Project: January – July 2019

1. Realizing Magnetic Skyrmions: Its synthesis and characterization.

Skyrmions are topologically protected (lack of inversion symmetry together with strong spin–orbit interaction) quasiparticles in the chiral lattice, where spins form vortex-like orientations. We would explore Skyrmion phase in a multiferroic insulator because of the possibility of manipulating it with external electric fields. Alternatively we would also employ a route to manipulate the Skyrmion phase by chemical doping wherein it is possible to enhance, suppress or split the Skyrmion phase. Role of spin orbit splitting, pressure, interatomic bond lengths and angles, strain, etc. will be investigated on the Skyrmion phase in bulk and thin film samples. You will be synthesizing appropriate compounds (bulk/thin films); will perform electronic and magnetic structure studies (on the synthesized compounds) and will be involved in analyzing synchrotron data. (Possibility of participation in Synchrotron experiment at Hamburg, Germany can be explored)

2. Atomically engineered hetrostructure: 2D electron gas at the oxide interface

The discovery of 2D electron gas coupled with superconductivity and ferromagnetism at the interface of two band-insulators, namely $LaAlO_3$ and $SrTiO_3$ have triggered much enthusiasm due to the complexities involved resulting from the presence of conflicting phenomena. Though it is believed that electron doping of the Ti states are responsible for the observed effect, substantial controversy exists in this regard. In this project we would like to address and analyze the above observations from an alternate perspective.

3. Introduction to Topological Dirac and Weyl-semimetals

Since the discovery of topological insulators, a rich variety of topological phases and gapless electronic excitations that are protected by topology and symmetry have been predicted and discovered. These new class of quantum materials show linear dispersion around nodes, termed Dirac or Weyl point, as the three-dimensional analogue of Graphene. In this project we would review this topic in greater detail based on band structure calculations, angle resolved spectroscopy and magnetic and transport properties. We would also synthesize and characterize a few appropriate systems (thin film/ bulk) to have a first hand knowledge of this emerging field.

4. Ferroelectric composite polymers: Fundamentals to applications

We will develop flexible ferroelectric polymer ceramic composites with high figure of merit. Idea is to form composite of Ferroelectric Ceramic + Ferroelectric polymer, bringing together the best of inorganic ceramics and electroactive polymers with improved properties e.g. high dielectric permittivity, improved piezoelectric response/coefficients, high breakdown strength, mechanical flexibility, formability etc. We will also develop appropriate device form the stated composites to trap the mechanical energy (if time permits).

5. Physics of next generation solar cell

It has been recently discovered that a new class of material based on Organic inorganic Hybrid perovskites can achieve extraordinary efficiencies and offers interesting scientific challenges like ferroelectricity, localized strain, temperature dependent photoinduced reversible phase separation, etc. In this project we would explore Physics of these materials, synthesize their nano-particles and try to develop other potential solar cell candidates with higher photovoltaic response.