INSTITUT DE PHYSIQUE ET CHIMIE DES MATERIAUX DE STRASBOURG

23, rue du Loess 67034 STRASBOURG Cedex 2

QMat international graduate school
Axe 1: Quantum Sciences and Materials

Mini symposium on light-matter interactions in nanostructures

Wednesday May 22, 2024 - 10:00-11:45
at the IPCMS Auditorium

10:00 – 10:30: Laëtitia Marty
Institut Néel, Grenoble
Graphene membranes for reduced impact from the susbtrate

10:30 – 11:00: Ursula Wurstbauer
Universität Münster, Germany
Collective excitations and moiré minibands in van der Waals stacks

11:00 – 11:15: Break

11:15 – 11:45: Tomáš Neuman
Institute of Physics of the Czech Academy of Sciences, Prague
Theory of scanning-tunneling-microscope-induced luminescence in organic dye molecules

This mini symposium will be followed by the PhD Defense of Aditi Moghe at 14:00 in the IPCMS Auditorium

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Abstracts:

10:00 – 10:30: Laëtitia Marty

Institut Néel, Grenoble

Graphene membranes for reduced impact from the susbtrate

Due to its monoatomic thickness, graphene is extremely sensitive to the environment, in particular to its host susbtrate. This is indeed visible as induced strain and doping. Raman spectroscopy is a valuable tool to investigate the influence or the substrate [1] and shows that suspending graphene as a membrane allows accessing its fundamental properties. Graphene membranes will be presented [2] and their use as platforms to address mechanical [3] and thermal responses.

References:
[1] Bendiab et al., Journal of Raman Spectroscopy, 49, 130 (2018).
[2] Reserbat-Plantey et al., Nano Letters, 14, 5044 (2014).
[3] Schwarz et al., Physical Review Applied, 6, 064021 (2016).

10:30 – 11:00: Ursula Wurstbauer

Universität Münster, Germany

Collective excitations and moiré minibands in van der Waals stacks

Two-dimensional (2D) materials exhibit unique properties due to their atomically thin structure and weak van der Waals (vdW) coupling between layers. This vdW nature allows for the precise engineering of 2D quantum systems through stacking, twisting, and inducing defects. External stimuli, such as electric or magnetic fields and charge doping, enable in-situ control of these systems.
Those vdW stacks can have properties individual layers or conventional 3D solids do not reveal: (i) layer-dependent magnetic order with strong coupling between spin, charge and lattice degree of freedom [1,2], (ii) twist-angle dependent moiré superstructure with periodic potential profiles and the formation of minibands [2] and (iii) momentum dependent hybridization of electronic state resulting in the competition between interlayer (IX) and intralayer (X) excitons [2-4]. Heterobilayers of transition-metal dichalcogenides such as MoSe2/WSe2 host dense ensembles of interlayer excitons potentially forming a coherent many-body state with spatially extended coherence properties at low temperature [5-6].
Here, we approach the electron-phonon, exciton-phonon coupling, the interaction with the spin degree of freedom as well as collective electronic excitations in those atomically thin crystals by means of low-temperature resonant inelastic light scattering (RILS) spectroscopy. RILS is a well-established powerful method to study low-dimensional interacting electronic systems [7] as well as (exotic) correlated phases [8]. In particular, in tWSe2 bilayers, we access a series of RILS modes showing a peculiar dependence on twist angle and temperature that are interpreted as single-particle like collective inter-moiré-band excitations (IMBE) [2]. These observations allow to quantitatively probe the formation of a series of moiré-bands and demonstrate the potential to study correlated electron phases in twisted bilayers.

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[1] J. Klein et al. ACS Nano, 17, 6, 5316–5328 (2023).
[2] M. C. Heißenbüttel et al. arXiv:2403.20174 (2024).
[2] N. Saigal et al. arXiv:2310.14417 (2023).
[3] J. Kiemle et al. Phys. Rev. B 101, 121404(R) (2020).
[4] F. Sigger et al. Appl. Phys. Lett. 121, 071102 (2022).
[5] L. Sigl et al. Physical Review Research 2, 042044(R) (2020).
[6] M. Troue et al. Phys. Rev. Lett. 131, 036902 (2023).
[7] S. D. Sarma et al. Phys. Rev. Lett. 83, 816 (1999).
[8] J. Liang et al. Nature, 628, 78-83 (2024).

11:15 – 11:45: Tomáš Neuman

Institute of Physics of the Czech Academy of Sciences, Prague

Theory of scanning-tunneling-microscope-induced luminescence in organic dye molecules

I will present a theoretical perspective on a microscopy technique that combines the atomic-scale resolution of a scanning-tunneling microscope (STM) with optics. I will explain how this method, taking advantage of phenomena such as the optical Stark shift or plasmonic Purcell effect, can reveal excited-state properties of nanoscale samples with unprecedented spatial resolution. Besides introducing the method and the mechanism of STM-induced luminescence (STML) applied to dye molecules, I will show theoretical considerations concerning some of its applications and extensions such as the study of vibronic features in the STML spectra and imaging or a theoretical view on correlated photon emission from electrically driven organic molecules in an STM.