Q 35: Quantum effects: QED I

Time: Thursday 10:30–12:00 Location: DO26 208

Group Report Q 35.1 Thu 10:30 DO26 208

Casimir-Polder forces: quantum friction to cross-polarisable media — •Stefan Yoshi Buhmann — Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

Quantum friction is a predicted contact-less drag force on two moving parallel dielectric plates. A simple model case to discuss this contested vacuum shear force is the Casimir–Polder force on a ground-state atom moving parallel to a plate. Using macroscopic quantum electrodynamics, we predict a friction force which converts the atom's kinetic energy into heat [1]. For an excited atom, we find that resonantly enhanced quantum friction or acceleration is possible [2].

To describe the same process from the perspective of a moving plate, one notes that to an observer at rest, moving dielectrics appear to exhibit electromagnetic cross-susceptibilities. We outline a quantisation scheme for the electromagnetic field for linear, cross-polarisable media [3]. We show that such media give rise to discriminatory Casimir–Polder forces on chiral molecules and that they could be used to detect CP-violating effects in molecules [4].

[1] S. Scheel and S. Y. Buhmann, Phys. Rev. A **80** (4), 042902 (2009).
[2] S. Y. Buhmann, *Dispersion Forces II – Many-Body Effects, Excited Atoms, Finite Temperature and Quantum Friction*, (Springer, Heidelberg, 2012).
[3] S. Y. Buhmann, D. T. Butcher and S. Scheel, New J. Phys. **14**, 083034 (2012).
[4] D. T. Butcher, S. Y. Buhmann and S. Scheel, New J. Phys. **14**, 113013 (2012).

Q 35.2 Thu 11:00 DO26 208

Pulse shape dependence in the dynamically assisted Sauter-Schwinger effect — Joachim Sicking, •Nikodem Szpak, and Ralf Schützhold — Fakultät für Physik, Universität Duisburg-Essen

The Sauter-Schwinger effect describes the non-perturbative electron-positron pair creation from the vacuum by a strong and slowly varying electric field $E_{\rm strong}$ via tunnelling. Due to the smallness of the associated probabilities for realistic electric fields, this fundamental prediction of quantum field theory has not been observed yet. The dynamically assisted Sauter-Schwinger effect corresponds to a strong (exponential) enhancement of the pair creation probability by an additional weak and fast electric or electromagnetic pulse. We find that this enhancement mechanism depends strongly on the shape of the fast pulse. For the Sauter profile $1/\cosh^2(\omega t)$ considered previously, the threshold frequency $\omega_{\rm crit}$ (where the enhancement mechanism sets in) is basically independent of the magnitude $E_{\rm weak}$ of the weak pulse – whereas for a Gaussian pulse $\exp(-\omega^2 t^2)$ or a sinusoidal profile $\sin(\omega t)$, the value of $\omega_{\rm crit}$ does depend (logarithmically) on $E_{\rm weak}/E_{\rm strong}$.

Q 35.3 Thu 11:15 DO26 208

Route from spontaneous decay to complex multimode dynamics in cavity QED — •Dmitry Krimer[1], Matthias Liertzer[1], Stefan Rotter[1], and Hakan E. Tureci[2] — [1]Institute for Theoretical Physics, Vienna University of Technology, A-1040, Vienna, Austria — [2]Department of Electrical Engineering, Princeton University, Princeton, New Jersey 08544, USA

We study the non-Markovian quantum dynamics of an emitter inside an open multimode cavity, focusing on the case where the emitter is resonant with high-frequency cavity modes [1]. Based on a Green's function technique suited for open photonic structures, we study the crossovers between three distinct regimes as the coupling strength is gradually increased: (i) overdamped decay with a time scale given by the Purcell modified decay rate, (ii) underdamped oscillations with a time scale given by the effective vacuum Rabi frequency, and (iii) pulsed revivals. The final multimode strong coupling regime (iii) gives rise to quantum revivals of the atomic inversion on a time scale associated with the cavity round-trip time. We show that the crucial parameter to capture the crossovers between these regimes is the non-linear Lamb shift, accounted for exactly in our formalism.

[1] D.O. Krimer, M. Liertzer, S. Rotter, and H. E. Tureci, arXiv:1306.4787

Q 35.4 Thu 11:30 DO26 208

Quantized radiation self-field of an ultra-thin foil interacting with laser pulses — •Constantin Klier and Hartmut Ruhl — Fakultät für Physik, LMU München

We have extended the particle-in-cell code PSC to describe self-field processes of quantum electrodynamics. First we present simulation results showing the effects of the quantization of the radiation self-field on laser-matter interaction. The code is next applied to the case of an ultra-thin foil interacting with circularly polarized laser pulses at laser field strength parameters a_0 = 300-500. Copious radiation of gamma photons and creation of electron-positron pairs in longitudinal direction are observed. For comparison an analytical solution of the one-dimensional foil movement and its self-fields is used to estimate the rates of photon and pair production of the foil.

Q 35.5 Thu 11:45 DO26 208

Assisted Multiphoton Pair Production in Periodic Fields — •Andreas Otto[1,2], Daniel Seipt[3,1], Hans Oppitz[1,2], and Burkhard Kämpfer[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden — [2]Institut für Theoretische Physik, Technische Universität Dresden, Zellescher Weg 17, 01062 Dresden — [3]Helmholtz-Institut Jena, Fröbelstieg 3, 07743 Jena

Strong time dependent, spatially homogeneous electric fields can produce electron-positron pairs through tunnelling and multiphoton processes, the so called dynamical Schwinger effect. This production rate can be greatly enhanced by combining two fields of different timescales and strengths. In the framework of a quantum kinetic equation we investigate the superposition of two periodic fields and show that, by suitable choice of parameters, one can achieve enhancement factors $\mathcal{O}(10^3)$-$\mathcal{O}(10^4)$ relative to the yields of the individual fields. We identify the strong non-linear enhancement as a result of the mutual field assistance resulting in special phase space structures. Their time dependence allows for a physical explanation of the enhancement in dynamically assisted Schwinger pair production in periodic fields.