K 5: Laserstrahlwechselwirkung und Laseranwendungen

Zeit: Dienstag 14:00–16:00 Raum: HS 4

K 5.1 Di 14:00 HS 4

Selective mode filter in a large mode area fiber inscribed by ultrashort laser pulses — •Ria G. Krämer[1], Christian Voigtländer[1], Jens U. Thomas[1], Daniel Richter[1], Andreas Tünnermann[1,2], and Stefan Nolte[1,2] — [1]Insitute of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-University Jena, Max-Wien-Platz 1, D-07743 Jena, Germany — [2]Fraunhofer Institute for Applied Optics and Precision Engineering, Albert-Einstein-Str. 7, D-07745 Jena, Germany

We demonstrate a selective mode filter in a few mode large mode area (LMA) fiber inscribed directly with ultrashort pulses. The mode filter consists of refractive index modifications written alongside the core, into the cladding, where the change of the refractive index is of the same order of magnitude as the difference between core and cladding. The presence of the modulation causes a perturbation of the guiding modes, leading to coupling between the modes. Depending on length and position of the modification, light will couple from the higher order to the fundamental mode or vice versa. To characterize the functionality of the mode filter, a femtosecond inscribed fiber Bragg grating (FBG) providing spectral separation of the core modes was used. First, the FBG was written, followed then by the mode filter. During the inscription process the reflection spectrum of the FBG was measured in situ using a supercontinuum source, providing a length dependent feedback of the mode filter. The reflectivity of the individual modes yields information about the suppression of the modes. We could filter separately either the fundamental or higher order mode.

K 5.2 Di 14:15 HS 4

Ultrasmall divergence of laser-driven ion beams from nanometer thick foils — •jianhui bin[1,2], wenjun ma[1,2], klaus allinger[1,2], hongyong wang[3], daniel kiefer[1,2], sabine reinhardt[1], peter hilz[1], konstantin khrennikov[1,2], stefan karsch[1,2], xueqing yan[3], ferenc krausz[1,2], toshiki tajima[1], dieter habs[1,2], and joerg schreiber[1,2] — [1]Faculty of Physics, Ludwig-Maximilians-Universitaet Muenchen, Am Coulombwall 1, 85748 Garching, Germany — [2]Max Planck Institute of Quantum Optics, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [3]State Key Laboratory of Nuclear Physics and Technology, Peking University, Beijing 100871, China

We report on experimental studies of divergence of proton beams from nanometer thick diamond- like carbon (DLC) foils irradiated by an intense laser with high contrast. Proton beams with extremely small divergence (half angle) of 2 degree are observed in addition with a remarkably well- collimated feature over the whole energy range, showing one order of magnitude reduction of the divergence angle in comparison to the results from μm thick targets. We demonstrate that this reduction arises from a steep longitudinal density gradient and an exponentially decaying transverse profile at the rear side of the ultrathin foils. Agreements are found both in an analytical model and in particle-in-cell simulations. Those novel features make nm foils an extremely attractive alternative for high flux experiments relevant for fundamental research in nuclear and warm dense matter physics.

K 5.3 Di 14:30 HS 4

Ultrafast electron kinetics in SiO2 under X-ray femtosecond irradiation — •Nikita Medvedev and Beata Ziaja — Center for Free Eelectron Laser Science (CFEL at DESY), Notkestr. 85, 22706 Hamburg

When a dielectric is irradiated with an ultrashort laser pulse at X-ray photon energy, various physical processes take place. The photons are absorbed mostly by the deep-shell electrons, which are then excited to the high energy states of the conduction band and/or to the continuum. These electron propagate further and perform secondary scatterings via elastic and inelastic channels. All these processes occur on femtosecond timescales. Material properties are then defined by the transient state of the electronic distribution within the solid. In this contribution we present a theoretical study of the ultrafast electron kinetics in solid SiO2, irradiated with the femtosecond X-ray laser pulse (~40 fs duration). The Monte-Carlo code, similar to [1,2], is applied to model the electron kinetics, which includes the primary ionization, secondary scattering of electrons, and Auger-decays of deep-shell holes. With the calculated transient electron density, the transient change of the optical properties (reflection, transmittance of visible light) of the material is estimated. The analysis of the results allows us to conclude that in the X-ray excited dielectric, the holes in the valence band give the dominant contribution to the the optical properties of the material on femtosecond scales.

[1] N. Medvedev, B. Rethfeld, NJP 12, 073037 (2010) [2] B. Ziaja, R.A. London, J. Hajdu, JAP 97, 064905 (2005)

K 5.4 Di 14:45 HS 4

Nonthermal phase transitions of semiconductors under femtosecond XUV irradiation — •Nikita Medvedev[1], Harald Jeschke[2], and Beata Ziaja[1] — [1]Center for Free Eelectron Laser Science (CFEL at DESY), Notkestr. 85, Hamburg — [2]Institut für Theoretische Physik, Goethe-Universität Frankfurt am Main

After high energy deposition into a semiconductor, an ultrafast phase transition can occur within ~100 fs, driven by the changes in the interatomic potential. This ultrafast damage takes place much before the electron-phonon coupling heats up the lattice. To study this, we apply a new hybrid model for tracing the XUV laser induced atom dynamics, taking into account non-equilibrium electron kinetics [1]. The atomic motion is modeled with tight binding molecular dynamics. For tracing the electron distribution we used a hybrid model: Monte Carlo method for high energy electrons combined with a temperature equation for the partially thermalized low energy electrons [1,2]. We found that the electron relaxation kinetics in diamond, leading to a transition to graphite, took place within ~50 fs after the exposure with the short laser pulse (10 fs). It was stimulated by a collapse of the band gap, when the number of electrons excited into the conduction band overcame 1.5 % of the valence electrons (corresponds to 0.7 eV/atom dose) [1]. These results demonstrate for the first time the non-thermal melting of semiconductors under the femtosecond XUV irradiation [1].

[1] N. Medvedev, H.O. Jeschke, B. Ziaja, NJP 14 (2012) [2] B. Ziaja, N. Medvedev, HEDP 8 (2012)

K 5.5 Di 15:00 HS 4

High Harmonic Generation from Relativistic Plasma Surfaces in Steep Plasma Density Gradients — •Erich Eckner[1], Christian Rödel[1,2], Daniel an der Brügge[3], Jana Bierbach[1,2], Mark Yeung[4], Thomas Hahn[5], Brendan Dromey[4], Dirk Hemmers[5], Georg Pretzler[5], Oswald Willi[5], Alexander Pukhov[3], Matthew Zepf[2,3], and Gerhard Paulus[1,2] — [1]Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena — [2]Helmholtz-Institut Jena, Fröbelstieg 3, 07743 Jena, Germany — [3]Institut für Theoretische Physik, Heinrich-Heine Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf — [4]Centre for Plasma Physics, Queen's University Belfast, BT7 1NN, United Kingdom — [5]Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf, Germany

High harmonic generation by the interaction of intense laser pulses from relativistically oscillating surface plasmas is studied experimentally. Our observations reveal that efficient generation ($10^{-4} \dots 10^{-6}$ at 20-40 eV) requires steep plasma density scale lengths ($L_p/\lambda < 1$). However, the harmonic efficiency declines for the steepest plasma density scale lengths $L_p \to 0$. We have further observed a strong influence of the plasma scale length on the spectral fine structure of the high harmonics. While sharp harmonic lines are obtained for short plasma scale lengths, an extended plasma profile leads to strongly modulated harmonic spectra. Our experimental findings are reproduced by numerical simulations and simple analytical models.

K 5.6 Di 15:15 HS 4

Modeling of finite systems irradiated by intense ultrashort hard X-ray pulses — •Zoltan Jurek[1], Beata Ziaja[1,2], and Robin Santra[1,3] — [1]Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron, Notkestrasse 85, D-22607 Hamburg, Germany — [2]Institute of Nuclear Physics, Polish Academy of Sciences, Radzikowskiego 152, 31-342 Krakow, Poland — [3]Department of Physics, University of Hamburg, Jungiusstrasse 9, 20355 Hamburg, Germany

Large number of experiments have already been carried out at the existing hard X-Ray Free-Electron Laser facilities (LCLS, SACLA) dur-

ing the recent years. Their great success generates even higher anticipation for the forthcoming X-ray sources (European XFEL).

Single molecule imaging and nanoplasma formation are the challenging projects with XFELs that investigate the interaction of finite, small objects, e.g. single molecules, atomic clusters with intense X-ray radiation. Accurate modelling of the time evolution of such irradiated systems is required in order to understand the current experiments and to inspire new directions of experimental investigation.

In this presentation we report on our theoretical molecular-dynamics tool able to follow non-equilibrium dynamics within finite systems irradiated by intense X-ray pulses. We introduce the relevant physical processes, present computational methods used, discuss their limitations and also the specific constraints on calculations imposed by experimental conditions. Finally, we conclude with a few simulation examples.

K 5.7 Di 15:30 HS 4

Ab initio simulations of laser-induced structural changes in solids — •Eeuwe S. Zijlstra — Theoretische Physik und CINSaT, Universität Kassel, Germany

The excitation of electrons in crystals by a femtosecond laser pulse leads to an abrupt change of the interatomic bonding properties, which can be described by means of laser-excited potential energy surfaces (PES). After introducing our in-house Code for Highly-excIted Valence Electron Systems (CHIVES), which can be used to perform ab initio molecular dynamics simulations on laser-excited PESs for cells with up to 1000 atoms. I will present results for TiO2 and silicon as a function of fluence, including coherent phonons, ultrafast phonon squeezing [1], and nonthermal melting. [1] E. S. Zijlstra, A. Kalitsov, T. Zier, and M. E. Garcia, Physical Review X (accepted).

K 5.8 Di 15:45 HS 4

Atomistic-continuum modeling of short pulse laser melting of semiconductors — •Vladimir Lipp[1,2], Dmitry Ivanov[1,2], Martin Garcia[2], and Baerbel Rethfeld[1] — [1]Technical University of Kaiserslautern, 67663 Kaiserslautern, Germany — [2]University of Kassel, 34132 Kassel, Germany

A combined atomistic-continuum computational technique for the description of the melting kinetics following short laser-pulse excitation of semiconductors is developed and applied to silicon. The method is based on the coupling of two different approaches: (i) the continuum model [1], which describes the laser light absorption, electron-phonon nonequilibrium and fast heat transport due to free carriers, and (ii) the molecular dynamics method, which accounts for the description of laser-induced nonequilibrium phase transition processes at atomic level. The combined model presented here unifies the advantages of both mentioned approaches [2] and allows a comprehensive study of the material behavior under the extreme conditions generated by ultrashort laser irradiation. Preliminary results on depth of laser-induced melting obtained with the combined model show good agreement with experiment. A recently developed new potential accounting for changes of the bonding state due to photo-excited free carriers [3] is a promising tool for the introduction of nonthermal processes in the description of silicon kinetics under strong nonequilibrium conditions. [1]. H.M. van Driel, Phys. Rev. B 35 (1987) 8166-8176. [2]. Dmitriy S. Ivanov and Leonid V. Zhigilei, Phys. Rev. B 68, 064114 (2003). [3]. Lalit Shokeen and Patrick K. Schelling, J. Appl. Phys. 109, 073503 (2011).