Heralded Entanglement of Single Rare-Earth Ion Qubits

A Ruskuc[1], C-J Wu[2], J Choi[3], S Hermans[1], and A Faraon[1]

[1] *Applied Physics, California Institute of Technology, Pasadena CA, USA*
[2] *Physics, California Institute of Technology, Pasadena CA, USA*
[3] *Electrical Engineering, Stanford University, Stanford CA, USA*
Contact Email: aruskuc@caltech.edu

Solid-state defects have emerged as leading candidates for quantum network nodes due to their compatibility with scalable device engineering and the presence of nuclear spins for local quantum processing. Recently we have demonstrated key milestones toward this application using single 171Yb ions in YVO4, coupled to a nanophotonic cavity. These include coherent optical and spin control, long-term quantum information storage, single-shot readout and a nuclear ancilla qubit.

Moving beyond a single quantum node, in this talk I will present progress towards remote entanglement between pairs of Yb qubits. As a first step, I will demonstrate time-resolved quantum interference between photons emitted by two spectrally resolved qubits coupled to the same nanophotonic cavity. By measuring photon arrival times with high precision, frequency information is erased. The resulting quantum beats are a critical demonstration of mutual photonic coherence.

Next, I will demonstrate a single photon protocol that heralds entangled two-qubit Bell states. A random quantum phase generated by the stochastic photon emission process is measured and corrected in real-time, enabling preparation of deterministic spin-entangled states. Critically, the narrow optical inhomogeneous distribution (200MHz) enables the entanglement of any pair of qubits regardless of their transition frequencies in a scalable fashion.

These results showcase single rare-earth ions as a promising platform for the future quantum internet.

References

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