A 24: Attosecond physics I

Time: Thursday 16:30–18:30 Location: BAR 205

A 24.1 Thu 16:30 BAR 205

Probing single-photon ionization on the attosecond time scale — •Kathrin Klünder[1], J. Marcus Dahlström[1], Mathieu Gisselbrecht[1], Thomas Fordell[1], Marko Swoboda[1], Diego Guénot[1], Per Johnsson[1], Jérémie Caillat[2], Johan Mauritsson[1], Alfred Maquet[2], Richard Taïeb[2], and Anne L'Huillier[1] — [1]Lund University, Department of Physics, Lund, Sweden — [2]Université Pierre et Marie Curie, Laboratoire de Chimie Physique-Matière et Rayonnement, France

Attosecond light sources allow us to measure fundamental quantities such as the time it takes for an electron to escape from an atom after photoabsorption [1]. We present an interferometric technique to time resolve photoemission on the attosecond time scale. We employ an attosecond pulse train for the excitation and a weak infrared laser field to probe the outgoing electron wave packet. We determine a difference in photoemission delay between electrons emitted from the 3s and from the 3p shells in argon as a function of excitation energy. We address the question of the influence of the probing field in the measurement process on this short time scales.

[1] M. Schultze *et al.*, Science **328**, 1658 (2010).

A 24.2 Thu 16:45 BAR 205

Qspider: Retrieval of the amplitude and phase of an electron wave packet using with attosecond and infrared pulses. — •Alexis Chacon[1] and Camilo Ruiz[2] — [1]Grupo de Investigación en Óptica Extrema (GIOE), Universidad de Salamanca, Pl. de la Merced s/n 37008 Salamanca. Spain — [2]Centro de Laseres Pulsados (CLPU), Pl. de la Merced s/n 37008 Salamanca. Spain

There is a large collection of optical techniques to characterize the amplitude and phase of a ultrashort laser pulse. Among these techniques there are SPIDER, FROG, FROG CRAB and RABBIT, etc. We propose to transfer some of the ideas of these optical techniques used for laser pulses but now for the characterization of electron wave packets (EWP) in atoms and molecules using attosecond pulse trains and infrared pulses. In particular, we try to implement the SPIDER technique to retrieve the amplitude and phase of an electron wave packet.

The SPIDER technique for laser pulses is based in the construction of an spectral interferogram and the application of an algebraic algorithm to obtain the spectral phase. The main elements used to build this interferogram are: 1) the generation of two copies of the pulse, 2) the use of a time delay between the two copies, 3) the introduction of a spectral shearing, and 4) the measurement of the spectral interferogram. The same steps can be implemented with EWP using the tools of attoscience.

In this paper we show the demonstration of the technique by retrieving the amplitude and phase of the electric dipole in the H_2^+ molecule and exploring the best parameters for an accurate retrieval.

A 24.3 Thu 17:00 BAR 205

Testing electron correlation in Helium using attosecond pulses — •Camilo Ruiz — Centro de Laseres Pulsados (CLPU), Plaza de la Merced s/n, Salamanca 37008, Spain

Using a full quantum model beyond the one dimensional model, we are able to study the double correlated double ionization of Helium in several regimes. For example in the near IR, we have investigated the correlated momentum distribution of both electrons from nonsequential double ionization of helium in a $\lambda = 800$ nm laser, with intensity $I = 4.5 \times 10^{14}$ W/cm^2.

We observe a fingerlike structure in the correlated electron momentum distribution that can be interpreted as a signature of the microscopic dynamics in the recollision process. To study related process such as the excitation by recollision we make use of attosecond pulses to probe the dynamics of ionization. In this paper we introduce this novel technique to estudy the interaction that could lead increase the accuracy of the description of the correlated processes.

A 24.4 Thu 17:15 BAR 205

Interference of two attosecond pulses in the process of ionization gating — •Christian Ott, Philipp Raith, Michael Schönwald, Andreas Kaldun, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

High-order harmonics are generated in neon using few-cycle (∼ 6 fs) carrier-envelope-phase(CEP)-stabilized laser pulses from a commercial TiSa laser amplifier in the 10^{14} W/cm^2 intensity regime. Exploiting spatio-temporally designed phasematching conditions resulting in ionization gating on the leading edge of the driving laser pulse, interference patterns of few (predominantly two) attosecond pulses in the 70 to 100 eV XUV spectral range have been experimentally observed in our lab at MPIK. The CEP dependence of these interference patterns will be presented, analyzed and compared to the theoretically expected phasematching response of coherently driven macroscopic media in the ionization gating regime. The results demonstrate the possibility to use collective coherence properties of a nonlinear medium towards attosecond pulse shape control.

A 24.5 Thu 17:30 BAR 205

High Harmonic Generation from liquid water droplets — •H.G. Kurz[1,2], D.S. Steingrube[1,2], T. Vockerodt[1,2], E. Schultz[1,2], D. Ristau[3], M. Lein[4], U. Morgner[1,2,3], and M. Kovacev[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Deutschland — [2]QUEST - Centre for Quantum Engeneering and Space-Time Research — [3]Laser Zentrum Hannover e.V., Deutschland — [4]Institut für theoretische Physik, Leibniz Universität Hannover, Deutschland

The generation of coherent radiation within the extreme ultraviolet spectral region is a vastly-growing research area of modern quantum optics. High Harmonic Generation (HHG) is based on nonlinear frequency conversion in gases, liquids and bulk media. With increasing target density, an enhancement of the conversion efficiency can be observed. Not only atoms serve as a target, but also clusters and molecules are extensively studied.

In this contribution, a micrometer-sized liquid water droplet source for debris-free HHG is presented, combining a high density with a molecular target. The droplets are prepared under vacuum condition, preventing reabsorption effects. The harmonic radiation is generated with a 100 fs, 795 nm laser pulse, provided by a chirped pulse amplification laser system. Results of pump-probe experiments and parametric studies concerning phase-matching effects are shown.

A 24.6 Thu 17:45 BAR 205

Beiträge der Elektronentrajektorien zur Erzeugung hoher harmonischer Strahlung in einer Semi-Infiniten Gaszelle — •Martin Kretschmar, Daniel S. Steingrube, Emilia Schulz, Uwe Morgner und Milutin Kovacev — Leibniz Universität Hannover, Institut für Quantenoptik, Welfengarten 1, D-30167 Hannover, Germany

Die Entstehung hoher harmonischer Strahlung (HHG) im Bereich des Plateaus wird weitestgehend durch zwei verschiedene Elektronentrajektorien bestimmt, welche sich aufgrund ihrer unterschiedlichen Kohärenzzeiten unterscheiden lassen. Untersuchungen hierzu wurden bereits am Gasjet durchgeführt [1]. Wir untersuchen die Beiträge der Elektronenbahnen und deren Beeinflussung über Variation einzelner Phasenanpassungsparameter in einer Semi-Infiniten Gaszelle. Hierzu wird ein Verstärkersystem mit einer Zentralwellenlänge von 800 nm sowie einer Pulsdauer von 30 fs nach einem Mach-Zehnder-Interferometer in die Semi-Infinite Gaszelle fokussiert, in welcher hohe harmonische Strahlung an Xe erzeugt wird. Wir identifizieren die Beiträge der Trajektorien zur harmonischen Strahlung über deren unterschiedliche Kohärenzzeiten. Darüber hinaus ist es möglich die Trajektorienbeiträge zu kontrollieren und somit die Erzeugung von Attosekundenpulsen zu beeinflussen.

[1] Bellini et al. Phys Rev A, Vol 60, No 6 , 1999

A 24.7 Thu 18:00 BAR 205

Sideband oscillation by two-color ionization experiments — •Alexander Sperl, Helga Rietz, Ram Gopal, Andreas Fischer, Konstantin Simeonidis, and Joachim Ullrich — MPI für Kernphysik, 69115 Heidelberg

Noble gas atoms can be ionized by irradiation with an extreme-ultraviolet (XUV) attosecond pulse train emitting electron wave packets. These pulses are synthesized from harmonics generated by focusing an infrared laser beam (IR with a pulse duration of 30 fs, single pulse energy of 0.6 mJ and wavelength at 777 nm) into an argon gas tube at a pressure of 80 mbar. Both the attosecond pulse train and the electron wave packets can be characterized by superimposing the XUV and the fundamental IR fields and considering the energy transfer to the electron wave packets as a function of time delay between both fields resulting in oscillating energy-sidebands, a technique referred to as RABBIT (reconstruction of attosecond beating by interference of two-photon transitions) [1], [2]. The three-dimensional dynamics of the photoelectrons however can now be studied in more detail by combining the XUV light source with a Reaction Microscope. In this context we changed the polarisation of the XUV and the IR fields with respect to each other by 90°, detecting a remarkable change of the angular distribution of the sideband-photoelectrons.

[1] H. G. Muller, et. al., Appl. Phys. B 74, 2002 [2] P. Johnsson, et. al., Journal of Modern Optics 53, 2006

A 24.8 Thu 18:15 BAR 205

Attosecond dynamics in few-cycle laser driven electron emission from sharp metal tips — •Markus Schenk, Michael Krüger, and Peter Hommelhoff — Max-Planck-Insitut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching bei München, Germany

By focusing low-power few-cycle Ti:Sa pulses tightly onto sharp tungsten tips strong-field effects such as peak suppression and peak shifting in ATP spectra have been observed [1,2]. Here we use carrier-envelope phase (CEP) stabilized pulses and measure the electron energy spectra for varying CEP. We observe a CEP dependent modulation in the current that increases in amplitude to about 40% for higher-energetic electrons. Furthermore we observe a clear change in the spectral peak visibility when the phase is changed by π. These findings can be understood in the picture of time-energy interferometry of the electron emission. For a double slit, fringes result in the energy domain, whereas no fringes result for the single slit. We compare our experimental findings with numerical integration of the time-dependent Schrödinger equation and find good agreement. With this interpretation sub-optical cycle (attosecond) and electric-field sign sensitive emission dynamics results. This system is complementary in nature to atomic systems, which is why we expect it to answer open questions of attosecond physics.

[1] M. Schenk, M. Krüger, P. Hommelhoff, accepted for publication in Physical Review Letters (2010)

[2] see contribution of M. Krüger et al. at this conference