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Kondo effect and STM spectroscopy of Dirac electrons in graphene[1]

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We show that graphene, whose low-energy quasiparticles display Dirac like behavior, may exhibit a two-channel Kondo effect in the presence of magnetic impurities. We present a large Nanalysis for a generic spin Slocal moment coupled to Dirac electrons in graphene and demonstrate that the corresponding Kondo temperature can be tuned by an experimentally controllable applied gate voltage. We also study the STM spectra of these Dirac electrons in the presence of such impurities and demonstrate that such spectra depend qualitatively on the position of the impurity atom in the graphene matrix. More specifically, for impurity atoms atop the hexagon center, the zero-bias tunneling conductance, as measured by a STM, shows a peak; for those atop a graphene site, it shows a dip. We provide a qualitative theoretical explanation of this phenomenon and show that this unconventional behavior is a consequence of conservation/breaking of pseudospin symmetry of the Dirac quasiparticles by the impurity. We also predict that tuning the Fermi energy to zero by a gate voltage would not lead to qualitative change in the shape of the conductance spectra when the impurity is atop the hexagon center. A similar tuning of the Fermi energy for the impurity atop a site, however, would lead to a change in the tunneling conductance from a dip to a peak via an antiresonance. We discuss some recent experiments on a doped graphene sample that seem to have qualitative agreement with our theory and suggest further experiments to test our predictions.

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