HL 120: Ultra-fast phenomena II

Time: Friday 11:30–12:45 Location: POT 006

HL 120.1 Fri 11:30 POT 006

High-harmonic generation by extreme nonlinear terahertz excitation of semiconductors — •Ulrich Huttner[1], Mackillo Kira[1], Stephan W. Koch[1], Olaf Schubert[2], Matthias Hohenleutner[2], Fabian Langer[2], Benedikt Urbanek[2], Christoph Lange[2], and Rupert Huber[2] — [1]Department of Physics, Philipps-University Marburg, 35032 Marburg, Germany — [2]Department of Physics, University of Regensburg, 93040 Regensburg, Germany

Combining theory and experimental results we demonstrate that one can access the regime of ultrafast coherent charge transport in semiconductors by applying extremely strong and ultrashort terahertz (THz) pulses with stable carrier envelope phase (CEP). Since the bandgap in semiconductors is typically much larger than the THz-photon energy, the THz excitation nonresonantly excites coherent polarization and currents. Modeling these processes with the semiconductor Bloch equations [1,2], we find that the strong THz field leads to intense high-harmonic generation (HHG) and dynamical Bloch oscillations [3]. Our experiments with a GaSe sample show harmonics up to the 22nd order. The HHG is strongly influenced by the dynamical Bloch oscillations that can be controlled via the CEP of the exciting THz-pulse.

[1] Golde, D. et al. - phys. stat. sol. b 248, 863-866 (2011).

[2] Kira, M. & Koch, S. W. - Semiconductor Quantum Optics: (Cambridge University Press, 2011).

[3] Schubert, O. et al. - Sub-cycle control of terahertz high-harmonic generation by dynamical Bloch oscillations, 2013, accepted for publication.

HL 120.2 Fri 11:45 POT 006

Phonon hardening and softening in femtosecond-laser-excited metals — •Naira S. Grigoryan, Fairoja C. Kabeer, Eeuwe S. Zijlstra, and Martin E. Garcia — Theoretische Physik, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

Many ultrafast structural phenomena in solids at high fluences are related to changes in the phonon frequencies at lower fluences. Here we studied the response of representative phonon modes of Mg and Cu to femtosecond-laser excitation using electronic-temperature-dependent density functional theory. We found softening of some and hardening of other lattice modes, where some modes even showed both behaviors as a function of the excitation strength. We relate the laser-induced changes in the phonon frequencies to changes in the ground-state electronic density of states following atomic displacement patterns in the directions of a phonon eigenmode. Using this relationship we established a general connection between the unexcited electronic structure of a material and the structural response to intense femtosecond-laser excitation.

HL 120.3 Fri 12:00 POT 006

Femtosecond Transmission Electron Diffraction on Single Crystalline Graphite — •Silvio Morgenstern, Christian Gerbig, Cristian Sarpe, Marlene Adrian, Arne Senftleben, and Thomas Baumert — University of Kassel, Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), D-34132 Kassel, Germany

In carbon layered materials (graphite, graphene) the electron subsystem, stimulated by optical excitations, is strongly coupled to a small set of optical phonons which limits the ballistic conductance. A detailed understanding of phonon decay mechanism is thus essential in improving the performance of carbon-based electronic devices [1,2]. Time-resolved electron diffraction has become a promising technique to observe dynamics at the molecular level with ultrafast precision [3,4]. We use a fs-transmission electron diffractometer to study the evolution of phonon decays in single crystalline graphite after ultrashort laser excitation. Our compact setup is well characterized [4] with excellent spatial-temporal resolution (coherence length > 8 nm, e-pulse duration < 200 fs [5]). In this contribution the generation and decay of coherent acoustic and optical phonons are discussed in dependence of film thickness down to few-layer graphene [6]. [1] T. Kampfrath et al., Phys. Rev. Lett. 95, 187403 (2005) [2] S. Schäfer et al., New J. Phys. 13, 063030 (2011) [3] M. Chergui & A. H. Zewail, Chem. Phys. Chem. 10, 28 (2009) [4] G. Sciaini & R. J. D. Miller, Rep. Prog. Phys 74, 096101 (2011) [5] C. Gerbig et al., submitted (2013) [6] C. Gerbig et al., in preparation (2013)

HL 120.4 Fri 12:15 POT 006

Effective potential for femtosecond-laser-excited silicon — •Bernd Bauerhenne, Eeuwe S. Zijlstra, and Martin E. Garcia — Theoretische Physik - Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

Effective potentials are a powerful tool for modeling femtosecond-laser materials processing where the spatial geometry of the laser is important and therefore a huge number of atoms must to be taken into account, like, ablation or spallation. Here we present a new effective potential for femtosecond-laser-excited silicon, which we test by accurately reproducing the physics of ultrafast melting.

HL 120.5 Fri 12:30 POT 006

Fractional diffusion in laser-excited silicon — •Tobias Zier, Eeuwe S. Zijlstra, and Martin E. Garcia — Theoretical Physics, University of Kassel, Germany

With an intense ultrashort-laser pulse excitation of crystalline Si one creates a highly nonthermal state, which is characterized by electrons with a temperature of several 10 000 K and ions close to room temperature. Due to this the interatomic bonds can soften or even break for sufficiently high excitations. In the latter case the crystalline structure disorders within several hundreds of femtoseconds. Therefore, this process is called ultrafast melting. The results of our performed ab initio MD-Simulations with supercells containing up to 800 atoms show for the first time that the atoms exhibit fractional diffusion during the ultrafast melting process, a behavior that was up to now only known for big molecules in solutions [1].

[1] E. S. Zijlstra, et al., Adv. Mater. 25, 5605 (2013)