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Does the postulate 'wave-particle duality' guide us to extract new knowledge out of nature?

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It is just below a century that the postulate, "wave-particle duality, was formalized to explain observed data in typical experiments involving double-slit diffraction or two-beam interferometers, mathematically expressed as the Superposition Principle (SP). The resultant amplitude $d(\tau)$ is given by:

(1) $$d(\tau) = a_1 e^{i2\pi f(t+\tau)} + a_2 e^{i2\pi ft}$$

Note that $\tau = (\tau_2 - \tau_1)$ (see top fig on right). $d(\tau)$, in Eq.1 in general, contains at least three variable parameters, depending upon the experimental conditions. Can a stable single elementary particle (photon or electron) carry all these variable parametric values? Further, linear superposition expression for SP in Eq.1 is not an observable! What is observable is the Superposition Effect, generated by a detector after it executes the nonlinear square modulus operation due to joint stimulation induced by the two field amplitudes:

(2) $$D(\tau) = \left|\chi a_1 r e^{i\pi} e^{i2\pi f(t+\tau)} + \chi a_2 e^{i2\pi ft}\right|^2$$

Here is the linear polarizability of the detector resonant to the intrinsic frequency of the photon or the particle.

The key point is that our mathematical expression Eq.1 for SP does not represent a single particle. SP is not observable. Therefore, we must not try to interpret observable SE of Eq.2 based upon Eq.1. Observables are generated through real physical *interaction processes* between some interactants. We make mistake by uncritically accepting that dark fringes in our superposition experiments are due to non-arrival of photons or particles. At the dark fringe locations, as per Eq.2, physically two out-of-phase oscillating fields are trying to stimulate the detecting particle. Therefore, it remains un-stimulated and hence cannot absorb any energy out of the two stimulating fields. These "out-of-phase" locations remain dark.

I will show videos of optical Mach-Zehnder interferometry to demonstrate that one needs the simultaneous presence of two signals on the opposite sides of the final beam combiner to generate observable superposition effects.

The top figure on the right underscores that we must have two signals arrive on a detector with two different phase –delays due to propagation, or path delays. The bottom figure on right illustrates the noticeable difference in the observable fringe contrast in double-slit experiments due to neutron particles (bottom left) and due to an optical beam. I will explain the causes. I will also extend the discussion to interpretation of Quantum of Mechanics.

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