Q 28: Quanteninformation: Photonen III

Zeit: Dienstag 16:30–18:00 Raum: VMP 6 HS-D

Q 28.1 Di 16:30 VMP 6 HS-D

A quantum interface between light and nuclear spins in quantum dots — •Heike Schwager, Geza Giedke, and Ignacio Cirac — Max-Planck Institut für Quantenoptik, Hans-Kopfermann Str. 1, 85748 Garching

The coherent coupling of flying photonic qubits to stationary matter-based qubits is an essential building block for quantum communication networks. We show how such a quantum interface can be realized between the polarized nuclear spins in a singly charged quantum dot strongly coupled to a high-finesse optical cavity and a traveling-wave optical field. By adiabatically eliminating the electronic degree of freedom different effective couplings can be achieved that enable write-in, read-out, and the generation of entanglement between the nuclei and the output field of the cavity.

Q 28.2 Di 16:45 VMP 6 HS-D

Towards coupling of a single emitter to a fiber based micro cavity — •Roland Albrecht[1], Benjamin Sauer[1], Christian Deutsch[2], Jakob Reichel[2], and Christoph Becher[1] — [1]Fachrichtung 7.3, (Technische Physik), Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken — [2]Laboratoire Kastler Brossel, ENS/UPMC-Paris 6/CNRS, 24 rue Lhomond, 75005 Paris, France

Coupling a single emitter to a micro cavity is a crucial step towards sucessful implementation of efficient single photon sources and of many quantum information protocols.[1] We here investigate fiber based Fabry Perot cavities which consist of a flat dielectric mirror and an optical fiber. This cavity design has several advantages: it is tunable, can be scanned transversally and is automatically fiber-coupled with very good efficiency. To achieve stable cavities, a concave impression has been produced on the fiber facet by laser machining prior to deposition of a dielectric coating. Cavities using mirrors with radii of curvature of about 50 μm, with a finesse of up to 300 and a length of a few micrometers have been realized. We use defect centers in diamond nanocrystals as single emitters. The diamond nanocrystals are deposited onto the flat mirror by spin coating. Theoretical considerations show that the chosen cavity parameters should allow for enhancement of the defect center spontaneous emission by coupling it to the microcavity due to the Purcell effect.

[1] S. Prawer and A.D. Greentree, Science 320, 1601 (2008)

Q 28.3 Di 17:00 VMP 6 HS-D

Fast Excitation and Photon Emission of a Coupled Atom-Cavity System — •Joerg Bochmann, Martin Mücke, Holger Specht, Bernhard Weber, David Moehring, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

Single atoms coupled to optical cavities provide unique systems to study light-matter interaction in the quantum regime. Naturally, these systems are well suited for atom-photon entanglement and distributed quantum networks [1].

We report on the fast excitation of a single Rb atom coupled to an optical cavity using laser pulses much shorter than all relevant processes [2]. The system subsequently displays an oscillatory energy exchange between atom and cavity field leading to pronounced amplitude modulations of the emitted single photons. We further show that the cavity frequency can be used as a parameter to design the single photon shape and spectrum, e.g. in a superpostion of two tunable frequencies.

[1] T. Wilk *et al.*, Science **317**, 488 (2007)
[2] J. Bochmann *et al.*, Phys. Rev. Lett. **101**, 223601 (2008)
[3] C. DiFidio *et al.*, Phys. Rev. A **77**, 043822 (2008)

Q 28.4 Di 17:15 VMP 6 HS-D

Mode mapping in waveguided parametric downconversion — •Andreas Christ, Kaisa Laiho, Andreas Eckstein, and Christine Silberhorn — Max Planck Research Group, Günther-Scharowsky-Str. 1/Bau 24, 91058 Erlangen, Germany

The process of parametric downconversion (PDC) has been found a reliable source of entangled photon pairs for quantum cryptography and quantum information. Recent developments in the source engineering are drawing the attention from the conventional sources to waveguided setups.

One of the advantages of waveguided PDC is the discrete mode propagation of signal, idler and pump in contrast to a continuum of spatial modes in bulk crystals. Therefore, an increase in collection efficiency over several orders of magnitude is expected.

We investigate the multimode PDC in waveguided periodically poled KTP structures. Our study of the spectral and spatial structure of the twin beams reveals a profound mapping from the spatial mode propagation into the frequency distribution of the generated biphotonic states: The disjoint spectral correlations are imprinted in the spectral marginal distributions of the generated PDC states.

Our results indicate that several spatial modes can be simultaneously excited in a waveguide. The discovered modal structures have to be taken into account when designing quantum information experiments: On the one hand our findings result in the need of additional filtering to shape the PDC states. On the other hand these effects can be utilized as a multiplexed source of entangled photon pairs.

Q 28.5 Di 17:30 VMP 6 HS-D

Amplification of a Laser Beam by a Single Molecule — •Jaesuk Hwang, Martin Pototschnig, Gert Zumofen, Robert Lettow, Alois Renn, Stephan Götzinger, and Vahid Sandoghdar — Laboratory of Physical Chemistry and optETH, ETH Zurich, CH-8093 Zurich, Switzerland

In a recent work, we showed that we can strongly couple a laser beam to a single emitter, achieving more than 10% extinction in transmission [1]. We have also shown theoretically that it is possible to reflect light with 100% efficiency from a two-level system [2]. In this presentation, we report on the amplification of a laser beam by a single molecule in free space. In order to populate the upper state of the molecule, a short pump pulse excites it to the first vibrational level of the electronic excited state. This state quickly relaxes to the vibrational ground state of the electronic excited state with 10 ns lifetime. During this time and before the next pulse arrives, a weak probe laser beam interacts with the inverted molecule. We observed that a starting 7 % extinction of the probe beam is transformed into a 0.6% amplification in the presence of the pumping beam [3]. We will present a simple theoretical model that yields a very good agreement with our experimental data. [1] G. Wrigge et. al. Nature Physics 4, 60-66 (2008). [2] G. Zumofen et. al. Phys. Rev. Lett. 101, 180404 (2008). [3] J. Hwang et. al. in preparation.

Q 28.6 Di 17:45 VMP 6 HS-D

Single molecule experiments challenge the strict particle aspect of the photon — •Karl Otto Greulich — Fritz Lipmann Institute Beutenbergstr.11 D07745 Jena

In the context of the photon, the definition of the term *particle* is not as straightforward as one might believe, with consequences for the meaning of the wave- particle dualism of light. The probably strictest definition of the photon as particle is given by the *accumulation time argument*, which requires that the spatial dimensions of the photon are much smaller than the absorbing atom or molecule and that its whole energy content is concentrated in this limited volume. Otherwise the extremely short interaction time of a few femtoseconds would make it impossible that a single atom or molecule can absorb a single, freely travelling photon. Here it is shown, using data from single molecule experiments, that the accumulation time argument has, so far, not yet been satisfied and therefore, the strict particle property of the photon is, so far, not been substantiated by experiments.