O 30: Focus Session: Phonon Polaritons: Opportunities for THz Nanooptics I

Time: Tuesday 10:30–13:00 Location: HE 101

Invited Talk O 30.1 Tue 10:30 HE 101

Recent Progress in Nonlinear Phononics and Josephson Plasmonics — •Andrea Cavalleri — Max Planck Institute for the Structure and Dynamics of Matter, Center for Free-Electron Laser Science (CFEL), Hamburg, Germany

In this talk I will discuss some recent applications of strong field THz and mid infrared pulses, which are used to control and to interrogate quantum materials. Especially, I will cover experiments in unconventionla superconductors and ferroelectrics.

Invited Talk O 30.2 Tue 11:00 HE 101

Femtosecond nanoscopy of collective excitations in semiconductors — •Markus A. Huber[1], Fabian Mooshammer[1], Markus Plankl[1], Leonardo Viti[2], Fabian Sandner[1], Miriam S. Vitiello[2], Tyler L. Cocker[1], and Rupert Huber[1] — [1]University of Regensburg, 93040 Regensburg, Germany — [2]NEST CNR, 56127 Pisa, Italy

Far-field multi-THz studies are intrinsically limited in their spatial resolution to the scale of the probing wavelength by diffraction. Scattering-type scanning near-field optical microscopy (s-SNOM) overcomes this limitation by utilizing the electric near fields below the apex of a sharp metallic tip. Using ultrafast multi-THz s-SNOM we probe the transient, nanoscale dielectric functions of materials upon photoexcitation by femtosecond near-infrared pulses. We apply the system to investigate the plasmonic response in a single InAs nanowire, where ultrafast near-field tomography reveals the < 50 fs build-up of a surface depletion layer. Additionally, we resolve the oscillating electric near field on the wire surface directly in the time domain and demonstrate a spatial and temporal resolution of 10 nm and 10 fs, respectively. We also show that the insulator-to-metal phase-switching behavior in strained VO_2 nanobeams can be predicted via the local contrast of the pump-probe response at room temperature. Finally, we trace the evolution of photo-activated surface phonon-plasmon polaritons in custom-tailored black phosphorus/SiO_2 heterostructures on the nanoscale. These polaritons feature key elements for ultrafast control: ≈ 50 fs switch-on times and constant energy and momentum.

Invited Talk O 30.3 Tue 11:30 HE 101

Boron nitride nanoresonators for phonon-enhanced molecular vibrational spectroscopy at the strong coupling limit — •Marta Autore[1], Peining Li[1], Irene Dolado[1], Francisco J. Alfaro-Mozaz[1], Ruben Esteban[2,3], Ainhoa Atxabal[1], Fèlix Casanova[1,3], Luis E. Hueso[1,3], Pablo Alonso-González[4], Javier Aizpurua[2,5], Alexey Y. Nikitin[1,3], Saül Vélez[1,6], and Rainer Hillenbrand[1,3] — [1]CIC nanoGUNE, San Sebastián, Spain — [2]Donostia International Physics Center, San Sebastián, Spain — [3]IKERBASQUE, Basque Foundation fro Science, Bilbao, Spain — [4]Departamento de Física, Universidad de Oviedo, Spain — [5]Centro de Física de Materiales, San Sebastián, Spain — [6]Department of Materials, ETH Zürich, Switzerland

Surface enhanced infrared spectroscopy is a powerful strategy to increase the vibrational signature of molecules in FTIR spectroscopy, by means of the confined and enhanced field on the surface of plasmonic objects. Another option to enhance and confine IR light into subwavelength scale is to use phonon-polaritons (PhPs) in polar crystals or layered materials. In particular, the van der Waals material hexagonal boron nitride (hBN) hosts low-loss and high-momenta hyperbolic PhPs in the reststrahlen band (1360-1610 cm-1). We employ phononic antennas, hBN ribbons, to detect small amounts of organic molecules via IR transmission. The interaction between PhPs and molecular vibrations reaches the onset of the strong coupling regime. PhP nanoresonators thus could become a viable platform for sensing and active control of chemical reactivity and IR quantum cavity optics experiments.

Invited Talk O 30.4 Tue 12:00 HE 101

Ballistic surface plasmons in high mobility Dirac liquid of graphene — •Dmitri Basov — Columbia University, New York NY USA

Optical spectroscopies are an invaluable resource for exploring new physic of new quantum materials. Surface plasmon polaritons and other forms of hybrid light-matter polaritons provide new opportunities for advancing this line of inquiry. In particular, polaritonic images obtained with modern nano-infrared tools grant us access into regions of the dispersion relations of various excitations beyond what is attainable with conventional optics. I will discuss this emerging direction of research with two examples from graphene physics: i) ultrafast dynamics of hot photo-excited electrons [2]; and ii) ballistic electronic transport at low temperatures [3].

[1] D.N. Basov, M.M. Fogler and F. J. Garcia de Abajo *Polaritons in van der Waals materials*, Science 354, 195 (2016). [2] G. X. Ni, L. Wang, M. D. Goldflam, M. Wagner, Z. Fei, A. S. McLeod, M. K. Liu, F.Keilmann, B. Özyilmaz, A. H. Castro Neto, J. Hone, M. M. Fogler and D. N. Basov Nature Photonics 10, 244 (2016) [3] G. X. Ni, A. S. McLeod, L. Xiong et al. [submitted].

Invited Talk O 30.5 Tue 12:30 HE 101

Novel Materials and Approaches for Dynamic IR Nano-Optics — •Joshua Caldwell — Mechanical Engineering, Vanderbilt University, Nashville, TN USA

The field of nanophotonics is based on the ability to confine light to sub-diffractional dimensions. Up until recently, research in this field has been primarily focused on the use of plasmonic metals. However, the high optical losses inherent in such metal-based surface plasmon materials has led to an ever-expanding effort to identify, low-loss alternative materials capable of supporting sub-diffractional confinement. Beyond this, the limited availability of high efficiency optical sources, refractive and compact optics in the mid-infrared to THz spectral regions make nanophotonic advancements imperative. One highly promising alternative are polar dielectric crystals whereby sub-diffraction confinement of light can be achieved through the stimulation of surface phonon polaritons within an all-dielectric, and thus low loss material system. Due to the wide array of high quality crystalline species and varied crystal structures, a wealth of unanticipated optical properties have recently been reported. This talk will discuss recent advancements from our group including the realization of localized phonon polariton modes, the observation and exploitation of the natural hyperbolic response of hexagonal boron nitride. Beyond this, methods to improve the material lifetime, realize active modulation and to induce additional functionality through isotopic enrichment and hybridization of optical modes will also be presented.