Department of Instrumentation and Applied Physics
Seminar Series

Polar Topological Texture in Oxides

Abstract: Polar topological structures such as vortices and skyrmions offer promising pathways toward low-power, high-density, and CMOS-compatible nanoelectronic devices due to their intrinsic stability, ultrasmall dimensions, and rich functional properties.1-2 However, their practical application remains limited by challenges in controlled manipulation and post-synthesis tunability. In this study, we demonstrate real-time control of polar vortices and skyrmions in PbTiO3/SrTiO3 superlattices using localized electric fields and thermal stimuli. Piezo response force microscopy (PFM) and scanning transmission electron microscopy (STEM), complemented by phase-field simulations, reveal reversible motion, reshaping, and annihilation of vortex structures, along with electric-field and temperature-dependent evolution of skyrmion phases. Correlation function analysis confirms a liquid-like skyrmion state, enabling tunable phase behavior. These findings establish a framework for dynamic control of polar topologies, advancing their integration into reconfigurable and energy-efficient topological devices.

References:

1. Yadav, A. K. et al. Observation of polar vortices in oxide superlattices. Nature 534, 138–138 (2016).
2. Das, S. et al. Observation of room-temperature polar skyrmions. Nature 568, pages368–372 (2019)
3. Das, S. et al. Local negative permittivity and topological phase transition in polar skyrmions. Nature Mat. 20, 194-201 (2021).
4. Hong, Z. et al. Topological textures in polar materials. Nat Phys. 22, 1022 (2026).
5. Gupta, P. et al, Controlled motion of polar vortex boundary in oxide heterostructures. Nature Comm (2026)

Date: 28th October 2026

Time: 3:00 PM

Venue: SV Narasaiah Auditorium

Scan for online



DR. SUJIT DAS
ASSISTANT PROFESSOR,
INDIAN INSTITUTE OF SCIENCE

Refreshments will be served after the seminar

About the Speaker

Dr. Sujit Das obtained his B.Sc. in Physics from Calcutta University, India in 2009 and M.Sc. in Physics from Indian Institute Technology Kanpur, India in 2011. He then pursued his Ph.D. at The Leibniz Institute for Solid State and Materials Research in Dresden (IFW Dresden) and Martin Luther University (MLU) Halle-Wittenberg, Germany in Condensed Matter Physics -Experiment. His research focused on the magnetic order at coherent oxide interfaces. After he obtained his PhD in 2016, he continued his research career in the University of California, Berkeley, USA as a postdoctoral researcher. His research areas focus on the synthesis of ferric thin films, particularly on ferroelectric superlattices, ferroelectric quantum topological system by Laser MBE and characterization with different technique. Presently he is an assistant professor at Indian Institute of Science, Bengaluru, India. His primary research interest is on ferroelectric/multiferroic topology, Transition metal nitride, Tunable capacitors, single spin manipulation and device.