Modelling the Hanbury Brown - Twiss Effect: The Mid-Twentieth Century Revolution in Optics

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Abstract:

In January 1956, the British radio astronomer Robert Hanbury Brown and his colleague, Richard Q. Twiss, published the results of a deeply puzzling experiment. They had just put into practice a novel instrument for measuring the diameters of radio stars and they were eager to apply it to visible stars. In the radio star version, radio waves from the stellar source stimulated currents in two separated aerials. Each current fluctuated and the degree to which their fluctuations were correlated as the separation between the aerials varied gave the data from which the star's diameter could be calculated. The experiment they published in early 1956 was designed to show that visible light from a common source that struck two separated photoelectric detectors would also produce currents whose fluctuations would show correlations that varied with the detectors' separation. This laboratory experiment was to be the proof-of-principle needed for building a visible star instrument.

Physicists greeted this result with a certain amount of skepticism. The authors had analyzed both the radio instrument and their experiment with light using classical electromagnetic theory. But photoelectric detectors rely on a quintessentially quantum effect. How could the experiment be adequately treated by classical theory?

A first answer to this puzzle was given at the end of the 1950s by a theory that treated light waves classically and the photoelectric process by quantum statistical mechanics. But in 1963, Harvard professor Roy J. Glauber put forth a fully quantum electrodynamic theory. Two rival theories were now on the table and a fairly acrimonious controversy ensued. Partisans of the semiclassical approach pointed to the deeper insight it gave into physical processes. Glauber and his followers pointed to the greater generality provided by the fully quantum mechanical theory. Optical physicists gave themselves to searching reflection on the relation between the semiclassical and quantum electrodynamic explanations.

Meanwhile, the issue had become more complex as the first laser had been operated, and had been shown to give a form of light that was quite distinct from starlight and the tested the explanatory power of the contesting theories. It had also become more urgent, in that lasers looked as though they would have important applications and military agencies had therefore begun to pour money into optics research.

This bit of history, stretching from the mid-1950s to about 1970, has so far been the provice of physicists. In this talk, I propose to detail the controversies that occurred from 1956 until 1965. I will conclude by arguing that the topic is worth the attention of historians, philosophers and sociologists of science. It exhibits the way in which different subdisciplines intersect and transform each other. It shows how new devices

pose challenges to theory. And in the rhetoric that surrounded the controversy between classical and quantum theories, we see something of physicists' criteria for theory acceptance, of their views on realism vis-a-vis instrumentalism, and of how a "predecessor" theory relates to a "successor" theory in the real world.