Valley properties in tunable 2D materials and artificial van der Waals solids

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Atomically thin two-dimensional layered materials receive great interest because of their unique properties. Particularly, monolayers of semiconducting transition metal dichalcogenides (SC-TMDCs), excel due to their strong exciton dominated light matter interaction as well as tunable valley physics in mono- and hetero-bilayers. Key to this interest in SC-TDMC and related artificial van der Waals solids is the possibility to tune and engineer their properties on demand and on-chip by external stimuli such as electric fields, their dielectric environment or defects [1-3].
We demonstrate that the degree of valley polarization in monolayers, that is typically vanishingly small at elevated temperature, can be restored even at room temperature to a significant amount by increasing the electron doping concentration. We discuss the recovery is linked to a suppression of the Fröhlich exciton LO-phonon interaction that mediates a uniaxial long-range oscillating electric field braking the three-fold rotational symmetry [4]. Moreover, we report on multi-valley charge transfer excitons a.k.a. interlayer excitons (IX) in vdW hetero-bilayers [5,6]. Dependent on the degree of layer hybridization, those IX have a finite dipolar moment coupling to electric fields thus allowing their manipulation in field effect devices [9]. Our results provide fundamental insights into long-lived interlayer states in van der Waals heterostructures suitable to study bosonic many-body interactions.

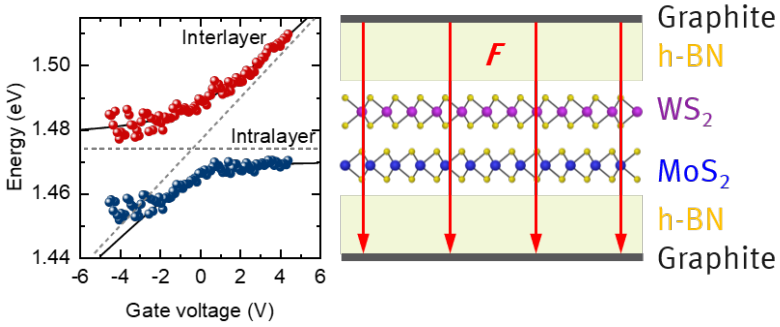

Figure 1: On the left panel electric field dependent anticrossing behavior if interlayer exciton emission due to coupling of electronic states and layer hybridization is depicted causing change if the IX frim interlayer to more intralayer nature. The right panel depicts a schematic of the TMDC hetero-bilayer embedded in a vdW field effect device.

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