Q 71: Nano-Optics

Time: Friday 14:30–16:30 Location: HS 3219

Q 71.1 Fri 14:30 HS 3219

Near-field Fano spectroscopy of MaPbI3 nanoparticles — Jinxin Zhan[1], •Tom Jehle[1], Sven Stephan[1], Sam Nochowitz[1], Petra Gross[1], Ekaterina Tiguntseva[2], Sergey Makarov[2], and Christoph Lienau[1] — [1]Universität Oldenburg, Germany — [2]St. Petersburg, Russia

Dielectric nanoparticles particles have optical shape resonances that confine light on the nanoscale in localized modes with well-defined spatial field profiles. A particularly interesting example are halide perovskite nanoparticles, for which the coupling between excitons and Mie modes results in Fano lineshapes in the spectral domain [1]. Here, we use a new broadband, interferometric sSNOM technique [2] to probe the time dynamics of the local optical near-fields of such particles. We measure amplitude and phase of the scattered light field in a broad spectral range and with 10 nm spatial resolution. Direct Fourier transformation gives the time dynamics of the local electric field, recorded with sub-cycle resolution. We uncover biexponential near-field decays with a characteristic destructive interference dip after a few fs. In the spectral domain, this corresponds to a Fano resonance with an unual 2π phase jump. We show that this signature arises from the intereference between spectrally broad dipole and narrow quadrupole resonances of the particles. Our results give new insight into the optical properties of high-index, active semiconductor nanoparticles with intriguing applicatoins for nanoscale all-opticals switching and lasing. [1] Tiguntseva, E. Y., et al. Nano Lett. 2018, 18 (2), 1185-1190. [2] Zhan, J., et al. Advanced Photonics 2020, 2 (04).

Q 71.2 Fri 14:45 HS 3219

Dynamics of exciton-polaritons in optically driven ZnO nano-particles — Andreas Lubatsch[1] and •Regine Frank[2,3] — [1]Physikalisches Institut, Rheinische Friedrich Wilhelms Universitaet Bonn — [2]College of Biomedical Sciences, Larkin University, Miami, Florida, USA — [3]Donostia International Physics Center, 20018 Donostia-San Sebastian, Spain

We implement externally excited ZnO Mie resonators in a framework of a generalized Hubbard Hamiltonian to investigate the lifetimes of excitons and exciton-polaritons out of thermodynamical equilibrium. Our results are derived by a Floquet-Keldysh-Green's functions formalism with Dynamical Mean Field Theory (DMFT) and a second order iterative per-turbation theory solver (IPT). We find polaritons that result from a Fano resonance in the sense of coupling of the continuum of the LDOS to the quantised ZnO resonator mode with lifetimes between 0.6 ps and 1.45 ps. Our results are compared to recent experiments of ZnO polariton lasers and to ZnO random lasers.

[1] A. Lubatsch, R. Frank, Appl. Sci. 2020, 10, 1836 [2] A. Lubatsch,R. Frank, Symmetry 2019, 11, 1246 [3] T.-C. Lu, et. al. Opt. Express 2012, 20, 5530

Q 71.3 Fri 15:00 HS 3219

Magnetoplasmonic routing components: isolator, switch, circulator — •Sevag Abadian, Michail Symeonidis, Marian Bogdan Sirbu, and Tolga Tekin — Fraunhofer IZM, Gustav-Meyer-Allee 25/Gebäude 17, 13355 Berlin

The surge in data traffic driven by mobile apps, high-definition content, IoT, and AR is intensifying the demand for data centers to rapidly process and store massive amounts of information. PICs hold promise for data centers by potentially reducing power consumption and space requirements while optimizing data traffic management. Advancement of routing components which play a pivotal role in enabling efficient and seamless data flow across diverse applications, is a must. To achieve these functionalities, a medium that breaks spatial and time symmetry is necessary. Among the different mechanisms used, magneto-plasmonics has emerged as an efficient tool to be exploited. Plasmonic slot waveguides can host coupled SPP modes which under external magnetization, loose their symmetric and anti-symmetric modal profiles and become asymmetric and anti-asymmetric. For isolators, this opens up the way for switching the light path in the forward and backward directions between the parallel plasmonic interfaces, allowing the creation of high amplitude difference when the backward travelling wave is completely absorbed or radiated by cavities or gratings. For switches or circulators, this opens up the way for switching the light path to one of the two or three arms. Magneto-plasmonics has emerged as a satisfactory solutions for integratable routing components with high efficiency and small footprint.

Q 71.4 Fri 15:15 HS 3219

Ultrafast near-field scanning optical oscilloscopy — •Juanmei Duan, Tom Jehle, Sam Nochowitz, and Christoph Lienau — Universität Oldenburg, D-26129, Germany

Metallic, dielectric and hybrid nanoparticles offer exciting opportunities to localize, manipulate and switch light on the nanoscale. A direct measurement of the local electric field at the surface of the nanostructures is challenging however, since these fields are often localized on exceedingly short length and time scales. While experiments such as attosecond photoelectron emission microscopy or phase-resolved photon-induced near-field electron microscopy have been proposed, direct time-resolved measurements are still lacking. Here, we describe and demonstrate a new experimental technique, ultrafast near-field oscilloscopy, to probe coherent optical near-fields in the time with nanometer spatial resolution. For this, amplitude and phase of the local near-field scattered by a sharp metal taper are recorded in a broad spectral range and on a time scale that is faster than the tip modulation period. This allows us to record spectra as a function of tip-sample distance, the key to probe tip-sample coupling experimentally. Direct Fourier transform of the scattering spectra gives the local near-field dyanamics with sub-cycle temporal and nanometer spatial resolution. We demonstrate the versatility of this new approach by probing near-fields of dielectric and semiconducting nanoparticles, as well as different localized and propagating plasmon mode of metal nanostructures.

Q 71.5 Fri 15:30 HS 3219

Ultrabright single photon sources from single molecules — •Subhabrata Ghosh, Yijun Wang, Maximilian Luka, and Ilja Gerhardt — light & matter Group, Institute for Solid State Physics, Leibniz University Hannover, Appelstrasse 2, D-30167 Hannover, Germany

A single photon source emits a stream of individual photons at most one at a time and one after the another. Single organic dye molecules are considered as versatile single photon sources due to their very narrow line widths and negligible spectral diffusion. One of the major issues with single photon sources is the engineering towards a maximal photon flux and how to detect these photons then efficiently. The brightness and purity of single photon sources are measured by saturation scans and intensity auto-correlation functions. The high brightness of the single photon sources with very narrow spectral width at 1K will be presented. These sources can play an important role in quantum communications and technology.

Q 71.6 Fri 15:45 HS 3219

On-chip interference of scattering from two individual molecules — •Alexey Shkarin[1], Dominik Rattenbacher[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, D-91058 Erlangen, Germany — [2]Department of Physics, Friedrich Alexander University Erlangen-Nuremberg, D-91058 Erlangen, Germany

Scaling up quantum optical networks entail interconnecting ever larger number of remote quantum emitters through optical means. The most technologically-compatible way of doing this involves coupling multiple emitters to photonic chip structures prepared according to the experimental requirements. Such efforts are frequently stymied by low coupling efficiency of emitters to photonic structures, which is often overcome through resonant enhancement. In our work, we employ on-chip disk resonators evanescently coupled to multiple dibenzoterrylene molecules serving as optically active quantum two-level system. To preserve the quality factor of the resonators, we use polyethylene (PE) as a host material for molecules. Somewhat surprisingly, despite disordered nature of PE we find that a large fraction of molecules preserve their excellent optical properties, including lifetime-limited linewidths. Thanks to the high resonator finesse, we observe Purcell enhancement of almost an order of magnitude in the emission and strong molecule-induced extinction of the resonator mode. Finally, we simultaneously couple two molecules at the same frequency and observe significant

suppression of backwards scattering compared to a single emitter.

Q 71.7 Fri 16:00 HS 3219

Fourier-limited Single Molecules on a Surface — •Masoud Mirzaei[1,2], Alexey Shkarin[1], Johannes Zirkelbach[1], Ashley Jiwon Shin[1], Jan Renger[1], Tobias Utikal[1], Stephan Götzinger[1,2,3], and Vahid Sandoghdar[1,2] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]Department of Physics, Friedrich-Alexander University Erlangen-Nürnberg, 91058 Erlangen, Germany — [3]Erlangen Graduate School in Advanced Optical Technologies (SAOT), Friedrich-Alexander University Erlangen-Nürnberg, 91052 Erlangen, Germany

We investigate the spectroscopic properties of individual dibenzoterrylene (DBT) molecules on pristine anthracene crystal surfaces at sub-Kelvin temperatures. By quantifying temperature-induced dephasing effects on the molecular transitions, we show that dephasing becomes negligible below 2K, leading to Fourier-limited zero-phonon lines in DBT. We report on the spectral stability of single molecule transitions as a function of laser power. Furthermore, polarization sensitive measurements allow us to determine the transition dipole orientation, which in turn provides direct information about the preferred orientation of DBT molecules on anthracene crystal surfaces, in agreement with theoretical predictions. Our work marks the first instance of a lifetime-limited emission for molecules placed on naked surfaces, opening the door to investigations in the deep optical near-field regime, where atomic-resolution microscopy can be combined with high-resolution molecular spectroscopy.

Q 71.8 Fri 16:15 HS 3219

High-resolution cryogenic spectroscopy of single organic molecules in printed nanocrystals — •Mohammad Musavinezhad[1,3], Jan Renger[1], Johannes Zirkelbach[1], Tobias Utikal[1], Claudio U. Hail[2], Dimos Poulikakos[2], Stephan Götzinger[1,3], and Vahid Sandoghdar[1,3] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]ETH, Zürich, Switzerland — [3]FAU Erlangen-Nuremberg, Erlangen, Germany.

Organic dye molecules have shown promising functionalities in quantum photonic devices, but deterministic control of the molecules' position and density remains a challenge. Here, we extend our previous efforts on printing organic nanocrystals (NCs) [1] to the new system of dibenzoterrylene (DBT) in anthracene (Ac). We examined the zero-phonon transitions of individual DBT molecules in printed Ac NCs at 2 K. By using high-resolution fluorescence excitation spectroscopy, we confirm that single-molecule transitions in printed NCs are nearly as narrow as their lifetime-limited counterparts in bulk Ac. Moreover, we show that resonance instabilities are typically less than one linewidth. We characterize the orientation and lateral coordinates of individual molecules in a large number of NCs to assess the degree of crystallinity and the lateral dimensions of the printed structures [2]. The combination of the emitters' subwavelength placement precision enabled by our nanoprinting method and their spectral quality makes them attractive candidates for integration into quantum optical circuits.

[1] Hail, C. U. et al., Nat Commun 10, 1880 (2019).
[2] Musavinezhad, M. et al., submitted.