Proposed research area by Dr. Ratnadwip Singha

My research interests span different types of quantum materials and their unconventional electronic properties. While the major focus of my group is to study the underlying fundamental physics of magnetic topological materials, we also aim to explore different avenues for their applications in functional devices with real-world use. Thus, reduction in material dimensionality becomes a key objective. We utilize a combination of theoretical material prediction, single crystal material synthesis, microscopic characterization techniques, and low-temperature electronic and magnetic properties measurements. Additionally, we are also regular users of national/international synchrotron scattering and high magnetic-field facilities. Some of the specific research areas for my group are as follows:

Topological materials:

Topology protected electronic states offer a unique opportunity to explore relativistic quantum phenomena in condensed matter systems [1]. While these are extremely important for fundamental physics understanding, topological materials are predicted to be an indispensable part of future quantum technologies developments.

Van der Waals systems:

Van der Waals compounds, the building block of present functional device technologies, possess enormous potential and opportunities for optoelectronic applications [2]. They offer high degree of tunability through construction of heterostructures and unique twistonics moire patterns. Furthermore, their physical properties drastically vary from bulk to nanometer thicknesses.

Frustrated magnets:

Local magnetic interactions at atomic level in certain crystallographic motifs produce frustrated magnetisms [3]. These complex magnetic states lead to unconventional magneto-electronic properties including new quantum states such as spin liquid, heavy fermions, and spin-density waves.

1. A. Bansil, Hsin Lin, and Tanmoy Das, *Colloquium: Topological band theory*, Rev. Mod. Phys. **88**, 021004 (2016).

2. K. S. Novoselov, A. Mishchenko, A. Carvalho, A. H. Castro Neto, *2D materials and van der Waals heterostructures*, Science **353**, 461 (2016).

3. Leon Balents, *Spin liquids in frustrated magnets*, Nature **464**, 199 (2010).