High temperature quantum oscillations in graphene/hBN superlattices

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In metals and semiconductors, cyclotron motion of charge carriers causes Landau quantization in the density of states which are responsible for oscillations in their transport properties when tuning magnetic field. The resulting Shubnikov-de Haas (SdH) oscillations occur at liquid helium temperatures since they rely on the coherence of electron waves along closed trajectories. Even in graphene with its massless Dirac spectrum and exceptionally large cyclotron gaps, SdH oscillations rarely survive above 100 K and magnetic fields of 30 T are required to see only the lowest landau levels at room temperature[1]. In this work, we report on a new type of quantum oscillation present in graphene superlattices[2] which are periodic with the magnetic flux pericing the superlattice unit cell, and exist in remarkably low-fields at high temperature (Fig.1). The oscillations were even observed at 100 ^{0}C in magnetic fields as low as 5 T. We attribute these high-temperature oscillations to the repetitive formation of Brown-Zak mini-bands[3] that occur at commensurable values of flux quantum per superlattice unit cell. Our work demonstrates previously unexplored physics of the Hofstadter butterflies at high temperatures.

References

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Figures

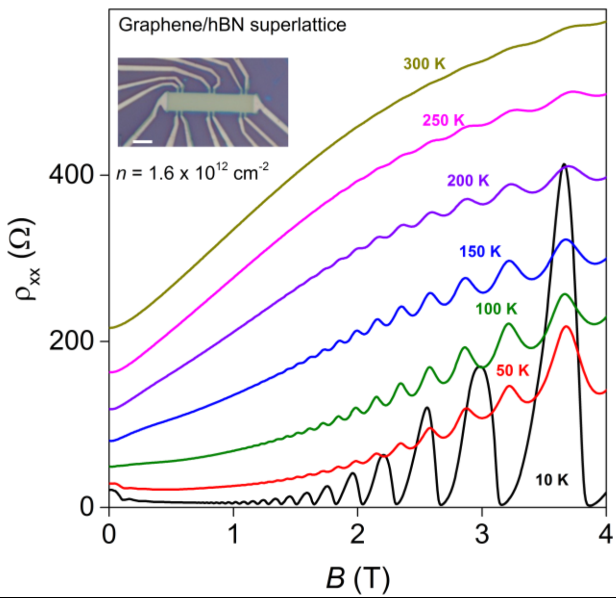

Figure 1: High Temperature quantum oscillations in a graphene superlattice. Longitudinal resistivity $\rho_{xx}(B)$ for temperatures between 10-300 K. At low *T* clear SdH oscillations are observed and the on-set of the quantum hall effect manifests around 4 T. By 50 K, SdH oscillations die out and a new oscillation is present with a different fundamental frequency. These Brown-Zak oscillations persist up to 300 K in this low-field regime. Inset: Optical image of the studied device, scale bar = 5 μm.