DF 11: Photonic Dielectrics II

Time: Wednesday 14:30–17:10 Location: WIL A317

Invited Talk DF 11.1 Wed 14:30 WIL A317

Real-time probing of structural dynamics in perovskite materials — •Thomas Elsaesser — Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, D-12489 Berlin, Germany

Femtosecond x-ray diffraction probes structural dynamics of solids in real-time and gives insight into reversible geometry changes on atomic length and time scales. After a brief introduction into this field, recent results on the lattice dynamics of ferroelectric $SrRuO_3/PbZr_{0.2}Ti_{0.8}O_3$ superlattice structures and their interplay with the electric polarization of the material are presented [1]. Ultrafast optical generation of mechanical stress allows for switching-off the polarization on a time scale of a few picoseconds. As a second example, magnetostriction in a ferromagnetic $SrRuO_3/SrTiO_3$ superlattice structure is analyzed in real time [2].
[1] C. von Korff Schmising et al., Phys. Rev. Lett. 98, 257601 (2007)
[2] C. von Korff Schmising et al., Phys. Rev. B 78, 060404(R) (2008)

5 min. break

DF 11.2 Wed 15:10 WIL A317

Ultrafast shape transformation dynamics of silver nanoparticles studied by femtosecond pulse-pair irradiation — •Akin Unal, Andrei Stalmashonak, Gerhard Seifert, and Heinrich Graener — Institut für Physik, Fachgruppe Optik, Martin-Luther-Universität, Hoher Weg 8, 06120 Halle, Germany

Spherical silver nanoparticles embedded in glass were irradiated by pairs of time-delayed laser pulses with equal intensities resulting in delay-dependent nanoparticle shape transformations. The corresponding permanent changes of the surface plasmon extinction bands are analyzed as a function of time delay and relative polarization of the pulse pairs. We find that the strongest nanoparticle shape changes, i.e. the highest aspect ratios, are achieved when the delay between pulse pairs is less than 3 ps. After 10 ps the aspect ratio is strongly reduced in the case of pulse pairs having identical polarization and vanishes using pulse pairs with orthogonal polarization. Estimations of the time dependence of "pulse-enhanced" (directed) and thermal (isotropic) electron emissions obtained from an extended two-temperature model indicate a decay of the relative contribution of directed electron emission on the same time scale of a few picoseconds. Our results strongly suggest that the electron and following ion emission from the nanoparticles are finished within less than 20 ps, and the directional memory is favorably defined by directed emission of hot electrons interacting with the laser field.

DF 11.3 Wed 15:30 WIL A317

Femtosecond white-light pump-probe investigation of laser-induced shape transformation of silver nanoparticles in glass — •Armin Warth, Gerhard Seifert, Jens Lange, and Heinrich Graener — Fachbereich Physik, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle

Soda lime-glasses containing spheroidal silver nanoparticles are used as the base material for production of high-quality polarisers, dichroic optical microstructures or long-time optical data storage. Permanent shape transformation of the nanoparticles can be induced by irradiation with intense femtosecond laser pulses. The most efficient transformation to spheroids with large aspect ratio is achieved in 'multi-shot mode', where several hundred laser pulses in the range of 0.2 - 0.5 TW/cm^2 on average hit one spot on the sample.

To study the ultra short dynamics of such irreversible, shot-by-shot increasing changes, we introduce a highly efficient femtosecond pump - supercontinuum probe setup, which allows us to monitor the changes of optical density with single shot precision. Thus we obtain the complete temporal evolution of spectral changes for each of the several hundred laser shots separately. I.e., after only one measurement cycle we end up with a data set that needs typically 3GB space for data storage. Examples for the results of these experiments are presented and discussed.

DF 11.4 Wed 15:50 WIL A317

Photorefraktive Gitter in Lithiumniobat-Kristallen erzeugt mit Femtosekunden-Laserpulsen* — •Dominik Maxein, Johanna Bückers, Daniel Haertle und Karsten Buse — Physikalisches Institut, Wegelerstr. 8, D-53115 Bonn, Deutschland

Der photorefraktive Effekt in Lithiumniobat-Kristallen ($LiNbO_3$) bietet einerseits die Möglichkeit, Brechungsindexstrukturen und diffraktive optische Elemente in $LiNbO_3$ einzuschreiben. Andererseits kommt es durch unerwünschte Brechungsindexänderungen zu „lichtinduzierter Streuung“ und zum „optischen Schaden“, was Anwendungen der Kristalle behindert.

Insbesondere nichtlineare Anwendungen gehen meist mit hohen Intensitäten einher. Darum ist es interessant, den photorefraktiven Effekt mit den hohen Intensitäten und kurzen Anregungszeiten von Femtosekunden-Pulsen zu untersuchen. Dazu werden bei 532 nm mit fs-Laserpulsen und mit cw-Laserlicht Brechungsindex-Gitter in eisendotiertes $LiNbO_3$ geschrieben und die Beobachtungen verglichen: Die Sättigungswerte der Brechungsindexänderungen verringern sich mit steigender Pulsenergie, was durch die Ein- und Zwei-Zentren-Modelle nicht vorhergesagt wird. Eine Verringerung des Fe^{2+}-Gehalts der Kristalle durch Oxidation erhöht die Schreibzeiten mit cw-Licht deutlich, während sie für fs-Pulse weitgehend unverändert bleiben. Mögliche Anregungs- und Ladungstransportmechanismen werden diskutiert, um die Ergebnisse zu erklären.

*Wir danken der DFG und der Deutschen Telekom AG für finanzielle Unterstützung.

DF 11.5 Wed 16:10 WIL A317

Photo-induced light scattering of femtosecond laser pulses in iron-doped lithium niobate crystals* — •Johanna Bückers, Dominik Maxein, Daniel Haertle, and Karsten Buse — Institute of Physics, University of Bonn, Wegelerstr. 8, 53115 Bonn, Germany

Lithium niobate is an advantageous material for photonics, e.g., holographic spectral filtering, optical image processing, and holographic diffraction can be realized. However, since lithium niobate crystals are photorefractive, illumination of the crystals is accompanied with undesirable effects like the "optical damage" and "photo-induced light scattering". Photo-induced light scattering leads to a loss of the transmitted light because of the self-amplification of weak scattered coherent light waves. Consequently, it causes a distortion of the beam shape of the incoming light wave and, thus, hinders photonic applications.

Our investigations show that for femtosecond laser pulses the light-induced scattering is reduced in $LiNbO_3$:Fe in comparison to illumination with cw laser light at 532 nm. Moreover, it is completely absent for femtosecond pulses in samples with sufficiently small Fe^{2+} content, in contrast to the scattering of cw light. Further differences are reflected in a slower buildup time, a narrower angular distribution of the scattered light, and a weaker Bragg selectivity for pulsed illumination. These characteristics can be attributed to the shorter coherence length of femtosecond pulses.

*Financial support from the Deutsche Forschungsgemeinschaft (FOR 557) and the Deutsche Telekom AG is gratefully acknowledged.

DF 11.6 Wed 16:30 WIL A317

Ab-initio determination of the pathways of laser-induced non-thermal melting of InSb — •Jessica Walkenhorst, Eeuwe S. Zijlstra, and Martin E. Garcia — Theoretische Physik, Fachbereich Naturwissenschaften, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

We performe ab-initio calculations and dynamical simulations to explain the pathways of ultrafast non-thermal melting in InSb during the first 100's of femtoseconds after intense femtosecond laser excitation. We compute the potential energy surface of femtosecond-laser-excited InSb along the directions in which the crystal becomes soft. Using dynamical simulations the time dependence of the atomic coordinates is obtained. We find that at high excitation densities the anharmonicity of the potential energy surface becomes significant after $\approx$ 100 fs. On the basis of our results we explain recent timeresolved x-ray diffraction experiments as reported by Lindenberg et al. [A. M. Lindenberg et al., Science 308, 392 (2005)]. Furthermore we compute the atomic density evolution in time after the laser excitation.

DF 11.7 Wed 16:50 WIL A317

Determination of the light-induced absorption by transient grating spectroscopy — •Hauke Brüning, Bettina Schoke, and Mirco Imlau — Department of Physics, University of Osnabrück,

Germany

Transient absorption spectroscopy is a well-known pump-probe technique for the study of optically-induced photochromic properties showing decay times in the ms and μs range. The spectral and temporal behavior of the light-induced absorption is determined from the transmission of white light or probe laser beams. Therefore, single intense laser pulses with a spatially homogeneous intensity distribution have to be applied for the pump process. In contrast, transient grating spectroscopy accounts for light diffraction from an optically-induced absorption grating recorded with spatially modulated pump light using a two-beam interferometer. For grating analysis, the probe-light diffraction efficiency is determined as a function of time and wavelength. Here we demonstrate the possibility to determine the light-induced absorption from transient grating spectroscopy in lithium niobate crystals as an example. Experimental results are presented for the particular case of the presence of mixed photochromic and photorefractive gratings, i.e. light-induced refractive-index changes contribute to the light diffraction as well. Theoretical considerations based on wave-mixing theory allowing for a comprehensive grating analysis are presented. Advantages of the procedure are discussed by comparison with results determined from transient absorption spectroscopy. *Financial support by the DFG (Projects IM37/5-1 and GRK 695).