Spin Hall Effect Induced by Resonant Skew Scattering in Graphene

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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.

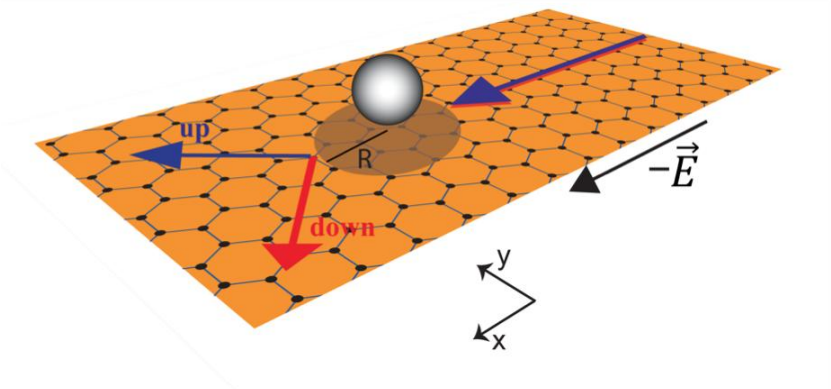
We consider a monolayer of graphene decorated by a small density of impurities generating a spin-orbit interaction in their surroundings. We show that large spin Hall effect develops through skew scattering and it is strongly enhanced in the presence of resonant scattering [1]. Unlikein two-dimensional 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

[1] A. Ferreira, T. G. Rappoport, M. A. Cazalilla, A. H. Castro Neto, Arxiv.1304.7511 (to be published in Phys. Rev. Lett.)

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.