Investigation of Light-matter Coupling with Moiré Excitons in TMDC Heterostructures

Background:
Transition metal dichalcogenide (TMDCs) materials have attracted enormous scientific attention because of their unique properties when thinned down to monolayer thickness, which is anticipated to yield new nanoelectronics, optoelectronics, and spintronics functionalities. In addition, heterostructures, artificially stacked monolayers of two different TMDCs materials (Fig. 1 a), may show beyond the presence of the quasi-particle intralayer exciton, hosted within the same material, an interlayer exciton characterized by charge carriers driving from the different monolayers. According to the alignment of those two materials (Fig. 1 b), Moiré-superlattices can be generated, leading the interlayer excitons to experience the effects of a Moiré periodic potential and, therefore, a strong permanent dipole moment. In this Master topic, those Moiré excitons, the quasi-particles trapped within the periodic potential, will be further exploited under the strong light-matter regime.

The project:
Incorporating TMDC heterostructures in a photonic microcavity, we expect to observe the presence of a quasi-particle polariton (Fig. 1 c), which appears as a signature of the strong coupling between the matter (excitons) and light (microcavity photons). Taking advantage of the well-controlled fabrication of twist angle heterobilayers (TMDC heterostructures formed by two different monolayers), we aim to explore light-matter interaction effects by embedding them in different types of metallic and dielectric microcavities. Furthermore, new regimes, such as Dicke superradiance and Bose-Einstein condensation of exciton-polaritons, will be deeply investigated in these systems.

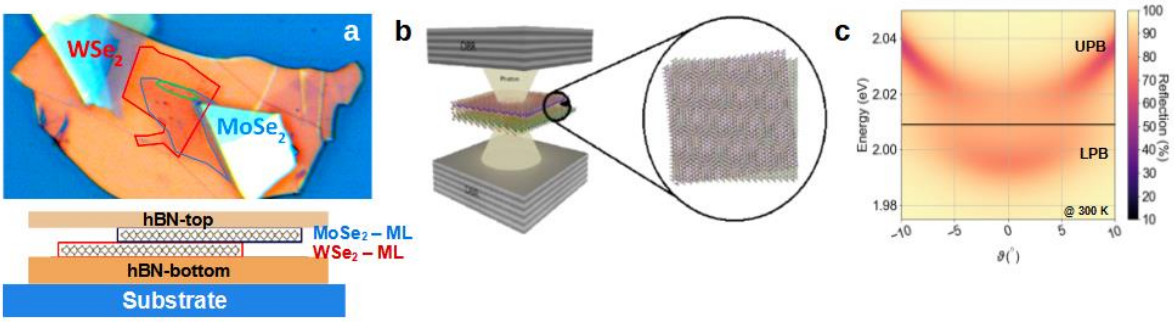

Figure 1: (a) Optical image and schematic of TMDC heterostructures, (b) Schematic of the TMDC heterostructure incorporated in microcavity (inset showing formed moiré pattern), (c) Calculated reflection showing anti-crossing behaviour which is spectral signature of strong coupling regime.

Your tasks:
- You will learn how to fabricate TMDC heterostructure samples by employing exfoliation technique and the dry-transfer method.
- You will support the development and the optimization of the dielectric mirrors (DBRs) and microcavities.
- You will perform TMDC heterostructure characterizations, which includes atomic force microscopy (AFM), photoluminescene (PL), micro-photoluminescence (µPL), second-harmonic generation (SHG) measurements.
- You will support quantum optical studies including second-order auto-correlation measurements, and time resolved µPL.

What you can expect:
- You will study a cutting-edge and exciting topic related to 2D materials and nanophotonics.

- You will work in a friendly environment and discuss with other motivated and talented scientists on a daily basis.
- We greatly value the importance of close training and support to students in all aspects. This will allow you to gain valuable experience in semiconductor science and quantum technology.

Prerequisite:
- A strong ambition and passion to carry out a project.
- The ability to co-work with others as one team.
- Having some basic knowledge in 2D materials, semiconductors, optoelectronic components, and quantum optics is advantageous.

Contact:

Chirag Palekar, EW 540	Dr. Bárbara Rosa, EW 249	Prof. Dr. Stephan Reitzenstein
c.palekar@tu-berlin.de	rosa@physik.tu-berlin.de	stephan.reitzenstein@physik.tu-berlin.de

Please don't hesitate to contact us at any time. We are always glad and open to provide more information!