INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Phases and Critical Analysis of Quantum Systems in presence of Quasiperiodic Potential

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SHORT ABSTRACT

Disorder is universal in quantum systems. It has an enormous effect on electronic motion in solids. Consequently, the system undergoes a localization transition from a metal to an insulator under the drive of random disorder strength in three dimensions. On the contrary, another type of deterministic potential, namely, the quasiperiodic (QP) potential allows exhibiting of the localization transition in one-dimensional systems.

In this thesis, our primary motivation is to study the localization properties corresponding to a dimer model in presence of the QP potential. More specifically, the dimer model has been chosen for the purpose of breaking the self-dual symmetry, thereby aiming to introduce mobility edge (ME) in the one-dimensional system. The combination of these two, such as the dimerization and the QP potential, reveals a noteworthy observation. In particular, the results which are analyzed via computing the participation ratio, eigenenergies, density of states and finite-size scaling analysis etc., imply a reentrant localization transition that transcends the existing conventional theory in literature. Further, we analyzed the critical behavior corresponding to this reentrant localization transition using a multifractal analysis, followed by a critical state analysis, and via computing the Hausdorff dimension. Moreover, this dimer model, aided by p-wave superconducting pairing in presence of QP potential, preserves topological properties, which was missing in the purely dimerized model with QP potential. Thus by exploring the localization and the topological properties, we have reported significant results on a series of phase transitions occurring in the system. While studying the localization properties via participation ratio, fractal dimension and level spacing, we

inferred two different types of anomalous MEs in addition to realizing a multifractal phase. Further, by examining the topological properties via calculating the real-space winding number and the number of Majorana zero modes, we observe several phase transitions from topologically trivial to topologically Anderson to Anderson localized phase.

In the end, in addition to the non-interacting one-dimensional quantum systems, we have also studied a two-dimensional interacting system in presence of a QP potential. Using the site-decoupled mean-field approximation, percolation analysis and the finite-size scaling analysis, we have explored the phase diagram, and subsequently investigated the critical properties of the various phase transitions occurring in the system.