HL 26: Quantum Dots and Wires: Quantum Optics I

Time: Tuesday 9:30–11:00 Location: H16

Invited Talk HL 26.1 Tue 9:30 H16

Exploring spin quantum state decoherence in optically active quantum dots — •Jonathan Finley — Walter Schottky Institut and Physik Department, Technische Universität München, Am Coulombwall 4, 85748 Garching, Germany

For spin qubits in optically active quantum dots (QDs) considerable progress has been made in uncovering the qubit dynamics in external magnetic fields ($\mathbf{B}_{ext} \geq 50$ mT). In contrast, decoherence at $\mathbf{B}_{ext} \sim$ 0T and specifically the role of quadrupolar coupling of nuclear spins is comparatively poorly understood. Phenomenological models of decoherence typically include *two* basic types of spin relaxation: fast dephasing due to static but randomly distributed hyperfine fields ($\sim$ 2ns) and a much slower process ($\geq 1\mu$s) of irreversible monotonic relaxation due either to nuclear spin co-flips or many-body interaction effects. Our results show that electron spin relaxation is determined by *three* rather than two distinct stages (1). The additional stage corresponds to the effect of coherent precession processes that occur in the nuclear spin bath itself, leading to a relatively fast but incomplete non-monotonic relaxation at intermediate timescales and vanishing exernal magnetic fields ($\sim$ 750 ns). The interplay between field induced electron spin motion and the quadrupolar induced dynamics of the nuclear field are probed using spin echo. Moreover, we show how new information about spin dynamics can be obtained from direct measurements of two-time spin time correlators ($g^3(\tau_1,\tau_2)$).(2,3) - Refs: (1) A. Bachtold et al., Nature Physics (2015). DOI: 10.1038/nphys3470, (2) A. Bechtold et al. arXiv:1511.03684, (3) R. B. Liu et al, New. J. Phys, 12 013018, (2010)

HL 26.2 Tue 10:00 H16

Dependency of semiconductor quantum dot shape on absorption and pump probe spectra in negatively charged quantum dots — •Matthias Holtkemper, Doris Reiter, and Tilmann Kuhn — Institut für Festkörpertheorie, Universität Münster, 48149 Münster, Germany

Optically operated semiconductor quantum dots (QDs) are promising structures for quantum information, single photon sources and spintronics. In single QD experiments the geometric properties of the QD often play a vital role, however this is experimentally hard to access. Therefore simulations are essential to gain a detailed understanding of the electronic structure and dynamics in QDs in dependence of the QD geometry. We present a systematic analysis of absorption and pump-probe spectra for negatively charged QDs. To be specific, we model a negatively charged CdSe QD using a configuration interaction approach with a harmonic confining potential and include the direct Coulomb interaction as well as the short-range Coulomb exchange interaction (SRE). We calculate trion and charged biexciton states and compute the dynamics after a pump pulse using a Lindblad model. We discuss trends in the spectra caused by a variation of QD volume, asymmetry and height but also of the SRE strength and the difference between electron and hole confinement length. Our results enable us to extract geometric information about a QD from its absorption spectrum.

HL 26.3 Tue 10:15 H16

Transfer of a quantum state from a photonic qubit to a gate defined quantum dot — •Benjamin Jöcker[1], Pascal Cerfontaine[1], Beata Kardynal[2], and Hendrik Bluhm[1] — [1]JARA-Institute for Quantum Information, RWTH Aachen University, D-52056 Aachen, Germany — [2]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, D-52425 Jülich, Germany

An interface between a well-functioning, scalable stationary and a photonic qubit could substantially advance quantum communication applications and serve as an interconnect between future quantum processors. Qubits consisting of gate-defined quantum dots in GaAs are electrically controllable with high fidelity, whereas self-assembled quantum dots are established as an optical interface.

Here, we discuss a procedure to transfer the state of a photonic qubit to a quantum dot spin qubit. In the device under consideration a gate-defined quantum dot is tunnel-coupled to an optically addressable self-assembled quantum dot. When a photon is absorbed in the latter, an exciton is created whose spin configuration depends on the polarization of the photon. By applying an in-plane magnetic field, one can optically address exciton states with identical hole spin. As a result, no quantum information remains in the self-assembled quantum dot when the electron is transferred adiabatically to the gate-defined quantum dot. Using experimentally realistic parameters, we find that this transfer can be completed within the coherence time. We also consider an extension of the protocol to two-electron spin qubits, which have the advantage of being controllable via the exchange interaction.

30 min. Coffee Break