A 24: Interaction with Strong or Short Laser Pulses III (joint session A/MO)

Time: Thursday 14:30–16:00 Location: F107

Invited Talk A 24.1 Thu 14:30 F107

Intra-cavity photoelectron tomography with an intra-cavity velocity-map imaging spectrometer at 100 MHz repetition rate — •Jan-Hendrik Oelmann[1], Tobias Heldt[1], Lennart Guth[1], Janko Nauta[1,2], Nick Lackmann[1], Valentin Wössner[1], Stepan Kokh[1], Thomas Pfeifer[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Current address: Department of Physics, Swansea University, Singleton Park, SA2, United Kingdom

In a first experiment, we used intra-cavity velocity-map imaging (VMI) at 100 MHz repetition rate to investigate multi-photon ionization (MPI) events of xenon with high count rates, even at very low intensities [1]. For that, ultrashort pulses from a near-infrared frequency comb laser were amplified in a passive femtosecond enhancement cavity that we now use for extreme-ultraviolet frequency comb generation [2].

For tomographic reconstruction of photoelectron angular distributions (PADs) [3], we developed a compact VMI spectrometer and a polarization-insensitive enhancement cavity [4]. We will present our new setup that collects electron-energy spectra at high rates and allows to tomographically reconstruct 3D PADs from intra-cavity xenon MPI.

[1] J. Nauta et al., Opt. Lett. 45(8), 2156 (2020). [2] J. Nauta et al., Opt. Exp. 29(2), 2624 (2021). [3] M. Wollenhaupt et al., Appl. Phys. B 95(4), 647-651 (2009). [4] J.-H. Oelmann et al., Rev. Sci. Instrum., accepted (2022).

A 24.2 Thu 15:00 F107

Free electron vortices in multiphoton ionization of molecules — •Darius Köhnke, Cornelia Opp, Tim Bayer, and Matthias Wollenhaupt — Carl von Ossietzky university Oldenburg, Institute of Physics, Germany

Since their theoretical proposal [1] and their first experimental demonstration [2], free electron vortices have attracted significant attention. So far, most of the theoretical and all of the experimental investigations were performed on atoms. Here, we present the first experimental demonstration of free electron vortices by multiphoton ionization (MPI) of molecules. Specifically, we study the creation of molecular vortices on C_{60} fullerenes using counter rotating circularly polarized femtosecond laser pulse sequences generated from a white-light supercontinuum. Since the discovery of the C_{60} molecule it has served as a benchmark system to study photo-induced dynamics in complex systems. Due to its high symmetry, the C_{60} molecule, is an ideal system to bridge the gap between atoms and more complex systems such as polyatomic molecules and clusters. It has been shown that C_{60} exhibits distinct atom-like electronic orbitals, termed superatomic molecular orbitals (SAMOS) [3], which play an important role in the MPI of fullerenes. By tomographic reconstruction of the three-dimensional photoelectron momentum distribution, we show that ionization from a SAMO with the polarization-tailored laser field creates a six-armed free electron vortex. [1] J. M. Ngoko Djiokap et. al, Phys. Rev. Lett., 115(11), 2015 [2] D. Pengel et. al, Phys. Rev. Lett., 118(5), 2017 [3] M. Feng et. al, Science, 320(5874), 2008

A 24.3 Thu 15:15 F107

Intra-cavity multiphoton processes in a standing wave frequency comb — •Tobias Heldt[1], Jan-Hendrik Oelmann[1], Lennart Guth[1], Janko Nauta[1], Prachi Nagpal[1], Nick Lackmann[1], Nele Griesbach[1], Christoph Düllmann[2], Thomas Pfeifer[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Johannes Gutenberg-Universität, 55099 Mainz, Germany

The coherence of frequency combs gives rise to a wide field of powerful spectroscopic techniques. Additionally, the high repetition rate of a comb leads to experimentally manageable count rates even for processes with low cross-sections. We use these properties to study the nonlinear regime of atomic and solid-state light-matter interaction. To reach the necessary field strengths, we enhance a frequency comb at 100 MHz in a cavity to intensities of over 10^{13} W/cm^2. The polarization insensitive bow-tie ring cavity supports counterpropagating pulses which collide in the focus, where they generate a standing wave for the time of the pulse overlap. This geometry is promising because not only does it reduce the interaction volume, enhancing the resolution of our velocity map imaging (VMI) spectrometer [1], but it also allows Doppler-free excitation of atoms. The polarization of both pulses can be controlled independently and an additional third pulse renders versatile pump-probe experiments possible. Further, we plan to probe the field with nanometric tips and we investigate how plasmons could lead to an excitation of the nuclear isomeric state of thorium-229 on such tips. [1] J.-H. Oelmann et al., Rev. Sci. Instrum., accepted (2022)

A 24.4 Thu 15:30 F107

Time-resolved three-body fragmentation of the CH2I2 molecule upon XUV irradiation — •Florian Trost[1], Severin Meister[1], Hannes Lindenblatt[1], Kirsten Schnorr[1], Sven Augustin[1], Yifan Liu[1], Farzad Hosseini[2], Mustafa Zmerli[2], Markus Braune[5], Marion Kuhlmann[5], Sergio Díaz-Tendero[4], Fernando Martín[4], Renaud Guillemin[2], Maria Novella Piancastelli[3], Marc Simon[2], Thomas Pfeifer[1], and Robert Moshammer[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Sorbonne Université, Paris — [3]Uppsala Universitet — [4]Universidad Autónoma de Madrid — [5]DESY, Hamburg

Knowledge of de-excitation, charge redistribution and fragmentation of molecules upon XUV irradiation is essential for our understanding of light-matter interaction. Here I present the sequential three-body fragmentation of diiodomethane (CH2I2) following 4d inner-shell ionisation of one iodine atom. The data was obtained by time-resolved XUV-XUV pump-probe measurements using the reaction microscope endstation at the free-electron laser FLASH2 at DESY. In the two-step dissociation 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.

A 24.5 Thu 15:45 F107

Time operator, real tunneling time in strong field interaction and the attoclock. — •Ossama Kullie — Institute for Physics, University of Kassel.

In the present work [1], we show that our real tunneling time relation derived in earlier works [2] can be derived from an observable or a time operator, which obeys an ordinary commutation relation. Moreover, we show that our real tunneling time can also be constructed from the well-known Aharonov-Bohm time operator. This shows that the specific form of the time operator is not decisive, and dynamical time operators relate identically to the intrinsic time of the system. It contrasts the famous Pauli theorem, and confirms the fact that time is an observable, i.e. the existence of time operator and that the time is not a parameter in quantum mechanics. Furthermore, we discuss the relations with different types of tunneling times such as Eisenbud-Wigner time, dwell time and the statistically defined tunneling time. We conclude with the hotly debated interpretation of the attoclock measurement and the advantage of the real tunneling time picture versus the imaginary one. [1] O. Kullie, Phys. Rep. 2020,2, 233. [2] O. K. Phys. Rev. A. **92**, 052118 (2015), O. K. Ann. of Phys. **389**, 333 (2018),[4] O. K. Mathematics **6**, 192 (2018).