

There are points where QED does not do so well: the X-rays emitted by atoms in which a muon has replaced an electron, the radioactive decay of positronium (an "atom" consisting of an electron and a positron) and electron-positron collisions in which particles other than electrons and muons are produced. On the whole, however, it comes through rather well.

But, meanwhile, back at the optical ranch, theorists have found that they can explain a number of supposedly quantum results, including some of the early observations out of which QED developed, by nonquantum theories. Mandel reviewed some of these neoclassical explanations, concentrating especially on the theory put forth by E. T. Jaynes of Washington University in St. Louis, because it makes some predictions that differ from QED. Other attempts are content to provide alternate explanations for the various phenomena that QED also explains.

That grand example of the textbooks, the photoelectric effect, which led Einstein to invoke quanta, it turns out can be quite well explained by a nonquantum theory, one based on waves and classical fields. The necessity of using Bose-Einstein statistics in electrodynamic calculations, a consequence of the tendency of photons to come in bunches, can also be explained neoclassically. If one splits a beam of light with a half-silvered mirror so that part of the light comes off at a 90-degree angle and the rest goes on straight and one then puts photon counters at the ends of the two beams, there should be no coincidences between the counts. Individual photons are not split, so different ones go off in the different directions. Strangely enough, this too can be explained neoclassically.

However the neoclassical theory tends to fail when it postulates extended time in something like the emission of light, where QED predicts an instantaneous occurrence. It also fails in predicting the width of lines in the spectra of scattered light and in certain experiments with polarized light. Altogether, though, Mandel says, nonquantum theories can account for more than most people think. Nevertheless he concludes that none of the non-quantum offerings is likely to replace QED.

Was the effort of devising them then wasted? Not at all, says Mandel. "We've been obliged to critically confront evidence and reopen questions long thought settled." The activity may help put electrodynamics on a firmer conceptual foundation, and it goes to show that in physics nothing is sacrosanct. No theory, however successful, is beyond criticism. □

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# New Books

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