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If EM Waves do Not Interfere, What Causes Interferograms?

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ABSTRACT

Photonics engineers involved in designing and operating Fourier transform spectrometers (FTS) often rely on Maxwell's wave equations and time-frequency (distance-wavenumber) Fourier theory as models to understand and predict the conversion of optical energy to electrical signals in their instruments. Dr. Chandrasekhar Roychoudhuri and his colleagues, at last year's conference, presented three significant concepts that might completely change the way we comprehend the interaction of light and matter and the way interference information is generated.

The first concept is his non-interaction of waves (NIW) formulation, which puts in place an optical wave description that more accurately describe the properties of the finite time and spatial signals of an optical system. The second is a new description for the cosmic EM environment that recognizes that space is really filled with the ether of classical electromagnetics. The third concept is a new metaphysics or metaphotonics that compares the photon as a particle in a void against the photon as a wave in a medium to see which best explain the twelve different aspects of light. Dr. Henry Lindner presents a compelling case that photons are waves in a medium and particles (electrons, protons, atoms) are wave-structures embedded in the new ether. Discussion of the three new principles is intended to increase the curiosity of photonics engineers to investigate these changes in the nature of light and matter.

Keywords: Roychoudhuri, NIW, non-interaction of waves, interferometer, spectrometry, Maxwell's wave equation, Fourier theory

1. INTRODUCTION

The purpose of this paper is twofold. The first is to give the author an opportunity to study and review radically new information about the nature of the photon, the nature of space, and the relationship between light and matter. The new epistemology proposes new properties for space and for the photons, electrons, and atoms that form the basis for photonic work. The new epistemology is currently being developed by leading theoretical physicists in the SPIE community[1-3]. There are challenges to these new ideas from others in the group[4,5]. These counter arguments steer the group towards a physics that is self-consistent and best fits the observations and measurements that have been made. Dr. Chandrasekhar Roychoudhuri and his colleges are looking at existing photonics with the ultimate goal of producing ideas that are as objective and as comprehensive as possible.

The second purpose of the paper is to provoke an interest in the observations, discussions, arguments and conclusions that were presented in session 8121 during last year's conference. These sessions were entitled "The nature of light: what is a photon." Presenters in the 8121 sessions introduced important and significant work moving towards a greater understanding of the fundamental nature of the photon and it is expected that the practicing photonics engineer will find this new metaphysics to be intriguing, thought provoking, and significantly beyond what they currently understand the photon and electron to be.

If I do not fully understand the nature of the photon, can I still develop a sensor to successfully measure light?

The answer to this is "of course." In the day-to-day process that takes a sensor from concept to a flight qualified instrument[6], a detailed comprehensive understanding of the exact nature of the photon is not exactly needed to successfully produce a quality result. Ingle and Crouch[7] describe the photon as, "…discrete packets of electromagnetic energy…that have a wave character…" This alludes to the particle/wave duality of the photon. They introduce the equation

$$E_p = \frac{hc}{\lambda}$$

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to state the relationship between the energy of each photon and its wavelength and velocity. This equation allows photometric energy to be expressed either as Joules/second for radiant flux or quanta/second for photon flux.

$$\varphi_e = \frac{hc}{\lambda} \varphi_p.$$

Using this equation shows that, as long as the units remain consistent throughout the preparation process, it does not matter which aspect of the photon is used.

In both cases, the energy of the photon is not directly observable and it is the conversion to an electrical signal that is of primary interest. After the collected signal photons have been processed with appropriate optics, apertures, field stops, beam splitters, optical filters, and detectors(s), the resulting signal becomes electrical in nature, and the radiometric "measurement" is developed using the electrical signal. Using calibration techniques, the electrical signal derived from observing a well characterized blackbody producing a low uncertainty Planck function emission is used to infer the radiometric energy associated with the collected signal photons.

From the above discussion, it is clear that it is not necessary to completely understand the latest photonics models when one undertakes to prepare a sensor to make observations. Even so, it is satisfying to have the best insight possible into the latest photonics and to feel that physics make sense with respect to the work the photonics engineer is performing from day-to-day.

2. PARTICLE OR WAVE - WHERE'S THE INTERFERENCE?

During SPIE's conference in 2011 in session 8121, over 55 papers were presented that dealt with the question of, "What is a photon?" These presentations, added to earlier information from previous years, have produced an important body of work. This paper looks at the re-emergence of the classical EM as the basis for the new metaphysics and at the implications of based photonics on our understanding of wave/particle duality. Finally, the principle of non-interference of waves (NIW) is reviewed to show its central role in understanding interference and diffraction phenomenon and the critical importance of the detector in the information gathering process.

Ether or "the grid" or a Cosmic Complex Tension Field (C^2TF)

Perhaps the most unexpected idea to emerge from last year's 8121 sessions was to hear that C^2TF was once again the medium responsible for EM propagation. The re-emergence of C^2TF as a medium was presented in the paper[1] entitled "*The constancy of c everywhere requires the cosmic space to be a stationary and complex tension field*." This paper presents the compelling argument that the void of space is actually filled with ether or a Cosmic Tension Field (C^2TF), as Dr. Roychoudhuri has named it. In his book, "*The Lightness of Being; Mass, Ether, and Unification of Forces*," Frank Wilczek[9] calls it "the Grid," implying this field is analogous to the electric grid that supplies power to our homes and workplaces. This new ether or Complex Cosmic Tension Field, permeating through all space, becomes a universal substrate that has the potential to profoundly change the way we think about the structure of fundamental particles and the way light and matter interact.

The implication that the C^2TF is the physical description comes from the solution of the wave function that describes plane wave EM propagation. In the solution, phase velocity and wavelength, are governed by the angular frequency ω and the three constitution parameters that are associated with any medium (ε, μ, and σ). The constitution parameters, ε ,μ and σ, are respectively the electrical permittivity, the magnetic permeability, and the conductivity. In general, $\varepsilon = \varepsilon_r(r, \theta, t)\, \varepsilon_0$ and $\mu = \mu_r(r, \theta, t)\, \mu_0$. Together, these three constants form the basis for the cosmic complex tension field. For free space, where $\varepsilon = \varepsilon_0$, $\mu = \mu_0$ and $\sigma = 0$, the field is isotropic and homogenous. Roychoudhuri defines ε_0 as the tension in the tension field and μ_0 as the restoring force. The units for μ_0 are $[\frac{As}{Vm}]$ and for ε_0 they are $[\frac{Vs}{Am}]$ where V is volts, A is Amperes, m is meters and s is in seconds. From the solution for the propagation of EM plane waves, the velocity of light is $c = \frac{1}{\sqrt{\varepsilon_0\, \mu_0}}$ for free space. Given that the effective speed of light is less than c in a lossy medium, the implication is that the tension field imposes a maximum speed on light and that speed is c. It also follows that c will always constant in free space because ε_0 and μ_0 are everywhere constant. Another significant result, based on Einstein's famous equation, $E = mc^2$ or $m = E\varepsilon_0\, \mu_0$, implies that mass is a function of the same constants that created the tension field. Roychoudhuri[10] goes on to assert that, "…gravity, in general relativity, appears as a curvature of space (some gradient in the potential tension field?)…It does not make sense to negate that the cosmic space is some form of Complex Cosmic Tension Field or C^2TF."

Roychoudhuri's narrative then moves ahead to suggest that the elementary particles, such as electrons and protons, are localized, complex, three dimensional, non-linear, resonant undulations of the C^2TF and to postulate that regional gradients in the C^2TF account for the four forces in nature. This is a theory that unites the four forces. This is the unification that Einstein sought for with his theory of general relativity.

The above discussion assumed that the C^2TF was static; a condition that is true in deep space. Near the earth or near any other large bodies, the field begins to change from one that is predominantly static to a more dynamic form. Near a large body, "space" (or the C^2TF) begins to "accelerate" and flow towards the center of that large body. This "flowing space" produces gradients that become the gravitational force associated with that body. It seems likely, that the gradients that lead to the forces in the C^2TF, exist because ε_r, μ_r or σ are varying as functions of distance or time.

Is a photon a particle, a wave, both, or neither?

It is an understatement to say that the exact nature of the photon still eludes the efforts of the photonics community to know exactly what its nature is: the photon continues to be a very enigmatic entity. Over the years leading theoreticians have devoted much thought and effort in trying to define just what a photon is and, from this effort, many different points of view have emerged. All are controversial.

Richard Feynman[8] defines the photon as, "a new kind of particle to add to the electron, the proton and the neutron." He defines the interaction of electrons and protons as electromagnetic theory which becomes quantum electrodynamics (QED) when things are made "quantum-mechanically" correct. He goes on to write that, "the fundamental theory of the interaction of light and matter, or electric field and charges, is our greatest success so far in physics." Earlier he writes, "One of the consequences (of QED) is that things which we used to consider as waves also behave like particles and particles behave like waves. "…quantum mechanics unifies the idea of the field and its waves, and the particles, all into one." He goes on to assert that, in general, the aspect (particle or wave) of the photon morphs between the two depending on the frequency. Feynman also adds, "we could have been speaking of the creation of particles, as for instance the emission of light. When the light is emitted, a photon is 'created'." Again he emphasizes that the photon is a particle. The standard models used in photonics today are based on Maxwell's four equations. Maxwell's equations (borrowed from Faraday, Ampere and Gauss) model electrical and magnetic phenomena and provide the basis for describing how light propagates through the cosmos. Einstein's special relativity comes into play to describe how electrical and magnetic fields interact as features of Einstein's physics. Quantum electrodynamics (QED) merges quantum mechanics with Maxwell's equations to provide the basis for how matter interacts with light. Richard Feynman, in his "Lectures on Physics," describes QED as the "fundamental theory of the interaction of light and matter, or electric field and charges, is our greatest success in physics;" Where, in classical physics, the basic building blocks of physics were particles (matter) and waves (light), QED claims photons, electrons, and protons each have particle and wave properties. In spite of its "weirdness," QED is currently accepted as the most successful of theories with experimental results clearly validating the theory.

In spite of QED's great success, the particle aspect of the photon is nearly always the characteristic feature that is described as "weird" and the property that has to be "accepted because it is just the way things are." No author argues with the "wave theory" representation for the photon, but labeling a photon as a particle is always contentious. Where Roychoudhuri[10] writes that the photon is defined as a discrete indivisible wave packet of energy, Feynman asserts that a photon is clearly a particle[9] but goes on to say, in his book, "*QED: The strange theory of Light and Matter,"* that some anonymous author, as a joke, had written that, "light is a wave on Mondays, Wednesdays, and Fridays and a particle on Tuesdays, Thursdays, Saturdays and Sundays." Even Feynman had some ambivalence about the photon. Current scientific conventional wisdom says that the proton is either a particle or a wave depending on the experimental measurement or theory under consideration. Depending on circumstances, light is then either a freely propagating wave in an electromagnetic medium or a particle moving through a void depending on whether light as a particle or light as a wave best explains the phenomena. This subjective use of the different properties of the photon is an unsettling feature of QM and QED. This leads to a contradiction because the photon should be one or the other. If a photon was truly both (wave in a medium and particle in a void) either model should have the capability to fully describe any of the twelve phenomenology of light. Clearly, the duality model cannot do this since the "wave model" is needed for some cases and the "particle model" is needed for the rest. The choice defends on what the observer thinks is appropriate.

Dr.Lindner[3] believes that the photon should be categorized as a wave in a medium. He does not accept the ambiguity associated with the wave-particle duality. He writes, "The questions are: does the light emitted from an individual electron consist of a flying particle, or of a wave-packet?" His position is "that the photon cannot simultaneously be both a flying particle and a wave packet; the two descriptions are logically and physically incompatible." He presents the following truth table to consider the photon as a wave in a medium (etherism) or as a particle (atomism) in a void to see which form best accounts for observed phenomena. Of course, "wave in a medium" implies the medium is a C^2FT.

Table 1: Comparison of the photon as a "wave in a medium" and as a "particle in a void" versus observed phenomena.

Best Explains observed phenomena	Wave in Medium	Particle in void
Wavelength and frequency	yes	no
Polarization	yes	no
Invariant velocity	yes	no
Super positioning	yes	no
Spreading or diffraction	yes	no
Continuous spectrum	Yes	no

Best explains observed phenomena	Wave in Medium	Particle in void
Laser	yes¥	Yes*
Blackbody Effect	yes¥	Yes*
Photoelectric effect	yes¥	Yes*
Compton effect	yes¥	Yes*
Anti-correlation	yes¥	Yes*
QED	yes¥	Yes*

¥ Requires light-electron interactions to be quantized plus background radiation.
*Requires wave theory to model and predict quantized events. (Table source: Lindner[12])

In the first section of the table, Lindner argues that clearly the listed phenomena can best be accounted for by waves in a medium. In the second section, the aspect is not as straightforward and requires further resolution.

Is the electron a particle or a wave structure?

To determine the correct explanation (etherism or atomism) for the second set of six items, Lindner[13] has developed a radically new wave theory of light and matter that redefines the photon as a wave packet and the electron as a wave structure. He writes:

1) "**An electron is an extended EM wave-structure:** it is not a point particle. It is composed of circulating EM waves. It is not a particle associated with a field: it is its EM field. It is as large as its influence in space."

2) "**The electronic wave structure is quantized:** The amplitudes and other physical parameters of an electron's EM wave are fixed by its structure. Only the wavelength-frequency varies and determines the momentum a free electron (de Broglie relation: $\rho \sim h/\lambda$)."

3) "**Electrons incorporate and expel EM waves:** Absorbed waves increase the electron's frequency."

4) "**Electronic wave-energy exchange with the environment is quantized:** Other physical parameters of the wave quanta that electrons absorb (amplitude, length, width) are fixed by the electron's wave-structure. Only the frequency-wavelength is variable and determines the energy of the quantum ($E = hf$)."

5) "**Planck's constant, h, is an electron-structure constant:** It describes electrons ($m_e = \frac{2R_\infty h}{c\alpha}$) and the quanta they emit and absorb. It is applicable to all phenomena and "particles" involving electrons and positrons. It does not describe free EM radiation."

6) "**Free EM waves are not quantized:** A quantum of light is emitted as a distinct wave-packet, but upon emission begins to spread in space like all waves (Huygens Fresnel principal). It ceases to exist qua quantum."

7) "**Quanta are emitted directionally:** As in a beam, not with spherical symmetry in all directions. Upon emission of a quantum, an electron recoils in opposite directions. Individual electronic emissions therefore do not obey the inverse square law."

8) "**Spatial spreading is proportional to wavelength:** The shorter the wavelength, the less the spreading of the wave-packet after emission. At very short wave lengths, the emitted quantum may appear to not spread at all over short distances."

9) "**Energetic background radiation:** In any space, there is significant EM wave energy of all frequencies for all near and distant sources (man-made, thermal radioactive, solar, Cosmic, etc.). This radiant energy creates a highly energetic EM background (quantum fluctuation, the "mode")."

10) "**Wave interference is not destructive:** The amplitudes of innumerable waves for all sources at all distances are superimposed at any given point in space. Wave energy is not destroyed. The EM background is more energetic than previously assumed (quantum fluctuations)."

11) "**Electrons are coupled to the background radiation and other electrons:** An electron cannot exclude background waves. Its wave are constantly superpositioning with background wave and the waves of other electrons. This coupling induces both quantum absorptions and emissions."

12) "**The absorbed quantum is the product of superpositioning:** Its energy does not usually come from the known source only, but from the superposition of source and background waves."

13) "**No independent knowledge of emitters:** In any laboratory set up, the location, timing, number, direction, and spread of emitted quanta are unknown. Statements about emissions are only inferences from detection events."

14) "**Statistical prediction:** Since the quantum emissions in the source cannot be known, nor the background radiation or the state of the receiving electrons, we can only make statistical predictions concerning where and when detection events occur."

Under this new formulation, a particle (photon) does not act on another particle (electron) any longer. Rather, a wave (photons) acts on wave structures (electrons). Under this new epistemology, the second six phenomena can be now assigned to the "wave in a medium" column because all interactions are between photons (wave-packets) and electrons (wave-structures).

Non-interaction of waves (NIW)

In the literature and in concept, it is often taught and accepted that waves interact directly with each other to produce interference and diffraction phenomenon when in fact the NIW principle emphasizes that it is the superposition of waves on a detector that produces the effect. Figure 1 illustrates this misconception. Ambroselli[11] writes, "First and foremost, one needs to remember that such detectors represent the only way we interact with and gather information about the physical world." Under the NIW principle, there is no modification to the amplitude, frequency or phase of emitted waves until they encounter a detecting dipole.

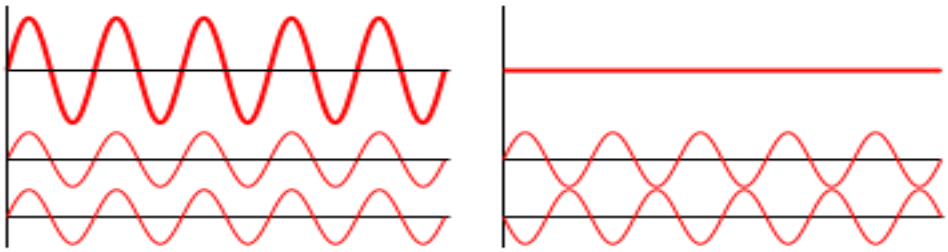

Figure 1: Basic diagrams illustrating the two one-dimensional interference patterns. Constructive interference is shown on the left along with destructive interference on the right. (Source: Wikipedia "interference")

The graphics shown in Figure 1 are typical of the simple diagrams used to present interference phenomenon.

In Figure 2, two-dimensional physical waves are shown propagating over the surface of a water tank. They are spreading out synchronously in the circular patterns typical of wave action produced by "point sources." The areas of constructive and destructive interference are clearly seen in the photograph as manifested by the surface of the water, which is acting as the detector. Here the height of the water above or below the mean value indicates the action of wave energy combining to produce constructive and destructive points across the surface.

Figure 2: Planar interferences, destructive and constructive, propagating from two quasi point sources showing circular waves centered on the two different point sources. (Source: Wikipedia "interference")

The idea behind NIW is best summarized by the poem by Christina Rossetti.

Who has seen the wind?
Neither I nor you:
But when the leaves hang trembling,
The wind is passing through.

Who has seen the wind?
Neither you nor I:
But when the trees bow down their heads,
The wind is passing by.

3. CONCLUSION

A new metaphysics based on the idea of a cosmic complex tension field (C^2TF) has emerged as a possible theory for everything. It proposes a new epistemology that unifies the four forces of nature into one grand theory. Roychoudhuri *et al.* have presented a compelling case for C^2TF that re-instates this new "ether" as the propagating medium for electromagnetic waves as was imagined in classical physics. The presence of C^2TF restores a missing symmetry. In the classical view, a medium was needed to support the transmission of waves. Based on C^2TF as the propagating medium for EM, Dr. Lindner has gone on to also reconsider the basic structure of photons, electrons, and atoms in terms of this new paradigm.

From Table 1, Dr. Lindner has compared the twelve attributes of a photon for the two possible cases. In the first case, the photon is modeled as a "wave in a medium" (wave theory). In the second case, it is modeled as a particle in a void (particle theory). For the first six aspects of light, particle theory clearly does not provide the better explanation for these phenomena. None of them can be explained by a particle flying through a void. On the other hand, each one follows the physics if it is assumed that they are attributes of a wave in a medium.

Current conventional wisdom suggests the final six items in the truth table would be best explained if light was considered to be a particle. Dr. Lindner just abandons the particle (photon in a void) interaction with a particle (electrons as particles) and replaces them with the photon as a wave-packet and the electron as a wave-structure. Assuming this new view explains the last six items in Table 1, circumvents the assumed particle-particle interaction, and replaces it with a new interaction form that is based on wave-packets (photons) interacting with wave-structures (electrons).

Based on the claims stated in Table 1, Dr. Lindner has developed a compelling new semi-classical physics that is based on the assumption that space is not a void but rather contains a transmission medium for EM waves, photons are never particles but wave-packets instead, and electrons and atoms are not particles but rather wave-structures.

These fourteen points emphasize over and over the importance of superposition in understanding of the interaction of light with matter. They also describe the great complexity to be found in the EM environment and in making measurements of that environment.

Another important point is that the exchanges between electrons and the environment are quantized, while free EM waves are not. The assumption that light was quantized was central to the idea that the photon was a particle in a void.

Lindner goes on to state that the new metaphysics that he has constructed has to survive a number of conditions to emerge as a theory of everything. According to Lindner[3], his new theory, Etherism, is required:

1) to be without contradictions,
2) to be comprehensive with the ability to explain all aspects of any phenomenon,
3) to be coherent with all other accepted theories,
4) to correspond to the facts of observation and experimentation,
5) to be simple with no unnecessary postulates,
6) to have predictive power,
7) and to be testable.

The seventh requirement is perhaps the most important consideration. QED's success in determining Dirac's number validates the theory because of the excellent agreement between the theory and measurements. A similar degree of agreement will be needed to confirm C^2TF as a theory that can be accepted on a par with QED. Compelling measured data is needed to satisfy the critics of C^2TF concerning this new paradigm hypothesis.

Being aware of the NIW principle is important for two reasons. The first focuses on the paramount importance of the detector in obtaining information from propagating waves. Detectors are the only "eyes" available to the photonics engineer to gain information about the different phenomena in the natural world. In contrast to the "imagined interaction" of the waves themselves, detectors introduce distortions, uncertainty, and other limitations that lead to data that is not ideal. Ambroselli *et al.*[11] describes this limitation as a Permanent Information Challenge (PIC). This challenge will remain as long as information has is derived using detectors as the portal to the data. This situation will improve when new technology allows EM waves to be detected directly.

The second lesson from NIW is a reminder that it is best to know the correct physics behind any measurement to ensure attention is properly applied to the information gathering process. In the case of interference phenomenology, it does not make a difference if it is assumed that the interference pattern comes from the interaction of the waves or from the waves acting on the detector.

Future work would involve investigating the role of ε_r, μ_r or σ as the building blocks for the C^2TF to see if these point parameters can produce the necessary gradients needed to produce the new wave-structures that are key components in the new photonics. Connections and differences between etherism and string theory also need to be investigated to see the commonality between the two. One troubling aspect of string theory is the accepted belief that it is impossible to perform any experiments to support the theory. Does this have implications for etherism?

It takes a huge philosophical leap in the imagination to accept the notion that a C^2FT is the universal substrate for EM transmission, particles (electrons, protons, and neutrons) are really wave-structures, and the photon is not a particle in a void, but instead, a wave in a medium. The idea that waves easily divide or combine (via appropriate materials) particles helps one to accept the ideas behind either photons as waves and electrons as wave structures. Intuitively, in a choice between atomism and etherism, to favor an ether or wave-centric physics might be possible, but maybe only on a Monday, Wednesday, or Friday.

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