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Resonance Raman enhancement by the intralayer and interlayer electron-phonon processes in twisted bilayer graphene

Raman spectroscopy is a fundamental tool to study twisted bilayer graphene (TBG) systems since the Raman response is hugely enhanced when the photons are in resonance with transition between vHs and new peaks appear in the Raman spectra due to phonons within the interior of the Brillouin zone of graphene that are activated by the Moire superlattice. These new peaks can be activated by the intralayer and the interlayer electron-phonon processes [1]. In order to study how each one of these processes enhances the intensities of the peaks coming from the acoustic and optical phonon branches of graphene, multiple-excitation Raman measurements were performed in many different TBG samples with twisting angles between 4º and 16º and using several different laser excitation energies in the near-infrared (NIR) and visible ranges (1.39 eV to 2.71 eV). Distinct enhancements of the different phonons of graphene were observed for the intralayer and interlayer processes and results are nicely explained by theoretical calculations of the double-resonance (DR) Raman intensity in graphene by imposing the momentum conservation rules for the intralayer and the interlayer electron-phonon processes [2]. Our results show that the enhancement of the Raman response in all cases is affected by quantum interference and obey symmetry requirements for the DR Raman process in graphene.

References

[1] Resonance Raman enhancement by the intralayerand interlayer electron-phonon processes in twisted bilayer graphene, M. V. O. Moutinho, G. S. N. Eliel, A. Righi, R. N. Gontijo, M. Paillet, T. Michel, Po-Wen Chiu, P. Venezuela, and M. A. Pimenta, Scientific Reports, 11, 1, 17206 (2021)
[2] Intralayer and interlayer electron-phonon interactions in twisted graphene heterostructures, G. S. N. Eliel, M. V. O. Moutinho, A. C. Gadelha, A. Righi, L. C. Campos, H. B. Ribeiro, Po-Wen Chiu, K. Watanabe, T. Taniguchi, P. Puech, M. Paillet, T. Michel, P. Venezuela, and M. A. Pimenta, Nature Communications 9, 1221 (2018)

Figures

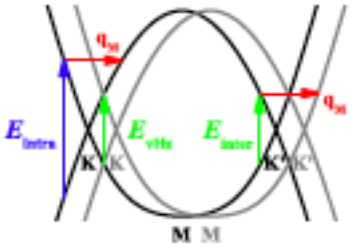

Figure 1: The blue (green) arrow depicts the intralayer (interlayer) electron-phonon process in twisted bilayer graphene