Coherence lifetime of chalcogenide glasses for quantum memory applications

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Quantum memories for storing single photons are important building blocks for quantum information processing systems. A successful quantum memory has to be capable of storing and faithfully reproducing on demand the quantum mechanical information carried by a photon written to the quantum memory device. Many material systems have been studied for creating quantum memories including color centers in diamond, rare-earth doped crystals and glasses, and atomic vapors [See e.g. 1,2]. Each material system comes with its own advantages such as long coherence times or large bandwidth.

For telecommunication systems it is desirable to have a quantum memory operating within the lowest loss window of optical fibers at wavelengths close to 1550 nm and erbium doped materials were considered for this application. Er-doped crystals with narrow linewidth transitions offer long coherence lifetimes while Er-doped glasses with large inhomogeneous linewidths offer the possibility of broad bandwidth (>100GHz) photonic information processing. Additionally, glasses can be drawn in to fiber waveguides to allow for long interaction lengths when only weakly doped with erbium to minimize ion-ion interactions. In earlier work [3] sulphide based glasses have shown longer coherence times than silicate glasses, typically used in erbium doped fiber amplifiers, with homogeneous linewidths as small as 287 KHz being demonstrated. In this work we perform a thorough composition search to obtain the optimum chalcogenide glass with the narrowest homogeneous linewidth. Three pulse photon echo measurements demonstrate that selenide glasses outperform sulphide glasses and that a few mol-% of Gallium, used to prevent clustering of the erbium ions, is required to achieve the maximum coherence lifetime. We demonstrate homogeneous linewidths as small as 170 KHz in an erbium doped selenide glass in a 6.5 Tesla magnetic field at a temperature of 1.5K.

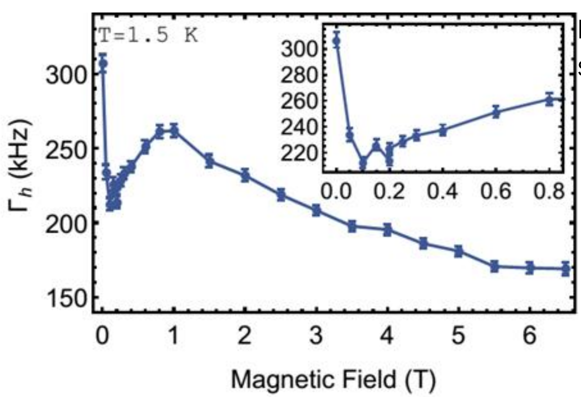

Figure 1 Homogeneous linewidth of erbium doped selenide glass as a function of magnetic field at 1.5K

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