



Institute Colloquium

S. N. Bose National Centre for Basic Sciences

(An Autonomous Research Institute established under DST, GOI)

Title: $4f$ - $3d$ Coupling and Magnetoelectricity in the Green Phase Cuprates

Abstract: Magnetically induced multiferroicity is often governed by the symmetry of transition-metal spin structures, with rare-earth ions playing only a secondary role. In this talk, I will discuss the Green-Phase Cuprates as a model system in which rare-earth-transition-metal ($4f$ - $3d$) interactions play a central role in shaping both magnetic ground states and magnetoelectric behavior. By systematically varying the rare-earth ion, these compounds exhibit a remarkable diversity of phenomena, including linear magnetoelectric effects, multiferroicity arising from cycloidal magnetic ordering, field-induced magnetoelectricity, and the complete absence of magnetoelectric response in nonmagnetic rare-earth analogues. The striking correlation between rare-earth magnetism and magnetoelectric behavior highlights the importance of $4f$ - $3d$ coupling in this family and identifies the Green-Phase Cuprates as a chemically tunable platform for exploring the interplay between $4f$ and $3d$ magnetism in complex oxides.

- 1) P. Yanda, N. V. Ter-Oganessian and A. Sundaresan, Linear Magnetoelectric Effect in Antiferromagnetic $\text{Sm}_2\text{BaCuO}_5$, *Phys. Rev. B*, 100, 104417 - 104420 (2019).
- 2) P. Yanda, I. V. Golosovsky, I. Mirebeau, N. V. Ter-Oganessian, Juan Rodríguez-Carvajal, and A. Sundaresan, Interplay of $4f$ - $3d$ interactions and spin-induced ferroelectricity in the green phase $\text{Gd}_2\text{BaCuO}_5$, *Phys. Rev. Research* 2, 023271 (2020).
- 3) P. Yanda, F. Orlandi, P. Manuel, N. Boudjada, Juan-Rodrigue Carvajal, and A. Sundaresan, Magnetic field induced ferroelectric state in centrosymmetric R_2BaCuO_5 ($\text{R}=\text{Dy}$ and Ho) *Phys. Rev. B* (2021).
- 4) P. Yanda, N. Boudjada, Juan-Rodrigue Carvajal, and A. Sundaresan, Exploring magnetism and magnetoelectric properties of R_2BaCuO_5 ($\text{R}=\text{Er}$, Eu , Y , Tm , and Lu): the role of $4f$ - d exchange coupling, *Phys. Rev. B* 109, 104411 (2024).
- 5) P. Yanda, N. Boudjada, J. Rodríguez-Carvajal, A. Sundaresan, Multiferroicity in the incommensurate phase of $\text{Yb}_2\text{BaCuO}_5$, *Phys. Rev. B* 112 (6), L060408 (2025).

Speaker: Prof. Athinarayanan Sundaresan

Professor in Chemistry and Physics of Materials Unit, JNCASR

Short Biography of the Speaker: Prof. A. Sundaresan obtained his Ph.D. from the Indian Institute of Technology Bombay and subsequently carried out research in France and Japan. He joined the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) in 2004 and is currently Professor in the Chemistry and Physics of Materials Unit. His research spans solid-state chemistry and condensed-matter physics, with emphasis on the discovery of inorganic materials exhibiting unusual magnetic, electronic, and structural properties. A major focus is the synthesis of novel and metastable materials using high-pressure and high-temperature techniques. His research interests include quantum and frustrated magnetism, superconductivity, multiferroics and magnetoelectric materials, and strongly correlated systems. His group combines materials synthesis and physical-property measurements with advanced techniques including synchrotron X-ray diffraction, neutron scattering, and muon spin spectroscopy (μSR), with the broader goal of understanding and controlling emergent properties in quantum and functional materials.



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