QPhysics AT QUEENS COLLEGE

Colloquium Notice

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Quantum theory of the extrinsic spin-Hall effect in graphene

Spintronics, the science that aims at utilising the spin degrees of freedom in addition to the charge of electrons for low-power operation and novel device functionalities, has seen rapid developments in the past decade. In particular, the Spin Hall (SH) effect, i.e. the emergence of a transverse spin current in response to an applied longitudinal electric field, has attracted much interest for the possibility of building all-electric Spin manipulation devices [1]. The effciency of the Spin current generation is measured by the SH angle. While in semiconductors the SH angle is quite small (0.0001-0.001) [2], it was shown that a giant SH conductivity can be achieved in Graphene decorated with small doses of resonant, Spin orbit active adatoms [3]. It was argued that in this case, the e_ect is mostly due to the semiclassical Skew scattering mechanism, where electrons of di_erent spins are scattered asymmetrically.

In this talk, I will present present a rigorous microscopic theory of the extrinsic spin Hall effect in disordered graphene based on a nonperturbative quantum diagrammatic treatment incorporating skew scattering and anomalous {impurity concentration-independent{ quantum corrections on equal footing [4, 5]. Our self-consistent approach {where all topologically equivalent noncrossing diagrams are resummed - unveils that the skewness generated by spin-orbit-active impurities deeply inuences the anomalous component of the SH conductivity, even in the weak scattering regime. This seemingly counterintuitive result is due to the symmetry structure induced by spin-orbit coupling, for which the commonly Gaussian white noise approximation is generally invalid. Our treatment shows that it is possible to experimentally access regions in parameter space where anomalous quantum contributions to the SH conductivity are dominant.

Finally, we assess the role of quantum interference corrections by evaluating an important subclass of crossing diagrams, considered only recently in the context of the anomalous Hall effect [6]. We show that diagrams encoding quantum coherent skew scattering events, display a strong Fermi energy dependence, dominating the anomalous spin Hall component away from the Dirac point. Our findings open up the intriguing prospect of measuring quantum interference fingerprints in nonlocal spin signals.

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[2] Y. K. Kato, R.C. Myers, A.C. Gossard and D. D. Awschalom, Science 306, 1910 (2004).
[3] A. Ferreira, T. G. Rappoport, M. A. Cazalilla, and A. H. Castro Neto, Phys. Rev. Lett. 112, 066601 (2014).
[4] M. Milletar__ and A. Ferreira, Phys. Rev. B 94, 201402(R) (2016)
[5] M. Milletar__ and A. Ferreira, Phys. Rev. B 94, 134202 (2016)
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Monday

April 3, 2017

Starts at 12:15 PM

Coffee at 12:00 PM

Physics Conference Room, SB B326