

Public Abstract

First Name:Subodha

Middle Name:

Last Name:Mishra

Adviser's First Name:Sashi

Adviser's Last Name:Satpathy

Co-Adviser's First Name:

Co-Adviser's Last Name:

Graduation Term:FS 2006

Department:Physics

Degree:PhD

Title:Theory of Photo-Induced Ferro-Magnetism in Dilute Magnetic Semiconductors

This thesis is a theoretical study of photo-induced ferro-magnetism in Dilute Magnetic Semiconductors. In this modern-day-world every body is familiar with electricity. The electric current is due to the motion of electrons in metallic wires. Electron has another physical quantity associated with it, that is the spin of the electron. Though not exactly, spin is like a rotation of the electron. It can be up or down. Electron has only two kinds of spin. It is actually a microscopic quantity (quantum in nature). It can have values  $1/2$  or  $-1/2$ . For almost a century we have made good use of the charge of the electron in the form of electric current. All the high tech instruments are possible due to the processing of the electron charge. But we have almost neglected the use of the spin of electron. In recent years, it is becoming clear that if spin of electron can be processed then it will lead to novel high-tech instruments which can not be fabricated using the charge of the electron alone. When light is incident on Dilute Magnetic Semiconductor 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. In this procedure we get the ground state energy of the system identical to the energy calculated in BV way without the excitations. 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 on the square of the coupling.