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Gate Map Tunneling Spectroscopy of Interactions in Graphene

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The local electron density of states (LDOS) in semiconductors and semimetals like graphene can be adjusted with respect to the Fermi energy by using an electric field applied by a nearby gate electrode. In this way interaction physics can be turned on and off as the electron density is modulated at the Fermi level in an applied magnetic field. Interaction physics in graphene has been an interesting subject since the first isolation of single layer graphene, due the singular nature of the Dirac point in the graphene spectrum. The electronic density of states at the Dirac point vanishes and the long-range Coulomb interactions are not effectively screened, which gives rise to a rich spectrum of interaction-driven physics in magnetic fields at low temperatures. In this talk, I will present recent experimental results in graphene on boron nitride substrates using gate mapping tunneling spectroscopy [1]. Gate map tunneling spectroscopy consists of series of single tunneling spectra obtained as a back gate voltage is varied to change the carrier density at the Fermi level. The gate maps show clear variations of the tunneling spectrum as a function of carrier density. The formation of Landau levels (LLs) in magnetic fields up to 8 T is observed to form a staircase pattern in maps of the tunneling conductance in the 2-dimensional tunneling bias voltage-gate voltage plane. LLs modulate the LDOS at the Fermi level as the carrier density is varied with the gate potential. An analysis of the LL peak positions shows that the graphene energy-momentum remains linear at low energies, but that the dispersion velocity is enhanced due to interactions as the density is lowered approaching the Dirac point. Interaction effects are also strongly seen near zero density by the opening of large Coulomb gaps in the tunneling spectra, which will be discussed in terms of the competing effects of residual substrate induced disorder and interactions.

[1] J. Chae *et. al.*, PRL **197**, 116802 (2012)