Realization of the contextuality-nonlocality tradeoff with a qubit-qutrit photon pair

With the support by the National Natural Science Foundation of China, the research team led by Prof. Xue Peng (**薛鹏**) at the Southeast University, reported the experimental realization of the contextuality-nonlocality tradeoff with a qubit-qutrit photon pair, which was published in *Physical Review Letters* (2016, 116: 090401).

Two of the most important ideas that distinguish the quantum world from the classical one are nonlocality and contextuality. In the classical world that we observe every day, an object can only be affected by nearby objects (locality), and when we make a measurement, the outcome does not depend on other independent measurements being made at the same time (noncontextuality). In contrast, quantum systems exhibit a wide range of non-classical and counter-intuitive phenomena, such as nonlocality and contextuality. To show that a quantum system is nonlocal or contextual, physicists have defined inequalities that assume a system is the opposite, e. g. Clauser-Horne-Shimony-Holt (CHSH) inequality to test nonlocality and Klyacko-Can-Binicio ğ lu-Shumovski (KCBS) inequality to test contextuality.

Both of these phenomena have been theoretically shown not to simultaneously exist in a quantum system, as they are just different manifestations of a more fundamental concept, the assumption of realism. The authors have for the first time experimentally confirmed that these two defining features of quantum mechanics never appear together. In the experiment, the authors used entangled photons to generate photonic qubit-qutrit systems. By performing various measurements on these photons, they observed that the two inequalities could be violated separately, but not at the same time. The results provide experimental evidence to show that quantum entanglement and contextuality are intertwined quantum resources. In addition, the results suggest the existence of a quantum resource, of which entanglement is a particular form. This experiment opens a door to observe other interesting phenomena, such as quantum nonlocality, based on local contextuality, and sheds new light on further explorations of the quantum resource.

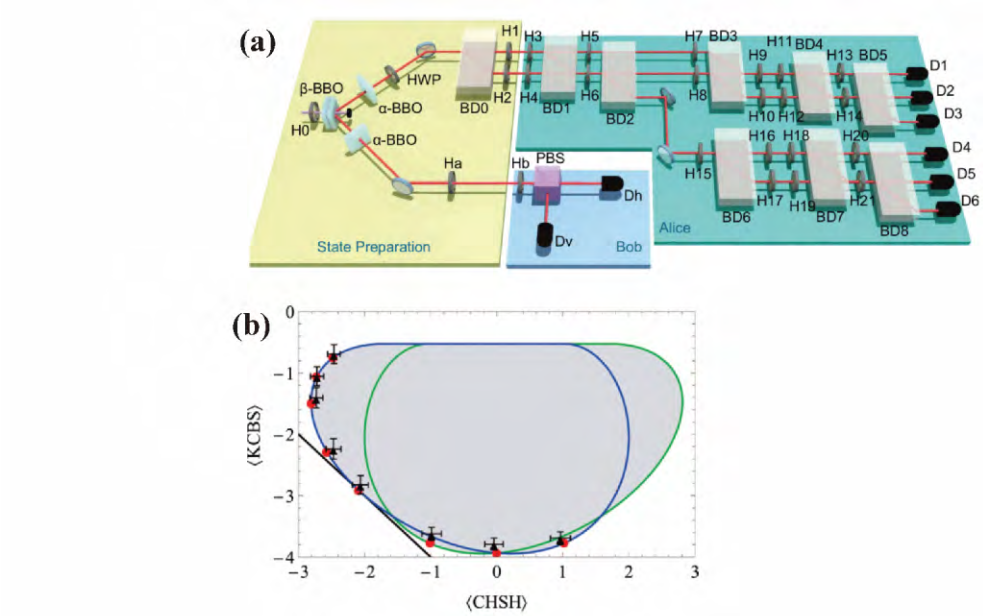

Figure (a) Experimental setup. H(WP): half-wave plate; BBO: barium-borate crystal; PBS: polarizing beam splitter; BD: beam displacer. (b) The region spanned by the allowed average values of CHSH, and KCBS operators can be divided into two overlapping parts and bounded by the solid curves. Every quantum state produces a point inside the region.