Comments in a similar vein and pointing out connections with previous work were received from J. T. Cushing and W. D. McGlinn, L. Diósi, and T. E. Kiess.

Comment on "Does Quantum Mechanics Violate the Bell Inequalities?"

In a recent paper [1], Santos claims that the long-standing proof [2] that Bell's theorem is inconsistent with the predictions of quantum mechanics may be invalid because the relevant initial state may be incapable of preparation. He points out that in a standard two-photon experiment, Bell's theorem is not violated if the single-particle probabilities are taken to be the total probabilities of detecting a photon in one channel or the other and if the joint probabilities are taken to be proportional to the photon-pair angular correlation function with allowance made for depolarization. He also states that the application of Bell's theorem to "the ensemble of photon pairs such that both members of the pair enter the corresponding apertures" is invalid because it implies assumptions about photons passing through the apertures which are "foreign to the quantum formalism."

The purpose of this Comment is to point out that the definition of a subensemble of photons where both members of the pair enter the corresponding apertures does not require any unjustified assumptions about the photon behavior in the absence of observation. It is fundamental to orthodox quantum mechanics that the quantum description should be appropriate to the whole experimental arrangement under consideration. It follows that, provided light can reach the detector only by passing through a lens or aperture and there is no alternative path, no error is introduced by assuming that the detected photons have actually passed through the aperture. Such an assumption is in fact implicit in Eq. (3) of Ref. [1], where the detection probabilities are related to the solid angle Ω subtended by the aperture at the source. Clearly it must also be a feature of any well-designed experiment. It is therefore completely consistent with quantum mechanics to define a subensemble consisting of pairs of particles which pass through the detector apertures. In this case, it follows that the "single-particle" probabilities used in the comparison with Bell's theorem are actually two-particle correlations measured with the polarizer removed on one side or the other. Indeed, this is the procedure actually followed in the experimental tests [3]. We can calculate these probabilities in a manner similar to that used by Santos [1] for the other probabilities. The joint probability that a photon is detected in direction $\mathbf{u}_1$ with polarization a_1 at the same time that the other member of the pair is detected in the direction $\mathbf{u}_2$ without its polarization being measured is (in the notation of Ref. [1])

$$p(\mathbf{u}_1 a_1, \mathbf{u}_2) = \langle\psi|U_1 A_1 U_2|\psi\rangle = 2(\Omega/8\pi)^2 \alpha(\theta,\varphi) .$$

When this form is used on the left-hand side of Eq. (1) of Ref. [1], which represents the Bell inequality, the standard result demonstrating the inconsistency of quantum mechanics and Bell's theorem [Eq. (2) of Ref. [1] in the limit of small depolarization] is obtained. Similar results have been obtained by Shimony [4] who calculated the appropriate correlation factors from a detailed quantum mechanical analysis of a complete experimental setup, including lenses and polarizers.

We can conclude that the answer to the question posed in the title to Ref. [1] is "yes."

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