Spectroscopic signatures of few-layer graphenes

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The world of 2D materials is bubbling with both theoretical and experimental activity. Within this, the family of few-layer graphenes is forever growing with each member exhibiting unique and novel properties depending on the twist and layer number of a given structure. A key component to understanding these exciting materials is being able to study the twist-dependent band structure, a task perfectly suited to Angle-resolved photoemission spectroscopy (ARPES) [1,2]. Additionally, we believe the complementary and non-invasive tools of Ramen and Optical absorption spectroscopy can offer many additional insights into these exciting materials [1]. A member of this exciting family is 4-layer graphenes (4LG) which under different stacking conditions it can provide several novel features. For example, when in an aligned configuration merging both Bernal and Rhombohedral features ABCB/ACAB, 4LG can be the thinnest material known to exhibit ferroelectricity [3]. Alternatively, when twisted in the middle from a Bernal stacked region 4LG (or twisted double bilayer graphene/tDBG) can exhibit flat bands and exciting correlated physics features such as superconductivity. In this work, we propose that APRES, Ramen and Optical absorption spectroscopy are the ideal techniques for characterising this material and display a range of useful spectra for identifying and studying these exciting few-layer graphene materials.

References

[1] A. McEllistrim, A. Garcia-Ruiz, Z. Woodwin, V. I. Fal'ko, arXiv:2302.07374, accepted in Phys. Rev. B (2023).
[2] J. E. Nunn, A. McEllistrim, A. Weston, A. Garcia-Ruiz, M. D. Watson, M. Mucha-Kruczynski, C. Cacho, R. Gorbachev, V.I. Fal'ko, and N.R. Wilson, arxiv:
[3] A. Garcia-Ruiz, V. V. Enaldiev, A. McEllistrim, and V. I. Fal'ko, accepted in Nano Lettes (2023).

Figures

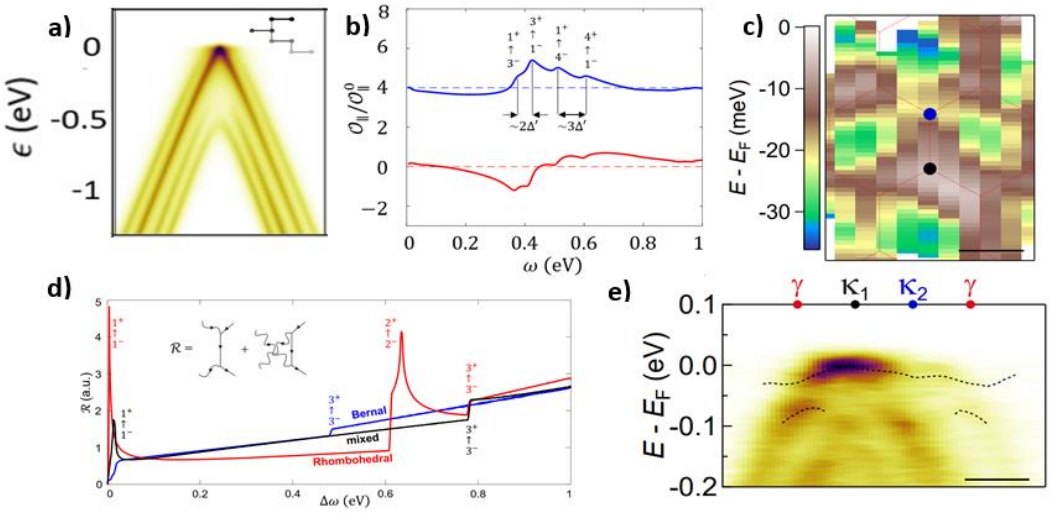

Figure 1: A collection of 4LG Spectra: a, e) Energy-momentum ARPES spectra for ABAC and tDBG @1.5° respectively. b) Real part of the in-plane optical conductivity for ABAC. c) Flat band surface topology of tDBG @1.5°. d) Electronic contribution to Raman scattering in Bernal (blue), rhombohedral (red) and mixed-stacking-ABAC/ABCB (black) 4LG. Plots a, b, d is taken from [1] and are based on theory calculations. Plots c, e is from [2] and were experimentally derived.