Q 19: Quantum Optics III

Time: Tuesday 11:00–12:30   Location: P 5

Q 19.1 Tue 11:00 P 5

Topological invariants in one-dimensional lossy quantum walks — •Manolo Rivera[1], Natalie Thau[1], Carsten Robens[1], Wolfgang Alt[1], Janos Asbóth[2], Dieter Meschede[1], and Andrea Alberti[1] — [1]Institut für Angewandte Physik, Bonn, Germany — [2]Wigner Research Centre for Physics, Budapest, Hungary

Quantum walks describe the motion of a quantum particle in discrete steps in time and space. It has been shown that quantum walks enable topologically protected edge states with two associated topological invariants [1]. Furthermore, the number of topologically protected edge states is equal to the difference of the two topological invariants (bulk-boundary correspondence principle). Recent theoretical work suggests that such topological invariants can be measured with a lossy quantum walk [2]. If we perform the split-step protocol and remove one spin species at each time step, the average position where the atom is removed is an integer equal to the sum of the two topological invariants. We here present the topological properties of the split-step protocol and our proposal to achieve the experimental realization of the lossy quantum walk using optimal coin and transport operations in order to measure the topological invariants associated to the unitary split-step quantum walk.

[1] J. K. Asbóth, H. Obuse, "Bulk-boundary correspondence for chiral symmetric quantum walks", Phys. Rev. B 88, 121406(R) (2013)

[2] J. K. Asbóth, T. Rakovszky, A. Alberti, "Detecting topological invariants via losses in chiral symmetric Floquet insulators", arXiv:1611.09670 [cond-mat.mes-hall] (2016)

Q 19.2 Tue 11:15 P 5

Ion traps as heat pumps — •Dawid Crivelli[1], Samuel Thomas Dawkins[1], Ferdinand Schmidt-Kaler[2], and Kilian Singer[1] — [1]Experimentalphysik I, Universität Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel, Germany — [2]Quantum, Institut für Physik, Universität Mainz, D-55128 Mainz, Germany

Thermodynamic machines can be reduced to the ultimate atomic limit [1], using a single ion as a working agent. The confinement in a linear Paul trap with tapered geometry allows for coupling axial and radial modes of oscillation.

A single ion can be driven against the tapered potential, compressing the radial degrees of freedom, which can be then used as a thermal medium. By performing work on the ion, heat is transported from a cold to a hot end of an engineered bath.

Extending the system to multiple ions, the external work induces a directional transfer of heat through the linear crystal. Ions at one side of the trap thus model a finite bath being cooled below its initial, Doppler limited, temperature.

[1] J. Rossnagel et al., "A single-atom heat engine", Science, Vol. 352, Issue 6283, pp. 325-329

Q 19.3 Tue 11:30 P 5

Experimentelle Demonstration einer Wärmekraftmaschine im quantenmechanischen Regime — •David von Lindenfels, Vidyut Kaushal, Johannes Rossnagel, Jonas Schulz, Ferdinand Schmidt-Kaler und Ulrich G. Poschinger — Johannes-Gutenberg-Universität, Mainz

Wir präsentieren eine Wärmekraftmaschine basierend auf einem $^{40}Ca^+$-Ion in einer Radiofrequenzfalle. Das Arbeitsmedium ist der Spin des Valenzelektrons, dessen Temperatur durch optisches Pumpen sowie Depolarisation zyklisch geändert wird. Das Ion befindet sich in einer phasenstabilisierten Stehwelle aus verstimmtem Licht mit entlang der Fallenachse alternierender zirkularer Polarisation [1]. Diese ruft über den ac-Stark Effekt eine spinabhängige optische Dipolkraft hervor und koppelt somit den Spin an den axialen Bewegungsfreiheitsgrad, der als Speicher für die gewonnene Arbeit dient. Wir demonstrieren das Anlaufverhalten der Wärmekraftmaschine im quantenmechanischen Regime der axialen Oszillation.

[1] C.T. Schmiegelow et al. PRL **116**, 033002 (2016), Phase-Stable Free-Space Optical Lattices for Trapped Ions

Q 19.4 Tue 11:45 P 5

Distinguishability and many-particle interference — •Stefanie Barz[1], Adrian Menssen[1], Alex Jones[1,2], Ben Metcalf[1], Malte C. Tichy[3], Steve Kolthammer[1], and Ian A. Walmsley[1] — [1]Clarendon Laboratory, Department of Physics, University of Oxford, OX1 3PU, United Kingdom, — [2]Blackett Laboratory, Imperial College London, SW7 2BW, United Kingdom, — [3]Department of Physics and Astronomy, University of Aarhus, DK-8000 Aarhus C, Denmark,

Quantum interference of two independent particles in pure quantum states is fully described by the particles' distinguishability: the closer the particles are to being identical, the higher the degree of quantum interference. When more than two particles are involved, the situation becomes more complex and interference capability extends beyond pairwise distinguishability, taking on a surprisingly rich character. Here, we study many-particle interference using three photons. We show that the distinguishability between pairs of photons is not sufficient to fully describe the photons' behaviour in a scattering process, but that a collective phase, the triad phase, plays a role. We are able to explore the full parameter space of three-photon interference by generating heralded single photons and interfering them in a fibre tritter. Using multiple degrees of freedom—temporal delays and polarisation— we isolate three-photon interference from two-photon interference. Our experiment disproves the view that pairwise two-photon distinguishability uniquely determines the degree of non-classical many-particle interference.

Q 19.5 Tue 12:00 P 5

Hong-Ou-Mandel interference in an integrated quantum optical waveguide device — •Polina Sharapova, Kai Hong Luo, Harald Herrmann, Matthias Reichelt, Christine Silberhorn, and Torsten Meier — Physics department and Center of Optoelectronics and Photonics Paderborn (CeOPP), University of Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany;

The Hong-Ou-Mandel (HOM) interference is one of the basic and important tools of modern quantum optics. A bulk HOM interferometer includes several quite large optical elements which makes it difficult to use and combine them in compact quantum computational circuits. Technologies that allow to realise quantum optical functionalities in small integrated systems are much more promising in this respect.

In this work we present a theoretical description of a HOM interferometer that can be realised in an integrated quantum optical chip based on, e.g., $LiNbO_3$ waveguide technology. The entire interferometer including several optical elements and the generation of photon pairs via parametric down conversion can be incorporated on a single chip using available fabrication techniques. Our theoretical approach is based on unitary transformations which describe the action of the optical elements and can easily be generalized to more complicated systems.

Q 19.6 Tue 12:15 P 5

Tailoring spatial light modes for sum-frequency generation in Lithium-Niobate waveguides — •Jano Gil López, Vahid Ansari, Markus Allgaier, Harald Herrmann, Raimund Ricken, and Christine Silberhorn — Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098.

Nonlinear optical processes in integrated quantum circuits has shown promising applications in manipulation of quantum states such as spectral bandwidth compression and changing the colour of single photons for interfacing different optical systems. Since it is impossible to design waveguides with single mode characteristics at different wavelengths, a special care has to be taken to tailor the spatial modes of the optical fields inside the waveguide structures.

Here we investigate the tailoring of spatial modes for sum-frequency generation in Lithium-Niobate waveguides for wavelengths between 500 nm to 1550 nm. We present spatially single-mode integrated waveguide circuits for such an optical nonlinear processes.