Quasiparticle interference of massless Dirac Fermions in molecular graphene

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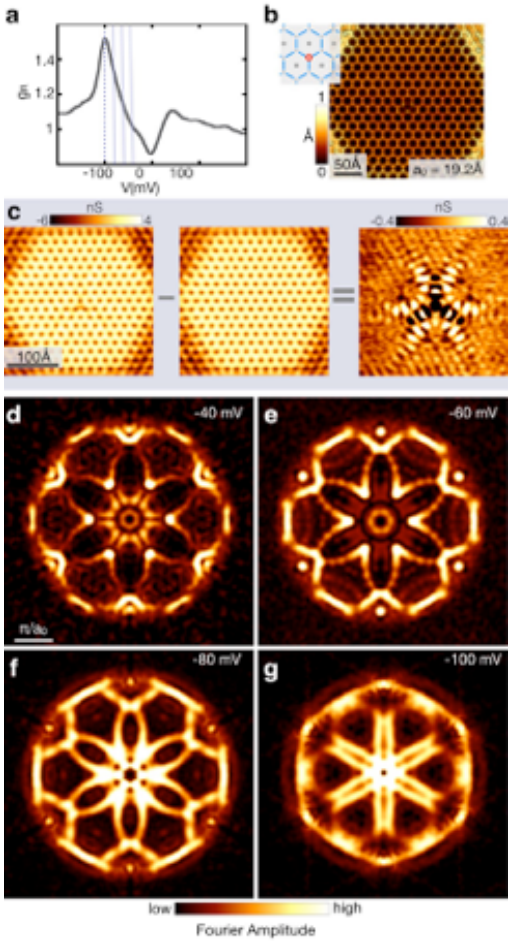
Abstract
We present scanning tunneling spectroscopic measurements of an assembled honeycomb lattice displaying a graphene-like band structure. Molecular graphene is the experimental realization of a novel class of solid-state artificial materials [1]. It is an artificial lattice created by atomic manipulation of single CO molecules on the surface of Cu (111) with a scanning tunneling microscope (STM). The periodic potential array generated by the assembled CO molecules reshapes the band structure of the surface states of the Cu (111) into a Dirac fermion system. We demonstrate the formation of Dirac cones and the presence of the pseudospin band polarization with tunneling spectroscopy and the Fourier analysis of the quasiparticle interference patterns created by local defects in the lattice. The experimental data was fit to a simple tight-binding model for the honeycomb lattice. We also demonstrate scattering selection rules determined by the presence of the pseudospin helicity characteristic of the honeycomb structure. The measurements presented here are the benchmark for this new form of quantum simulation, which offers unprecedented control over physical parameters, allowing experimental access to a unique set of quantum phenomena.

References
[1] Gomes, K. K., Mar, W., Ko, W., Guinea, F. & Manoharan, H. C., *Nature* **483** (2012), 306–310.

Figure



(a) Differential conductance spectrum of molecular graphene normalized to the spatially averaged spectra at bare Cu(111) surface. Dashed vertical lines indicate bias voltages where conductance maps were measured. (b) Topograph of molecular graphene lattice (lattice constant a_0=19.2Å) with an additional CO molecule placed near the center at a location equivalent to a carbon site in graphene. Data measured with bias voltage V = 10 mV and setpoint current I = 1.0 nA. Inset: schematic of molecular graphene lattice with extra CO defect (red). The CO molecules are represented by grey circles, the carbon sites by black dots. (c) Process of subtracting conductance maps to better visualize defect scattering. The conductance map without the defect (center) is subtracted from the map with the defect (left) to obtain the map of the scattering pattern Δg (right). (d-g) The Fourier transforms of the Δg conductance maps taken at four different bias voltages (V= 40 mV, 60 mV, 80 mV and 100 mV).