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Theory and Experiment in the Quantum-Relativity Revolution (Pais History of Physics Prize 2009)

STEPHEN BRUSH, University of Maryland

Does new scientific knowledge come from theory (whose predictions are confirmed by experiment) or from experiment (whose results are explained by theory)? Either can happen, depending on whether theory is ahead of experiment or experiment is ahead of theory at a particular time. In the first case, new theoretical hypotheses are made and their predictions are tested by experiments. But even when the predictions are successful, we can't be sure that some other hypothesis might not have produced the same prediction. In the second case, as in a detective story, there are already enough facts, but several theories have failed to explain them. When a new hypothesis plausibly explains all of the facts, it may be quickly accepted before any further experiments are done. In the quantum- relativity revolution there are examples of both situations. Because of the two-stage development of both relativity ("special," then "general") and quantum theory ("old," then "quantum mechanics") in the period 1905-1930, we can make a double comparison of acceptance by prediction and by explanation. A curious anti-symmetry is revealed and discussed.