Q 61: Quanteneffekte: Lichtstreuung

Time: Friday 10:30–12:30 Location: V7.01

Q 61.1 Fri 10:30 V7.01

Excitation of a single atom with a temporally shaped light pulses — Syed Abdullah Aljunid[1], Hoang Lan Dao[2], •Gleb Maslennikov[1], Yimin Wang[1], Valerio Scarani[1,3], and Christian Kurtsiefer[1,3] — [1]Centre for Quantum Technlogies, National University of Singapore — [2]University of Twente — [3]Department of Physics, National University of Singapore

We investigate the interaction between a single atom and optical pulses with a controlled temporal envelope. By switching the temporal shape from rising exponential to square profile, we show that the rising exponential envelope leads to higher excitation probability for a fixed photon number. The atomic transition saturates for ≈ 100 photons in a pulse. Rabi oscillations with 100 MHz frequency are visible in detected fluorescence for excitations powers of ≈ 1300 photons in a 15 ns pulse.

[1] Yimin Wang et al., Phys. Rev. A. **83** 063842 (2011)
[2] M. Stobińska et al., EPL 86 14007 (2009)
[3] I. Gerhardt et al., Phys. Rev. A **79** 011402(R) (2009)

Q 61.2 Fri 10:45 V7.01

Enhanced optical data storage up to 1 second by EIT in a doped solid — •Georg Heinze, Christian Hubrich, Simon Mieth, and Thomas Halfmann — Institut für Angewandte Physik, Technische Universität Darmstadt, Hochschulstr. 6, 64289 Darmstadt

Efficient and long-time storage of coherent optical data is one key ingredient towards future quantum information processing. Several approaches to implement quantum memories have been proposed and investigated. Among these, the storage of light in atomic coherences, driven by electromagnetically induced transparency (EIT) is a prominent example. But, similar to other coherent interactions also EIT suffers from decoherence. This is a major obstacle for quantum memories and limits both efficiency as well as storage time considerably.

The talk reports on the storage of light pulses and images by EIT in a rare-earth-ion doped solid (Pr^{3+}:Y_2SiO_5) – approaching storage times in the regime of 1 second. The long storage times are possible by a combination of powerful approaches: First, we apply well-defined static magnetic fields to minimize the perturbation of atomic coherences (which serve to store the optical information) from external spin fluctuations. Second, we increase coherence times by specific RF pulse sequences, which allow for efficient dynamic decoupling of the atomic coherences from the environment. Third, we apply feedback-controlled pulse shaping and evolutionary algorithms to automatically determine optimal preparation pulse sequences in the complex level system. The unique combination of these techniques enhances both the efficiency as well as the storage times by orders of magnitude.

Q 61.3 Fri 11:00 V7.01

Counting statistics of collective photon transmissions — Malte Vogl, •Gernot Schaller, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin, Berlin

We theoretically study cooperative effects in the steady-state transmission of photons through a medium of N radiators. Using methods from quantum transport, we find a cross-over in scaling from N to N^2 in the current and to even higher powers of N in the higher cumulants of the photon counting statistics as a function of the tunable source occupation. The effect should be observable for atoms confined within a nano-cell with a pumped optical cavity as photon source.

M. Vogl, G. Schaller, and T. Brandes, Annals of Physics **326**, 2827 (2011).

Q 61.4 Fri 11:15 V7.01

Multiple Scattering of Intense Laser Light by Cold Atoms — •Tobias Binninger, Thomas Wellens, Vyacheslav Shatokhin, and Andreas Buchleitner — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

An accurate description of multiple scattering of intense laser light by a cloud of cold atoms requires a combined treatment of the nonlinear atomic response to strong laser light and of the propagation of the scattered light fields through the atomic medium, since the latter determines the strength of the nonlinear saturation for atoms deep inside the bulk. For this purpose, we use a combination of two different methods: a 'pump-probe' approach previously developed in our group for double scattering of laser light by two two-level atoms [1], and a diagrammatic theory for multiple scattering by classical nonlinear scatterers [2]. Thereby, we find a set of equations describing the spatial distribution and spectra of the diffusing part of the light intensity in the bulk of the medium after average over the disordered positions of the scatterers. We present results of numerical simulations for the solutions of this set of equations.

[1] T. Wellens, T. Geiger, V. Shatokhin, and A. Buchleitner, Phys. Rev. A **82**, 013832 (2010)
[2] T. Wellens and B. Grémaud, Phys. Rev. Lett. **100**, 033902 (2008).

Q 61.5 Fri 11:30 V7.01

A quantum electrodynamical description of x-ray phase-contrast imaging — •Jan Malte Slowik[1,2] and Robin Santra[1,2] — [1]Center for Free-Electron Laser Science, DESY, Hamburg, Germany — [2]Department of Physics, University of Hamburg, Hamburg, Germany

X-ray phase-contrast imaging is nowadays a widely used imaging technique for weakly absorbing samples, for example biological and medical tissues. So far x-ray phase-contrast imaging has been described by classical diffraction theory.

In this work we aim at a quantum electrodynamical understanding of x-ray phase-contrast imaging. We will show that electronically elastic scattering of the quantized electromagnetic field can fully account for the classical description of phase-contrast imaging. Since phase-contrast is a near-field phenomenon, the standard treatment of scattering within quantum electrodynamics has to be modified to take the position of the detector into account. Thus a careful choice of the observable is essential.

Q 61.6 Fri 11:45 V7.01

The pump-probe approach to coherent backscattering of intense laser light by atoms with degenerate energy levels — •Ralf Blattmann — Physiklisches Institut Freiburg

Recently, we proposed the pump-probe approach to coherent backscattering (CBS) of laser light by cold two level atoms [1,2]. This approach allows to express the double scattering CBS signal in terms of single-atom responses and is a promising tool for a multiple scattering theory of intense laser light from cold atoms. In this talk we will present the generalization of this approach for two atoms with degenerate energy levels and show numerical results for two different atomic transitions.

[1] T.Wellens et al. PRA 81, 013832 (2010)
[2] T.Geiger et al. Photon.Nanostruct. 8, 244 (2010)

Q 61.7 Fri 12:00 V7.01

Quantum holograms based on the Faraday interaction. Spontaneous emission in such systems. — •Denis Vasilyev and Klemens Hammerer — Leibniz Universität Hannover, 30167 Hannover, Germany

We present a scheme for parallel spatially multimode quantum memory for light based on Faraday interaction of light with atoms. The medium for the hologram is a spatially extended ensemble of cold spin-polarized atoms. A quantum hologram capable of storing entangled images can become an important ingredient in quantum information processing and quantum imaging.

The Faraday interaction has been recognized as a valuable tool in the light to atoms memory mapping for atomic ensembles at room temperature. Much progress has been made using a spin 1/2 model for the atoms to describe the coherent transfer of information between the two parties. Real atoms have a complicated level structure which alters the dynamical equations and decay rates. In this work we take into account spontaneous emission and give the full level structure corrections for real atoms.

Q 61.8 Fri 12:15 V7.01

Direct detection of n-particle atomic correlations via light scattering — Luling Jin[1,2], Mihai Macovei[1], and •Jörg Evers[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Department of Physics, Northwest University, Xi'an, China

The creation and direct detection of n-particle atomic correlations in ensembles of atoms is discussed. For this, we study an ensemble of laser-driven atoms in which either a dipole-dipole or a Rydberg-Rydberg interaction leads to the formation of correlations between the internal degrees of freedom of the atom. We show that light scattering can be used to imprint information about these correlations onto light, and reveal how this information can be extracted from the statistical properties of the scattered light. As main result we find that observation in certain detection directions allows to directly and individually measure n-particle atomic correlations. Complementary, we discuss a method to experimentally determine the interesting detection positions.