Tunable electronic properties of twisted multilayer graphene

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Twisted bilayer graphene displays many fascinating properties that can be tuned by varying the twist angle between its layers. Indeed, the electronic flat bands and the corresponding strong electron localization are obtained near the magic angle (~1.1°), leading to the observation of several strongly correlated electronic phenomena [1]. Subsequently, the twisting effects have been recently extendly investigated in other multilayer (i.e., more than two layers) graphene systems, for example, see in Refs. [2]. Besides the common properties shared with the bilayer superlattice, twisted multilayer graphene systems exhibit distinct properties, due to the presence of a large number of layers as well as various stacking configurations. Remarkable features include the coexistence and interplay of ultraheavy and ultrarelativistic Dirac fermions [3], the coexistence of localized-delocalized electronic states [4], and largely tunable possbilities of their properties by external fields [5]. In this talk, we will discuss these remarkable properties of twisted multilayer graphene demonstrated by atomistic calculations [6]. The effects of a vertical electric field (as illustrated in Fig.1) will be emphasized. On basis of their tunable electronic properties, the corresponding optical spectra (as seen in Fig.2) is also presented.

References: **[1]** E.Y. Andrei and A. H. MacDonald, *Nat. Mater.* 19, 1265–1275 (2020); **[2]** S. Chen et al., *Nat. Phys.* 17, 374–380 (2021); C. Shen et al., *Nat. Phys.* 16, 520–525 (2020); J.M. Park et al., *Nat. Mater.* 21, 877–883 (2022); **[3]** S. Carr et al., *Nano Lett.* 20, 3030–3038 (2020); A. T. Pierce et al., arXiv:2401.12284; **[4]** L.-H. Tong et al., *Phys. Rev. Lett.* 128, 126401 (2022); **[5]** Z. Hao et al., *Science* 371, 1133-1138 (2021); **[6]** V. Hung Nguyen et al., *J. Phys. Mater.* 5, 034003 (2022); V. Hung Nguyen and J.-C. Charlier, in preparation.

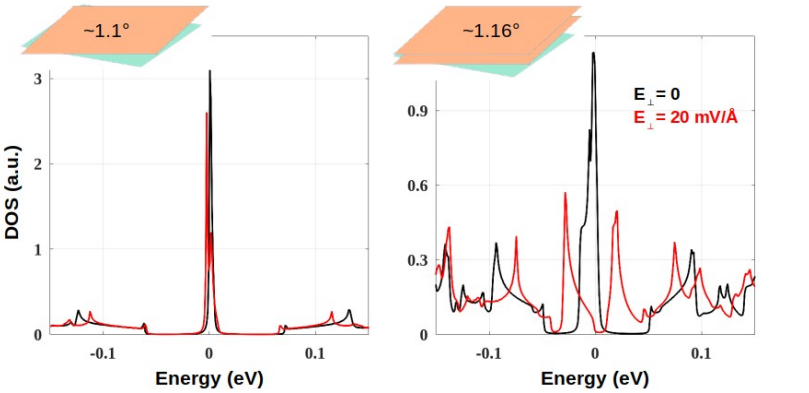

Figure 1: Electronic density of states without and with a vertical electric field $E_\perp$: comparison of twisted bilayer graphene (left) and twisted trilayer (bernal bilayer--monolayer) graphene (right) at the magic angle.

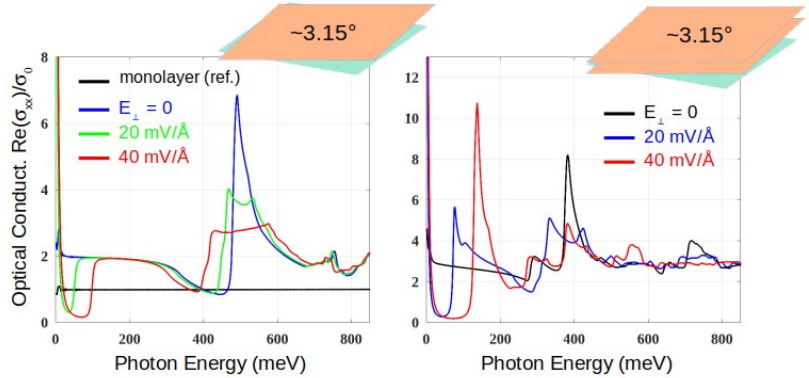

Figure 2: Optical conductivity without and with a vertical electric field $E_\perp$: comparison of twisted bilayer graphene (left) and twisted trilayer (bernal bilayer--monolayer) graphene (right). ($\sigma_0 = e^2\pi/2h$)