A 5: Interaction with intense laser pulses I: Atoms

Zeit: Dienstag 11:00–13:00 Raum: 3C

Hauptvortrag A 5.1 Di 11:00 3C

Time-resolved mapping of correlated electron emission from Helium atom in an intense laser pulse — •Camilo Ruiz Mendez — Max-Planck-Institut für Physik komplexer Systeme Nöthnitzer Straße 38 01187 Dresden

We apply and analyze the concept of mapping ionization time onto the final momentum distribution to the correlated electron dynamics in the non-sequential double ionization of Helium in a strong laser pulse ($\lambda = 800$ nm) and show how the mapping provides insight into the double ionization dynamics. To this end, we study by means of numerical integration of the time dependent Schroedinger equation of a fully correlated model atom the temporal evolution of the center-of-mass momentum in a short laser pulse.

Our results show that in the high intensity regime ($I_0 = 1.15 \times 10^{15}$ W/cm^2) the mapping is in good agreement with a classical model including binary and recoil rescattering mechanisms. In the medium intensity regime ($I_0 = 5 \times 10^{14}$ W/cm^2) we identify additional contributions from the recollision-induced excitation of the ion followed by subsequent field ionization (RESI).

A 5.2 Di 11:30 3C

Wavelength Dependence of Strong-Field Non-Sequential Multiple Ionization — •Manuel Kremer[1], Artem Rudenko[1], Bettina Fischer[1], Oliver Herrwerth[1], Vitor de Jesus[2], Karl Zrost[1], Georg Gademann[1], Konstantin Simeonidis[1], Thorsten Ergler[1], Bernold Feuerstein[1], Claus Dieter Schröter[1], Robert Moshammer[1], and Joachim Ullrich[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [2]Centro Federal de Educação Technológica de Química de Nilópolis, Rio de Janeiro, Brazil

We present recoil-ion momentum distributions for Non-sequential double and multiple ionization (NSDI, NSMI) of Ar and Ne by 1300nm laser pulses (pulse duration 35-40fs, peak intensity $3-5*10^{14}W/cm^2$) measured with a *Reaction Microscope*, and compare them with our earlier results at 800nm. The spectra at both wavelengths can be consistently interpreted within a simple semiclassical model which we developed earlier in order to explain atomic structure dependence observed at 800nm. There two mechanisms of NSDI have been considered: (i) direct (e,2e) ionization by the returning electron and (ii) recollision-induced excitation with subsequent field ionization (RESI). A deeper minimum at zero longitudinal momentum for 1300nm is shown to be due to the suppression of the contribution from the latter channel. In good agreement with the results of the calculation, we found that at both wavelengths RESI mechanism is more important for Ar than for Ne.

A 5.3 Di 11:45 3C

Experiments on non-sequential double ionization of Ne and Ar using a femtosecond laser oscillator — •yunquan liu[1], sebastian tschuch[1], martin dürr[1], artem rudenko[1], robert moshammer[1], joachim ullrich[1], martin siegel[2], and uwe morgner[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]University of Hannover, Welfengarten 1, D-30167 Hannover, Germany

We report on first proof-of-principles results on non-sequential double ionization of argon and neon achieved by using a newly developed long-cavity Ti:sapphire femtosecond oscillator with a pulse duration of 45 fs and a repetition of 6.2 MHz combined with a dedicated reaction microscope. Under optimized experimental conditions, peak intensities larger than 2.3×10^{14} W.cm^{-2} have been achieved. Ion momentum distributions were recorded for both rare gases and show significantly different features for single as well as for double ionization. For single ionization of neon a spike of zero-momentum electrons is found when decreasing the laser intensity towards the lowest ionization rate we can measure which is attributed to a non-resonant ionization channel. As to double ionization, the longitudinal momentum distribution for Ne^{2+} displays a clear double-hump structure whereas this feature is found to be smoothened out with a maximum at zero momentum for Ar^{2+}.

A 5.4 Di 12:00 3C

Density-functional approach to strong-field electron dynamics of the Helium atom — •Mark Thiele and Stephan Kümmel — Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth

Time-dependent density-functional theory is a formulation of quantummechanics that uses the density as the basic variable. In principle, it provides a computationally attractive approach to non-perturbative processes. We investigate its performance by applying it to the one-dimensional Helium atom in a strong laser field. Specifically, we analyze an approximation of the correlation-potential that is adiabatic in time but exact otherwise. Our results show that this approximation yields excellent results for processes like the Helium double ionization. This finding has important consequences for the development of density-functionals for strong-field processes.

A 5.5 Di 12:15 3C

Ionization dynamics of multiply charged ions in intense laser fields — •Henrik G. Hetzheim, Guido R. Mocken, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The ionization dynamics is an essential process of the interaction of atoms with intense laser fields [1]. In order to compensate the high atomic field strength in hydrogen-like multiply charged ions, strong laser fields are necessary to stimulate the ionization dynamics. We focus on the investigation of the initial ionization process, when the electron leaves the nucleus. The angular distribution of the outgoing electron provides a tool to determine the associated field strength [2], which is experimentally difficult to measure [3]. The analysis of the ionization process is carried out by solving the Dirac equation in two dimensions, where the magnetic field force of the laser field is taken into account.

[1] Y. I. Salamin, S. X. Hu, K. Hatsagortsyan, C. H. Keitel, Phys. Reports **427**, 41–155 (2006)
[2] in preparation
[3] G. A. Mourou, T. Tajima, S. V. Bulanov, Rev. Mod. Phys. **78**, 309–371 (2006)

A 5.6 Di 12:30 3C

Long-orbit effects in nonsequential double ionization — •Sergey Popruzhenko[1], Nikolay Shvetsov-Shilovski[2], Sergey Goreslavski[2], and Wilhelm Becker[3] — [1]Max-Planck Institut für Kernphysik, Heidelberg, Deutschland — [2]Moscow Engineering Physics Institute, Moscow, Russia — [3]Max-Born-Institut, Berlin, Deutschland

Basic quantum processes with atoms and molecules subject to intense laser fields, including above-threshold ionization, generation of high-order harmonics and nonsequential double ionization (NSDI), can be described and understood within the concept of complex quantum trajectories (orbits). The quantum orbits approach not only allows us to evaluate transition amplitudes, which are inaccessible by other methods, but also provides a simple semiclassical picture capable of predicting new effects. Usually the quantum orbit shortest in time provides the major contribution to the probability amplitude, while the long orbits are of minor importance, due to the photoelectron wave packet spreading. In this work, we show that in the case of NSDI in elliptically polarized light long orbits corresponding to the second and the third returns of the photoelectron to its parent ion contribute more than the first one. We discuss a qualitative effect based on the left-right asymmetry in the electron-electron correlation spectra, which permits us to discriminate the return contributing most under certain conditions. We also propose an experimental scheme for the visualization of this effect.

A 5.7 Di 12:45 3C

Strong field tunneling without ionization — Thomas Nubbemeyer[1], •Karsten Gorling[1], Alejandro Saenz[2], Ulli Eichmann[1], and Wolfgang Sandner[1] — [1]Max Born Institut, Max Born Str 2a 12489 Berlin — [2]AG Moderne Optik, Institut für Physik, Humboldt-Universität zu Berlin

In the tunneling regime of strong laser field ionization we measure a substantial fraction of neutral atoms surviving the laser pulse in excited states. The measured neutral atom yield extends over several orders of magnitude as a function of laser intensity. Our findings are compatible with the strong field tunneling-plus-rescattering model, confirming the existence of a widely unexplored neutral exit channel which originates from tunneling within a narrow range of the laser field phase (*frustrated tunneling ionization*). Both quantum mechanical and semi-classical calculations show that the interaction with combined Coulomb and laser fields leads to a neutral excited state distribution centered around $n = 6 - 10$, in agreement with the experimental results.