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Locking of the quantum dot electron-nuclear spin system to a resonant laser

ALEXANDER HOEGELE, LMU Munich, Department of Physics and Center for NanoScience, Munich, Germany

The electron-nuclear spin system in quantum dots is a paradigm for the study of the central spin problem - a localized spin coupled to a mesoscopic spin bath. We present our recent laser absorption measurements of the quantum dot electron-nuclear spin system. Our results demonstrate that quantum dot absorption spectra are strongly influenced by the nuclear spin physics. At moderate magnetic fields and for a wide range of system parameters the hyperfine coupled electron-nuclear system provides for active locking of quantum dot optical transitions to the laser resonance. The nuclear spin ensemble polarizes dynamically and ensures bi-directional tracking of the laser frequency detuning over tens of natural linewidths. Our analysis reveals that on-resonance locking is associated with a narrowing of the nuclear Overhauser field variance pointing towards increased electron spin coherence time in a controlled nuclear spin environment.