INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE

2A & 2B, Raja S.C. Mullick Road, Jadavpur, Kolkata-700032, India

Seminar Notice

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School of Physical Sciences

Title:	**Spin-orbit proximity effect in ferromagnetic metals: Fundamentals and spintronic applications**
Speaker:	**Kapildeb Dolui,Department of Physics & Astronomy, University of Delaware, USA**
Date:	**April 5, 2019 (Friday)**
Time:	**4:00 p.m.**
Venue:	**Seminar Room - C404,3rd Floor, Centenary Building, IACS**
Abstract:	The control of recently observed spintronic effects in topological-insulator/ferromagnetic-metal (TI/FM) heterostructures is thwarted by the lack of understanding of band structure and spin texture around their interfaces. This talk will discuss our recently developed approach [1] to this problem where we combine density functional theory (DFT) with Green's function techniques to obtain the spectral function at any plane passing through atoms of TI (such as Bi_2Se_3) and FM (such as Co) or normal metal (such as Cu) layers comprising the interface. In contrast to widely assumed but thinly tested Dirac cone gapped by the proximity exchange field spectral function, we find that the Rashba ferromagnetic model describes the spectral function on the surface of Bi_2Se_3 in contact with Co

	near the Fermi level, where circular and snowflake-like constant energy contours coexist around which spin locks to momentum. The remnant of the Dirac cone is hybridized with evanescent wave functions injected by metallic layers and pushed, due to charge transfer from Co or Cu layers, few tenths of eV below the Fermi level for both Bi_2Se_3/Co and Bi_2Se_3/Cu interfaces while hosting distorted helical spin texture wounding around a single circle. Crucially for experiments on spin-orbit torque in TI/FM heterostructures [3], few monolayers of Co adjacent to Bi_2Se_3 host spectral functions very different from the bulk metal, as well as in-plane spin textures (despite Co magnetization being out of plane) due to proximity spin-orbit coupling in Co induced by Bi_2Se_3. I will also discuss spectral functions and spin texture at heavy-metal/FM (such as Ta/Co and Pt/Co) [2] and Weyl-semimetal/FM interfaces, as well as how DFT Hamiltonian of these heterostructures can be combined [3,4] with Keldysh Green's functions to compute field-like and antidamping-like components of spin-orbit torque or spin memory loss at interfaces from first principles [2]. Spin pumping and related phenomena have been observed recently in heavy metals and topological insulators, where the spin-orbit coupling (SOC) plays an essential role. Conventional spin-mixing conductance (SMC), which governs the magnitude of pumped spin current, is not well-defined when SOC is present directly at the interface. Nevertheless, an effective SMC can be extracted as the prefactor of spin current vs. precession cone angle dependence, where we compute spin current using density functional theory (DFT) combined with Floquet-nonequilibrium Green function (Floquet-NEGF) formalism. Here we calculate the spin-mixing conductance for two terminal geometry with multilayer heterostructure consisting of Cu/X/Co/Cu, where X = Bi2Se3, Pt and W. We show that SMC gets reduced in the presence of interfacial SOC. However, stacking sequence and

materials selection for constituting the heterostructure can eventually modulate the SMC.

References

1. J. M. Marmolejo-Tejada, K. Dolui, P. Lazić, P.-H. Chang, S. Smidstrup, D. Stradi, K. Stokbro, and B. K. Nikolić, Nano Lett. **17**, 5626 (2017).
2. K. Dolui and B. K. Nikolić, Phys. Rev. B **96**, 220403 (2017).
3. F. Mahfouzi, B. K. Nikolić, and N. Kioussis, Phys. Rev. B **93**, 115419 (2016).
4. F. Mahfouzi and B. K. Nikolić, SPIN **3**, 1330002 (2013).

All are cordially invited to attend the seminar