Dirac physics in artificial graphene

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Artificial graphene (AG) is a man-made nanomaterial that can be constructed by arranging molecules on a metal surface or by fabricating a quantum-dot lattice in a semiconductor heterostructure. In both cases, AG resembles graphene in many ways, but it also has additional appealing features such as control over the lattice constant, system size and geometry, and edge configuration.

Here we use realistic real-space modeling to calculate the electronic structure of AG with a particular focus on finite-size AG flakes. We demonstrate gradual formation of the Dirac point as the flake size or the potential depth is increased (figure, left panel). We find excellent agreement with the experimental density of states. Then we analyze the response of the flake to an external, perpendicular magnetic field, and find the formation of Hofstadter’s butterfly patterns (figure, right panel). We also demonstrate the stability of the Dirac point under external perturbation to assess the experimental capabilities of the AG system. Finally, we analyze the role of electron-electron interactions with density-functional and path integral Monte Carlo calculations.