International Journal of Arts and Humanities (IJAH)
Bahir Dar, Ethiopia
Vol. 9 (1), S/No 32, JANUARY, 2019:130-139
ISSN: 2225-8590 (Print) ISSN 2227-5452 (Online)
DOI: http://dx.doi.org/10.4314/ijah.v9i1.13

Two Crucial Experiments on the Nature of Light: Beyond the Bounds of Wave-Particle Duality

[1]Emedolu, C. C., [2]Ihejirika, C. & [3]Nnamdi, B. S.
Department of Philosophy
Faculty of Humanities
University of Port Harcourt, Port Harcourt
Rivers State, Nigeria
E-mail: [1]dongaphilsemd@yahoo.com; [2]cardinalihejirika@gmail.com; [3]docgurubeennamdi@gmail.com

Abstract

The wave-particle duality of light has been hanging over the clouds of science as an insuperable mystery. Debates have gone on for centuries as to which of the two aspects of light best represents the natural property of light. On the one hand, the particle theory of light camp made its own submissions a long time ago with many experimental demonstrations to confirm its position. On the other hand, the wave theory of light camp did organize or face some experiments to corroborate its own position. But then, a middle ground interpretation was shoveled-in by Niels Bohr during the second decade of the 20th Century. For him, the two aspects of light are complementary and Louis de Broglie popularized it, despite the halting beginnings of the complementarity Thesis. A double-slit experiment was, however, organized to show that light has these dual aspects. The central thesis of this paper is that though light exhibits these dual aspects, it is fundamentally a wave. The paper adopts the historiographical approach in navigating this lingering issue of the nature of light in the history of science.

Introduction

In the later part of Greek antiquity, Strato of Lampsacus gave the earliest insight into the corpuscularian (particulate) view of light. In the words of Lindberg: "Corpuscular ideas are most obvious in Strato's belief that light is a material emanation…" (1992, p.77). This means that he achieved the particle vision of light long before the mediaeval Robert Grosseteste, who argued that, light was the first material (prime matter) element in the universe (Emedolu 2019, p.54). In other words, it was from light source that materiality sprang in the entire universe. As such, matter subsists in the faintest flicker of light.

In spite of all the quarrels and criticisms within the scientific community – often signaling the heterodox nature of science – scientists are not oblivious of the fact that they are seeking to create the best and most rewarding picture(s) of reality. Criticism, as Karl Popper, Imre Lakatos, Alan Musgrave and other philosophers of science agree, brings about growth or progress in science. The fact remains that strong and honest disputes within the scientific community have never been considered as anomalous right from antiquity till date. Science lives on strife as much as philosophy. Conflict is, indeed, the oxygen that energizes science. Yet, in his wake in the *Prolegomena to any Future Metaphysics,* Immanuel Kant wonders why science should be so progressive or successful and philosophy settles for moving round in a circle. The answer to Kant's aporetic wonder is found in experimentation. Whereas scientists appeal to experiment in order to settle their disputes, philosophers have no such empirical sanctuary to run to in terms of adjudicating over pure abstract intellectual issues. Scientists will always have the patience to wait until an enlightening experiment emerges. Of course, Kant clearly knew that a man who focuses on the empirical aspect of reality has a very great advantage over the philosopher who busies himself with transcendental ideas that often lack empirical proofs. Even the tool of logic cannot help philosophers in settling all their disputes, because of the conditionalities of Antinomies of Reason. Reason, Kant says, can produce perfectly valid but contradictory arguments that cannot be settled by any appeal to the empirical world.

Given early debates on the nature of light, this paper focuses on two different experiments that expressly verified both the wave and particle theory of light. How possible can this be that, the two theories of light are both true? How can one explain the validity of two seemingly contradictory experimental results? How does one characterize the real nature of light beyond the fabrics of classical and quantum physics? St Augustine of Hippo (354-430) had earlier forewarned, in the Patristic period, that the nature of light is in-explainable even though we all see and seem to know what light is. But whenever one is asked to define it one is at a loss.

It is pretty difficult to make a complete historical survey of the wave-particle duality of light. But one must begin from somewhere and touch a few watersheds in the history of the two aspects of light. In what follows, then, we shall look at the modern relegation of ether and the implacable sustenance of the corpuscularian inheritance of light; we shall highlight the experiment that confirms Augustine Jean Fresnel's wave theory of light; we shall discuss theQuantum narrative of the wave-particle imbroglio and its skirmishes. Ultimately, we shall offer two favorable experimental supports for Bohr's and de Broglie's dual aspects of lightand render our conclusion.

Modern Relegation of the Ether and the Ascendancy of Corpuscularian View of Light

In the modern era of science, the battle over the existence of the ether hewed a scintillating new ground for itself. It was moved to the grand field of optics or light. Within this spectrum or context of optics, the modern battle ensued in the seventeenth and eighteenth centuries, wherein the particle theory of light was debunked. To be sure, in his early 1660s studies in optics, Christiaan Huygens, the great Dutch scientist, re-launched the existence of the ether as a medium through which light travels. This is in consonance with the medieval view that no light travels or descends without passing through a medium. It is often represented in the famous Latin quip: *Lumen superno non descenditindumento*. Basically speaking, the wave interpretation of light in the modern period reads: "Light was thought of as a transverse vibration in a universal medium, the ether. The ether was supposed to permeate the whole universe and to be the stationary background to all motions" (Harré 1981, p.117). Unfortunately, Huygens' wave theory could not, by way of experimental demonstration, address "the rectilinear propagation of light". This anomaly was indeed a great blow on the wave conception of light. Hence, the scientific community had to look for a way out.

Eventually, the Newtonian particle/corpuscular theory of light overtook Huygens' wave theory, largely because of the latter's incapacity to respond to the issue of rectilinear propagation or what Nikola Tesla later dubbed as longitudinal perturbation or disturbance in the ether. Isaac Newton verily upheld the particle theory of light devoid of ether. In fact, for Newton, ether was an occult feature or quality that should not be considered in science, since it does not uphold the *vera causa* principle of modern empirical science, handing out the strong charge that for any theoretical entity to be accepted in science, it must be capable of producing some palpable effects. To be sure, it was for this same *vera causa* principle that Newton applied his famous dictum, *Hypotheses non fingo*, to nail the Cartesian Vortex or Ether Hypothesis.

Ideologically speaking, some scholars have earnestly doled out the charge that Newton wielded the big stick when he became the president of the Royal Society of London to inaugurate the reign or dominance of the particle theory of light. In point of fact, Newton truly battled his forebear, Huygens, over the latter's waves-in-ether theory of light. Given Newton's mechanistic orientation, the bumping particles assumption of the universe seemed far much better than the introduction of the so-called occult ether medium. He eventually undercut the comprehensive theory of ether and rather gave to us what is known today as the "corpuscularian inheritance" of light. In fine, Larry Laudan provides a summary chronicle on the battle between the wave and corpuscular/particle theorists in the 18^{th} and 19^{th} Centuries in the following words:

> Several points about the historical record are uncontested. Let me begin with a summary of those: through much of the 18th century, Huygens' wave theory of light was eclipsed by Newton's corpuscular theory, not least because it seemed that Huygens could not explain the rectilinear propagation of light. At the turn of the 19th century, Thomas Young attempted to revive the wave theory using it to explain phenomena of diffraction and optical interference such as the colors of thin films and diffraction. Young's theory in turn failed to be able to account for polarization. Then Fresnel came up with a kinematic model which conceived light as a transverse vibration transmitted in an elastic etherial fluid… During the early 1830s, Cauchy developed a dynamical wave theoretic model that explained dispersion as well (1992, p. 213).

Augustin Jean Fresnel's Wave Nature of Light and its Strong Experimental Backing

In the early 19th Century Thomas Young made serious efforts to bring back the glory of wave theory of light. He failed precisely because no experiment was as at that time devised to answer or "account for the polarization of light" (Laudan 1992, p.213). Of course, this became a nagging nightmare for the entire scientific community till quantum mechanics was brought to bear on the issue of polarization. As it stands, Laudan sums up the long historical battle that smoothen the rough path for the quantum scientists thus: "After intense debate among physicists in the 1820s and early 1830s, most scientists had come to accept the superiority of the wave theory by the late 1830s, although a few hold-outs persisted for another generation" (1992, p.213).

Having highlighted the foregoing and subtly establishing it as fact that two contending theories of light are at this material point in time trying to undermine and eliminate each other, we need to look more closely at Fresnel's experimental exploit. Within the clear dispensation of corpuscularian/particle or Newtonian theory of light, David Brewster was conducting some experiments and produced substantial phenomena that enabled an advocate of the rival *wave theory* of light to complete his rival or competing edifice. The story of this unwitting discovery by Brewster and its appropriate use by Fresnel runs thus:

> We now speak of Fresnel's laws, the sine and tangent laws for the intensity of reflected polarized light, but Brewster published them in 1818, five years before Fresnel's treatment of them within wave theory. Brewster's work established the material on which many developments in wave theory were to be based….
>
> Brewster firmly held to the 'wrong' theory [i.e., the particle theory of light] while creating the experimental phenomena that we can understand only with the 'right' theory [i.e., the wave theory of light], the very theory that he vociferously rejected (Hacking 1983, p.157).

Here one is clearly reminded of the autonomy of scientific experiment discourse. Indeed, the passage casts one's mind back to what happened between the phlogiston theorist Joseph Priestly and the oxidation theorist Lavoisier. Truly, a well-designed scientific experiment – with complete material procedure, instrumental model and phenomenal model – speaks quite independent of any scientific theory (Emedolu 2017, p.19). As Max Planck says, experimental result is indeed Nature's answer to the question posed in any scientific theory. Members of rival theories can make good use of effects/phenomena created in the process of scientific experimentation by their rival or counterpart group. This depicts the heterodox character of the scientific community and, more particularly, the fact that science is oriented towards the pursuit of truth. If one says, like Bas C. van Fraassen does (in *The Scientific Image*), that science ultimately aims at producing empirically adequate theory (or the best picture of the world), then we can say to him that scientists live in a manner that shows they are searching for truth. The sort of truth scientists are looking for is the one that will make them absolute masters and possessors of the universe (to borrow an expression from René Descartes).

Meanwhile, in "Fresnel, Poisson and the White Spot: The Role of Successful Prediction in the Acceptance of Scientific Theories," John Worrall presents the strong and captivating debate which ensued in the early nineteenth century between the particle theory of light and the wave theory of light advocates. Worrall writes:

> Augustin Jean Fresnel, in 1819…, sent to the Academy a long memoir which attempted to show in detail how all diffraction phenomena could be explained on the supposition that light consists of wave-like disturbances transmitted through an all-pervading medium. This theory was, of course, not new in the early nineteenth century, but it had long been regarded as discredited. The prevailing view, invariably described as Newtonian amounted (at any rate on a "realistic" interpretation) to the theory that light consists of material particles subject to short range forces emanating from ordinary "gross" matter. This emission theory formed a central plank of the Laplacian approach to physics, which was dominant in France at the time (1989, pp.135-136).

The interesting aspect of this tale is that it was a fight between corpuscularian (particle/Newtonian) theorists and an ether or wave theorist (Fresnel), whereby the latter takes his war to a seasoned commission of prize judges whose members were virtually all particle theorists (Newtonians). In science, this is quite a normal practice. I insist once more that, if scientists are not looking for truth, then it is quite amazing why one should send one's papers to a trial jury made up of one's enemies. One who referees any paper should be one who somewhat understands or aligns with the viewpoint of the writer. This is why we condemn or oppose T.S. Kuhn's idea that two or more scientists whose theories are incommensurable live in quite separate worlds. Believe it or not, there must always be room for inter-paradigmatic communication. This room is brought about by the facticity of what Ian Hacking calls, in *Representing and Intervening*, "home-truth" about certain entities under scientific investigations.

Now, Worrall projects the fact that it is not enough to postulate a hypothesis or formulate a theory, but that one must be able to stand within the trajectory range of all possible predictive consequences of such a theory and/or hypothesis. Fortunately, Fresnel was able to do such a committed standing to his wave or undulatory theory of light, which, of necessity, proves the existence of ether. To all intents and purposes, a crucial experiment was contrived (after Poisson's prediction of *white spot* at the center of the cast shadow) to test Fresnel's theory, which was, of course, proven right. Poisson was a hardcore light-particle theorist of the Laplacian School, a bye-blow (or off-shoot) of the comprehensive School of Lagrange, if I am permitted to use such terms. Poisson's master Pierré Simon Laplace was an ardent supporter or disciple of Joseph Louis Lagrange, one of the modern developers of the calculus, alongside his forebears Gottfried von Leibniz and Newton, and his own successors, Augustin Louis Cauchy and Karl Weierstrass. Worrall articulates what actually transpired by way of confrontation between Poisson and Fresnel in these crisp words:

> Poisson demonstrated that Fresnel's wave theory of diffraction has a patently absurd consequence: it implies that if a small opaque disc is held in the light emanating from a small hole, the center of the disc's shadow will be bright, just as bright indeed as if no obstacle had been placed in the light's path. Arago tested this consequence; lo and behold, he found the white spot! (1989, p.136).

This particular success of the wave-theory of light was attributed though to Fresnel's "invention of a new method of observing and measuring diffraction fringes" (Worrall 1989, pp.141-142). Considering the novelty of the evidence, many scientists came to believe that Fresnel's theory is after all "objectively superior" and lays claim to being "better empirically supported than the old [particle theory of light]." Yet Worrall says: "'Switching to' or 'preferring' a theory need not – in my view – involve believing it to be true" (1989, p.146). This reminds one of the argumentFraassen made between "belief" and "acceptance," which is currently not part of our concern in this paper.

Despite the success of the wave theory of light that admits the existence of ether, Henri Poincaré (a mitigated or moderate conventionalist) clearly doubts the truth about the existence of the ether. In *Science and Hypothesis*, Poincaré points out that, Maxwell's electro-magnetic theory is a direct rebuttal of the ether theory – a view we scarcely share with him. Yet Poincaré insists that "No theory seemed established on firmer ground than Fresnel's, which attributed light to the movements of the ether." He, however, contends that Fresnel never set out "to know whether there really is an ether, if it is or is not formed of atoms, if these atoms really move in this way or that; his objective was to predict optical phenomena." Poincaré, ultimately, stresses that Fresnel's theory only enables us to infer ether by indirection; that Fresnel's "differential equations are always true"; and that Fresnel's entire work was not in vain, as it is still relevant in many ways, though “Maxwell’s theory is today preferred” (Poincaré 1990, p.46).

Now, a few years after Fresnel’s exploits, Foucault also carried out an experiment in 1850 which tries to evaluate the motion of light in various media. In doing this, Foucault demonstrated that light moves “faster in water than in air”. Incidentally, Helen Lauer writes:

> This effect was deduced from Huygens’ hypothesis that light is propagated in a wave-like motion through the ether, presumed to fill all space. A competing hypothesis of Newton claimed that the motion of light consists of a stream of tiny fast-moving particles. From Newton’s theory it can be deduced that light should move measurably faster through the air than it moves through water, since water offers a greater resistance to the moving particles. Foucault’s result, made possible by advances in physical optics in his time, provided a methodologically good reason for rejecting Newton’s corpuscular theory of light (2003, p.312).

Given the predicament of the corposcularian theory, Bas C. van Fraassen asked a reasonable question which is followed up with an answer thus: “When Huyghens’s waves-in-the-ether theory defeated Newton’s particle theory of light, was that a setback for materialism? Surely not, although the ether was a continuous medium, not particulate” (2002, p.52). Rom Harré, for his own part, tries to paint the scenario of the storm that hit the Newtonian particle theory of light in the following dirge: “What was light? The particle theory of Descartes and Newton had slowly been replaced by a wave theory” (1981, p.117). But, then, in quantum mechanics, both aspects of light are seen as complementary by Niels Bohr and Louis de Broglie.

Quantum Narrative of the Wave-Particle Imbroglio and its Skirmishes

A closer look at de Broglie’s matter wave phenomenon and or his earth-shaking support for Bohr’s quantum Thesis of complementarity in wave-particle duality of light/radiation will go a very long way in giving us one solid picture of quantum reality. In other words, a studied investigation of de Broglie’s accomplishments opens our eyes to more facts about quantum view of light.In a very characteristic way, de Broglie made a hypothetical submission which reads: “Since light, which we usually think of as a wave, can exhibit particle-like behavior, perhaps a particle of matter, like an electron, can exhibit wavelike behavior” (Walker 2007, p. 1017). This marks a giant stride in the long-lived research on the nature of light. A Nobel Prize was, of course, awarded to this bourgeoning physicist for this fabulous wave-particle duality Thesis.

In point of fact, the then young physicist, de Broglie (1892-1987), was following the long history of the debate on wave-particle duality of light and listened keenly to every argument, especially, from the potpourri of relativity and quantum physicists. Being so “influenced by the fact that radiation …has dual nature (,) … ‘De Broglie came to the important conclusion that a kind of wave is associated with material particles.’ And this led to the ‘experimental confirmation of matter wave’” (Emedolu 2007, p.160-161). It is important though to stress that when de Broglie arrived at his matter-wave intuition (or conception) in 1927 in his Ph.D. thesis, a few quantum physicists doubted its validity or veracity, to such an extent that, his supervisor sent the work to Albert Einstein for some comments. Whatever remarks the cut-and-dried Relativity physicist made, what became crucial is that, particle theory and wave theory of light were both accepted (as earlier decreed by Bohr in his complementarity principle) and are still being used in the field of science today. Could it then be that reality embraces these double dimensions? Here, Werner Heisenberg provides a ready answer, “Bohr advocated the use of both pictures, which he called ‘complementary’ to each other. The two pictures are of course mutually exclusive, because a certain thing cannot at the same time be particle (i.e., substance confined to a very small volume) and a wave (i.e., a field spread out over a large space), but the two complement each other” (1958, p.49). Can matter actually resolve itself into wave? If this is not the case, to what extent then can one determine the exclusivity of the two, even as the ether lives on? Be that as it may, Popper at least gave his comforting words that, “…de Broglie’s prediction of the wave character of matter (was) first confirmed experimentally by Davisson and Germer” (2002, p.90).

The muddling of these two aspects or dimensions of light is as a result of certain or several experimental demonstrations. It must be noted that experiment is the very foundation of quantum mechanics. If any experiment can show at once how light is a wave and a particle, then the quantum physicist feels he has no other option than to accept it. Thus far, we need to cast a further penetrating look at the very experiment that validated the critical position on the dual nature of light. This famous experiment is called double-slit experiment.

Experimental Support for Bohr’s and de Broglie’s wave-particle Duality

Long before the wake of Bohr and de Broglie, Thomas Young first designed the double slit experiment in 1803, using the sun’s rays. This experiment had made a significant impact, only that it was not taken too seriously by some scientists. One may, to a reasonable degree, say that the experiment accurately validates both the wave and particle dimensions of light. Does this very experiment then suggest that the Thesis of dual nature of light can comfortably be defended? Emedolu puts it thus: “The double-slit (experiment) on wave-particle duality has somewhat doused the heated debate by using the same experimental design [or material procedure] to prove [or rather demonstrate] both the particle and the wave nature of light” (2010, pp.73-74).

Henceforth, we may try to explain it in simplest and rawest terms. In the double-slit experiment, two different holes are made and electrons are used as light sources. The first hole through which electrons enter is big enough to allow an electron pass through like a “bouncy little ball”. The second hole is so tiny that an electron is expected or supposed not to pass through it, if it is actually a particle. But the experimentalists discover to their great surprise that an electron is able to perform some kind of maneuver that enables the so-called electron particle to swim through the smaller slit. This unique feat can only be achieved by a wave. Therefore, the double-slit experiment simply shows that electron behaves both like a particle and a wave. The experimental demonstration of electron’s wave pattern of behaviour by the Scottish C. P. Thomson can never be erased from the history of contemporary science. Whence, the dual status of electron is a strong confirmation of de Broglie’s matter-wave Thesis, a view that matter at once has the wave aura around it and wave character within its very core.

In a typical quantum scenario, some sort of electron or atom gun is used to fire electrons through two openings or slits close to one another. When one consciously observes the result, one notices that only two bars are made on the screen. But if there are no observers, some levels of wave interferences are noticed, so much so that a multiple of five or six different bars is created on the screen. This leads to some kind of quantum mystery, wherein a role could be created for consciousness in quantum experiments. But this question is beyond the scope of this paper. What essentially is being hammered home here is that an electron or a full atom can behave both as a pure hard mater or particle and as a streaming wave.

The buoyant Otto Stern (1888-1969), in his experiments, sufficiently demonstrated the wave quality of matter by properly adapting the molecular beam apparatus. He first did this, of course, with the help of his assistant, H. Gerlach. The Stern-Gerlach experiment on the wave aspect of matter led to the discovery of the third quantum number. Harré commented:

> It was after the war [World War I] that he [Stern] developed his molecular beam methods for studying free atoms, on the analogy of light beams. His beams of atoms, upon which the experiment described in this section depended, were the basis of his demonstration of the wave-like properties of matter, which in classical physics, had been assumed to be wholly particle-like. In 1923 he moved to Hamburg to his own laboratory. With new and greater facilities, he was able to develop the molecular beam methods still further, and it was there that the actual demonstrations of the wave aspects of matter were achieved (1981, pp.198-199).

In another special round of experiment, Stern collaborated with Estermann who had mastered the technique of using crystals to diffract electrons round about 1929. This technique “had been developed by Elsasser and refined by Davisson and Germer in 1927” (Harré 1981, p.203). This Stern’s breakthrough experiment is celebrated by Harré in the following manner:

> The beam-producing equipment with its contra-rotating wheels was used to be sure that all the atoms were at the same speed. The beam-producer was coupled with a lithium crystal for a target, and with a detector to measure the angle through which atoms were diffracted. If they were being mechanically reflected, behaving as stream of particles, as tennis balls do when reflected off a volley board, then the angle of reflection would be about the same as the angle of incidence. But if they were being diffracted, behaving like a wave, then there should be a spread of diffracted atoms, like a diffracted wave front.
>
> … Stern and Estermann found just the distribution, or spread, that they were expecting. The pressure in their little collecting ‘jar’ rose to a peak in just the way it should if the beam of helium atoms was behaving like a wave (1981, pp.205-206).

The fact that Otto Stern was (in 1943) awarded the Nobel Prize shows that his experiments were well received and considered very significant. But in all, much as his experiments were highly regarded, they are only pointing back to and foregrounding the ancient claim of the existence of the ether loudly verbalized by Anaxagoras and Aristotle. To be sure, the ***ether*** is the queen of all-pervading waves in the universe. If wave is ever established, as it has been done in the case of electro-magnetic wave and gravity wave, then we have taken the shortest step towards asserting the existence of the ether.

Beyond the experimental demonstrations of Otto Stern, and, of course, that of the Scottish C. P. Thomson, de Broglie’s work was greatly appreciated by Erwin Schrödinger. De Broglie’s impact in quantum physics can never be neglected. Schrödinger strongly argued that electron is not a particle but merely a matter wave. This, indeed, ushered in the new wave mechanics associated with quantum physics. Heinz Pagels sums up the agony that trailed this position thus:

> The ‘Schrödinger equation’ applied to all sorts of quantum problems. A series of experiments supported Schrödinger’s and de Broglie’s thesis that electrons exhibited defraction – there was no doubt that true waves were

> involved. But waves of what? The problem of the interpretation of the de Broglie-Schrödinger waves became the central puzzle of the new wave mechanics (1982, p. 62).

Thus far, we wish here to counter Hans Reichenbach's idea that, the only direct meaning de Broglie's wave-particle duality discovery has is "that the same physical reality admits of two possible interpretations, each of which is as true as the other, although the two cannot be combined into one picture" (1951, p.175). In our view, we say that such combination is at once both possible and plausible if at all humans can rid their minds of the logic of exclusion. We submit that the interpretations are simply showing different capabilities and manifestations or aspects of the same reality that are both compatible and complementary. This is not to say that are unaware of the fact that Popper muted that the, "attempt to explain the dualism of particle and wave in terms of 'complementarity'" is completely invalid (2002, p.297). To be sure, our use of the term "complementary" is quite different from the technical understanding of it in quantum physics. Yes, the two aspects manifest themselves at many instances, but the more fundamental character of light is wave. It is always a fallacy to think that we have grasped all the possibilities of an entity in all imaginable interactive media or environment. The moment Reichenbach understands this possibility then it will become clearer to him how "two possible interpretations" might be telescoped together or woven into each other without contradictions.

Conclusion

Having come thus far, we need to reach a conclusion based on Anaxagoras' primordial ether phenomenon. We dare say that, one who accepts the existence of the ether can still defend the particulate view of light. But many thinkers in our time tend to believe that the comprehensive theory of ether is antithetical to the corpuscular view of light. Just like Aristotle and Descartes, we do not think they are mutually exclusive. The fact is that particles can still pass through ether and retain their corpuscular character. Specifically speaking, the ether theory could be seen as a more comprehensive theory that houses both the wave and particulate theory of light. The ether can as well be seen as that which possibilizes the matter-wave hypothesis. This, essentially, shows that one who accepts the existence of ether can still at once defend the particulate and wave views of light. incidentally, the ether cannot be said to be any concrete, particulate individual thing. Its refined nature makes it closer to pure spirit, which in our age can be crudely translated as a disembodied/pure or non-compact sort of wave. Hence, if light is seen as a wave, then it must always be perceived as a compact kind of wave.

Hence, our interpretation, as it were, comes very close to Einsteinian rendering that energy comes in packets of photon. Photons are energy bundles or quanta and could be taken as the very prime matter that was formed from ether (parent wave or primordial energy), as Grosseteste claimed in the middle Ages. Therefore, it is in light or electron that we see the closest link between wave and matter. At bottom, wave or energy is more primordial to any form of matter. This position is further buttressed by James Redfield, when he argues that, "…the basic stuff of the universe, at its core, is…a kind of pure energy…" (1994, p.58). Anaximander knew very well that pure energy could be converted to matter with an accelerated motion which the pre-Socratics referred to as "aideos kinesis" (eternal motion). Interestingly, it took quantum physicists two and a half millennia to come to the realization of this fact, say, that energy could be run at great velocity in the Sea of Potential to give rise to matter or particles. With this, we think the abiding mystery or paradox of light has been dissolved. Light is both a wave and a particle. Everything depends on the angle from which one wants to approach this seemingly strange phenomenon of light; but, all the same, it has a wave source. Hence, its first characterization is wave, precisely as luminiferous (to borrow a popular mediaeval term).

References

Emedolu, C.C. & Onuoha, J.A. (2007). *The concept of science as an ideology: Silhouette of the anarchist*. Port Harcourt: University of Port Harcourt Press.

Emedolu, C.C. (2010). *Originality*, Vol. II. Port Harcourt: University of Port Harcourt Press.

Emedolu, C. C. (2017). Ian Hacking on the primacy and autonomy of scientific experiment: Perspectives in the history and philosophy of science. *Explorer: African Journal of Philosophy, Arts and Social Sciences*. Vol. 1. No.1. Pp. 8-20.

Emedolu, C. C. (2019). Experimentation in the Mediaeval Period of science: A brief historical excursus. In Emedolu, C. C.&Gwunireama, I. U. (eds.). *Ramifications of philosophic wisdom,*Pp.49-62. Port Harcourt: University of Port Harcourt Press.

Hacking, I. (1983) *Representing and intervening: Topics in the philosophy of natural sciences.* Cambridge: Cambridge University Press.

Harré, R. (1981). *Great scientific experiments*. Oxford: Oxford University Press.

Heisenberg, W. (1958). *Physics and philosophy: The revolution in modern science*. New York: Harper Torchbooks.

Laudan,L. (1992). Waves, particles, independent tests and the limits of inductivism. *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*. Vol. 2. Symposia and Invited Papers, Pp. 212-223.

Lauer, H. (ed.) (2003). The standard 'foundationalist' view of testing empirical hypotheses, and the 'Holist' challenge to that view. In Lauer, H. (ed.) *History and philosophy of science for African undergraduates*. Ibadan: Hope Publications.

Pagels, H. R. (1982) *The cosmic code: Quantum Physics as the language of nature*. New York: Bantam Books.

Popper, K. (2002). *The logic of scientific discovery.* London: Routledge.

Redfield, J. (1994). *The Celestine Prophecy: An adventure*. London: Bantam Books.

Reichenbach, H. (1951). *The rise of Scientific Philosophy*. Berkeley: University of California Press.

Stewart, I. (1989).*Does God play dice? The mathematics of chaos*. Cambridge: Blackwell.

Walker, J. S. (2007).*Physics*. 3rd Ed. San Francisco: Pearson Educational Inc.

Worrall, J. (1989) Fresnel, poisson and the white spot: The role of successful predictions in the acceptance of scientific theories. In Gooding, D., Pinch, T., & Schaffer, S. (eds.)*The uses of experiment: Studies in the natural sciences*. Cambridge: Cambridge University Press.