A 13: Interaction with Strong or Short Laser Pulses I

Time: Wednesday 14:00–16:00 Location: F 107

Invited Talk A 13.1 We 14:00 F 107

Testing strong-field CED and QED with intense laser fields — •Antonino Di Piazza, Karen Z. Hatsagortsyan, Ben King, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Strong laser fields can be employed to test classical and quantum electrodynamics (CED and QED, respectively) under extreme conditions. A fundamental problem in electrodynamics is the "radiation reaction" problem: classically, an accelerated electron emits radiation and this emission alters the motion of the electron itself. The Landau-Lifshitz equation consistently describes the electron's motion in an external field by including radiation reaction. We explore a new scenario in which this equation can be in principle tested experimentally for the first time and with presently available laser technology [1]. We will also briefly address quantum vacuum polarization effects. We demonstrate the possibility of observing electron-positron pair production in laser and nuclear fields, by controlling the tunneling barrier through the assistance of an additional high-energy photon [2]. Finally, by exploiting the quantum interaction among real photon in vacuum, we propose a double-slit-like experiment devoid of any material parts [3].

[1] A. Di Piazza, K. Z. Hatsagortsyan, and C. H. Keitel, Phys. Rev. Lett. **102**, 254802 (2009).
[2] A. Di Piazza *et al.*, Phys. Rev. Lett. **103**, 170403 (2009).
[3] B. King, A. Di Piazza, and C. H. Keitel, Nature Photonics (in press).

A 13.2 We 14:30 F 107

Study of electron-nuclear correlation using the multi-configuration time-dependent Hartree approach — •Chirag Jhala and Manfred Lein — Centre for Quantum Engineering and Space-Time Research (QUEST) and Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany.

The multi-configuration time-dependent Hartree (MCTDH) approach [1] is a well known tool to study the nuclear dynamics in multi-dimensional systems. The extension of the MCTDH approach to study multi-electron dynamics is known as the multi-configuration time-dependent Hartree Fock (MCTDHF) approach. We propose to use the MCTDH approach to study the correlated electron-nuclear dynamics in H_2^+ and H_2 model systems driven by strong laser pulses. We evaluate various observables, e.g. high-harmonic generation (HHG) spectra, frequency-time analysis, fragmentation and survival probabilities and time-dependent densities, to compare the performance of MCTDH approach with the exact calculation. We demonstrate that the performance of MCTDH approach converges towards the exact results with increasing number of configurations and that a moderate number of configurations is sufficient to yield reliable results.

[1] M. H. Beck, A. Jäckle, G. A. Worth and H.-D. Meyer, Physics Reports **324**, 1 (2000).

A 13.3 We 14:45 F 107

Complete QED theory for trident pair production in strong laser fields — •Huayu Hu, Carsten Müller, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Heidelberg

The creation of electron-positron pairs in strong laser fields is encountering a growing interest in recent years. It has been stimulated by a pioneering experiment at SLAC [1] which realized multiphoton pair production in relativistic electron-laser collisions for the first time. Here, we develop a complete laser-dressed QED description of this process, which treats the competing reaction channels involved in a unified way. We calculate the dependence of the production rate on the laser parameters as well as the angular and momentum distributions of the three final-state particles. An overall good agreement with the measurements is obtained. We also study the process in a manifestly nonperturbative domain.

[1] D. Burke et al., Phys. Rev. Lett. 79, 1626 (1997)

A 13.4 We 15:00 F 107

Relativistic high-order harmonic generation: Drift compensation and phase coherence — •Markus C. Kohler, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland

The progress in the high-order harmonic generation (HHG) with atomic targets above photon energies of 10 keV is hindered by relativistic effects. We put forward strategies to counteract the relativistic drift [1,2] and to achieve phase-matching at a high free-electron background for HHG in the relativistic regime. A complete, quantitative analysis of the macroscopic HHG yield from a gas jet for relativistic laser intensities is presented. Crucial issues influencing the efficiency are discussed. Two setups are considered: The driving field for HHG is either the field of counterpropagating strong attosecond pulses or that of an infrared laser field assisted by ultraviolet photons. The phase matching is achieved by either employing the additional HHG phase depending on the time delay between the driving pulses or quasi-phase matching schemes. In the optimized conditions, HHG with photon energies of several tenths of keV is feasible.

[1] K. Z. Hatsagortsyan, M. Klaiber, C. Müller, M. C. Kohler, and C. H. Keitel, J. Opt. Soc. Am. B **25**, 93 (2008).
[2] M. Klaiber, K. Z. Hatsagortsyan, C. Müller, and C. H. Keitel, Opt. Lett. **33**, 411 (2008).

A 13.5 We 15:15 F 107

Magnetic Deflection TOF Imaging von Ionen aus Silberclustern in starken Laserfeldern — •Christian Schaal, Robert Irsig, Josef Tiggesbäumker und Karl-Heinz Meiwes-Broer — Inst. f. Physik, Universität Rostock

Bei der Analyse der Ionen aus der Coulombexplosion von Clustern beobachtet man extrem hohe Ladungszustände als auch enorme Rückstoßenergien (KE). Der Zusammenhang zwischen q und KE ist bislang erst wenig untersucht worden. Eine Möglichkeit bietet hier die Technik des Magnetic Deflection Time-of-Flight Imaging (MD-TOF). Sie wurde schon früher von Lezius et al. [1] zur Analyse hoch energetischer, vielfach geladener Ionen aus Coulombexplosion von Clustern vorgestellt. Die Ionen werden in einem Wiley-McLaren TOF-MS beschleunigt und entsprechend ihrer kinetischen Energie und q/m-Verhältnis durch ein homogenes Magnetfeld, rechtwinklig zur Ausbreitungsrichtung der Ionen, abgelenkt. Diese Technik haben wir nun durch die Verwendung eines zeit- und ortsempfindlichen Delay-Line-Detektors erweitert, und untersuchen die Ionisationsdynamiken von Metallclustern in intensiven Laserfeldern. Erste Ergebnisse von Energie- und Impulsverteilung von Silberionen aus Clustern ($N \sim 1200$) werden diskutiert.

[1] M. Lezius, S. Dobosz, D. Normand and M. Schmidt, Phys. Rev. Lett. **80, 2**, 261 (1998)

A 13.6 We 15:30 F 107

Coulomb Explosion of Clusters Irradiated with Intense Femtosecond X-Ray Pulses — •Sebastian Schorb[1], D. Rupp[1], M. Adolph[1], T. Gorkhover[1], T. Möller[1], N. Timneanu[2], J. Andreasson[2], B. Iwan[2], M. Seiwert[2], J. Haidu[2], K. Hoffmann[3], N. Kandadai[3], A. Helal[3], H. Thomas[3], J. Keto[3], T. Ditmire[3], G. Doumy[4], L. DiMauro[4], M. Hoener[5], B. Murphy[5], N. Berrah[5], J. Bozek[6], M. Messerschmidt[6], and C. Bostedt[6] — [1]Institut für Optik und Atomare Physik, Technische Universität Berlin — [2]Uppsala University — [3]Fusion Research Center, University of Texas — [4]Department of Physics, The Ohio State University — [5]Department of Physics, Western Michigan University — [6]LCLS, SLAC National Laboratory

Free Electron Lasers open the door for novel experiments such as single shot imaging of molecules. For the success of the imaging experiments a detailed understanding of the ligth – matter interaction in the x-ray regime is pivotal. We have performed first investigations about intense x-ray – cluster interaction with femtosecond pulses from the Linac Coherent Light Source (LCLS) free electron laser in Stanford. We have studied the Coulomb explosion of argon clusters as a function of intensity and pulse length. The ionization dynamics in the keV photon energy regime will be compared to previous experiments in the soft x-ray regime at FLASH.

A 13.7 We 15:45 F 107

Abhängigkeit der Populationswahrscheinlichkeit eines atomaren Zwei-Niveau-Systems von der Träger-Einhüllenden-Phase eines fs-Laserpulses — •Anne Harth[1,2], Daniel S. Steingrube[1,2], Thomas Binhammer[1,2], Fabian Elster[1,2], Luis

Santos[2,3] und Uwe Morgner[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Hannover, Germany — [2]Quest: Center for Quantum Engineering and Space-Time Research, Hannover, Germany — [3]Institut für Theoretische Physik, Leibniz Universität Hannover, Hannover, Germany

Die Untersuchung von Effekten der Träger-Einhüllenden-Phase (CEP) von sub-10-fs-Laserpulsen in Wechselwirkung mit Atomen war bisher auf Ionisationsprozesse beschränkt und damit auch auf Laser-Verstärker-Systeme. Theoretische Arbeiten haben jedoch bestätigt, dass auch die Populationswahrscheinlichkeit gebundener atomarer Energie-Niveaus eine CEP- Abhängigkeit aufweist. Dieses eröffnet nun die grundsätzliche Möglichkeit, die CEP-Abhängigkeit direkt mit einem Laser-Oszillator mit Pulsenergien im nJ-Bereich untersuchen zu können.

Wir präsentieren ein theoretisches Modell, um den CEP-Effekt für unseren oktavbreiten CEP-stabilisierten Ti:Saphir-Laseroszillator in unterschiedlichen atomaren Systemen abzuschätzen. Auf dieser Basis werden die experimentellen Möglichkeiten und Grenzen diskutiert.