

A nine-point argument on “What is A Photon?”

M.G. Raymer
Oregon Center for Optics
University of Oregon, Eugene OR

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This is meant to be a tentative list, showing how an answer to the posed question *might look*.

1. The only fundamental physical entities are fields (not waves or particles)
2. Fields are functions of space and time. They are necessarily extended over space and time.
3. When two fields interact, they do so in a point-wise manner. (Interaction Hamiltonians depend on distances between points. (e.g., interaction of an electron in a potential)
4. Quote Alfred Landé (taken from Proc. of SPIE article of Andrei Khrennikov, vol. 5866, pg.100):
“Photonic particles, once introduced by Einstein as a heuristic hypothesis, are abandoned in the modern theory of fields. The substance of light is a continuous field which carries energy, hence mass... Light quanta appear in the theory only as quantum numbers attached to the radiation oscillators.”*
5. A photon is an excitation of a field. The conventional interpretation of the violation of Bell’s inequalities implies this must be a quantum field.
6. The real mystery is in measurement. Collapse of the wave function (or state) is just another way to describe (non-classical) correlation of successive measurements.
7. The most fertile new experimental area in which to look for clues is Quantum Information Science. Multiparticle measurement is the essence of QIS.
8. A quantum state is nothing more than a collection of acquired information about a part of nature. (For review, see **)
9. Combining “8” with “5”, we arrive at: A photon is a state of a field. That is, a photon is information.

* A. Lande, *New foundations of quantum mechanics* (Cambridge Univ. Press, Cambridge, 1965)

** For elementary discussion see "Measuring the quantum mechanical wave function," M. G. Raymer, *Contemp. Physics* 38, 343 (1997). For more technical discussion see "Experimental Quantum State Tomography of Optical Fields and Ultrafast Statistical Sampling," Michael G. Raymer and Mark Beck, in *Quantum State Estimation*, eds. M. Paris and J. Rehacek, Springer Verlag (2004); and other chapters in this volume.