Q 16: Quantum Optics III

Time: Tuesday 11:00–13:00 Location: C/HSO

Q 16.1 Tue 11:00 C/HSO

Reliable quantum certification for photonic quantum technologies — Leandro Aolita[1], •Christian Gogolin[1,2], Martin Kliesch[1], and Jens Eisert[1] — [1]ICFO - The Institute of Photonic Sciences, Av. Carl Friedrich Gauss 3, 08860 Castelldefels (Barcelona), Spain — [2]MPQ - Max Planck Institute of Quantum Optics, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Photonic devices involving many optical modes promise major advances in quantum technologies, with applications ranging from quantum metrology over quantum computing to quantum simulations. A significant current roadblock for the development of such devices, however, is the lack of practical reliable certification tools. Here, we present one such tool. We start by carefully defining different notions of quantum-state certification tests. Then, we introduce an experimentally friendly, yet mathematically rigorous, certification test for experimental preparations of arbitrary m-mode pure Gaussian states as well as a class of pure non-Gaussian states common in linear-optical experiments, including those given by a Gaussian unitary acting on Fock basis states with n bosons. The protocol is efficient for all Gaussian states and all mentioned non-Gaussian states with constant n. We follow the formal mindset of an untrusted prover, who prepares the state, and a skeptic certifier, equipped only with classical computing and single-mode measurement capabilities. No assumptions are made on the type of quantum noise or experimental capabilities of the prover.

Q 16.2 Tue 11:15 C/HSO

N00N states from a single non-linear device — •Regina Kruse[1], Linda Sansoni[1], Sebastian Brauner[1], Raimund Ricken[1], Craig S. Hamilton[2], Igor Jex[2], and Christine Silberhorn[1] — [1]Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn — [2]FNSPE, Czech Technical University in Prague, Břehová 7, 115 19, Praha 1, Czech Republic

In the quest for miniaturised devices for quantum information applications, integrated optics offers solutions for the generation and interfacing of photonic quantum states. Here, we present a dual-channel, integrated N00N state source, based on type-0 parametric down-conversion in a periodically poled waveguide coupler. With this approach, we eliminate narrow-band spectral filtering to make the photons indistinguishable, as well as phase-stabilisation, which is needed for the pump light in conventional multi-channel devices [1,2]. We discuss the generation protocol for photons in this type of structures [3] and measure a state fidelity of $\mathcal{F} = (84,1 \pm 2,6)\%$. Furthermore, we show the 2-photon N00N state interference, exhibiting twice the fringe frequency [4], as compared to classical light.

[1] H. Jin, et al., PRL 113, 103601 (2014)
[2] J. W. Silverstone, et al., Nature Phot. 8, 104 (2014)
[3] R. Kruse, et al., NJP 15, 083046 (2013)
[4] J. P. Dowling, Contemp. Phys. 49, 125 (2008)

Q 16.3 Tue 11:30 C/HSO

A fully integrated single-pass squeezer — Michael Stefszky and •Christine Silberhorn — Universität Paderborn

We will present current results from a recently developed fully integrated single-pass squeezer. This device performs the second-harmonic generation, local oscillator shaping, and the squeezing on a single chip in a double-pass configuration. Photorefractive effects are minimised by producing the second harmonic field in the same device, ensuring optimal mode overlap between this field and the fundamental. The rejected fundamental light that exits the waveguide is in the same spatial mode as the squeezed light and is used as the local oscillator in a homodyne setup, resulting in high visibilities. The device has low losses (0.03dB/cm), high nonlinearity (up to 14%/Wcm^2) and is as long as most current technologies allow for (83mm).

Q 16.4 Tue 11:45 C/HSO

Giant twin-beam generation along the pump energy propagation — •Kirill Spasibko[1,2,3], Angela Pérez[1,2], Polina Sharapova[3], Olga Tikhonova[3], Maria Chekhova[1,2,3], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [3]Department of Physics, M.V.Lomonosov Moscow State University, 119991 Moscow, Russia

Twin-beam squeezed vacuum state is a very exciting non-classical state of light. In theory, it exhibits perfect photon-number correlation between the beams, so that with this state even the Bell's inequalities could be, in principle, violated. On the other hand, this state can be macroscopic, therefore light-light and light-matter interactions would be much more efficient with it.

Unfortunately generation of bright twin beams requires using of short pump pulses or tight focusing. In this case the effects of transverse (spatial) and longitudinal (temporal) walk-off appear in the nonlinear medium. This limits the generation of bright twin beams.

In this work we have shown that extremely bright twin beams can be generated via high-gain parametric down conversion if one of the twin beams is emitted along the pump Poynting vector or its group velocity matches that of the pump. Moreover, we have shown that effects of spatial and temporal walk-off can be useful for the shaping of the emitted twin beams, especially for the reduction of their number of spatial and temporal modes.

Q 16.5 Tue 12:00 C/HSO

Cooperative spontaneous emission, numerical studies — •Paul Huillery, Hannes Busche, Matthiew P. A. Jones, and Charles S. Adams — Joint Quantum Centre (JQC) Durham-Newcastle, Department of Physics, Durham University, South Road, Durham, DH1 4ET, United Kingdom

The spontaneous emission of photons from atomic ensembles initially excited have been shown to exibit interesting cooperative behaviors such as increased emission rate (superradiance) or spatial directionnality [1]. This process is today connected to experimental challenges aiming for example to develop quantum memories, single photons sources or quantum repeaters [2],[3].

After a brief review of this context, we will show in this talk spatial emission patterns from choosen atomic ensembles, obtained numerically. Motivated by the volunty to give comprehensive pictures, we will consider samples from 2 to thousands of atoms and study the case of realistic experimental preparation.

[1] M.O. Scully et al., Phys. Rev. Lett. 96, 010501 (2006)
[2] K. Hammerer et al., Rev. Mod. Phys. 82, 1041 (2010)
[3] L.-M. Duan et al., Nature 414, 413 (2001)

Q 16.6 Tue 12:15 C/HSO

Waveguide QED with a nonlinear dispersion relation — •Michael Peter Schneider[1] and Kurt Busch[1,2] — [1]Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin — [2]Humboldt-Universität zu Berlin, Institut für Physik, AG Theoretische Optik & Photonik, Newtonstr. 15, 12489 Berlin

We calculate the Green's function of two photons in a one-dimensional waveguide with an embedded two-level system. The waveguide exhibits a nonlinear dispersion relation, $\epsilon(k) = vk + \gamma k^2$, with $\frac{\gamma}{v} \ll 1$. We find that the dominant effect with respect to the linear dispersion relation is a renormalization of the scattering matrix. Numerical calculations confirm the validity of the renormalization for energies which are not too close to a band edge, where new physical processes become dominant.

Q 16.7 Tue 12:30 C/HSO

The semiclassical approximation in non-simply connected spaces — •Stefan G. Fischer[1], Clemens Gneiting[1], and Andreas Buchleitner[1,2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität, Hermann-Herder-Str. 3, D-79104 Freiburg, Germany — [2]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität, Albertstr. 19, D-79104 Freiburg, Germany

When a quantum system is effectively confined to a two-dimensional plane, the exclusion of a singular point leads to interesting topological interference effects. The experimental framework is provided by subjecting particles to a vector potential in otherwise field-free space, as it is well known from the Aharonov-Bohm effect for a single particle, and leads to exchange interactions of identical particles other than those of bosons or fermions. We give a semiclassical description of such phenomena, in which interference effects can be intuitively related to the underlying structure of classical trajectories.

Q 16.8 Tue 12:45 C/HSO

A Statistical Benchmark for BosonSampling — •Mattia Walschaers[1,2], Jack Kuipers[3,4], Juan-Diego Urbina[3], Klaus Mayer[1], Malte C. Tichy[5], Klaus Richter[3], and Andreas Buchleitner[1,6] — [1]Physikalisches Institut, Albert-Ludwigs Universität Freiburg, Freiburg, Germany — [2]Instituut voor Theoretische Fysica, University of Leuven, Leuven, Belgium — [3]Institut für Theoretische Physik, Universität Regensburg, Regensburg, Germany — [4]D-BSSE, ETH Zürich, Basel, Switzerland — [5]Department of Physics and Astronomy, Aarhus University, Aarhus, Denmark — [6]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universitaet Freiburg, Albertstr. 19, 79104 Freiburg

A long standing endeavour in the field of quantum computation, is to challenge and even falsify the extended Church-Turing thesis, which states that any efficient computation performed by a physical device can be performed in polynomial time by a classical computer. Much as quantum information science has progressed, for an actual falsification, an actual physical device is required. As universal quantum computers still are out of reach, the BosonSampler, an optical setup that can efficiently probe many-boson interferences, has attracted much attention as a candidate for such a device. One huge problem, however, is certification of the process, after all, how could one verify whether a device works the way it should work, if its outputs are by definition unfeasible to simulate on a classical computer? In this contribution, we show that a careful statistical assessment, based on the theory of complex systems, can provide a solution.