A 9: Interaction with strong laser pulses II

Zeit: Dienstag 14:00–16:00 Raum: 5M

Hauptvortrag A 9.1 Di 14:00 5M

Correlated electron dynamics in few-cycle pulses — •Andreas Becker — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, D-01187 Dresden

Electron correlation consitutes a basic resource for the understanding of the dynamics of many-particle systems. Its relevance becomes particular obvious in the double ionization by intense Ti:sapphire laser radiation (for a review see e.g. [1]). We have recently analyzed the ionization of two-electron atoms [2] and molecules [3] using ab-initio simulations beyond the conventional one-dimensional approximation. In the model [2] the electron correlation is included in its full dimensionality, while the center-of-mass motion is restricted along the polarization axis. The analysis of the numerical results reveals two pathways of non-sequential double ionization, namely the emission of a highly correlated electron pair and the ionization of previously excited ions, which are both linked to the return of an initially singly ionized electron wave packet to the residual ion.

[1] A.Becker et al., J. Phys. B **38** (2005) S753
[2] C.Ruiz et al., Phys. Rev. Lett. **96** (2006) 053001
[3] S.Baier et al., Phys. Rev. A **74** (2006) 033405

A 9.2 Di 14:30 5M

Molecular tomography: test of accuracy and improvements using time-dependent calculations — •Elmar van der Zwan[1] and Manfred Lein[2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland — [2]Institut für Physik, Universität Kassel, Deutschland

Recently a method to perform tomographic imaging of molecular orbitals using High Harmonic Generation (HHG) has been proposed [1]. The method is based on the simplification that the returning electron in the three-step model can be modeled as a plane wave. We investigate the effect of this assumption in a time-dependent calculation by numerically comparing results for the final reconstructed orbital using two different methods which, without the plane-wave assumption, should lead to identical results; namely the reconstruction based on dipole matrix elements or on momentum matrix elements. An error reduction scheme is developed to post-process the results. Using *a priori* constraints like compactness and realness of the orbital, and knowledge about the type of error introduced, we can remove a large part of the error. We present results for molecules with both anti-symmetric and asymmetric valence orbitals, as they cause problems in the original scheme.

[1] J. Itatani, J. Levesque, D. Zeidler, H. Niikura, H. Pépin, J.C. Kieffer, P.B. Corkum and D.M. Villeneuve. *Tomographic imaging of molecular orbitals*. Nature 432, 867-871 (2004)

A 9.3 Di 14:45 5M

Ionisation von Atomen mit Lichtpulsen aus einem 6 MHz Laseroszillator — •Sebastian Tschuch[1], Yunquan Liu[1], Martin Dürr[1], Robert Moshammer[1], Joachim Ullrich[1], Martin Siegel[2] und Uwe Morgner[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Leibniz-Universität Hannover, Welfengarten 1, 30167 Hannover

Durch innovative Laserkonzepte ist es heutzutage möglich Intensitäten von $10^{14} - 10^{15}$ W/cm^2 direkt mir einem Laseroszillator zu erzeugen. Im Vergleich zu verstärkten Lasersystemen ergibt sich eine um 3 Großenordnungen höhere Pulswiederholrat [1]. Diese Lichtquelle macht Ionisationsexperimente bei kleiner Ereigniswahrscheinlichkeit möglich und erschließt somit einen interessanten Intensitätsbereich, der durch den Übergang von der Multiphotonenionisation zur Feldionisation beschrieben werden kann. Von besonderem Interesse ist dabei das Verhalten der nichtsequenziellen Doppelionisation, so sagt z.B. das semiklassische "recollision model" eine Intensitätsschwelle vorher. Im Beitrag werden erste Ergebnisse eines neuen Versuchaufbaus diskutiert.

[1] S. Dewald et. al., Opt.Lett. 31 (2006), 2072

A 9.4 Di 15:00 5M

Coulomb effects in strong-field ionization — •Sergei Popruzhenko — Max-Planck-Institut für Kernphysik, Postfach 10 39 80, 69029 Heidelberg, Germany

Recent high-resolution experiments with atoms subjected to short intense laser pulses have generated new interest to the role of long-range atomic field in the ionization dynamics. Here we present a new method of including Coulomb effects in the description of the strong field ionization. The approach is based on the Kapitza method of separation the classical electron dynamics into fast oscillations and slow-varying motion. The method is applied for description of the Coulomb peculiarities in above-threshold ionization (ATI) spectra. In particular, the cusp and the double-hump structures in the photoelectron momentum distribution in a linearly polarized field, as well as the fourfold symmetry violation of the angular distributions with elliptical laser polarization are reproduced in good agreement with the data. Besides, the method gives an insight into the problem: why do Coulomb effects in ATI spectra remain quite pronounced even in the strong-field limit? Basically, this feature results from the fact that relatively weak but slow-varying Coulomb force induces an accumulating effect which can survive after averaging over many laser periods.

A 9.5 Di 15:15 5M

Plasmon-enhanced multiple ionization C_{60} in intense short pulse laser fields down to 9 fs — •Ihar Shchatsinin, Tim Laarmann, Gero Stibenz, Günter Steinmeyer, Andrei Stalmashonak, Nickolai Zhavoronkov, Claus Peter Schulz, and Ingolf Volker Hertel — Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, Max-Born-Str. 2A 12489 Berlin-Adlershof, Germany

The interaction of C_{60} fullerenes with 800 nm laser pulses as short as 9 fs at intensities up to 4×10^{14} Wcm^{-2} is investigated with photoion spectroscopy. The excitation time lies well below the characteristic time for electron - electron and electron - phonon coupling. Thus, energy deposition into the system is much shorter than the energy redistribution among the various electronic and nuclear degrees of freedom. The observations indicate that for final charge states $q > 1$ the C_{60} giant plasmon resonance is involved in the absorption process and a significant amount of large fragments is created through non-adiabatic multi-electron dynamics (NMED) even with 9 fs pulses [1]. In contrast, singly charged ions are generated by an essentially adiabatic single active electron mechanism (SAE) and negligible fragmentation is found when 9 fs pulses are used. These findings promise to unravel a long standing puzzle in understanding C_{60} mass spectra generated by intense fs laser pulses.

[1] I. Shchatsinin, T. Laarmann, G. Stibenz, G. Steinmeyer, A. Stalmashonak, N. Zhavoronkov, C. P. Schulz and I. V. Hertel, J. Chem. Phys. 125 (2006) 194320/1-15

A 9.6 Di 15:30 5M

Nonsequential double recombination in intense laser fields — Peter Koval, Florian Wilken, •Dieter Bauer, and Christoph Keitel — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg

A second plateau in the harmonic spectra of laser-driven two-electron atoms is observed both in the numerical solution of a low-dimensional model helium atom and using an extended strong field approximation [1]. It is shown that the harmonics well beyond the usual cut-off are due to the simultaneous recombination of the two electrons, which were emitted during different, previous half-cycles. The new cut-off is explained in terms of classical trajectories. Classical predictions and the time-frequency analysis of the ab initio quantum results are in excellent agreement. The mechanism corresponds to the inverse single photon double ionization process in the presence of a (low frequency) laser field. Its low efficiency can be enhanced with the help of attosecond xuv pulses that control the emission times of the two electrons.

[1] P. Koval, F. Wilken, D. Bauer, C.H. Keitel, Phys. Rev. Lett. (accepted); preprint physics/0609010.

A 9.7 Di 15:45 5M

Orbital imaging with high harmonics: single- vs. multi-electron approach — •Gerald Jordan and Armin Scrinzi — TU Wien, Institut für Photonik

The imaging of molecular orbitals by electron rescattering is revisited from the multi-particle point of view. The interpretation of the experimental data has so far largely relied on the single-active electron approximation, whereby the imaged object is identified with the HOMO of the molecule. In multi-electron systems, correlation tends

to blur the distinction between individual orbitals. We investigate the viability of the single-electron approximation and the significance of the single-electron orbitals (in particular the Dyson orbital).

We use the MCTDHF (multi-configuration time-dependent Hartree-Fock) method to systematically account for correlation effects. Laser ionization of a 3-dimensional model diatomic molecule is simulated with 2 and 4 active electrons. The high harmonic spectra obtained with MCTDHF are compared with two single-electron models based on the Dyson orbital: the strong-field approximation (Lewenstein model), and the solution of the TDSE for an effective 1-electron Hamiltonian with the Dyson orbital built in as the ground state.

The Lewenstein spectra fail to qualitatively reproduce the multi-electron results. Solution of the 1e-TDSE allows to further distinguish between effects related to the SFA and the SAE. The features of the harmonic spectra are associated with the time structure of the rescattering current, which in turn reflects molecular multi-electron ionization dynamics.