Spin Hall Effect Induced by Resonant Skew Scattering in Graphene
Tatiana G. Rappoport\textsuperscript{1}, Aires Ferreira\textsuperscript{2}, Miguel A. Cazalilla\textsuperscript{3}, Antonio H. Castro Neto\textsuperscript{2,4}.

\textsuperscript{1} Instituto de Física, Universidade Federal do Rio de Janeiro, CP 68.528, 21941-972 Rio de Janeiro, RJ, Brazil
\textsuperscript{2} Graphene Research Centre and Department of Physics, National University of Singapore, 2 Science Drive 3, Singapore 117546, Singapore
\textsuperscript{3} Department of Physics, National Tsing Hua University, and National Center for Theoretical Sciences (NCTS), Hsinchu City, Taiwan
\textsuperscript{4} Department of Physics, Boston University, 590 Commonwealth Avenue, Boston, MA 02215, USA
tgrappoport@if.ufrj.br

Abstract

The spin Hall effect is the appearance of a transverse spin current in a non-magnetic conductor by pure electrical control. The extrinsic spin Hall effect originates from the spin-dependent skew scattering of electrons by impurities in the presence of SOI and can be used for an efficient conversion of charge current into spin-polarized currents. Recently, it has been explored for replacing ferromagnetic metals with spin injectors in spintronics applications.

We consider a monolayer of graphene decorated by a small density of impurities generating a spin-orbit interaction in their surroundings. We show that large spin Hall effect develops through skew scattering and it is strongly enhanced in the presence of resonant scattering \cite{1}. Unlike two-dimensional electron gases (2DEG), for which resonant enhancement of skew scattering requires resorting to fine tuning, our proposal takes advantage of graphene being an atomically-thin membrane, whose local density of states easily resonates with several types of adatoms, molecules, or nano-particles.

Our single impurity scattering calculations show that impurities with either intrinsic or Rashba spin-orbit coupling in a graphene sheet originate robust spin Hall effect with spin Hall angles comparable to those found in metals. Also, the solution of the transport equations for a random distribution of impurities suggests that the spin Hall effect is robust with respect to thermal fluctuations and disorder averaging.

References


Figures

Schematic picture of extrinsic spin Hall effect generated by transport skewness. An impurity (sphere) near the graphene sheet causes a local spin-orbit field with range $R$. The scattering of components with positive (negative) angular momentum is enhanced (suppressed) for charge carriers with spin up (down), resulting in a net spin Hall current.