REINTERPRETATION OF TWO-PHOTON INTERFERENCE EXPERIMENT USING ADVANCED FIELD

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The recent two-photon interference experiments by Wang, Zou, and Mandel, with and without a time-dependent light switch introduced into one of interferometer arms, indicate the collapse of photon waves along empty arms, not travelled by the detected photon, at a critical moment on the light cone backwards from the detected photon. It is proposed to interpret the Schrödinger's retarded wave equation as an operator acting on the advanced field satisfying the final condition of the experiment. In this time-symmetrical formulation the advanced field of the detected particle guides the retarded wave from the particle source not to enter empty arms, and the critical moment is interpreted as the time of the passage of the advanced field through the light switch. By changing the relative optical lengths of interferometer arms and observing the independence of the result of the experiment on the relative position of the detectors, we could conceive of the unarousal of the empty wave destined to collapse.

Key words: quantum mechanics, quantum optics, advanced effect.

As early as 1928, Eddington [1] suggested to interpret the probability density of finding a particle at a given spatial position as the product of two waves travelling in opposite directions in time, one carrying information forward from the past, say, at $-T$ and the other backward from the future at $T$. This motivated Schrödinger [2] to write a paper in 1932 attempting to reformulate quantum mechanics starting from a pair of initial and final probability densities at times $-T$ and $T$ in the hope that his equation would evade quantum jumps.
In a similar attempt, Cramer [3] in 1986 extended an earlier source-absorber description by Wheeler, Feynman, Dirac and others [4] to a transactional interpretation of quantum mechanics. In this interpretation a quantum event is described as a transaction between the particle source and the absorber through the exchange of retarded and advanced waves. On various occasions, Costa de Beauregard [5] has advocated time-symmetric causation in quantum mechanics. The present paper fits into this tradition of time-symmetrical physics. For the past years the time-symmetrical models have mostly been discussed in forums dedicated to open questions in physics because of the lack of experimental means to verify or refute the model. Now the time seems to be ripe for the earlier conceptual models to be subject to experimental verification or refutation using modern technology.

Recently, Wang, Zou, and Mandel [6] carried out two-photon interference experiments [7] to test a prediction of the time-asymmetric de Broglie guided-wave theory which tells that the wave has a physical reality independent of its association with the detected photon. The results of the experiment clearly contradicted what is expected on the basis of the guided-wave theory, but were in good agreement with the prediction of the standard quantum theory, implying the collapse of the wave function along empty paths at the moment of the photo-detection.

In the succeeding “delayed choice” [8] type experiment involving a “quantum eraser” [9] Wang, Zou, and Mandel [10] introduced a time dependent light switch [11] into one of photon paths [12]. They found that the visibility of the interference effect is completely determined by the action of the switch which is generally closed but opens at one critical moment on the light cone backward from the detected photon. The authors summarize their experimental findings by writing: “The state vector of the detected photon reflects not only what is known but to some extent also what is knowable in principle.” [10]

The present paper attempts to understand the results of the experiments by Wang, Zou, and Mandel, with [10] and without [6] the delayed choice apparatus, on the same footing by reinterpreting Schrödinger's retarded wave equation as an operator, in the sense of the theory of generalized functions, acting on the advanced field satisfying the final conditions of the observing system. Schrödinger’s equation thus reinterpreted “knows” the delayed alteration of the experimental arrangements and “reflects not only what is known—initial conditions—but to some extent”—after the arrival of the advanced wave—“also what is knowable in principle”—the principle of time symmetrical causation.

To illustrate the experiment, we use the simplified geometry of the experimental setup reproduced from the reference [6]. Fig. 1