PASSIVE AND DETERMINISTIC PHOTON-ATOM GATES

Single-photon Raman interaction (SPRINT) is a passive, interference-based effect that creates a deterministic coupling between single photons and a 3-level quantum emitter such as a single atom. As recently demonstrated [1,2], SPRINT enables controlling the state of a single atom deterministically by a single photon. It requires no control-fields, takes place 'automatically' at the timescale of the cavity-enhanced spontaneous emission, and can be harnessed to perform a variety of photon-atom and photon-photon quantum gates [3,4].

I will describe our recent demonstration of a SPRINT-based quantum SWAP gate between a flying photonic qubit (encoded in the two possible input modes) and a stationary atomic qubit.

Our realisation relies on a nanofiber-coupled microsphere resonator coupled to single Rb atoms. We apply the SWAP gate twice to demonstrate a passive quantum memory, i.e. to map the state of a photon onto the atom and then back onto a readout photon, achieving non-classical fidelities (0.74-0.77) in both directions at ~70% efficiency, with ~50 ns gate time. Requiring no control fields and applicable to any waveguide-coupled material Lambda system, this scheme can potentially provide a versatile building block for quantum networks and for the manipulation of single photons and photonic states.

Refs: