Special Seminar

Jun. 26, 2015 (Friday)

TIME Jun. 26, 2015, 14:00 ~ 15:30
TITLE Towards Optimal Spin Generation – Spin-Hall Metals, Topological Insulators, and Graphene
SPEAKER Dr. Ching-Tzu Chen
IBM Thomas J. Watson Research Center
PLACE Rm716, CCMS & New Physics Building, NTU

Abstract

Efficient charge-spin conversion in spin current generation is of utmost importance for low-power spintronics applications. Conventional spin generation employs spin injection via tunnel junctions in which each electron imparts no more than a quantum of spin angular momentum. In this seminar we will discuss how, leveraging on spin Hall effect, one can overcome this charge-spin conversion limit. Specifically, we will explore three material systems: 5d spin-Hall metals, topological insulators, and graphene/magnetic-insulator bilayers. In our second work, we have solved the well-known difficulty in the preparation of the entangled photon pair coming from its low signal intensity. We have proposed and demonstrated a new scheme to perform the alignment without any difficulty utilizing the pump beam, whose detail will be discussed in the talk.

Spin Hall effect (where an applied charge current yields a transverse spin current) and the surface-state spin-momentum locking in topological insulators both originate from the band structure anomalies associated with strong spin-orbit coupling. To accurately characterize the charge-spin conversion efficiency, we introduce a 4-terminal spin-polarized tunneling technique that can measure the strength of spin Hall effect and its energy dependence in both metals and highly resistive materials [1]. Comparing the tunneling data in topological insulators with results in spin Hall metals, our experiments show that in a surface-transport dominated topological insulator, the charge-spin conversion characterized by the dimensionless spin-Hall angle can exceed ~20, at least two orders of magnitude larger than all known spin-Hall metals [2].

In the last example, we investigate the curious case of graphene where spin-orbit coupling is negligible. Applying a Zeeman field in this 2D Dirac system has been shown to generate a spin-Hall-like spin current [3]. Here we provide a quantitative measurement of charge-spin conversion in graphene. Furthermore, we will demonstrate

that a proximal ferromagnetic layer can greatly enhance such Zeeman-induced spin Hall effect via exchange coupling. To conclude, we will discuss potential applications that may ensue from the strong spin-orbit coupling materials and graphene spintronics.

[1] "**Spin Hall tunneling effect spectroscopy**" Luqiao Liu, Ching-Tzu Chen, J. Z. Sun, **Nature Phys. 10**, 561 (2014).

[2] "**Spin-polarized tunneling study on spin-momentum locking in topological insulators**" Luqiao Liu, A. Richardella, Ion Garate, Yu Zhu, Nitin Samarth, Ching-Tzu Chen, **arXiv:** 1410.7494

[3] "**Giant spin-Hall effect induced by the Zeeman interaction in graphene**" D. A. Abanin et al., **Phys. Rev. Lett. 107**, 096601 (2011). D. A. Abanin et al., **Science** 332, 328 (2011).