Ghost Anti-Crossing caused by Umklapp Scattering in 2D Heterostructures

Matthew Hamer
Abigale Graham, Roman Gorbachev, Vladimir Fal'ko. Neil Wilson
Department of Physics and Engineering, University of Manchester, Manchester, UK
Matthew.Hamer@Manchester.ac.uk

Two-dimensional materials characteristically have weak van der Waals interactions between layers allowing 2D heterostructures to be designed by stacking 2D crystals. Generally, the electronic structures of individual 2D layers are retained in the heterostructure, with weak coupling between layers. However, these weak inter-layer interactions can lead to dramatic twist-angle dependent effects, such as transforming normally metallic graphene into a superconductor by a "magic angle" moiré superlattice potential [1]. This has led to the new field of twistronics, engineering electronic structure and properties through twist-angle dependent interactions.

Here we report a new twistronic effect whereby it is possible to engineering strong interlayer coupling at defined energy and momenta in otherwise weakly coupled systems. This result, observed in angle resolved photoemission spectroscopy (ARPES) [2], is measured in heterostructures of graphene combined with semiconducting post transition metal chalcogenides and can be explained by Umklapp scattering. This effect is important as it provides a new tool for controlling charge transport between layers of 2D materials.

References

[1] Cao, Yuan, Valla Fatemi, Shiang Fang, Kenji Watanabe, Takashi Taniguchi, Efthimios Kaxiras, and Pablo Jarillo-Herrero. *Nature* 556.7699 (2018): 43-50.

[2] Hamer, M. J., Zultak, J., Tyurnina, A. V., Zólyomi, V., Terry, D., Barinov, A, et al. *ACS nano*, *13*(2), (2019) 2136-2142.

Figures

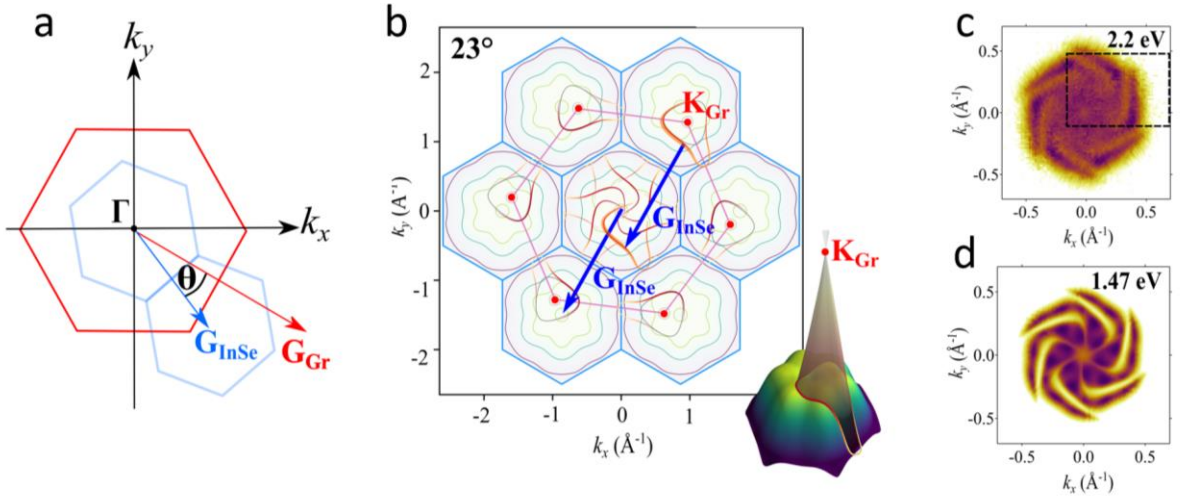

Figure 1: Twistronic effects in InSe, revealed by ARPES. (a) Schematic representing how the Brillouin zone of InSe and graphene overlap at different twist angles. (b) Depiction of how InSe and graphene bands interact with twist angle (at energy near the valence band maximum). (c) ARPES cross sectional slice at constant energy and (d) DFT calculation.