Is QED Necessary?

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The recent literature of optical coherence theory and quantum electronics all appears to be based on one underlying assumption--sometimes stated explicitly and forcefully, sometimes requiring a little reading between the lines to see--but never absent. This assumption is: present Quantum Electrodynamics has, at least for phenomena in this field, an Absolute and Final validity that makes it, in effect, a kind of Oracle competent to make pronouncements about the validity of all other (e.g. semiclassical) theories.

Throughout the history of science, it has been doubt, and not faith, that first points the way to new advances; we have recently learned this lesson anew from Lee and Yang, in their analysis of the evidence for the supposedly universal principle of parity conservation. As this example shows, it is possible, even in science, to build up a considerable body of folklore; i.e., assertions which are supported by neither logic nor fact but which, for some unaccountable reason, are believed in so strongly that they paralyze our thinking in certain areas.

In the interest of seeing clearly where we stand at present, we consider it useful to adopt the posture of the Devil's Advocate and reason from two rather heretical premises:

(1) The test of any proposed semiclassical treatment of radiation phenomena is not whether it agrees with QED, but whether it agrees with experiment.

(2) By exploiting new technological advances (lasers, photomultipliers, fast pulse circuits, etc.) in optical experiments we can subject both QED and semiclassical theory to new fundamental tests in areas where they have not heretofore been confronted with experiment; i.e., QED is itself on trial here just as much as any other theory.

From this standpoint we survey the present theoretical and experimental situation with a particular view toward finding feasible optical experiments in which the differences between QED and semiclassical theory could be reduced to issues of fact rather than faith. It will develop that virtually all the fundamental experiments on which present theory is based have, for technical reasons, been performed under conditions where these differences could not have been observed. However, using presently available tools these experiments can be repeated under conditions of far greater control and far more detailed observation; in particular, masses of statistical data which could heretofore not even be recorded, much less processed, can now be handled routinely. A few specific experiments which appear capable of resolving theoretical questions concerning details of spontaneous emission and the photoelectric effect, and of testing the uncertainty relations for electromagnetic field components, will be described.