Abstract for an Invited Paper
for the MAR07 Meeting of
The American Physical Society

# Theory of quantum transport in graphene and nanotubes

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In graphene, electronic states are described by Weyl's equation for a massless neutrino [1,2]. The system has a topological singularity at the origin of the wave vector ($\mathbf{k}=0$), giving rise to nontrivial Berry's phase when $\mathbf{k}$ is rotated around the origin [3]. The singularity causes various zero-mode anomalies such as discrete jumps in the diagonal [4], off-diagonal Hall [5], and dynamical conductivity [6] at the Fermi energy corresponding to $\mathbf{k}=0$. In the presence of a magnetic field, a Landau level with zero energy exists independent of the strength of the field [7], giving rise to a singular diamagnetism of graphene and the large magnetic anisotropy of the carbon nanotube [8] used extensively for the observation of the Aharonov-Bohm effect [9,10]. In the absence of a magnetic field, the system belongs to a symplectic universality class even in the presence of scatterers unless their potential range is smaller than the lattice constant. Being combined with the presence of an odd number of current carrying channels, this leads to the absence of backward scattering [11] and the presence of a perfectly conducting channel [12], making a metallic carbon nanotube a perfect conductor with ideal conductance exhibiting intriguing frequency dependence [13,14]. In the presence of scatterers with range smaller than the lattice constant, the system crossovers from the symplectic to an orthogonal class [15,16], and to a unitary class if higher order $\boldsymbol{k}\cdot\boldsymbol{p}$ terms causing trigonal warping are considered [17] or in magnetic fields [18]. These symmetry crossovers manifest themselves as strong difference in localization effects due to disorder in both graphene [18,19] and a carbon nanotube [20].

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