To moiré or not to moiré, that is the question

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Magnetic fields are of uttermost relevance to unveil the peculiar properties of 2D materials. On the other hand, their full potential related to 2D heterostructures (HSs) has not been fully unleashed, yet. Here, we show how magnetic fields are a precious tool to investigate the moiré effect in HSs made of transition metal dichalcogenides (TMDs).

Moiré interlayer excitons (MXs) are electron-hole pairs localised by the periodic (moiré) potential forming when stacking 2D layers with a non-null twist angle, see Fig. 1(a). MXs in TMD HSs have shown promise for the formation of Bose-Einstein condensates and highly correlated exciton states, or as nanoscale-ordered quantum emitters. In all cases, the properties of MXs and their stability against temperature play a crucial role.

In this talk, we address these pivotal aspects by investigating the magneto-optical response of $MoSe_2/WSe_2$ HSs with nearly 0° twist angle. By exploiting the high sensitivity of the gyromagnetic (g-) factor to the electronic structure of the levels involved in the excitonic recombination, we unveil the presence of electron-hole pairs localised in different minima of the moiré potential featuring different local atomic registry [1], see Figs. 1(b-c). Furthermore, we show how the exciton dynamics and photoluminescence (PL) emission lineshape evolution with temperature reveal clear signatures that MXs de-trap from the moiré potential and turn into free interlayer excitons (IXs) for temperatures above 100 K. We further demonstrate that the MX-to-IX transition results in a striking change of the exciton gyromagnetic factor when the moiré potential is not capable to localise excitons at elevated temperatures [1].

Our results demonstrate that magnetic fields represent an extremely sensitive tool to establish the confined or not nature of interlayer excitons in moiré superlattices.

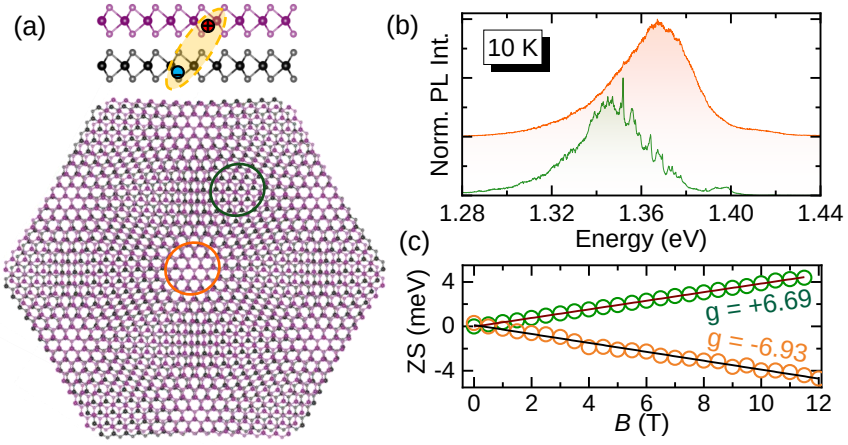

Figure 1: (a) Sketch of the interlayer exciton and moiré pattern. (b-c) PL spectra (b) and Zeeman splitting (c) of MXs at two different powers in a $MoSe_2/WSe_2$ HS with ∼ 0° twist angle. The different g-factors reveal that MXs are trapped in different atomic registries, highlighted by the circles in panel (a).

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