The quantum phase of fermions in an 1D lattice.

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One-dimensional systems are wonderful systems on which interactions play a very special role and whose physics is drastically different from the one known in higher dimensions. The one dimensional character makes the problem simple enough so that rather complete solutions could be obtained using specific method and yet complex enough to lead to incredibly rich physics.

From an experimental point of view, one-dimensional systems were mostly at the beginning a theorist's toy. Experimental realizations are started to appear with polymers and organic compounds. But in the last 30 years or so we have seen a real explosion of realization of one dimensional systems. The recent progress in the Bose condensation in optical traps offer great promises for the future in realizing one-dimensional systems of fermions or bosons with unique properties. These experimental developments have of course triggered a corresponding burst theoretical activity and our understanding of such systems has considerably progressed during this period. New the tools have been developed and new concepts have emerged.

The lecture is intended to present this fascinating one-dimensional physics. The Luttinger liquid theory (LLT) particle is introduced. LLT is a theory of interacting one-dimensional, analogous to the Fermi liquid for interaction electrons in three dimensions. We start with the Hubbard model. The exact diagonalization (ED) and density matrix renormalization Group (DMRG) as methods to solve the model and finding its eigenstates and eigenvalues are presented.

More, the nearest neighbor interaction, dipolar interaction and other interactions are added to the fermionic Hubbard model and the properties of their ground states that evaluated for different the Hamiltonian parameters are investigated. Therefore, the phase diagram of the model is determined. To study ground state, we use LL parameters and different correlation functions.

References

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