Multiphoton Cluster-State Generation using a C-band Quantum Dot

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The realisation of the quantum internet requires secure long-distance quantum networks capable of distributing entanglement between distant nodes. Entangled photons are the natural carriers of quantum information, and for fibre-based networks the telecom C-band (~1550 nm) is crucial due to minimal transmission loss. Photonic cluster states provide intrinsic redundancy and resilience to photon loss, making them valuable for measurement-based quantum computation and all-optical memoryless quantum repeaters [1]. However, *on-demand multiphoton entanglement generation in the lowest-loss telecommunication window* has remained elusive. Our earlier results showed that quantum dot-based entanglement sources can help bridge this gap [2]. Despite significant progress in the 900 nm region [3], comparable performance has yet to be achieved in the telecom C-band.

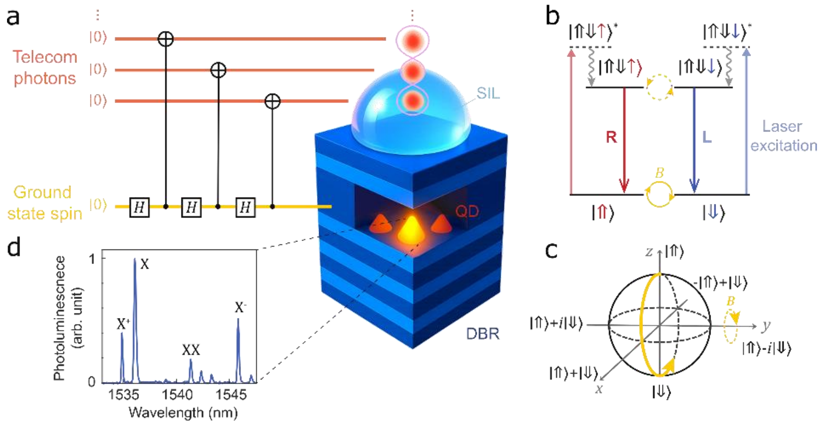

Fig. 1: *Implementation of a scalable entanglement generation protocol using a telecom C-band QD.*

In this work we utilise a spin-qubit, based on a positively charged exciton (X^+), confined in a self-assembled InAs/InP quantum dot (QD). For the first time, we demonstrate, multi-qubit entanglement between the hole's spin and the polarisation of sequentially emitted photons directly in the telecom C-band. Furthermore, we discuss potential realistic improvements, outlining a viable path for practical generation of larger entangled states. Our results close the performance gap between short-wavelength quantum dot systems and existing telecom infrastructure, establishing a route towards scalable photonic cluster states for fibre-based quantum network applications.

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