A 8: Interaction with intense laser pulses II: Molecules and beyond

Zeit: Dienstag 14:00–16:00 Raum: 3C

Hauptvortrag A 8.1 Di 14:00 3C

Applications of laser aligned molecules — •Henrik Stapelfeldt — Department of Chemistry, University of Aarhus, Denmark

Moderately intense, non-ionizing laser pulses can align molecules along axes fixed in the laboratory [1]. This talk will initially discuss recent results aimed at controlling the 3-dimensional alignment of asymmetric top molecules. In particular, we show how a long laser pulse can strongly confine one axis of a molecule while a second, much shorter pulse, sets the molecule into controlled rotation about the axis arrested. As a result strong 3D alignment occurs immediately after the short pulse and is repeated periodically reflecting the revolution about the axis aligned. Our method opens new directions for field-free 3D alignment and for controlling internal rotations of molecules [2].

Second, we report the first experimental observations of orientationally resolved photoelectron angular distributions using laser aligned molecules [3]. The effect is illustrated by field-free aligned carbon disulfide molecules singly ionized by multiphoton absorption from an intense 800 nm pulse. The experimental results are compared to calculations with the strong field approximation.

[1] H. Stapelfeldt and T. Seideman, Rev. Mod. Phys., 75, 543 (2003). [2] S. S. Viftrup, V. Kumarappan, S. Trippel, H. Stapelfeldt E. Hamilton and T. Seideman, Phys. Rev. Lett., 99, 143602 (2007). [3] V. Kumarappan, et al., to be submitted (2007).

A 8.2 Di 14:30 3C

Electron-nuclear correlation in above-threshold-ionization of molecular hydrogen — •Stefan Pieper[1] and Manfred Lein[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Institut für Physik, Universität Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany

The ionization of molecules in strong, short laser pulses leads due to the absorption of many photons to "ATI peaks" in the kinetic-energy spectrum of the emitted electron. Because of the occupation of various vibrational levels of the remaining ion, the ATI peaks are smeared out. This is a consequence of energy loss for some electrons in favor of the ionic vibration. The numerical simulation of a model hydrogen molecule via solving the time-dependent Schrödinger equation shows that the intrinsic, discrete energy scale of the vibrational levels leads to the observation of novel correlation effects such as spectral enhancements within the rescattering plateau for certain vibrational states.

A 8.3 Di 14:45 3C

Ionization and fragmentation of C_{60} fullerenes as a function of the fs laser light ellipticity — •Ihar Shchatsinin[1], Tim Laarmann[1], Nick Zhavoronkov[1], Claus Peter Schulz[1], and Ingolf Volker Hertel[1,2] — [1]Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, Max-Born-Str. 2a, D-12489 Berlin, Germany — [2]Department of Physics, Free University Berlin, Arnimallee 14, D-14195 Berlin, Germany

The C_{60} fullerene is an interesting model to study the interaction dynamics of a large but finite system with strong laser fields. In the current work we have investigated the effect of the laser radiation ellipticity on the ionization and fragmentation of C_{60} utilizing both time-of-flight mass and photoelectron spectroscopy. A strong influence of the light ellipticity on the formation of fragments and parent ions was found for 27 fs laser pulses centred at 800 nm in the intensity range between 0.5×10^{14} W/cm^2 and 4.3×10^{14} W/cm^2. For the lower laser intensities photo ionization and photo fragmentation yields decrease with increasing ellipticity, while for the highest laser intensities the yields show a rise when the laser polarization is changed from linear to circular. It clearly indicates that recollisions during the strong field excitation can play only a minor role under the present experimental conditions. Possible theoretical models explaining these results will be discussed in detail. Comparison between the experimental observations and theoretical description allows to obtain new information about properties of C_{60} and to make a further step towards full understanding of fs laser induced dynamics in large and complex systems.

A 8.4 Di 15:00 3C

Einfachionisation kleiner, ausgerichteter Moleküle in starken Laser-Feldern — •Moritz Meckel[1], André Staudte[1,2], Daniel Comtois[3], Dirk Zeidler[2,4], David Villeneuve[2], Paul Corkum[2] und Reinhard Dörner[1] — [1]Institut für Kernphysik, J. W. Goethe-Universität Frankfurt, Max-von-Laue-Straße 1, Frankfurt, Deutschland — [2]National Research Council, 100 Sussex Drive, Ottawa, Ontario, Kanada — [3]INRS-Énergie, Matériaux et Télécommunications, 1650 boul. Lionel-Boulet, Varennes, Québec, Kanada — [4]Carl Zeiss SMT AG, Rudolf-Eber-Straße 2, Oberkochen, Deutschland

Mittels der Technik der "impulsiven Molekülausrichtung" ("Impulsive Molecular Alignment") ist es möglich, die räumliche Orientierung der Achsen kleiner Moleküle zu kontrollieren.
Die Impulse von Elektronen, die bei der Einfachionisation derart ausgerichteter N_2- und O_2-Moleküle in starken ($I = 3 \cdot 10^{14} \frac{W}{cm^2}$), nicht-resonanten ($\lambda = 800nm$), ultrakurzen ($\tau = 40fs$) Laser-Pulsen entstehen, wurden mithilfe der COLTRIMS-Technik bestimmt. Die Elektronen-Impulsverteilungen aus "alignten" und "anti-aligneten" Molekülen werden verglichen.

A 8.5 Di 15:15 3C

Finite-size, geometry, and many-electron effects in strong field ionization — •Dieter Bauer[1] and Sergey Popruzhenko[1,2] — [1]Max Planck Institute for Nuclear Physics, Heidelberg, Germany — [2]Moscow State Engineering Physics Institute, Moscow, Russia

We investigate the strong field ionization dynamics of finite-size systems such as metal clusters and C_{60}. By comparing the results from the numerical solution of the time-dependent Schrödinger equation in single active electron approximation with those from time-dependent density functional theory (i.e., the solution of the corresponding time-dependent Kohn-Sham equation) we identify the role of the collective electron motion inside the target system. By comparing, e.g., the results for C_{60} with those for a metal cluster of the same size we identify the role of the geometry of the target. We find that the non-adiabatic dynamics inside the target may lead to extended cut-offs in the above-threshold ionization spectra which depend on the laser frequency and the target size. The geometry of the target affects the angular distribution of the photoelectrons.

A 8.6 Di 15:30 3C

Laser-assisted pair creation — •Erik Lötstedt, Ulrich D. Jentschura, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

We present results on the laser-assisted Bethe-Heitler pair creation process. With Bethe-Heitler pair creation is understood the process where an electron-positron pair is created by a photon with energy $\hbar\omega$ in the vicinity of a nucleus. We study the modification of this process in the presence of a strong laser field, however with a peak electric field strength below the critical Schwinger field. The matrix element is related to that of laser-assisted bremsstrahlung [1,2] by a crossing symmetry. Especially interesting is here the transition from $\hbar\omega < 2mc^2$, where the process is laser-induced, to the laser-assisted case where $\hbar\omega > 2mc^2$. Here ω is the angular frequency of the non-laser mode photon, and m the electron mass. Also treated is a novel algorithm for the numerical evaluation of generalized Bessel functions, a type of special function occurring in the theoretical description of laser-matter interaction.

[1] E. Lötstedt, U. D. Jentschura, and C. H. Keitel, Phys. Rev. Lett. **98**, 043002 (2007).
[2] S. Schnez, E. Lötstedt, U. D. Jentschura, and C. H. Keitel, Phys. Rev. A **75**, 053412 (2007).

A 8.7 Di 15:45 3C

Magnetic-field effects in electron-positron pair creation by counterpropagating laser pulses — •Matthias Ruf, Guido R. Mocken, Carsten Müller, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

Until now the study of electron-positron pair production by counterpropagating laser fields has been based on the approximation of neglecting the spatial dependence of the field. We employ a numerical approach [1] by propagating a negative-energy Dirac electron on a two-dimensional grid via the split-operator algorithm. This enables us to take the magnetic field of the laser pulses into account. We show that for high frequencies the creation process is strongly affected: the production probability is reduced, the resonant Rabi-oscillation pat-

tern is significantly modified and the resonance positions are shifted and multiplied [2].

[1] G. R. Mocken and C. H. Keitel, J. Comp. Phys. 199, 558 (2004)

[2] M. Ruf, G. R. Mocken, C. Müller, K. Z. Hatsagortsyan and C. H. Keitel: in preparation