Announcing the Final Examination of Gyanendra Dhakal for the degree of Doctor of Philosophy in Physics

Date: April 06, 2022
Time: 3:00 p.m.
Room: PSB 160
Zoom Link: https://ucf.zoom.us/j/92670718774
Dissertation title: observation of anisotropic properties in topological quantum materials

Abstract:
The discovery of the three-dimensional topological insulator (TI) has enormously impacted our understanding of quantum materials. These novel materials are characterized by the topology rather than some order parameters. The TIs are the materials that exhibit insulating properties in the bulk while possessing the metallic state on the surface. After the discovery of TIs, other topological semimetallic (TSM) states were discovered, which enhanced the understanding and widened the reach of topological materials. Discoveries of various topological phases such as Dirac, Weyl, nodal line semimetals, etc., provided not only novel quasi-particles in condensed matter physics but also promised the discoveries of new technology based on these topological quantum materials. The next focus of the recent research has been on understanding the interplay among topology, superconductivity, magnetism, geometry, correlation, etc. In this thesis, using angle-resolved photoemission spectroscopy (ARPES), time-resolved ARPES (tr-ARPES), magnetic and transport measurements, in conjunction with first-principles calculations, we studied diverse anisotropies in different topological quantum materials, where anisotropic properties are originated due to the numerous factors including geometry, crystalline symmetry, magnetic orientation, and topology.

First, we studied the electronic structures of transition metal dipnictides, which crystallize in the low symmetry space group; found that these crystals show different surface behaviors with different cleaving planes. These materials show high magnetoresistance despite having topologically trivial band structures. Next, we investigated the anisotropic Dirac cone structure in a tetradymite material, which features the Dirac node arc state in addition to the anisotropic Dirac cone at a high symmetry point away from the zone center. Our topological analysis shows that the material possesses multi-fermionic states, which is rare in topological quantum materials. In our next project, we chose a kagome lattice-based material that could provide an ideal platform to study the interplay among geometry, magnetism, correlation, and topology. We investigated magnetic, transport, and electronic structure, in which we revealed that the material possesses anisotropic Hall resistivities and demonstrates multi-orbital fermiology. Finally, using tr-ARPES we revealed the cooling mechanism of the transient topological bulk state in a nodal line semimetal, and our theoretical analysis corroborates our experimental results that the optical and acoustic phonon relaxation follows the linear decay process.

Outline of Studies:
Major: Physics

Education Career:
M. S. Tribhuvan University, Nepal, 2015

Committee in Charge:
Dr. Madhab Neupane (Chair)