Atomically thin heterostructures made from graphene and transition metal dichalcogenides: emerging photonic and opto-electronic building blocks

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Two-dimensional materials compose a toolkit of atomically-thin crystals with remarkable electronic, optical, spin and valley properties. These assets can be enhanced by stacking 2D layers into so-called van der Waals heterostructures and thereby tailoring novel functionalities and devices. The performance of such devices is governed by near-field coupling through, e.g., interlayer charge and/or energy transfer. New concepts and experimental methodologies are needed to properly describe atomically sharp heterointerfaces. This presentation will focus on model heterojunctions made from transition metal dichalcogenide (TMD) monolayers coupled to graphene monolayers.

First, I will describe the most salient fingerprints of near-field coupling, namely fast (picosecond) energy transfer and slower, photoinduced extrinsic charge transfer to graphene [1]. Second, I will demonstrate that graphene does not only neutralize TMD monolayers leading to the complete absence of light emission from charged excitonic species but also enables selective energy transfer, leading to bright, single and narrow-line PL arising solely from TMD neutral excitons (X^0, see Fig. 1) [2]. Finally, I will discuss the implications of our results for opto-valleytronics and chiral optics [3], in light of our recent studies of large valley polarization and coherence in TMD-graphene heterostructures [4].

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References

[1] G. Froehlicher, E. Lorchat, S. Berciaud, Phys. Rev. X **8** 011007 (2018)
[2] E. Lorchat, L. E. Parra López *et al.*, Nature Nanotechnology (in press, arXiv:1908.10690)
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Figures

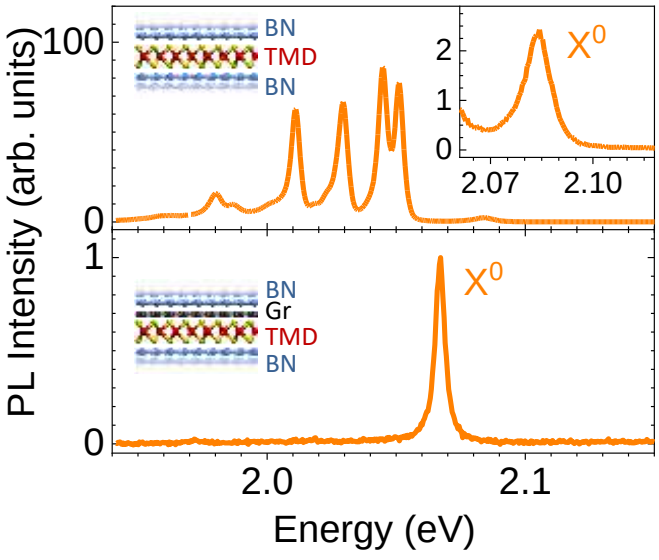

Figure 1: Bright, single narrow-line photoluminescence (PL) from a WS_2/Graphene heterostructure capped in hexagonal boron nitride (BN) (bottom). The PL of the BN-Capped WS_2 reference is shown in the upper pannel for comparison. Data from Ref. [2].