Superposition effect is a "local" phenomenon when we investigate the processes behind release of photo electrons

Chandrasekhar Roychoudhuri]
Physics Department, University of Connecticut
54 Ahern Lane, Storrs, CT 06269-5192, USA

Abstract: The "locality" of superposition effect becomes evident when one explicitly models the light-matter stimulation and energy exchange processes using basic QM recipe of taking square modulus of simultaneous dipolar stimulations of the detecting molecules by all waves.
OCIS codes: (270.0270) Quantum optics; (260.3160) Interference; (030.5260) Photon counting; (040.5160) Photodetectors.

1. "Measurement Problem" as invisible processes facilitating the energy exchange in quantum transitions

The founding fathers of quantum mechanics correctly recognized that the "measurement problem" is a serious issue in the context of interpretation of quantum mechanics. The "problem" is now assumed to be resolved using various mathematical theorems. That the "measurement problem" is not really resolved can be appreciated when we focus on illuminating the invisible interaction processes that give rise to the measurable data. In reality, it is an information retrieval problem out of any phenomenological observations [1, see Ch.12]. Any observed phenomenon (measured data) is generated as a quantitative change in our instrument. It happens through some physical transformations experienced by our chosen interactants through exchange of energy facilitated by some allowed mutually stimulating force. All forces being of finite range, the interactants must be within the range of each other's mutual physical influence (or physical entanglement) for energy exchange to proceed in a causal manner. Unfortunately, we never have complete information about any individual interactant. We do not even know what electrons and photons are! Hence, the measured data cannot directly give us complete information about any one of the desired parameters of the interactants. We are forced to create interpretative "information" to fill up the lack of direct information in our measured data. Absence of such real information cannot be solved by mathematical theorems alone. Thus, the measurement problem can be overcome, but only slowly as we keep on observing innumerable observations; while iteratively re-examining the foundational postulates to help us visualize the interaction processes.

2. Modeling the dipolar excitation process

Niels Bohr repeatedly underscored his philosophy and pragmatic advice that "no elementary quantum phenomenon is a phenomenon until it is a registered phenomenon."[2]. Let us apply this philosophy to superposition effects as a light-matter interaction phenomenon, while incorporating Willis Lamb's semi-classical model [3,4]. A detector's real resultant dipolar stimulation under the influence of multiple superposed waves must be constructed. If we represent χ as the linear polarizability of the dipole stimulated simultaneously by n-wave packets $E_n(\nu_n)$ where ν_n is a proper resonance frequency within the quantum band and $h\nu_n$ is the QM transition energy of individual electrons undergoing appropriate level transition within the band; then:

$$\psi_{res.} = \sum_n \chi_n(\nu_n)E_n(\nu_n) = \chi\sum_n E_n(\nu_n) \tag{1}$$

$$D_{res.} = |\psi_{res.}|^2 = \left|\sum_n \chi_n(\nu_n)E_n(\nu_n)\right|^2 = \chi^2 \left|\sum_n E_n(\nu_n)\right|^2 \neq [h\nu]_{En.Av.} \tag{2}$$

$$\langle D_{res.}\rangle = \left\langle |\psi_{res.}|^2 \right\rangle = \left\langle \left|\sum_n \chi_n(\nu_n)E_n(\nu_n)\right|^2 \right\rangle = \chi^2 \left\langle \left|\sum_n E_n(\nu_n)\right|^2 \right\rangle = [h\nu_n]_{En.Av.} \tag{3}$$

In Eq.1 $\psi_{res.}$ represents the resultant real physical conjoint dipolar amplitude undulation. The allure of "hidden parameters" arises only if we keep on relegating $\psi_{res.}$ to the status of abstract mathematical probability amplitude only. Note that in the second step of Eq.1 we have taken χ out of the summation sign under the assumed approximation that χ_n is a constant for a narrow band of optical frequencies. This mathematically allowed step of taking out a "constant multiplier" out of the summation (or an integral) operation imposes dramatic changes in the possible interpretations of embedded physical processes. In the first step of Eq.1, we are summing conjoint dipolar stimulations executed by a single dipole. In the second step of Eq.1, we are *apparently* all summing the wave amplitudes, not dipolar stimulations. But we know that in the linear domain and in the absence of resonant detectors, EM wave amplitudes (photon wave packets) do not sum their amplitudes to create new wave energy distribution [1]. That is created by quadratic detectors, as in Eq.2. It is thus imperative, that we pay close attention to identifying appropriate physical parameters in any physical interaction and how we utilize mathematical rules that have been invented before we have learned to model physical interaction processes. The same problem can be appreciated in the first two steps of Eq.2. The first step correctly implies that a quantum detector carries out energy absorption while filling up its "quantum cup" [1,5] with energy from all the stimulating wave packets proportional to the collaborative square modulus of their individual amplitudes $E_n(\nu_n)$. The cross products in Eq.2, an exact recipe of QM, do not at all indicate that one "indivisible photon" fills up the "quantum cup" out of many photons to release one photo electron. As before, the second expression in Eq.2 incorrectly implies that the square modulus of the field amplitudes generate the interference fringes. The inequality in the third step of the Eq.2 has been presented to underscore again that this quantum cupful of energy is not due to the presence of "indivisible quanta". Further, the equality does not hold for individual events as there are continuously varying cosine factors embedded in the square modulus operation; only ensemble average can generate precisely predicted oscillatory fringe energy variations. This is re-emphasized in Eq.3.

In actual photoelectric experiments, whether one is registering superposition fringe shape or communication data structure; only a large number of ensemble-averaged data validate the relevant phenomenon. So, we should restrain from drawing any phenomenological conclusion out of a single event, following Bohr's teachings. Besides, the QM theory has never demanded a postulate, correctly so, that all quantum transition must be triggered by a quantum donor having the exact quantum cup of energy [6]. We know that in the quantum world, a single quantum entity can undergo a single quantum transition facilitated by many-body collisions. Further, a classical kinetic electron in a He-Ne laser discharge tube can share a portion of its classical kinetic energy to raise a Ne-atom from its ground state to the upper lasing level while filling up its required quantum cup. This is classical-QM energy exchange. We add He-atoms to enhance the efficiency of population inversion because He-atoms can also get excited by kinetic electrons to an upper level; which is energetically similar to Ne-atoms. So, a collision between an excited He-atom with an un-excited Ne-atom facilitates the exchange of the required quantum cupful of energy to the Ne-atoms. This is a quantum-quantum collision and energy exchange.

Do individual "clicks" in the photo detecting electronics validate the definiteness of indivisible single photon? The "clicks", or the amplified individual current pulses, consist of billions of electrons generated by the amplifying electronics. Rigorous experimentation could validate that the current pulse was triggered by a single original photo electron. But, that does not conclusively validate that the quantum cupful of energy absorbed by a quantum mechanical dipole has been derived from a single indivisible photon. Even the excitation process driven QM formalism [Eq.1-3], indicates that all the superposed wave packets are contributing energy proportional to the square modulus of the sum of all the stimulating amplitude wave packets, not just only one of the wave packets. Thus, even our working mathematical rules do not decisively imply "single photon interference" is really the physical process [7].

That the wave amplitudes do not interact has been underscored by the father of wave propagation, Huygens [8] and later, endorsed by the father of the quantum concept, Planck [9], while deriving his radiation law. Had Einstein focused on the dipolar stimulation required for any bound electron to be stimulated before it could be released, instead of trying to defy Planck, most likely he would have assigned the "quantumness" to bound "photo electrons" and would have discovered quantum mechanics some 20 years earlier in a form different from those given by Heisenberg and Schrödinger!

Even Einstein, the father of "indivisible quanta" of 1905, 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."* [10]

3. Conclusions

The "locality" of superposition effect becomes logically self-evident when we recognize that the registered energy re-distribution is displayed after quantum mechanical transformations experienced by assemblies of miniscule dipolar molecular detector arrays after they have been simultaneously and locally stimulated by multiple wave packets. Energy re-distribution does not take place magically during the propagation of waves through multiple paths. Wave amplitudes do not interact with each other.

We have implemented Bohr's advice, "no elementary quantum phenomenon is a phenomenon until it is a registered phenomenon" ; by first analyzing the classic quantum mechanical "Measurement Problem" and found that invisible interaction processes must be modeled explicitly to explain any physical phenomenon. Since superposition effects becomes a "registered phenomenon" only after a dipolar quantum detector undergoes some physical transformation (release of a photoelectron, etc.); we have modeled dipolar excitation following Lamb's semi-classical model. The Eq.1-3 clearly demonstrates that wave amplitudes, by themselves, do not interfere to create new energy distribution (interference fringes) [xx]. The registered fringes are generated due to "quantum cup" like energy absorbing behavior of our quantum detectors. And these cups can be simultaneously filled by portions of energy out of multiple wave packets at the same time. We should now feel comfortable to discard the ad hoc hypothesis of "single photon interference"; because it is not supported by QM recipe of energy absorption process, especially when we formulate the recipe to emulate the interaction process and follow Bohr's philosophy of a "registered phenomenon".

4. References

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