Long-Distance Measurement-Device-Independent Multiparty Quantum Communication[1]

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The Greenberger-Horne-Zeilinger (GHZ) entanglement, originally introduced to uncover the extreme violation of local realism against quantum mechanics, is an important resource for multiparty quantum communication tasks. But the low intensity and fragility of the GHZ entanglement source in current conditions have made the practical applications of these multiparty tasks an experimental challenge. At the same time, recent years have witnessed many important progresses on experimental quantum communication for two parties. For example, the recorded distance for two-party quantum key distribution (QKD) has been more than 300 km for standard telecom fiber links, while quantum teleportation has been demonstrated over a distance of more than 100 km for free-space channels. By sharp contrast, the experimental distribution of the GHZ entanglement was achieved only recently, over a distance of less than 1 km for each party of the GHZ-entangled photons.

In this Letter, we propose a feasible protocol for distributing the post-selected GHZ entanglement over a distance of more than 100 km for experimentally accessible parameter regimes. The post-selected GHZ entangled states can then be used for information-theoretically secure measurement-device-independent (MDI) multiparty quantum communication, or for the test of local realism in the multiparty setting, over a long distance. Making use of the decoy-state and MDI protocols for QKD, we show that for the experimentally accessible parameters, the information-theoretically secure MDI quantum cryptographic conferencing with the conventional weak coherent state sources can be implemented over a distance of about 180 km, as well as the MDI quantum secret sharing with the heralded single-photon sources (the conventional weak coherent state sources together with the quantum non-demolition measurement of the single-photon state components) over a distance of about 220 km (180 km). These distances are significantly beyond what one could expect previously for multiparty quantum communication with the GHZ entanglement. Our proposal thus suggests an important avenue for practical long-distance multiparty quantum communication. The extension of our scheme to more legitimate users is straightforward.

[1] Y. Fu, H.-L. Yin, T.-Y. Chen, and Z.-B. Chen, Phys. Rev. Lett. 114, 090501 (2015).