Q 44: Quantum information: Photons and nonclassical light II

Time: Thursday 14:00–15:45 Location: UDL HS3038

Q 44.1 Thu 14:00 UDL HS3038

Optimal Control of the quantum state of a microwave cavity field — •Katharina Rojan[1], Daniel Reich[2], Christiane Koch[2], and Giovanna Morigi[1] — [1]Universität des Saarlandes, D-66123 Saarbrücken — [2]Universität Kassel, D-34132 Kassel

Quantum state preparation of the electromagnetic field is a prerequisite for quantum networks. In microwave cavity quantum electrodynamics the field can be manipulated by atomic beams which cross the resonator. We consider the question, how to prepare an arbitrary target state of the cavity by means of the interaction with a single atom, assuming that both cavity and atom are driven by external fields. We identify the time-dependent dynamics which is required in order to achieve a set of target states using Optimal Control Theory based on Krotov's method [2]. We analyse the efficiency for preparation of Fock states $|n\rangle$, Fock states superpositions $(|0\rangle + |n\rangle)/\sqrt{2}$ and Schroedinger cat states of the resonator field. We show that, for the parameters of the experiment at ENS in Paris [3], time scales of the order of tens of microseconds are needed in order to achieved infidelities below 10^{-4}. The scaling of the time scale needed for preparing states $(|0\rangle+|n\rangle)/\sqrt{2}$ as a function of n is discussed as well as pulses which are robust against parameter fluctuations.

[1] C. Law and J.H. Eberly, Phys. Rev. Lett. **76**, 1055 (1996)
[2] D.M. Reich, M. Ndong, and C.P. Koch, J. Chem. Phys. **36**, 104103 (2012)
[3] S. Haroche and J.-M. Raimond, *Exploring the Quantum* (Oxford Graduate Texts, New York, 2006)

Q 44.2 Thu 14:15 UDL HS3038

Measuring the local environment of a quantum dot — •Clemens Matthiesen, Megan Stanley, Jack Hansom, Claire Le Gall, and Mete Atature — Cavendish Laboratory, Department of Physics, University of Cambridge, UK

The electronic level structure and optical transitions of quantum dots (QDs) are subject to fluctuating electric fields from nearby charge traps and a noisy Overhauser field from local nuclear spins [1,2]. The resultant inhomogeneous electron spin dephasing and a reduced photon spectral purity are detrimental to the use of QDs in quantum information processing. Pulling together experimental results from intensity autocorrelations, counting statistics and high-resolution emission spectra of QD resonance fluorescence (RF), we obtain a detailed self-consistent picture of the environment dynamics. Full counting statistics quantify steady-state spectral diffusion and provide a means to distinguish blinking or switching from continuous spectral shifts. The intensity autocorrelation $g^{(2)}$ reveals noise amplitudes and their timescales and together with a theoretical model enables identification of the respective origins. We find electric field noise to be dominant down to a 100 μs timescale, while Overhauser field variations feature on faster timescales. High-resolution emission spectra offer a sensitive probe of the nuclear field dispersion, and, in agreement with the autocorrelations, point to a static Overhauser variance at different Rabi frequencies. [1] A. N. Vamivakas et al., Phys. Rev. Lett. 107, 166802 (2011) [2] A. V. Kuhlmann et al., Nature Phys. 9, 570-575 (2013)

Q 44.3 Thu 14:30 UDL HS3038

State tomography with time multiplexing InGaAs detectors — •Georg Harder[1], Libor Motka[2], Bohumil Stoklasa[2], Luis L. Sánchez-Soto[3,4,5], Jaroslav Řeháček[2], Zdeněk Hradil[2], and Christine Silberhorn[1] — [1]Integrated Quantum Optics, Applied Physics, University of Paderborn, D-33098 Paderborn — [2]Department of Optics, Palacký University, 77146 Olomouc, Czech Republic — [3]Max Planck Institute for the Science of Light, D-91058 Erlangen — [4]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, D-91058 Erlangen — [5]Departamento de Óptica, Facultad de Física, Universidad Complutense, 28040 Madrid, Spain

Time multiplexing is a costeffective method to obtain photon number resolution with binary detectors. In contrast to Si APDs operating in the visible wavelength rage, InGaAs APDs for the near infrared wavelength range suffer from afterpulsing effects which renders the standard detector models inaccurate. We show that despite these strong imperfections, reliable state reconstruction is possible by applying detector tomography. We reconstruct the photon number distribution of two-mode PDC states and single mode heralded states.

Q 44.4 Thu 14:45 UDL HS3038

Strong interactions in an ultracold Rydberg gas — •Hannes Gorniaczyk, Christoph Tresp, Johannes Schmidt, and Sebastian Hofferberth — Universität Stuttgart, Deutschland

Strong photon-photon coupling can be achieved in highly nonlinear media such as Rydberg atoms under the condition of electromagnetically induced transparency (EIT). Such a system enables the implementation of fundamental building blocks for photonic information processing in classical and quantum mechanical devices. More fundamentally, interacting Rydberg polaritons form a strongly correlated many-body system with the unique property that the interacting particles can be converted into free photons at any time.

We present our realization of two color Rydberg EIT in a high optical density medium consisting of ultracold Rb87 atoms in an optical trap. The strong optical nonlinearity of this medium enables the realization of an all-optical switch, where the presence of a weak light field has a drastic effect on the transmittance of a second light field through the medium. In our talk, we present our progress towards demonstrating a single photon switch.

Q 44.5 Thu 15:00 UDL HS3038

Beating the One-Half Limit of Linear-Optics Bell Measurements with unentangled Ancillae — •Fabian Ewert and Peter van Loock — Institut für Physik, Johannes Gutenberg Universität Mainz, Staudingerweg 7, 55128 Mainz

Bell measurements are fundamental building blocks in various quantum algorithms, such as quantum teleportation. It is well known, that the discrimination of the Bell states is possible with a probability of 50% at best, when using only passive linear optics and arbitrarily many vacuum mode ancillae. By adding unentangled single-photon ancillae, we are able to surpass this limit and reach a success probability of 75%. We discuss the error robustness of the proposed scheme and a generalisation to reach a success probability arbitrarily close to 100%.

Q 44.6 Thu 15:15 UDL HS3038

BosonSampling with controllable distinguishability — •Max Tillmann — Universität Wien, Photonic Quantum Computation and Quantum Simulation, Wien, Österreich

Intermediate models of quantum computation have opened an alternative scheme to experimentally prove the supremacy of quantum information processing. In the case of photons, BosonSampling computers have raised significant interest by solving computational hard problems very resource efficient. Indistinguishable photons are processed via passive optical networks and a photon counting measurement is performed. While a few dozen of photons and sufficiently large optical interferometers hold the promise to outperform conventional computers, error-correction schemes are limited. Therefore a evaluation of possible error sources is important for the correct operation of a BosonSampler. Especially distinguishability of the processed photons may limit scalability of this computational model. We introduce and experimentally test a scheme to relate the computational result to the transition-matrix immanants. These generalizations of the permanent give access to tighter estimates of the underlying BosonSampling distribution and thus might become a crucial tool for such computations under realistic experimental conditions.

Q 44.7 Thu 15:30 UDL HS3038

Boson-Sampling in the light of sample complexity: a review — •Christian Gogolin, Martin Kliesch, Leandro Aolita, and Jens Eisert — Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany

BosonSampling is a classically computationally hard problem that can — in principle — be efficiently solved with quantum linear optical networks. Recently, this has lead to an experimental race to implement such devices. In this talk we provide a review of the state of affairs concerning the possibility of certifying BosonSampling devices. We discuss in detail the following issues: 1. The use of symmetric and non-symmetric algorithms for distinguishing the BosonSampling distribution from some other particular distribution. Here, we present new results on partial certification from moments of the photon-number distributions with methods from representation theory. 2. The impossibility of an efficient classical certification. 3. Classical simulation of BosonSampling experiments in the presence of errors.