

Quantum Phase Transitions in Disordered Superconducting Thin Films

Min-Chul Cha

Department of Applied Physics, Hanyang University—Ansan, Korea

In the past decade, superconducting thin films have served as a pioneering experimental system showing quantum phase transitions. By controlling the thickness of film or the applied magnetic field, phase transitions at zero temperature have been tuned between an insulating state and a superconducting state. Observations of scaling behavior near the transition strongly support that the nature of transition is, indeed, governed by a quantum criticality. However, consensus in experiments has not been achieved. For example, many disordered thin films show metallic behavior in the intermediate region. In addition, the universal features of the transition predicted by theories have not been observed.

Theoretically the zero-temperature superconductor-to-insulator transitions have been discussed in the boson Hubbard model, in which Cooper pairs, preformed at finite temperature, are treated as bosonic particles. In this model, superconductivity sets in when the condensation of bosons occurs. The boson Hubbard model has emerged as a prototypical model for strongly correlated bosonic systems. It has been adopted to describe the transitions of bosonic atoms confined in a optical lattice, He atoms adsorbed in porous media, and Josephson-junction arrays.

In this work, we discuss theoretical approaches to the quantum phase transition observed in disordered superconducting films, based on the boson Hubbard model. In particular, we focus on the role of disorder and discuss some numerical evidences supporting that the weak and strong disorder regimes are separated as a function of the disorder strength.