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STM on Gate-Tunable Graphene

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We have successfully performed atomically-resolved scanning tunneling microscopy and spectroscopy (STS) on mechanically exfoliated graphene samples having tunable back-gates. We have discovered that the tunneling spectra of graphene flakes display an unexpected gap-like feature that is pinned to the Fermi level for different gate voltages, and which coexists with another depression in density-of-states that moves with gate voltage. Extensive tests and careful analysis show that the gap-feature is due to phonon-assisted inelastic tunneling, and the depression directly marks the location of the graphene Dirac point. Using tunneling spectroscopy as a new tool, we further probe the local energetic variations of the graphene charge neutral point (Dirac point) to map out spatial electron density inhomogeneities in graphene. Such measurements are two orders of magnitude higher in resolution than previous experiments, and they can be directly correlated with nanometer scale topographic features. Based on our observation of energy-dependent periodic electronic interference patterns, our measurements also reveal the nature of impurity scattering of Dirac fermions in graphene. These results are significant for understanding the sources of electron density inhomogeneity and electron scattering in graphene, and the microscopic causes of graphene electron mobility.