**Announcing the Final Examination of Md Mofazzel Hosen for the degree of Doctor of Philosophy in Physics**

**Date:** February 18, 2020
**Time:** 10:00 a.m.
**Room:** PSB 160/161
**Dissertation title:** Discovery of new topological quantum materials by photoemission.


**Abstract:**
A topological insulator (TI) is a novel electronic state of quantum matter characterized by a bulk insulating band gap and spin polarized metallic surface states. Recently, the idea of topologically protected surface states extended to semimetallic/metallic systems such as Dirac and Weyl semimetals. Unlike topological insulators where only surface states are interesting and topologically protected, Dirac and Weyl semimetals feature unusual bands both on the surface and in the bulk. Dirac semimetals show photon-like linear band dispersion and exhibit a variety of exotic properties that include surface Fermi arcs as well as large magnetoresistance and high carrier mobility. A new type of topological phase known as the topological nodal-line/loop semimetal (TNLS) has been lately proposed. Unlike zero-dimensional (0D) band touching in Dirac semimetals, nodal semimetals have 1D band touching in momentum space and requires extra symmetry protection. By utilizing angle-resolved photoemission spectroscopy (ARPES) and time-resolved-ARPES study in parallel with *first-principles* calculations, we discover the nodal-line state in ZrSiS-family. The Si-square net structure with nonsymmorphic symmetry in ZrSiS-family has been further predicted as the potential ground to host 2D Dirac fermion state. However, the observed surface state at the corner of the Brillouin zone of this family is gaped out. Our study discovers a naturally tuned nodal-line semimetal with the gapless 2D Dirac fermion in ZrGeTe. Although nodal semimetal can originate in both time-reversal (*T*) or inversion symmetry broken materials but most of the experimentally discovered TNLS are nonmagnetic in nature. Our study reveals the first magnetic nodal-line state in GdSbTe where combination of broken *T*-symmetry and roto-inversion symmetry provides the topological protection. Like the Fermi arc in Weyl semimetal, drumhead surface state is considered to be the characteristic signature of TNLS. Using ARPES and quantum oscillation measurements, we discover the first in-plane and clean drumhead surface state in $SrAs_3$. Furthermore, all the above discussed topological states are observed in different materials. Therefore, we investigate if it is possible to have multiple topological states in a single material. From our ARPES and *first-principles* study, we identify multiple fermionic state in a single material $Hf_2Te_2P$. Our comprehensive study of electronic structure not only provides the fascinating new quantum states but also lays out the foundation for potential future quantum computer, low power electronics, etc.


**Outline of Studies:**
Major: Physics

**Educational Career:**
M. S. University of Central Florida, USA, 2016
B. S. University of Dhaka, Bangladesh, 2013

**Committee in Charge:**
Dr. Madhab Neupane (Chair)
Dr. Talat S. Rahman
Dr. Yasuyuki Nakajima
Dr. Alexei V. Fedorov, Lawrence Berkeley National Lab (External Committee Member)

Approved for distribution by Dr. Madhab Neupane, Committee Chair, on January 17, 2020.

The public is welcome to attend.