A 18: Interaction with strong or short laser pulses I

Time: Wednesday 16:30–18:30 Location: BAR 106

A 18.1 Wed 16:30 BAR 106

Controlling quantum beat structures in the photoionization continuum of neon — •Henning Geiseler, Horst Rottke, Günter Steinmeyer, and Wolfgang Sandner — Max-Born-Institut, Max-Born-Str. 2a, 12489 Berlin

The coherent excitation of an ensemble of high lying bound states in an atomic system by an ultrashort XUV pulse, followed by ionization of these states with a delayed IR probe pulse leads to quantum beats in the delay dependent photoelectron spectrum. We performed measurements of these quantum beats in neon, observing a dependence on the ionization pulse intensity. To account for this dependence, we developed a model that involves an IR laser pulse induced coupling of the bound states, which are excited by the XUV pulse, to a lower lying state in the neon atom.

A 18.2 Wed 16:45 BAR 106

High-Harmonic Generation via Continuum-Wave Packet Interference — •Markus C. Kohler, Christian Ott, Philipp Raith, Robert Heck, Ines Schlegel, Christoph H. Keitel, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

High-Harmonic Generation is investigated theoretically in the over-the-barrier ionization regime revealing a significant coherent radiation response of continuum-continuum (CC) harmonics. Their emission happens when two parts of the electronic wave function being ionized in different half cycles of the laser recollide at the same time. The emission energy of these CC harmonics is exactly the kinetic-energy difference of the two wave packets.

A time-frequency analysis shows that the process entirely dominates coherent HHG emission after the ground state has been depleted. Moreover, we show that CC harmonics exhibit a different phase-matching behavior compared to the traditional continuum-bound harmonics and can therefore be isolated. Our analytic results suggest that CC harmonics might be employed for a new type of molecular tomography where the potential-energy landscape of a molecule could be imaged. Additionally, we advance the interference model of HHG.

[1] Markus C. Kohler, Christian Ott, Philipp Raith, Robert Heck, Iris Schlegel, Christoph H. Keitel, and Thomas Pfeifer, Phys. Rev. Lett 105, 203902 (2010)

A 18.3 Wed 17:00 BAR 106

Low-Energy Structures in Strong Field Ionization Revealed by Quantum Orbits — •Tian-Min Yan[1,2], Sergey Popruzhenko[3], Marc Vrakking[4,5], and Dieter Bauer[1] — [1]Institut für Physik, Universität Rostock, 18051 Rostock, Germany — [2]Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg, Germany — [3]National Research Nuclear University "Moscow Engineering Physics Institute", Kashirskoe Shosse 31, 115409, Moscow, Russia — [4]FOM-Institute AMOLF, Science Park 113, 1098 XG Amsterdam, The Netherlands — [5]Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin, Germany

Experiments on atoms in intense laser pulses and the corresponding exact ab initio solutions of the time-dependent Schrödinger equation (TDSE) yield photoelectronic spectra with low-energy features that are not reproduced by the otherwise successful work horse of strong field laser physics: the "strong field approximation" (SFA). In the semi-classical limit, the SFA possesses an appealing interpretation in terms of interfering quantum trajectories. It is shown [1] that a conceptually simple extension towards the inclusion of Coulomb effects yields very good agreement with exact TDSE results. Moreover, the Coulomb quantum orbits allow for a physically intuitive interpretation and detailed analysis of all low-energy features in the semi-classical regime, in particular the recently discovered "low-energy structure" [2,3].

[1] Tian-Min Yan, S.V. Popruzhenko, M.J.J. Vrakking, D.Bauer, Phys. Rev. Lett. (in press). [2] C.I. Blaga et al., Nature Physics 5, 335 (2009). [3] W. Quan et al., Phys. Rev. Lett. 103, 093001 (2009).

A 18.4 Wed 17:15 BAR 106

Induced inverse bremsstrahlung for cluster nanoplasmas in intense laser fields — •Max Moll[1], Paul Hilse[1], Thomas Bornath[2], Manfred Schlanges[1], and Vladimir P. Krainov[3] — [1]Institut für Physik, Universität Greifswald, Germany — [2]Institut für Physik, Universität Rostock, Germany — [3]Moscow Institute for Physics and Technology, Russia

During the interaction of noble gas clusters with intense laser fields, nanoplasmas with high density and high temperature are created. The heating of the clusters is significantly determined by inverse bremsstrahlung of the electrons due to electron-ion collisions. In this contribution we investigate the dependence of the heating rate on relevant parameters such as the mean ion charge, the laser field strength or the velocity of the electrons. Heating rates are calculated in first Born approximation as well as using a classical approach by solving Newton's equation. We study the influence of the inner ionic structure of the noble gas ions (Ar, Kr, Xe) on the heating rates which can be achieved by the use of appropriate model potentials. Also considered are screening effects due to the surrounding plasma medium.

The dependence of the results on the kinetic energy of the electrons is discussed. The comparison with Coulomb-particles in the different approximations shows that it is important to account for the inner ionic structure.

A 18.5 Wed 17:30 BAR 106

Pump-probe scattering experiments on exploding rare gas clusters at LCLS X-FEL — •Tais Gorkhover[1], Marcus Adolph[1], Daniela Rupp[1], Sebastian Schorb[1], Thomas Möller[2], Robert Hartmann[4], Daniel Rolles[3], Artem Rudenko[3], Ilme Schlichting[3,5], Lothar Strüder[4], Bill White[2], Joachim Ullrich[6], Ryan Coffee[2], and Christoph Bostedt[2] — [1]TU Berlin — [2]LCLS, Stanford — [3]ASG — [4]MPI HLL — [5]MPI MF — [6]MPI K

The interaction of strong, short laser pulses with large atomic clusters has become a vivid research field. The key point is the strongly increased energy absorption compared to single atoms, which has been shown for intense IR and up to VUV laser radiation. These results trigger an ongoing debate about the fs-fast absorption and recombination mechanisms, which happen during the cluster burst.

Our experiment gives a new insight by imaging the explosion dynamics at ~100 fs to 3 ps after the laser pulse in single shot modus. It was performed at the Linac Coherent Light Source (LCLS), which is recently the brightest available X-ray source with fs-pulse durations. Nm sized clusters were probed by the intense focused FEL beam after being irradiated with a strong, fs Ti:Sa pulse (800 nm). The cluster-pulse interaction was observed using simultaneously pnCCD detectors (scattering and fluorescence analysis) and ion /electron spectrometers (ionization processes insight). First results will be presented from both observation methods. This experiment was realized in the CFEL-ASG Multi-Purpose (CAMP) End Station.

A 18.6 Wed 17:45 BAR 106

Carrier-Envelope-Phase Effects in Non Sequential Double Ionization of Rare Gases — •Boris Bergues[1], Matthias Kübel[1], Nora G. Johnson[1,5], Kelsie J. Betsch[2], Robert R. Jones[2], Gerhard G. Paulus[3], Robert Moshammer[4], Joachim Ullrich[4], Ferenc Krausz[1], and Matthias F. Kling[1,5] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany. — [2]University of Virginia, Charlottesville, VA, USA — [3]Friedrich-Schiller-Universität, Jena, Germany — [4]Max-Planck-Institut für Kernphysik, Heidelberg, Germany. — [5]Kansas State University, Manhattan, KS, USA

Non-sequential Double Ionization (NSDI) of atoms in strong laser fields has been the subject of numerous experimental and theoretical studies. Yet, the mechanisms that govern this process are not fully understood. Advances in ultra-fast lasers technology have permitted the generation of light pulses with a duration close to a single optical cycle, which can be used to study quantum dynamics with attosecond time resolution. Using a reaction microscope in combination with the recently developed single-shot Carrier-Envelope-Phase (CEP) measurement technique, we investigate the sub-cycle dynamics of the NSDI process in Argon atoms exposed to near single-cycle laser pulses. Measurements of CEP-resolved two-electron coincidence spectra of NSDI are presented and discussed.

A 18.7 Wed 18:00 BAR 106

Correlated electron dynamics in high-order harmonic gener-

ation from H_2 — •Jing Zhao and Manfred Lein — Institut für Theoretische Physik and Centre for Quantum Engineering and Space-Time Research (QUEST), Leibniz Universität Hannover, Appelstraße 2, D-30167 Hannover, Germany

High-order harmonic generation from an H_2 model molecule is investigated by numerical solution of the two-electron Schrödinger equation. The harmonic spectrum is modulated by both structural and multi-electron dynamical interference effects. We reproduce the extrema by a simple model, based on the location of the hole left in the parent ion after ionization, the electronic wave-packet motion between ionization and recombination, and the recombination phase. Thus, the spectrum provides information about the location of the hole. It is found that the minimum at intermediate harmonic orders is mainly due to structural interference, while the minimum near the cutoff region is predominantly due to dynamical interference.

A 18.8 Wed 18:15 BAR 106

Ionization of atoms by strong infrared fields: Solution of the time-dependent Schrödinger equation in momentum space for a model based on separable potentials — Hugues Tetchou Nganso[1,2], Yuri Popov[3], Bernard Piraux[1], •Javier Madroñero[4], and Moïse Godfroy Kwato Njock[2] — [1]Université Catholique de Louvain, Belgium — [2]University of Douala, Cameroon — [3]Moscow State University, Russia — [4]Technische Universität München, Germany

We consider the ionization of atomic hydrogen by a strong infrared field. By starting from the corresponding time-dependent Schrödinger equation in momentum space, we develop a model in which the kernel of the non-local Coulomb potential is replaced by a finite sum of separable potentials. Each separable potential supports one bound state of atomic hydrogen. Here, we consider only the 1s, 2s and 2p states. In this way, the full 3-dimensional Schrödinger equation reduces to a system of a few coupled 1-dimensional linear Volterra integral equations. This model is a theoretical tool to understand the actual role of the atomic potential in the intensity regime where tunnel ionization is supposed to take place and where the experimental data for the first ATI peaks are in contradiction with the theoretical predictions based on the strong field approximation model.