SYKM 1: Lichtausbreitung in kohärent präparierten Medien I

Zeit: Donnerstag 14:00–16:00 Raum: VMP 6 HS-D

Hauptvortrag SYKM 1.1 Do 14:00 VMP 6 HS-D

Diffusion of Slow and Stored Light in Vapor — •N. Davidson[1], O. Firstenberg[2], M. Shuker[2], R. Pugatch[1], and A. Ron[2] — [1]Department of Physics of Complex Systems, Weizmann Institute of Science, Israel — [2]Physics Department, Technion, Israel

Electromagnetically induced transparency (EIT) occurs when a pump field and a probe field, excite two atomic levels to a common upper level, creating a coherent superposition that reduces the absorption of the probe. Due to the narrow transparency line, the group-velocity of the probe pulse is remarkably small. Moreover, if the pump is shut off during the slow probe propagation, the probe is stored in the atomic ensemble, to be retrieved upon reopening the pump.

We present an extensive theoretical and experimental study of the effect of thermal atomic motion on EIT. Due to frequent collisions with the much denser noble buffer gas, the atomic motion is diffusive, which leads to various interesting phenomena. A direct consequence of the diffusion of atoms is the diffusion of a stored image throughout the storage duration [1]. The complex amplitude undergoes diffusion and therefore interference occurs. Specifically, high-order Gaussian transverse-modes are topologically stable and self-similar upon storage [2]. During the slow propagation of the probe in the medium, the combined light-matter excitation exhibits diffusion and diffusion-like behavior.

We also study motional broadening and narrowing mechanisms on the EIT spectra, such as Doppler broadening, Dicke narrowing, and Ramsey narrowing [3]. We present spectroscopic measurements which manifest these mechanisms. Due to its quadratic dependence on the transverse wave-numbers, the Dicke-narrowing term is also responsible for many interesting spatial effects. Most intriguing is a regime where the Dicke term dominates the dispersion, and may be utilized to cancel the paraxial optical diffraction [4], to manipulate the position of a localized probe beam, and to induce effective electric and magnetic fields that act on the probe's envelope. Finally, we present a regime where the EIT complex spectrum is universal, equals to the Laplace transform of the recurrence probability or a random walker, and depends only on the dimensionality of space [5].

[1] M. Shuker, O. Firstenberg, R. Pugatch, A. Ron, and N. Davidson, PRL 100, 223601 (2008). [2] R. Pugatch, M. Shuker, O. Firstenberg, A. Ron, and N. Davidson, PRL 98, 203601 (2007). [3] O. Firstenberg, M. Shuker, R. Pugatch, D. R. Fredkin, N. Davidson, and A. Ron, PRA 77, 043830 (2008). [4] O. Firstenberg, M. Shuker, N. Davidson, and A. Ron, PRL, in press. [5] R. Pugatch, O. Firstenberg, M. Shuker, and N. Davidson, submitted to PRL.

Hauptvortrag SYKM 1.2 Do 14:30 VMP 6 HS-D

EIT and light storage in a Mott insulator — •Stefan Kuhr[1], Ute Schnorrberger[1], Stefan Trotzky[1], Jeff Thompson[1], Rami Pugatch[2], Nir Davidson[2], and Immanuel Bloch[1] — [1]ohannes-Gutenberg Universität, Institut für Physik, Staudingerweg 7, 55128*Mainz, Germany — [2]Department of Physics of Complex Systems,* Weizmann Institute of Science, Rehovot 76100,* Israel

We experimentally demonstrate electromagnetically induced transparency and light storage with ultracold ^{87}Rb atoms in an optical lattice. Atoms in a Mott insulator (MI) state in a deep optical lattice with unity filling experience no collisional interaction and almost no diffusion. This results in ultralong light storage times of about 200 ms, to our knowledge the longest ever achieved in ultracold atomic samples. Using the differential light shift of a spatially inhomogeneous far detuned light field we imprint a "phase gradient"across the atomic sample, resulting in controlled angular redirection of the retrieved light pulse.

As an alternative to storing light pulses, one can directly create an atomic superposition state by applying an rf+microwave pulse. A subsequent turning-on of the coupling field leads to a creation of a probe field. Using this method we investigated the dependence of the coherence time as a function of dimensionality and lattice depth and monitored the evolution of the coherence between singly and doubly occupied sites in the MI.

Hauptvortrag SYKM 1.3 Do 15:00 VMP 6 HS-D

Light interactions in Rydberg ensembles — •Charles Adams — Department of Physics, Durham University, UK

Atoms in highly excited Rydberg states exhibit strong interactions over distance scales of a few microns. In our work we exploit the enhanced sensitivity of Rydberg states to control the propagation of light through an atomic ensemble. For example, if the atoms are prepared in a dark state corresponding to a superposition of ground and Rydberg states [1] the medium acquires a giant electro-optic effect many orders of magnitude larger than other systems [2]. In ultra-cold ensembles we have observed Rydberg dark states with linewidths of 200 kHz and have demonstrated the on-set of interactions effects as the Rydberg population is increased [3]. Our eventual goal is to exploit this interaction induced non-linearity to control pulse propagation at the single photon level.

[1] AK Mohapatra et al. Phys. Rev. Lett. 98, 113003 (2007). [2] AK Mohapatra et al. Nature Phys. 4, 890 (2008). [3] KJ Weatherill et al. J. Phys. B 41, 201002 (2008).

SYKM 1.4 Do 15:30 VMP 6 HS-D

Resonance beating of light stored using atomic spinor polaritons — •Leon Karpa, Frank Vewinger, and Martin weitz — Institut für Angewandte Physik der Universitsität Bonn, Wegelerstr. 8, 53115 Bonn, Germany

Electromagnetically induced transparency (EIT) is a quantum interference effect that allows for the transmission of light through an otherwise opaque atomic medium [1]. Media exhibiting EIT have remarkable properties, as very low group velocities [2]. Associated with a slow light propagation are quasiparticles, the so-called dark polaritons, which propagate through the medium with the speed of the group velocity [3]. We investigate the storage of light in atomic rubidium vapor using a multilevel-tripod scheme. In the system, two collective dark polariton modes exist, forming an effective spinor quasiparticle. Storage of light is performed by dynamically reducing the optical group velocity to zero. After releasing the stored pulse, a beating of the two reaccelerated optical modes is monitored. The observed beating signal oscillates at an atomic transition frequency, opening the way to novel quantum limited measurements of atomic resonance frequencies and quantum switches [4].

[1] See e.g.: M. Fleischhauer, A. Imamoglu, and J. P. Marangos, Rev. Mod. Phys. 77, 633 (2005).

[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, F. Vewinger, and M. Weitz, Phys. Rev. Lett. 101, 170406 (2008).

SYKM 1.5 Do 15:45 VMP 6 HS-D

Dirac dynamics of stationary light in 1D: Klein tunneling and Zitterbewegung — •Johannes Otterbach, Razmik Unanyan, and Michael Fleischhauer — Fachbereich Physik, Univ. of Kaiserslautern, 67663 Kaiserslautern, Germany

In order to create nonlinear interactions between single photons in an atomic ensemble it is necessary to have long interaction times and high electric fields per photon. One possibility to achieve this is to use stationary light in setups exhibiting electromagnetically induced transparency (EIT). We analyze the ultimate limit of compression of stationary photonic excitations and show that at pulse lengths as small as the absorption length the probe pulses have to be described by an effective Dirac equation for a two-component spinor. The effective speed of light and the effective mass entering this equation can be controlled externally and can be made many orders of magnitude smaller than the corresponding quantities for graphene, fermionic atoms and electrons. Consequently relativistic behavior can be observed at much larger length scales and much lower energies. As a result of this the compression limit is given by the corresponding Compton length and can be macroscopic. We discuss certain predictions of the Dirac theory as e.g. Klein tunneling and the Zitterbewegung. A comparison between the effective theory and exact numerical simulations is made.