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INVESTIGATING THE LIMITS OF FREE SPACE BELL-STATE SYNCHRONIZATION

Abstract

Bell-states are special quantum states that provide a resource that will enable the quantum internet. They are necessary for a large number of novel quantum communication algorithms from QKD (Quantum Key Distribution) through teleportation to quantum repeaters. Currently only free-space quantum communication can provide us with high quantum fidelity low-loss link that are necessary to bridge global distances. Terrestrial links over a 144 km link have been experimentally realized, and satellite-ground links have demonstrated the ability to share Bell states between distant communicating parties over 1200 km. Although polarization is strongly preserved in a free space link, for high fidelity, state corrections must be applied. One of these corrections is the polarization direction synchronization which is relatively straightforward and can even be done with stronger non-quantum sources. However, the phase difference between term of the superposition can only be fully corrected with non-local measurements. In our system we experimentally investigate this process using a tiltable phase plate, whose effective thickness is the function of the tilt angle. This system decouples the polarization direction synchronization from the relative phase correction, since it does not alter the computational basis states. We simulate attenuation and turbulence in a free space link and find the optimal tilt angle by finding the extremum in coincidences along a specific basis vector in a diagonal basis. Finding this optimal tilt angle is done by performing coincidence measurements in pre-selected tilt angles and then fitting a curve with a known shape on the measurement results. The optimal tilt angle is then determined by a local extremum of the fitted curve. This process is straightforward due to having only one degree of freedom, and thank to the curve fitting process, the results are good quality even in noisy environments. We found that we have sufficiently good quality results even when the noise level is comparable to the signal level. We tested the quality of the synchronization with Bell-test experiments, and consistently found good violations of the CHSH inequality.