Investigating modulation of Coulomb interaction in graphene on a high-κ dielectric

K. Rubi,[1] **J. Hu**,[2] **M. Bal**[3], **M. Chan**[1], **A. Ariando**[2], **U. Zeitler**[3], **N. Harrison**[1]

[1] *National High Magnetic Field Laboratory, Los Alamos National Laboratory, Los Alamos, NM 87545, USA*

[2] *Department of Physics, National University of Singapore, 117551 Singapore*

[3] *High Field Magnet Laboratory (HFML-EMFL), Radboud University, 6525ED Nijmegen Netherlands*

Graphene on $SrTiO_3$ (STO) exhibits interesting quantum phenomena, such as quantum Hall ferromagnetism [1] and charge-density-wave order [2]. These effects are believed to stem from the large dielectric permittivity of STO [1,2,3,4], which is expected to significantly screen Coulomb interactions in graphene. However, angle-resolved photoemission spectroscopy (ARPES) measurements reveal that the Fermi velocity of carriers in graphene on STO is comparable to that of graphene on conventional substrates SiO_2 and hBN [5], suggesting minimal screening of Coulomb interactions.

To further investigate the electronic band properties and resolve the question of interaction screening in graphene on STO, we conducted electrical transport measurements in high magnetic fields up to 60 T, across a broad temperature range of 1.5–300 K. In this talk, we will present findings inferred from the quantum Hall effect and quantum oscillations results on graphene/STO devices (Fig 1). Our detailed analysis of the back-gate and temperature dependence of these phenomena indicates a strong effect of the STO substrate on the Fermi energy of graphene, but not on its Fermi velocity.

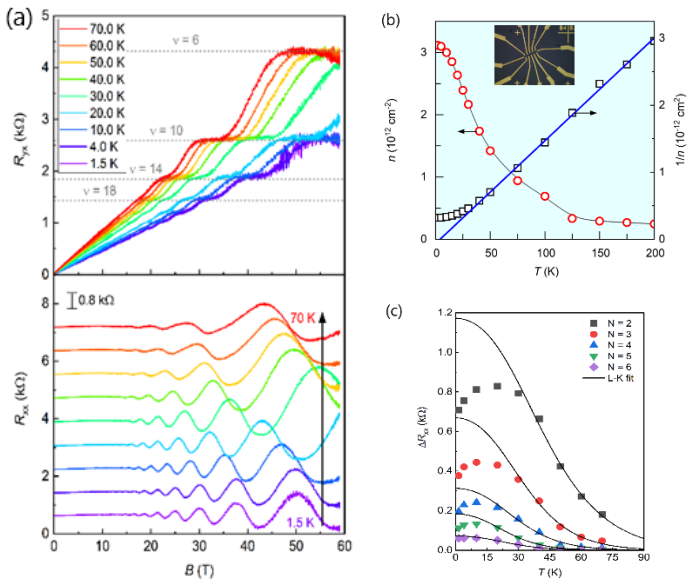

Figure 1. (a) Quantum Hall effect and quantum oscillations in a Graphene/STO measured at various temperatures and high magnetic fields up to 60 T. The observed shifts in the quantum Hall plateau and oscillations are attributed to changes in graphene's Fermi energy, influenced by the dielectric permittivity of STO. (b) Temperature dependence of carrier density in Graphene/STO. (c) Anomalous thermal damping of quantum oscillations.

[1] L. Veyrat *et al*., *Science* **367**, 781 (2020).
[2] A. Coissard *et al*., *Nature* **605**, 51 (2022).
[3] N. J. G. Couto *et al*., *Phys. Rev. Lett.* 107, 225501 (2011),
[4] R. Obata et al., Adv. Mater. 36, 2311339 (2024).
[5] H. Ryu et al., Nano Lett. 17, 5914 (2017)

+ Author for correspondence: rubi@lanl.gov