Q 53: Quantum Information: Photons and Nonclassical Light 1

Time: Thursday 14:30–16:00 Location: SCH 251

Q 53.1 Thu 14:30 SCH 251

Experimental Qudit Entanglement — •Daniel L. Richart[1,2], Yvo Fischer[1,2], Wieslaw Laskowski[1,2,3], and Harald Weinfurter[1,2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str.1 D-85748 Garching, Germany — [2]Ludwig-Maximilians-Universität, Schellingstr. 4, D-80797 München, Germany — [3]Instytut Fizyki Teoretycznej i Astrofizyki, Uniwersytet Gdánski, PL-80-952 Gdánsk, Poland

Entangled qudits, i.e. entangled higher dimensional states, have been proven to offer potential applications in the field of quantum computation and communication, e.g. for the implementation of more efficient quantum gates and more secure Quantum Key Distribution schemes. We make use of a scalable scheme using unbalanced interferometers to encode energy-time entangled [1] qudits first on a 2x4 dimensional Hilbert space. We experimentally demonstrate entanglement between both ququats by performing a Bell test [2], and further characterize them by dimension and state witnesses. Potential applications in the field of quantum metrology are discussed.

[1] J.D. Franson et al., PRL 62, 2205 (1989) [2] Vertesi et al., PRL 104, 060401 (2010)

Q 53.2 Thu 14:45 SCH 251

Testing spectral modes in parametric downconversion — •Malte Avenhaus[1], Andreas Christ[2], Katiúscia N. Cassemiro[1], and Chrstine Silberhorn[1,2] — [1]Max-Planck Institute for the Science of Light, Erlangen, Germany — [2]University of Paderborn, Applied Physics, Paderborn, Germany

Parametric downconversion has found wide application in quantum optics. Great effort has recently been attributed to generate states with either a very large number of modes, or to design PDC sources that work in the single mode regime. While the first approach offers a large extent of spectral entanglement, the latter can be used to implement pure heralded single photon sources.

For characterizing these sources recent focus was based on gaining an operational value that estimates the number of modes from specific measurements on the output state. Here, we focus on a way to directly access the spectral structure of the modes generated, by seeding the source with a spectrally shaped coherent beam.

Q 53.3 Thu 15:00 SCH 251

Useful multiparticle entanglement applied for sub shot noise phase estimation — •Roland Krischek[1,2], Christian Schwemmer[1,2], Witlef Wieczorek[1,2,3], Harald Weinfurter[1,2], Philipp Hyllus[4], Luca Pezzé[5], and Augusto Smerzi[4] — [1]Max-Planck-Institut für Quantenoptik, D-85748 Garching, Germany, — [2]Fakultät für Physik, Ludwig-Maximilians-Universität München, D-80799 München, Germany — [3]University of Vienna, Faculty of Physics, Boltzmanngasse 5, A-1090 Vienna, Austria — [4]BEC-CNR-INFM and Dipartimento di Fisica, Università di Trento, I-38050 Povo, Italy — [5]Laboratoire Charles Fabry de l'Institut d'Optique, F-91403 Orsay Cedex, France

The goal of quantum enhanced metrology is to develop methods to improve the precision of measurements using non-classical resources. To this aim, a parameter, for example, a phase shift has to be determined with a precision beyond the classical shot noise limit. In general, quantum correlations are necessary but not sufficient to achieve measurement sensitivities beyond the shot noise limit. Therefore we developed theoretically and demonstrated experimentally for a 4 photon symmetric Dicke state the condition to recognize useful multiparticle entanglement for the estimation of an unknown phase shift. We implemented a maximum likelihood as well as a Bayesian phase estimation protocol and demonstrate the enhanced sensitivity obtained for an entangled symmetric Dicke state.

Q 53.4 Thu 15:15 SCH 251

Near-unity collection efficiency of single photons using a planar dielectric antenna — •Kwanggeol Lee, Xuewen Chen, Hadi Eghlidi, Philipp Kukura, Alois Renn, Vahid Sandoghdar, and Stephan Götzinger — Laboratory of Physical Chemistry, ETH Zürich, CH-8093 Zürich, Switzerland

Single-photon sources have been discussed as the building blocks of quantum cryptography, optical quantum computation, spectroscopy, and metrology. However, the feasibility of these proposals depends on the availability of single photons with a high fidelity. For sources based on single emitters, this implies near-unity collection efficiency into well-defined modes. Some of the current state-of-the-art efforts aimed at achieving these criteria have been demonstrated, but despite an impressive progress the results still fall short. In particular, a collection efficiency of 38% were reported using microresonators[1], while a nanowire device reached an efficiency of 72% at cryogenic temperatures[2]. Here we report on a broad-band room-temperature scheme, which uses a layered dielectric structure for tailoring the angular emission of a single oriented molecule such that more than 96% of the emitted photons are collected with a microscope objective, leading to recorded photon count rates of about 50 MHz[3]. Our approach is wavelength insensitive and compatible with cryogenic experiments and can therefore be extended to other solid state emitters, including defect centers in diamond and semiconductor quantum dots. [1] S. Strauf et al. Naure Photon. 1, 704-708 (2007). [2] J. Claudon et al. Nature Photon. 4, 174-177 (2010). [3] K-G. Lee et al. Nature Photon., to appear.

Q 53.5 Thu 15:30 SCH 251

Towards experiments with atoms in coupled cavity arrays — Guillaume Lepert[1], Michael Trupke[2], •Michael Hartmann[3], Martin Plenio[4], and Ed Hinds[1] — [1]Centre for Cold Matter, Imperial College, Prince Consort Road, London SW7 2BW, United Kingdom — [2]Technische Universität Wien - Atominstitut, Stadionallee 2, 1020 Wien, Austria — [3]Technische Universität München, Physik Department, James-Franck-Strasse, 85748 Garching, Germany — [4]Universität Ulm, Institut für Theoretische Physik, Albert-Einstein-Allee 11, 89069 Ulm, Germany

The physics of coupled quantum emitters or strongly interacting polaritons in arrays of coupled cavities has attracted considerable interest in recent years. Yet experimental realisations, in particular with optical photons, are still scarce. Here we describe a technologically viable platform for experiments with atoms or other quantum emitters in coupled optical cavity arrays. The envisaged solution requires only existing fabrication techniques and realistic performance parameters. The device uses open Fabry-Perot micro-cavities to couple to the emitters. The central innovation of this design is to connect the microcavities via evanescently-coupled resonators on a photonic waveguide chip. Based on these premises we present a theoretical analysis of two possible experiments and discuss further, more advanced applications.

Q 53.6 Thu 15:45 SCH 251

Spectroscopy of a single molecule with a stream of lifetime-limited single photons — Yves Rezus, •Samuel Walt, Gert Zumofen, Alois Renn, Stephan Götzinger, and Vahid Sandoghdar — ETH Zürich, Laboratory of Physical Chemistry (LPC), 8093 Zürich, Switzerland

An important elementary process in quantum information processing is the transfer of a single excitation between two quantum emitters. We report on the first realization of such an experiment in a direct fashion, where lifetime-limited single photons emitted by a single molecule are used as the source for the coherent excitation and spectroscopy of a second single molecule at a distance of more than 2m.