Q 36: SYPC: From Atoms to Photonic Circuits 1

Time: Thursday 10:30–12:30 Location: V47.01

Invited Talk Q 36.1 Thu 10:30 V47.01

Quantum Communication: real-world applications and academic research — •Nicolas Gisin — GAP, University of geneva

Quantum communication is the art of transferring a quantum state from one place, Alice, to another, Zeus. The simplest technique consists in merely sending a system carrying the quantum state, typically a photon, directly from Alice to Zeus. This is basically the way commercial quantum key distribution apparatuses work today, though direct communication is definitively limited to a few hundreds of km due to losses in optical fibers. But there are more sophisticated ways to realize quantum communication, each more fascinating than the other. First, one could exploit 2-photon entanglement and their EPR-like correlations. Next, one could perform quantum teleportation, a mind-boggling 3-photon process. All these have been demonstrated in and outside labs. But the real grand challenge for quantum communication is much more ambitious and fascinating: teleport a quantum state along a chain of sections: from A to B, then from B to C and so on until Y to Z. Moreover, in order to outperform direct communication, the process should be efficient. This requires that the A-B and B-C and * Y-Z entanglements necessary for quantum teleportation, must all be ready before one starts the teleportation processes. This, in turn, implies that the entanglement must be in-between quantum memories located at each node A, B, C, etc, able to hold the quantum state for ms.

Invited Talk Q 36.2 Thu 11:00 V47.01

Trapping and Interfacing Cold Neutral Atoms Using Optical Nanofibers — •Arno Rauschenbeutel — Vienna Center for Quantum Science and Technology, TU Wien–Atominstitut, Stadionallee 2, 1020 Wien, Austria

We have recently demonstrated a new experimental platform for trapping and optically interfacing laser-cooled cesium atoms [1]. The scheme uses a two-color evanescent field surrounding an optical nanofiber to localize the atoms in a one-dimensional optical lattice 200 nm above the nanofiber surface. At the same time, the atoms are efficiently interrogated with light which is sent through the nanofiber. Remarkably, an ensemble of 2000 trapped atoms yields an optical depth of up to 30, equivalent to 1.5 % absorbance per atom. Moreover, when dispersively interfacing the atoms, we observe ~ 1 mrad phase shift per atom at a detuning of six times the natural linewidth [2].

Our technique provides unprecedented ease of access for the coherent optical manipulation of trapped neutral atoms and opens the route towards the direct integration of atomic ensembles into fiber networks, an important prerequisite for large scale quantum communication. Moreover, our nanofiber trap is ideally suited to the realization of hybrid quantum systems combining atoms with solid state quantum devices.

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[1] E. Vetsch *et al.*, Phys. Rev. Lett. **104**, 203603 (2010).

[2] S. T. Dawkins *et al.*, Phys. Rev. Lett. **107**, 243601 (2011).

Q 36.3 Thu 11:30 V47.01

Quantum networking with time-bin encoded qubits, qutrits and qquads using single photons from an atom-cavity system — Peter B. R. Nisbet-Jones, Jerome Dilley, Oliver Barter, •Annemarie Holleczek, and Axel Kuhn — Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU

We report on the production of time-bin encoded qubits, qutrits and qquads which are one fundamental building block in quantum information processing, networking and cryptography. They are produced by full coherent control of the single-photon generation in a strongly coupled atom-cavity system. This allows for the preparation of single photons in an n-time-bin superposition state with arbitrarily defined amplitudes and phases. The qubits', qutrits' and qquads' properties are determined and demonstrated with the help of a small linear optics quantum network [1].

[1] P. B. R. Nisbet-Jones, et al., "Quantum networking with time-bin encoded qubits, qutrits and qquads using single photons from an atom-cavity system," *in preparation* (2011).

Q 36.4 Thu 11:45 V47.01

Highly efficient, fibre-integrated single photon to single mode coupling - based on defect centres in nanodiamonds — •Tim Schröder[1], Masazumi Fujiwara[2], Tetsuya Noda[2], Hong-Quan Zhao[2], Oliver Benson[1], and Shigeki Takeuchi[2] — [1]Nano-Optics, Humboldt University — [2]RIES, Hokkaido University, Japan

Recently, the most direct approach to fabricate a reliable single photon source, by mounting a single quantum emitter on an optical fibre, was demonstrated*. A nanodiamond containing a single nitrogen vacancy (NV) centre was placed on the fibre facet. Such a system easily integrates into fibre optic networks for quantum cryptography and is promising for quantum metrology applications.

Here, we present a tapered fibre based single photon system that has an even wider application range. Single nanodiamonds containing NV centres are deposited on such a tapered fibre of 273 nm in diameter. The tapered fibres were fabricated from standard single mode fibres. For the deposition on the taper, a dip-coating technique was developed, that enables controlled deposition of nanodiamonds and other nanoparticles. For a single NV centre, 689 kcts/s of single photons are coupled into a single mode. The system was cooled to cryogenic temperatures and can be coupled evanescently to other nanophotonic structures, such as microresonators. It is suitable for integrated quantum transmission experiments, two-photon interference, quantum-random-number generation. As a nanoprobe it can be used for well localized, ultra-sensitive sensing applications such as nanomagnetometry.

* Schroeder et al. Nano Letters 11, 198, 2011

Q 36.5 Thu 12:00 V47.01

Towards optical quantum logic: Source, interface and memory — Jerome Dilley, Peter B. R. Nisbet-Jones, •Annemarie Holleczek, Oliver Barter, and Axel Kuhn — Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU

We present a highly efficient, deterministic source of indistinguishable photons which is based on a vacuum stimulated Raman process (V-STIRAP) in a strongly coupled atom-cavity system [1]. This device operates intermittently for periods of up to $100\mu s$, with a single-photon repetition rate of 1 MHz, and an efficiency of greater than 65% [2]. The single photons are not only produced on demand but also with total control of their shape and intrinsic phase. In addition, we present a scheme how a single photon can be reabsorbed by the emitting atom as this is the key to a single-photon quantum memory [3].

[1] A. Kuhn and D. Ljunggren, Contem. Phys. **51**, 298 (2010).

[2] P. B. R. Nisbet-Jones, et al., New J. Phys. **13**, 103036 (2011).

[3] J. Dilley, et al., arXiv 1105.1699 (2011).

Q 36.6 Thu 12:15 V47.01

Asymmetric-coupled vertical quantum dots: Towards a light controlled quantum gate — •Elisabeth Koroknay[1], Christian Kessler[1], Matthias Reischle[1], Ulrich Rengstl[1], Moritz Bommer[1], Robert Rossbach[1], Heinz Schweizer[2], Michael Jetter[1], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Allmandring 3, 70569 Stuttgart, Germany — [2]4. Physikalisches Institut, Pfaffenwaldring 57, 70569, Stuttgart, Germany

In this talk we show the route towards the realization of a laterally and vertically positioned triple dot structure consisting of a tunnel-coupled vertical asymmetric double quantum dot structure (ADQD) and a single dot (larger than the ADQD). The triple dot structure serves as a quantum gate with the ADQD as source dot and the large dot as target dot. The coupling between source and target is achieved by light induced dipole fields originating from the ADQD which influence via the Stark effect the target dot transition.

The quantum dot (QD) structures are grown by metal-organic vapor-phase epitaxy (MOVPE) on GaAs substrates. The ADQD consists of two vertically stacked differently sized InP QDs embedded in GaInP, grown lattice matched to GaAs. Time integrated and time-resolved photoluminescence (PL) measurements have been performed on ADQDs to investigate the coupling behavior. For the target QD the InGaAs material system was chosen to clearly differ in emission energy of the InP ADQD. Next to our growth efforts we present structural and optical analysis of the current status.