On intrinsic properties of ultraclean graphene at charge neutrality point

Ian Babich
Iakov Reznikov, Jinpei Zhao, Allesandro Principi, Alexander Kazantsev, Kenji Watanabe, Takashi Taniguchi, Kostya S. Novoselov, Alexey I. Berdyugin
I-FIM, NUS, Block S9, Level 9, Science Drive 2, Singapore
Ian.babich.a@gmail.com

Since the discovery of graphene there has been extensive interest in understanding limits of relativistic dispersion very close to charge neutrality point (CNP), where screening length diverges, and electron-electron interactions start to play significant role[1]. Among theoretical scenarios, there are many-body gap opening at CNP and change of the spectrum[2]. However, it is extremely challenging to approach CNP close enough to study such effects, due to extrinsic inhomogeneities such as electron-hole puddles[3]. So far, only suspended graphene devices have provided some insights into this system, showing diverging Fermi velocity when approaching CNP[4]. In our work, we assembled a dual-gated high-angle twisted bilayer graphene, in which one can independently tune charge densities on each layer. We find that when doping of one of the layers increases, we completely suppress inhomogeneities in the other layer, as evident from the onset of Landau quantization already at 4 mT at 2 Kelvin. Surprisingly, our measurements reveal a bandgap at the neutrality point of such ultraclean graphene, with a gap size of 4 meV. Increased homogeneity and gap observation are reproducible across multiple devices. We investigate the origin of this bandgap and discuss various scenarios for its formation.

References

[1] Kotov, Valeri N., et al. *Reviews of modern physics* 84.3 (2012): 1067.
[2] Drut, Joaquín E., and Timo A. Lähde. *Physical review letters* 102.2 (2009): 026802.
[3] Yankowitz, Matthew, et al. *Nature Reviews Physics* 1.2 (2019): 112-125.
[4] Elias, D. C., et al. *Nature Physics* 7.9 (2011): 701-704.