A 23: Strong laser fields - I (joint session A/MO)

Time: Tuesday 14:00–15:45 Location: K 2.019

Invited Talk A 23.1 Tue 14:00 K 2.019

Multiphoton Ionization of Chiral Molecules — •Thomas Baumert — Institut fuer Physik der Universitaet Kassel, Germany

Molecular chirality is widely recognized for its relevance to the building blocks of life and its vital role for medicine and health. Chiral recognition in the gas phase using electromagnetic radiation is an emerging research field and promising for fundamental research as well as for applications due to the non-interacting nature of molecules in the gas phase. Photoelectron angular distributions after one photon or multiphoton ionization turned out to be especially sensitive to that end and are usually measured by velocity map imaging (VMI) techniques. The corresponding circular dichroism is termed photoelectron circular dichroism (PECD). Based on electric dipole interaction, its magnitude of up to a few ten percent typically surpasses that of other chiroptical techniques and can be turned into a highly sensitive analytic tool with respect to investigation of enantiomeric excess. Resonance-enhanced multi-photon ionization (REMPI) gives access to electronic intermediates and, with the help of femtosecond laser excitation and ionization, PECD has been demonstrated on bicyclic ketones. As more angular momentum can be transferred in a multiphoton process in comparison to single photon ionization, higher order nodal structures were observed. An exploration of the nuclear and electron dynamics of the intermediate resonance may stimulate the development of laser driven purification schemes. In this talk I will present the field and our experiments. References are compiled for example in our latest publication: Kastner et al. JCP 2017, Vol. 147, 013926 (9 pp)

A 23.2 Tue 14:30 K 2.019

Non-linear dichroism in atomic ionization — •Jiri Hofbrucker[1,2], Andrey V. Volotka[1], and Stephan Fritzsche[1,2] — [1]Helmholtz Institute, Jena, Germany — [2]Friedrich-Schiller University Jena

Dichroic behavior is usually associated with an interaction of polarized atomic or chiral molecular target and circularly polarized light. However, in a non-linear interaction regime, elliptically polarized light ionizing symmetric target also produces a dichroic photoelectron angular distributions. The fundamental origin of this asymmetry explains why is the elliptical dichroism strictly a feature of multi-photon processes only, and why it is never observed in the single photon ionization process. Being energy and system specific, this phenomena give us an opportunity to study many-electron effects as well as fundamentals of non-linear light-matter interaction. Observation of this phenomena in two-photon ionization of an inner-shell shell electron of a rare gas atom is proposed.

A 23.3 Tue 14:45 K 2.019

Spin polarization and spin filtering of free electrons in bichromatic laser fields — Matthias M. Dellweg and •Carsten Müller — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf

Coherent electron scattering from intense laser fields of high frequency is studied theoretically. By solving the time-dependent Dirac equation it is shown that the combination of a fundamental laser mode with a counterpropagating second harmonic may act as a spin filter for free electrons, provided the field polarizations are chosen properly [1]. Besides, a spin-polarizing interferometric electron beam splitter is presented which relies on an arrangement of three pairs of counterpropagating laser waves [2]. The proposed laser field configuration is shown to exert the same effect on free electrons as an ordinary Stern-Gerlach magnet does on atoms.

[1] M. M. Dellweg and C. Müller, Phys. Rev. A 95, 042124 (2017)
[2] M. M. Dellweg and C. Müller, Phys. Rev. Lett. 118, 070403 (2017)

A 23.4 Tue 15:00 K 2.019

Deterministic control with sequences of intense pulses — •Stefano M. Cavaletto, Zoltan Harman, Thomas Pfeifer, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

Coherent-control methods and pulse-shaping technology have revolutionized our access to the quantum properties of matter. However, with widely used measurement-driven techniques, such as adaptive feedback control, the complex reaction pathways followed by an optimally controlled system often remain concealed. With intense time-dependent pulses dressing the atomic level structure, only a limited number of effective pulse-shaping strategies have been identified. Here, we put forward a deterministic scheme to fully reconstruct the action of an intense pulse on a quantum system from absorption-spectroscopy measurements, including the dependence upon possibly unknown pulse properties and atomic structures [S. M. Cavaletto *et al.*, *Phys. Rev. A* **95**, 043413 (2017)]. An optimal pulse sequence based on this extracted information can then be designed, facilitating manipulation and interpretation of the chosen control strategy. The scheme may be implemented also at x-ray energies with intense pulses from free-electron lasers, representing an effective route to x-ray quantum control.

A 23.5 Tue 15:15 K 2.019

Isotopic shifts measured via strong-field laser-atom interaction — •Nicolas Camus, Sofia Botsi, Lutz Fechner, Jose Crespo López-Urrutia, Thomas Pfeifer, and Robert Moshammer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

High-precision measurements of isotopic shifts in the energy levels of atoms can provide sensitive tests of our understanding of relativistic and QED effects [1]. We present a novel spectroscopic method to measure small isotopic shifts utilizing the coherent population of different states arising from strong-field ionization. We experimentally measure the isotope shift between ^{36}Ar, ^{38}Ar and ^{40}Ar for the $3s^23p^5$ ($^2P_{3/2} \rightarrow {}^2P_{1/2}$) transition in singly charged argon ions. We measure it by implementing a Ramsey-like scheme using two ultrashort (6 fs) laser pulses. The first laser pulse excites the system into a coherent superposition of the aforementioned states by removing an electron from the atomic p-shell of the neutral atom. This superposition leads to a spin-orbit wave packet (SOWP) oscillating with a period of T = 23.3 fs that lasts for long times (tens of ns). The second delayed pulse probes, after ∼170.000 cycles, the wavepacket dynamics of the system by further ionization, allowing for a precision determination of the spin-orbit frequency at the $\Delta E/E \sim 10^{-7}$ level . The detection of the different argon isotopes is made by a time-of-flight spectrometer. [1]. I. I. Tupitsyn et al., PRA 68, 022511 (2003)

A 23.6 Tue 15:30 K 2.019

Two pulse characterization by interferometric imaging of self-diffraction — •Christoph Leithold[1], Jan Reislöhner[1], Holger Gies[2,3], and Adrian N. Pfeiffer[1] — [1]Institute of Optics and Quantum Electronics, Abbe Center of Photonics, Friedrich Schiller University Jena, Germany — [2]Theoretisch-Physikalisches Institut, Abbe Center of Photonics, Friedrich Schiller University Jena, Germany — [3]Helmholtz-Institut Jena, Germany

A pulse characterization scheme based on interferometric, spectrally resolved imaging of self-diffraction [1] is presented. Similar to interferometric FROG [2] and MEFISTO [3], interferograms of the nonlinear signal are recorded for different pulse delays. Due to the noncollinear nature of the setup, it can be applied to over octave spanning waveforms by separating signals on the spatial frequency axis. Additionally to the temporal waveform the method also resolves one spatial dimension and is therefore not limited by geometrical effects like beam smearing [4], known from other noncollinear schemes. In fact, both fundamental pulses can be recovered from the same measurement. The retrieval of the pulses is carried out solely in the (temporal) frequency domain and can be done analytically as well as iterative numerically which is more robust when dealing with noisy data. [1] C. Leithold, J. Reislöhner, H. Gies and A.N. Pfeiffer Opt. Lett. 42, No. 23 in press. [2] G. Stibenz and G. Steinmeyer, Opt. Express 13, 2617 (2005). [3] Amat-Roldan, I. G. Cormack, P. Loza-Alvarez, and D. Artigas, Opt. Lett. 30, 1063 (2005). [4] A. C. Tien, S. Kane, J. Squier, B. Kohler, and K. Wilson, J. Opt. Soc. Am. B 13, 1160 (1996).