Seminar, Department of Physical Sciences, Bose Institute, Kolkata

Insights into quantum magnetism: A concise account of my research

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Abstract: The study of quantum phases in strongly correlated electron systems has unveiled a myriad of emergent phenomena arising from the complex interplay of competing phases. However, the exploration of emergent properties has transcended beyond these systems, necessitating a radical redefinition that leads to the new paradigm of quantum materials. At the microscopic level, all materials are governed by the laws of quantum mechanics, making quantum materials a unifying thread linking researchers across physics, materials science, and engineering. These materials host a diverse array of ingredients, including many-body interactions among spins, electrons, and phonons. Notably, the relative strengths of these interactions can be precisely tuned through chemical composition or by manipulating physical parameters such as pressure, temperature, magnetic field, or dimensionality. This tuning facilitates the emergence of novel phases of matter, such as superconductivity, Bose-Einstein condensation, charge or spin order, and multiferroicity, as well as exotic excitations like fractional excitations, composite fermions, magnetic monopoles, skyrmions, and Majorana fermions. Beyond the fundamental interest in understanding these materials, there is significant potential for controlling their properties for practical applications.

The overarching goal of my research is to leverage the most exciting and innovative quantum materials displaying novel states of matter to investigate the intricate interplay among charge/orbital, spin, and lattice degrees of freedom.

My work has focused on exploring exotic magnetism, multiferroicity, unconventional superconductivity, non-trivial topological states, and novel functionalities in transition metal oxide-based quantum materials. Achieving high-quality samples is crucial for such studies, necessitating the synthesis and rigorous characterization of polycrystalline and single crystalline compounds through magnetic, electric, and thermal measurements.

To delve deeper into the unusual magnetic and electric properties at the microscopic level, I employ advanced techniques such as x-ray spectroscopy, neutron scattering, and muon spin relaxation. These sensitive probes can detect subtle magnetic effects, revealing both static and dynamic behaviours that other methods might miss.

In this talk, I will illuminate the key intellectual questions driving my research, such as the connections between different aspects of multiferroic materials and the emergent excitations in geometrically frustrated compounds. I will share the critical skills acquired during my PhD and postdoctoral research, highlighting selected research projects in detail [1-4].

References:

- 1. J. Sannigrahi et al.: Role of crystal and magnetic structures in the magnetoelectric coupling in CaMn7O12. Phys. Rev. B 109 054417 (2024).
- 2. J. Sannigrahi et al.: Orbital effects and the Affleck-Haldane type spin dimerization in Ba4Ru3O10. Phys. Rev. B 103 144431 (2021).
- 3. J. Sannigrahi et al.: Commensurate to incommensurate magnetic phase transition in Honeycomb-lattice pyrovanadate Mn2V2O7. Phys. Rev. Materials 3 113401 (2019).
- 4. J. Sannigrahi et al.: First-order valence transition: Neutron diffraction, inelastic neutron scattering, and x-ray absorption investigations on the double perovskite Ba2PrRu0.9Ir0.1O6. Phys. Rev. B 99 184440 (2019).

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<u>Venue:</u> Physics Seminar Room (204, second floor, UAC, BI)