Q 22: Quantum Optics I

Time: Monday 16:15–17:45 Location: S Gr. HS Maschb.

Q 22.1 Mon 16:15 S Gr. HS Maschb.

Experiments on photon bunching of a LED

— •Andreas Zmija, Peter Deiml, Stefan Funk, Gisela Anton, Adrian Zink, Dmitry Malyshev, and Thilo Michel — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

We built a Hanbury Brown-Twiss like intensity interferometer used for detecting photon correlations on the order of sub-nanoseconds by time tagging the arrival times of photons in two photomultipliers. The wavelength filtered light from a green LED is used as thermal light source to evaluate a bunching signal in the temporal second-order correlation function. The experimental setup will be shown and setup-specific artefacts and disturbances will be discussed. Furthermore, results of a 60 hour intensity interferometry measurement of the LED-light are presented which show a clear photon bunching signature. Moreover, a quantitive analysis of the bunching peak, in particular of the time evolution of its significance, is given and the stability of measurement systematics is discussed.

Q 22.2 Mon 16:30 S Gr. HS Maschb.

Observation of Hong-Ou-Mandel-interference in PT-symmetry

— •Friederike Klauck, Lucas Teuber, Marco Ornigotti, Matthias Heinrich, Stefan Scheel, and Alexander Szameit — Universität Rostock, Institut für Physik, Albert-Einstein-Str. 23, 18055 Rostock

A broad variety of Parity-Time-symmetric systems and classical effects has been studied in photonics. However, the field of PT-symmetric quantum optics is left uncharted to this day. Here, we report on the first observation of quantum multi-particle interference in a lossy directional coupler. We achieve a Hong-Ou-Mandel dip with a visibility of $90 \pm 4\%$ and find that the antisymmetric loss distribution in the system systematically shift the interference in towards shorter propagation distances.

Q 22.3 Mon 16:45 S Gr. HS Maschb.

Hanbury Brown Twiss intensity interferometry with picosecond-resolution

— •Sebastian Karl[1], Raimund Schneider[1,2], Stefan Richter[1,2], and Joachim von Zanthier[1,2] — [1]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [2]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, 91058 Erlangen, Germany

The ability to measure temporal intensity correlation functions with high contrast can be regarded as the first step towards spatial Hanbury Brown Twiss (HBT) intensity interferometry [1]. Such measurements have been recently performed using the light of arc lamps [2] or real stars [3]. The contrast in these measurements critically depends on the time resolution of the detectors. We present a setup and results for the measurement of temporal intensity correlations with a resolution < 90 picoseconds using a xenon arc lamp. These measurements fit our theory and simulations extremely well [4]. In the light of recent revivals of HBT measurements [3] we discuss a setup to measure temporal intensity correlations of bright stars even on telescopes with a diameter of only 0.5 meters.

[1] R. Hanbury Brown, R. Q. Twiss, Nature 177, 27 (1956). [2] P. K. Tan et al., Astrophysical JL 789, L10 (2014). [3] W. Guerin et al., MNRAS 472, 4126 (2017). [4] R. Schneider et al., Appl. Opt. 57, 7076 (2018).

Q 22.4 Mon 17:00 S Gr. HS Maschb.

Probing quantum dynamical couple correlations with time-domain interferometry

— Salvatore Castrignano and •Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Spatial and temporal correlations among particles are key to the exploration of complex many-body phenomena. However, it remains a challenge to access such correlations in many experimental settings of interest. Time-domain interferometry (TDI) is a promising method to characterize spatial and temporal correlations over longer timescales. TDI relies on the interference of two indistinguishable scattering pathways, which probe a target at different times. The interference signal then contains information about the so-called intermediate scattering function and the related dynamical couple correlations characterizing the target. TDI has been theoretically studied and experimentally demonstrated using x-ray scattering ([1,2] and references therein), though only for classical target systems. In this talk, we will present a quantum analysis [3], and suggest a scheme which allows to access quantum dynamical correlations. We further show how TDI can be used to exclude classical models for the target dynamics, and illustrate our results with the toy model system of a single particle in a double well potential.

[1] A. Q. R. Baron et al., Phys. Rev. Lett. 79, 2823 (1997)
[2] M. Saito et al., Sci. Rep. 7, 12558 (2017)
[2] S. Castrignano and J. Evers, arXiv:1805.01672 [quant-ph]

Q 22.5 Mon 17:15 S Gr. HS Maschb.

Spatial-temporal correlations of the light of an ion crystal

— •Stefan Richter[1], Sebastian Wolf[2], Andre Weber[3], Yury Prokazov[4], Evgeny Turbin[1], Joachim von Zanthier[1], and Ferdinand Schmidt-Kaler[2] — [1]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, Staudtstraße 1, 91058 Erlangen — [2]QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55128 Mainz, Germany — [3]LIN, Leibniz Institute for Neurobiology, Brenneckestraße 6, 39118 Magdeburg — [4]Photonscore GmbH, Brenneckestraße 6, 39118 Magdeburg

We measured first [1] and second order correlation functions of the light spontaneously emitted from a trapped, cold two-ion crystal for various detector positions in the temporal regime. Strikingly, the $g^{(2)}(\vec{x},\tau)$ signal shows bunching or antibunching for different observer positions [2]. Position sensitive Micro Channel Plate detectors developed for applications in fluorescence lifetime microscopy combining a high spatial resolution with temporal resolution. By using two detectors in correlation mode, it is possible to implement intensity interferometry with the light of a two-ion crystals. The spatial modulation of $g^{(2)}(\vec{x}_1,\vec{x}_2,\tau)$ was predicted in [3] and can now be measured by recording the corresponding two photon events for any time difference ΔT and corresponding positions $\vec{x}_1$ and $\vec{x}_2$. After the event stream is recorded, the correlations for arbitrary geometries can be reconstructed.

[1] S. Wolf et al., Phys. Rev. Lett. 116, 183002 (2016)
[2] S. Wolf et al., in preparation
[3] C. Skornia et al., Phys. Rev. A 64, 063801 (2001)

Q 22.6 Mon 17:30 S Gr. HS Maschb.

Macroscopicity of quantum mechanical superposition tests via hypothesis falsification

— •Björn Schrinski[1], Stefan Nimmrichter[2], Benjamin A. Stickler[1], and Klaus Hornberger[1] — [1]Fakultät für Physik, Universität Duisburg-Essen, Duisburg — [2]Centre For Quantum Technologies, National University of Singapore

We discuss a macroscopicity measure for quantum superposition tests [1] that quantifies how empirical evidence gathered in a superposition experiment falsifies macrorealistic modifications of quantum mechanics. So far, a quantitative assessment of the macroscopicity has only been formulated for experiments yielding a well-defined interference visibility. We extend this notion of macrosocopicity by establishing a general scheme based on Bayesian hypothesis testing in the parameter space characterizing the macrorealistic modifications. Based on this we assess the macroscopicity reached in recent quantum experiments, i.e. squeezed collective spin states [2], Leggett-Garg-tests [3], and the entanglement between micromechanical oscillators [4,5].

[1] S. Nimmrichter and K. Hornberger, Phys. Rev. Lett. 110, 160403 (2013)
[2] T. Berrada et al., Nat. Commun. 4, 2077 (2013)
[3] C. Robens et al., Phys. Rev. X 5, 011003 (2015)
[4] R. Riedinger et al., Nature 556, 473-477 (2018)
[5] C.F. Ockeloen-Korppi et al., Nature 556, 478-482 (2018)