Q 10 Quanteneffekte I

Zeit: Montag 14:00–16:00 Raum: HII

Q 10.1 Mo 14:00 HII

Can fractal fluctuations be observed in atom-optics kicked rotor experiments? — •Andrea Tomadin[1,2] and Sandro Wimberger[2] — [1]Scuola Normale Superiore, Piazza dei Cavalieri, I-56100 Pisa — [2]Dipartimento di Fisica E. Fermi, Università degli Studi di Pisa, Largo Pontecorvo 3, I-56127 Pisa

Spectral arguments predict the existence of parametric fractal fluctuations in the $\delta-$kicked rotor model owing to the strong "dynamical localization" of the eigenstates [1].
We present a comprehensive discussion of the possibility of observing such dynamically-induced fractality in the atom-optics realization of the kicked rotor. The influence of the atoms' initial momentum distribution is studied as well as the systematic dependence of the expected fractal dimension on finite-size effects of the experiment (detection windows and finite measurement times). Our results show that clear signatures of fractality could be observed in experiments with flashed optical lattices, which already offer an excellent control on interaction times and the initial atomic ensemble [2].

[1] I. Guarneri and M. Terraneo, Phys. Rev. E **65**, 015203(R) (2001).
[2] C. Ryu, M. Andersen, A. Vaziri, M.B. d'Arcy, J.M. Grossmann, K. Helmerson, and W.D. Phillips, in preparation (2005).

Q 10.2 Mo 14:15 HII

Large refractive indices in collective atomic systems — •Mihai Macovei and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg.

Large indices of refraction have been suggested as candidate for a number of fascinating applications. Typically, however, they are accompanied by a large absorption of the medium, which prohibits a useful implementation [1]. We show that collective interactions of atoms via the vacuum fluctuations of the surrounding electromagnetic reservoir are suitable to generate transparent media with large indices of refraction of order 10 or high dispersion of arbitrary sign. For this purpose, we consider an atomic system consisting of two ensembles of two-level atoms with somewhat different transition frequencies and interacting with a single moderately strong laser field. Depending on the resonance condition for each kind of atom, one of the atomic species may contribute to a high refractive indices while the other one shifts the weak probe susceptibility resulting in zero absorption [2].

[1] M. O. Scully and M. S. Zubairy, *Quantum Optics* (Cambridge University Press, Cambridge, U.K. 1997).
[2] Mihai Macovei and Christoph H. Keitel, J. Phys. B: At. Mol. Opt. Phys. **38**, L315 (2005).

Q 10.3 Mo 14:30 HII

Measurement of the separation between atoms beyond diffraction limit — •J. Evers[1,2], J.-T. Chan[2], M. O. Scully[2,3], and M. S. Zubairy[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Institute for Quantum Studies and Dept. of Physics, Texas A&M University, College Station, Texas 77843-4242 — [3]Princeton Institute for Materials Research, Princeton University, Princeton, NJ 08544-1009

Precision measurement of small separations between two quantum objects has been of interest since the early days of science. Here, we discuss a scheme which yields spatial information on a system of two identical atoms placed in a standing wave laser field [1]. The information is extracted from the collective resonance fluorescence spectrum of the two particles, relying entirely on far-field imaging techniques. Both the interatomic separation and the positions of the two particles within the standing wave field relative to the nodes can be measured with fractional-wavelength precision over a wide range of sub-wavelength distances.

[1] J. Chang, J. Evers, M. O. Scully and M. S. Zubairy, quant-ph/0508010.

Q 10.4 Mo 14:45 HII

Geometry-dependent dynamics of two Λ-type atoms via vacuum-induced coherences — •J. Evers, M. Kiffner, M. Macovei, and C. H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The dynamics of a pair of atoms can significantly differ from the single-atom dynamics if the distance of the two atoms is small on a scale given by the relevant transition wavelengths [1]. Here, we discuss two nearby three-level atoms in Λ-configuration, and focus on the dependence of the optical properties on the geometry of the setup. We find that in general transitions in the two atoms can be dipole-dipole coupled by interactions via the vacuum field even if their transition dipole moments are orthogonal. We give an interpretation of this effect and show that it may crucially influence the system dynamics. In particular, for a fixed setup of driving fields and detectors, the spatial orientation of the two-atom pair decides if the system reaches a true constant steady state or if it exhibits periodic oscillations in the long-time limit. As an example observable, we study the resonance fluorescence intensity, which is either constant or is modulated periodically in the long-time limit.

[1] Z. Ficek and R. Tanas, Phys. Rep. 372, 369 (2002).

Q 10.5 Mo 15:00 HII

Quantum interference enforced by time-energy complementarity — •M. Kiffner, J. Evers, and C. H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The interplay of the concepts of complementarity and interference in the time-energy domain are studied. In particular, we theoretically investigate the fluorescence light from a $J = 1/2$ to $J = 1/2$ transition that is driven by a monochromatic laser field. We find that the spectrum of resonance fluorescence exhibits a signature of vacuum-mediated interference effects, whereas the total intensity is not affected by interference. We demonstrate that this result is a consequence of the principle of complementarity, applied to time and energy. Since the considered level scheme can be found e.g. in $^{198}Hg^{+}$ ions, our setup turns out to be an ideal candidate to provide evidence for as yet experimentally unconfirmed vacuum-induced atomic coherences.

Q 10.6 Mo 15:15 HII

Nonlinear vacuum effects in strong laser fields — •Antonino Di Piazza, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

Quantum electrodynamics predicts that the vacuum in the presence of strong electromagnetic fields behaves in general as a nonlinear birefringent dielectric medium. We investigate the feasibility that by using strong laser fields, some nonlinear vacuum effects are observed experimentally. In particular, we show that by making three terawatt optical laser beams to collide in vacuum, then photons are expected to be scattered in the collision (assisted photon-photon scattering). Also, we propose a possible experimental setup to measure the vacuum refractive indices in the presence of a strong standing wave generated by two equal counterpropagating optical laser beams with intensity of the order of 10^{23} W/cm^2.

Q 10.7 Mo 15:30 HII

Quantum Reflection of thermal atoms from nano-crafted structures — •Ulrich Warring — Physikalisches Institut Heidelberg, Philosophen Weg 12, 69120 Heidelberg

In the Heidelberger Atomic Beam Spin Echo (ABSE) spectrometer, we have recently succeeded to detect Quantum Reflection (QR) of ^{3}He atoms from plain and well-characterized surfaces. For semi-conductors, we find that QR takes place at the transition from the van der Waals dominated part of the interaction potential to the Casimir-Polder part. In order to investigate the topological aspects of the Casimir-Polder force, we studied QR from different gratings. Depending on the shape and the orientation of these nano-structures, dramatic changes in reflectivity were observed. Quantitatively, the data are explained by an earlier breakdown of the WKB-approximation. Observed dispersion in the reflected intensity is quantitatively explained in terms of Quantum Diffraction.

Q 10.8 Mo 15:45 HII

Quantum mechanical detector model for a moving spread-out quantum particle — •Jens Timo Neumann[1], Gerhard C. Hegerfeldt[1], and Lawrence S. Schulman[2] — [1]Institut für Theoretische Physik, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Physics Department, Clarkson University, Potsdam, New York 13699-5820, USA

Although the space- and time-resolved detection of moving particles is

more or less a standard technique for sufficiently fast particles, an extension to single cold atoms showing quantum effects is far from obvious: Concerned with a spreading and extending wave packet, one is faced with highly nontrivial quantum mechanical questions. A deep understanding of these questions can be expected to prove useful in many applications. We investigate a spin-based detector model for the detection of such a moving spread-out quantum particle; the center-of-mass motion as well as the actual detection process are formulated in terms of quantum physics without any recurrence to classical approximations. The relation to the recently proposed fluorescence model for the measurement of quantum arrival times is discussed.