Institute Colloquium

S. N. Bose National Centre for Basic Sciences

(An Autonomous Research Institute established under DST, GOI)

Title: Classical Computing with Quantum Materials

Abstract: I will discuss how topological properties of quantum materials can be a game-changer for classical computing devices. Specifically, I will illustrate with four attributes:

(a) Enhanced lifetime, as in ultrasmall skyrmions - vortex like magnetic excitations - where topological protection allows them to shrink below the fundamental super-paramagnetic thermal limit for high density digital, as well as native analog memory applications [1].

(b) Engineered tunneling across barriers through added symmetry indices – such as Klein and anti-Klein tunneling in of Dirac fermions in graphene, which can be used to bypass the mobility-bandgap trade-off and build a switch that operates at high mobility [2].

(c) Novel actuating schemes – such as the turning on and off of topological semi-metal surface states using a strain gated in/out-of-plane magnet. Such a gating mechanism can be used to design a compact processor-in-memory (PiM) stack that can bypass the Von Neumann latency of data transfer between memory and logic cores [3].

(d) Enhanced sensitivity. Since topological Dirac cone materials tend to exhibit spin-momentum locking, and each spin preferentially couples with circularly polarized photons of a definite helicity, we can realize an enhanced nonlinear photogalvanic effect in a topological insulator for potential use in higher contrast imaging and chiral photochemistry in a compact electronic chip [4].

In other words, these four attributes – topology driven lifetime, transmission, actuation and sensing, can be used to accomplish entirely different goals in low-power classical computing and sensing.

[1] "Skyrmionics - Computing and Memory Technologies based on Topological Excitations in Magnets", H Vakili et al, J. Appl. Phys. 130, 070908 (2021).

[2] "Graphene Transistor Based on Tunable Dirac-Fermion-Optics", K Wang et al, PNAS 116, 6575 (2019).

[3] "Strained-topological-insulator spin-orbit torque random-access-memory bit cell for energy-efficient processing in memory", MG Morshed et al, Phys Rev Appl. 23, 014071 (2025).

[4] "Enhanced detection of circularly polarized photons with topological materials", H Sharifpour et al, arxiv: 2602.00251

25th JUNE, 2026

4.00 PM

At FERMION HALL

YouTube Link

Webinar Link

Speaker: *Prof Avik Ghosh is a Professor of Electrical and Computer Engineering and Professor of Physics at the University of Virginia*

Short Biography of the Speaker:

Prof. Avik Ghosh is professor of Electrical Engineering and Physics at the University of Virginia. His group models low power electronics for next generation computing systems, ranging from sensors to AI to low power memory and logic. These models span the entire range from atomistic quantum chemistry to large scale circuits. Ghosh has written over 200 papers, two textbooks, given ~150 talks worldwide, and won the NSF CAREER award, the IBM faculty award, an ARMY best paper award, is fellow of the UK based Institute of Physics and senior member of IEEE. His group's work on negative index in graphene was voted by editors of Physics World as one of the top 10 physics breakthroughs of 2016.