

Coupled Dirac Fermions and Neutrino-like Oscillations in Twisted Bilayer Graphene

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The low-energy quasiparticles in graphene can be described by a Dirac-Weyl Hamiltonian for massless fermions, hence graphene has been proposed to be an effective medium to study exotic phenomena originally predicted for relativistic particle physics, such as Klein tunneling and Zitterbewegung. In this work, we show that another important particle-physics phenomenon - the neutrino oscillation can be studied and observed in a particular graphene system, namely, twisted bilayer graphene. It has been found that graphene layers grown epitaxially on SiC or by the chemical vapor deposition (CVD) method on metal substrates display a stacking pattern with adjacent layers rotated by an angle with respect to each other. The quasiparticle states in two distinct graphene layers act as neutrinos with two flavors, and the interlayer interaction between them induces an appreciable coupling between these two flavors of massless fermions, leading to neutrino-like oscillations. In addition, our calculation shows that anisotropic transport properties manifest in a specific energy window, which is accessible experimentally in twisted bilayer graphene. Combining two graphene layers enables us to probe the rich physics involving multiple coupled Dirac fermions.