All-photonic quantum teleportation with remote quantum dots

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Quantum information distribution over quantum networks is essential for advancing secure communication and distributed quantum computing. To achieve this, reliable and efficient sources of flying qubits are crucial. GaAs quantum dots are promising candidates due to their outstanding features [1-3]. However, these quantum dots often exhibit dissimilar emission properties, so interfacing two distinct emitters is generally a significant challenge. We address this issue through a state-of-the-art combination of the engineering of the emitter electronic structure, a photonic cavity [4], and a high-time-resolution detection system, allowing us to reach high indistinguishability and entanglement simultaneously. Thanks to these techniques, we successfully demonstrated photonic quantum teleportation between two separate quantum dots over a fiber and free-space quantum network laid over the Sapienza University campus [5]. We manage to surpass the classical limit employing loose temporal post-selection and we overall reach average teleportation fidelities as high as F=0.79±0.01 on a fiber-only network and F=0.80±0.04 on the fiber and free-space hybrid network. Our achievement showcases the potential of engineered quantum dots for the realization of quantum relays and quantum repeaters and paves the way for the implementation of practical quantum networks.

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[5] Laneve, A. et al. "Quantum teleportation with dissimilar quantum dots over a hybrid quantum network." *arXiv preprint arXiv:2411.12387* (2024)

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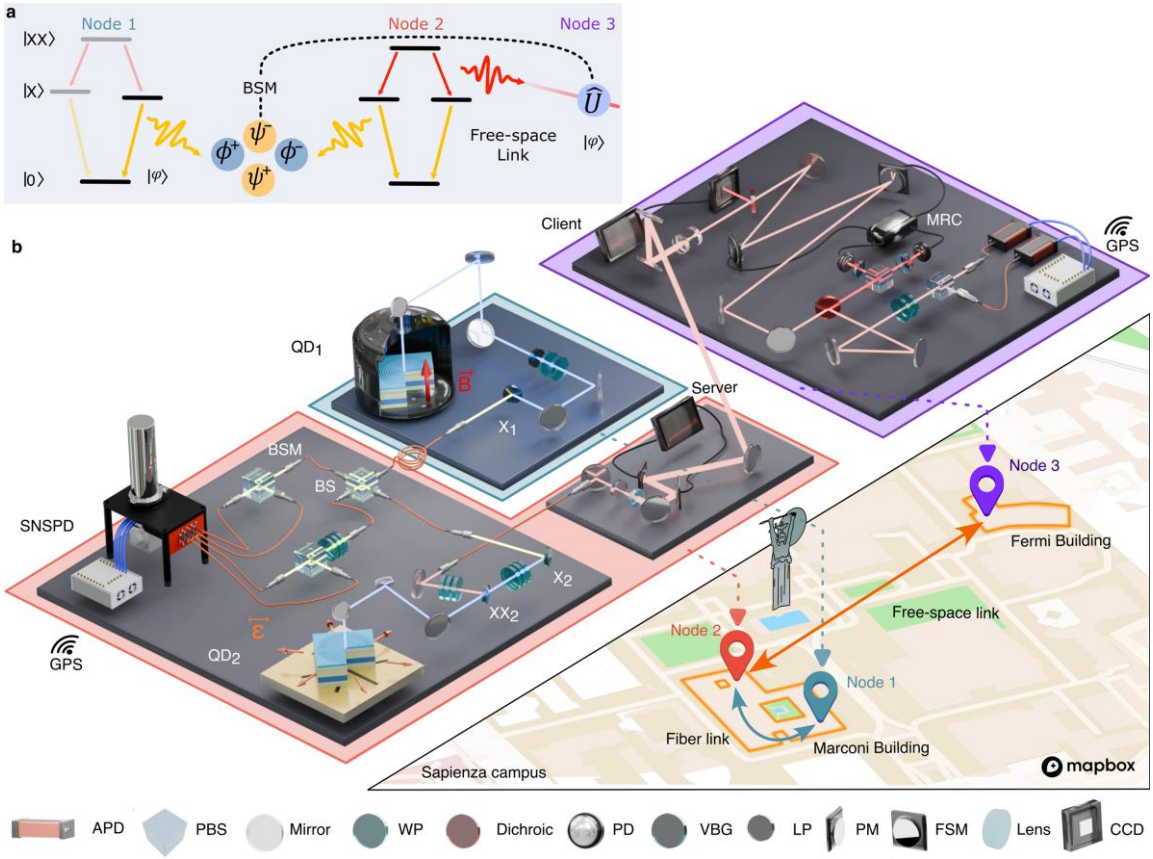

Fig. 1: Sketch of the urban quantum teleportation network. **a**, Scheme of the quantum teleportation protocol as implemented with two QDs over a network including a free-space link. **b**, Depiction of the teleportation experimental realization over the Sapienza University campus.

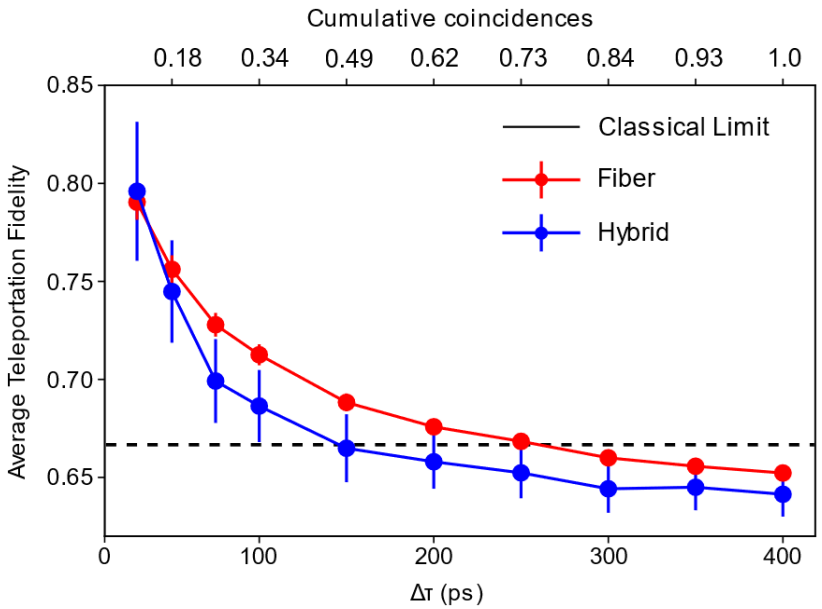

Fig. 2: Teleportation fidelity as a function of temporal post-selection of Bell state measurement events. The results for a fiber-only network are compared to the ones over a fiber and free-space hybrid network.