Nanoscale Rare Earth Doped Crystals for Optical Quantum Technologies

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Nanoscale systems offer new functionalities in quantum technologies, like single-qubit control and detection or extremely localized sensing. The ability to couple qubits with light is an attractive feature for these systems to enable interfacing with photonic qubits, creating light-matter entanglement or fast processing of quantum information. Rare-earth ions are promising candidates for this purpose, as they can show record-long optical and spin coherence lifetimes in bulk crystals. However, maintaining these properties at the nanoscale can be challenging, as surface effects, for example, can cause strong dephasing.

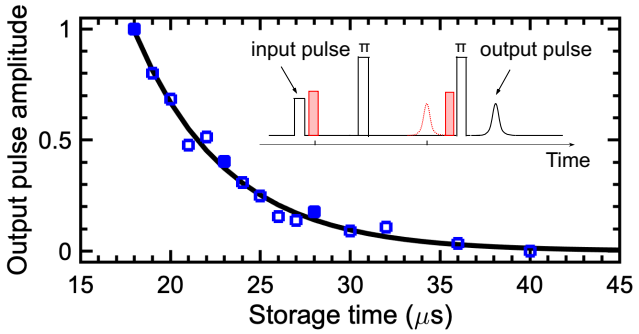

Figure 1: Coherent optical storage in europium doped nanoparticles using an electro-optic protocol

In this talk, I will discuss recent results obtained with rare-earth-doped nanoparticles and thin films. Some of these materials show optical and spin coherence lifetimes in the µs and ms range, respectively, at low temperature. These are unrivaled values for optically addressable spins in a nano-material. These crystalline nanostructures could be placed in high-finesse fiber-based cavities to achieve efficient optical control and readout of nuclear spin qubits. Combined with rare-earth unique, coherent properties, this scheme opens the way to quantum memories with single-ion processing capabilities, single-photon sources or highly scalable quantum processors.

References

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