

APR18-2018-000722

Abstract for an Invited Paper
for the APR18 Meeting of
the American Physical Society

LeRoy Apker Award Talk: Bell's Inequality and Beyond with Astronomical Photons

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Photons from distant astronomical sources can be used as classical random bits to conduct fundamental tests of quantum nonlocality and wave-particle duality. First, I report on a test of Bell's Inequality in which the measurement basis choices are determined by a pair of Milky Way stars in order to address the locality and freedom-of-choice loopholes. Explaining our 11-sigma Bell violation in a local realist framework would require a classical conspiracy exploiting the freedom-of-choice loophole to have acted 600 years ago. Second, I discuss the demonstration of a next-generation astronomical random number generator which can output 12 billion-year-old random bits generated by distant quasars with redshifts up to 3.9. Finally, I will discuss how I leveraged our instrumentation to obtain a new constraint on violations of the Weak Equivalence Principle, and report an upper bound complementary to existing results in the literature.