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Experimental test of a Bell inequality with nonmaximally entangled states

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Abstract:

A loophole-free violation of a Bell inequality, which would refute local realism, has not been achieved yet. A violation of the Eberhard inequality using nonmaximally entangled states allows closure of the detection loophole with a detection efficiency above 2/3. In this thesis, polarization-entangled photon pairs were generated in nonmaximally entangled states using a Sagnac source. The produced states were investigated with avalanche photodiodes and highly-efficient transition-edge sensors for their implementation in a conclusive Bell experiment based on the Eberhard inequality. For each of the produced states, a density matrix was reconstructed from measurements performed with avalanche photodiodes. A highly-efficient detection system based on superconducting transition-edge sensors read out by superconducting quantum interference devices was successfully operated. Using this novel detection system, an unprecedentedly high heralding efficiency was directly observed and a measurement of the Eberhard inequality was performed with results not yet adequate for a violation.