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Probing layer imbalance in bilayer graphene with electrostatic capacitance measurements

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In bilayer graphene, application of an external electric field modulates both the charge carrier density and the band structure itself. In particular, application of an electric field perpendicular to the sample plane opens up a band gap in the bilayer graphene energy spectrum, leading to insulating behavior at charge neutrality. Using capacitance measurements, we extract the electronic compressibility as a function of density, applied bias, and temperature. We find that the compressibility remains high even in the region in which a gap is expected, confirming that the insulating behavior observed in transport is due to transport via localized states. Temperature dependent capacitance measurements allow us to estimate the gap in the spectrum, which we find to be in qualitative agreement with that measured by optics. Away from charge neutrality, the density dependence of the compressibility is consistent with hyperbolic electronic bands. Features identified with the $1/\sqrt{\epsilon}$ van Hove singularity—expected for the nearly quartic dispersion of gapped bilayer graphene—are observed near the band edge. These features show a polarization dependent asymmetry, appearing only where the near layer is at lower energy layer for the corresponding carrier type. Using a model of bilayer graphene that incorporates the finite interlayer separation, we show that capacitance measurements in bilayer graphene are sensitive to *layer indexed* compressibilities, in addition to the total charge compressibility. This allows an unambiguous determination of the layer polarization of the ground state, a particularly useful tool in the study of the broken symmetry states observed at high magnetic field.