

MO 22: Poster: Molecules in Strong Fields

Time: Thursday 17:00–19:00

Location: Tent C

MO 22.1 Thu 17:00 Tent C

Dissociation Dynamics of Diiodomethane following XUV-induced inner-shell ionisation — ●F. TROST¹, H. LINDENBLATT¹, S. MEISTER¹, K. SCHNORR¹, S. AUGUSTIN¹, G. SCHMID¹, Y. LIU¹, P. SCHOCH¹, F. HOSSEINI², M. ZMERLI², M. BRAUNE⁵, M. KUHLMANN⁵, S. DÍAZ-TENDERO⁴, F. MARTÍN⁴, R. GUILLEMIN², M.-N. PIANCASTELLI³, M. SIMON², T. PFEIFER¹, C. D. SCHRÖTER¹, and R. MOSHAMMER¹ — ¹Max-Planck-Institut für Kernphysik, Heidelberg — ²Sorbonne Université, Paris — ³Uppsala Universitet — ⁴Universidad Autónoma de Madrid — ⁵DESY, Hamburg

Knowledge of de-excitation, charge redistribution and fragmentation of molecules upon XUV irradiation is essential for our understanding of light-matter interaction. Here, the sequential three-body fragmentation of diiodomethane (CH₂I₂) following 4d inner-shell ionisation of one iodine atom is presented. The data was obtained by a time-resolved XUV-XUV pump-probe measurement using the reaction microscope endstation at the free-electron laser FLASH2 at DESY. In the two-step dissociation process of the CH₂I₂ molecule a rotating intermediary state is identified through time-resolved 3D momentum correlation of the fragments. These results are supported by classical as well as quantum-mechanical simulations.

MO 22.2 Thu 17:00 Tent C

Energy and Charge Transfer in Xenon Dimers and Trimers after XUV-photoionization at FLASH2 — ●HANNES LINDENBLATT¹, KIRSTEN SCHNORR², SVEN AUGUSTIN², SEVERIN MEISTER¹, FLORIAN TROST¹, PATRIZIA SCHOCH¹, GEORG SCHMID¹, YIFAN LIU¹, MARKUS BRAUNE³, MARION KUHLMANN³, ROLF TREUSCH³, CLAUDIUS DIETER SCHRÖTER¹, THOMAS PFEIFER¹, and ROBERT MOSHAMMER¹ — ¹Max-Planck-Institut für Kernphysik, Heidelberg — ²Paul Scherrer Institut, Villigen, Schweiz — ³DESY, Hamburg

We investigated the relaxation dynamics of xenon dimers and trimers employing momentum coincidence spectroscopy at the reaction microscope beamline FL26 at FLASH2. Using the grazing incidence split, delay and focusing optics, an XUV-XUV pump-probe scheme was utilized to track dissociation dynamics. On the poster, we present the measurement scheme and time-resolved results for different fragmentation channels. For example, in dimer-fragmentation we identified the role of radiative electron-transfer, and for trimers the so-called electron transfer-mediated decay (ETMD3), where all three atoms are involved, was observed as function of time.

MO 22.3 Thu 17:00 Tent C

Time-resolved Imaging of CH₄ Fragmentation in Strong Laser Fields — ●WEIYU ZHANG, DAVID VACAS CHICHARRO, NIKOLAS RAPP, THOMAS PFEIFER, and ROBERT MOSHAMMER — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Deutschland

With a Reaction Microscope (ReMi) [1] the ionization and dissociation dynamics of methane in strong laser fields were studied in a series of pump-probe experiments. For the creation of temporally separated laser pulses and pulse shaping a spatial light modulator (SLM) was used. It allows control of laser pulses in terms of amplitude, polarization, and phase [2, 3]. By employing the SLM technique we successfully compressed the laser pulses to below 10 fs and achieved a precise control over the time-delay between the two pulses. Upon strong-field ionization the molecule undergoes fragmentation and Coulomb explosion (CE) [4] and the corresponding ionic fragments are collected with the ReMi. For example, in the case of CE the initial inter-nuclear distances can be determined via the measurement of final kinetic energies, and in pump-probe measurements the evolution of the molecular geometry is visualized as function of time. Selected results will be presented and discussed.

References:

- [1] J. Ullrich et al., 2003, Rep. Prog. Phys. 66, 1463-1545
- [2] Stefanie Kerbstadt, 2016, MA thesis. Universität Oldenburg
- [3] T Brixner and G Gerber, 2001, Opt. Lett. 26,557-559
- [4] Larsen, J et al., 1998, J. Chem. Phys. 109, 8857-8863

MO 22.4 Thu 17:00 Tent C

Dynamics of Molecules in Intense Laser Fields Studied with a

Reaction Microscope — ●MARTÍN GARRO, ARNE SENFTLEBEN, and JOCHEN MIKOSCH — Institut für Physik, Universität Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany

Intense laser fields can drive coherent electronic dynamics in a molecule on a timescale faster than the optical cycle of the light field. Electron wavepackets released by field-assisted tunneling ionization can be accelerated and driven back to the ion core with substantial energy by the action of the oscillating laser field. Different attosecond processes may ensue upon return of the continuum wavepacket. Here we are particularly interested in the aspect of a laser-driven scattering experiment which leads to the diffraction of the wavepacket encoding structural information on the molecule.

A Reaction Microscope allows us to experimentally investigate the electron dynamics of molecules exposed to strong ionizing fields with coincidence detection of electron and ion momenta. On the one hand side, we will present our previous work on laser-driven rescattering with two different, simultaneously created electron wavepackets in the 1,3-butadiene molecule. We show that the return probability of the electron depends on the molecular frame and contains structural information of the ionized orbital. On the other hand we will discuss our progress towards recollision and diffraction experiments on chiral molecules at the University of Kassel.

MO 22.5 Thu 17:00 Tent C

Electron-nuclear energy sharing through low-energy inelastic recollisions in dissociative multiphoton ionization of D₂ — ●SEBASTIAN HELL¹, GERHARD G. PAULUS^{1,2}, and MATTHIAS KÜBEL^{1,2} — ¹Institute for Optics and Quantum Electronics, Universität Jena, D-07743 Jena, Germany — ²Helmholtz Institute Jena, D-07743 Jena, Germany

Inelastic electron recollisions are known to contribute to high (*i.e.* several eV) kinetic energy release (KER) ion emission from D₂ in strong laser fields. Low-KER ion emission (*i.e.* up to few eV), however, is typically understood to result from single or multiphoton absorption from the laser field. Using coincidence detection of the correlated final states of photoelectron and ionic fragments, we investigate the dissociative ionization of D₂ in an intense 515 nm laser field with a half-frequency perturbation. Our experimental results show unambiguous fingerprints of low-energy inelastic electron recollisions contributing to dissociation of D₂⁺, even at KER below 1 eV. Our observations provide evidence for vibrational excitation and dissociative electron capture following laser-driven electron collisions.

MO 22.6 Thu 17:00 Tent C

Time-resolved measurement of laser-induced dissociation of the argon dimer cation with a two-color pump-probe scheme — ●BO YING^{1,2,3}, GIORGIO VISENTIN^{2,3}, MATTHIAS KÜBEL^{1,2}, STEPHAN FRITZSCHE^{2,3,4}, and GERHARD G. PAULUS^{1,2,3} — ¹Institute of Optics and Quantum Electronics, Friedrich Schiller University Jena, Max-Wien-Platz 1, 07743 Jena, Germany — ²Helmholtz Institute Jena, Fröbelstieg 3, 07743 Jena, Germany — ³GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany — ⁴Institute for Theoretical Physics, Friedrich Schiller University Jena, Max-Wien-Platz 1, 07743 Jena, Germany

We present the time-resolved measurements of the photodissociation dynamics in the argon dimer cation Ar₂⁺, utilizing a pump-probe technique involving two different colors. In the experiment, the first laser pulse dissociates the generated Ar₂⁺ ions, and the consequent dynamics are probed by a time-delayed second pulse. In contrast to the previous measurements of the simplest molecular ion H₂⁺, the delay-dependent kinetic energy distribution of the fragments not only shows the breakage of Ar₂⁺ on the femtosecond time scale, but also reveals some intriguing features. Calculations of the potential energy curves of Ar₂⁺ and Ar₂ help to understand the origin of such features, which results from the inherent multielectron nature of these heavy ions. This capability paves the way to investigate the temporal dynamics of hitherto unexplored molecular ion targets.

MO 22.7 Thu 17:00 Tent C

Studies on the construction of a neon recycling system for High Harmonic Generation — ●RON DUCKE, MAXIMILIAN POL-LANKA, MAXIMILIAN FORSTER, and REINHARD KIENBERGER — Chair

for Laser and X-Ray Physics E11, Technical University Munich, Germany

The poster deals with a current project in which a neon recycling system is being implemented in our attosecond laboratory. In that, high harmonics, which are high-energy ultrashort light pulses, are generated in a vacuum chamber. For this purpose, neon gas is fed into this chamber and a pulsed near-infrared laser is focused on it. This produces the aforementioned high harmonics. By superimposing these pulses with the near-infrared laser pulse, physical effects can be measured in the attosecond range. This measurement technique is known as "attosecond streaking". The consumption of the required neon gas is one of the main costs of operating the laboratory (ca. 40.000 € in 2022). Previously, the gas was released into the exhaust air after passing through the chamber. The current attempt is to implement a recirculation of the neon gas. My efforts are aimed at reducing neon consumption and making the laboratory more sustainable on the one hand, but also massively reducing the costs of running the laboratory on the other. The first step is to collect the gas from the chamber and analyze its composition. The required set-up includes three pumps, a gas sampling bag and a measuring chamber with a mass spectrometer.

MO 22.8 Thu 17:00 Tent C

Attosecond Electron Dynamics of Surface-Oriented Iodomethane on Pt(111) — •SVEN-JOACHIM PAUL¹, PASCAL SCIGALLA¹, CHRISTIAN SCHRÖDER¹, KONSTANTIN SEIDENFUS¹, PETER FEULNER², and REINHARD KIENBERGER¹ — ¹Chair for laser and x-ray physics, E11, Technische Universität München, Germany — ²Surface and Interface Physics, E20, Technische Universität München, Germany

We report on attosecond streaking measurements of the electron photoemission process from Pt(111) surfaces covered in well-oriented iodomethane molecules. Attosecond streaking allows for the measure-

ment of relative time delays in photoemission from two energetically different bound electronic states. For this experiment, the photoemission from the platinum valence band has been timed against the photoemission of the iodine 4d orbital in iodomethane. A routine has been developed to control the self-assembly surface orientation process of the adsorbed iodomethane molecules by varying the coverage of the Pt(111) crystal. Depending on the surface coverage, iodomethane aligns vertically or horizontally on the surface. This enables the study of photoemission dynamics through a well-oriented potential. Attosecond streaking has then been systematically performed for nine different surface coverages, most of them in the sub-monolayer regime. With that, first-ever insights into the influence of adsorbate potential orientation and density on photoemission delay were possible.

MO 22.9 Thu 17:00 Tent C

Attosecond Chronoscopy of CO-Structures on Pt(111) — •KONSTANTIN SEIDENFUS, PASCAL SCIGALLA, SVEN-JOACHIM PAUL, and REINHARD KIENBERGER — Chair for Laser and X-Ray Physics, E11, Technische Universität München, Germany

This work investigates time delays occurring in the electron photoemission process of a Carbon-monoxide-covered Pt(111)-Surface, for which the attosecond streaking technique is used. The relative time delay in photoemission of multiple energetic differently bound electronic states can be measured with this technique. In this case, the platinum valence band is measured against the carbon valence band, at different coverages. A routine for sub-monolayer accurate, reproducible surface coverages of CO is developed and tested with TPD. Carbon monoxide has previously been investigated in the gas phase, where it was measured against a helium reference. CO orients itself vertically on the surface of the platinum crystal, whereas in gas the orientation is incoherent. This enables one to gain additional insight into the physical effect of an oriented potential on the photoemission process.