹⁴ and David Lindberg’s authoritative work on *Theories of Vision from Al-Kindi to Kepler*.¹⁵ They both established the contours of the field that is now recognized as ‘history of optics.’ Both works 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 skewed the question by shifting focus from light to sight. It is still instructive to remember 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.'¹⁶ But the hexaemeral tradition remained elusive, if not unknown, to Ronchi and he could not follow the *Genesis* lead further. In trying to unfold the story of light, Ronchi was left only with ancient Greek theories of light to work with. That is when he made 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.'¹⁷

For Ronchi, who at this point has been influential for all subsequent discussion, Greek thought did not ask the question: what is light? Instead, it asked the question: what is sight? This shift in the object of enquiry, sight instead of light, was for Ronchi empirically attested: that is what we get from the known sources. One may wonder whether Ronchi would be willing to reconsider if he were shown different textual evidence. Be it as it may, with him started a process of assimilation between the history of light and 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, amongst other things, the fact that Ronchi emphasised *light* over sight.¹⁸ Given the fact that Ronchi in the end did not follow the path of an independent enquiry into the nature of light but subordinated it to the study of visual theories, Lindberg's critique might appear a bit overzealous. After all, Lindberg, too, acknowledged light as a possible field of independent historical study, but followed, in the end, 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.'¹⁹

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 alternatives, the way of light and the way of sight. If they opted for the way of sight, it was because they thought it fitted better with how the source material treated the subject matter. The possibility of an independent enquiry into the nature of light in the pre-modern world was still a viable option, theoretically at least. But it was left for others to undertake.

Today we know that volunteers have been scant. A survey of the existing literature betrays a steady preference for the visual approach.²⁰

III.

For Ronchi, Lindberg and many other historians of optics, the enquiry into the nature of light was a theoretically valid question, though not one that they could – or chose to – pursue in practice. That was not the case with another group of scholars who contested altogether the *possibility* of a genuine enquiry into the nature of light in pre-modern thought. The new thesis was first argued by one of the most influential voices in continental scholarship, the French Gérard Simon. Simon accused Ronchi and Lindberg of assimilating light (the light ray) with sight (the visual ray).²¹ He thereupon completely rejected their approach, dedicating a whole book to show that

‘the centre 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.’²²

Simon’s concern was that contemporary scholars, like Ronchi and Lindberg, read the sources anachronistically, though without being probably aware of it (victimes d’ une illusion rétrospective):²³ they force the ancient texts by unduly modernising their meaning, assuming that pre-modern thinkers had the same interests as we do (fausser indûment des centres d’intérêt qui ne sont plus les nôtres), not realising that ancient sources were asking radically different questions than us (questions radicalement différentes).²⁴ 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 vision, since the proprium of light was to make feel, whether by dazzle or by making the blue, the red or the green visible.’²⁵ Simon, therefore, firmly argued that the history of optics was not the history of light, but the history of the transformation of a discipline and its subject matter: from sight to light (‘du visible à la lumière’).²⁶ 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 book aims to establish.’²⁷ But this was consistent with his broader view on the archetypical function of vision in the ancient world.²⁸ For Simon, every transformation of optics was not 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 of the subject matter of a scientific discipline but a broader change in the way we understand the objects of knowledge (objets du savoir).²⁹

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 enquiry.³⁰ 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, the American 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.'³¹ 'The proper and primary end of Perspectivist optics,' Smith repeatedly argued, *pace* Lindberg, 'was to make full and coherent sense not of light but of sight.'³² Smith then generalised the thesis. In a recently published monumental monograph Smith aims to capture the whole history of optics as the transition from pre-modern to modern optics – the celebrated passage 'from sight to light' – as a *paradigm shift*. In the opening paragraph of his book Smith 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.'³³

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 pre-modern and modern optics.³⁴ According to the pre-modern optical paradigm, light was not the primary object of scientific enquiry. 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 enquiry into light. To be clear, Smith does not go as far as to challenge the intelligibility of the ancient sources. But he does recognise the archetypal 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 ('Keplerian turn').³⁵ It was a change in world view, with 'ramifications in such apparently disparate fields as theology, literature, and art.'³⁶

Up to now, 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, 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 consent: 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 enquiry 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 enquires into the nature of light in the pre-modern world as an integral, *auxiliary* part of the study of sight; the genuine enquiry into light as an 'objective,' *physical* agent in the world will have to wait for the paradigm shift that occurred in the seventeenth century.³⁷ 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.³⁸

In the remainder, I want to pursue the insight of Ronchi and Lindberg that a vision-independent enquiry 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* enquiry into the nature of physical light independently 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 enquiry into the ancient physics of light, my argument also aims to put under deeper scrutiny the oculocentric narrative in the history of optics.

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 colours (67C–68D).³⁹ 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 has curiously escaped the attention of most textbooks on the history of optics. Even more unnoticed have gone 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 it is to these passages that I shall turn.

The Timaean theory of vision is well-known.⁴⁰ 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 colours (67C–68D). Clearly, light is the key element in the Platonic theory of vision. Daylight, the visual current and, eventually, colours are all described as different kinds of light. 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 eye-ball 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.”⁴¹

Now, the question that both Ronchi and Lindberg solicited us to ask, but Simon denied, 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 remarks. We find there two insightful leads: that light and colours are kinds of fire, and that the particular details of the relation between fire, light and colours are dealt with in the second part of the treatise, namely at 58C for light and at 67C for colours. Let us turn to the part of the *Timaeus* that explains further the relation between fire and light (58C), keeping colours (67C) in the background for the time being.

The theory of vision belongs to the first part of the *Timaean* main discourse, the so-called ‘craftsmanship of intellect’ (29d7–47e2). 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 behaviour of the four elemental bodies (fire, air, water and earth). In 58C–60E the varieties of the four elemental bodies are defined and described, first of which comes fire. Let me here briefly reproduce and compare two accounts of the relevant passage (58C). In 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 ἀπὸν, 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.’⁴²

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.’⁴³

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: 1) that light is the second species of fire; and that because it is so, 2) 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 line of a long interpretative tradition.⁴⁴ 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), etc. 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 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 enquiry 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 Timaeian 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 sense of a loose analogy, one may even suggest that Plato's light-particles fulfil a function similar to our light-quanta or photons. They mark the limits of the sensible, corporeal dimension.⁴⁵

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. Secondly, 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 Timaeian 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 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.'⁴⁶

Indeed, the physics of fire/light refers to the theory of vision (φῶς δὲ τοῖς ὀμμασι παρέχει, 58C) precisely because fire functions as an *explanans* of sight: all the elements of vision (daylight, the visual current and colours) and the processes that bring them together (their coalescence according to the principle 'like to like') are explained as interactions of different streams of particles of fire. In fact, one could see the Timaeian 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 Timaeian theory of vision can be seen as a special case of application of the Timaeian physics of light,⁴⁷ 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.

One must be aware, however, that mechanical causation – viz. the physics of light – is not the only *explanans* of vision. The *Timaeus* argues, against the materialist physicists, for a teleological over against a purely mechanical explanation of the world.⁴⁸ In the words of Broadie again:

'Most thinkers, he [sc. 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).⁴⁹

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 disfavoured teleological causation as a method of explaining the world. Moreover, there has been some kind of subordination of the Timaeon theory of light. Not to sight (hence no oculocentrism) but 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 Timaeon 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 Timaeon 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 Timaeon teleology, the proper enquiry 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 [sc. 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.’⁵⁰

In the Timaeon 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 colours, which exist independently of vision. In the words of 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.’⁵¹

But colours, as effluences of flame, belong to the same species of fire as light, i.e. they are streams of fire particles commensurate with light. What is true for Timaeon colours must then also be true for Timaeon 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 told again, is the study of sight, as the etymology betrays (from ὄψις = view, sight, vision, aspect).⁵² The change in perspective creates a tension between modern and ancient optics in the sense that the same name denotes two different fields of scientific enquiry: 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 enquiry 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 also 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.'⁵³ 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 enquire also into the past of the subject matter itself: *the history of the physics of light*. In this paper, I have argued that such an enquiry 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 ancient physics of light, as the *Timaeus* suggests, then we have clear antecedents of the subject matter of modern optics in the ancient world. Secondly, 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 which follows the path of sight and a luminocentric approach which 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 stand here in front of 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 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 colours, as streams of fire particles commensurate with light) and their coalescence.⁵⁴ 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 here focused on the Platonic *Timaeus* in order to support my argument. But the *Timaeus* alone is no insignificant evidence. The Timaeian theory of light, vision and colours has, famously, important antecedents: it modifies and further develops basic insights of Empedocles, the Pythagoreans and the Atomists.⁵⁵ It also has a lasting influence in western culture, echoing even as far as Goethe's celebrated poem from the *Farbenlehre*.⁵⁶ The prehistory and the aftermath of the Platonic theory of light suggest a wider presence of similar theories in the ancient world and invite further research. The aim of this paper 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 made the historian look aside or even look away from ancient theories of light. This paper is a call to look back and to look again.⁵⁷

¹ In the translation of Elizabeth Key Fowden and Nicolas Pilavachi in Paul Kalligas, *The Enneads of Plotinus: A Commentary*, 3 vols, vol. 1 (Princeton: Princeton UP, 2014), p. 217.

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

³ Ian Walmsley, *Light: A Very Short Introduction* (Oxford: OUP, 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 Press, 1996), pp. 1, 4.

⁶ See James McEvoy, *Robert Grosseteste* (Oxford: OUP, 2000), p. 90.

⁷ See Clare Riedl, *Robert Grosseteste: On Light* (De Luce) (Milwaukee: Marquette UP, 1942), p. 5; MacKenzie, *The Obscurism of Light*, pp. 7-24.

⁸ See Karl Gronau, *Poseidonios und die jüdisch-christliche Genesisexegese* (Berlin: Teubner, 1914), pp. 22-4; Gregory of Nyssa, *Apologia in Hexaemeron*, §10 (GNO IV 1 p. 20 = PG 44, 72C-73A).

⁹ 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* (Mohr Siebeck: Tübingen, 2009).

¹⁰ See David Runia, *Philo of Alexandria and the Timaeus of Plato* (Leiden: Brill, 1986).

¹¹ See Werner Beierwaltes, *Lux intelligibilis: Untersuchung zur Lichtmetaphysik der Griechen* (Munich: Novotny & Sölner, 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. by Charles Kannengieser and Williams Petersen (Notre Dame, IN: University of Notre Dame Press, 1988), pp. 215-30; Valentin Nikiprowetzky, “Thèmes et traditions de la lumière chez Philon d’Alexandrie,” *Studia Philonica Annual* 1989, 1:6-33.

¹² The scene has changed after the landmark studies of Jean De Groot, *Aristotle and Philoponus on Light* (New York, NY: Garland Publishing, 1991; repr. Routledge, 2017) and Richard Sorabji, *Philoponus and the Rejection of Aristotelian Science*, 2nd ed. (London: Institute of Classical Studies, 2010).

¹³ See Peter Adamson, “Vision, Light and Color in Al-Kindi, Ptolemy and the Ancient Commentators,” *Arabic Sciences and Philosophy*, 2006, 16:207-36; David Whidden, *Christ the light: The Theology of Light and Illumination in Thomas Aquinas* (Minneapolis, MN: Fortress Press, 2015), pp. 47-68.

¹⁴ Bologna: Zanichelli, 1939, translated into English by V. Barocas as *The Nature of Light: An Historical Survey* (London: Heinemann, 1970). All citations are from the English translation.

¹⁵ Chicago: Chicago UP, 1976.

¹⁶ Ronchi, *ibid.*, p. 2.

¹⁷ *Ibid.*, p. 4.

¹⁸ See David Lindberg, “New Light on an Old Story,” (Review of Ronchi), *Isis*, 1971, 62:522-4, on p. 522.

¹⁹ Lindberg, *Theories of Vision*, p. x.

²⁰ See, from recent literature, Gábor Zemplén, *The History of Vision, Colour, & 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: OUP, 2012); Harald Siebert, "Transformation of Euclid's *Optics* in Late Antiquity," *Nuncius*, 2014, 29:88-126. But cf. the suggestions of Sylvia Berryman, 'Euclid and the Sceptic: A Paper on Vision, Doubt, Geometry, Light and Drunkenness,' *Phroneisis*, 1998, 43:176-96, esp. 194-6: Euclid's visual ray model dependent on its underlying theory of light; Colin Webster, "Euclid's *Optics* and Geometrical Astronomy," *Apeiron*, 2014, 47:526-51: Euclidean *Optics* dependent on propositions and proofs from the astronomical tradition (celestial illumination).

²¹ See Gérard Simon, *Le regard, l'être et l'apparence dans l'optique de l'antiquité* (Paris: Seuil, 1988), pp. 23-4.

²² *Ibid.*, p. 25.

²³ *Ibid.*, p. 23. See also Gérard Simon, "De la reconstitution du passé scientifique," reprinted in *Sciences et savoirs aux XVIe et XVIIe siècles* (Villeneuve d'Ascq: Septentrion, 1996), pp. 11-29, with the charge against Ronchi and Lindberg on p. 16.

²⁴ *Ibid.*, p. 25.

²⁵ *Ibid.*, p. 14. See also Simon, "De la reconstitution du passé scientifique," pp. 20-1: whichever ancient theory of light we take, 'light always plays an auxiliary role (un rôle d'adjuvant), never that of a protagonist.'

²⁶ *Ibid.*, pp. 11-20. See also p. 89 for the transformation thesis in the context of Simon's work.

²⁷ *Ibid.*, p. 11.

²⁸ *Ibid.*, pp. 16-7.

²⁹ *Ibid.*, p. 17. See also Simon, "De la reconstitution du passé scientifique," pp. 21-7. 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," available online at https://www.cairn-int.info/article-E_RHS_601_0203--.htm (last access February 2018).

³⁰ Simon is standard reference in French literature see, for example, the papers of Anca Vasiliu, "La parabole platonicienne du regard" and Muriel Pardon-Labonnelie, "Isis 'Pupille de l'univers': L'emprise de l'oculistique égyptienne sur l'oculistique gallo-romaine," in *Lumière et vision dans les sciences et dans les arts: De l'antiquité au XVIIe siècle*, ed. by Michel Hochmann and Danielle Jacquart (Genève: Droz, 2010), pp. 1-44 (on p. 6) and pp. 45-64 (on p. 45) respectively.

³¹ A. Mark Smith, "What Is the History of Optics Really About?," *Proceedings of the American Philosophical Society*, 2004, 148:180-94, on p. 181.

³² A. Mark Smith, "Bringing the Scientific Revolution into Focus: The Case of Optics," in *Lumière et vision*, pp. 163-86, on p. 165.

³³ A. Mark Smith, *From Sight to Light: The Passage from Ancient to Modern Optics* (Chicago: Chicago UP, 2015), p. ix.

³⁴ See also Smith, "Medieval Optics," on pp. 180, 193-4; "Scientific Revolution," on p. 166.

³⁵ Smith, *From Sight to Light*, pp. x, 2, 277.

³⁶ *Ibid.*, p. 277.

³⁷ According to Smith, "Medieval Optics," on p. 183, in the pre-modern 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’ (on p. 191).

³⁸ See Jacques Blamont, “Du regard à la lumière,” in *Du visible à l’intelligible: lumière et ténèbres de l’antiquité à la renaissance*, ed. by Christian Trottman 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,’ (italics in the original; my translation).

³⁹ See Lindberg, *Theories of Vision*, pp. 5-6; Darrigol, *A History of Optics*, pp. 5-6; Smith, *From Sight to Light*, pp. 29-30, 44-5.

⁴⁰ For a state of the art discussion see Thomas Johansen, *Plato’s Natural Philosophy* (Cambridge: CUP, 2004), pp. 110-4; Andrea Nightingale “Sight and the Philosophy of Vision in Classical Greece: Democritus, Plato and Aristotle” in *Sight and the Ancient Senses* ed. by Michael Squire (London: Routledge, 2016), 54-67, esp. 57-62.

⁴¹ Francis Cornford, *Plato’s Cosmology: The Timaeus of Plato* (London: Routledge, 1937; repr. Cambridge, IN: Hackett, 1997), p. 152.

⁴² A. E. Taylor, *A Commentary on Plato’s Timaeus* (Oxford: Clarendon, 1928), p. 410.

⁴³ Cornford, *Plato’s Cosmology*, p. 247.

⁴⁴ 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; Proclus, *In Timaeum*, II.8.22-5; 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.

⁴⁵ So at least was Timaeian light understood in the later tradition, see Proclus, *In Timaeum*, II.8.23-5; 9.3-4; 9.12-6; John Finamore, “Iamblichus on Light and the Transparent,” in *The Divine Iamblichus: Philosopher and Man of Gods*, ed. by Henry Blumenthal and Gillian Clark (Bristol: Classical Press, 1993), pp. 55-64, esp. 57-9.

⁴⁶ Sarah Broadie, *Nature and Divinity in Plato’s Timaeus* (Cambridge: CUP, 2012), p. 181 (italics in original).

⁴⁷ So, for example, Galen, see Carlos Lorrain, *Galens Kommentar zu Platons Timaios* (Stuttgart: Teubner, 1992), fr. 18 on p. 134, with references.

⁴⁸ Mechanical causation is auxiliary causation: συναίτια 46d1; συμμεταίτια 46e6. On the relation with primary, teleological causation see Johansen, *Plato’s Natural Philosophy*, pp. 106-16; David Sedley, *Creationism and Its Critics in Antiquity* (Berkeley, Ca: University of California Press, 2007), pp. 113-27.

⁴⁹ Broadie, *Nature and Divinity*, p. 174.

⁵⁰ *Ibid.*, pp. 182-3.

⁵¹ Katerina Ierodiakonou, “Plato’s Theory of Colours in the *Timaeus*,” *Rhizai*, 2005, 2:219–33, on p. 232.

⁵² See Smith, *From Sight to Light*, pp. ix, 25.

⁵³ Smith, *ibid.*, 25.

⁵⁴ So, too, Proclus, *In Timaeum*, II.8.1-7; Calcidius, *In Timaeum*, §§244-5.

⁵⁵ See Kelli Rudolph, “Sight and the Presocratics: Approaches to Visual Perception in Early Greek Philosophy,” and Andrea Nightingale “Sight and the Philosophy of Vision in Classical

Greece: Democritus, Plato and Aristotle” in *Sight and the Ancient Senses*, 36-53 and 54-67, with references.

⁵⁶ For the constant echo of the Timaeian theory of vision in later theories see David Hahm, “Early Hellenistic Theories of Vision and the Perception of Color,” in *Studies in Perception: Interrelations in the History of Philosophy and Science*, ed. by Peter Machamer and Robert Turnbull (Columbus: Ohio State UP, 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. by Robert Nelson (Cambridge: CUP, 2000), 143-68 ; Roland Betancourt, “Why Sight Is Not Touch: Reconsidering the Tactility of Vision in Byzantium,” *Dumbarton Oaks Papers* 70 (2016): 1-23.

⁵⁷ This paper was stimulated by a PhD research project on the *Metaphysics of Light in the Hexaemeron* supported by the Arts and Humanities Research Council, the George and Marie Vergottis Foundation, the Leventis Foundation and the Faculty of Divinity, University of Cambridge. I am particularly grateful for comments offered in various stages by Rowan Williams, David Sedley, Catherine Rowett, Katerina Ierodiakonou, Barrie Fleet, Christian Hengstmann, the editor of this journal and two anonymous reviewers. Though I have profited enormously from them, I remain solely responsible for all shortcomings.