ABSTRACT

The most remarkable aspect of topologically ordered phases is that they house anyon quasiparticles with fractional charges and fractional statistics, both of which are invisible in the conventional phases. Using the groundbreaking fractional quantum Hall effect (FQHE) experiment, these phases were identified and are gaining a lot of attention. Due to the fact that the Hamiltonian for the strongly correlated system of FQHE can't be exactly solved, a model wave function plays the most important role in identifying the characteristics of the FQHE state and this thesis makes a significant contribution to that purpose. Almost all the states in the lowest Landau level (LLL) behave in a likewise manner providing Abelian statistics of quasiparticles. Our theoretical findings suggest some unconventional nature of the known state which could be verified by further experimental investigations.

After the experimental observation of the 4/11 state in the range $1/3 < \nu < 2/5$ in the LLL, the available theoretical studies suggest it to be an unconventional state due to its inconsistency with all existing theories. The nature of the incompressibility of this state demands two-body V_3 pseudo-potential, a repulsive interaction among two particles with relative angular momentum 3, as an important part that is explored by an unconventional correlation. The unavailability of any ground state wave function for this unconventional 1/3 state has motivated us to propose a suitable wave function for this state which is further utilized for the study of the unconventional 4/11 state.

There are several proposals for the second Landau level for hosting non-Abelian anyons, which have been found to be a promising candidate states for topological quantum computation. However, no theory for true FQHE in the LLL provides such a phenomenon. In the lowest Landau level, 2/5 and 2/3 states are well described by composite fermion theory suggesting Abelian quasiparticle excitations. However, for the 2/5 state, another wave function, the so-called Gaffnian wave function, was suggested which provides non-Abelian excitations but fails to reflect the incompressibility of the state and is thus considered to be a quantum critical state. We interpret the Gaffnian wave function as the inter-flavor pairing of the composite fermions and suggest a modified-Gaffnian wave function with a minimal modification of the flux correlation so that the amalgamation of these wave functions can represent the exact Coulomb ground state providing all the theoretical properties. Due to the pairing, our proposed wave function is predicted to host non-Abelian quasiparticles. Using a similar analogy of Gaffnian and modified-Gaffnian wave function, we proposed a wave function for the 2/3 state with a new kind of pairing mechanism. This paired state, which will possibly harbor non-Abelian quasiparticle, has been numerically studied and having a very good matching with the exact ground state strongly suggests its candidature to be a true ground state of 2/3 state.

Key words: Fractional Quantum Hall Effect, Anyons, Non-Abelian Statistics.