SPINS ON GRAPHENE

H. C. Manoharan

Department of Physics, Stanford University, Stanford, California 94305, USA

We experimentally probe the addition of the spin degree of freedom to the local physics of graphene. This real spin degree of freedom is expected to become intertwined in various coherent scattering processes involving the pseudospin and valley degrees of freedom intrinsic to single monolayers of graphene. Low-temperature scanning tunneling microscopy of spin impurities on the surface of graphene reveals the Kondo ground state for massless Dirac fermions. We observe Kondo temperatures of ~15 K and a spectacular bimodal lineshape of the Kondo resonance. Using Fourier-transform scanning tunneling spectroscopy and concomitant measurements in a high magnetic field, we deduce the origin of these ground states: the characteristics of this emergent many-body state show a deep connection to the same pseudospin-conservation or pseudospin-breaking that result in weak antilocalization vs. weak localization, and the appearance or destruction of the Berry phase. We comment on the accessibility of two-channel Kondo physics in this system, based on multiple Dirac electron flavors arising from the presence of spin, pseudospin, and chirality in the screening reservoirs. This work was performed in collaboration with L. S. Mattos, C. R. Moon, M. W. Sprinkle, C. Berger, K. Sengupta, A. V. Balatsky, and W. A. de Heer. We wish to thank the U.S. DOE, NSF, and ONR for support.