

Urgency of Evolution-Process Congruent Thinking

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1. Introduction: The name of the field, Biophotonics [1] derives from the assumption that light emitted by atoms and molecules are indivisible discrete packets of Einsteinian “light quanta”, later named as photons. The purpose of this brief article is to alert the practitioners of the photon (light) related scientific fields that to be able to contribute really new fundamental concepts in science, one must learn to question the very foundational postulates of “working” theories based upon the *interaction processes* that are revealed by the latest experiments. We can extract more useful properties of atoms and molecules when exposed to infrared and visible light wave packets; if we would stop assigning some of the response properties of atoms and molecules, like their quantized energy levels, or their spin, to the intrinsic characteristics of light waves. We need to learn to develop sufficient inner confidence to appreciate that all “working” theories are “work-in-progress. Science never has a final theory!

2. Light is diffractively spreading classical wave packets: Diverse electromagnetic waves emitted from radio antennas (or your cell phones) to atomic and molecular dipolar emissions due to quantum transitions, do not consist of “indivisible light quanta”, albeit the fact that these quantum transitions do take place in emitting or absorbing a quantum cupful of energy prescribed correctly by Quantum Mechanics (QM) as $\Delta E_{mn} = h\nu_{mn}$. Such an energy-balance equation, in our energy conserving universe, allows us to correctly carry out the “book keeping” without our knowledge about the invisible interaction processes that are going on behind the scene; which represents real physics! The dipolar frequency ν_{mn} in $\Delta E_{mn} = h\nu_{mn}$ represents resonant dipolar excitation $d(\nu_{mn}) = \chi(\nu_{mn})E(\nu_{mn})$ before any quantum transition can take place; where $\chi(\nu)$ represents the **linear** electrical polarizability of the quantum dipole. However, with our convenient “book keeping” mind set, we keep on ignoring the interaction processes that precedes any QM transition, even though Nobel Laureate Lamb underscored the correct semi-classical model of photo electric transitions [2]. How surprising it is that we prefer to follow the interpretations by next generation discoverers more so than the primary path setters. Planck was the original Guru of formalizing the quantum concept in atomic emission and absorption while deriving the correct law for the measured Blackbody Radiation. He underscored in his book [3] that even though the molecular emissions and absorptions are discrete in energy, (i) they evolve and propagate as diffractively spreading wave packets and (ii) without interacting (interfering) with each other. This Non-Interaction of Waves, or NIW, is another fundamental universal property of all crossing wave amplitudes that we have been failing to recognize because our final measurements always represent the correct energy balancing book keeping method. Even Einstein, the father of photoelectric effect and the originator of the concept, “indivisible light quanta”, alerted us some time before his death: “All the fifty years of conscious brooding have brought me no closer to the answer to the question: **What are light quanta?** Of course today everybody thinks he knows the answer, but he is deluding himself.” [4].

It was Einstein’s genius mind which correctly discovered the quantumness buried in the photoelectric data with the induced dipolar oscillation ν . Unfortunately, he assigned it to light (“light quanta”), instead of to electron binding energy. But, that was some 20 years before the discovery of QM. Today, we know through photo electron spectroscopy [5] that all electrons in material media are bound quantum mechanically $\Delta E_{mn} = h\nu_{mn}$, as before ν_{mn} being the resonant oscillation of the electron as a locally bound dipole. Had Einstein correctly assigned the quantumness to the electrons, we would have gone through much less sufferings; because he would have invented the quantum mechanics some 20 years earlier in a different form!

Framing the questions determine the answers [6, see Ch.12]. However, our cultural training skews our thinking and framing our enquiring questions to derive answers out of nature. Recall that even after fifty years, Einstein was

still recapitulating the same 1905 question, “What are light quanta?” with his own *built-in* incorrect answer. Of course, here we should underscore that Gamma rays do behave like somewhat like bullets without undergoing measurable diffractive spreading like the rest of the EM waves. So, there must be new physics buried behind non-spreading Gamma rays, yet to be discovered. Somebody should carry out the double-slit experiment using Gamma ray bullets.

Millikan’s experimental validation of Einstein’s photoelectric effect can be presented by Eq.1, and by the plot of Fig.1 [7]. The stopping potential V reflects the kinetic energy of the released photo electron, $(1/2)mv_{el.}^2$.

$$h\nu = \phi_{work\ fn.} + (1/2)mv_{el.}^2 \quad (1)$$

So, the stopping potential V in Fig.1 and the optical frequency ν of the impinging radiation, are the two key relevant physical parameters. Causal mathematical relation of Eq.1 is postulated by Einstein. It is an energy-balance equation. It has no capability of telling us about the invisible physical interaction processes behind the excitation of the photoelectrons inside the metal before being released. If we do not frame our enquiring questions to know more about the nature; we cannot expect to understand them.

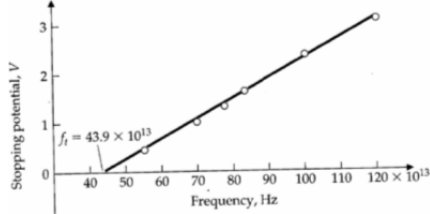


Figure 1. Millikan’s plot of photoelectric effect.

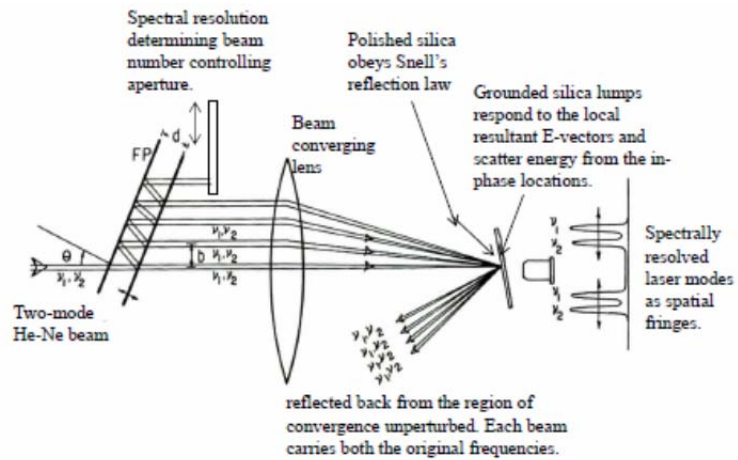


Figure 2. Experimental demonstration of Non-Interaction of Waves

However, that was 20 years before the invention of Quantum Mechanics (QM). We now know that all measured QM energy transfer must be ensemble averaged $\langle X \rangle$ or $\langle h\nu \rangle$. Let us now build up the physical process driven equation presented in Eq.2. The measurable energy transfer is the ensemble average of the square modulus of the resonant amplitude stimulation of the bound electron $\langle |\psi_{res.}|^2 \rangle$. The bound electrons’ dipolar stimulations are induced by a band of resonant optical wave packets simultaneously passing through the detector. Only this band of frequencies ν_q , defined by detector’s quantum mechanical energy band, can excite the resonant dipolar oscillations. The total stimulation is $\psi_{res.} = \sum_q \chi(\nu_q)E(\nu_q)$, where $\chi(\nu_q)$ is the linear polarizability and $E(\nu_q)$ is the driving EM wave amplitudes. It is almost impossible to isolate a single diffractively spreading optical wave packet, except inside a micro cavity. Eq. 2 is now an interaction process mapping equation that also accommodates Einstein’s original energy-balancing postulate as ensemble average, along with semi classical dipolar stimulations; which triggers the QM transitions.

$$\langle h\nu \rangle = \langle |\psi_{res.}|^2 \rangle = \langle \left| \sum_q \chi(\nu_q)E(\nu_q) \right|^2 \rangle = \chi^2 \langle \left| \sum_q E(\nu_q) \right|^2 \rangle = \langle \phi_{work\ fn.} + (1/2)mv_{el.}^2 \rangle \quad (2)$$

QM does not also underscore that, before undergoing the transition, the dipoles fill up their quantum cups out of all the in-phase passing-by stimulating wave packets from a spatial volume of $(10\lambda)^3$ to $(100\lambda)^3$, depending upon the incident flux density [6; see Ch.10]. We never needed the concept of light quanta, except for Gamma arrays!

3. Non-Interaction of Waves (NIW): Notice, now the mathematical rule-congruent 4th step (or, the last but one) of Eq.2. We have taken χ^2 out of all three mathematical operations, (i) summing of all the dipolar stimulations by the dipole, (ii) taking the square modulus by the dipoles and (iii) taking ensemble average by the human apparatus. These “approximations” turn out to be correct only when $\chi(\nu)$ is really independent of the optical frequencies ν_q ; but it is experimentally realistic for some cases. With χ^2 out of $|\sum_q E(\nu_q)|^2$, the modeling of physical interaction process has been destroyed. The math now tells us that the fields carry out both the physical steps of summing the mutual amplitudes and then carrying out the nonlinear square modulus of themselves and thereby creating re-distribution of the field energy in space and in time. As if the detectors are passive recipient of this re-distributed energy! *We have become servants to human invented mathematical rules.* We have started telling nature how she ought to behave; instead of humbly continuing to discover how she really works. Our “working” wave equations tell us that propagating waves are **linear excitation** of a mother tension field [6; see Ch.11]. They do not possess the capacity to operate on each other in the absence of an interacting medium. We know this. But, somehow, we have been perpetually training ourselves to ignore this property of nature.

When we image a particular scenery of our interest on our retina by gathering light by our eye lenses; the light arrives to us after crossing through innumerable other light beams from other sceneries that our eyes are not interested in collecting. The image of our chosen scenery remains stable in spite of continuously being crossed by other innumerable unwanted beams simply because propagating wave amplitudes do not interact with each other. When one thinks carefully, this NIW property is built into Maxwell’s wave equation and the key optical diffraction integral based upon Huygens-Fresnel integral [6 see Ch.3&4]. All continued progresses in optical science and engineering, for over two hundred years, owe their successes to Huygens-Fresnel diffraction integral [8], whether it is the manipulation of light beams via simple lenses, prisms and gratings; or via more sophisticated active devices like lasers, modulators, etc. QM has never succeeded in inventing any better equation to propagate diffractively spreading optical waves than the HF integral!

Let me now describe one of my 1975 experiments; which I carried out to validate NIW; while recognizing that optical spectrometers, consisting of passive and linear optical components, are not capable of carrying out all the necessary complex mathematical algorithms prescribed by Fourier theorem. The deeper implications in various optical phenomena can be found from the book [6] and the relevant papers can be downloaded from the web [9]. The book also develops photon as a classical wave packet; a model that is also congruent with the current QM. Conceptually, it is a simple experiment. A pair of beam splitters are set parallel to each other and tilted on to the oncoming narrow He-Ne laser beam. It now functions as a beam replicator. A controlled set of the emergent parallel beams are focused on to a one-sided ground glass. Notice that the polished surface (facing the beam replicator) of the ground glass reflects all the convergent laser beams into a new set of divergent beams where each beam preserves its key incident characteristics and independent directions of propagation. Their convergence on to a common small spot did not change the behavior of the Poynting vectors of the individual beams. This is NIW. This is also “old hat”. These reflection characteristics have been derived by Fresnel well before Maxwell derived his wave equation (1864). However, the small lumps of grounded silicate molecules of the grounded side (away from the beam replicator) scatters light depending upon the resultant (superposed) stimulating electric vector amplitude. Wherever the silicate lumps experience resultant zero electric vector stimulations, they do not scatter any light; implying dark fringe location. Wherever the silicate lumps experience resultant non-zero electric vector stimulations, they do scatter light; implying bright fringe locations. So, the enlarged image of this ground glass surface shows beautiful dark-bright fringes (see Fig.2). This is superposition effect as observable through *light-matter interaction*. Variation in scattered intensity that generates the observable fringes is due to phase sensitive intensity scattering properties of small scale silicate lumps. This is not mathematical superposition principle given by the direct mathematical summation of wave amplitudes in the absence of interacting material. Wave amplitudes do not sum by themselves (NIW property)!

4. Processes Buried Behind Measurements: Let us re-visit the Eq.1 & 2 again. Einstein’s original photo electric Eq.1 is correct. Yet, it does not give us any entry into the invisible physical interaction processes that go on

before the photo electrons get released. But, Eq.2, reframed following Lamb, gives a lot deeper access to imagine how the interaction processes go on before the release of a photo electron. The final step in any measurement is some quantifiable physical transformation (like, say, the photo electric current). But, any physical transformation must be preceded by some conservative energy exchange process between a set, or a pair, of interactants under the guidance of one of the four known forces of interactions. All forces being of finite range, the interactants must be within each other's sphere of *local* influence. Thus, all interactions are necessarily *local*. Mystical "nonlocality" is a mathematical interpretation; it is not based upon ontological processes behind real interactions going on in nature. This brief analysis of interaction processes gives us another deeper insight into our limitations in creating a *final theory* about any natural phenomenon. To simplify our capability to interpret nature, we carry out experiments with interactants of our interests using, usually, only with one force of interactions, even though they are susceptible to all the four forces to different degrees. A free electron in a discharge tube appears to follow the voltage gradient in the tube. We ignore the pull of gravity because it is miniscule; but the Earth, the Sun and all the billions of stars in our galaxy, and all the galaxies in the universe, are also contributing to the electron's constrained behavior congruent with the evolution of the cosmic universe. Everything in this universe is inter-related, albeit, rather weakly. Thus, we can never gather absolutely complete information about any natural entity. This *perpetual information retrieval problem* keeps us deprived from constructing any final theory. The best approach is that every new generation keeps on challenging the foundational postulates of every *working theory* left by the previous generation. Then, iteratively re-construct them using the newer data available from more and more refined experiments as our technology keeps evolving. The principle of evolution applies to scientific theories as well (6, see Ch.12).

5. Relevance to Biophotonics: The molecules, usually under study in Biophotonics, are very complex. Their emergent properties (measured data) do not always allow us to set simple physics-like equations consisting of one or two parameters. So, it is more important to imagine and visualize the invisible interaction processes and refine them repeatedly and iteratively before accepting the prevailing mode of assumptions that light is quantized, has spin, etc. These are usually, the properties of the quantum mechanical molecular dipoles stimulated by simple EM wave packets. Better understanding of complex molecules can be achieved using this semi-classical model of interactions between classical waves and quantum molecules. Specifically in this "International Year of Light", Biophotonics scientists should be able find many better and many newer molecular properties that are remaining suppressed by quantized model of light. Physicists do not have the final/complete theory for anything, not even for photons [10]. All scientific thinking must keep on evolving. Biological evolution process, in the final analysis, is nothing but a collection of set of molecular interactions processes from bottom up. From individual viruses to multi-cellular humans, all are constantly striving to do better than their current best by contriving tools of molecules or more complex entities as innovative engineers. Iterative attempts to achieve engineering successes are not constrained by limited theoretical knowledge. Humans have started developing theories barely a few hundred years ago! We are in the Knowledge Age due to our successes in utilizing photons and electrons in building the global internet system. However, we still do not know exactly what electrons and photons are. Our engineering successes in constructing evolution-process congruent tools and technologies are much more urgently needed than evolution-process negligent theories. Thus, it is fitting to urge the Biophotonics practitioners to become evolution-process congruent thinkers and become more productive by being harmonious with nature. Drive to *conquer* nature is a poor paradigm!

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