Announcing the Final Examination of K A M Hasan Siddiquee for the degree of Doctor of Philosophy in Physics

Date: April 5, 2021
Time: 2:30 p.m.
Zoom Link: https://ucf.zoom.us/j/98898332900?pwd=Rm5NTUVUYnZ4UnpMUERrTmtSSDFiQT09
Meeting ID: 988 9833 2900
Passcode: 646218

Dissertation title: Superconductivity and Topological Properties in a Topological Semimetal

Abstract:
Topological superconductors (TSCs) in which superconductivity and topological properties are combined are characterized by topologically protected gapless states in the superconducting gaps. Realized in the gapless states of TSCs, Majorana fermions, which are particles and their own antiparticles, have crucial importance in quantum computation and spintronic device applications because of the exotic nature. Despite extensive study for the confirmation of TSCs, the observation of Majorana fermions in bulk superconductors has not been settled yet. According to a theory proposed by Fu and Berg, the identification of superconducting pairing states and nailing down the Fermiology of the normal states are crucial prerequisites in search of TSCs. In this dissertation, we investigated the superconducting and normal states of the binary stannide $CaSn_3$ with a cubic structure, a promising candidate for a TSC. In a detailed study of upper critical fields in the superconducting state of $CaSn_3$, we find that the anisotropy of the upper critical field shows two-fold symmetry about a C_4 axis which can be ascribed to an unconventional pairing state associated with nematic superconductivity. Besides the anisotropy, the temperature dependence of upper critical fields strongly deviates from that of the conventional depairing field described by Werthamer-Helfand-Hohenberg theory, consistent with odd-parity pairing. The possible odd-parity nematic superconducting state in $CaSn_3$, together with a fully-gapped state suggested by muSR measurements, meets one of the proposed prerequisites for topological superconductivity. We also present a detailed study of de Haas van Alphen quantum oscillations in a single crystal of $CaSn_3$ with torque magnetometry. In conjunction with density functional theory-based calculations, the observed quantum oscillation frequencies indicate that the Fermi surfaces of $CaSn_3$ enclose an odd number of time-reversal-invariant momenta, satisfying one of the other proposed criteria to realize topological superconductivity. Our findings will provide a new insight to identify topological superconductivity in quantum materials.

Outline of Studies:
Major: Physics

Educational Career:
M.S. in Physics, University of Dhaka, Bangladesh, 2012
B.Sc. in Physics, University of Dhaka, Bangladesh, 2010

Committee in Charge:
Dr. Yasuyuki Nakajima (Chair)
Dr. Richard A. Klemm (Vice Chair)
Dr. Madhab Neupane (Committee Member)
Dr. Fernando Javier Uribe Romo (External Committee Member)

Approved for distribution by Dr. Yasuyuki Nakajima, Committee Chair, on March 17, 2021.

The public is welcome to attend remotely.