O 11: Plasmonics and Nanooptics I

Time: Monday 15:00–17:00 Location: PHY C213

O 11.1 Mon 15:00 PHY C213

Quasistatic plasmon resonances in the visible spectral range of arbitrary shaped nano-grooves — •Camille Maxime[1,2], Aude Barbara[1,2], and Pascal Quemerais[1,3] — [1]Institut Néel, CNRS-UJF, Grenoble, France — [2]IAPP, TU Dresden, Germany — [3]MPI-PKS, Dresden, Germany

As we previously reported, plasmonic resonances inside rectangular nano-grooves periodically made on a silver surface present a cross-over between two physical regimes [1]: an optical one for groove widths w larger than 10 nm, and a quasistatic one for lower values. In that case, the grooves resonate in the visible range even for grooves height h of only a few nanometers (5-15 nm). A very strong light absorption occurs at the resonance together with an electric field intensity enhancement (EFIE) of about 400. These results were obtained with a method only available for rectangular shapes. To generalize, we have implemented a surface integral method [2] and adapted it to periodic profiles to avoid surface boundaries problems. As an example, the behaviour of Gaussian shaped grooves was studied. It fully confirms the transition to a quasistatic regime as the groove width decreases leading to unusual EFIE (up to about 10000) and a very strong light absorption. These original results are fundamental to explain surface enhanced Raman scattering (SERS) experiments such as the historical ones of Albano et al.[3].

[1] J. Le Perchec et al., *Phys. Rev. Lett.* **100**, 066408 (2008)
[2] A.A. Maradudin et al., *Ann. Phys.* **203**, 255 (1990)
[3] E.V. Albano et al., *Phys. Rev. Lett.* **51**, 2314 (1983)

O 11.2 Mon 15:15 PHY C213

Coupled nanoantenna plasmon resonance spectra from two-photon laser excitation: longitudinal and transversal emission — •Matthias D. Wissert[1], Carola Moosmann[1], Konstantin S. Ilin[2], Michael Siegel[2], Uli Lemmer[1], and Hans-Jürgen Eisler[1] — [1]Light Technology Institute, DFG Heisenberg Group 'Nanoscale Science', Karlsruhe Institute of Technology, Germany — [2]Institute of Micro- and Nanoelectronic Systems, Karlsruhe Institute of Technology, Germany

We report on the plasmonic mode relaxation of coupled optical gold nanoantennas under two-photon laser excitation at 810 nm [1]. An oil immersion objective lens is used both for the excitation and detection channel. The plasmon emission intensity from single nanostructures is detected using a single-photon-counting avalanche photodiode, the response spectrum is observed with an EMCCD camera.

We show that the plasmon spectra are very similar to the well known scattering resonances [2] for such structures, albeit now obtained from single frequency excitation. We also show that not only the longitudinal, but also the transversal plasmon mode can be excited, using excitation light polarized exclusively along the long axis of the dipole antenna.

[1] M.D. Wissert, K.S. Ilin, M. Siegel, U. Lemmer, and H.-J. Eisler, Nano Letters **10**, 4161 (2010)
[2] M.D. Wissert, A.W. Schell, K.S. Ilin, M. Siegel, and H.-J. Eisler, Nanotechnology **20**, 425203 (2009)

O 11.3 Mon 15:30 PHY C213

Metallic nanorod arrays: negative refraction and optical properties explained by retarded dipolar interactions — •René Kullock[1], Stefan Grafström[1], Paul R. Evans[2], Robert J. Pollard[2], and Lukas M. Eng[1] — [1]Institut für Angewandte Photophysik, TU Dresden, 01062 Dresden, Germany — [2]Centre for Nanostructured Media, IRCEP, The Queen's University of Belfast, Belfast BT7 1NN, UK

Two-dimensional (2D) arrays of metallic nanorods arranged perpendicular to a substrate exhibit novel optical features: a short-axis resonance, and several long-axis surface plasmon resonances (LSPRs) which appear for excitation with p-polarized light at specific angles of incidence [1]. Especially the first LSPR mode is very sensitive to both geometry and environment. In order to make it accessible for different applications, a fundamental physical understanding is indispensable.

Here, we theoretically treat such a 2D nanorod array by applying the retarded dipolar interaction model (DIM). First, we nicely follow the LSPR changes when extending our calculations from the single nanorod to a 2D array of nanorods [2]. Then, using the DIM model we are able to explain how the LSPR depends on several physically relevant parameters, such as the nanorod length, diameter, neighboring distance, material, and surroundings. Furthermore, the DIM also delivers conditions under which negative and extraordinary positive refraction in such metallic nanorod arrays will occur.

[1] R. Kullock et al., *Opt. Express 16, 21671 (2008)*
[2] R. Kullock et al., *J. Opt. Soc. Am. B 27, 1819 (2010).*

O 11.4 Mon 15:45 PHY C213

Photoemission Microscopy on Surface Plasmon Polaritons in Ag Islands — Niemma Buckanie, Pierre Kirschbaum, Simon Sindermann, Michael Horn-von Hoegen, and •Frank Meyer zu Heringdorf — Universität Duisburg-Essen, Fakultät für Physik and Center for Nanointegration (CeNIDE), Lotharstrasse 1, 47057 Duisburg, Germany

The interaction of frequency doubled femtosecond laser pulses with Silver islands on Si in a photoemission electron microscope provides a fantastic toolbox to study the interaction of light with surface plasmon polaritons (SPP) in small Ag islands. In two photon photoemission microscopy (2PPE PEEM), SPPs are imaged as a time-integrated superposition of the electric field of the propagating SPP wave with the electric field of the exciting laser pulse that hits the surface under grazing incidence. A quantitative analysis of the experimentally observed moiré pattern allows studying of the SPP field strength and a determination of the propagation direction of the SPP. At the rear edge of the island the SPP wave can be converted back into light. The resulting superposition of the converted light with the incident laser pulse is manifested in an enhanced photoemission yield behind the island.

O 11.5 Mon 16:00 PHY C213

Experimental observation of decoupled plasmon resonances in metallic nanoparticles — •Reto Giannini[1], Yasin Ekinci[1,2], and Jörg F. Löffler[1] — [1]Laboratory of Metal Physics and Technology, Department of Materials, ETH Zurich, 8093 Zurich, Switzerland — [2]Laboratory for Micro and Nanotechnology, Paul Scherrer Institute, 5232 Villigen PSI, Switzerland

The optical response of designed metallic nanostructures is of high interest due to its importance in sensing applications, nanoantennas and nanooptics. With the aim to analyze the optical response of metallic nanostructures in the visible wavelength range, we produced metallic nanoparticles with the simple geometry of cylinders standing on a glass substrate by e-beam lithography. Additionally, a measurement set-up was established that allows the directional excitation of nanoparticles in three dimensions. Based on the analysis of the nanocylinders, we show experimental evidence that the overall optical response of such a system is the superposition of individually tunable plasmon resonances, i.e. normal modes. In the case of the cylinder, three normal modes associated with the main axes and therefore excitable by a polarization along these axes have been observed. Finally, these results are compared with FEM-based simulations.

O 11.6 Mon 16:15 PHY C213

Modeling Metallic Nanostructures using a Discontinuous Galerkin Approach — •Jens Niegemann, Michael König, Christopher Prohm, Timo Köllner, and Kurt Busch — Institut für Theoretische Festkörperphysik and DFG-Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology (KIT), 76128 Karlsruhe, Germany

Over the past few years, the discontinuous Galerkin time-domain (DGTD) method has established itself as an extremely powerful and efficient numerical technique in the field of photonic. Due to its combination of an accurate spatial discretization with an explicit time-stepping scheme, the DGTD method is particularly well suited for studying ultra-short and/or plasmonic phenomena. Furthermore, the method is readily extended to also treat hydrodynamic equations, which allows us to also model the nonlocal and nonlinear properties of metallic nanostructures.

Here, we discuss our recent advances in using the DGTD method for the simulation of plasmonic devices. In particular, we present first results on a full hydrodynamical simulation of small metallic nanostructures.

O 11.7 Mon 16:30 PHY C213

Mode imaging and selection in strongly coupled nanoantennas — Jer-Shing Huang[1], •Johannes Kern[1], Peter Geisler[1], Pia Weinmann[2], Martin Kamp[2], Alfred Forchel[2], Paolo Biagioni[3], and Bert Hecht[1] — [1]Experimental Physics 5, University of Würzburg, Germany — [2]Technische Physik, University of Würzburg, Germany — [3]CNISM, Politecnico di Milano, Italy

Plasmonic nanostructures consisting of gold nano-wire pairs offer a large variety of different modes, depending on their geometric arrangement, for which the optical near-fields can be strongly confined in nanometerscale gaps. Of particular interest are modes which couple only weakly to the radiation field, e.g. due to a quadrupolar charge distribution. For such modes, simulations predict that the corresponding resonances should exhibit comparatively large quality factors due to the absence or the reduction of radiation damping.

In order to demonstrate a correspondence between simulations and experiments, we strive to fabricate gold nanostructures that are free of defects and exhibit ultra-smooth surfaces. To achieve this goal, we apply top-down nanofabrication methods, which rely on focused-ion-beam milling of large, but ultrathin single-crystalline gold flakes.

We will discuss simulations and experimental investigations of strongly-coupled optical antennas selectively excited to their antibonding resonance.

O 11.8 Mon 16:45 PHY C213

Size, gap, shape, and material dependence of third harmonic generation from bowtie nanoantenna arrays — •Mario Hentschel[1,2], Tobias Utikal[1,2], Markus Lippitz[1,2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, D-70569 Stuttgart, Germany — [2]Max-Planck-Institute for Solid State Research, Heisenbergstr. 1, D-70569 Stuttgart, Germany

We investigate third harmonic generation from gold bowtie nanoantenna arrays. We fabricated 9x11 arrays of 125x200 nanoantennas each, varying continuously the gap size as well as the bowtie size. Both structural parameters determine the resonance wavelength of these plasmonic dimers, leading to a wide range of resonance positions from 690 nm to 1020 nm. The linear transmittance spectra are measured by an FTIR microscope. 8 fs broadband laser pulses with a center wavelength of 820 nm are utilized to generate the third harmonic signal. We find that surprisingly the third harmonic signal does not scale with shrinking gap size as expected, but is rather a function of resonance energies in the hybridized plasmonic dimer. The third harmonic signal is strongest for maximum overlap of the extinction spectrum of the nanostructures and the laser spectrum, as well as when the plasmonic oscillator strength is largest. Furthermore we study variations of the nanoantenna system in order to gain further insight in the harmonic generation process. We are going to present resent results on the THG conversion efficiencies for different antenna designs, such as rod-, sphere-, and gap-antennas, as well as for different antenna materials.