THEORY OF PHOTO-INDUCED FERRO-MAGNETISM IN DILUTE MAGNETIC SEMICONDUCTORS

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ABSTRACT

This thesis is a theoretical study of photo-induced ferro-magnetism in Dilute Magnetic Semiconductors. When light is incident on these systems, electrons and holes are created across the band gap. These particles interact with the impurity magnetic moments and mediate ferro-magnetism when temperature is lowered. This is a situation similar to the famous Rabi problem of a two state system coupled to time-dependent oscillating electric field. Ours is a multi-state system with electrons and holes coupled to an oscillating electric field. This is a generalization of the Rabi problem which shows also a phase transition from para to ferromagnetic state. We first study some model one and two state systems. We show by performing appropriate unitary transformations, it is possible to eliminate the time from the time-dependent Hamiltonians and get the eigen energies. Since our system of electrons and holes in contact with the photon bath is in a steady state, we calculate the free energy of the system. We study the problem of phase transition in two different ways , one by constructing Bogoliubov-Valatin quasi particles and the other by BCS wave function approach as in the low-temperature superconducting phenomenon. This also establishes that BCS and BV approaches are equivalent mean-field methods. We calculate magnetization of the system in a self-consistent mean-field way. The magnetization and thereby the critical temperature is dependent on the photon energy incident on the system. By increasing the light coupling to the particles the transition temperature increases. Also by increasing the frequency of the light, the transition temperature is increased. Since more and more of the electrons and holes are created, these carriers mediate more with the magnetic moments and flip their moments into the ferro-magnetic state. It is also found that even when light energy is below the band-gap there is still magnetization and a ferro-magnetic state is still possible. It is interesting to find a linear dependence of critical temperature T_c on the coupling J^2.