INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

In the thesis, we investigate various intriguing properties and phases of interacting bosons in different optical potentials. Our primary focus is to explore the tunneling dynamics and ground state properties of correlated bosons and how these exotic quantum features can be manipulated via tuning the fundamental properties of the system, such as, interactions, depth and geometry of the trapping potential etc. The thesis is divided mainly into two parts depending on the methodologies, namely, the Bose-Hubbard model (BHM) and the Multiconfigurational time-dependent Hartree approach for bosons (MCTDHB) employed to tackle various interesting quantum features. First, with BHM we study the quantum dynamics of correlated bosons in a double well potential. We capture interesting distinctive features for tunneling dynamics in presence of both attractive and repulsive interactions for weak and strong coupling regimes and also explore the sensitivity of the dynamics on different initial configurations in which the system is prepared. Hence, the role of an external driving on the tunneling dynamics of interacting bosons confined in a double-well potential, such as, emergence or suppression of chaotic dynamics in presence of such driving is thoroughly investigated. Further, we analyze the effect of time-dependent synthetic magnetic fields on the quantum phase transition, that is, the Mott-insulating (MI) to the superfluid (SF) phase transition. In the second part of thesis with MCTDHB, first we simulate an experimental scenario where as if the 'charged' bosons are placed in a constant electric field, thereby inducing a tilt in the optical potential and subsequently we analyze the ground state properties, such as, fragmentation and condensation of bosons in such a tilted triple well potential. Here we obtain how the interplay of the interaction strength and the tilt parameter can be used to manipulate correlations and fragmentation of these many-boson systems. We also investigate the dynamics of interacting bosons confined in a temporally driven tilted double well potential that imitates a quantum seesaw and how it can be exploited to control the tunneling dynamics of these interacting bosons. Furthermore, we simulate a system of few bosons confined in a two-dimensional single harmonic trap in presence of a synthetic gauge field and investigate the many-body dynamics of such a system. Finally, the importance of the second formalism that has been employed to deal with various topics, namely, MCTDHB formalism for a tilted triple well corresponding to both contact and long range interaction potential as a prototype example is presented in the thesis.