Q 65: Quantum information: Quantum computers and communication II

Time: Friday 14:00–15:45 Location: DO26 207

Q 65.1 Fri 14:00 DO26 207

The Silicon Vacancy centre in diamond as a superb single photon source — •Lachlan Rogers, Kay Jahnke, Liam McGuinness, and Fedor Jelezko — Institut für Quantenoptik, Universität Ulm, Ulm, Germany 89081

The negatively charged silicon-vacancy (SiV) colour centre in diamond shows promise as a single photon source for quantum communications and flying-qubit information processing. Often these technologies demand that individual photons are indistinguishable, and scalability requires that this condition even applies to photons from multiple emitters. Typical solid-state single photon sources require tuning to improve spectral overlap between distinct emitters, but we have observed SiV centres which intrinsically show almost identical emission (spectral overlap of up to 83%) and near transform-limited excitation linewidths. Recent developments in understanding the fundamental physics of SiV make it possible to tentatively explain why this colour centre is such a superb single photon source.

Q 65.2 Fri 14:15 DO26 207

NV- based quantum repeaters — •Burkhard Scharfenberger[1], William J. Munro[2,1], Hideo Kosaka[3], and Kae Nemoto[1] — [1]National Institute of Informatics, 2-1-2 Hitotsubashi, Chiyoda-ku, Tokyo 101-8430, Japan — [2]NTT Basic Research Laboratories, NTT Corporation, 3-1 Morinosato Wakamiya, Atsugi, Kanagawa 243-0198, Japan — [3]Reaserch Institute of Electrical Communication, Tohoku University, Sendai 980-8577, Japan

In the context of quantum information processing, the NV- center in diamond has been proposed and studied as a stable, optically readable solid state qubit and by now the basic techniques like initialisation and (single-shot) readout have been successfully demonstrated.

Here, we present a comparison of various schemes using the NV-center as a node within a quantum repeater. This is based on detailed studies looking at achievable fidelities for coherent manipulation of NV centers with and withough adjacent, strongly hyperfine-coupled carbon 13C nuclear spin where we found, that a bare NV-center allows high-fidelity control with simple square driving pulses, while this is only approxixmately true only when ignoring the nitrogen spin.

The repeater schemes we considered therefore use no more than one local memory qubit at each node, relying on high fidelity of the initial entangling link. Entanglement swapping can be achieved either via local gate operations as in the standard repeater or by making use of the special structure of the A2 state in the NV's excited state manifold.

Q 65.3 Fri 14:30 DO26 207

Isotopic sideband properties of SiV^- — •Andreas Dietrich, Lachlan Rogers, and Kay Jahnke — Institut für Quantenoptik - Universität Ulm, Ulm, Deutschland

Single photon emitters are essential for the growing fields of quantum communication and information processing. The negatively charged silicon-vacancy (SiV^-) center in diamond is an promising candidate for such a single photon emitter. However for proper applications a deeper understanding of the physical structure and properties of this color center is needed. To get more inside into the center we probed the sideband of SiV^-. Of special interest therein are the 64 meV and 128 meV phonon peaks in this sideband. We present a method measuring these peaks in bulk diamond at cryogenic temperature. Using the isotopic shift, we examine the influence of mass changes on the phonons. Thereby we get new information about the physical properties of this color center.

Q 65.4 Fri 14:45 DO26 207

Polarisation results giving insight into the electronic and physical sturcture of the silicon-vacancy center in diamond. — •Kay D. Jahnke[1], Lachlan J. Rogers[1], Marcus W. Doherty[2], Andreas Dietrich[1], Liam McGuinness[1], Christoph Müller[1], Tokuyuki Teraji[3], Junichi Isoya[4], Neil B. Manson[2], and Fedor Jelezko[1] — [1]Institut für Quantenoptik und IQST, Universität Ulm, D-89081 Ulm, Germany — [2]Laser Physics Centre, Research School of Physics and Engineering, Australian National University, ACT 0200, Australia — [3]National Institute for Materials Science, 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan — [4]Research Center for Knowledge Communities, University of Tsukuba, 1-2 Kasuga, Tsukuba, Ibaraki 305-8550, Japan

In recent times the negatively-charged silicon-vacancy (SiV^-) center in diamond has shown promise as a single photon source for quantum communications and information processing. However, the center's implementation in such quantum technologies is hindered by contention surrounding its fundamental properties. Here we present optical polarization measurements of single centers in bulk diamond that resolve this state of contention and establish that the center has a $\langle 111 \rangle$ orientated split-vacancy structure with D_{3d} symmetry. Furthermore, we identify an additional electronic level and the presence of dynamic Jahn-Teller effects in the center's 738 nm optical resonance.

Q 65.5 Fri 15:00 DO26 207

Spectral properties of single photons emitted by a single ion — •Tristan Tentrup, Marc Bienert, Jürgen Eschner, and Giovanna Morigi — Saarland University, Saarbrücken, Germany

To realize quantum networks one needs flying qubits that transfer the information between the nodes. This can be implemented by means of single ions (the nodes) that emit and absorb single photons (the flying qubits). The probability of absorption of single photons in this case is also determined by the spectral shape of the incident photon. Hence it is important to characterize and control the photon spectral properties. In this contribution we theoretically characterize the wave packet of a photon emitted by a single atom following a spontaneous Raman transition in a 3-level scheme, including the effect of the finite branching ratio. We determine the state of the emitted photon for several excitation schemes which have been experimentally discussed so far.

Q 65.6 Fri 15:15 DO26 207

Teleportation of flying qubits emitted from semiconductor quantum dots — •Thomas Kreissl, Tim Kroh, Otto Dietz, and Oliver Benson — AG Nanooptik, Humboldt-Universität zu Berlin

The distribution of quantum states over long distances is essential for quantum cryptography. Todays fibers restrict quantum communication to distances of about 100 km. Only quantum repeaters allow quantum key distribution over much longer distances by swapping the entanglement of spatially distant photon pairs.

We set up a two-color, folded-sandwich [1], parametric down conversion source to create entangled photon pairs. With these photon pairs we want to demonstrate the coalescence [2] and teleportation of flying qubits emitted from semiconductor quantum dots.

[1] Steinlechner F, et al., Optics Express 2013, 21, 11943
[2] Polyakov SV, et al., Phys Rev Lett. 2011, 107, 157402

Q 65.7 Fri 15:30 DO26 207

Quantum State Discrimination of Phase Shift-Keyed Coherent States — •Christian R. Müller[1,2], Christoffer Wittmann[1,2], Mario A. Usuga[4], Masahiro Takeoka[5], Denis Sych[1,2], Ulrik L. Andersen[3], Gerd Leuchs[1,2], and Christoph Marquardt[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Department of Physics, University of Erlangen-Nuremberg, Germany — [3]Department of Physics, Technical University of Denmark, Kongens Lyngby, Denmark — [4]Department of Photonics Engineering, Technical University of Denmark, Kongens Lyngby, Denmark — [5]National Institute of Information and Communications Technology, Tokyo, Japan

Coherent states have an outstanding importance in optical communication protocols as they are loss-tolerant and readily produced signal carriers. However, coherent states are mutually non-orthogonal and hence cannot be discriminated without errors [1,2]. We will present quantum receivers for the discrimination of phase-shift keyed alphabets [3]. The error rates are minimized by photon counting detectors and optimized, feedback mediated displacements prior to the detectors. We show that the standard quantum limit can be surpassed significantly for any signal power.

[1] C. W. Helstrom, Mathematics in Science and Engineering (Academic, New York, 1979), Vol. 123
[2] C. Wittmann et al. Phys. Rev. Lett. 101, 210501 (2008)
[3] C. R. Müller et al. New Journal of Physics 14 (2012) 083009