Q 1: Quantum Effects: Light Scattering and Propagation I / Interference and Correlations I

Time: Monday 14:00–16:00 Location: A 310

Q 1.1 Mo 14:00 A 310

Propagation of quantum fluctuations in EIT media — •Marc Bienert[1] and Pablo Barberis-Blostein[2] — [1]Theoretische Physik, Universität des Saarlandes, 66041 Saarbrücken — [2]Instituto de Investigaciones en Matemáticas Aplicadas y en Sistemas, Universidad Nacional Autónoma de México, 04510 México D.F., Mexico

We analyze the propagation of a pair of quantized fields inside a medium of three-level atoms in a Lambda configuration. We calculate the stationary quadrature noise spectrum of the field, in the case where the probe field is in a squeezed state and the atoms show electromagnetically induced transparency. We find an oscillatory transfer of the initial quantum properties between the probe and pump fields which is most strongly pronounced when both fields have comparable intensities. This implies that the quantum state measured after propagation can be completely different from the initial state, even though the mean values of the field are unaltered. We furthermore address the case where the two fields drive the Lambda system in two-photon resonance but detuned from the excited state and discuss the influence of the Doppler width on the propagation.

Q 1.2 Mo 14:15 A 310

Spinor Slow-Light with variable effective mass and anomalous localization — •Johannes Otterbach[1], Razmik Unanyan[1], Michael Fleischhauer[1], Julius Ruseckas[2], Viaceslav Kudriasov[2], and Gediminas Juzeliunas[2] — [1]Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institute of Theoretical Physics and Astronomy, Vilnius University, 01108 Vilnius, Lithuania

Recently, systems showing an effective Dirac-like time evolution, such as graphene, have acquired a lot of interest. We here show how to create light-matter quasi-particles, so-called dark-state polaritons (DSP), obeying an effective Dirac equation in 1D. These spinor-like objects posses an effective "speed of light", given by the group velocity of slow-light, which can be externally controlled and be made many orders of magnitude smaller than the vacuum speed of light. Furthermore the mass of these spinor slow-light polaritons (SSP) is adjustable in size and sign on a small length scales. It has been shown that a 1D model of random mass Dirac particles shows unusual correlations. For a random mass with vanishing mean value there exists a zero energy (mid-gap) state which decays according to a power-law. We use the freedom of our SSPs to create a spatially randomly varying mass and thus observe the creation of such unusual mid-gap states and discuss a possible experimental implementation and its limitations.

Q 1.3 Mo 14:30 A 310

Photons Walking the Line: Quantum Walk with adjustable Coin Operations — •Andreas Schreiber[1], Katiuscia Cassemiro[1], Vaclav Potocek[2], Aurel Gabris[2], Peter J. Mosley[1], Erika Andersson[3], Igor Jex[2], and Christine Silberhorn[1] — [1]MPI for the Science of Light, IQO Group, Erlangen, Germany. — [2]Department of Physics, FNSPE, Czech Technical University in Prague, Praha, Czech Republic. — [3]SUPA, School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, United Kingdom.

A major topic in the field of quantum information is the development and investigation of quantum algorithms. Recent works have shown that the quantum analogue of a well known model in natural science, namely random walks, constitute a universal platform for performing computation.

Towards this application we present the first robust implementation of a coined quantum walk over five steps using only passive optical elements. By employing a fiber network loop we keep the amount of required resources constant as the walker's position Hilbert space is increased. We observed a non-Gaussian distribution of the walker's final position, thus characterizing a faster spread of the photon wave-packet in comparison to the classical random walk. The walk is realized for different coin settings and initial states, which opens the way for the implementation of a quantum walk-based search algorithm.

Q 1.4 Mo 14:45 A 310

Phase dependent dynamics in a loop of microresonators — •Sandra Isabelle Schmid, Keyu Xia, and Jörg Evers — Max-Planck Institut für Kernphysik, Heidelberg, Germany

In recent years, chains of coupled microcavities have received considerable attention [1]. Here, we study arrays of microresonators which are arranged in a loop configuration [2]. This allows photons to travel along closed loop pathways and thereby gives rise to quantum interference between different evolution pathways in the microresonators [3]. As our model system, we consider three whispering gallery mode microresonators which are coupled via their evanescent fields. In addition, one of the resonators is coupled to a tapered fiber, and we use the transmitted and reflected light as observables. In particular, we study the interplay of the different pathways a photon can take in scattering from the input to an output mode of the fiber. We show that due to the loop configuration, the optical properties of the resonator structure become dependent on the phases of the complex coupling constants describing the coupling of the different resonators. Finally, possible applications are discussed.

[1] M. A. Popovic et al., Optics Express **14**, 3 (2006); M. Hammer, Opt. Quantum Electron., **40**, 821 (2008)
[2] M. A. Popovic et al., Conference on lasers and electro optics, **1-9**, 1600 (2008)
[3] M. Mahmoudi and J. Evers, Phys. Rev. A **74**, 063827 (2006)

Q 1.5 Mo 15:00 A 310

Photon crystallization in driven dissipative arrays of nonlinear optical resonators — •Michael Hartmann — Technische Universität München, Physik Department, 85748 Garching, Germany

Possibilities to observe strong correlations of interacting polaritons have received considerable attention in recent years [1]. Early works have mostly addressed equilibrium phenomena that have previously been observed in other realizations. For polaritons, it is however experimentally more feasible to study driven dissipative systems. I will discuss the steady states of such systems and their characteristic correlations. Interestingly, these show spatial density-density correlations, which indicate that the polaritons crystallize despite being injected by a coherent light source and damped by the environment.

[1] Hartmann, Brandão and Plenio, Laser & Photon. Rev. **2**, 527556 (2008).

Q 1.6 Mo 15:15 A 310

Photon-number selective group delay in cavity induced transparency — •Gor Nikoghosyan and Michael Fleischhauer — Department of Physics and research center OPTIMAS, University of Kaiserslautern, Germany

Electromagnetically induced transparency (EIT) is an interference effect that results in a dramatic reduction of the group velocity of a propagating weak probe pulse accompanied by vanishing absorption. The group velocity of the probe depends on the intensity of a coupling field which has to be strong and thus it is usually a classical laser beam. In the present work we propose a scheme where the coupling field is substituted by a quantized cavity field. The adiabatic transfer of probe photons to the cavity mode modifies the refractive index of medium in a similar manner as the coupling field does in the case of ordinary EIT. We show that our system can be used to generate and control quantum pulses of light with very high accuracy. In particular it can be used to spatially separate the single photon from higher photon-number components of a few photon probe pulse and thus to create an optical Fock-state filter or a deterministic single-photon source.

Q 1.7 Mo 15:30 A 310

Phase-controlled pulse propagation in media with cross coupling of electric and magnetic probe field component — •Robert Fleischhaker and Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Recently, quantum optical systems interacting with both the electric and the magnetic component of a probe beam have received considerable interest as a candidate for materials with a negative index of refraction [1]. In addition to a large medium density, a cross coupling of electric and magnetic field component was proposed to enhance the inherently weak magnetic response of the medium [2].

Here, we discuss light propagation dynamics in media with such a cross coupling independent of negative refraction and at much lower densities [3]. First, we derive and solve the wave equations for a probe pulse for general medium response coefficients. Then, we apply these results to a specific atomic example system in which cross couplings are induced by additional control fields. We show that the cross-couplings render the propagation dynamics sensitive to the relative phase of the additional fields, and this phase dependence enables one to control the pulse during its propagation through the medium. Our results demonstrate that the magnetic field component of a probe beam can crucially influence the system dynamics already at experimentally accessible parameter ranges in dilute vapors.

[1] J. Kästel et al., Phys. Rev. Lett. **99**, 073602 (2007)
[2] J. B. Pendry, Science **306**, 1353 (2004)
[3] R. Fleischhaker and J. Evers, Phys. Rev. A **80**, 063816 (2009)

Q 1.8 Mo 15:45 A 310

Thermalisierung eines zweidimensionalen Photonengases in einem optischen Hoch-Finesse-Resonator — •Jan Klärs, Frank Vewinger und Martin Weitz — Institut für Angewandte Physik der Universität Bonn, Weglerstraße 8, D-53115 Bonn

Bose-Einstein-Kondensation, die makroskopische Besetzung des energetischen Grundzustands in einem Bose-Gas unterhalb einer kritischen Temperatur, wurde in verschiedenen physikalischen Systemen realisiert. Obwohl die Plank'sche Hohlraumstrahlung das vielleicht bekannteste Bose-Gas ist, stellt sie einen Ausnahmefall dar, da sie keine Bose-Einstein-Kondensation bei niedrigen Temperaturen zeigt. Anstatt den energetisch niedrigsten Zustand zu besetzen, gehen die Photonen stattdessen in den Wänden verloren, da für sie keine Teilchenzahlerhaltung gilt (verschwindendes chemisches Potential).

Wir berichten hier von der Realisierung eines zweidimensionalen Photonengases in einem optischen Hoch-Finesse-Mikroresonator, das eine thermische Besetzung transversaler Moden bei gleichzeitig frei einstellbarem chemischen Potential zeigt. Die Thermalisierung wird durch mehrfache resonante Streuung der Photonen an Farbstoffmolekülen innerhalb des Resonators erreicht, dessen Geometrie zusätzlich für eine nicht-verschwindende (effektive) Photonenmasse und ein Fallenpotential sorgt - notwendige Vorraussetzungen für eine Bose-Einstein-Kondensation von Photonen. Als ein Beispiel für die ungewöhnlichen Systemeigenschaften zeigen wir, dass der Thermalierungsprozess zu einer Minimierung der potentiellen Energie der Photonen und damit zu einer Konzentrierung im Mittelpunkt des Fallenpotentials führt.