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A cavity-enhanced waveguide quantum memory

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Communication of quantum information, like its classical counterpart, requires data synchronization. In other words, one must be able to store the information and retrieve it when needed. An optical quantum memory is an interface that stores the information encoded in a photon and recalls it on demand. A promising protocol to implement a practical optical quantum memory is the Atomic Frequency Comb (AFC). A major advantage of the AFC protocol is its high multimode storage capacity. This is important for quantum communication purposes because it increases the success rate of distributing entanglement between two distant parties by means of a quantum repeater.

The efficiency of a memory is defined as the probability of successful storage and subsequent retrieval of the information. Achieving high efficiency has been an ongoing challenge in experimental implementations of optical quantum memories. According to a theoretical proposal, by embedding the AFC memory crystal in an impedance matched cavity, the efficiency can approach 100%. This proposal has been executed experimentally and an efficiency of 58% was reported. Despite this relatively high efficiency, cavity misalignment and line-width narrowing due to the slow light effect were in the way of further enhancement of the efficiency.

Here I report our experimental work to implement the theoretical proposal in a wave-guiding rare earth ion doped crystal (Ti:Tm:LiNbO3), cooled down to cryogenic temperatures. The wide acceptance bandwidth of the storage medium (˜100 GHz) leaves the cavity enhanced memory unaffected by cavity line-width narrowing. Furthermore, the cavity is formed in a waveguide, and as a consequence, the cavity response is relatively immune to misalignment. This experiment is a step toward realizing long distance quantum communication relying on entanglement distribution.

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