Q 12: Quantum Technology

Time: Wednesday 16:30–18:30 Location: P

Q 12.1 Wed 16:30 P

Nanofabricated and integrated colour centres in SiC with excellent spin-optical coherence — •Florian Kaiser[1], Charles Babin[1], Rainer Stöhr[1], Naoya Morioka[1], Tobias Linkewitz[1], Timo Steidl[1], Raphael Wörnle[1], Di Liu[1], Erik Hesselmeier[1], Vadim Vorobyov[1], Andrej Denisenko[1], Mario Hentschel[1], Christian Gobert[2], Patrick Berwian[2], Georgy Astakhov[3], Wolfgang Knolle[4], Sridhar Majety[5], Pranta Saha[5], Marina Radulaski[5], Nguyen Tien Son[6], Jawad Ul-Hassan[6], and Jörg Wrachtrup[1] — [1]Universität Stuttgart, Germany — [2]Fraunhofer IISB, Erlangen, Germany — [3]HZDR, Dresden, Germany — [4]IOM, Leipzig, Germany — [5]University of California, Davis, USA — [6]Linköping University, Sweden

We demonstrate that silicon vacancy (VSi) centres in semiconductor silicon carbide (SiC) are prime candidates for scalable integration into nanophotonic cavities. To this end, we show:

1.) Low-energy ion-assisted implantation without degradation of spin-optical coherences.

2.) Reliable operation of VSi centres in nanophotonic waveguides with little to no degradation of spin-optical coherences.

3.) Operation of VSi centres at high temperatures (T=20 K), while coherently controlling multiple nuclear spin qubits with near unity fidelity.

Our work represents a major step forward towards integrated multi-spin-multi- photon interfaces for distributed quantum computation and communication.

Q 12.2 Wed 16:30 P

Magnetometry on spin-crossover complexes using nitrogen-vacancy centers in nanodiamonds — •Isabel Manes[1], Jonas Gutsche[1], Tim Hochdörffer[1], Gereon Niedner-Schatteburg[2], and Artur Widera[1] — [1]Physics Department, Technische Universität Kaiserslautern und Forschungszentrum OPTIMAS, 67663 Kaiserslautern — [2]Chemistry Department, Technische Universität Kaiserslautern, Erwin-Schrödinger-Str. 52 67663 Kaiserslautern

Using various measurement protocols, the nitrogen-vacancy (NV) center's spin state can be optically initialized and read out. Magnetically, electrically and thermally sensitive, NV centers in nanodiamonds have been used as multipurpose nanoscale sensors.

Here, we present the application of NV centers as magnetic-field sensors to detect changes of magnetic fields caused by the spin transition of a chemical spin-crossover (SCO) complex. The examined polymeric Fe(II)-SCO complex is expected to switch from its diamagnetic low-spin state of $S = 0$ to a paramagnetic high-spin state of $S = 2$ per Fe(II) ion at $\sim 47\,^\circ$C. This thermally-induced SCO would cause a change in a local magnetic field. Using a simple model, we estimate this change to be in the order of 1 mT. Experimentally, we deposit nanodiamonds of approximately 700 nm average size and with less than 1 ppm NV centers on a thin-layer sample of the SCO complex. We perform temperature-dependent CW optically detected magnetic resonance spectroscopy using a self-built temperature-controlled sample holder. With temperatures rising above 47 °C, resonance frequencies are expected to shift in the MHz range.

Q 12.3 Wed 16:30 P

GHz Rydberg Rabi flopping towards an on-demand single-photon source — •Max Mäusezahl[1], Annika Belz[1], Florian Christaller[1], Felix Moumtsilis[1], Hadiseh Alaeian[2], Harald Kübler[1], Robert Löw[1], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Departments of Electrical & Computer Engineering and Physics & Astronomy, Purdue University, West Lafayette, IN 47907, USA

Fast coherent control of Rydberg excitations is a key component for quantum logic gates [1] and on-demand single-photon sources based on the Rydberg blockade as demonstrated for room-temperature rubidium atoms in a micro-cell [2]. We pursue an evolution of this single-photon source by employing state-of-the-art 1010 nm fiber amplifiers [3] to drive a Rydberg excitation via the 6P intermediate state. This, together with nanosecond density-switching light-induced atomic desorption (LIAD) pulses, will allow MHz repetition rates and significantly higher photon yields. Here we report on our current observation of GHz Rabi flopping to 32S and 40S Rydberg states. Such excitation timescales also pave the way towards fast optimal control methods for high fidelity Rydberg logic gates.

[1] Saffman, Journal of Physics B 49, 20 (2016)
[2] Ripka et al., Science 362, 6413 (2018)
[3] de Vries et. al., Optics Express 28, 12 (2020)

Q 12.4 Wed 16:30 P

Autonomous Single Atom Heat Engine — •Bo Deng, Moritz Göb, Max Masuhr, Kilian Singer, and Daqing Wang — Institut für Physik, Universität Kassel, Kassel, Germany

Here, we present our recent advances towards realizing an autonomous heat engine with a single atomic ion. The engine is based on a single $^{40}Ca^{+}$-ion confined in a tapered Paul trap. We propose implementing thermal baths with two tightly focused laser beams at different frequency detunings from the Doppler cooling transition. Furthermore, we employ a sub-Hertz linewidth laser system to address the $4^2S_{1/2}$ to $3^2D_{5/2}$ quadrupole transition. This will be used to perform sideband resolved ground state cooling, enabling the utilization of quantum reservoirs[1] to drive the single-atom heat engine.

[1]A. Levy, M. Göb, B. Deng, K. Singer, E. Torrontegui and D. Wang, *Single-atom Heat Engine as A Sensitive Thermal Probe*, New Journal of Physics **22.9**(2020)

Q 12.5 Wed 16:30 P

A fiber-based endoscope with integrated microwave antenna for magnetic sensing — •Stefan Dix[1], Jonas Gutsche[1], Erik Waller[2], Georg von Freymann[1,2], and Artur Widera[1] — [1]Department of Physics and State Research Center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Fraunhofer Institute for Industrial Mathematics ITWM, 67663 Kaiserslautern, Germany

Fiber-based endoscopes are established and widely applied as local fluorescence detectors for various samples, replacing bulky microscopes. Recently, fiber-based sensors with integrated diamonds containing nitrogen-vacancy (NV) centers have been developed. For magnetic field sensing using NV centers, a microwave field addresses a transition in the NV center. The microwave fields needed close to the fiber tip are usually created using thin wires.

Here, we present an integrated fiber-based sensor with a direct-laser-written (DLW) silver antenna structure on a multimode-fiber facet with a 50 μm core diameter and the implementation of a static magnetic field with an optional ring magnet around the fiber for the measurement of low magnetic fields. We present the characteristics of the applied microwave field, which we measure via network analysis as well as Rabi spectroscopy of diamonds with a diameter of $\sim$15 μm containing $\sim$3.5 ppm NV centers. We find a sensitivity of a few 100 nT/Hz$^{1/2}$ of our sensor. Our endoscope thus points toward possible applications for remote measurements of vector-magnetic fields.

Q 12.6 Wed 16:30 P

Generation of Optical Pulses for Solid-State Qubit Control — •Kilian Unterguggenberger[1], Laura Orphal-Kobin[1], and Tim Schröder[1,2] — [1]Department of Physics, Humboldt-Universität zu Berlin, Germany — [2]Ferdinand-Braun-Institute, Berlin, Germany

Many quantum information protocols proposed for solid-state qubits require coherent optical pulses as an elementary tool for, e.g., single-shot readout and spin-photon entanglement. Pulse lengths on the nanosecond timescale and pulse areas matching the respective Rabi frequency are required to address, for example, diamond color centers.

To achieve a short rise time and a high extinction ratio, we shape the light emitted by a narrow-bandwidth diode laser with an electro-optical modulator (EOM) in a Mach-Zehnder interferometer configuration. While commonly utilized for telecommunication with infrared light, operating an EOM at shorter, visible wavelengths is challenging due to the excitation of impurity sites in the waveguide material. The induced charge diffusion creates an internal electric field, causing the operation point of the modulator to drift. We stabilize the system using an active control feedback loop and characterize its performance. A fully polarization-maintaining fiber-coupled beam path makes the system flexible and enables precise pulse area adjustments using polarization optics.