Q 34: Quantum Effects: QED I

Time: Wednesday 11:00–12:30 Location: B/SR

Group Report Q 34.1 Wed 11:00 B/SR

Electromagnetic friction on moving atoms – an analysis within quantum field theory — Francesco Intravaia[1], Vanik E. Mkrtchian[2,3], Stefan Buhmann[4], Stefan Scheel[5], Diego A. R. Dalvit[6], and •Carsten Henkel[3] — [1]Max-Born-Institut Berlin, Germany — [2]Armenian Academy of Sciences, Armenia — [3]University of Potsdam, Germany — [4]Albert-Ludwigs-Universität Freiburg, Germany — [5]Universität Rostock, Germany — [6]Los Alamos National Laboratory, USA

An atom moving near a macroscopic body experiences an electromagnetic friction force that depends on velocity v and temperature T. The quantum limit $T = 0$ has given rise to different predictions in the literature [1]. We revisit this problem in the formulation put forward by G. Barton [2] based on a quantum field theory of an atom and plasmon-polariton modes of the surface. We show that the way the atom is boosted from being initially at rest to a constant velocity gives rise to a different power dissipated into surface plasmons and the associated friction force. We find a subtle cancellation between the processes creating one and two photons that results in a leading-order contribution to the friction force which scales as v^3 at zero temperature and small velocities.

[1] A. I. Volokitin and B. N. J. Persson, *Rev. Mod. Phys.* **79** (2007) 1291; S. Scheel and S. Y. Buhmann, *Phys. Rev. A* **80** (2009) 042902; F. Intravaia, R. O. Behunin, and D. A. R Dalvit, *Phys. Rev. A* **89** (2014) 050101(R)
[2] G. Barton, *New J. Phys.* **12** (2010) 113045

Q 34.2 Wed 11:30 B/SR

Quantum Friction in Different Regimes — •Juliane Klatt and Stefan Y. Buhmann — Albert-Ludwig University, Freiburg

Quantum friction is the velocity-dependent force between two polarizable objects in relative motion, resulting from field-fluctuation mediated transfer of energy and momentum between them. Due to its short-ranged nature it has proven difficult to observe experimentally.

Theoretical attempts to determine the precise velocity-dependence of the quantum drag experienced by a polarizable atom moving parallel to a surface arrive at contradicting results. Scheel[1] and Barton[2] predict a force linear in relative velocity v, the former using the quantum regression theorem and the latter employing time-dependent perturbation theory. Intravaia[3], however, predicts a v^3 power-law starting from a non-equilibrium fluctuation-dissipation theorem.

In order to learn where exactly the above approaches part, we set out to perform all three calculations within one and the same framework: macroscopic QED. In addition, we include contributions to quantum friction from Doppler shift and Röntgen interaction, which play a role for perpendicular motion and retarded distances, respectively, and consider non-stationary states of atom and field.

[1] S. Scheel and S. Y. Buhmann, Phys. Rev. A **80** (2009)
[2] G. Barton, New J. Phys. **12** (2010)
[3] F. Intravaia et al., Phys. Rev. A **89** (2014)

Q 34.3 Wed 11:45 B/SR

Influence of dissipation on two-atom dispersion interactions — •Pablo Barcellona and Stefan Yoshi Buhmann — Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

We consider the dispersion interaction between two neutral, ground-state atoms at zero and finite temperature by means of a dynamical approach. Our result differs from the previous ones obtained with time-independent perturbation theory because it correctly accounts for the influence of dissipation via the atomic decay rates. Modern measurements of Casimir force seem to suggest a suppressed influence of dissipation. Our new result shows similar features and can hence help resolve the Drude-plasma debate.

We also consider the interaction between a ground-state atom and an excited atom. There are discordant results in the literature for the retarded potential: one oscillating and one monotonous. Our dynamical result uniquely leads to the oscillating result when taking into account the decay rates.

Q 34.4 Wed 12:00 B/SR

High fidelity quantum state transfer between photonic qubits and matter qubits in free space using electromagnetically induced transparency — •Nils Trautmann and Gernot Alber — Institut für Angewandte Physik, Technische Universität Darmstadt,D-64289, Germany

We propose a procedure to achieve high fidelity conversion between a photonic qubit encoded in a single photon wave packet and a matter qubit encoded in the atomic level structure of a single atom in free space with a high success probability. This procedure makes use of electromagnetically induced transparency in order to control the interaction between the atom and the radiation field. Thereby, a matter qubit can be converted into a photonic qubit stored in a time-symmetric single photon wave packet which can be absorbed almost perfectly by a second atom due to time reversal symmetry. By absorbing such a single photon wave packet, the photonic qubit can be converted back into a matter qubit thereby achieving a high fidelity quantum state transfer between distant matter qubits. In contrast to already known schemes, the protocol proposed in this article does not rely on high finesse cavities and optical fibers and is compatible with a free space communication channel.

Q 34.5 Wed 12:15 B/SR

Atomic mirror effect based on correlations among atoms — •Qurrat-ul-Ain Gulfam[1] and Zbigniew Ficek[2] — [1]Department of Physics, Jazan University, Jazan, Saudi Arabia — [2]The National Center for Mathematics and Physics, KACST, Riyadh, Saudi Arabia

Reflection of light off correlated two-level identical atoms has been investigated. In schemes demonstrating the atomic mirror effect, usually atoms have to be coupled with external media such that a unidimensional emission from the system is ensured. On the contrary, here, we have considered a real 3-dimensional dipole-dipole interaction among free space atoms. The directionality in the collective spontaneous emission is induced by the interaction-based effects. Clear evidence of the mirror effect like in a one dimensional cavity has been noticed in position configurations as simple as 3-atom linear chain. Atomic interactions also strongly affect the angular distribution of the first order correlation function detected in the far field. Such analysis allows to determine the suitable directions for enhanced reflectivity.

[1] D. E. Chang, et al, Phys. Rev. Lett., **110**, 113606 (2013).