



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : Kallol Mondal

Roll Number : 126121017

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Name of Thesis Supervisor(s) : Prof. C. Y. Kadolkar

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SHORT ABSTRACT

In this thesis, we have extensively worked on the nature of the ground state of different frustrated magnets, especially on kagome lattice and the possible magnetic long-range order state in those systems. Due to low dimensionality, a higher degree of frustration and larger quantum fluctuations makes kagome Heisenberg antiferromagnet(KHAF) a suitable candidate to host a quantum spin liquid ground state. In the isotropic case, i.e., in the absence of DMI, the ground state of kagome Heisenberg antiferromagnet is argued to be a Z_2 chiral topological spin liquid. We have mainly focused on the effect of anisotropies like Dzyaloshinskii-Moriya interaction(DMI) on the ground state manifold of kagome Heisenberg antiferromagnet. So, the presence of DMI can be identified as a perturbation to the Heisenberg Hamiltonian. So, it is expected that the DMI can potentially destroy the spin liquid state and induce magnetic order in the system through a quantum phase transition. DMI is a special kind of anisotropy that arises in a lattice where there is a lack of inversion symmetry and originates from the spin-orbit coupling. Up to what extent DMI induces magnetic order in the system and understanding the zero temperature magnetic structure is the objective of the present thesis. Since there is a possibility of a magnetic long-range order state, induced by DMI, we have used Schwinger boson mean-field theory(SBMFT) to study the above problems. SBMFT is an elegant way to study both the long-range ordered state as well as spin liquid state. Magnetic long-range order is induced by the condensations of Schwinger bosons. Now, the effect of the in-plane component and out-of-plane component of DMI is quite different. The planar component favors the canting of the spins from the kagome plane leading to the non-coplanar spin structure, whereas the out-of-plane component favors the planar spin structure. Thus, we have considered two separate problems when the in-plane component is small

compared to the out-of-plane component of DMI, and the other one, when both are comparable or in-plane component, is dominant over the out-of-plane component. In our first work, we have calculated the ground state phase diagram when the in-plane component is quite small compared to the out-of-plane component, and that is the case of Herbertsmithite. This material does not show any sign of freezing down to very low temperatures, but the experimental results predict the presence of DMI. It was not very clear why this material does not freeze, and the possible explanation was the presence of a quantum critical point. Thus we have computed the ground state phase diagram using SBMFT. We have calculated properties associated with each of the phases to interpret the experimental result of Herbertsmithite. In the next work, we investigate the possible regular magnetic order(RMO) for the spin models based on group theoretical approach for kagome and triangular lattices. The main reason to study these RMOs is that they are the good variational candidates for the ground states of these kinds of frustrated magnets. In this thesis, we followed the prescription introduced by Messio et al. (L. Messio, C. Lhuillier, and G. Misguich, Phys. Rev. B, 2011, 83, 184401) for p6m group and extended their work for different subgroups of p6m, i.e., p3, p31m, p3m1, and p6 in Hermann-Mauguin notations. We have listed all the possible classical ground state spin configurations for these groups. In our last work, we consider the case where the in-plane component is dominant over the out-of-plane component, which is the case of vesignieite. Motivated by the experimental result of vesignieite that the ground state in $Q = 0$ magnetic long-range order state, we looked at the mean-field Ansatz, which mimics the above ground state in the large S-limit. We have obtained the ground-state phase diagram of this model and calculated properties of different phases. In order to have better insight into the problem, we have also studied the above model numerically using exact diagonalization(ED) up to a system size $N = 30$. We have compared the obtained results from these two approaches. We have made an attempt to interpret the experimental of vesignieite result from our calculation.