Q 11: Quantum effects: QED

Time: Monday 14:00–16:00 Location: F 342

Group Report Q 11.1 Mon 14:00 F 342

Strong-Field QED Processes in Short Intense Laser Pulses — •Daniel Seipt[1,2], Tobias Nousch[1,2], Andreas Otto[1,2], Alexander I. Titov[1,3], and Burkhard Kämpfer[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, POB 510119, 01314 Dresden, Germany — [2]TU Dresden, Institut für Theoretische Physik, 01062 Dresden, Germany — [3]Bogoliubov Laboratory of Theoretical Physics, JINR, Dubna 141980, Russia

Strong-field QED processes in intense laser fields are presently of great interest in view of upcoming high-intensity laser facilities such as ELI. In this talk I will present recent results of our group on strong-field QED processes such as high-intensity one- and two-photon Compton scattering [1,2] as well as the cross channel pair production processes [3]. These processes are described using QED in the Furry picture with laser dressed Volkov states. The effects of the short laser pulse length of a few tens of femtoseconds are discussed. Furthermore, results for the dynamical Schwinger effect in time dependent electric fields as well as the modification weak interaction processes in intense laser fields are presented [4].

[1] D. Seipt and B. Kämpfer, Phys. Rev. A **83**, 022101 (2011). [2] D. Seipt and B. Kämpfer, Phys. Rev. D **85**, 101701 (2012). [3] T. Nousch, D. Seipt, B. Kämpfer and A. I. Titov, Phys. Lett. B **715**, 246 (2012). [4] A. I. Titov, B. Kämpfer, H. Takabe and A. Hosaka, Phys. Rev. D **83**, 053008 (2011).

Q 11.2 Mon 14:30 F 342

Collapse-revival dynamics in strongly laser-driven electrons — •Oleg Skoromnik[1], Iliya Feranchuk[2], and Christoph Keitel[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg, Germany — [2]Belarusian State University, Minsk, Belarus

The relativistic quantum dynamics of an electron in an intense single-mode quantized electromagnetic field is investigated with special emphasis on the spin degree of freedom. In addition to fast spin oscillations at the laser frequency, a second time scale is identified due to the intensity dependent emissions and absorptions of field quanta. In analogy to the well-known phenomenon in atoms at moderate laser intensity, we put forward the conditions of collapses and revivals for the spin evolution in laser-driven electrons starting at feasible $10^{18}\mathrm{W/cm}^2$, arXiv:1209.1939.

Q 11.3 Mon 14:45 F 342

Stochasticity effects in quantum radiation-reaction — •Norman Neitz and Antonino Di Piazza — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

Radiation-reaction effects in the collision of a strong laser pulse with a thin plasma foil have been shown to reduce the energy spread of the generated ion beam in the classical regime [1]. Here, we study the evolution of the energy distribution of an electron beam colliding with an intense laser pulse via a kinetic approach [2] in the framework of strong-field QED [3], and show that in the quantum regime radiation-reaction effects induce the opposite effect, i.e., the electron beam spreads out after interacting with the laser pulse. We identify the physical origin of this opposite tendency in the intrinsic stochasticity of quantum photon emission and then of quantum radiation-reaction [4]. Our numerical simulations indicate that the experimental investigation of the predicted effects of stochasticity is in principle feasible with present technology.

[1] M. Tamburini et al., New. J. Phys. **12**, 123005 (2010).
[2] V. N. Baier, V. M. Katkov and V. M. Strakhovenko, "Electromagnetic processes at high energies in oriented single crystals" (World Scientific, Singapore, 1998).
[3] A. Di Piazza *et al.*, Rev. Mod. Phys. **84**, 1177 (2012).
[4] N. Neitz and A. Di Piazza, to be submitted.

Q 11.4 Mon 15:00 F 342

Photonic Coupling of Cold Molecules at Large Distances — •Harald R. Haakh, Sanli Faez, and Vahid Sandoghdar — MPI for the Science of Light, Erlangen, Germany

Recent theoretical studies have shown that tightly confined guided optical modes can facilitate the strong coupling of individual quantum emitters to these modes. In particular, plasmonic waveguides, tapered optical fibers and slot dielectric waveguides have been considered for such studies, whereby the latter have the advantage of not suffering from propagation loss.

In this presentation, we extend these platforms to the coherent interaction of several molecules at large separations via the guided mode of an optical fiber with a nanoscopic core diameter. We consider the interaction at strong and weak excitation and discuss how the high degree of control made possible by the large spatial dimensions allows for controlled switching of the nonlinear scattering of photon wave packets. Furthermore, we investigate the impact of dephasing in the solid state.

Q 11.5 Mon 15:15 F 342

Coherent interaction of single quantum emitters in a one-dimensional waveguide — Sanli Faez, •Pierre Türschmann, Stephan Götzinger, and Vahid Sandoghdar — Max Planck Institute for the Science of Light and Friedrich Alexander University, Erlangen, Germany

The coherent interaction of propagating photons and single emitters has become of great interest during the last years because of its potential application in quantum information science. Recently, several theoretical and experimental studies have considered the coupling of atoms to guided modes. Such a system is expected to show intriguing new bound states of light and matter. In our laboratory, we investigate these phenomena by using organic molecules embedded in an organic matrix that is placed in the core of a hollow fiber. At cryogenic temperatures of 1.4 K the scattering cross section of the emitters approaches their theoretical limit, which is comparable with the fiber mode cross section, thus allowing an efficient interaction with the guided photons. We present first results of the coherent coupling of single molecules to the fiber mode and discuss various ideas that exploit this interaction.

Q 11.6 Mon 15:30 F 342

Dynamischer Schwinger-Effekt: Paarproduktion in zeitabhängigen elektrischen Feldern — •Andreas Otto[1,2], Daniel Seipt[1,2], Tobias Nousch[1,2] und Burkhard Kämpfer[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, PF 510119, 01314 Dresden, Germany — [2]Institut für theoretische Physik, TU Dresden, 01062 Dresden, Germany

In den Antinoden mehrerer überlagerter linear polarisierter Laserpulse entstehen starke periodische elektrische Felder mit einer Homogenitätslänge, die sehr viel größer ist, als die Compton-Wellenläge von Elektronen und Positronen. Für ultra-starke Laserpulse entsteht somit die Möglichkeit der Elektron-Positron-Paarerzeugung durch den dynamischen Schwinger-Effekt, der insbesondere als Ausgangspunkt der Entwicklung von Lawinen weiterer Paare derzeit intensiv untersucht wird. In dem Vortrag werden Simulationen des dynamischen Schwinger-Effektes vorgestellt und verschiedene durch die beiden Parameter (Feldfrequenz und Feldstärke) bestimmte Regime für zeitlich ausgedehnte Laserpulse untersucht. Neben der Dynamik der Phasenraumverteilung der Quasiteilchen ist vor allem die Paaranzahl im asymptotischen Endzustand bei zeitlich begrenzten Laserpulsen von Interesse. Es werden Resultate für verschiedene Einhüllende von ultrastarken und ultra-kurzen Laserpulsen erläutert.

Q 11.7 Mon 15:45 F 342

Pair production in short intense laser pulses near threshold — •Tobias Nousch[1,2], Daniel Seipt[1,2], Burkhart Kaempfer[1,2], and Alexander I. Titov[3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, POB 510119, 01314 Dresden, Germany — [2]TU Dresden, Institut für Theoretische Physik, 01062 Dresden, Germany — [3]Bogoliubov Laboratory of Theoretical Physics, JINR, Dubna 141980, Russia

We study finite-size effects in the process of e^+e^- pair production via the non-linear Breit-Wheeler process in ultra short laser pulses. Based on the Nikishov-Ritus method we use laser dressed electron and positron wave functions to derive the differential and total pair production cross section, focusing on the effects of a finite pulse duration. For short laser pulses with very few oscillations of the electromagnetic field we find an increase of the pair production rate below the perturbative weak-field threshold. The strong enhancement below the weak-field threshold is traced back to the finite bandwidth of the laser pulse. A folding model accounts for the interplay of the frequency spectrum and the intensity distribution in the course of the pulse.