A 20: Experiments with FLASH and FEL perspectives: an overview

Zeit: Donnerstag 11:00–13:00 Raum: 3C

Hauptvortrag A 20.1 Do 11:00 3C

On the path towards table-top free-electron-lasers — •Florian Gruener[1], Matthias Fuchs[2], Raphael Weingartner[2], Benjamin Marx[2], Stefan Becker[2], and Dieter Habs[2] — [1]Max-Planck Institute of Quantum Optics, Garching, Germany — [2]University of Munich, Munich, Germany

One of the key projects within the Cluster of Excellence "Munich-Centre for Advanced Photonics" (MAP) is the realization of a table-top free-electron-laser (FEL). In general, FELs are the world's most brilliant light sources allowing totally new experiments, such as "4D imaging" in the X-ray range like single molecule imaging. Owing to the immense size and costs, world-wide only a few X-ray FELs are planned and only a few VUV FELs are in operation. These large-scale FELs are based upon conventional electron accelerators. In contrast, we propose to utilize laser-plasma accelerated electrons with their unprecedented high peak currents. In principle this allows to shrink the size of an FEL down to meter-scale instead of tens or hundred of meters. In this talk the principle possibility is discussed as well as the milestones planned on the path towards the first proof-of-principle experiment. The potential of such future table-top FELs is immense as their smaller size and higher photon energies reachable than in case of large-scale XFELs would even allow the usage in hospitals for medical diagnostic (such as phase-contrast imaging for mammography). We also address applications in nuclear physics.

A 20.2 Do 11:30 3C

Two-photon ionization of neon at 91 eV photon energy — •Ulrike Frühling[1], Marek Wieland[2], Elke Plönjes-Palm[1], Michael Gensch[1], and Markus Drescher[2] — [1]Desy, Hamburg — [2]Universität Hamburg

For measurement of the temporal properties of optical pulses the nonlinear response of an optical medium on two optical fields of different or the same color is often used to realize cross- or autocorrelation schemes. The observation of nonlinear processes e.g. multiphoton-ionisation induced by short-pulse coherent extreme ultraviolet (XUV) radiation opens up the possibility of applying these correlation techniques in the XUV range. We have studied two-photon ionization of neon by photoelectron spectroscopy at the soft-x-ray free-electron laser in Hamburg (FLASH). The photon energy was 91 eV. The XUV-beam was focused using a multilayer mirror to irradiance levels of up to $10^{14} W/cm^2$, leading to features in the electron spectrum which can be attributed to nonlinear processes.

A 20.3 Do 11:45 3C

Atoms in the focus of an extreme-ultraviolet laser — •Mathias Richter[1], Andrei A. Sorokin[1,2], Kai Tiedtke[3], and Hubertus Wabnitz[3] — [1]Physikalisch-Technische Bundesanstalt, Abbestraße 2-12, 10587 Berlin, Germany — [2]Ioffe Physico-Technical Institute, Polytekhnicheskaya 26, 194021 St. Petersburg, Russia — [3]Deutsches Elektronen-Synchrotron, Notkestraße 85, 22603 Hamburg, Germany

First investigations at the new Free-electron LASer in Hamburg FLASH [1] on rare gases have shown that multiphoton ionization at photon energies above ionization thresholds is dominated by sequential processes via ionic states [2]. However, in a recent work on xenon atoms, irradiance levels of more than 1000 terawatt per square centimeter were achieved at a photon energy of 93 electron volts by microfocusing of the FLASH beam with the aid of a spherical extreme-ultraviolet multilayer mirror [3]. Although these experiments were performed within the regime of the classical photoelectric effect, explanation of the unexpected high degrees of photoionization observed seems to be beyond the scope of the perturbation theory and photons as the light particles. As an extension of this study, we present and discuss, here, also new results on the generation of Li-like neon under similar conditions.

[1] W. Ackermann et al., Nature Photonics 1, 336 (2007)
[2] A. A. Sorokin et al., Phys. Rev. A 75, 051402(R) (2007)
[3] A. A. Sorokin et al., Phys. Rev. Lett. 99, 213002 (2007)

A 20.4 Do 12:00 3C

Xe clusters in intense laser pulses of the FLASH FEL: on vs. below 4d innershell resonance excitation — •Heiko Thomas[1], Christoph Bostedt[1], Matthias Hoener[1], Ekaterina Eremina[1], Thomas Möller[1], Hubertus Wabnitz[2], and Rolf Treusch[2] — [1]IOAP - Technische Universität Berlin — [2]Hasylab at DESY

The interaction of rare gas clusters with intense vacuum ultraviolet radiation from the DESY free electron lasers has yielded many surprising results. In first experiments performed with 100 nm radiation at power densities up to 10^{13} W/cm^2 the clusters disintegrated completely in a strong Coulomb explosion and kinetic energies of the resulting ions up to a few keV were measured.

We have investigated the interaction of intense light pulses from the FLASH - FEL below (32 nm) and in (13 nm) the Xe giant 4d resonance at power densities up to 10^{15} W/cm^2. The data show for resonant excitation significantly higher charge states and higher kinetic energies of the ions leaving the cluster. However, both experiments at short wavelength exhibit lower energy absorption compared to the previous investigations at 100 nm. In addition to the wavelength dependence, the data will be discussed in terms of cluster size and laser intensity.

A 20.5 Do 12:15 3C

Ultrafast imaging of clusters with intense soft - ray pulses from the FLASH - FEL — •Christoph Bostedt[1], Ekaterina Eremina[1], Daniela Rupp[1], Markus Adolph[1], Heiko Thomas[1], Matthias Hoener[1], Hubertus Wabnitz[2], Rolf Treusch[2], and Thomas Möller[1] — [1]IOAP - Technische Universität Berlin — [2]Hasylab at DESY

Intense, short laser pulses in the x-ray regime from free-electron lasers (FELs) hold great promise for future single-shot imaging experiments on individual molecules. We have performed first scattering experiments on atomic clusters with $\lambda = 13$ nm laser pulses at intensities up to 10^{14} W/cm^2 from the FLASH-FEL at DESY in Hamburg. The data shows clear diffraction patterns for single cluster, two-cluster, and double-cluster events. Comparing the scattering data to classical Mie theory unveils distinct differences for the depth of the minima and the slope of the data which can be attributed to the changing optical constants of the cluster in an intense laser pulse and softening of the cluster edge due to the onset of Coulomb explosion. Further, the possibility of probing transient plasma properties through scattering experiments with atomic clusters is discussed.

A 20.6 Do 12:30 3C

Untersuchung von Mehr-Photonen-Prozessen in Edelgasen mit winkelauflösender Photoelektronenspektroskopie am FLASH — •Markus Braune[1], Axel Reinköster[1], Jens Viefhaus[2], Bernd Lohmann[3] und Uwe Becker[1] — [1]Fritz-Haber-Institut der MPG, 14195 Berlin — [2]DESY, 22607 Hamburg — [3]Universität Münster, 48149 Münster

Mit winkelauflösender Photoelektronenspektroskopie wurden in Experimenten bei FLASH Mehr-Photonen-Ionisationsprozesse verschiedener Edelgase untersucht. Man beobachtet intensive sequentielle und etwa 100mal schwächere simultane Ionisationsprozesse, deren Zwischen- und Endzustände anhand der Photoelektronenenergien unterschieden werden können. Besondere Bedeutung hat die Analyse der Abhängigkeit der Signalstärke von der Lichtintensität und der Winkelverteilung der Photoelektronenemission dieser Prozesse. In den Intensitätsverläufen zeigt sich die Abhängigkeit der nachfolgenden Prozesse von der Erzeugung des ionischen Targets durch die Primärionisation. Die Winkelverteilungen der Photoemission enthalten Anteile höherer Ordnungen und weichen von einer reinen Dipolverteilung ab, welche nur von einem Parameter β_2 bestimmt ist. Der entsprechenden Parameter β_4 der höheren Ordnung kann bestimmt und mit neuesten theoretischen Rechnungen verglichen werden. Durch Messungen dieser Art werden systematische Studien verschiedener Ionisationsstufen des Targets und die Wechselwirkung zwischen simultanen und sequentiellen Prozessen möglich. Ergebnisse von den jüngsten Experimenten werden vorgestellt.

A 20.7 Do 12:45 3C

From Fission to Explosion: a Momentum Resolved Survey over the Rayleigh Instability Barrier — •Matthias Hoener[1], Sebastian Schorb[1], Heiko Thomas[1], Lutz Foucar[2], Thomas Möller[1], and Christoph Bostedt[1] — [1]IOAP, TU Berlin, Germany — [2]IKP, Uni Frankfurt a.M., Germany

We investigated the fragmentation processes of Ne (liquid)- and Xe (solid)-clusters with a momentum resolving reaction microscope. Irra-

diating different sized clusters with different excitation energies leads through Auger decays to a distinct amount of average charge on the clusters. Through variation of inner coulombic energy (E(coul)) and surface tension (E(sur)) we can set the fissility X of the the system (X=E(coul)/2E(sur)) based on the liquid trop model (LDM) for macroscopic particles. The fissility determines the scenario of fragmentation: X $<$ 1, non-isotropic fission into a few large, less energetic ions, X $>$ 1, isotropic explosion into many small, energetic ions. The COLTRIMS system enables us to detect all generated ionic fragments in a momentum resolved manner. In this way we can determine the three dimensional fragmentation geometry in dependance of X and the phases of the clusters. Both, the fragmentation pattern of liquid Ne- and solid Xe-clusters, show a very different behavior for the two regimes. The clusters show for X $<$ 1 a fission-like behavior and for X $>$ 1 an explosion-like behavior in qualitative agreement with the LDM. However, the data show a strong correlation of the fragmentation with the cluster phase.