O 57: Plasmonics and nanooptics: Light-matter interaction, spectroscopy II

Time: Wednesday 10:30–12:30 Location: HSZ/0403

Invited Talk O 57.1 Wed 10:30 HSZ/0403

From Plasmonic Near-Fields to Electron Dynamics - A Photoemission Perspective — •Pascal Dreher — Faculty of Physics and Center for Nanointegration, Duisburg-Essen (CENIDE), University of Duisburg-Essen, 47048 Duisburg, Germany — Present Address: Institut für Physikalische und Theoretische Chemie, Universität Würzburg, Am Hubland, 97074 Würzburg

Electromagnetic near-fields are ubiquitous in solid-state physics. At surfaces, interfaces, and in nanostructures they control dynamical processes and shape optical and electronic material properties. By concentrating electromagnetic energy to subwavelength volumes, near-fields enable tailored nanoscale light-matter interactions relevant to plasmonics, nanophotonics, and ultrafast carrier dynamics. A detailed understanding of these interactions, however, requires experimental access to the full three-dimensional, time-dependent vectorial structure of near-fields, ideally in conjunction with direct probes of the electronic excitations they launch.

In this talk, I will address these needs using two complementary experimental approaches: polarimetric photoemission microscopy that maps vectorial near-fields at surfaces, and time- and angle-resolved photoemission that probes the resulting charge-carrier dynamics. Using surface plasmon polaritons as a prototypical platform, it will be demonstrated how these methods allow to relate near-field dynamics and light-matter interactions at the native length, momentum, time, and energy scales.

O 57.2 Wed 11:00 HSZ/0403

Steps Towards Excitation of Quantum Emitters with Switchable Nonlinear Near Fields — •Valentin Dichtl, Thorsten Schumacher, and Markus Lippitz — Experimental Physics III, University of Bayreuth

The third-order nonlinear material response of noble metals enables the formation of the third-harmonic near field around a plasmonic nanostructure. The corresponding spatial emission pattern of the third-harmonic hot spots changes drastically when the fundamental wavelength is slightly tuned over a linear resonance of the nano antenna [1]. This effect can be used to spatially tailor the near field for excitation of various emitters – such as molecules or quantum dots – beyond the diffraction limit.

We identified distinct differences in the nonlinear scattering behavior between the complentarry plasmonic structures rod and slit [2]. Building on this insight we compare these geometries in terms of their suitability for single emitter excitation.

We demonstrate non-destructive third-harmonic generation in close proximity to fluorescent dyes. Finally, we discuss spectral and temporal strategies for discriminating photons originating from fluorescence versus those from harmonic generation.

[1] Wolf, D. *et al.* Shaping the nonlinear near field. *Nat. Commun.* 7:10361 (2016). doi: 10.1038/ncomms10361
[2] Dichtl, V. *et al.* The Nonlinear Limit of Babinet's Principle. *Nano Lett.* 2025, 25, 11084-11088. doi: 10.1021/acs.nanolett.5c02210

O 57.3 Wed 11:15 HSZ/0403

Intrinsic plasmon canalization in the natural biaxial van-der-Waals material $MoOCl_2$ — •Farid Aghashirinov[1], Andrea Manchini[2], Lin Nan[2], Giacomo Venturi[2], Nicola Melchioni[2], Florian Mangold[1], Bettina Frank[1], Antonio Ambrosio[2], and Harald Giessen[1] — [1]4-th Physics Institute, University of Stuttgart, Stuttgart, Germany — [2]Vectorial Nano-Imaging, Istituto Italiano di Tecnologia, Milano, Italy

We investigate directional near-infrared plasmon polaritons in exfoliated $MoOCl_2$ flakes on SiO_2 substrates, excited using gold disk nanoantennas and probed with scattering-type scanning near-field optical microscope (s-SNOM). $MoOCl_2$ is a natural van der Waals material that supports low-loss, in-plane hyperbolic plasmons and exhibits strong optical anisotropy: polarization along the short axis yields metallic behaviour, while alignment with the long axis produces a dielectric response [1]. Using a widely tunable broadband laser from Stuttgart Instruments, we map the polariton dispersion across a broad spectral range and identify distinct propagation regimes. In our work, we observe plasmon-polariton canalization for the first time, where wavefronts propagate without divergence. These measurements highlight $MoOCl_2$ as a broadband, highly directional natural polaritonic platform.

[1] G. Venturi et al., Nat Commun 15, 9727 (2024)

O 57.4 Wed 11:30 HSZ/0403

Toward Plasmonic Neuronal Architectures at the Nanometer Scale — •Christopher Weiss[1], Tobias Eul[2], Emily Kruel[1], Mario Pfeiffer[1], Bert Lägel[1], Benjamin Stadtmüller[2], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS, RPTU University Kaiserslautern-Landau, Germany — [2]Experimentalphysik II, Institute of Physics, University of Augsburg, Germany

Classical von-Neumann computers face severe energy and speed limitations when operating large artificial neural networks, motivating alternative computing concepts beyond the traditional architecture. Plasmonic nanostructures offer a promising route toward ultrafast and highly integrated neuromorphic systems by enabling strong optical confinement at the nanoscale. We present a concept for a plasmonic neuronal cell that combines multiplexed signal reception, static weighting, and nonlinear activation within a single device. Optical inputs encoded in the orbital angular momentum of light are directed into separate dielectric-loaded surface-plasmon-polariton waveguides. Synaptic weighting is implemented through nanoscale gaps, whose attenuation characteristics are analyzed using finite-difference time-domain simulations and experimentally validated by photoemission electron microscopy. Nonlinear activation is provided by plasmon-enhanced two-photon photoemission. These results establish the essential functional components required for ultrafast plasmonic neuromorphic architectures.

O 57.5 Wed 11:45 HSZ/0403

Optical resonance tuning of single polystyrene microspheres using the phase-change material In_3SbTe_2 **as a switchable mirror** — •Rebecca Rahmel, Hristiyana Kyoseva, Lukas Conrads, Thomas Taubner, and Gero von Plessen — I. Institute of Physics (IA), RWTH Aachen University

The optical resonances of dielectric nanoparticles and microparticles can be modified via their size, shape and configuration [1]. Dielectric particles in particle-on-mirror (PoM) geometries show rich optical responses due to their low losses and electric and magnetic multipolar Mie modes [2]. Cueff et al. introduced the concept of a switchable mirror to tune the resonances of dipole emitters using the phase-transition material VO_2 [3]. Here we tune the infrared multipolar Mie resonances of dielectric polystyrene (PS) microspheres using a switchable mirror made of the phase-change material In_3SbTe_2 (IST). IST exhibits a phase change between an amorphous dielectric and crystalline metallic phase in the infrared [4,5] and can be locally switched under the PS microspheres, creating a PoM geometry. Measuring the scattering spectra of the PS microspheres before and after switching, we achieve huge shifts of the resonance wavelength from 5.2 to 8.9 μm. Our work is a first step towards the controlled tuning of multipolar Mie modes of various particles using reprogrammable IST mirror structures.

[1] Kuznetsov et al. *Science* **354**, aag2472 (2016) [2] Yao et al. *ACS Nano* **18**, 26, 16545-16555, (2024) [3] Cueff et al. *Nat. Com.* **6**, 8636 (2015) [4] Heßler et al. *Nat. Com.* **12**, 924 (2021) [5] Conrads et al. *Opt. Mat. Ex.* **15**, 2664-2687 (2025)

O 57.6 Wed 12:00 HSZ/0403

Spectral tuning of hyperbolic shear polaritons in monoclinic gallium oxide via isotopic substitution — •G. Carini[1], M. Pradhan[2], E. Gelzinyte[1], A. Ardenghi[3], S. Dixit[4], M. Obst[5,6], A. S. Senarath[4], N. S. Mueller[1], G. Alvarez-Perez[1,7], K. Diaz-Granados[4], R. A. Kowalski[4], R. Niemann[1], F. G. Kaps[5], J. Wetzel[5], R. B. Iyer[2], P. Mazzolini[8], M. Schubert[9,10], J. M. Klopf[11], J. T. Margraf[12], O. Bierwagen[3], M. Wolf[1], K. Reuter[1], L. M. Eng[5,6], S. Kehr[5,6], J. D. Caldwell[4], C. Carbogno[1], T. G. Folland[2], M. R. Wagner[3], and A. Paarmann[1] — [1]FHI, Berlin, Germany — [2]University of Iowa, Iowa City, IA, USA — [3]PDI, Berlin, Germany — [4]Vanderbilt University, Nashville, TN, USA — [5]TUD, Dresden, Germany — [6]EXC 2147 (ct.qmat), Dresden, Germany — [7]IIT, Lecce, Italy — [8]University of Parma, Parma, Italy — [9]University of Nebraska, Lincoln, NE, USA — [10]Lund University, Lund, Sweden — [11]HZDR, Dresden, Germany — [12]University of Bayreuth, Bayreuth, Germany

This contribution reports a significant spectral tuning of hyperbolic shear polaritons (HShPs) in monoclinic gallium oxide (bGO) via isotopic substitution. HShPs are imaged in real-space with near-field optical microscopy, allowing for a model-free estimation of the frequency shift. Complementary far-field measurements and *ab initio* calculations - in good agreement with the near-field data - confirm the effectiveness of this estimation. This combined study demonstrates the possibility to support such highly directional polaritons in a hitherto inaccessible range, with great promise for future applications.

O 57.7 Wed 12:15 HSZ/0403

Vibrationally Induced Resonances in Nanolasers based on Plasmonic Cavities — •Kai Müller[1], Kimmo Luoma[2], and Christian Schäfer[3] — [1]Institut für Theoretische Physik, Technische Universität Dresden, D-01062 Dresden, Germany — [2]Department of Physics and Astronomy, University of Turku, 20014 Turku, Finland — [3]Institute of Applied Physics, TU Wien, Wiedner Hauptstrasse 8-10/134, Vienna, 1040, Austria

Optical circuits and light sources, such as lasers, undergo continuous miniaturization. In recent years, this trend has been taken to its extreme with lasers comprising only a few molecules confined in plasmonic nanocavities. Here, we use a novel method that combines the Bogoliubov-Born-Green-Kirkwood-Yvon (BBGKY) hierarchy with the hierarchical equations of motion (HEOM) to provide theoretical predictions for the quantum dynamics of this few-emitter lasing system. Our approach is informed from first principles and explicitly accounts for the entire vibrational manifold of each molecule in addition to the cavity. We show how the form of the vibrational spectrum influences the lasing process and uncover resonant enhancements in the lasing intensity, which are absent if the coherent drive and vibrational relaxation are combined into the commonly used effective incoherent drive.