Chapter 6

Discussion and Conclusion

In this thesis, we study the influence of disorders to a two-dimensional Josephson junction arrays in the granular superconductor. We approach this problem by mapping to the quantum spin-$\frac{1}{2}$ XY model. The disorder we discuss here is caused by the charge fluctuation due to the randomness in grain size and also the impurities introduced to the junctions. Physically, the critical phenomena of a such system is due to the competition between charging energy and Josephson coupling energy. The critical phenomena of a such system in the presence of charging energy was studied in the MFA in Chapter 3. In Chapter 4 we perform the Monte Carlo simulation for the large grain size where the charging energy can be ignored. We find out that the randomness in Josephson coupling energy arising from the impurity introduced into the system could causes the phase transition as we tune the impurity concentration to some certain finite value. The Josephson junction arrays, physically, can also be viewed as a vortex structure in

superconductor. The vortex creep in disodered films is an interesting problem, since it has a bearing on such fundamental questions like the Anderson localization in 2D system, and variable-range hopping of vortices. We address this problem in the second part of this dissertation. We approach this problem by using the concept of variable-ranged hopping conductivity and modified Efros's model to calculate the variable-ranged hopping conductivity. We find out that Coulomb gap exists in the large U limit (small grain size) while in the small U limit, there is no Coulomb gap, since in this limit the vortex-antivortex pairs are formed in each grain and eventually screen out the logarithmic interaction among the vortices. This result agrees with our expectation since the nature of the Coulomb gap arises from the interplay between disorders and interactions.