MAS20-2020-000066

Abstract for an Invited Paper
for the MAS20 Meeting of
the American Physical Society

STM-based fabrication and characterization of quantum dots in graphene

DANIEL WALKUP, National Institute of Standards and Technology

When a gate-tunable two-dimensional electron system (2DES) lies atop a flake of hexagonal boron nitride (hBN), charged defects in the hBN can modify the gating locally, creating a potential landscape for the 2DESs mobile electrons. By pulsing the voltage of a scanning tunneling microscope (STM) tip we create controlled, semi-permanent pockets of these charged defects on the scale of tens of nanometers, inducing corresponding charge puddles in the 2DEG. Here we study monolayer graphene, where Klein tunneling inhibits confinement except in the presence of a Landau-quantization-inducing magnetic field. In such fields the charge pockets are transformed into concentric series of compressible and incompressible rings, corresponding to partially- and fully-filled Landau levels respectively. In this regime the incompressible rings act as tunnel barriers within the graphene, isolating the compressible rings and producing clear Coulomb blockade peaks in dI/dV spectra observed in spectroscopic imaging STM, alongside the usual features due to local density of states. This produces a new and phenomenologically rich quantum dot system in which serial single-electron charging of the dots is tunable via back gate and sample bias voltages, as well as the position of the STM tip. We investigate this system in two basic regimes: (1) where two partially-filled Landau levels compete within a single charge pocket, the tunnel barrier between them remaining intact, and (2) when two adjacent pockets are subject to charging, and the tunnel barrier between two pockets of the same Landau level is tunable, the dots merging when they become sufficiently large.