Q 57: Quanteneffekte (QED / Lichtstreuung)

Zeit: Freitag 11:00–13:00 Raum: 2D

Q 57.1 Fr 11:00 2D

Jaynes-Cummings Ladder in Quantum-Dot Microcavities — •Lukas Schneebeli, Mackillo Kira und Stephan Koch — Department of Physics and Materials Sciences Center, Philipps-University Marburg, Renthof 5, 35032 Marburg, Germany

The quantum-optical hierarchy problem for dots in microcavities in the strong-coupling regime is analyzed using a cluster-expansion approach [1]. Resonance fluorescence spectra are discussed for several excitation conditions.

[1] M. Kira, S.W. Koch/Progress in Quantum Electronics 30 (2006), 155-296

Q 57.2 Fr 11:15 2D

From a single-photon emitter to a single ion laser — •Helena G. Barros[1,2], François Dubin[1], Carlos Russo[1,2], Andreas Stute[1,2], Piet O. Schmidt[1], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Universiät Innsbruck, Technikerstr. 25, A-6020 Innsbruck — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Otto-Hittmair-Platz 1, A-6020 Innsbruck

A single atom interacting with a single mode of a cavity is the building block of a laser from a fundamental point of view. In this work, we study a single $^{40}Ca^+$ ion coupled to a high finesse optical resonator. In particular, we evaluate the statistical properties of emitted cavity photons for different regimes of operation.

In the experiment, a drive laser together with an optical cavity excites an off-resonant Raman transition that connects the $S_{1/2}$ and $D_{3/2}$ levels of the $^{40}Ca^+$ ion. Population gets transferred from $S_{1/2}$ to $D_{3/2}$ while emitting a photon into the cavity. The excitation cycle is closed by a recycling laser that brings the atomic population back to the initial state $S_{1/2}$ via resonant excitation of the $P_{1/2}$ state. The photons leave the cavity at a rate of 54 kHz and are sent to a Hanbury-Brown & Twiss setup, where photon-photon correlations are measured. For weak recycling laser intensity, the system is operating as a single-photon source. In this regime, we can tune the statistics of the photon arrival times from sub-Poissonian to super-Poissonian behaviour. For faster recycling rates, we observe a single-atom laser at threshold. Different criteria for lasing in such a system are discussed.

Q 57.3 Fr 11:30 2D

Non-perturbative vacuum-polarization effects in proton-laser collisions — •Antonino Di Piazza, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Merging of laser photons can occur due to the polarization of vacuum in the collision of a high-energy proton beam and an intense laser field [1]. The photon merging rate is calculated by exactly accounting for the laser field which involves a highly non-perturbative dependence on the laser field parameters, namely its intensity and frequency. It is shown that even non-perturbative vacuum-polarization effects could be in principle experimentally measured by combining proton accelerators presently available with the next generation of table-top petawatt lasers.

[1] A. Di Piazza, K. Z. Hatsagortsyan, and C. H. Keitel, Phys. Rev. Lett. (in press). See also arXiv:0708.0475 [hep-ph].

Q 57.4 Fr 11:45 2D

Slow light in inhomogeneous and transverse magnetic fields — •Leon Karpa and Martin Weitz — Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn, Germany

Electromagnetically induced transparency allows for light transmission through dense atomic media by means of quantum interference of absorption amplitudes[1]. Media exhibiting electromagnetically induced transparency have interesting properties, such as very slow group velocities[2]. Associated with the slow light propagation are quasiparticles, so-called dark polaritons, which are mixtures of a photonic and an atomic contribution[3]. We have carried out experiments, where circularly polarized light traversing a rubidium gas cell under EIT conditions is deflected by an inhomogeneous magnetic field. The obtained results can be described in terms of dark state polaritons having a nonzero effective magnetic moment[4]. In subsequent experiments, electromagnetically induced transparency and slow light have also been observed with a transverse magnetic field orientation. Such a configuration can be used in further studies of the quasiparticle nature of slow light, as in a planned Aharonov-Casher experiment.

[1] See e.g.: E. Arimondo, Prog. Opt. **35**, 257 (1996).
[2] See e.g.: L. V. Hau et al. Nature (London) **397**, 594 (1999).
[3] M. Fleischhauer and M. D. Lukin, Phys. Rev. Lett. **84**, 5094 (2000).
[4] L. Karpa and M. Weitz, Nature Physics **2**, 332 (2006).

Q 57.5 Fr 12:00 2D

Nonlinear Effects in Pulse Propagation through Doppler-Broadened Closed-Loop Atomic Media — •Robert Fleischhaker and Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg

Nonlinear effects in pulse propagation through a medium consisting of four-level double-Λ-type systems are studied theoretically. We apply three continous-wave driving fields and a pulsed probe field such that they form a closed interaction loop. Due to the closed loop and the finite frequency width of the probe pulses the multiphoton resonance condition cannot be fulfilled, such that a time-dependent analysis is required. By identifying the different underlying physical processes we determine the parts of the solution relevant to calculate the linear and nonlinear response of the system. We find that the system can exhibit a strong intensity dependent refractive index with small absorption over a range of several natural linewidths. For a realistic example we include Doppler and pressure broadening and calculate the nonlinear selfphase modulation in a gas cell with Sodium vapor and Argon buffer gas. We find that a selfphase modulation of π is achieved after a propagation of few centimeters through the medium while the absorption in the corresponding spectral range is small.

Q 57.6 Fr 12:15 2D

Lossless Negative Refraction in An Active Dense Gas of Atoms — •Jörg Evers, Peter P. Orth, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Heidelberg

Negative index materials promise far-reaching applications in a broad range of areas from sub-wavelength imaging to antenna design. Since current designs are passive, however, negative index materials suffer from losses, prohibiting applications in particular towards optical frequencies. Here we predict lossless negative refraction in an active, i.e. amplifying, dense gas of atoms [1]. External laser fields are used to tune the medium's electromagnetic response and an additional weak pumping field controls the absorption properties. We identify metastable Neon as a suitable experimental candidate at infrared frequencies. Our approach provides negative refraction without losses as required for applications and offers the unique opportunity to study the controlled transition to active negative index material.

[1] P. P. Orth, J. Evers, and C. H. Keitel, arXiv:0711.0303

Q 57.7 Fr 12:30 2D

Controlled Coupling of Counterpropagating Whispering-Gallery Modes by a Single Rayleigh Scatterer: A Classical Problem in a Quantum Optical Light — Andrea Mazzei[1], •Stephan Götzinger[2], Leonardo Menezes[1], Gert Zumofen[2], Oliver Benson[1], and Vahid Sandoghdar[2] — [1]Institut für Physik, Humboldt-Universität zu Berlin, 10117 Berlin, Germany — [2]Laboratory of Physical Chemistry, ETH Zürich, CH-8093 Zürich, Switzerland

It is well established that the radiative properties of atoms can be strongly modified by coupling them to resonators. A corner stone of such modifications is the change of the photonic density of states caused by the boundary conditions imposed by a cavity. We investigate the analogy between this quantum optical scenario and the classical phenomenon of Rayleigh scattering in the presence of a high-finesse cavity.

We present experiments where a single subwavelength scatterer is used to examine and control the backscattering induced coupling between counterpropagating high-Q modes of a microsphere resonator [1]. Our measurements reveal the standing wave character of the resulting symmetric and antisymmetric eigenmodes, their unbalanced intensity distributions, and the coherent nature of their coupling. We discuss our findings and the underlying classical physics in the framework common to quantum optics and provide a particularly intuitive explanation of the central processes.

[1] A. Mazzei et al., Phys. Rev. Lett. 99, 173603 (2007).

Q 57.8 Fr 12:45 2D

Improving High-Finesse Cavities: Corrections beyond the Paraxial Approximation — •Martin Zeppenfeld, Michael Motsch, Pepijn W.H. Pinkse, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Increased atom-light interactions in a cavity due to many degenerate modes are of great interest for many experiments in quantum optics. While every second transverse mode of a confocal resonator is degenerate within the framework of the paraxial approximation, it is by no means to be expected that this remains the case when taking into account corrections to the paraxial approximation.

Spheroidal coordinates and the associated spheroidal wave functions can be used to construct a set of exact solutions to Maxwell's equations in free space which reduce to the Laguerre-Gaussian modes in the short wavelength limit. Using these solutions, we calculated first-order corrections to the resonance frequencies of modes in a two-mirror Fabry-Perot resonator. For a confocal resonator, the mode degeneracy is lifted. The calculations are supported by measurements with a high finesse cavity.