Q 48: Quantum Optics II

Time: Thursday 10:30–12:30 Location: S Ex 04 E-Tech

Q 48.1 Thu 10:30 S Ex 04 E-Tech

The generation of counterpropagating photons with high-order orbital angular momentum in periodic waveguides — Elisabeth Wagner[1], Mikolaj Schmidt[2], Michael Steel[2], and •Polina Sharapova[1] — [1]Department of Physics and CeOPP, University of Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [2]Macquarie University Research Centre in Quantum Science and Technology (QSciTech), MQ Photonics Research Centre, Department of Physics and Astronomy, Macquarie University, New South Wales 2109, Australia

One of the promising and attractive sources of high-dimensional entanglement are orbital angular momentum (OAM) states of light. The (almost) unlimited value of orbital number leads to an unrestricted range of basis states, so-called OAM modes, which may enable larger-alphabet quantum key distribution and provide high-dimensional quantum information resistant to eavesdropping.

In this work we theoretically describe the generation of entangled counterpropagating photons with high-order OAM in a four-wave-mixing process which takes place in a periodic waveguide. Under the assumption of non-degenerate pumps, the signal and idler modes are phase matched by using of two helical grating structures with different periodic lengths. Manipulating of the frequency of the signal and idler photons with using of different helical waveguiede structures was shown. Creating of artificial intensity profiles of the generated photons was demonstrated.

Q 48.2 Thu 10:45 S Ex 04 E-Tech

Counter propagating OAM carrying light structures for novel optical trapping geometries — •Jan Stegemann, Valeriia Bobkova, Ramon Runde, and Cornelia Denz — University of Muenster, Correnstr. 2, 48149 Muenster, Germany

Within the last years, structuring light fields in a complex way has become a topic of particular interest for implementations in quantum optics, cold gases, information optics and for optomechanical particle trapping. Using fast, computer driven devices with high resolution, as e.g. liquid crystal-based spatial light modulators it is possible to tailor all degrees of freedom of light, namely amplitude, phase and polarization, and also allow for dynamic applications of structured light. A dynamic complex light modulation for optical trapping of special interest is the transfer of optical angular momentum (OAM) to matter since it allows for rotary motion. In this work, we suggest and demonstrate a novel OAM carrying beam structure, which contains two counter rotating transverse of OAM carrying Laguerre-Gaussian beams with different radii and investigate its properties for particle trapping at the example of nanoscale silica beads. Transfer of OAM induces their rotation. Thus, the forces, which induce the rotation of the particles caused by OAM, are pointing in the opposite directions for inner and outer rings. Experimentally, we employ advanced holographical beam shaping by phase-only spatial light modulation. We investigate the potential application of such a light structures for e.g. nanoscale particle sorting by size.

Q 48.3 Thu 11:00 S Ex 04 E-Tech

Optical Binding Energy: Contributions from Octupole Coupling — •A Salam — Department of Chemistry, Wake Forest University, Winston-Salem, NC 27109-7486, USA

Following a pioneering QED calculation by Thirunamachandran of the radiation-induced dispersion energy shift between a pair of electric dipole polarisable molecules [1], higher-order contributions dependent upon magnetic dipole and electric quadrupole couplings have been evaluated [2-4]. We account for electric octupole coupling and calculate, within QED theory [5], the optical binding energies between an electric dipole polarisable molecule and another that is either mixed dipole-octupole or pure octupole polarisable, and between two mixed dipole-octupole polarisable species. Additional leading order corrections to the dipolar shift are found that depend explicitly on the octupole weight-1 moment, as also occurs in resonance energy transfer [6], and pair [7,8] and three-body [9] dispersion interactions.

[1] T. Thirunamachandran, Mol. Phys. 40, 393 (1980). [2] A. Salam, Phys. Rev. A 73, 013406 (2006). [3] A. Salam, J. Chem. Phys. 124, 014302 (2006). [4] K. A. Forbes and D. L. Andrews, Phys. Rev. A 91, 053824 (2015). [5] A. Salam, Molecular Quantum Electrodynamics, Wiley, Hoboken, 2010. [6] A. Salam, J. Chem. Phys. 122, 044112 (2005). [7] A. Salam and T. Thirunamachandran, J. Chem. Phys. 104, 5094 (1996). [8] A. Salam, Mol. Phys.https://doi.org/10.1080/00268976.2018.1509143 [9] S. Y. Buhmann and A. Salam, Symmetry 10, 343 (2018).

Q 48.4 Thu 11:15 S Ex 04 E-Tech

A Stern-Gerlach separator of chiral enantiomers based on the Casimir-Polder potential — •Fumika Suzuki[1,2], Takamasa Momose[1], and Stefan Yoshi Buhmann[2,3] — [1]Department of Chemistry, University of British Columbia, Canada — [2]Institute of Physics, University of Freiburg, Germany — [3]Institute of Physics, University of Freiburg, Germany

We propose a method to separate enantiomers using parity violation in the Casimir-Polder potential between chiral mirrors and chiral molecules. The proposed setup involves a molecular beam composed of chiral molecules passing through a planar cavity consisting of two chiral mirrors. Enantiomers of opposite handedness are deflected differently due to a chiral dependence of the Casimir-Polder potential resulting in the separation of the enantiomers. Our setup provides an alternative experimental tool for enantiomer separation, as well as to shed light on the fundamental properties of the Casimir-Polder potential.

arXiv:1808.08642

Q 48.5 Thu 11:30 S Ex 04 E-Tech

Quantum-enhanced imaging — Marta Gilaberte Basset, Josué R. Léon Torres, and •Markus Gräfe — Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Jena, Germany

Nowadays, quantum physics turned from purely fundamental science to a research field with real-life applications. In particular, quantum photonics promises novel approaches for quantum enhanced-imaging. For instance "quantum imaging with undetected photons" was first implemented by the Zeilinger group in Vienna. Based on Mandels induced coherence, it becomes possible to image an object with light that never interacted at all with the object. It is worth to explicitly mentioned, thtat in stark contrast to Ghost imaging, here neither any coincidence detection is necessary nor any detection of the light that interacted with the object. By exploiting non-degenerated spontaneous parametric down conversion, photon pairs with large wavelength difference can be harnessed. The obvious advantage of this technique is that the wavelength of the idler photons can be tailored to match the interesting spectral range of the object (e.g. far IR, THz, deep UV). At the same time, the signal photons, which are actually detected, can stay in the VIS range where, e.g., Si-based detectors are optimized. We present a revised implementation of this imaging scheme. Our ansatz aims for robust, miniaturized and mobile realization, by employing a single crystal scheme. Besides the application for biomolecules, fundamental aspects like the influence of spatial correlation vs. momentum correlation on the imaging properties are under investigation.

Q 48.6 Thu 11:45 S Ex 04 E-Tech

Ghost imaging with broad-area superluminescent diodes — •Kai Hansmann and Reinhold Walser — Institut für Angewandte Physik, Technische Universität Darmstadt, Hochschulstr. 4a, 64289 Darmstadt

Ghost imaging is an imaging technique, which utilizes correlations between photons to produce images. The first realization of such an imaging scheme used quantum entangled photons from a parametric down conversion source [1]. Subsequently, it has been shown that ghost images can also be obtained through means of classical correlations [2].

Most classical ghost imaging setups use pseudo-thermal light, with correlation times in the ms-scale, for image generation. The recent development in two-photon-absorption detection enables correlation measurements for genuine thermal light in the fs-region. This makes it possible to utilize spectrally broadband light sources, like broad-area quantum-dot superluminescent diodes, to produce ghost images [3].

We investigate the temporal and spatial correlations of such light sources and compare theoretical descriptions with experimental results to confirm such sources can be used in ghost imaging.

[1] T.B. Pittmann et al., *Optical imaging by means of two-photon quantum entanglement*, Phys. Rev. A, **52**, R3429 (1995).
[2] R.S. Bennink et al., *"Two-Photon" coincidence imaging with a clas-*

sical source, Phys. Rev. Letters, **89(11)**, 113601 (2002).
[3] S. Hartmann et al., *A novel semiconductor-based, fully incoherent amplified spontaneous emission light source for ghost imaging*, Scietific Reports, **7** (2017)

Q 48.7 Thu 12:00 S Ex 04 E-Tech

Measuring the Electromagnetic Vacuum Using Nonlinear Crystals — •Frieder Lindel[1], Robert Bennett[1,2], and Stefan Yoshi Buhmann[1,2] — [1]Institute of Physics, University of Freiburg — [2]Freiburg Institute for Advanced Studies (FRIAS), Germany

When quantising the electromagnetic radiation field, one of the most fascinating consequences is the existence of fluctuations associated with the zero point energy. These vacuum fluctuations do not exist in the classical theory but still govern important observable processes in nature such as spontaneous emission, the Lamb shift or dispersion forces. All these processes show the existence of vacuum fluctuations only indirectly through their influence on other objects. Hence it was not until recent experiments that vacuum fluctuation have been observed directly for the first time using nonlinear crystals [1].

Using macroscopic quantum electrodynamics [2], we derive a general framework for the propagation of a laser field through a nonlinear crystal in the presence of vacuum fluctuation and hence for the description of these experiments. It does not include the paraxial approximation and it allows for general properties of the crystal, including absorption and dispersion, for reflective interfaces and for arbitrarily shaped input laser fields. Our results show that using nonlinear crystals one can in principle measure different properties of the vacuum fluctuations and hence analyse this fascinating state of the radiation field.

[1] C. Riek et al., Science **350**, 420 (2015)
[2] S. Y. Buhmann, *Dispersion Force I* (Springer, Berlin Heidelberg, 2012)

Q 48.8 Thu 12:15 S Ex 04 E-Tech

Über die duale Natur der Konstanz der Lichtgeschwindigkeit — •Helmut Hansen — Obere Scharr 5, 23896 Panten

Nirgends kommt der Widerspruch zwischen Teilchen- und Wellenbild mit solcher Schärfe zum Bewusstsein wie beim Licht. (Harry Paul) Ungeachtet dieses Widerspruches wissen wir jedoch, dass beide Bilder gleichermaßen notwendig sind, um das Wesen des Lichtes verstehen zu können. Keines der beiden Bilder reicht - für sich genommen - aus, um dieses Verstehen zu ermöglichen.

Angesichts der Erkenntnis, dass nur beide Bilder gemeinsam ein vollständiges Verstehen der Natur des Lichtes eröffnen, erscheint es als eine natürliche Annahme, dass auch die Konstanz ihrer Geschwindigkeit nur dann tiefer verstanden werden kann, wenn sie ebenfalls - entsprechend der allgemeinen Natur des Lichtes - sowohl dem Wellen- als auch dem Teilchenbild Rechnung trägt.

Es zeigt sich jedoch, dass die Konstanz der Lichtgeschwindigkeit, wie sie durch den Physiker Albert Einstein 1905 im Rahmen der Speziellen Relativitätstheorie als Prinzip in die Physik eingeführt worden ist, allein auf das Wellenbild Bezug nimmt, während das Teilchenbild keinerlei Berücksichtigung findet.

In dem Vortrag soll daher geschildert werden, ob und unter welchen Bedingungen Einsteins Theorie um dieses Teilchenbild komplettiert werden kann - und zu welchen Einsichten die Annahme eines solchen Bildes bezüglich der Konstanz der Lichtgeschwindigkeit führt.