Q 7: Nano-Optics (Microscopy and Plasmonics)

Time: Monday 14:00–16:00 Location: a310

Invited Talk Q 7.1 Mon 14:00 a310

Phonon engineering and manipulation at the nanoscale — •Ilaria Zardo — Department of Physics, University of Basel, CH-4056 Basel, Switzerland

The recently growing research field called "Nanophononics" deals with the investigation and control of vibrations in solids at the nanoscale. Phonon engineering leads to a controlled modification of phonon dispersion, phonon interactions, and transport. Nonetheless, it requires new theoretical and experimental methods, especially when combined with low dimensional physics, which is one of the most promising routes for thermal management and for controlling photon-phonon and electron-phonon interactions.

In this talk, we discuss how phononic properties can be engineered in nanowires and the challenges and progresses in the measurement of phonons and phonon transport of nanostructures.

Q 7.2 Mon 14:30 a310

Coherent plasmonics: a single molecule makes a plasmonic nanoparticle more transparent — •Johannes Zirkelbach[1], Jan Renger[1], Tobias Utikal[1], Stephan Götzinger[1,2], and Vahid Sandoghdar[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Friedrich-Alexander University Erlangen-Nuremberg, Erlangen, Germany

A plasmonic nanoparticle creates a strong extinction shadow detectable in transmission. We demonstrate that a single molecule placed in the near-field of a plasmonic particle can substantially reduce this extinction shadow, making the plasmonic particle more transparent. To achieve this, we prepare a thin molecular crystal doped with dibenzoterrylene (DBT) molecules on a nanostructured array of gold nanoantennas at liquid helium temperature. We then select individual molecules through high-resolution laser spectroscopy and investigate their near-field coupling to nearby gold nanoantennas by recording both extinction and fluorescence excitation spectra. We present a quantitative analysis of the observed spectral lines and comparison with an analytical model, revealing a coherent interaction between the light fields scattered from a molecule and a gold nanoparticle [1].

[1] J. Zirkelbach, et al., in preparation.

Q 7.3 Mon 14:45 a310

Extreme laser background suppression for resonant fluorescence of a quantum emitter — •Meryem Benelajla[1,2], Elena Kammann[1], and Khaled Karrai[1] — [1]attocube systems AG, Eglfinger Weg 2, 85540 Haar bei München — [2]LPCNO INSA CNRS UPS, 135 Av. Rangueil , 31077 Toulouse, France

Confocal microscope is widely used in quantum optics for studying resonant fluorescence properties of semiconductor nanostructures. However, such challenging measurements require the suppression of laser background by several order of magnitudes.One way to do that is to use cross polarization confocal microscopy. Normally, high quality commercial crossed polarizers allows a laser suppression down to 5 to 6 orders of magnitudes. Surprisingly, when used in combination with a confocal microscope, the extinction ratio is boosted up to 9 order of magnitudes. This unexpected but very welcome enhancement finds its origin in the Imbert-Fedorov effect, now commonly referred to as Spin Hall effect of light, which manifests itself in the reflectivity of a Gaussian laser beam off a mirror. In this presentation, we will discuss in details the physics and optics of such a remarkable effect, which we mapped in details for the first time.

Q 7.4 Mon 15:00 a310

Plasmon-assisted Purcell enhancement of silicon-vacancy color centers in diamond membranes — •Haritha Kambalathmana[1], Assegid Mengistu Flatae[1], Stefano Lagomarsino[1], Florian Sledz[1], Lukas Hunold[1], Claudio Biagini[2], Francesco Tantussi[2], Francesco De Angelis[2], and Mario Agio[1] — [1]Laboratory of Nano-Optics, University of Siegen, 57072 Siegen, Germany — [2]Istituto Italiano di Tecnologia, 16163 Genova, Italy

Ultrafast solid-state single-photon sources are desirable in quantum information science and fundamental quantum optics. Currently, we have developed techniques for the fabrication and optical characterization of single-photon sources based on silicon-vacancy (SiV) color centers in diamond [1]. We have experimentally shown that plasmonic gold nano-cones enhance the radiative decay rate by more than three orders of magnitude and boost the efficiency of quantum emitters [2]. We fabricate gold nano-cones on a commercially available atomic force microscopy probe by gold deposition followed by focused ion beam milling. The SiV centers are shallow-implanted in thin diamond membrane to provide the required dimension for near-field interaction in a controlled manner. Theoretical calculations show that the fabricated nano-cones can provide more than four orders of magnitude enhancement in the Purcell factor and a quantum efficiency of 80% [3]. References:[1] S. Lagomarsino, et al., Diam. Relat. Mater. 84, 196 (2018). [2] A. M. Flatae, et al., J. Phys. Chem. Lett. 10, 2874-2878 (2019). [3] H. Kambalathmana, et al., Proc.SPIE 11091, 1109108-1 (2019).

Q 7.5 Mon 15:15 a310

Few-cycle oscillator-based nonlinear and strong-field nanooptics — •Liping Shi[1,2], Uwe Morgner[1,2], and Milutin Kovacev[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]Cluster of Excellence PhoenixD (Photonics, Optics, and Engineering - Innovation AcrossDisciplines), Hannover, Germany

The study of strong-field nonlinear optical effects usually relies on a chirped-pulse amplifier system, which will unwantedly stretch the pulse duration and sacrifice the repetition rate of a seeded oscillator. Here we employ plasmonic and Mie-type optical nanoantennas to amplify the electric near-field strength of a few-cycle Ti:Sapphire oscillator, demonstrating unique advantages of the oscillator-based nonlinear and strong-field effects. First, we can produce a nanoscale ultra-broadband deep ultraviolet light source. Second, due to the giant field gradient in the vicinity of optical nanoantennas, a post-tunneling electron experiences a strong ponderomotive acceleration. This results in a novel mechanism of femtosecond near-field ablation and thin-film deposition. Third, the high-repetition rate of the low-fluence oscillator allows us to investigate some effects that require low-threshold while multi-shot exposure, such as the self-enhanced nonlinear response of silicon nanodisks resonant at anapole modes.

Q 7.6 Mon 15:30 a310

Strong coupling of single quantum dots in a plasmonic antenna at room temperature — •Hsuan-Wei Liu[1], Randhir Randhir Kumar[1], Stephan Götzinger[2,1], and Vahid Sandoghdar[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Friedrich Alexander University of Erlangen-Nürnberg, Erlangen, Germany

Plasmonic antennas are capable of enhancing the spontaneous emission rate of single emitters due to their strong electric field confinement [1]. It has been reported that a nanogap antenna formed by a gold nanoparticle separated from a metallic substrate by a thin dielectric gap can achieve ultra-strong enhancement [2]. When the enhanced emission rate is fast enough to compete with the room temperature dephasing and the plasmon losses rates, the emitter starts to interact coherently with the plasmon mode, bringing the system into the strong coupling regime. In this study, we demonstrate a significant enhancement of a single quantum dot coupled to a plasmonic nanogap antenna. We observe an ultrafast fluorescence lifetime less than 38 ps limited by the instrumental response function. Moreover, by controlling the position of the quantum dot with respect to the nanogap antenna, we can tune the system from the weak coupling to the strong coupling regime leading to vacuum Rabi splitting in the fluorescence spectra [3].

[1] Matsuzaki *et al.*, *Sci. Rep.* **7**, 42307 (2017). [2] Chikkaraddy *et al.*, *Nature* **535**, 127-130 (2016). [3] Liu *et al.*, *in preparation.*

Q 7.7 Mon 15:45 a310

Development of 3D Metallic Microstructures for Light Concentration — •Lei Zheng[1,2] and Bernhard Roth[1,2] — [1]Hannover Centre for Optical Technologies, Leibniz Universität Hannover, Nienburger Straße 17, 30167 Hannover, Germany — [2]Cluster of Excellence PhoenixD (Photonics, Optics, and Engineering-Innovation Across Displine), Hannover, Germany

3D metallic Microstructures with symmetrically curved surfaces are developed for surface plasmon polariton (SPP) deflection and concentration with the perspective to be employed for future sensing applications. The designed structures were first fabricated on a glass substrate using two-photon polymerization (2PP), and then covered with a 60 nm thick gold film by sputtering. Surface plasmon polaritons (SPPs) propagating on the fabricated structure are generated through a straight line on the structure surface. Leakage radiation microscopy (LRM) is used here for the excitation and observation of SPPs. When focusing the laser beam onto the straight excitation line, SPPs can be excited towards both sides of the line. The characterization results on different structures have shown that SPPs can be deflected and partly concentrated when they propagate around the raised part of the metallic structure. The maximum electromagnetic energy concentration can be reached when SPPs propagate towards the center of the raised part of the structure. An investigation on the energy concentration performance of the proposed metallic structures with respect to different structure profiles is analytically and experimentally carried out. The work towards realization of novel optical sensing devices is discussed.