Generating entangled Single-photon pairs with Rb atoms

Fenglei Gu

Lorentzweg 1, 2628 CJ Delft, The Netherlands

f.gu@tudelft.nl

Abstract:
Entangled single-photon pairs (ESPP) are essential for quantum communication. The current widely used ESPP source is the spontaneous parameter down-conversion (SPDC) source[1]. However, there is a trade-off between the emitting rate and the single-photon purity in this type of ESPP source which limits its performance for quantum communication. Here we proposed a new type of ESPP source based on a single Rubidium (Rb) atom [2, 3] strongly coupled to nanocavities which would circumvent this dilemma. By making the Rb atom emit both a telecom photon and an optical photon at the same time (Fig. 1), we devise an ESPP source with qubits encoded in time-bins. Moreover, the telecom photon is suited for low-loss propagation in optical fibers while the optical photon is directly compatible with Tm-doped-crystal quantum memories [4] (Fig. 2). Thus, no additional frequency conversion is needed. Through numerical simulations, this atomic ESPP source shows a photon purity of 96% while maintaining a tunable repetition rate up to 5MHz for realistic experimental parameters. We believe that his novel type of ESPP source is within experimental reach in the near term and that it can significantly boost the performance of quantum repeaters based on Tm-doped multi-mode memories.

References

[1]Magnitskiy, S., et al. "A SPDC-based source of entangled photons and its characterization." Journal of Russian Laser Research 36.6 (2015): 618-629.

[2]Mücke, Martin, et al. "Generation of single photons from an atom-cavity system." Physical Review A 87.6 (2013): 063805.

[3]Darquié, Benoit, et al. "Controlled single-photon emission from a single trapped two-level atom." Science 309.5733 (2005): 454-456.

[4]Askarani, Mohsen Falamarzi, et al. "Long-Lived Solid-State Optical Memory for High-Rate Quantum Repeaters." Physical review letters 127.22 (2021): 220502.

Figures

Figure 1: The optical-trapped cold Rb atom (solid red dot) that is designed to emit two entangled photons. Thus, it is coupled to two nanophotonic cavities of different resonance frequencies.

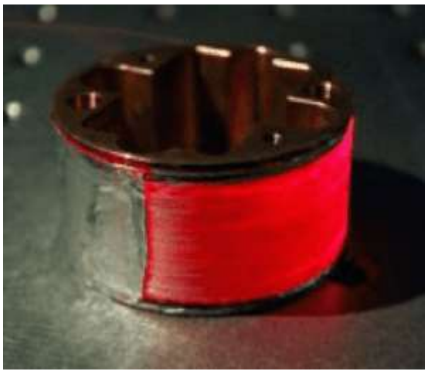

Figure 2: An experimental sample of thulium-doped yttrium gallium garnet (Tm: YGG)which could serve as a photon memory. (The picture is adapted from: https://qutech.nl/lab/tittel-lab/tittel-lab-research-overview/quantum-memory/)