Q 20: Quantum Information (Solid State Systems)

Time: Monday 16:15–17:45 Location: S HS 002 Chemie

Group Report Q 20.1 Mon 16:15 S HS 002 Chemie
Deterministische nm-Implantation von seltenen Erden — Karin Groot-Berning[1], Georg Jacob[1], •Felix Stopp[1], Thomas Kornher[2], Roman Kolesov[2], Samuel T. Dawkins[3], Kilian Singer[3], Jörg Wrachtrup[2] und Ferdinand Schmidt-Kaler[1] — [1]QUANTUM, Institut für Physik, Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany — [2]3. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart — [3]Experimental Physik, Universität Kassel, Heinrich-Plett- Straße 40, 34132 Kassel, Germany

Wir stellen die nm-genaue Implantation von einzelnen Praseodym-Ionen in YAG-Kristalle vor. Es wird eine lineare Paulfalle mit einzelnen gefangenen lasergekühlten Ca^+-Ionen eingesetzt [1]. Aus einer externen Ionenquelle werden zusätzlich Dotierungsionen wie z.B. Pr^+ eingefangen und sympathetisch gekühlt. Die Paulfalle erlaubt einen weiten Bereich für die Speicherung und Kühlung bis zu einer Masse von $^{232}Th^+$ [2]. Wir extrahieren $^{141}Pr^+$-Ionen bei 5.9 keV und fokussieren sie zur Implantation in einen YAG-Kristall auf 23(8) nm genau. Die solchermaßen dotierten Kristalle zeigen im konfokalen Mikroskop genaue 2D-Muster der implantierten seltenen Erdionen. Neben Praseodym stellen auch Cer-Ionen interessante Kandidaten für optisch nachweisbare Ionen im Festkörperkristall dar. In einem neuen Aufbau zielen wir auf eine weitere Verbesserung der räumlichen Präzision sowie der Rate an Implantationen mit unterschiedlichen Dotierungsionen.

[1] Jacob et al., Phys. Rev. Lett. 117, 043001 (2016)
[2] Groot-Berning, arxiv: 1807.05975 (2018)

Q 20.2 Mon 16:45 S HS 002 Chemie
A Solvable Quantum Model of Dynamic Nuclear Polarization in Quantum Dots — •Thomas Nutz[1], Edwin Barnes[2], and Sophia Economou[2] — [1]Imperial College London — [2]Virginia Tech

Quantum dot single photon sources could enable a range of important quantum technologies, yet electron spin decoherence due to the electron-nuclear interaction has been limiting experimental progress. At the same time strong and surprising dynamic nuclear polarization (DNP) effects have been observed, which could be used to overcome the dephasing problem. However the mechanism of angular momentum transfer between electron spin and nuclear spins remains a matter of controversy for important experimental settings. We formulate a model of DNP induced by continuous wave lasers that simultaneously takes into account optical driving, decay, and electron-nuclear interactions, which turns out to be centrally important for the buildup of DNP. We find an exact and analytically tractable expression for the steady state of an arbitrary number of nuclear spins under the approximation of uniform electron-nuclear coupling strengths. Our model reproduces both the flat-top and the triangular absorption line shapes seen in experiments and referred to as line dragging. Furthermore we predict a novel DNP effect that can give rise to nuclear spin polarization which tends to cancel the effect of an external magnetic field. This exact solution therefore provides an explanation for experimentally observed DNP effects and predicts interesting novel phenomena, which could pave the way towards QD-based quantum technologies. Preprint available: ArXiv:1811.10491.

Q 20.3 Mon 17:00 S HS 002 Chemie
Toward a single shot readout of silicon vacancy centres in silicon carbide. — •Charles Babin — 3. Physikalisches Institut, Universität Stuttgart, 70569 Stuttgart, Germany

Solid state quantum systems with optically interfaced spins are a promising platform for quantum information processing. A scalable system should present spin-optical properties that are insensitive to the environment. Additionally a large fraction of photons should be resonantly emitted. Those criteria are met by the silicon vacancy center in silicon carbide.

Nonetheless, the fluorescence rate is limited by a strong phonon coupling to a metastable state manifold. Further, the associated spin flip present a limitation for the single shot readout fidelity. This talk addresses strategies to overcome these issues. I will show the first promising results on the deterministic implantation of single defect into nano-photonics cavities, intended the fluorescence rate via Purcell enhancement. I will also present a protocol to realize a deterministic readout of the electron spin via a nuclear spin memory.

Q 20.4 Mon 17:15 S HS 002 Chemie
Investigation of the charge state and spectroscopy of the tin-vacancy centre in diamond — •Johannes Görlitz[1], Dennis Herrmann[1], Morgane Gandil[1], Philipp Fuchs[1], Takayuki Iwasaki[2], Takashi Taniguchi[3], Mutsuko Hatano[2], and Christoph Becher[1] — [1]Fachrichtung 7.2, (Experimentalphysik), Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken — [2]Department of Electrical and Electronic Engineering, Tokyo Institute of Technology, Meguro, Tokyo 152-8552, Japan — [3]Advanced Materials Laboratory, National Institute for Material Science, 1-1 Namiki, Tsukuba, 305-0044, Japan

Recent experiments have proven colour centres in diamond to be highly suitable for application in quantum information processing. Nevertheless there is an ongoing search for a colour centre combining the milliseconds electron spin coherence times of the nitrogen vacancy centre at room temperature with the insensitivity to electrical field noise and the close to unity Debye-Waller factor of the silicon vacancy (SiV) centre. One promising candidate to achieve this aim is the tin vacancy (SnV) centre. Its negative charge state exhibits a similar electronic fine structure as the SiV but exceeds its ground state splitting by a factor of 20 and thereby potentially enables long spin coherence times at liquid helium temperatures. The neutral charge state, however, remains unstudied so far. We here present spectroscopic investigations on the SnV(-) centre such as polarization, lifetime, Debye-Waller factor and temperature dependence of linewidth and lineshifts. Furthermore we provide first spectroscopic studies of the neutral charge state.

Q 20.5 Mon 17:30 S HS 002 Chemie
Effective T_2 enhancement by feed forward decoupling — •Georg Braunbeck, Andreas Michael Waeber, Maximilian Kaindl, and Friedemann Reinhard — Walter Schottky Institut and Physik-Department, Technische Universität München, Am Coulombwall 4, 85748 Garching, Germany

Tuning a quantum sensor into maximum sensitivity generally also renders it most vulnerable to noise. The state-of-the-art solution is to tailor the sensor's spectral sensitivity, usually implemented via complex dynamical decoupling sequences.

In my talk, I will present an alternative approach that we termed "feed forward decoupling". It is based on the insight that we can remove the decoherence effect of a classical noise source by recording it alongside the quantum signal and adapting the readout phase to the result. I will present a proof-of-concept implementation on a nitrogen-vacancy center disturbed by a randomly fluctuating current in a nearby conductor. The scheme effectively increases T_2 in a Hahn echo measurement and can moreover be extended to a self-learning algorithm that learns the noise-correction on the fly.

Finally, I will discuss the limits and possible applications of this method. One of the most promising areas are experiments using strong control pulses, where small fluctuations translate into strong decoherence.