Tata Institute of Fundamental Research
Survey No. 36/P, Gopanpally Village, Serilingampally, Ranga Reddy Dist., Hyderabad – 500 046

Webinar

Emergent phenomena of polar topologies

Sujit Das

Unité Mixte de Physique CNRS Thales, France

Complex topological configurations are a fertile arena to explore novel emergent phenomena and exotic phases in condensed-matter physics. The recent discovery of polarization vortices and the associated complex-phase coexistence and response under applied fields in ferroelectric oxide superlattices, has opened up new vistas to explore topology, emergent phenomena, and approaches for manipulating such features with electric fields[1,2]. Here, by varying epitaxial constraints we report the discovery of room-temperature polar skyrmions in a lead-titanate layer confined by strontium-titanate layers[3]. Phase-field modelling and second- principles calculations reveal that the polar skyrmions have a skyrmion number of +1, and resonant soft X-ray diffraction experiments show circular dichroism confirming chirality. Such nanometer-scale polar skyrmions are the electric analogs of magnetic skyrmions, and could advance ferroelectrics towards new levels of functionality. Using macroscopic dielectric measurements, we demonstrate that polar skyrmions in $(PbTiO_3)_n/(SrTiO_3)_n$ superlattices are distinguished by a sheath of negative permittivity at the periphery of each skyrmion which enables a strong enhancement of the effective dielectric permittivity as compared to the individual $SrTiO_3$ and $PbTiO_3$ layers[4,5] and phenomenon could be controlled by electric field and temperature. Such phenomena could advance ferroelectrics towards new levels of functionality.[6]

References:

1. Yadav, A.K., Nelson, C.T. et al., Observation of polar vortices in oxide superlattices. Nature 530, 198-201 (2016).
2. Damodaran, A., Clarkson, J., Hong, Z., Liu, H. et al., Phase coexistence and electric-field control of toroidal order in oxide superlattices. Nat. Mater. 16, 1003 (2017).
3. Das, S et al, Observation of room temperature polar skyrmions. Nature 568, 368-372 (2019).
4. Yadav, A. K., …., Das, S. et al, Spatially Resolved Steady State Negative Capacitance. Nature 565, 468-471 (2019).
5. Das, S. et al, Local negative permittivity and topological phase-transition in polar skyrmions. Nature Materials 20, 194 (2021)
6. Li, Q., …., Das, S. et al, Collective excitations of polar vortices. Nature (press).

Thursday, Apr 15th 2021

4:00 PM