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Prospects and challenges for quantum dots in quantum networks

Optically active quantum dots (QDs) provide a natural interface between confined spins and photons, lending themselves for implementations of stationary and flying quantum bits. Coherent control on the level of a confined spin in a single QD is experimentally well established [1] and entanglement between such a spin and a scattered photon was recently confirmed in several labs [2]. Moving towards quantum networks requires entangling remote spins as the immediate next step, bringing challenges due to the QD's mesoscopic nature into sharp focus: between any pair of QDs the solid-state environment gives rise to uncorrelated electric and magnetic field noise. I will show how fingerprints of the noise dynamics show up as resonance fluorescence fluctuations which can be captured in the intensity statistics of the photons [3]. Hence, we can distinguish between local environment noise sources and quantify their effects for individual QDs. A single electron confined in a QD acts as a noise sensor in this case. I will then introduce an unconventional example of a quantum network, where a QD is coupled to a single trapped ytterbium atom. The spectral bandwidth mismatch between the two fundamentally different systems is overcome using elastic scattering from the QD [4] and a high-finesse optical cavity for the ion.

References

[1] D. Press et al., Nature 456, 218 (2008) [2] K. De Greve et al., Nature 491, 421 (2012); W.B. Gao, et al., Nature 491, 426 (2012); J. R. Schaibley et al., PRL 110, 167401 (2013) [3] C. Matthiesen et al., Scientific Reports 4, 4911 (2014) [4] C. Matthiesen et al., Nature Comms. 4, 1600 (2013)

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