Quantum Transport Properties of Graphene Nanoribbons and Nanojunctions

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The discovery of graphene and successive fabrication of graphene devices [1,2] have triggered intensive and diverse research on carbon related systems. The honeycomb crystal structure of single layer graphene consists of two nonequivalent sublattices and results in a unique band structure for the itinerant π-electrons near the Fermi energy which behave as massless Dirac fermion. In graphene, the presence of edges can have strong implications for the spectrum of the p-electrons. In graphene nanoribbons with zigzag edges, localized states appear at the edge with energies close to the Fermi level.[3] In contrast, edge states are absent for ribbons with armchair edges. Recent experiments have succeeded to synthesize graphene nanoribbons using lithography techniques[4], chemical techniques.[5,6]

In my talk, we focus on edge and geometry effects of the electronic properties of graphene nanoribbons. The electronic states of graphene nanoribbons crucially depend on the edge orientation and boundary condition [3,7] (1) In zigzag nanoribbons, for disorder without inter-valley scattering a single perfectly conducting channel emerges associated with such a chiral mode due to edge states, i.e. the absence of the localization.[8-10] (2) In armchair nanoribbons, the single-channel transport subjected to long-ranged impurities is nearly perfectly conducting, where the backward scattering matrix elements in the lowest order vanish as a manifestation of internal phase structures of the wavefunction.[10,11] This phase structure can be related to the existence of Berry phase.[12] (3) Nano-graphene junctions are shown to have the zero-conductance anti-resonances associated with the edge states. The relation between the condition of the resonances and geometry is discussed.[13] (4) Finally, we will discuss the effect of edge chemical modification on magnetic properties of nanographene systems.[14]

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