Ultra-fast Dynamics in FEL Light Pulses (SYUF)

veranstaltet vom
Fachverband Atomphysik (A)

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Übersicht der Hauptvorträge und Fachsitzungen

(Hörsaal VMP 8 HS)

Hauptvorträge

SYUF 1.1	Mi	14:00–14:30	VMP 8 HS	**Atoms and molecules in intense FEL radiation** — •Artem Rudenko
SYUF 1.2	Mi	14:30–15:00	VMP 8 HS	**Electronic decay in clusters and molecules subject to intense FEL radiation** — •Vitali Averbukh, Ulf Saalmann, Jan Michael Rost
SYUF 1.3	Mi	15:00–15:30	VMP 8 HS	**Spectroscopy of Highly Charged Ions with Free Electron Lasers** — •Sascha Epp, Martin Simon, Thomas Baumann, Günter Brenner, Volkhard Mäckel, Paul Mokler, Hiro Tawara, Natalia Guerassimova, Evgeny Schneidmiller, Rolf Treusch, José Crespo Lopéz Urrutia, Joachim Ullrich
SYUF 1.4	Mi	15:30–16:00	VMP 8 HS	**Ultra-fast dynamics in atoms and solids** — •Alexander Föhlisch
SYUF 2.1	Mi	16:30–17:00	VMP 8 HS	**Pump-probe experiments at FLASH** — •Stefan Düsterer
SYUF 2.2	Mi	17:00–17:30	VMP 8 HS	**Chemistry with Free Electron Laser Radiation: Proof of Principle** — •Simone Techert
SYUF 2.3	Mi	17:30–18:00	VMP 8 HS	**Ultrafast processes and single shot imaging of clusters with intense soft x-ray radiation from the FLASH free electron laser** — •Christoph Bostedt
SYUF 2.4	Mi	18:00–18:30	VMP 8 HS	**Ultrafast Coherent Diffractive Imaging at FLASH** — •Henry Chapman

Fachsitzungen

SYUF 1.1–1.4	Mi	14:00–16:00	VMP 8 HS	**SYUF I**
SYUF 2.1–2.4	Mi	16:30–18:30	VMP 8 HS	**SYUF II**

SYUF 1: SYUF I

Zeit: Mittwoch 14:00–16:00 Raum: VMP 8 HS

Hauptvortrag SYUF 1.1 Mi 14:00 VMP 8 HS

Atoms and molecules in intense FEL radiation — •Artem Rudenko — Max Planck Advanced Study Group at CFEL, Nottkestrasse 85 22607 Hamburg

The emission of few electrons from atoms, molecules, clusters or solids constitutes one of the most fundamental processes occurring when intense VUV or X-ray radiation interacts with matter, underlying essentially all practical applications of free-electron lasers. Recent development of the Free electron LASer in Hamburg (FLASH) along with the progress in high-harmonics generation made multi-photon multi-electron transitions in this energy range experimentally accessible, triggering enormous theoretical interest and opening the way for a variety of time-resolved imaging schemes. Here an overview of recent experimental studies on few-photon-induced fragmentation of rare gas atoms and simple diatomic molecules performed at FLASH employing coincident cold-target recoil ion and electron momentum spectroscopy will be presented. Particular examples include a disentanglement of sequential and direct ('non-sequential') mechanisms for few-photon double ionization of Ne and He atoms, identification of different dissociation and Coulomb explosion pathways in FEL-induced fragmentation of N2, O2, D2 molecules, and the results of the first VUV-VUV pump-probe experiments. The latter measurements not only allow for a time-resolved mapping of fragmenting molecular states, but also yield valuable information on the properties of the FEL pulse via channel-selective analyses of autocorrelation-like patterns.

Hauptvortrag SYUF 1.2 Mi 14:30 VMP 8 HS

Electronic decay in clusters and molecules subject to intense FEL radiation — •Vitali Averbukh, Ulf Saalmann, and Jan Michael Rost — Max Plank Institute for the Physics of Complex Systems, Dresden, Germany

Electronic decay sets in after ionization or excitation of an inner-shell electron by absorption of a high-energy photon, and can proceed by a wide variety of physical mechanisms leading to emission of secondary electrons on femto- or attosecond time scales. A distinctive feature of the interaction of molecules and clusters with intense FEL pulses is the capability of the FEL to promote the target system into a highly ionized state well within the pulse duration. Practically, this means that the electronic decay processes induced by the FEL radiation occur in a highly charged environment. In this presentation, I will review our recent theoretical work on the effect of the charged environment on the intra- and inter-atomic decay processes in clusters and molecules. It will be shown that the presence of a neighboring charge can affect the decay rates, sometimes daramatically, through the distortion of atomic orbitals involved in the non-radiative electronic transitions. Moreover, it will be argued that for the processes leading to emission of relatively slow secondary electrons, the mere concept of the exponential decay characterized by a rate may no longer be applicable because of the trapping of the emitted electrons by the neighboring charges.

Hauptvortrag SYUF 1.3 Mi 15:00 VMP 8 HS

Spectroscopy of Highly Charged Ions with Free Electron Lasers — •Sascha Epp[1], Martin Simon[2], Thomas Baumann[2], Günter Brenner[2], Volkhard Mäckel[2], Paul Mokler[2], Hiro Tawara[2], Natalia Guerassimova[3], Evgeny Schneidmiller[3], Rolf Treusch[3], José Crespo Lopéz Urrutia[2], and Joachim Ullrich[2] — [1]Max Planck Advanced Study Group at CFEL, 22603 Hamburg, Germany — [2]Max-Planck-Institute für Kernphysik, 69117 Heidelberg, Germany — [3]DESY, 22603 Hamburg, Germany

Resonant laser spectroscopy of soft x-ray transitions in highly charged ions (HCIs) by means of Free Electron Lasers (FELs) has been proven to be a promising technique with the potential for unprecedented precision on energetic transitions unreachable by traditional laser spectroscopy. The technique relies on combining a state-of-the-art EBIT with a FEL (like FLASH), measuring the resonant fluorescence yield by the trapped HCIs after their excitation as a function of the wavelength of the FLASH-light. Three fundamental transitions at energies E_0 were investigated, namely $1s^2 2s\ ^2S_{1/2}$–$1s^2 2p\ ^2P_{1/2}$ in Li-like Fe^{23+} at 48.6 eV, Li-like Cu^{27+} at 55.2 eV, and $1s^2 2s\ ^2S_{1/2}$–$1s^2 2p\ ^2P_{3/2}$ in Fe^{23+} at 65.3 eV. The latter demonstrates resonant laser spectroscopy of multiply or highly charged ions at more than one order of magnitude higher transition energies as reported elsewhere. We attain presently a resolution of $E_0/\mathrm{FWHM} = 2500$ for the individual spectral lines, resulting in a relative precisions of 8 parts-per-million (ppm) for the determination of the center-of-mass wavelength per hour of beamtime.

Hauptvortrag SYUF 1.4 Mi 15:30 VMP 8 HS

Ultra-fast dynamics in atoms and solids — •Alexander Föhlisch — Institut für Experimentalphysik, Universität Hamburg, Germany

In materials science and femtochemistry, the frontier of knowledge spans from molecular surface dynamics for heterogeneous catalysis with little explored transition states to functional materials with often surprising properties and phase transitions as well as to chemical dynamics in solution. In these systems the interplay between local properties and nanoscale phenomena govern their physics and chemistry - and femtosecond soft X-ray pulses are ideal probes of their dynamics. FLASH has allowed us to take a great step into femtosecond time resolved X-ray methods based on innovative instrumentation for femtosecond time resolved soft X-ray spectroscopy and resonant X-ray scattering methods. In this talk the new physics we can access is explored through our research of femtosecond time resolved photoemission as well as resonant inelastic and elastic X-ray scattering for materials science at FLASH.

SYUF 2: SYUF II

Zeit: Mittwoch 16:30–18:30 Raum: VMP 8 HS

Hauptvortrag SYUF 2.1 Mi 16:30 VMP 8 HS

Pump-probe experiments at FLASH — •Stefan Düsterer — DESY, Hamburg, Germany

The free-electron laser FLASH is a unique tool to explore ultra-high intense XUV region. Besides the unrivalled intensity, the ultra-short pulse duration of only 10fs- 50 fs enables a wide field of time-resolved experiments. Several different pump-probe schemes have been implemented in the last years at FLASH. Besides XUV+XUV and the novel XUV+THz option, so far mainly XUV+optical pump-probe experiments have been performed. Besides a short overview of the various developments of the pump-probe infrastructure the talk will mainly focus on recent results of time-resoled experiments combining the FLASH-XUV radiation with optical femtosecond pulses.

Hauptvortrag SYUF 2.2 Mi 17:00 VMP 8 HS

Chemistry with Free Electron Laser Radiation: Proof of Principle — •Simone Techert — Max Planck Institute for Biophysical Chemistry, 37077 Goettingen, Germany

With their unique properties of brilliance, coherence and time-resolution free electron lasers open new possibilities for x-ray science. We will discuss the possibility of using FEL soft x-ray radiation for photo-inducing chemical reactions in the solid state. Recent ultrafast studies at the FLASH facility in Hamburg suggest that element specific excitations with FEL radiation lead to specific product states which can not be created by other methods. These states have been investigated by ultrafast optical reflectometry in a FLASH pump / optical light probe configuration. Furthermore, we have studied the ultrafast structural response function of supramolecular nanocrystals with a structural periodicity of 5.6 nm. These systems fulfil the Bragg condition in the soft x-ray regime and allow femtosecond time-resolved x-ray diffraction experiments. To our knowledge these are the first diffraction experiments on periodic structures with FEL radiation (down to a resolution of 0.2 Å) and confirm the possibility of using FEL radiation in crystallographic studies. By photon absorption from ultrafast optical laser sources elementary silver is formed in organic - inorganic composite nanocrystals. We have investigated the initial, ultrafast structural

steps underlying this chemical reaction.

Hauptvortrag SYUF 2.3 Mi 17:30 VMP 8 HS
Ultrafast processes and single shot imaging of clusters with intense soft x-ray radiation from the FLASH free electron laser — •Christoph Bostedt — Insitut f. Optik und Atomare Physik, Technische Universität Berlin

For many potential experiments with free electron lasers it is of fundamental importance to study the absorption and ionization properties of nanoscale systems in the short-wavelength strong-field domain.

We have performed first experiments about the soft x-ray laser pulse - cluster interaction with a combined spectroscopy and imaging approach. The new data show qualitatively different processes for (soft) x-ray pulses from the optical strong field regime. Electrons are emitted from the clusters in a direct multistep photoionization process and plasma type absorption is not significant. Resonant excitation of Xe clusters at 90 eV and power densities exceeding 10^{14} W/cm^2 yield high charge states of up to 9^+. The investigation of core - shell systems gives evidence for efficient charge redistribution within the cluster, leading to explosion of the cluster outer layers and recombination of the nanoplasma core.

For single-shot imaging of clusters with intense short wavelength radiation a new detector system has been developed. Mie calculations indicate that the optical constants of the clusters, which are inherently coupled to its electronic structure and thus charge states, change during the femtosecond pulse. The results show that ultra fast scattering is a promising approach to study transient states of matter on a femtosecond time scale.

Hauptvortrag SYUF 2.4 Mi 18:00 VMP 8 HS
Ultrafast Coherent Diffractive Imaging at FLASH — •Henry Chapman — CFEL, DESY, Hamburg, Germany

We have carried out high-resolution single-pulse coherent diffractive imaging at the FLASH free-electron laser. The intense focused FEL pulse gives a high-resolution low-noise coherent diffraction pattern of an object before that object turns into a plasma and explodes. We are developing imaging of biological specimens beyond conventional radiation damage resolution limits, developing imaging of ultrafast processes and testing methods to characterize and perform single-particle imaging. In particular our method of time-delay holography gives measurements of the dynamics of materials irradiated with intense FEL pulses, with 1 fs temporal resolution.