A 9: Interaction with Strong or Short Laser Pulses I

Zeit: Dienstag 10:30–12:30 Raum: VMP 6 HS-C

Hauptvortrag A 9.1 Di 10:30 VMP 6 HS-C

Atomic and molecular ionization dynamics in strong laser fields: Excited neutral fragments after tunneling

— •Ulli Eichmann — Max-Born Institut, Berlin, Germany

Ionization and fragmentation dynamics of atoms and molecules in strong laser fields has been well studied with a strong focus on charged fragments and high harmonic generation. In this talk we report our observation of excited neutral fragments after exposing atoms and molecules to strong laser fields. Our experiments have been made possible by direct detection of excited neutral atoms. An explanation of the creation of excited states of atoms in strong laser fields can be found in an extension of the rescattering model by a process which we call Frustrated Tunnel Ionization (FTI)[1]. It leads to the recapture of those electrons into bound excited states which tunnel within a narrow range of laser field phases that does not allow for a high enough drift energy to escape. Results from semi-classical calculations are in quantitative agreement with full quantum mechanical calculations. More striking appears the extrapolation to molecules, where we observe the appearance of fast excited neutral fragments after exposure of diatomic molecules to a strong laser pulse, an hitherto unobserved fragmentation channel [2]. We show that polarization dependent measurements of the excited neutral fragment yield and correlated measurements of ions and excited neutral atoms together with classical Monte Carlo simulations confirm our assumption on the underlying model.

[1] T. Nubbemeyer et al., PRL 101, 233001 (2008).
[2] B. Manschwetus et al., PRL, submitted (2008).

Fachvortrag A 9.2 Di 11:00 VMP 6 HS-C

Pikosekunden-Elektronenbeugung von selektiv ausgerichteten Molekülen

— Peter Reckenthäler[1,2], Martin Centurion[1], Werner Fuss[1], Alexander Apolonski[2], Ferenc Krausz[1,2] und •Ernst Fill[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [2]Ludwig-Maximilians-Universität München, Am Coulombwall 1, 85748 Garching

Die Aufklärung der Struktur großer Moleküle ist eine der großen Herausforderungen der strukturellen Biologie und Chemie. Um die Grenzen der gegenwärtigen Technik - Röntgenbeugung von Molekülen in kristalliner Phase - zu überwinden, demonstrieren wir Elektronenbeugung von ausgerichteten Molekülen in der Gasphase.

Der Wirkungsquerschnitt eines parallelen Photodissoziations-Übergangs ist proportional zum Quadrat des Cosinus des Winkels zwischen Polarisationsrichtung und Dissoziationsachse. Aus diesem Grund zeigen die erzeugten Radikale eine transiente Ausrichtung parallel zur Polarisation, während die undissoziierten Moleküle in einer Ebene senkrecht dazu ausgerichtet sind. Wir zeigen dies durch zeitaufgelöste Elektronenbeugung von photodissoziiertem 1,2-Diiodotetrafluoroethan (C2F4I2).

Die Moleküle werden in einem Überschallstrahl durch linear polarisierte UV Laserpulse dissoziiert. Synchron mit den Laserpulsen treffen Pikosekunden-Elektronenpulse auf die Moleküle und werden an diesen gebeugt. Die Bilder zeigen eine deutliche Anisotropie der Beugungsringe. Mit Hilfe der Pump-Abfrage-Technik wird die Dephasierung des erzeugten Rotationswellenpakets verfolgt.

A 9.3 Di 11:30 VMP 6 HS-C

Coulomb-corrections for strong field ionization using quantum trajectories

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A theory describing above-threshold ionization of atoms and ions in a strong electromagnetic field is presented [1]. It is based on the widely known strong field approximation and incorporates the Coulomb interaction between the photoelectron and the nucleus using the method of complex classical trajectories. By comparing our predictions with the results of *ab initio* numerical solutions we show that the new theory provides a significant improvement over the Coulomb-free strong field approximation [1,2]. Moreover, with the same method a simple, analytical, nonrelativistic ionization rate formula for atoms and positive ions in intense ultraviolet and x-ray electromagnetic fields is derived. The rate is valid at arbitrary values of the Keldysh parameter and confirmed by results from *ab initio* numerical solutions [3]. The proposed rate is particularly relevant for experiments employing the new free electron laser sources.

[1] S.V. Popruzhenko and D. Bauer, J. Mod. Opt. 55, 2573 (2008).
[2] S.V. Popruzhenko, G.G. Paulus, and D. Bauer, Phys. Rev. A 77, 053409 (2008).
[3] S.V. Popruzhenko, V.D. Mur, V.S. Popov, and D. Bauer, Phys. Rev. Lett. 101, 193003 (2008).

A 9.4 Di 11:45 VMP 6 HS-C

Time resolved two-color scattering experiments on clusters at the FLASH-FEL

— •M. Adolph[1], D. Rupp[1], D. Wolter[1], S. Schorb[1], H. Thomas[1], R. Unterumsberger[1], R. Hartmann[2], N. Kimmel[2], L. Strüder[2], D. Rolles[3], A. Rudenko[3], K.U. Kühnel[4], J. Ullrich[4], T. Feigel[5], H. Wabnitz[6], T. Laarmann[6], R. Treusch[6], T. Möller[1], and C. Bostedt[1] — [1]TU - Berlin, IOAP — [2]MPI Halbleiterlabor — [3]ASG/MPG — [4]MPI Kernphysik — [5]Frauenhofer IOF — [6]DESY

The rapid development of ultra bright soft X-Ray sources (FEL) makes the imaging of nano samples and bio molecules might become feasible. The evolution and interaction of nano scale samples in the X-Ray laser pulses is only scarcely investigated, even though it is critical for the success of the prospective imaging experiments. We are developing an experimental approach for two-color scattering experiments based on the inherently correlated harmonics of the FEL for studying the X-Ray inducted dynamics in clusters. The wavelength separation and pulse delay are realized with multilayer optics. The detector unit is based on three pn-CCD cameras. With this setup first single shot, single wavelength scattering experiments have already been accomplished. The obtained scattering data has been compared with simulations based on Mie's theory. Free parameters for this calculation are the size parameter, describing the ratio of the cluster size and the wavelength, and the complex refractive index. The refractive index is correlated to the electronic structure of the cluster. The experiments shed light on the electron dynamics during the femtosecond X-Ray pulses.

A 9.5 Di 12:00 VMP 6 HS-C

Interference phenomena in strong field ionization of noble gas dimers

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Strong-field photoionization of argon, krypton and xenon dimers by a 30 fs laser pulse ($\lambda = 800nm$) is investigated below the saturation intensity of the respective atom using electron-ion coincidence momentum spectroscopy. The dimers undergo single or double ionization, resulting in either a molecular ion or Coulomb explosion of the dimer.

The momentum distribution of the photoelectrons from single ionization of the dimers shows a prominent feature originating from the two center structure of the dimers. This feature can not be reproduced completely by a SFA based simulation, which incorporates 2-center interference [1]. More complex electron dynamics during the ionization process may be responsible for the observed deviations.

Coulomb explosion allows the investigation of double ionization of the dimers with fixed in space molecular axis. The atomic ions angular distribution is nearly isotropic (see also [2]). Their kinetic energy distribution is very sharp and corresponds to the Coulomb repulsion energy at the equilibrium internuclear separation of the neutral dimer.

[1] Z.Ansari *et al.*, New Jour. of Phys. **10**, 093027 (*2008*)
[2] S. Minemoto and H. Sakai, Phys. Rev. A **75**,033413 (*2007*)

A 9.6 Di 12:15 VMP 6 HS-C

Acceleration of Electrons in Vacuum with Intense Laser Pulses

— •Stefanie Lourenco, Nicolas Kowarsch, and Werner Scheid — Theoretische Physik, Justus Liebig Universität Gießen, Deutschland

High intense laser pulses can be used in order to achieve high energies (TeV) for electrons in future accelerators. We study the acceleration of electrons in the vacuum with short laser pulses which have an extension of roughly a half wave length. For that we consider a three-dimensional laser pulse which approximately solves the Maxwellian's equations. For a laser pulse forming a plane wave in the transversal direction the electron acceleration can be expressed in simple analytical formulas. Next we plan to solve the Maxwell's equations exactly for a three-dimensional short laser pulse. Then we can calculate the electron acceleration more precisely.