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LeRoy Apker Award Talk: Testing Hidden-Variable Theorems with Single-Photon Entangled States

BRYCE GADWAY, SUNY Stony Brook / Colgate University

An ensemble of single photons created in a hyperentangled Bell state were used to test a broad class of Hidden-Variable Theorems (HVTs). Specifically, the class of HVTs based on the joint assumption of Realism and Non-Contextuality (NC) – the premise that values associated with one observable are independent of which commuting observables may be measured simultaneously – known as NCHVTs, and first examined by Bell as well as Kochen and Specker, were addressed using these single-photon states entangled in polarization and direction of momentum. A Clauser-Horne-Shimony-Holt (CHSH) Inequality was applied, with the factorization condition that is usually satisfied by a Non-Locality assumption being instead satisfied by the assumption of NC, due to the inherently local nature of detection events for single particles. The basis rotations and projections necessary for testing the CHSH Inequality were accomplished using interferometers and standard polarization optical elements. A violation of the CHSH Inequality was observed, ruling out either Realism or Non-Contextuality – or possibly both. The tenability of Contextual HVTs remains, trivially, as the predictions of such a theory can map one-to-one to the predictions of Quantum Mechanics.