Q 15: Nano-Optics (Plasmonics)

Time: Monday 14:00–16:00 Location: S SR 112 Maschb.

Invited Talk Q 15.1 Mon 14:00 S SR 112 Maschb.

Tunable and nonlinear resonant semiconductor metasurfaces — •Isabelle Staude — Friedrich Schiller University Jena, Germany

Optical metasurfaces composed of designed Mie-resonant semiconductor nanoparticles arranged in a planar fashion offer comprehensice control over the properties of light fields. Most prominently, such metasurfaces can impose a spatially variant phase shift onto an incident light field, thereby providing control over its wave front with high transmittance efficiency. However, the optical response of most semiconductor metasurfaces realized so far was permanently encoded into the metasurface structure during fabrication. Recently, a growing amount of research is concentrating on obtaining dynamic control of their optical response, with the aim of creating metasurfaces with functionalities that can be altered or programmed on demand. This talk will provide an overview of our recent advances in dynamically tunable Mie-resonant semiconductor metasurfaces. In particular, by integrating silicon metasurfaces into liquid-crystal (LC) cells, we can tune their linear-optical transmittance and reflectance spectra by application of a voltage. Based on this method, we experimentally demonstrate a transparent metasurface display device operating in the visible spectral range. In order to drastically enhance the tuning speed, we furthermore consider the transient changes of the optical properties of semiconductor materials when optically pumped by femtosecond laser pulses. These changes can lead to pronounced changes of the resonance condition for semiconductor metasurfaces at an ultrafast time scale, offering unique opportunities for ultrafast wavefront shaping.

Q 15.2 Mon 14:30 S SR 112 Maschb.

Topological quantum dots: a novel platform for quantum optics — •Marie Rider[1], Vincenzo Giannini[1,2], Peter Haynes[1,3], and Derek Lee[1] — [1]Department of Physics, Imperial College London, London, UK — [2]Instituto de Estructura de la Materia (IEM-CSIC), Consejo Superior de Investigaciones Científicas, Madrid, Spain — [3]Department of Materials, Imperial College London, London, UK

Topological insulators (TIs) are a distinctive class of materials, which are insulating in the bulk but support topologically protected conducting surface states. Since their discovery, most work on these materials has focused on their electronic properties, whilst their interaction with electromagnetic fields has largely been untouched. In small topological insulator nanoparticles (TINP) such as those studied by Siroki et al [1], the dispersion relation of the topological surface states is no longer continuous but discretized. This system forms a type of topological quantum dot. By studying the optical transition properties between the states of the topological quantum dot we explore their use as a lasing system. The optical properties of the particle can be tuned by varying particle size, light frequency and light polarization, providing a toolbox for quantum optics and quantum information technologies.

References [1] G Siroki, D.K.K. Lee, P.D. Haynes 2016 Nature Comms Vol, 7-12375

Q 15.3 Mon 14:45 S SR 112 Maschb.

Silver nanowires with optimized silica coating as versatile plasmonic resonators — •Martin Rothe[1], Yuhang Zhao[2], Günter Kewes[1], Zdravko Kochovski[2], Wilfried Sigle[3], Peter A. van Aken[3], Christoph Koch[4], Matthias Ballauff[2,5], Yan Lu[2,6], and Oliver Benson[1] — [1]Humboldt Universität zu Berlin & IRIS Adlershof, Nanooptics, Berlin, Germany — [2]Helmholtz Zentrum Berlin für Materialien und Energie, Institute of Soft Matter and Functional Materials, Berlin, Germany — [3]Stuttgart Center for Electron Microscopy, Max Planck Institute for Solid State Research, Stuttgart, Germany — [4]Humboldt Universität zu Berlin & IRIS Adlershof, Structure Research and Electron Microscopy, Berlin, Germany — [5]Humboldt Universität zu Berlin, Department of Physics, Berlin, Germany — [6]Institute of Chemistry, University of Potsdam, Potsdam, Germany

Metal nanowires are advantageous plasmonic nanostructures as they offer large interaction volumes, tunable resonances and good coupling opportunities. An additional dielectric coating can be used for distance control but it must in no case degrade the plasmonic properties. We have synthesized silver nanowires of 70nm in diameter with a nm-sized silica shell of homogeneous and smooth surface quality using a modified Stöber method [1]. Transmission electron microscopy, dark-field scattering spectroscopy, electron-energy loss spectroscopy and thorough numerical simulations have been used to study individual nanowires and thus introduce them as usable building blocks for integrated hybrid plasmonic systems. [1] arXiv:1811.07671 [physics.optics] (2018)

Q 15.4 Mon 15:00 S SR 112 Maschb.

Modeling of harmonic generation in plasmonic structures with complex geometries — •Josselin Defrance, Lili Gui, Mario Hentschel, Harald Giessen, and Thomas Weiss — 4th Physics Institute and Research Centers SCoPE, University of Stuttgart, Germany

The harmonic generation in plasmonic structures has been the subject of many studies over the recent years. In this context, numerical methods play a crucial role in order to understand and enhance the nonlinear optical phenomena. Among the plethora of potential methods, we will focus here on the Fourier modal method and show how to combine it for second-harmonic emission with curvilinear coordinates in order to achieve a faster convergence of the numerical results [1]. Particularly, we will discuss how to include the hydrodynamic model to account for electron-electron interaction inside metallic nanostructures. In addition, we will show numerical results of third-harmonic emission from chiral nanoantenna arrangements.

[1] J. Defrance et al., Opt. Express **26**, 13746-13758 (2018).

Q 15.5 Mon 15:15 S SR 112 Maschb.

Applying machine learning techniques to reconstruct the wave functions from the near-field spectra — •Fulu Zheng and Alexander Eisfeld — Max Planck Institute for the Physics of Complex Systems, Germany

In molecular aggregates, electronic eigenstates are typically delocalized over many molecules due to inter-molecular excitonic coupling. Knowledge about these states is crucial to understand and interpret the optical and transfer properties of the aggregates. In contrast to traditional far-field spectroscopy, near-field spectroscopy applies an inhomogeneous field to provide insights to the aggregate eigenstates, including those optically inaccessible in far-field spectroscopy. Using an electronmagnetic field generated by a metallic nano-tip, we calculate near-field spectra for molecular aggregates for different tip positions. Machine learning techniques are adopted to reconstruct the eigenstate wave functions from the calculated spectra. For not too large aggregates, we find that the eigenstate wave functions can be nicely reproduced.

Q 15.6 Mon 15:30 S SR 112 Maschb.

Electron near-field circular dichroism — •Tyler Harvey, Jan-Wilke Henke, Ofer Kfir, and Claus Ropers — IV. Physical Institute: Solids and Nanostructures, University of Göttingen, Germany

Although absorption or emission of a single photon by an electron is forbidden in free space by energy-momentum conservation, this interaction is possible in the presence of a surface. A surface breaks translation symmetry and allows for coupling between electron momentum and the electromagnetic field amplitude [1,2]. The strength of this coupling depends on the shape and optical properties of the surface, as well as the incident optical power. Because electron beams can be focused to sub-nanometer spots in modern electron microscopes, this interaction, called photon-induced near-field electron microscopy (PINEM) can be employed to image plasmonic modes and optical properties with nanometer spatial resolution.

In this presentation, we demonstrate the ability to probe chirality with PINEM. Circular dichroism spectroscopy with visible light and x-rays has long been used to characterize chiral-structured materials, magnetism and chiral electronic states. By illuminating a sample with left- and right-circularly polarized light and measuring the difference in coupling strength with electrons, we probe chiral optical near fields with nanometer spatial resolution. This technique may enable the investigation of chiral optical and electronic states in plasmonic nanostructures, molecules and atoms with sub-nanometer spatial resolution.

[1] B. Barwick et al., Nature 462 (2009) 902.
[2] A. Feist et al., Nature 521 (2015) 200.

Q 15.7 Mon 15:45 S SR 112 Maschb.

Determining pH-dependent Quantum Efficiency of Emit-

ters by Using a Metal Sphere — •Ersan Özelci[1,2,3], Bastian Rühle[2], Günter Kewes[1], Florian Weigert[2], Ute Resch-Genger[2,3], and Oliver Benson[1,3] — [1]Humboldt-Universität zu Berlin — [2]Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin — [3]School of Analytical Sciences Adlershof (SALSA), Berlin

One of the key spectroscopic performance parameters of molecular and nanoscale emitters is the photoluminescence quantum yield (PL-QY) that provides a direct measure for the number of emitted per absorbed photons. PL-QY can be measured by different methods in various environments and from the ensemble to the single emitter level [1-2]. A particular challenge is to determine changes of the PL-QY of emitters in liquids. Here we adapt a method based on the modification of the radiative decay of emitters by a nearby metal surface [3]. We solve the problem of fixing the emitter-surface distance by trapping organic dyes in a mesoporous silica film [4]. As organic dye we chose fluorescein, which exhibits pH-dependent fluorescence properties [5]. Our results reveal an increase in fluorescein PL-QY from about 25% to 73% with pH increasing from 5.5 to 7.5 showing the applicability of our approach for quantitative measurements.

[1] Würth et al., Anal. Bioanal. Chem. 407, 59-78 (2015). [2] Abbandonato et al., Nanoscale 10, 7147-7154 (2018). [3] Lunnemann et al., ACS Nano 7, 5984-5992 (2013). [4] Innocenzi et al., Chem. Soc. Rev. 42, 4198-4216 (2013). [5] Sjöback et al, Spectrochimica Acta Part A: Mol. Biomol. Spec. 51, 7-21 (1995).