Developments in erbium-based quantum memories, using the RASE protocol.

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Erbium-based quantum memories have shown very promising results in recent years [1]. This success is owed to the material properties of $^{167}Er:Y_2SiO_5$, which will be presented in the context of our recent experimental demonstrations using the Rephased Amplified Spontaneous Emission (RASE) protocol.

The RASE protocol is a promising method for generating time-separated entangled states of light, where one of these light states is stored in a quantum memory. The first light state is generated using an inverted ensemble of atoms as a gain medium to amplify the vacuum state, creating Amplified Spontaneous Emission (ASE). This also generates entanglement between the ASE and the atomic ensemble. The state of the ensemble is recalled using rephasing π-pulses, similar to a photon echo, creating a second light state called Rephased Amplified Spontaneous Emission (RASE). ASE and RASE are time-separated and form a two-mode squeezed state.

Using the RASE protocol, our lab has shown: entanglement between the ASE and RASE fields, high rephasing efficiencies (up to 80%), multimode storage (70 temporal modes), and (more recently) hyperfine storage beyond 1 second. Our next suite of experiments aims to demonstrate entanglement swapping, using the RASE protocol, over a long industrial fibre channel.

First, I will present an overview of our quantum memory experiments using $^{167}Er:Y_2SiO_5$, and the RASE protocol. Then I will discuss our recent work demonstrating hyperfine rephasing, entangling two spectrally separated memories.

References

[1] J. Stuart, arXiv:2409.12503