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Electronic compressibility of bilayer graphene

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We have recently measured the electronic compressibility of bilayer graphene [1], allowing exploration of the thermodynamic density of states as a function of applied electric and magnetic fields. Utilizing dual-gated field-effect devices, we can independently vary both the carrier density and the size of the tunable band gap. An oscillating voltage applied to a back gate generates corresponding signals in the top gate via electric fields lines which penetrate the graphene, thereby allowing a direct measurement of the inverse compressibility, K^{-1}, of the bilayer [2]. We have mapped K^{-1}, which is proportional to the inverse density of states, as a function of the top and back gate voltages in zero and finite magnetic field. A sharp increase in K^{-1} near zero density is observed with increasing electric field strength, signaling the controlled opening of a band gap. At high magnetic fields, broad Landau level (LL) oscillations are observed, directly revealing the doubled degeneracy of the lowest LL and allowing for a determination of the disorder broadening of the levels. We compare our results to tight-binding calculations of the bilayer band structure, and to recent theoretical studies of the compressibility of bilayer graphene. Together, these clearly illustrate the unusual hyperbolic nature of the low energy band structure, reveal a sizeable electron-hole asymmetry, and suggest that many-body interactions play only a small role in bilayer-on-substrate devices.
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[2] J. P. Eisenstein, L. N. Pfeiffer, and K. W. West, Phys. Rev. Lett. **68**, 674 (1992); Phys. Rev. B **50**, 1760 (1994).