Q 3: Quantum Effects: QED I

Time: Monday 14:30–16:15 Location: P 4

Q 3.1 Mon 14:30 P 4

Casimir effect for perfect non-reciprocal conductors: An analytic extension of Casimir's original work — •Stefan Rode, Robert Bennett, and Stefan Yoshi Buhmann — Albert-Ludwigs University of Freiburg, Germany

We present the Casimir effect for boundary conditions involving perfect electromagnetic conductors (PEMCs), which are a class of non-reciprocal materials that interpolate between perfectly electrically conducting and perfect magnetically conducting media. Based on the dyadic Green's tensor of the electromagnetic field between two reciprocal plates, we demonstrate the construction of the corresponding quantity for two perfectly reflecting non-reciprocal plates. We then calculate the Casimir force between two PEMC plates in terms of the parameter that specifies the degree of mixing between electric and magnetic responses. Our results are simple analytic expressions, which can be related to the electric-magnetic duality symmetry of the electromagnetic field.

Q 3.2 Mon 14:45 P 4

Casimir forces in media: comparison of microscopic and macroscopic descriptions — •Friedrich Burger, Johannes Fiedler, and Stefan Yoshi Buhmann — Institute of Physics, University of Freiburg, Germany

We consider the Casimir force between two dielectric bodies in a medium, motivated by a recent debate initiated by Raabe and Welsch [1]: the Casimir force as an effective electromagnetic force on a dieletric object due to a second object can be expressed as a surface integral over a stress tensor. Two alternative choices, the Maxwell stress tensor [1] on the one hand and the Abraham-Minkowski stress tensor [2] on the other, then lead to different results when the objects are embedded in a medium. We analyse a setup of two dielectric spheres within a medium [3] and present a comparison of both approaches with the result obtained from microscopic Hamaker theory [4].

[1] C. Raabe and D.-G. Welsch, Phys. Rev. A **71**, 013814 (2005).
[2] I. Dzyaloshinskii, E. M. Lifshitz and L. P. Pitaevskii, Adv. Phys. **10** 165 (1961).
[3] A. Sambale, S. Y. Buhmann and S. Scheel, Phys. Rev. A **81**, 012509 (2010).
[4] H. C. Hamaker, Physica **4**, 1058 (1937).

Q 3.3 Mon 15:00 P 4

Dispersion forces in inhomogenous media — •Johannes Fiedler[1], Priyadarshini Thiyam[2], Mathias Boström[2], Michael Walter[1,3], and Stefan Yoshi Buhmann[1] — [1]Institute of Physics, University of Freiburg, Germany — [2]Department of Materials Science and Engineering, Royal Institute of Technology, Sweden — [3]Fraunhofer Institute for Mechanics of Materials, Germany

Dispersion forces, such as Casimir forces between dielectric bodies and van der Waals forces between neutral particles, are a consequence of the ground-state fluctuations of the electromagnetic field [1]. In modern precision experiments and theories, these forces are usually studied in vacuum [2]. However, typical realistic systems arising in nature, e.g. in biological contexts, often involve particles embedded in liquid solvent media. The latter can strongly modify the van der Waals interaction. Due to the Pauli blocking the solvent forms a void, or real cavity, around the particles [3], which has to be taken into account when studying the van der Waals interaction. We investigate the influence of such a solvent on the dispersion force for a quasi one-dimensional model cases of two plates of finite thickness and infinite lateral extension on the one hand and two atoms on the other. We model the real cavity by a realistic density profile of the solvent near the interacting objects and compare our results with those obtained from a simpler hard-cavity model with step-function profile.

[1] S.Y. Buhmann, Dispersion forces I, Springer (Heidelberg, Berlin) 2012. [2] S. K. Lamoreaux, Phys. Rev. Lett. **78**, 5 (1997). [3] A. Held, M. Walter, J. Chem. Phys. **141**, 174108 (2014).

Q 3.4 Mon 15:15 P 4

Relevance of non-equilibrium effects for dispersion forces — •Francesco Intravaia — Max-Born-Institut, 12489 Berlin, Germany

Non-equilibrium systems are omnipresent and in recent years they have attracted a constantly growing attention due to their relevance for fundamental physics as well as for modern nanotechnology. Progress in manipulating atomic and condensed matter systems has stimulated the investigation of a particular class of non-equilibrium phenomena, which is represented by dynamical dispersion forces. These forces, whose origin is deeply rooted in quantum theory, are at the origin of contactless quantum friction between two objects moving with constant velocity relative to each other. Unfortunately, the detailed quantitative description of non-equilibrium systems is rather challenging and the most common approaches rely on the assumption that corrections to the associated equilibrium characteristics are relatively small. We show that this assumption fails for quantum friction and underestimates by approximately 80% the magnitude of the drag force [1]. Our results show that the correlations among the components of driven but steady-state quantum systems invalidate the so-called local thermal equilibrium approximation, also calling for a critical reexamination of this approach for describing the physics of non-equilibrium systems.

[1] F. Intravaia, R. O. Behunin, C. Henkel, K. Busch, and D. A. R. Dalvit, Failure of local thermal equilibrium in quantum friction, Phys. Rev. Lett. 117, 100402 (2016).

Q 3.5 Mon 15:30 P 4

Casimir-Polder Interaction across Timescales — •Juliane Klatt and Stefan Yoshi Buhmann — Physikalisches Institut, Albert-Ludwigs-Universität, Freiburg

Casimir-Polder interaction is the fluctuation-mediated interplay between a neutral but polarizable microscopic object, e.g. an atom, on the one hand and a macroscopic body on the other. For an atom at rest, the three most common approaches to describing such interaction - perturbation theory, Markovian master equations and linear response theory - yield compatible results. For an atom moving relative to the macroscopic body, however, the predictions of these three methods strongly disagree.

This discrepancy can be attributed to incompatible assumptions regarding the power spectra as implied by the aforementioned approaches, which in turn is a manifestation of the mutually exclusive temporal regimes to which the seemingly contradicting results apply. The different Casimir-Polder dynamics in these temporal regimes can be understood in analogy to the observation that the spontaneous decay of an excited atom in free space undergoes three, qualitatively distinct, phases - Gaussian decay, exponential decay and powerlaw decay - each of which can be reproduced by the corresponding method, i.e. perturbation theory, Markovian master equations and linear response, respectively.

We here employ time-convolutionless projection operator techniques in order to develop a comprehensive description of Casimir-Polder interaction across all timescales.

Q 3.6 Mon 15:45 P 4

Casimir-Polder Potential for an Atom driven by a Laser Field — •Sebastian Fuchs, Robert Bennett, and Stefan Buhmann — Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

Within the framework of Macroscopic QED we study the interaction between an atom driven by a coherent laser field with a surface and compute the Casimir-Polder potential. We use two different ideas to approach this goal. If the atom is not driven resonantly and remains in its initial state, we can split the dipole moment into a free contribution coming from spontaneous polarization according to Macroscopic QED, and the induced part given by a polarizability and the driving field. The total Casimir-Polder potential also consists of the standard Casimir-Polder part, the induced potential. We contrast this to a resonantly driven atom showing Rabi oscillations between its excited state and the ground state. In a next step we seek to extend this model to a larger number of atoms and investigate the collective behavior using Dicke states.

Q 3.7 Mon 16:00 P 4

Dynamical Casimir effect in a spinor BEC — •Karsten Lange[1], Jan Peise[1], Bernd Lücke[1], Ilka Kruse[1], Frank Deuretzbacher[2], Luis Santos[2], Wolfgang Ertmer[1], and Carsten Klempt[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Institut für Theoretische Physik, Leibniz Universität Hannover

One of the most surprising predictions of quantum theory is the generation of particles out of the vacuum by suddenly changing the boundary conditions. This effect is known as the dynamical Casimir effect. Originally, it was proposed for mirrors that move at relativistic speeds. We realize an analogous effect in our ^{87}Rb spinor BEC by changing the the energy of initially empty spin modes. Firstly, we demonstrate the creation of spin excitations in these vacuum states. Secondly, we employ atomic homodyning to prove that the created excitations are entangled.