HL 27: Plasmonics and Nanooptics III: Light-Matter Interaction

Time: Monday 17:00–18:30 Location: TRE Ma

HL 27.1 Mon 17:00 TRE Ma

Momentum distribution of hot electrons in resonantly excited gold nanorods revealed by time of flight k-resolving photoemission spectromicroscopy — •Martin Lehr[1], Benjamin Foerster[2,3], Katja Krüger[2], Mathias Schmitt[2], Carsten Sönnichsen[2], Gerd Schönhense[1], and Hans Joachim Elmers[1] — [1]Institut für Physik, Johannes Gutenberg-Universität, Staudinger Weg 7, D-55128 Mainz, Germany — [2]Institut für physikalische Chemie, Johannes Gutenberg-Universität, Duesbergweg 10-14, D-55128 Mainz, Germany — [3]Graduate School for Excellence Materials Science in Mainz, Johannes Gutenberg University Mainz, Staudingerweg 9, D-55128 Mainz, Germany

We investigate plasmon assisted photoemission from individual Au nanorods using a time-of-flight momentum resolving photoemission electron microscope (ToF k-PEEM). The Au nanorods are taylored to obtain a localized plasmon polartion resonance wavelength of 800 nm with a linewidth of just 44 nm. The Au nanorods adhere to a transparent In-Sn oxide substrate enabling illumination from the rear side at normal incidence. The two momentum components parallel to the surface and the kinetic energy of the electrons are measured simultaneously. Both properties depend on laser power and polarization confirming a plasmon assisted emission process mediated by the optical field enhancement at the nanorod's ends. The exponential intensity decrease of emitted electrons with increasing kinetic energy reveals the distribution of hot electrons leading to an additional emission process with a characteristic homogeneous momentum distribution.

HL 27.2 Mon 17:15 TRE Ma

Plasmon polaritons in cubic lattices of interacting metallic nanoparticles — •Simon Lamowski[1], Felicitas Hellbach[1], Eros Mariani[2], Guillaume Weick[3], and Fabian Pauly[1] — [1]Department of Physics, University of Konstanz, D-78457 Konstanz, Germany — [2]Centre for Graphene Science, Department of Physics and Astronomy, University of Exeter, Stocker Rd. EX4 4QL Exeter, UK — [3]Institut de Physique et Chimie des Matériaux de Strasbourg, Université de Strasbourg, CNRS UMR 7504, F-67034 Strasbourg, France

We investigate theoretically plasmon polaritons in cubic lattices of interacting spherical metallic nanoparticles [1]. Dipolar localized surface plasmons on each nanoparticle couple through the near field dipole-dipole interaction and form collective plasmons, which extend over the whole metamaterial. Coupling these collective plasmons in turn to photons leads to plasmon polaritons. We derive within a quantum model general semi-analytical expressions to evaluate both plasmon and plasmon-polariton dispersions that fully account for nonlocal effects in the dielectric function of the metamaterial. Within this model, we discuss the influence of different lattice symmetries and predict related polaritonic gaps within the near-infrared to the visible range of the spectrum that depend on wavevector direction and polarization.

[1] S. Lamowski, F. Hellbach, E. Mariani, G. Weick, and F. Pauly, arXiv:1606.04897.

HL 27.3 Mon 17:30 TRE Ma

Relaxation of single and collective electron excitations investigated with time- and energy-resolved PEEM — •Michael Hartelt[1], Anna-Katharina Mahro[1], Tobias Eul[1], Benjamin Frisch[1], Philip Thielen[1], Deirdre Kilbane[1,2], Mirko Cinchetti[1,3], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Germany — [2]School of Physics, University College Dublin, Ireland — [3]Experimentelle Physik VI, Fakultät Physik, TU Dortmund, Germany

The generation of hot carriers through the internal decay of plasmons in metallic materials has received considerable attention lately, due to its wide range of potential applications [1]. Understanding the differences between photoinduced and plasmon-induced hot electrons is essential for the construction of devices for plasmonic energy conversion. To distinguish between the two processes, it is advantageous to make use of the time-resolved 2-photon-photoemission (TR-2PPE) method that is an established tool for the study of hot electron lifetimes [2] in combination with Photoemission Electron Microscopy (PEEM). This allows us to study hot electron dynamics on the femtosecond and nanometer scale by analyzing the energy distribution and relaxation dynamics of the photoemitted electrons. Here, we present first results of time and energy resolved PEEM (TR-ER-PEEM) measurements of localized and propagating plasmons (LSP and SPP) with focus on the relation between spectral features and local near-field distributions.

[1] Brongersma et al., Nature nanotechnology 10.1 (2015)
[2] M. Bauer et al., Progress in Surface Science 90, 319 (2015)

HL 27.4 Mon 17:45 TRE Ma

Parallel mapping of optical near-field interactions by molecular motor-driven quantum dots — Friedrich W. Schwarz[1], Hannah S. Heil[1], Heiko Gross[2], •Jens Ehrig[1], Bert Hecht[2], and Stefan Diez[1] — [1]B CUBE & cfaed, Technische Universität Dresden — [2]Nano-Optics and Biophotonics Group, Universität Würzburg

Absorption and emission rates of photons by quantum emitters strongly depend on the emitters' local environment. This enables the precise control of light–matter interactions, essential for the development of future opto-electronics devices. The design, characterization and optimization of such devices requires high-resolution, yet high-speed and non-invasive tools that allow the nm-precise mapping of the involved optical near-field interactions. Toward this end, we investigate the near-field interaction of optical dipole emitters with nanostructures by recording the fluorescence intensity of quantum dots attached to microtubules being transported across the nanostructure by molecular motors. The power of this parallel approach to near-field imaging is demonstrated by the nm-precise mapping of near-field interactions between individual quantum dots and nanoslits of 110 to 240 nm widths engraved in 25 nm gold layers. The results of these measurements are in excellent agreement with finite-difference time-domain simulations. Thus, by using a minimalistic biomolecular machinery, we are able to perform parallel superresolution mapping of near-field interactions in a virtually artifact-free fashion. We foresee broad applications, such as large-scale multi-probe imaging of meta-surfaces to further the understanding of light-matter interactions.

HL 27.5 Mon 18:00 TRE Ma

Adaptive spatial resolution in the finite-difference modal method for the derivation of electromagnetic fields — •Izzatjon Allayarov, Martin Schäferling, Maxim Nesterov, and Thomas Weiss — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

Optical devices based on nanostructures have many applications in different fields. For example, it has been shown that photonic crystal slabs can be used to control the polarization state emitted by quantum emitters [1]. One very efficient numerical method to model the optical properties of photonic crystal slabs and periodic arrays of nanoantennas is the Fourier modal method. However, due to the underlying Fourier basis, the Fourier modal method suffers from the Gibbs phenomenon, which results in spurious oscillations of the electromagnetic near fields around interfaces between different materials.

As an alternative to the Fourier basis, we have implemented a finite-difference basis for modal methods based on the approach in [2] and combined it with the coordinate transformation methods that are well-established in the standard Fourier modal method [3]. Thus, we have achieved significantly better convergence of the electromagnetic near fields as compared to the standard Fourier modal method as well as the finite difference modal method without coordinate transformations.

[1] S. V. Lobanov et al., Opt. Letters **40**, 1528 (2015).
[2] I. Semenikhin and M. Zanuccoli, JOSA A **30**, 2531 (2013).
[3] T. Weiss et al., Opt. Express **17**, 8051 (2009).

HL 27.6 Mon 18:15 TRE Ma

Strong Coupling of Single Excitons to Curved Optical Nanostructures — •Daniel Hernangómez-Pérez[1,2], Rui-Qi Li[2,3], Francisco José García-Vidal[2,4], and Antonio I. Fernández-Domínguez[2] — [1]Institute of Theoretical Physics, University of Regensburg, D-93050 Regensburg, Germany — [2]Departamento de Física Teórica de la Materia Condensada and Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, E-28049 Madrid, Spain — [3]Key Laboratory of Modern Acoustics, MOE, Institute of Acoustics, Department of Physics, Nanjing University, Nanjing 210093, People's Republic of China — [4]Donostia International Physics Center (DIPC), E-20018 Donostia/San Sebastián, Spain

We systematically analyze plasmon-exciton coupling for a quantum dot situated in-between two nanoparticles. To that purpose, we employ a systematic quasi-analytical approach inspired by transformation optics, which allows us to study the impact of geometry and material configurations in the quantum dynamics. We show that the coupling to multipolar dark modes close to the plasmon resonances allows to enter into a regime wheret the dynamics can be reversible and compare our findings to recent experiments. The findings presented here may serve as a guidance to additional future experiments and for the development of new quantum plasmonic devices. References: PRL 117, 107401 (2016), Nature 535, 127 (2016)