Q 10: Ultrakurze Laserpulse: Anwendungen

Time: Monday 14:00–16:00 Location: V38.01

Q 10.1 Mon 14:00 V38.01

Optical field enhancement at sharp tips — •Sebastian Thomas, Markus Schenk, Michael Krüger, Michael Förster, Lothar Maisenbacher, and Peter Hommelhoff — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching bei München, Germany

The electric field of an electromagnetic wave is significantly enhanced at structures smaller than the wavelength. We investigate field enhancement of laser pulses at sharp nanotips by performing numerical simulations with the finite-difference time-domain (FDTD) method. In the simulations, we observe a highly localized enhanced field at the apex of the tips. By analyzing a large series of simulations, we characterize the magnitude of the enhancement for a wide range of parameters and find that it mainly depends on the tip's radius of curvature and the optical properties of the tip material. We will present our results, which clarify the mechanism behind the enhancement, and compare the simulation data with experimental data.

Experimentally, we study the photoemission of electrons from a nanometric metal tip under laser illumination [1]. The enhanced electric field enables us to observe strong-field effects even at low pulse energies. The magnitude of the field enhancement found in the simulations broadly agrees with our experimental data.

[1] see other contributions of the authors

Q 10.2 Mon 14:15 V38.01

Electron dynamics and electron-phonon coupling in laser excited dielectrics — •Nils Brouwer[1], Orkhan Osmani[1,2], and Bärbel Rethfeld[1] — [1]Technische Universität Kaiserslautern — [2]Universität Duisburg-Essen

When transparent dielectrics are irradiated by intense laser pulses, electrons are excited to the conduction band by multi-photon absorption. These free electrons can absorb more photons to gain sufficient energy for impact ionization and thus excite even more electrons. We apply the Boltzmann equation to model the transient electron and phonon dynamics of dielectrics irradiated by femtosecond laser pulses. We analyze the dependence of electron-phonon coupling on pulse parameters as well as on free electron density and free electron energy density. For the equilibrium case, we calculate a density and temperature dependent electron-phonon coupling parameter suitable to enter two-temperature heat conduction equations.

Q 10.3 Mon 14:30 V38.01

Erzeugung von sub-100 nm Strukturen durch 2-Photonen-Polymerisation mit sub-10-fs Laserpulsen — •Moritz Emons[1], Matthias Pospiech[1], Kotaro Obata[2], Boris Chichkov[2] und Uwe Morgner[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]Laser Zentrum Hannover, Hollerithallee 8, 30419 Hannover

Wir präsentieren sub-100 nm kleine Strukturen die mit Hilfe der Zwei-Photonen-Polymerisations (2PP) Technologie erzeugt wurden. Möglich wurde dies durch die Verwendung von Laserpulsen mit Dauern von weniger als 10 fs, welche in einem nicht-kollinearen parametrischen Verstärker (NOPA), bzw. einem kommerziellen fs-Oszillator erzeugt wurden. Die Größe der realisierten Nanostrukturen liegt weit unter der Beugungsbegrenzungen aus der klassischen Optik, was im Wesentlichen dadurch gegeben ist, dass die verwendeten Strahlquellen mit ihren besonderen zeitlichen und energetischen Eigenschaften zur Verfügung stehen. Das 2PP-Verfahren ermöglicht eine weitgehend flexible räumliche Gestaltung der Energiedeposition im Material, wodurch eine dreidimensionale Strukturierung im Volumen ermöglicht wird, die gezielt auf die Erfordernisse technischer und biomedizinischer Fragestellungen angepasst werden kann. Anhand dieses Vortrags sollen die erzielten Ergebnisse von unterschiedlichen Lasersysteme verglichen werden.

Q 10.4 Mon 14:45 V38.01

Erzeugung Harmonischer Strahlung mit Goldnanoantennen — •Nils Pfullmann[1,2], Christian Waltermann[1,2], Milutin Kovacev[1,2], Vanessa Knittel[3], Rudolf Bratschitsch[3], Alfred Leitenstorfer[3] und Uwe Morgner[1,2] — [1]QUEST Centre for Quantum Engineering and Space-Time Research — [2]Institut für Quantenoptik, Leibniz Universität Hannover — [3]Department of Physics and Center for Applied Photonics, University of Konstanz

Nanoantennen aus Metall zeigen im optischen Bereich ähnliche Eigenschaften wie makroskopische Antennen im Radiofrequenzbereich. Durch eine passend gewählte Geometrie kann eine Überhöhung des elektrischen Feldes eines gepulsten Lasers um mehrere Größenordnungen in einem kleinen Volumen erreicht werden. Die Feldstärken können dabei so hoch werden, dass die Erzeugung Hoher Harmonischer Strahlung demonstriert wurde.

Wir zeigen unsere Experimente zur Wechselwirkung ultrakurzer Laserpulse mit unterschiedlichen Nanoantennen-Geometrien sowie deren Simulation mittels der FDTD-Methode. Aus den Simulationsdaten lassen sich u.a. die maximale Feldüberhöhung als auch die erwartete Temperaturverteilung in den Antennen berechnen, um diese für die Erzeugung harmonischer Strahlung zu optimieren. Experimentell wurden Harmonische bis zur siebten Ordnung in einem Xenon-Gasstrahl beobachtet und das Temperaturverhalten der verwendeten Antennen untersucht.

Q 10.5 Mon 15:00 V38.01

Electron Rescattering effects in photoemission from a nanoscale metal tip — •Markus Schenk[1], Michael Krüger[1], Georg Wachter[2], Christoph Lemell[2], Joachim Burgdörfer[2], Michael Förster[1], Sebastian Thomas[1], Lothar Maisenbacher[1], and Peter Hommelhoff[1] — [1]Max-Planck-Institut für Quantenoptik, Garching bei München, Germany — [2]Institut für Theoretische Physik TU Wien, Austria

We show experimental and theoretical investigations of electron rescattering effects in photoemission induced by few-cycle laser pulses from metal nanotips. At nearfield-enhanced light intensities exceeding $\sim 10^{12}\,\mathrm{W/cm^2}$ a pronounced plateau structure builds up in the high-energy part of the electron spectra. Similar to strong-field experiments with atomic gases, this plateau can be understood in terms of light-field governed electron motion controlled on the sub-fs timescale [1,2]. In a simplistic picture, the electron undergoes classical-particle like propagation after emission and scatters elastically at the metal surface.

A more sophisticated solid-state modelling with time-dependent density functional theory (TDDFT) supports this notion [3]. It enables by comparison to extract the enhanced intensity at the nanometric tip and compare it to simulations of field enhancement [4]. Most recent results will also be discussed.

[1] M. Krüger, M. Schenk, P. Hommelhoff, *Nature* **475**,78 (2011)
[2] M. Schenk, M. Krüger, P. Hommelhoff, *PRL* **105**, 257601 (2010)
[3] G. Wachter et al., *manuscript in preparation*
[4] see also contribution of Sebastian Thomas et al.

Q 10.6 Mon 15:15 V38.01

Femtosecond transmission electron diffraction on single crystalline graphite — •Christian Gerbig, Silvio Morgenstern, Vanessa Sporleder, Cristian Sarpe, Matthias Wollenhaupt, and Thomas Baumert — Universität Kassel, Institut für Physik und Center of Interdisciplinary Nanostructure Science and Technology (CINSaT), D-34132 Kassel, Germany

We use a self-referencing highly compact femtosecond transmission electron diffractometer [1,2] to study the evolution of strongly coupled optical phonons and lattice phonon thermalization [3] in single crystalline graphite [4] after ultrashort laser excitation.

[1] M. Chergui & A. H. Zewail, Chem. Phys. Chem. **10**, 28 (2009)
[2] G. Sciaini & R. J. D. Miller, Rep. Prog. Phys **74**, 096101 (2011).
[3] S. Schäfer *et al.*, New J. Phys. **13**, 063030 (2011)
[4] J. C. Meyer *et al.*, Appl. Phys. Lett. **92**, 123110 (2008)

Q 10.7 Mon 15:30 V38.01

High-power widely tunable sub-20 fs Gaussian laser pulses and their application for nonlinear nano-plasmonic spectroscopy — •Bernd Metzger[1], Andy Steinmann[1], Mario Hentschel[1,2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Max-Planck-Institute for Solid State Research, Heißenbergstraße 1, 70569 Stuttgart, Germany

We demonstrate the generation of widely tunable sub-20 fs Gaussian-shaped laser pulses using a grating-based 4-f pulse shaper and a liquid crystal spatial light modulator. Our pump source is an Yb:KGW solitary mode-locked oscillator at 44 MHz repetition rate which is coupled into a large mode area microstructured fiber to generate a broad spectrum from below 900 nm to above 1150 nm. These pulses are precompressed by a prism sequence and subsequently sent into the pulse shaper. We use a multiphoton intrapulse interference phase scan for phase shaping and iterative amplitude optimization to achieve Gaussian-like tunable sub-20 fs pulses with output powers of up to 140 mW as well as nontunable pulses with 310 mW output power as short as 11.5 fs. Moreover we demonstrate second and third harmonic generation experiments on different kind of plasmonic nanostructures, utilizing the wide tuning range of our presented laser source.

Q 10.8 Mon 15:45 V38.01

Direct Writing of 3-D Waveguides with Bragg Structure in Bulk Glass — •Markus Thiel, Günter Flachenecker, Jörg Burgmeier, and Wolfgang Schade — Fraunhofer Heinrich Hertz Institute, Fibre Optical Sensor Systems, EnergieCampus, Am Stollen 19A, 38640 Goslar

Optical fiber Bragg gratings are mainly used for sensing mechanical stress or temperature. Waveguide Bragg structures in integrated optics are used as resonators or optical frequency filters. While Bragg gratings can be produced with femtosecond Laser pulses without much efforts in fibers it is much more challenging to apply this technique for generating such structures in transparent bulk materials. For this reason most Bragg structures in photonic chips are realized by lithographic techniques and only a view publications report about waveguide Bragg gratings processed by femtosecond lasers [1, 2]. In this talk we present a new direct writing procedure for realizing waveguide Bragg structures in bulk glasses. Firstly we present a new technique for controlling the waveguide diameter by processing 3-D waveguide bundles. Furthermore we show how to optimize the coupling coefficient for Bragg reflections of light by controlling the writing parameters and precise positioning of the Bragg grating structures within the waveguide bundle.

References:
1. G.D. Marshal, M. Ams, M.J. Withford, Opt Lett, 31, 2690 (2006)
2. H Zhang, S.H. Eaton, P.R. Herman, Opt Lett, 32, 2561 (2007)