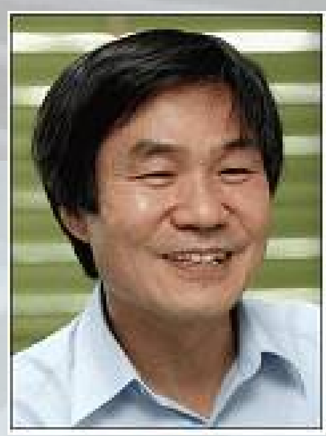
Tsinghua University
Department of Physics

Thursday Colloquium 2012 Spring

Unconventional interference pattern originated from electron scattering at the graphene edge

In graphene, the valley degeneracy and the pseudospin arise as new types of quantum degrees of freedom due to the honeycomb lattice comprising two inequivalent Dirac points (K to K‘) and two sublattices (A and B), respectively. It has been known that a conventional metal with a terrace and step can be modeled as a two-dimensional free electron gas and the standing wave formed at the edge can be analytically solved. Now, a question arises how the existence of two inequivalent valleys and two sublattices in graphene affects the scattering and the standing wave pattern at the edge. We have solved electron scattering problems at various graphene edges using a nearest-neighbor tight-binding method and first-principles calculations, and compared theoretical results with experimental data from scanning tunneling microscopy. The armchair edge shows almost perfect intervalley (K to K‘ and vice versa) scattering regardless of the passivating hydrogen atoms at the edge. We have observed, unlike in conventional metals, beating and rapidly oscillating patterns in the charge density profile by quantum interference of scattering waves at the edges, which are in excellent agreement with the STM experiment. The pseudospin is shown to be preserved in the intervalley scattering process. Structural reconstruction of the armchair edge can produce the mixing with the intravalley scattering for incident electronic waves with oblique angles. In contrast, the zigzag edge gives rise to only intravalley scattering accompanying a change in the pseudospin orientation, and the resulting pattern is similar to the case of conventional free-electron-like metals.The effect of super-periodic defects at the graphene edge is also discussed.

Abstract



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