MA 33: Quantum information systems I (with HL/TT)

Time: Wednesday 15:00–16:30 Location: POT 006

MA 33.1 Wed 15:00 POT 006

Improving the efficiency of passive Hall effect circulator — •Giovanni Viola[1] and David DiVincenzo[1,2] — [1]Institute for Quantum Information , RWTH Aachen — [2]Department of Theoretical Nanoelectronics, Peter Gruenberg Institute, Forschungszentrum Juelich

Low temperature microwave technology and the implementation of quantum computation require circulators as building blocks. Three-port circulators are examples of non-reciprocal devices; they should be passive, low noise and must operate at and below microwave frequencies. It is known that the Hall effect in the quantum regime shows non reciprocal behavior, and it can be utilized in a straightforward way in the realization of highly lossy circulators as well as gyrators. We have analyzed the physical origin of this lossy behaviour and, based on this understanding, developed a novel device that improves efficiency by dealing with the galvanic loss of the earlier designs. These novel circulators and gyrators are particularly suitable for current experiments: they are characterized by low loss and should be suitable for low temperature operation.

MA 33.2 Wed 15:15 POT 006

Large-scale density functional theory study of localization of donor electrons in phosphorus-doped silicon — •Pengxiang Xu[1], Elias Rabel[2], Wei Zhang[1], Riccardo Mazzarello[1], Rudolf Zeller[2], and Stefan Blügel[2] — [1]Institute for Theoretical Solid State Physics, RWTH Aachen, 52074 Aachen, Germany — [2]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The spin of an electron bound to a Phosphorus impurity in lightly Phosphorus-doped Silicon is a promising system for the realization of a spin quantum bit. By using two highly scalable density functional theory codes, KKRnano and QUICKSTEP, we investigate the structural and electronic properties of large models of P-doped Si containing up to 10^4 atoms, focusing in particular on those properties which are relevant to their application as spin qubits.

Computation of the electronic structure of a P impurity as a function of the isotropic doping fraction enable us to determine the doping potential, the doping density and the exchange interaction between donor electrons up to inter-impurity distances of approximately six nanometers.

Our density functional calculations reveal details in the density and potential distribution of the dopants, which are not evident in calculations that do not include explicit treatment of the P donor atom and the relaxation of the crystal lattice.

MA 33.3 Wed 15:30 POT 006

Deterministic Entanglement of Distant Nitrogen Vacancy Centers on an Integrated Photonic Platform — •Janik Wolters[1], Julia Kabuss[2], Andreas Knorr[2], and Oliver Benson[1] — [1]Humboldt-Universität zu Berlin, Institut für Physik, AG Nano-Optik, Newtonstraße 15, 12489 Berlin — [2]Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin

The nitrogen vacancy (NV) defect center in diamond has emerged as one of the most promising candidates for future solid state quantum technology. In particular recent progress on the integration of NV centers into photonic hybrid platforms attracted attention [1]. We explore the prospects of such an integrated quantum hybrid platform. The applicability of a robust, fast and deterministic entanglement scheme [2] is evaluated. Using realistic conditions and parameters (cavity quality factors, radiative dephasing and spectral diffusion) we find that significant entanglement can be generated between medium distant NV centers via a shared cavity mode. These studies outline a route towards deterministic quantum information processing on a realistic solid state platform.

[1] Wolters, J. et al. Enhancement of the zero phonon line emission from a single nitrogen vacancy center in a nanodiamond via coupling to a photonic crystal cavity. Appl. Phys. Lett. 97, 141108 (2010).

[2] Imamoglu, A. et al. Quantum Information Processing Using Quantum Dot Spins and Cavity QED. Phys. Rev. Lett. 83, 4204 (1999).

MA 33.4 Wed 15:45 POT 006

Interaction between differently charged states of the nitrogen vacancy in diamond — •Dion Braukmann[1], J. Debus[1], D. Dunker[1], V. Yu. Ivanov[2], D. R. Yakovlev[1], and M. Bayer[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, 44227 Dortmund, Germany — [2]Institute of Physics, Polish Academy of Sciences, 02668 Warsaw, Poland

The nitrogen vacancy (NV) in diamond is studied on account of its possible applications in spin-electronics. Temperature-stable properties are ranked among the main advantages of the NV center: Even at room temperature spin coherence times exceed one second.[1] The NV center appears in differently charged states. About 70% are negatively charged (NV^-), the rest are neutral (NV^0) centers. In contrast to the NV^-, the NV^0 is poorly investigated. For single NV centers it was shown that both charge states can transform into each other. In that context, an ensemble of NV centers has not been studied yet. We report on polarization-dependent optical characterization of ensembles of NV^- and NV^0 centers in diamond subjected to high magnetic fields, thus providing insight into their level structures. The talk will be focused on interactions between both charged states. We observe a strong increase in NV^- ZPL intensity and a characteristic resonance of the NV^- ZPL energy when the NV^0 center is excited resonantly. This behavior can either be explained by a change in the charge state or by a Förster resonant energy transfer. Both possibilities will be discussed in detail.

[1] P. C. Maurer et al., Science, 336, 1283 (2012).

MA 33.5 Wed 16:00 POT 006

Few spin NMR of external spins using a strongly coupled sensor in diamond — •Christoph Müller[1], Xi Kong[2], Jiangming Cai[3], Kristina Melentijević[1], Alastair Stacey[4], Matthew Markham[4], Daniel Twitchen[4], Junichi Isoya[5], Sébastien Pezzagna[6], Jan Meijer[6], Jiangfeng Du[2], Martin Plenio[3], Boris Naydenov[1], Liam McGuinness[1], and Fedor Jelezko[1] — [1]Institute for Quantum Optics, University Ulm, Germany — [2]Hefei National Laboratory for Physics Sciences at Microscale and Depatment of Modern Physics, University of Science and Technology of China, Hefei, China — [3]Institute for Theoretical Physics, University Ulm, Germany — [4]Element Six, Ltd, Ascot, Berkshire, United Kingdom — [5]Research Center for Knowledge Communities, University of Tsukuba, Ibakiri, Japan — [6]Experimental Physics II, University Leipzig, Germany

Negatively charged nitrogen-vacancy (NV^-) centres in diamond, located around 2 nm below the diamond surface were used as a NMR sensor at room-temperature. Strong coupling between the electron spin of the NV^- centre and external nuclear ^{29}Si spins on the diamond surface made it possible to measure the NMR signal aroused by four nuclear spins. With the achieved signal to noise ratio, single spin sensitivity within seconds is possible. In addition, the field gradient created by the NV^- centre itself combined with compressed sensing enables to locate the detected individual nuclei with Angstrom resolution.

MA 33.6 Wed 16:15 POT 006

Increasing the creation yield of shallow nitrogen-vacancy centers by surface plasma termination — •Christian Osterkamp[1], Jochen Scharpf[1], Sebastien Pezzagna[2], Jan Meijer[2], Thomas Diemant[3], Rolf Jürgen Behm[3], Boris Naydenov[1], and Fedor Jelezko[1] — [1]Institut für Quantenoptik, Ulm University, Albert Einstein Allee 11, 89081 Ulm, Germany. — [2]Institut für Experimentelle Physik II, Abteilung Nukleare Festkörperphysik, Universität Leipzig, Linnestraße 5, 04103 Leipzig, Germany. — [3]Institut für Oberflächenchemie und Katalyse, Ulm University, Albert-Einstein-Allee 47, 89081 Ulm, Germany.

Single nitrogen-vacancy (NV) centers in diamond close to the crystal surface are very promising magnetic field sensors with very high sensitivity and nanometer spacial resolution. The fluorescence of single NVs can be detected and its electron spin can be polarized, read-out and manipulated at ambient conditions. Here we report the enhanced creation of very shallow (less than 3 nm below the diamond surface) NVs by using fluorine and oxygen plasma treatment. We observe a four fold increase - from 0.11 % to about 0.45 % in the production yield when the sample surface is terminated with fluorine or oxygen atoms [1]. This effect is explained by the stabilization of the NV's negative charge state which is influenced by the various impurities present on the diamond surface.

[1]: Osterkamp et al., Appl. Phys. Lett. 103 (19), S.193118. (2013)