Abstract for an Invited Paper
for the DAMOP09 Meeting of
The American Physical Society

Towards Quantum Repeaters[1]

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The ultimate limit of direct point to point quantum key distribution is around 300-500 km. Longer distances fiber-based quantum communication will require both high-fidelity entanglement swapping and multi-mode quantum memories. A new protocol for an efficient multimode quantum memory based on atomic ensembles has been developed and demonstrated. The rare-earth ions ensemble is "frozen" in a crystal inside a cryostat. The protocol, named AFC (Atomic Frequency Comb) is inspired from photon echoes, but avoids any control light pulse after the single-photon(s) is (are) stored in the medium, thus avoiding any noise due to fluorescence. First results on the new protocol for quantum memories in Nd:YVO4 doped crystals demonstrate a quantum light-matter interface at the single-photon level. The coherence of the re-emitted photons is investigated in an interference experiment showing net visibilities above 95%. Further results in Nd:YSO (Geneva), Tm:YAG (Paris) and Pr:YSO (Lund) shall also be presented. Many hundreds of km long quantum communication is a long term objective. Many of the necessary building blocks have been demonstrated, but usually in independent experiments and with insufficient fidelities and specifications to meet the goal. Still, today's the roadmap is relatively clear and a lot of interesting physics shall be found along the journey.

[1]In collaboration with Mikael Afzelius, Hugues de Riedmatten and Christoph Simon Björn Lauritzen, Jirí Minár, and Imam Usmani.