Quantum Networks with Spins in Cavities

B. Merkel, N. Wilson, V. Crépel, L. Weiß, A. Gritsch, and A. Reiserer

Quantum Networks Group, MPI of Quantum Optics, Garching, Germany
E-mail: Andreas.reiserer@mpq.mpg.de

Spins in solids can exhibit strong optical transitions and exceptional coherence properties. This makes them a promising system towards the realization of global quantum networks. Pioneering experiments have shown entanglement between two remote spins, associated with the Nitrogen-vacancy (NV) center in diamond, over a distance of 1.3km [1]. However, exploring the full potential of quantum networks requires to further increase the separation and number of entangled particles. In this respect, two major challenges have to be addressed. First, one has to overcome inevitable imperfections in the control of the spins via quantum error correction. I will present first results in this direction, namely the distillation of entanglement between remote spins [2].

The second challenge is that the efficiency of photonic quantum network links has to be increased by orders of magnitude. To this end, we are working towards a deterministic spin-photon interface that is implemented by embedding spins in micrometer-thin crystals into Fabry-Perot resonators [3]. This should enable an increase of the remote entanglement rate between Nitrogen-Vacancy spins by more than three orders of magnitude.

Further enhancement, in particular over long distances, would require to convert the emitted photons to the telecommunication frequency band where the absorption of glass fibers is minimal. A potential alternative is to use Erbium spins, which is the only known impurity with coherent optical transitions in this frequency regime. Recent experiments have shown Purcell enhanced emission [4]. However, the 14 ms long lifetime of the excited states of Erbium requires to strongly improve the cooperativity. I will present the current status of a new experiment that tries to achieve this via High-finesse Fabry-Perot resonators with mode volumes approaching a single cubic wavelength.

References

[1] Hensen et al. Nature 526, 682 (2015)
[2] Kalb*, Reiserer*, Humphreys* et al. Science 356, 928 (2017)
[3] Bogdanovic et al. Appl. Phys. Lett. 110, 171103 (2017)
[4] Miyazono et al. Appl. Phys. Lett. 108, 011111 (2016)