

Exploring the moiré effect in 2D superlattices with magnetic fields

Elena Blundo

Walter Schottky Institute, Technical University of Munich

The weak van der Waals interlayer interaction that characterises layered crystals has opened new avenues for the creation of heterostructures (HSs) where the twist angle between the constituent materials represents a powerful new degree of freedom. Twisting generates in fact a periodic interference pattern, the moiré pattern (Fig. 1a), resulting in a potential landscape that strongly affects the system (opto)electronic properties. In semiconducting HSs based on transition metal dichalcogenides (TMDs, such as MoSe₂, WSe₂ and WS₂) interlayer excitons (IXs) form (Fig. 1b), with electrons and holes lying in the different materials of the HS. The moiré potential can localise IXs resulting in the so-called moiré excitons (Fig. 1c), opening opportunities for Bose-Einstein condensation, strongly correlated excitonic phases, or quantum emission.

In this talk, I will discuss the properties of twist-engineered moiré excitons in HSs made of TMDs, by considering several material combinations and twist angles. Magneto-photoluminescence studies are employed to reveal how interlayer coupling and moiré confinement determine the exciton energy, lifetime, spin-valley selection rules, spatial localisation, and thermal stability [1,2]. Our investigations show that the exciton gyromagnetic (g -) factor is a distinctive property that depends on the specific TMDs, twist angle and atomic registry. In turn, the g -factor encodes crucial information to understand the electronic nature of moiré excitons, allowing us to shed light on their stability as a function of carrier density and temperature [1]. These results provide new insights into the fundamental physics of moiré excitons, paving the way towards the achievement of engineered states in 2D HSs.

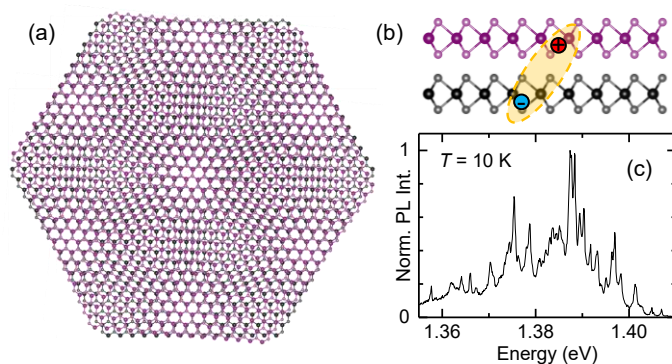


Fig. 1. (a) Sketch of a 2D heterostructure made of TMDs with non-null twist angle, giving rise to the formation of a moiré pattern. (b) Sketch of an interlayer exciton. (c) Typical photoluminescence spectrum of moiré-trapped interlayer excitons in a MoSe₂/WSe₂ heterostructure.

[1] E. Blundo et al., Nat. Commun. 15, 1057 (2024).

[2] P. Soubelet et al., Nat. Commun. 16, 8735 (2025).