INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	Priyanka Sinha
Roll Number	:	166121018
Programme of Study	:	Ph.D.

Thesis Title:Transport properties of 2D semi-Dirac systems: Effects of spin-orbit coupling and magnetic field

Name of Thesis Supervisor(s)	:	Prof. Saurabh Basu
Thesis Submitted to the Department/ Center	:	Physics
Date of completion of Thesis Viva-Voce Exam	:	25.04.2022
Key words for description of Thesis Work	:	Semi-Dirac, tight-binding, spin-orbit coupling, magnetic field

---

SHORT ABSTRACT

In this thesis, our work addresses the outcomes of the transport measurements in the presence of spin-orbit couplings and an external magnetic field in a two-dimensional (2D) semi-Dirac system. Semi-Dirac systems are characterized by a parabolic band dispersion along one direction in the Brillouin zone, and linear along the other direction. All the while, we have compared our results with those for the Dirac materials, a well-known example being graphene. Our results have exciting prospects for engineering tunable transport properties for 2D materials in the presence of spin-orbit couplings and magnetic field. Thus, our work mainly focuses on two novel phenomena, that is, the quantum spin Hall effect and the quantum Hall effect in a semi-Dirac system. To begin with, in the presence of spin-orbit coupling, we essentially study the quantum transport properties of a 2D semi-Dirac system modeled by a Kane-Mele Hamiltonian. We have systematically explored the relative strengths of the intrinsic (Haldane type, but with different fluxes for different spin degrees of freedom) and Rashba spin-orbit couplings on the edge states of a nanoribbon both analytically and numerically, and its band structures. Further, we have numerically studied the transport properties, such as the charge conductance, local density of states, etc via Landauer-Büttiker approach. We have observed significant deviations in the transport properties owing to the anisotropic band dispersion of the semi-Dirac system as compared to the results known for Dirac materials. In the next part, we have introduced a uniform magnetic field perpendicular to the plane of the system and hence explored its effects on the transport characteristics using Kubo formula. We looked into the features of the density of states, properties of the Landau levels, Hofstadter butterfly spectrum, and as well as the magneto-transport properties, such as the longitudinal and the transverse (Hall) conductivities. In addition, we have also explored the magneto-optical properties as a function of the incident photon energies in the near ultraviolet-visible regime and studied the effects of electron filling, circular polarization, Faraday rotation, etc.