Q 1: Quantum Optics I

Time: Monday 11:30–13:00 Location: C/HSO

Q 1.1 Mon 11:30 C/HSO

Time multiplexed photonic quantum walks — •Thomas Nitsche[1], Fabian Elster[1], Sonja Barkhofen[1], Aurél Gábris[2], Jaroslav Novotny[2], Igor Jex[2], and Christine Silberhorn[1] — [1]Applied Physics, University of Paderborn, Warburger Strasse 100, 33098 Paderborn, Germany — [2]Department of Physics, Faculty of NuclearSciences and Physical Engineering, Czech Technical Universityin Prague, Brehová 7, 115 19 Praha, Czech Republic

Photonic quantum walk systems can be considered as a standard model to describe the dynamics of quantum particles in a discretized environment and serve as a simulator for complex quantum systems, which are not as readily accessible. However their experimental realization requires setups with increasing complexity in terms of number of modes and control of the system parameters. A key element for a versatile simulator is the ability to control the quantum-coin, which is the main entity responsible for the evolution of the quantum walk. Breaking links in the underlying graph structures leads to the concept of percolation, addressed in recent theoretical studies. In a generalization the graph topology can even change in time, modelling a randomly evolving, fluctuating medium. Yet, the implementation of dynamically changing graphs poses severe challenges. Here, we present an experiment with precise dynamical control of the underlying graph structure, facilitating the blending of percolation with a genuine quantum process while exploiting the high intrinsic coherence and versatility of a time-multiplexed quantum walk architecture.

Q 1.2 Mon 11:45 C/HSO

A simple method for direct quantum pulse characterization in the time domain — •Markus Allgaier, Vahid Ansari, Viktor Quiring, Raimund Ricken, Hubertus Suche, Benjamin Brecht, and Christine Silberhorn — Applied Physics, University of Paderborn, Warburger Straße 100, 33098, Paderborn

We explore a new approach for measuring the time domain structure of ultra fast single photon pulses at telecom wavelength based on the quantum pulse gate (QPG) recently introduced by our group [1]. Our dispersion engineered QPG enables efficient group-velocity matched sum frequency conversion where the converted photon is in the visible range, which allows for easy detection. The temporal resolution of the process can be as short as the pump pulse duration, which is in the range of 100 fs. We propose to use this device for direct quantum pulse characterization in the time domain by sampling the single photon pulse with a short pump pulse.

[1] B. Brecht, et al., Phys. Rev. A 90, 030302(R) (2014)

Q 1.3 Mon 12:00 C/HSO

Spectral noise analysis of optical frequency comb for quantum limited parameter estimation — •Valerian Thiel, Jonathan Roslund, Roman Schmeissner, Claude Fabre, and Nicolas Treps — Laboratoire Kastler Brossel, UPMC-Sorbonne Université, ENS, College de France, CNRS, Paris, France

Femtosecond optical frequency combs have found a widespread use in domains like metrology, spectroscopy, ranging measurements and optical clocks. In the general case of parameters estimation, we derived the ultimate limit of sensitivity, the so-called Cramér-Rao bound, and we showed that it can be experimentally achieved using a balanced homodyne detection.

In all these measurements, the knowledge of the frequency dependent noise of the comb is essential to assess the actual sensitivity of a given measurement scheme. Using experimental methods that were developed for quantum optics, we introduce a novel technique to assess the combs noise: a single-shot spectrally resolved multipixel homodyne detection that allows to characterize both the amplitude and the phase noise of the comb, as well as spectral correlations. We then extract noise matrices and provide an experimental realization of uncoupled broadband noise modes.

This is applied to absolute distance estimation using a solid-state frequency comb where both amplitude and phase noise of the source prevent one from achieving a quantum limited measurement.

Q 1.4 Mon 12:15 C/HSO

Noise in the Beam Width of Spatial Optical Modes — •Vanessa Chille[1,2,4], Peter Banzer[1,2,3], Andrea Aiello[1,2], Gerd Leuchs[1,2,3], Christoph Marquardt[1,2], Nicolas Treps[4], and Claude Fabre[4] — [1]Max Planck Institute for the Science of Light, Guenther-Scharowsky-Str. 1/Bldg. 24, D-91058 Erlangen, Germany — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Staudtstr. 7/B2, D-91058 Erlangen, Germany — [3]Department of Physics, University of Ottawa, 25 Templeton, Ottawa, Ontario, K1N 6N5 Canada — [4]Laboratoire Kastler Brossel, Sorbonne Université - UPMC, ENS, Collège de France, CNRS; 4 place Jussieu, 75252 Paris, France

Fundamental limits in imaging and beam focusing originate from the spatial distribution of quantum noise. Here we investigate quantum fluctuations in the beam width of transverse optical modes. We start by defining a quantum operator measuring the beam width and study its characteristics. An eigenmode is derived and the canonically conjugate variable of the beam width is determined for a fundamental Gaussian mode. For the very common case of single mode states, we present investigations on the noise of the beam width for coherent and Fock states when the spatial modes represents Hermite-Gauss, Laguerre-Gauss and flattened Gaussian beams. For multimode states with small quantum fluctuations, as for instance in the case of coherent states, the noise of the beam width can be attributed to one particular spatial mode. We give explicit examples.

Q 1.5 Mon 12:30 C/HSO

Experimental implementation of a quantum pulse gate for ultrafast quantum temporal modes — •Vahid Ansari, Markus Allgaier, Raimund Ricken, Viktor Quiring, Hubertus Suche, Benjamin Brecht, and Christine Silberhorn — Integrierte Quantenoptik, Universität Paderborn, Warburger Str. 100, D-33098 Paderborn

We recently demonstrated a Quantum Pulse Gate (QPG), which can operate on temporal modes of ultrafast quantum states [1]. Here we experimentally present benchmarks for the operation of QPG utilising single photons generated in a process of Parametric Down-conversion (PDC) [2]. We show a highly efficient QPG operation on PDC photons using extremely low pump energies. In addition, we show the temporal mode-selective operation of QPG on the PDC photons. The application of QPG along with single photons in different temporal modes is a promising candidate for high-dimensional quantum information coding.

[1] Brecht, et al., Phys. Rev. A 90, 030302(R) (2014)
[2] Harder, et al., Opt. Exp. 21, 13975 (2013)

Q 1.6 Mon 12:45 C/HSO

Experimentally investigating the frequency dependence of the scattering phase in a spontaneous Raman process — •Philipp Müller, Pascal Eich, Michael Schug, Christoph Kurz, and Jürgen Eschner — Experimentalphysik, Universität des Saarlandes, Saarbrücken, Germany

Controlled photon-to-atom quantum state transfer is essential for atom-based quantum networks, a crucial prerequisite being the complete control over the quantum-mechanical phase of the atom–photon system [1].

We implement our experimental protocol for heralded photon-to-atom quantum state transfer [2] using a single trapped calcium-40 ion and laser photons. To investigate the effect of the frequency spectrum of the absorbed photon on the atomic state, we analyze the phase of the final atomic superposition revealing the phase difference of the complex absorption profiles of the two involved Raman transitions. The experimental results are compared with results of numerical simulations.

[1] M. Schug et al., Phys. Rev. A **90**, 023829 (2014)
[2] C. Kurz et al., Nat. Commun. **5**, 5527 (2014)