Q 41: Nano-Optics I

Time: Wednesday 14:30–16:30 Location: B/gHS

Group Report Q 41.1 Wed 14:30 B/gHS

Quantum sensing using single nitrogen vacancy color centers in diamond — •Elke Neu, Patrick Appel, Arne Barfuss, Marc Ganzhorn, Jean Teissier, Lucas Thiel, Daniel Riedel, Dominik Rohner, and Patrick Maletinsky — University of Basel, Department of Physics, 4056 Basel, Switzerland

Single nitrogen vacancy (NV) color centers in diamond represent stable quantum emitters. They simultaneously offer coherent, optically addressable electronic spin-states and are highly suitable as nanoscopic sensors for e.g magnetic fields and optical near fields. Efficient fluorescence extraction is vital for applying NV centers as single photon sources and sensors, however, it is intrinsically challenging due to the high refractive index of diamond. We present novel photonic devices namely diamond nanopillars with optimally aligned NV centers [1] as well as a low-loss, broadband optical antenna [2] for efficient photon collection. For both approaches, we reach photon count rates in the order of one MHz. Importantly, the dielectric antenna in principle allows for near-unity collection efficiency and fully preserves the NV spin coherence time of $T_2 > 100$ μs. Our unique diamond nanostructures enable various applications such as high-performance quantum sensing or the study of hybrid quantum systems. We will present examples in nanoscale NV magnetometry and near field optical imaging, as well as coupling of NV spins to diamond nanomechanical oscillators [3].

[1] E. Neu et al., Appl. Phys. Lett., 104, 153108 (2014)
[2] D. Riedel et al., accepted at Phys. Rev. Appl. (2014)
[3] J. Teissier et al., Phys. Rev. Lett., 113, 020503 (2014)

Q 41.2 Wed 15:00 B/gHS

Optical extinction measurements on SiV centers in diamond — •Aroosa Ijaz, Lachlan Rogers, Peter Siyushev, and Fedor Jelezko — Institute for Quantum Optics, Universitat Ulm, Germany

Silicon vacancy (SiV) centers in diamond are currently gaining scientific interest predominantly due to their uniquely attractive optical spectrum. The narrow zero-phonon line contains 70% of the emission, and exhibits excellent spectral stability. Beyond applications as single photon sources and resources for quantum information processing and communication, these properties are ideal for examining fundamental interactions between light and single quantum emitters. We perform optical extinction measurements on single SiV centers in bulk diamond. This involves detecting interference between the reflection of the incident resonant laser form the diamond surface and the coherent fluorescence of the SiV center. Such investigations can provide a clear idea about the overlaps of orbital wavefunctions by looking into the absorption, scattering and extinction cross-sections of SiV centers in diamond. This technique may also provide a high contrast detection of SiV centers and hence pave the way towards single-shot optical readout of electron spin.

Q 41.3 Wed 15:15 B/gHS

Reliable optical identification of silicon isotope enables observation of nuclear spin in a silicon vacancy centre — •Andreas Dietrich[1], Mathias Metsch[1], Jan Binder[1], Kay Jahnke[1], Junichi Isoya[2], Philip Hemmer[3], Alexander Kubanek[1], and Fedor Jelezko[1] — [1]Institute of Quantum Optics, University Ulm, Germany — [2]National Institute for Materials Science, Namiki, Tsukuba, Ibaraki, Japan — [3]Electrical & Computer Engineering Department, Texas A&M University, USA

The silicon-vacancy centre (SiV) in diamond has exceptional spectral properties for single-emitter quantum information applications. Most of the fluorescence is concentrated in a strong zero phonon line (ZPL), with a weak phonon sideband extending for 100 nm that contains several clear features. We demonstrate that a local phonon mode causes the ZPL to shift with the silicon isotope, allowing optical identification of the silicon isotope present in a single SiV centre. This is of interest for quantum information applications since only the silicon-29 isotope has nuclear spin. We have made use of this technique to observe the nuclear hyperfine splitting of silicon-29 in SiV. This was done via coherent population trapping (CPT)

Q 41.4 Wed 15:30 B/gHS

Bulk-like spectral lines from SiV centres nanodiamonds (~50nm) — •Uwe Jantzen[1], Kay Jahnke[1], Clemens Schäfermejer[1], Valery Davydov[2], Viatcheslav Agafonov[3], Alexander Kubanek[1], Lachlan J. Rogers[1], and Fedor Jelezko[1] — [1]Institut für Quantenoptik, 89081 Ulm, Germany — [2]Institute for High Pressure Physics, Russian Academy of Sciences, Troitsk, Moscow 142190, Russia — [3]GREMAN, UMR CNRS-CEA 6157, Université F. Rabelais, 37200 Tours, France

The silicon vacancy (SiV) center in bulk diamond is known to have outstanding optical properties. Its strong zero-phonon line (ZPL) contains 70% of the total fluorescence and exhibits lifetime-limited linewidths. Additionally, SiV seems immune to spectral diffusion. These properties make it a promising candidate for quantum information processing. Many applications aim to utilize this color center in nanodiamonds, however this changes the optical properties due to surface effects and distortions in the lattice structure. Even the best reported SiV in nanodiamonds have ZPL features ten times broader than measured in bulk diamond. Here we report SiV centres in ~50nm nanodiamonds which exhibit excitation linewidths of 240MHz at 4K (less than double the bulk-diamond results). These unique optical properties are probably due to the novel HPHT process used to synthesise the nanodiamonds[1]. [1] Davydov, V. A., et al. (2010) JETP Letters 99, 585*89. doi:10.1134/S002136401410004X

Q 41.5 Wed 15:45 B/gHS

Spin properties of the silicon-vacancy color center in diamond — •Jonas Nils Becker[1], Benjamin Pingault[2], Christian Hepp[2], Carsten Arend[1], Victor Waselowski[3], Jeronimo Maze[3], Mete Atatüre[2], and Christoph Becher[1] — [1]Universität des Saarlandes, Saarbrücken, Germany — [2]Cavendish Laboratory, University of Cambridge, United Kingdom — [3]Pontificia Universidad Catolica de Chile, Santiago, Chile

Color centers in diamond have emerged as promising systems for quantum information processing as they can provide sufficiently long spin coherence times. We here present a detailed investigation of the electronic structure of the negatively charged silicon-vacancy (SiV) center. We examine the fluorescence properties of single SiV centers implanted in single crystalline diamond at cryogenic temperatures and in magnetic fields up to 7T. We show that the results are in good agreement with simulations obtained from a group theoretical model. This paves the way to access the spin degree of freedom of the SiV center. In a first experiment, we demonstrate spin-selective fluorescence of the SiV, probing its excited state spin. We show that our model can be extended to correctly describe this selectivity, and it allows predictions about the ground state spin properties of the center. This understanding of the spin properties is the basis for more advanced experiments such as all-optical coherent manipulation schemes. As a first step we here show the preparation of coherent superpositions of ground states by coherent population trapping.

Q 41.6 Wed 16:00 B/gHS

All-optical formation of coherent dark states of silicon-vacancy spins in diamond — •Benjamin Pingault[1], Jonas Becker[2], Carsten Schulte[1], Carsten Arend[2], Christian Hepp[1], Tillmann Godde[3], Alexander Tartakovskii[3], Matthew Markham[4], Christoph Becher[2], and Mete Atature[1] — [1]Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom — [2]Universitat des Saarlandes, Saarbrucken, Germany — [3]Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom — [4]Element Six Ltd., Global Innovation Centre, Didcot, United Kingdom

Colour centres in diamond have demonstrated a remarkable versatility for various applications in quantum information processing, magnetometry and in biological systems. Among them, the silicon-vacancy centre (SiV) is attracting an increasing attention due to its strong fluorescence into its zero-phonon line as well as its recently evidenced ground state spin, making it a potential candidate as a spin-photon interface. We here present our recent realisation of coherent population trapping on a single SiV, in which we optically create a coherent superposition of spin in the ground state. This allows us to determine for the first time a coherence time for the spin state in this system.

Q 41.7 Wed 16:15 B/gHS

Coupling of color centers to open-access microcavities —

•Alexander Bommer[1], R. Falkowski[1], P. Dolan[2], A. Trichet[2], J. Smith[2], A. Schell[3], O. Benson[3], L. Gines[4], O. Williams[4], and C. Becher[1] — [1]Fachrichtung 7.2, (Experimentalphysik), Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken — [2]Departement of Materials, University of Oxford, Parks Road, Oxford OX1 3PH, United Kingdom — [3]Humboldt-Universität zu Berlin, Institut für Physik, AG Nanooptik, Newtonstraße 15, 12489 Berlin, Germany — [4]School of Engineering, Cardiff University, Newport Road, Cardiff CF24 3AA, Wales, United Kingdom

The coupling of color centers in diamond such as Nitrogen Vacancy (NV) and Silicon Vacancy (SiV) centers to microcavites is considered an essential building block for applications in quantum information technologies. We here report on the coupling of a single NV center to an all-fiber-cavity and show enhancement of emission into the cavity, making use of the emitters large phonon sideband [1]. Much larger enhancement is predicted for emitters with smaller linewidths, such as the SiV center, allowing efficient cavity coupling even at room temperature. We here present our progress towards open-access microcavities for SiV wavelengths and the production of SiV centers in nanodiamonds. [1]Appl. Phys. Lett. 105, 073113 (2014)