Q 65: Nano-Optics IV

Time: Friday 11:00–12:15 Location: C/HSO

Q 65.1 Fri 11:00 C/HSO

Waveguiding and polarization control of extreme-ultraviolet radiation — •Sergey Zayko[1], Murat Sivis[1], Sascha Schäfer[1], Tim Salditt[2], and Claus Ropers[1] — [1]IV. Physical Institute, University of Göttingen, 37077 Göttingen, Germany — [2]Institute for X-Ray Physics, University of Göttingen, 37077 Göttingen, Germany

Coherent diffractive imaging (CDI) at extreme-ultraviolet (EUV) frequencies allows for the investigation of field distributions in nanoscale structures [1]. Here, we study the propagation of EUV light in extended metallic slit-waveguides by means of CDI, utilizing a high-harmonic generation source. In particular, the field distribution at the exit aperture of the waveguides is reconstructed from the far-field diffraction pattern using an iterative phase retrieval algorithm. The exit wave is governed by multiple scattering within the depth of the metal slit, and we find pronounced waveguiding with a significant polarization contrast. Our experimental results show good agreement with semi-analytical and numerical simulations and will allow for new optical elements such as mode filters, polarizers and waveplates for EUV and soft-X-ray radiation.

Q 65.2 Fri 11:15 C/HSO

Field Emission from Metal Nanotips with Terahertz Radiation — •Georg Herink, Wimmer Lara, and Ropers Claus — IV. Physical Institute, University of Göttingen, 37077 Göttingen, Germany

Traditionally, Terahertz (THz) radiation is regarded as being non-ionizing. However, recent advances in table-top THz generation schemes and the field enhancement at metallic nanostructures, provide for local electric fields that are sufficiently high to induce tunneling, e.g., in scanning tunneling microscopy [1]. Here, we experimentally demonstrate THz-induced field emission into the vacuum from the apex of single metallic nanotips [2]. We observe electron kinetic energy distributions which are a result of the sub-cycle emission and acceleration of electrons at the peak of the single-cycle transient [3]. Using a recently introduced THz near-field streaking technique [4], we temporally resolve the enhanced near-field at the nanostructure and map the onset of field emission for increasing THz field strengths. In addition, we utilize the ultrafast emission process to study hot electron relaxation in nanotips. In a pump-probe experiment, we generate hot electrons via femtosecond pulses at 800nm wavelength and resolve ultrafast hot electron dynamics within the apex via THz-induced field emission.

[1] M. Eisele, T. L. Cocker, M. A. Huber, et al., Nature Photonics 8, 620-625 (2013). [2] G. Herink, L. Wimmer, C. Ropers, New Journal of Physics, accepted for publication (2014). [3] G. Herink, D. R. Solli, M. Gulde, C. Ropers, Nature 483, 190-193 (2012). [4] L. Wimmer, G. Herink, D. R. Solli, et al., Nature Physics 10, 432-436 (2014).

Q 65.3 Fri 11:30 C/HSO

Electron-light interaction in optical near-fields studied by ultrafast electron microscopy — •Armin Feist, Katharina Echternkamp, Jakob Schauss, Sergey Yalunin, Sascha Schäfer, and Claus Ropers — IV. Physical Institute, University of Göttingen, 37077 Göttingen, Germany

Ultrafast transmission electron microscopy (UTEM) is a laser pump/electron probe technique, utilized to study laser-induced dynamics on a nanometer length scale [1]. Moreover, UTEM can be applied to locally probe optical near-fields [2].

Here, we study the coherent interaction of swift electrons with optical near-fields in UTEM [3]. We recently modified a commercial Schottky field emission TEM (JEOL JEM-2100F) for pulsed operation using localized nonlinear photoemission from a needle-shaped nanoscopic tip. Electron pulses of 700 fs duration and spot diameters below 10 nm are obtained in the sample plane. Positioning the electron beam in close vicinity to an illuminated nanostructure allows an otherwise forbidden dipolar coupling between free electrons and the optical near-field. This leads to the formation of spectral side bands, corresponding to the absorption and emission of multiple photons. Raster-scanning the electron beam enables the mapping of the optical near-fields. The field dependent sideband populations reveal the quantum coherence of the process.

[1] A.H. Zewail, Science, 328, 187 (2010). [2] B. Barwick et al., Nature, 462, 902 (2009). [3] A. Feist et al., submitted (2014).

Q 65.4 Fri 11:45 C/HSO

Optical field enhancement at nanotips: dependence on geometry and material — •Sebastian Thomas[1], Georg Wachter[2], Michael Förster[1], Christoph Lemell[2], Joachim Burgdörfer[2], and Peter Hommelhoff[1] — [1]Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstraße 1, D-91058 Erlangen — [2]Technische Universität Wien, Wiedner Hauptstraße 8-10, A-1040 Wien

The enhancement of optical electric fields at nanostructures enables a large variety of applications due to the localization of electromagnetic energy on a sub-wavelength scale. Previously, we studied optical field enhancement at tungsten and gold nanotips and found relatively low enhancement factors both in experiments and in simulations, in good agreement with each other [1]. Here we present additional numerical simulations of optical near-fields at nanotips with a wide range of parameters. We find that both the radius of curvature and the opening angle play a large role in the resulting field enhancement factor. The strongest field enhancement is observed at tips with small radii of curvature and large opening angles ($> 20°$ full cone angle). This is true for all materials. Additionally, tips made of plasmonic materials like gold or silver achieve a higher field enhancement factor than other materials under some conditions due to resonance effects.

[1] S. Thomas, M. Krüger, M. Förster, M. Schenk, P. Hommelhoff, Nano Letters 13, 4790 (2013)

Q 65.5 Fri 12:00 C/HSO

Quantum single-electron tunnelling motor — •Pablo Carlos Lopez[1], Alan Celestino[1], Alex Croy[1,2], and Alex Eisfeld[1] — [1]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [2]Department of applied Physics, Chalmers University of Technology, 41296 Göteborg, Sweden

In Ref [1] the dynamics of a nano-electromechanical rotor driven by a single-electron tunneling has been considered using classical equations of motion for the rotor and a mean field approach. The device is described by a rod that has attached two quantum dots on its extremities. The rod can freely rotate about a fixed axis. The device is located between two Fermionic baths which couple to the rod via tunneling of single electrons to the quantum dots. The baths also provide a static bias voltage that drives the system. In the classical treatment of Ref [1] some interesting phenomena have been observed, like a negative differential conductance. Possible applications of such device are for example signal amplification, current rectification and viscosity measurements.

In the present work we present a full quantum description of this system and discuss similarities and differences to the classical results.

[1] EPL (Europhys Lett) 98, 68004