Q 46: Quanteneffekte: Lichtstreuung und Ausbreitung

Zeit: Donnerstag 10:30–12:15 Raum: VMP 6 HS-E

Q 46.1 Do 10:30 VMP 6 HS-E

Negative refraction in atomic two-component media — •Bastian Jungnitsch[1,2] and Jörg Evers[2] — [1]Institut für Quantenoptik und Quanteninformation, Technikerstraße 21a, 6020 Innsbruck, Austria — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

We discuss the feasibility of negative refraction at optical wavelengths and low absorption in gases consisting of two species of atoms. In such a setup, one species contributes the electric response, and the other one the magnetic response, respectively.

To obtain a negative refractive index, both responses must be large. We therefore optimize the typically small magnetic susceptibility in different systems. Specifically, we investigate a mechanism in closed-loop systems that enhances the magnetic response by a scattering of the electric probe field component into the magnetic probe transition. In addition to a parametric enhancement by a factor of α^{-1} [1], where α is the fine structure constant, we find a strong non-parametric enhancement of the response [2].

Based on these findings, we calculate the refractive index for several combinations of two realistic level schemes. Since we consider active media, potential instabilities of the probe field are also addressed. As the main result, we obtain high negative refractive indices at vanishing absorption for several candidate systems.

[1] J. B. Pendry, Science 306, 1353 (2004).
[2] B. Jungnitsch and J. Evers, Phys. Rev. A 78, 043817 (2008)

Q 46.2 Do 10:45 VMP 6 HS-E

Sub-wavelength position measurements with running wave driving fields — •Jörg Evers[1] and Sajid Qamar[1,2] — [1]MPI für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Centre for Quantum Physics, COMSATS Institute of Information Technology, Islamabad, Pakistan

Spatial precision measurements are of interest both for a number of important applications and from a fundamental point of view. Applications arise, e.g., in life sciences, and more basic questions are related, e.g., to the uncertainty principle. A wide class of proposals for position measurements with sub-wavelength precision based on quantum optical ideas makes use of standing wave light fields. The standing wave acts as a ruler for the position measurement, and at the same time forms a spatial intensity pattern that can encode position information via a intensity-dependent dynamics of the atom.

Here, we discuss a setup for sub-wavelength position measumerents of quantum particles which in contrast to previous work operates with running-wave laser fields. The position is encoded in the phase of the applied fields rather than in the spatially modulated intensity of a standing wave. This is achieved by deliberately breaking the phase matching condition usually assumed in related setups. Due to the running fields, cases where the atom remains undetected since it is close to a node of the standing wave field are avoided. Reversing the directions of the driving laser fields allows to switch between different magnification levels.

Q 46.3 Do 11:00 VMP 6 HS-E

Effective magnetic fields for stationary Dark-State Polaritons — •Johannes Otterbach[1], Razmik Unanyan[1], Julius Ruseckas[2], Gediminas Juzeliunas[2], and Michael Fleischhauer[1] — [1]Fachbereich Physik, Technische Universität Kaiserslautern, Germany — [2]Inst. of Theoretical Physics and Astronomy of Vilnius University, 01108 Vilnius, Lithuania

Recently there is a growing interest in creating effective magnetic fields for neutral particles to study many-body phenomena in the absence of Coulomb interactions. Here we propose a mechanism to create effective magnetic fields for light-matter quasi particles, so-called dark-state polaritons (DSP). These particles arise in the coherent Raman interaction of a weak probe field with an ensemble of Λ-type atoms driven by a strong classical control field. Upon misaligning these beams an effective magnetic field is created. Albeit the achievable magnetic field per particle is not higher than in cold atom gases, DSP have a number of advantages. By using counter propagating control beams stationary DSPs are created. At large pulse lengths these particles behave as bosonic Schrödinger particles with a variable mass which can be controlled externally. Thus their effective temperature can easily be controlled and be made very small. Finally a confinement to lower dimensions is readily done by wave-guide or resonator techniques. These effective fields can be used to study a variety of single- and many-particle effects as e.g. Lorentz forces for neutral particles, anyonic statistics, vortex lattices and the bosonic analogue of the fractional quantum Hall effect (FQHE).

Q 46.4 Do 11:15 VMP 6 HS-E

Dynamical control of pulse propagation in electromagnetically induced transparency — •Martin Kiffner[1,2] and Tarak Nath Dey[2,3] — [1]Physik-Department, Technische Universität München, D-85748 Garching, Germany — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [3]Indian Institute of Technology, Guwahati, Guwahati- 781 039, Assam, India

The phenomenon of electromagnetically induced transparency (EIT) gives rise to counterintuitive effects like the slowing and stopping of light and is of great importance, e.g., for the fields of quantum information theory and nonlinear optics [1].

In contrast to the generic EIT setup, we consider a phase modulated control field and demonstrate that this alteration gives rise to periodic changes of the transparency window in frequency space. This feature enables the propagation of probe pulses with disjoint frequency spectra at different times, and thus enhances the potential of EIT media for the purpose of signal processing. For the explanation of our results, we put forward the concept of time-dependent susceptibilites that yields qualitative as well as quantitative agreement with the numerical integration of Maxwell-Bloch equations. Our theoretical model also applies to other systems.

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

Q 46.5 Do 11:30 VMP 6 HS-E

Coherent Spin Manipulation in Diamond — •Eric Kessler, Géza Giedke, and Juan Ignacio Cirac — Max-Planck-Institut für Quantenoptik, Garching, Germany

Diamond, as a pure and clean material, seems to be an attractive playground for solid state quantum computation. For instance, the carbon nuclear spins display extremely long decoherence times even at room temperature due to their weak mutual interaction. On the other hand however, single nuclear spins are hardly addressable individually.

This drawback can be overcome by the use of intentionally implanted defects like the NV (Nitrogen-Vacancy) Center. Those impurities bring physical richness into the system and open the possibility of coherent manipulation of the nuclear spin system, as they both interact strongly with nuclear spins and are easily accessible via optical and microwave fields.

We present a method to simulate different classes of Hamiltonians in the nuclear Hilbert space using fast microwave and laser pulses resonant to the NV Center's transitions.

Q 46.6 Do 11:45 VMP 6 HS-E

New approach to multiple scattering of intense laser light by cold atoms — •Tobias Geiger[1,2], Thomas Wellens[1], Vyacheslav Shatokhin[2], and Andreas Buchleitner[1] — [1]Institute of Physics, University of Freiburg, Hermann-Herder- Str. 13, 79104 Freiburg, Germany — [2]Stepanov Institute of Physics, National Academy of Sciences, Nezavisimosti Avenue 68, 220072 Minsk, Belarus

We present two different methods to calculate the spectrum of laser light multiply scattered between cold atoms. The first approach uses the well-known master equation for the time evolution of the reduced atomic density matrix. Due to the exponentially large Hilbert space, this approach is limited to calculations with only a small number of atoms. Therefore, we would like to present a second approach, based on the solutions of the Bloch equations for each individual atom, which are linked to each other in a self-consistent way. We will prove the equivalence between both approaches for the case of two distant atoms, and discuss the possibility of spectral calculations for a disordered sample of many atoms.

Q 46.7 Do 12:00 VMP 6 HS-E

Four-wave mixing enhanced white-light cavity — •Jörg Evers and Robert Fleischhaker — MPI für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

In an optical cavity, the bandwidth of supported frequencies and the intensity buildup are inversely proportional. Thus, higher buildup is only possible at the cost of a reduced available frequency range, and this limits possible applications such as in gravitational wave detection. To overcome this limitation, the concept of a white-light cavity was developed, in which the bandwidth of the cavity is enhanced via a medium with negative dispersion inside the cavity. The negative dispersion leads to a frequency-dependent phase compensation that effectively renders a wider range of frequencies resonant with the cavity [1].

Here, we discuss a white-light cavity medium based on four-level atoms in double-Λ configuration. This configuration is known to exhibit resonantly enhanced four-wave mixing [2], such that the spatiotemporal dynamics inside the medium becomes relevant. We perform a full simulation of the propagation of all fields, and find that the probe field dispersion is in addition changed by a coherent field which is generated within the medium via four-wave mixing. Counterintuitively, this in-medium dynamics leads to a further enhancement of the cavity bandwidth [3].

[1] A. Wicht et al., Opt. Commun. 134, 431 (1997)
[2] M. Jain et al., Phys. Rev. Lett. 77, 4326 (1996)
[3] R. Fleischhaker and J. Evers, Phys Rev. A 78, 051802(R) (2008)