Quantum Simulation Using Quantum Degenerate Ytterbium Atoms in Optical Lattices

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The idea that a quantum system which is difficult to control and is never clean can be efficiently simulated by another quantum system which is easy to control and is super-clean, is sometimes referred to as Quantum simulation based on the Feynman's pioneering statement. From this point of view, we are aiming at realizing the quantum simulator of strongly-correlated systems which remain unsolved and are of particular importance in physics, with ultra-cold fermionic atoms in a three-dimensional optical lattice[1]. By performing the quantum simulation, we especially hope to provide a critical insight into the mechanism of the high-T_c superconductivity in cuprates which eluded the unified rigorous theoretical explanation of the observed behaviors,. With this cold atom system, we can finely control many important parameters such as temperature, on-site atom-atom interaction, tunneling rates between adjacent sites and layers, filling factor, and so on.

In particular, we plan to work with ytterbium (Yb) atoms since the Yb atoms are less sensitive to an external fluctuating magnetic field and have ultra-narrow optical transitions which are useful to probe weak interactions. Another important advantage of working with Yb atoms is the existence of a rich variety of isotopes, that is, two fermions and five bosons, which will extend the variety of the simulation. So far, we have succeeded in creating BEC and Fermi-degeneracy for Yb atoms, and also succeeded in loading the cold Yb atoms in a three-dimensional optical lattice at a period of 266 nm. We will report the present status of our research and the future plan.

References;

[1]W. Hofstetter, *et al.*, Phys. Rev. Lett. **89**, 220407(2002)