O 86: Plasmonics and Nanooptics VI

Time: Friday 10:30–13:00 Location: H36

O 86.1 Fri 10:30 H36

Modelling attosecond dynamics: tracking collective excitations — •Andrey Moskalenko, Yaroslav Pavlyukh, Jonas Wätzel, and Jamal Berakdar — Institut für Physik, Martin-Luther-Universität Halle-Wittenberg

The emergence of attosecond light sources is undoubtedly one of most exciting developments in science in the last decade and is expected to change significantly the face of physics, chemistry and biology research. A series of benchmark experiments on the attosecond electron dynamics in atomic, molecular and condensed matter systems reveal fundamentally new processes taking place in this time regime and evidence the high potential of this rapidly growing field. One of the fundamental open questions, which can be targeted with these new experimental tools, is how an inherent collective response of matter is formed on an ultrashort, possibly attosecond time scale. In this presentation we report on our progress towards modelling attosecond electron dynamics in clusters. Combining quantum chemical computation [1] with quantum kinetic methods we calculate the time-dependent light absorption and refraction in fullerene that serve as indicators for the emergence of collective modes. We trace on an attosecond time scale the collective excitations in this finite system and find distinct new features in this regime [2]. Finally, we discuss how to observe the predicted dynamics in a XUV-pump XUV-probe or in an attosecond streaking experiments.

[1] Y. Pavlyukh and J. Berakdar, Chem. Phys. Lett. 468, 313 (2009).

[2] A.S. Moskalenko, Y. Pavlyukh, and J. Berakdar, Phys. Rev. A 86, 013202 (2012).

O 86.2 Fri 10:45 H36

Plasmon-induced fluorescence and electroluminescence from porphine molecules on GaAs(110) in a scanning tunneling microscope — •Svenja Mühlenberend, Natalia L. Schneider, Markus Gruyters, and Richard Berndt — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany

An STM tip can be used to excite luminescence from atomic scale structures. For the investigation of molecular fluorescence, however, the coupling to metallic substrates has been a major issue as it largely inhibits fluorescence. The decoupling of molecules by e.g. multilayer arrangements or salt layers has been used to circumvent this difficulty. Here, we report on fluorescence from tetraphenyl-porphine molecules on a semiconductor (GaAs(110)) for very low coverages of less than 5% of a monolayer without any decoupling layer. Evidence for intramolecular Q-band transitions is found in the fluorescence spectra. The processes involved in exciting this molecular fluorescence will be discussed.

O 86.3 Fri 11:00 H36

Single giant pseudoconjugated macrocycles mimic light-harvesting complexes — Vikas Aggarwal[1], Alex Thiessen[2], Alisa Idelson[1], •Dominik Würsch[3], Thomas Stangl[3], Florian Steiner[3], Stefan-S. Jester[1], Jan Vogelsang[3], Sigurd Höger[1], and John Lupton[3] — [1]University of Bonn, Bonn, Germany — [2]University of Utah, Salt Lake City, Utah, USA — [3]University of Regensburg, Regensburg, Germany

Natural light-harvesting complexes have long served as model systems of the physics of molecular excitons. Synthetic model systems which mimic specific aspects of exciton coupling would allow investigating the effects of coupling in a highly defined system. Here we introduce giant shape persistent macrocycles of carbazole-enthynylene units of 7 nm diameter. Fully conjugated macrocycles are generally considered to be non-emissive because the fundamental oscillator mode is dipole forbidden. For every electron which moves in one direction there is another moving in exactly the opposite direction, resulting in a vanishing dipole moment. Spontaneous fluctuations in the conjugation lead to strongly allowed fluorescence of the system which enables single molecule studies of the emitter. We find that the conjugation varies with time resulting in jumps in the linear dichroism. The conjugation of the macrocycle is dynamically interrupted leading to more than one chromophore being present. Surprisingly, we find that the emission polarization can rotate without a change in transition energy, implying that the different chromophores on the ring remain susceptible to the same dielectric environment.

O 86.4 Fri 11:15 H36

Scanning probe techniques in quantum plasmonics — •Andreas W. Schell, Philip Engel, Günter Kewes, and Oliver Benson — Humboldt-Universität zu Berlin, AG Nanooptik

In recent years, scanning probe technologies like atomic force microscopy have developed into a versatile tool for nano-manipulation and nano-assembly tasks [1]. Using nano-manipulation approaches it has become possible to realize different configurations of the same constituents. Here, we will show the controlled coupling of a single photon emitting nitrogen vacancy (NV) center in nanodiamond to different plasmonic structures as well as its use as a probe for the local density of optical states (LDOS) at the nanoscale [2]. With the NV center glued to the tip of an atomic force microscope the LDOS is mapped out in a very controlled way in all three dimensions, giving insight into the local behavior of the emitter-plasmon coupling.

[1] A.W. Schell et al., Rev. Sci. Instrum. 82, 073709 (2011).

[2] A.W. Schell et al., Opt. Express. 19, 7914 (2011).

O 86.5 Fri 11:30 H36

Validity of the effective medium theory for hyperbolic layered materials in the presence of surface modes. — •Maria Tschikin[1], Philippe Ben-Abdallah[2], and Svend-Age Biehs[1] — [1]Carl von Ossietzky Universität, Institute of Physics, 26111 Oldenburg, Germany — [2]Laboratoire Charles Fabry, Institut d'Optique, CNRS, Université Paris- Sud, France

It is well known that the physics of periodic structures can be described by the effective medium theory (EMT) if the period of the structure is smaller than the wavelength of radiation. One example where the EMT is applied are bilayer structures with effective permittivity perpendicular $\epsilon_\perp$ and parallel $\epsilon_{||}$ to the optical axes. If both effective permittivities have different signs, i.e., $\epsilon_\perp \epsilon_{||} < 0$, than the dispersion relation for propagating modes inside the medium is hyperbolic. In these regions the local density of states can have large values in a broad frequency band which can be used for near-field energy conversion or broadband enhanced spontaneaus emission. We consider the particular case where surface modes appear inside the hyperbolic bands and show that the EMT can lead to wrong interpretations. In particular effects which are due to surface modes could be associated to hyperbolic modes. To this end, we compare exact S-matrix calculations with the results of EMT and determine the regions where EMT can lead not only to quantitatively but also to qualitatively wrong results.

O 86.6 Fri 11:45 H36

Nanoscale heat transfer: hyperbolic modes versus surface modes — •Svend-Age Biehs[1], Maria Tschikin[1], and Philippe Ben-Abdallah[2] — [1]Carl von Ossietzky Universität, Institute for Physics, 26111 Oldenburg, Germany — [2]Laboratoire Charles Fabry, Institut d'Optique, CNRS, Université Paris- Sud, France

The radiative heat flux at the nanoscale can be by orders of magnitude larger than that between two black bodies. Therefore, this effect is sometimes called super-Planckian thermal radiation. When considering polar materials like SiC, it was shown that at the nanoscale the dominant heat flux channel is due to surface phonon polaritons. Here, we show that for hyperbolic/indefinite materials one can also achieve very large heat fluxes without any surface modes. In this case, the dominant heat flux channel is due to frustrated total internal reflection modes. We show that this is a broad-band effect whereas the heat flux due to surface modes is a quasi-monochromatic effect which is preferable for applications in near-field thermophotovoltaics, for instance. Finally, we present exact calculations for multilayer structures and discuss the impact of hyperbolic modes and surface modes.

O 86.7 Fri 12:00 H36

Probing optical near-fields by photoemission of electrons with 1 nm resolution — •Sebastian Thomas[1], Michael Krüger[1], Michael Förster[1], Markus Schenk[1], and Peter Hommelhoff[1,2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Gemany — [2]Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, 91058 Erlangen, Germany

We present a new method of measuring optical near-field enhancement. In our experiments, we use a metal nanotip under laser illumination as an ultrafast source of photoelectrons. Some of the emitted electrons return to the tip surface within one optical cycle of the driving field, where they may gain energy by elastic rescattering [1]. This process crucially depends on the electric field strength in the immediate vicinity of the surface. By measuring the kinetic energy of rescattered electrons, we obtain the enhanced electric field strength within 1 nm from the tip surface [2]. This is close to the length scale of quantum plasmonics, and about an order of magnitude better than the previous record resolution [3].

Our results for the field enhancement factor at tungsten and gold tips are in good agreement with Maxwell simulations. Further simulations of nanotips with varying dielectric function give insight into the plasmonic characteristics of nanotips, which differ significantly from those of nanospheres.

[1] Krüger, Schenk, Hommelhoff, Nature 475, 78 (2011)
[2] Thomas et al., arxiv:1209.5195 (2012)
[3] Raschke et al., ChemPhysChem 6, 2197 (2005)

O 86.8 Fri 12:15 H36

Effect of size and shape of randomly distributed ZnO nanoneedle arrays on the localization of light fields — •Martin Silies[1], Manfred Mascheck[1], Slawa Schmidt[1], Janos Sartor[2], David Leipold[3], Takashi Yatsui[4], Kokoro Kitamura[4], Motoicho Ohtsu[4], Heinz Kalt[2], Erich Runge[3], and Christoph Lienau[1] — [1]Carl von Ossietzky Universität, Oldenburg, Germany — [2]Karlsruhe Institute of Technology, Germany — [3]Technische Universität Ilmenau, Germany — [4]University of Tokyo, Japan

We report on measurements about the influence of size, shape and diameter of arbitrarily arranged ZnO nanostructures on the localization of light. We use coherent, ultra-broadband Second Harmonic (SH) microscopy to investigate the spatial localization of light in nm-sized ZnO needle arrays. Strong fluctuations of the SH intensity inside different ZnO needle geometries are observed [1].

Comparison of the SH intensity distributions with predictions based on one-parameter scaling theory indicate that SH fluctuations may be taken as a quantitative measure to classify the degree of localization [2]. Surprisingly, the strongest localization signatures are found for densely packed arrays of thin needles with diameters in the 30 nm range. Our results indicate that for sufficient high filling factors and small needle diameters near-field coupling between neighbouring needles governs the localization. These findings are supported by 3D-FDTD simulations using a Maxwell equation solver.

[1] Mascheck et al., Nat. Phot. 6, 293 (2012)
[2] Abrahams et al., Phys. Rev. Lett. 42, 673 (1979)

O 86.9 Fri 12:30 H36

Time-resolved near field microscopy of a metal particles breathing oscillation — •Matthias Brandstetter[1,2], Ralf Vogelgesang[3], and Markus Lippitz[1,2] — [1]Max-Planck Institute for Solid State Research, Stuttgart, Germany — [2]University Stuttgart, Germany — [3]Carl von Ossietzky University Oldenburg, Deutschland

The localized surface plasmon resonance (LSPR) of a metal nanoparticle depends directly on the geometry and the dielectric constant of the nanoobject. Impulsive heating through a laser pulse launches acoustical oscillations of the whole particle. The mechanical oscillations lead to a local variation in the dielectric properties. Using an apertureless SNOM in a pump-probe configuration, we locally probe these changes of the dielectric properties of a nanoparticle on the picosecond timescale. The spatial resolution is defined by the near-field microscope (about 10 nm). The temporal resolution is just limited by the duration of the laser pulse, in our case to about one picosecond. This new device will allow us to investigate ultrafast processes on the nanoscale. We present our combination of an apertureless scanning near-field microscope and a pump probe setup as well as experimental results.

O 86.10 Fri 12:45 H36

Recent Progress in the Simulation of Plasmonic Systems with the DGTD Method — •Jens Niegemann — Institut für Feldtheorie und Höchstfrequenztechnik (IFH), ETH Zürich, Switzerland

Due to its flexibility and efficiency, the discontinuous Galerkin time-domain (DGTD) method has established itself as a popular method in the field of wave propagation. Here, we discuss our recent advances in using the DGTD method for the simulation of plasmonic and nanophotonic devices. In particular, we demonstrate how a memory-efficient formulation of curvilinear elements together with an implementation on graphics processing units (GPUs) significantly reduces the computational time. This allows large parameter scans or numerical optimizations with relatively little computational power.