# Topics on Ultracold gases in different lattice geometries

This talk is divided into three parts. In the first part, we consider a system of bosons in a two-leg ladder with half a magnetic flux quantum per plaquette. Using the density matrix renormalisation group (DMRG) method, we show that the phase diagram of such kinetically frustrated bosons displays three phases depending on the interaction : a weakly interacting chiral superfluid phase with staggered loop currents, the conventional Mot insulator at strong couplings, and a remarkable chiral Mott insulator (CMI) phase with staggered loop currents sandwiched between them at intermediate correlations.

The second part deals with bosons in an optical superlattice created by the superposition of two optical lattices with different frequencies. Previous studies have revealed an interesting phase diagram with a superfuid phase appearing even at higher coupling strengths, between two insulating phases. In this work, we linearly vary the superlattice potential with time, such that the system starts from one of the insulating phases. The time evolution takes the system through the superfluid phase, finally ending in the second insulating phase. Due to the intermediate critical superfluid phase, defects would be produced. Our analysis indicate a power-law dependence of the number of defects on the quench rate similar to the Kibble-Zurek mechanism.

The third and final part deals with the effects of spin and mass imbalance on a system of ultracold two-component fermions in a one-dimensional lattice with nearest neighbor interactions. This system, described by extended Hubbard model, has a rich phase diagram. With the help of matrix product states method, we analyse the effects of spin imbalance on the various observables relevant in the corresponding phases. Our results show interesting behavior of non-local orders like string correlations. Our initial findings also indicate the appearance of Fulde-Ferrell-Larkin-Ovchinnikov phase across a wide range of parameters. In the mass imbalance scenario, depending on the filling factors and the interaction amplitudes, different types of density orders are observed.