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DEPARTMENTAL SEMINAR

Condensed Matter and Materials Physics

07th January 2026 **11.30 AM** **ONLINE / FERMION**

SPEAKER

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TITLE OF THE TALK

Beyond-CMOS Computing: Novel, Energy-Efficient Spintronic Logic and Memory Platforms

ABSTRACT

Future logic-in-memory hardware requires non-volatile switching at ultralow voltages in CMOS-compatible material stacks. Here we outline a beyond-CMOS pathway that unifies magnetoelectric (ME) coupling, perpendicular magnetic anisotropy (PMA), and voltage-controlled magnetic anisotropy (VCMA) to enable deterministic, electric-field-only operation. Through interfacial engineering of metallic/oxide heterostructures, large PMA and voltage-tunable interlayer exchange can be realized, delivering robust readout alongside current-free write functionality [1,2]. Ultralow-voltage modulation of ferromagnetism further delineates the practical ME/VCMA operating window required to access sub-fJ switching regimes [3]. At the device level, integrated magneto-electric and spin-orbit building blocks support MESO switching pathways and associated logic primitives, and recent nanoscale demonstrations show voltage-based write and read at room temperature without charge-current write paths [4,5]. Collectively, these advances establish a credible route toward scalable, voltage-written non-volatile memory and MESO logic for beyond-CMOS computing. In parallel, the rapid growth of AI and generative AI is intensifying demand for energy-efficient, scalable memory technologies. Spintronic devices—particularly MRAM—are strong candidates, and recently we have advanced electric-field control of magnetism across multiple material platforms [6–7]. We leverage antiferromagnetic $BiFeO_3$ (BFO) as an ultrathin tunnel barrier and demonstrate tunnel magnetoresistance in epitaxial $SrRuO_3$/BFO/$LaSrMnO_3$ junctions, featuring robust multilevel resistance states that arise from layer-specific switching beyond the conventional triple spin-flip picture. Building on earlier studies of ferromagnetic-insulator spin-filter tunnel junctions employing $Sm_{0.75}Sr_{0.25}MnO_3$ barriers [8], we further show current-induced switching consistent with an inverse metamagnetic transition [9]. Together, these results point to a practical materials-and-device framework for energy-efficient, multilevel spintronic memory relevant to AI workloads and cryogenic electronics.

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