Q 16: Quanteneffekte (Interferenz und Korrelationen)

Zeit: Montag 16:30–18:45 Raum: 5E

Q 16.1 Mo 16:30 5E

Quantum correlations between photons scattered by strongly pumped regular structures — •Mihai Macovei, Jörg Evers, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Heidelberg.

Interference light phenomena as well as photon correlations attract considerable attention due to their enormous potential applications [1].

As, at strong driving, the scattered light separates into distinct spectral bands, it is naturally to consider interference effects resulting from individual spectral lines. Here spectral photon correlations and cross-correlations of light scattered by a regular structure of strongly driven atoms are investigated [2]. In particular, we focus on spatial second-order intensity-intensity correlation functions in two- and multi-atom systems. We show that the cross-correlations between photons emitted in the spectral sidebands violate Cauchy-Schwartz inequalities, and that their emission ordering cannot be predicted, thus suggesting quantum entanglement between the photons.

[1] Roy J. Glauber, Rev. Mod. Phys. 78, 1267 (2006).
[2] M. Macovei, J. Evers, G.-x. Li, and C. H. Keitel, submitted; quant-ph/0606151.

Q 16.2 Mo 16:45 5E

Photon antibunching from a single qantum dot-microcavity system in the strong coupling regime — •Stephan Götzinger[1], David Press[1], Yoshihisa Yamamoto[1], Stephan Reitzenstein[2], Carolin Hofmann[2], Andreas Löffler[2], Martin Kamp[2], and Alfred Forchel[2] — [1]E. L. Ginzton Laboratory, Stanford University, Stanford California 94305, USA — [2]Technische Physik, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Strong coupling in solid state systems is of great interest for a variety of quantum information applications. Although it has been demonstrated in several quantum dot-microcavity configurations, it was not verified that the system had one and only one emitter.

In our experiment, we observe antibunching in the photons emitted from a strongly-coupled single quantum dot and pillar microcavity on resonance. When the quantum dot was spectrally detuned from the cavity mode, the cavity emission remained antibunched, and also anticorrelated from the quantum dot emission [1]. Resonant pumping of the selected quantum dot via an excited state enabled these observations by eliminating the background emitters that are usually coupled to the cavity. This device demonstrates an on-demand single-photon source operating in the strong coupling regime, with a Purcell factor of 61 and a quantum efficiency of 97%.

[1] D. Press et al., quant-ph/0609193.

Q 16.3 Mo 17:00 5E

Two-Photon Optics — •Daniel Schlenk[1] and Harald Weinfurter[1,2] — [1]Department für Physik der LMU, Schellingstraße 4/III, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching

The properties of imaging systems can be described by the point-spread function, which is determined by diffraction. A shorter wavelength results in a smaller diffraction pattern and therefore allows (in principle) a better resolution. It has been shown [1,2,3] that entangled n-photon states offer diffraction effects of the wavelength divided by n, if a n-photon detection is performed.

Here we use this feature to enhance the resolution of an imaging system. An image of the biphotons (signal and idler) created in a type I collinear down conversion is formed by a lens, and recorded by scanning a single mode fiber through the image plane and detecting pairs of photons (coincidences) behind a beam splitter with avalanche photodiodes. The point-spread function of the biphotons was by a factor of 1.7 smaller than the one of single photons.

[1] Ph. Walther et al., Nature 429, 158 (2004)
[2] M. W. Mitchell et al., Nature 429, 161 (2004)
[3] M. C. Teich and B. A. E. Saleh, Cesk. Cas. Fyz 47, 3-8 (1997)

Q 16.4 Mo 17:15 5E

Decoherence measurements and visualisation of the quantum-classical border using an electron interferometer — •Peter Sonnentag and Franz Hasselbach — Institut für Angewandte Physik, Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen

The incompatibility of the quantum mechanical superposition principle with our everyday experience of a ‘classical’ world has been a longstanding problem, nowadays being solved by the theory of decoherence. To investigate decoherence experimentally, we used free electrons interacting by Coulomb force with a truly macroscopic and theoretically nontrivial environment, the electron and phonon gas inside a semiconducting plate. The electron beam in a biprism interferometer is split into two parts which travel over the plate at the same, small height, but laterally separated. The induced currents inside the plate encounter ohmic resistance, leading to Joule heating which quantum-mechanically means a disturbance of the electron and phonon gas [1]. As this disturbance is different for the two paths of the beam electron, entanglement between beam electron and plate is formed, leading to a decrease in fringe visibility. The experiment also allows for an intuitive explanation in terms of which-path information.

Our results are quantitatively compared with different theoretical calculations. Furthermore, our modification of the original proposal [1] enabled us to directly visualize the quantum-classical border in single interferograms.

[1] J. R. Anglin, W. H. Zurek, Phys. Rev. **A** 55 (1997) 4041.

Q 16.5 Mo 17:30 5E

Photon statistics in the cooperative spontaneous emission — •Vasily V. Temnov and Ulrike Woggon — Experimentelle Physik IIb, Universität Dortmund, Otto-Hahn-Str. 4, 44221 Dortmund, Germany

The statistics of photons emitted by an incoherently pumped ensemble of N two-level systems coupled to a single damped cavity mode is investigated numerically by Monte-Carlo simulations [1]. Below the lasing threshold the second-order photon correlation function $g_2(\tau)$ shows a giant photon bunching with $g_2(0) >> 1$, strongly exceeding the bunching factor $g_2(0) \sim 2$ for thermal radiation. The dependence of bunching behavior on the homogeneous, inhomogeneous broadening and the number of emitters N in the atomic ensemble is investigated. The maximum bunching factor is found for N=2 and is explained by the cooperative evolution through the superradiant (Dicke) states [2] resulting in the emission of photon pairs.

[1] V.V. Temnov and U. Woggon, Phys. Rev. Lett. 95, 243602 (2005)
[2] R.H. Dicke, Phys. Rev. 93, 99 (1954)

Q 16.6 Mo 17:45 5E

Riemann-Zetafunktion als Autokorrelationsmessung eines Quantenzustands — •Rüdiger Mack und Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm

Die Faktorisierung von Zahlen mit Hilfe eines Quantencomputers, die Quantenkryptographie oder die Ähnlichkeit zwischen den statistischen Verteilungen der Energieniveaus eines Billards und den Nullstellen der Riemann-Zetafunktion weisen auf eine enge Verbindung zwischen Quantenmechanik und Zahlentheorie.

Die Entwicklung von ultrakurzen Laserpulsen und die Fortschritte der Ionenfallentechnologie haben die Möglichkeit eröffnet, die Zeitentwicklung von Wellenpaketen auch tatsächlich zu beobachten. Die Bewegung von Rydberg-Elektronen, die Schwerpunktsbewegung von Ionen in Paul-Fallen oder Atome in stehenden Wellen sind nur einige wenige Beispiele in denen Wellenpakete heute praktisch routinemäßig erzeugt und modifiziert werden. Zentraler Punkt all dieser Experimente ist die Messung der Autokorrelationsfunktion, die den zeitabhängigen Überlapp zwischen dem entwickelten Zustand und dem Anfangszustand des Quantensystems darstellt.

Durch die semiklassische Rydberg-Klein-Rees Inversionsmethode ist es möglich, ein Potential zu finden, dessen Energieeigenwerte logarithmisch verteilt sind. Die Autokorrelationsfunktion der Bewegung eines speziell präpariertes Wellenpacket in solch einem Potential ist die Riemann-Zetafunktion.

Q 16.7 Mo 18:00 5E

Electromagnetically Induced Transparency in an optical dipole trap — •Harald Kübler[1], Bernd Kaltenhäuser[1], Andreas Chromik[1], Jürgen Stuhler[2], Atac Imamoglu[3], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]Toptica Photonics AG, Lochhamer Schlag 19, 82166 Graefelfing, Germany — [3]Institut für Quantenelektronik, ETH Höggerberg, Wolfgang-Pauli-Str. 16, CH-8093 Zürich, Switzerland

Inhomogeneous magnetic fields are limiting the applications of electromagnetically induced transparency like slow light, quantum memory and quantum repeaters. As an optical dipole trap works independent of magnetic fields, we are able to apply a homogeneous field, which enables us to overcome these limitations. We use Rubidium atoms in a CO2-laser dipole trap, which is directly loaded from a magneto-optical trap.

We present EIT measurements with co propagating Raman laser beams showing absorptive and dispersive features with a width less than 10kHz.

Q 16.8 Mo 18:15 5E

Photon second order correlations vs. interference for a single atom in a half cavity — •Daniel Rotter[1], Francois Dubin[1], Manas Mukherhjee[1], Carlos Russo[1], Juergen Eschner[3], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Austria — [2]"Osterreichische Akademie der Wissenschaften, Austria — [3]Institute for Photonic Sciences (ICFO), Spain

We present experiments with a single Ba^{+} ion in a Paul trap, continuously laser-excited at Doppler cooling conditions. A part of the resonance fluorescence emitted by the ion is retro-reflected, thus leading to single-photon interference fringes of high contrast [1]. We investigate the second order photon correlations, varying the relative distance between the ion and the retro-reflecting mirror. We demonstrate that the measured correlations can be tuned smoothly from an antibunching minimum to a bunching-like maximum. Our analysis concerns the non-Markovian regime, i.e. the detection of photon pairs separated by large time intervals is modulated by single-photon interference. The field establishment in a half-cavity interferometer is revealed.

[1] J. Eschner et al., Nature **413**, 495 (2001).

Q 16.9 Mo 18:30 5E

Non-destructive measurements on the Cs clock transition: towards atomic spin squeezing — •Patrick Windpassinger, Daniel Oblak, Niels Kjaergaard, and Eugene Polzik — Niels Bohr Institute, Blegdamsvej 17, Copenhagen, Denmark

We use a nondestructive interferometric measurement of the clock states populations of an ensemble of laser-cooled and trapped Cs atoms to study the state evolution when the sample is subjected to light and microwave pulses.

The nondestructive character of the measurement allows us to follow online the quantum state of the system while it is being engineered. Here we show measurements of Rabi-oscillations on the clock transition which allow us to produce states on a generalized Bloch sphere. Ultimately, the dispersive character of the measurement leads to squeezing of the population number difference of the clock states and the sensitivity of the setup should allow us to observe squeezing as sub-projection noise.