

Quantum non-locality without reference frame

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Quantum communication employs the counter-intuitive features of quantum physics to perform tasks that are impossible in the classical world. It is crucial for testing the foundations of quantum theory and promises to revolutionize our information and communication technologies. However, for two or more parties to execute even the simplest quantum transmission, they must establish, and maintain, a shared reference frame. This introduces a considerable overhead in communication resources, particularly if the parties are in motion or rotating relative to each other. We experimentally demonstrate how to circumvent this problem with the efficient transmission of quantum information encoded in rotationally invariant states of single photons. By developing a complete toolbox for the efficient encoding and decoding of quantum information in such photonic qubits, we demonstrate the feasibility of alignment-free quantum key-distribution, and perform a proof-of-principle alignment-free entanglement distribution and violation of a Bell inequality. Our scheme should find applications in fundamental tests of quantum mechanics and satellite-based quantum communication.

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