INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	MIJANUR ISLAM
Roll Number	:	196121109
Programme of Study	:	Ph.D.

Thesis Title: INVESTIGATION OF CHARGE AND SPIN PERSISTENT CURRENT CHARACTERISTICS AND TOPOLOGICAL ASPECTS OF PSEUDOSPIN-1 α-T_3 LATTICE SYSTEMS

Name of Thesis Supervisor(s)	:	Prof. Saurabh Basu
Thesis Submitted to the Department/ Center	:	10/01/2025
Date of completion of Thesis Viva-Voce Exam	:	17/04/2025
Key words for description of Thesis Work	:	α-T_3 lattice, quantum ring, corbino disk, topological phase transitions

SHORT ABSTRACT

We study prototype of a pseudospin-1 fermionic α-T_3 model, which smoothly interpolates between graphene (α = 0) and a dice lattice (α = 1). For α ∈ [0, 1], the band structure features a flat band at zero energy separating two linearly dispersive Dirac cones. We explore persistent charge and spin transport in an α-T_3 quantum ring (QR) analytically in presence of a magnetic field, and systematically examine how different spin-orbit couplings (SOC) (both Haldane and Rashba types) impact Aharonov-Bohm oscillations and persistent currents in the spin and charge sectors. We also include (topological) defects to assess spintronic applications of our ring setup. We broaden our perspectives and examine an α-T 3 system as an electron pump, a gedanken experiment contemplated by Laughlin to demonstrate quantum Hall effect. Interestingly, the Fano factor reveals distinct transport regimes, demonstrating ballistic, Poissonian and diffusive behaviour for different values of α. Next, to shed light on the topological properties, we consider phases and phase transitions therein solely impacted by the electron-phonon coupling in the spin-orbit coupled α-T_3 bulk and ribbon systems. Our model demonstrates multiple topological phase transitions shown via the presence (or absence) of chiral and helical edge modes in semi-infinite ribbon geometries which are further evidenced by computing the Z and Z_2 invariants.