A 16: Interaction with strong or short laser pulses I

Time: Tuesday 14:30–16:30 Location: C/kHS

A 16.1 Tue 14:30 C/kHS

Stark dynamics revealed by the zero-energy-structure in strong-field photoelectron spectra — •Elias Diesen, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Dresden

A pronounced feature ("zero-energy-structure") at the meV scale has been observed [1] in photoionization spectra in the IR, high-intensity tunneling regime. We show that this peak is formed by a general mechanism: the constant electric field in the detector apparatus ionizes Rydberg states created by frustrated tunneling ionization [2]. The detailed structure of the peak is revealed using classical calculations, giving interesting general results on the Stark problem in this unusual regime and showing excellent agreement with experiments.

[1] Dura et al, Sci. Rep. 3, 2675 (2013)
[2] Nubbemeyer et al., Phys. Rev. Lett. 101, 233001 (2008)

A 16.2 Tue 14:45 C/kHS

Population of doubly excited states in the tunneling regime — •Lutz Fechner[1], Nicolas Camus[1], Andreas Krupp[1], Joachim Ullrich[2], Thomas Pfeifer[1], and Robert Moshammer[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Physikalisch-Technische Bundesanstalt, Braunschweig

The mechanism of frustrated tunneling ionization (FTI) has been identified recently as being responsible for the population of Rydberg states in strong laser fields in the tunneling regime [1]. Using a Reaction Microscope we obtained highly resolved electron momentum distributions resulting from ionization of noble gases at various wavelengths from 400 to 1600 nm. We present unique features visible in the low momentum regions that arise from autoionizing doubly excited states. Possible population scenarios include the excitation of the electronic core by the resonant recapturing of a slow, recolliding electron and thus a possible connection to dielectronic recombination processes [2, 3].

[1] T. Nubbemeyer et al., *Phys. Rev. Lett.* **101**, 233001 (2008)
[2] J.B.A. Mitchell et al., *Phys. Rev. Lett.* **50**, 335 (1983)
[3] D.S. Belic et al., *Phys. Rev. Lett.* **50**, 339 (1983)

A 16.3 Tue 15:00 C/kHS

Strong Field Ionization in ω-2ω Laser Pulses: Phase-of-the-Phase Spectroscopy — •Slawomir Skruszewicz, Josef Tiggesbäumker, Karl-Heinz Meiwes-Broer, Mathias Arbeiter, Thomas Fennel, and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

Coherent superposition of fundamental 800 nm (ω) laser beam with its second-harmonic (2ω) creates laser pulses with asymmetrical electric field distribution [1]. Controlling of the relative phase between them with sub-fs precision enables obtaining the relative-phase-tagged photoelectron spectra. Thus, the electron recollision dynamics can be studied in more details than conventional photoelectron spectroscopy. Here, we propose 'phase-of-the-phase spectroscopy' which applied to rare gas atoms and CO_2 unambiguously identifies photoelectrons that rescatter during first and second re-encountering their parent ion. Simple modelling in terms of Simple Man's Theory shows universality of the rescattering features. However closer inspection reveals finer details which are target sensitive and can be used to imaging electronic structure of the scattering center.

References: [1] N. Dudovich et al., Nature Physics **2**, 781 (2006) [2] S. Skruszewicz et. al., Int. J. Mass. Spectr. **365**, 338 (2014) [3] S. Zherebtsov et. al., New. J. Phys. **14**, 075010 (2012)

A 16.4 Tue 15:15 C/kHS

Measurements and Semi-classical analysis of Above Threshold Ionization Spectra in Orthogonal Two Color Fields — •Daniel Würzler[1,2], Max Möller[1,2], Max Sayler[1,2], and Gerhard G. Paulus[1,2] — [1]Institute of Optics and Quantum Electronics, Friedrich Schiller University Jena, Germany — [2]Helmholtz Institute Jena, Germany

Recent research shows that orthogonally polarized two color laser (OTC) fields can be used to gain control over sub-cycle electron dynamics in strong-laser ionization. While existing studies mainly focus on high harmonic spectra or electron-ion coincidence measurements done with a COLTRIMS, here we present electron spectra for Ne and Xe in OTC fields measured via velocity map imaging. To analyze these spectra, a semi-classical model is used to describe changes in the electron interference pattern and map the electron dynamics introduced by changing the phase between the two field components.

A 16.5 Tue 15:30 C/kHS

Exact correlated electron dynamics in full dimensionality: Applying time-dependent renormalized-natural-orbital theory (TDRNOT) to 3D He — •Julius Rapp, Martins Brics, and Dieter Bauer — Universität Rostock, Germany

A numerically affordable exact two-body scheme is desirable not only for describing driven He but any process where the single-active-electron picture breaks down due to two-body correlations.

In this talk we discuss the conceptual challenges when applying the recently introduced [1-3] TDRNOT scheme to He in full dimensionality. After expanding both the natural orbitals and their effective potentials in spherical harmonics we find that compared to the 1D-model case additional degeneracies in the occupation numbers can occur. As a result, one has to employ a suitable propagation scheme that is capable of handling these possible degeneracies. Moreover, we present several techniques to keep the numerical effort manageable. Finally, the practicability of TDRNOT implemented on a desktop computer for the exact treatment of both electrons in 3D He, subject to a strong laser field, is analyzed.

[1] M. Brics and D. Bauer, Phys. Rev. A **88**, 052514 (2013).
[2] J. Rapp, M. Brics, and D. Bauer, Phys. Rev. A **90**, 012518 (2014).
[3] M. Brics, J. Rapp, and D. Bauer, Phys. Rev. A **90**, 053418 (2014).

A 16.6 Tue 15:45 C/kHS

Nonsequential double ionization and radiation/absorption spectra with time-dependent renormalized-natural-orbital theory — •Martins Brics, Julius Rapp, and Dieter Bauer — Universität Rostock, Rostock, Germany

Time-dependent renormalized-natural-orbital theory (TDRNOT) is a promising approach to describe correlated electron quantum dynamics, even beyond linear response. It has been shown in [1] that TDRNOT with only two renormalized natural orbitals (RNOs) per spin is capable of describing correlated phenomena such as doubly excited states, autoionization, and Fano profiles in the photoelectron spectra for He. Here we go one step further and investigate the performance of TDRNOT for processes which involve more than two RNOs.

As the first test case we consider nonsequential double ionization (NSDI) as it is a very correlated process and therefore many RNOs are needed to describe it. Our two main observables for NSDI are the double-ionization probability and correlated photoelectron spectra. It is found that TDRNOT reproduces the celebrated NSDI "knee," i.e., a many-order-of-magnitude enhancement of the double-ionization yield (as compared to purely sequential ionization) with only the ten most significant natural orbitals (NOs) per spin. Correlated photoelectron spectra—as "more differential" observables—require more NOs [2].

The second test case is radiation/absorption spectra. Here we look at absorption line-shapes showing Lorentz/Fano profiles and ATI spectra.

[1] M. Brics, D. Bauer, Phys. Rev. A **88**, 052514 (2013).
[2] M. Brics, J. Rapp, D. Bauer, Phys. Rev. A **90**, 053418 (2014).

A 16.7 Tue 16:00 C/kHS

Spin Effects in Strong-Field Breit-Wheeler Pair Production — •Martin J.A. Jansen and Carsten Müller — Heinrich-Heine-Universität Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf

As predicted by Breit and Wheeler in 1934, highly energetic photons can materialize upon collision into electron-positron pairs. Owing to the ever increasing photon densities in current laser systems, this fundamental effect comes into reach of experimental capabilities and has actually been seen for the first time in the SLAC E144 experiment [1].

In this contribution, we investigate spin effects in Breit-Wheeler pair production induced by the collision of a laser field and high-energy gamma quanta. We present detailed calculations within the framework of strong-field QED. The laser field is modelled by a plane wave of either infinite or finite duration, where the latter allows for a more

realistic description of typical high-intensity laser fields. By comparing results obtained for scalar and spinor particles, respectively, we extend a previous study on the subject [2] and gain new insights into the fundamental role played by the particle spin in the pair production process.

[1] D. Burke et al., Phys. Rev. Lett 79, 1626 (1997)
[2] S. Villalba-Chavez and C. Müller, Phys. Lett. B 718, 992 (2013)

A 16.8 Tue 16:15 C/kHS

Narrowband inverse Compton scattering x-ray sources at high laser intensities — •Daniel Seipt[1], Sergey Rykovanov[1], Andrey Surzhykov[1], and Stephan Fritzsche[1,2] — [1]Helmholtz-Institut Jena, Fröbelstieg 3, 07743 Jena — [2]Universität Jena, Institut für Theoretische Physik, 07743 Jena

Narrowband x- and gamma-ray sources based on inverse Compton scattering of laser light suffer from a limitation of the allowed laser intensity due to the onset of nonlinear effects, which limits the photon yield. At high laser intensity the ponderomotive force changes the electrons' longitudinal velocity and leads to a variable red-shift during the scattering such that the scattered radiation's spectral bandwidth increases. In this talk I will discuss the possibilities to use chirped laser pulses to compensate this ponderomotive broadening and to reduce the bandwidth of the spectral lines, which would allow to operate narrowband Compton sources in the high-intensity regime [1]. The optimal frequency modulation of the initial laser pulse is derived from the strong-field QED scattering matrix element for nonlinear Compton scattering in the Furry picture, where the electron recoil and spin are taken into account [2].

[1] B. Terzić et. al., Phys. Rev. Lett. **112**, 074801 (2014).
[2] D. Seipt et. al., to appear.