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Research Subjects: Statistical Mechanics, Phase Transitions, Quantum Spin systems,

Nonequilibrium Phenomena

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1. Magnetization Processes in Quantum Triangle Lattices

We studied the magnetization process in weakly XY-anisotropic antiferromagnetic Heisenberg spin systems. The magnetization processes of this type of model at finite temperatures were studied in their corresponding classical models, where we found very complicated successive phase transitions. They reflect magnetic-field-dependence of the entropy of various nearly degenerate ordered states of the models. We found that the quantum fluctuation causes the same effects on the stabilization of successive phases in the field in the ground state. We studied the quantum models in the approximation where use a $3 \times \infty$ lattice instead of the two-dimensional triangular lattice. This lattice can be studied by PWFRG method and DMRG method.

It has been found that this lattice is exactly the same as the system of alternate-triangle tube material. The existence of the gap between the ground state and the excited states is a matter of interest. Although in the regular triangle tube, the existence of the gap is known, in the present case there may be a ground state phase transition, which is under investigation.

2. Nature of Ferrimagnetic Order in Quantum Spin Systems

We have investigated types of ferrimagnetism in the ground state of quantum spin systems. The most familiar type is the Lieb-Mattis type in the antiferromagnetic model on bipartite lattices with different number of sublattice sites. On the other hand, in the case of frustrated lattices, the ground state spin configuration is often non-collinear, and they show a non-collinear ferrimagnetic states. In order to realize these types of ferrimagnetism in a lattice and to study the phase transitions between them, we investigate a lattice with frustrated interactions. We find that this model contains two types of ferrimagnetism as a function of the parameter. Furthermore we found that the system has an incommensurate spin configuration The wavelength of the oscillation changes with a parameter. The mechanism of this behavior is now under investigation.

3. Quantum Effects on the Charge Transfer Spin-Crossover Phenomena

As a new frontier of studies of the phase transition, phase transition of structure of materials due to charge transfer and also magnetic phase transition on such materials have been attracted interests. In some materials of this type, in the low temperature configuration the magnetic atoms are surrounded by non-magnetic atoms and the interaction between magnetic atoms is expected to be very small. Nevertheless, magnetic ordering occurs. Mechanism of this magnetic order is an interest problem. We have proposed that thermal fluctuation may assist the magnetic order. However this mechanism has been shown to be difficult at least in two-dimensional systems. Thus, we proposed alternate mechanisms including ones due to quantum fluctuation. We demonstrated that quantum mixing due to the DM interaction helps the magnetic order, and electron hopping also helps the order. We also studied effects of photo-irradiation on systems which shows the photomagnetism.

4. ESR Study on Nano-scale Molecular Magnets

We have developed a numerical method to obtain the ESR by means of direct numerical evaluation of the Kubo formula. We have studied characteristics of ESR absorption as functions of the frequency of the AC field ω and the strength of the static field H_0. In particular, we have studied the temperature dependence of total amplitude of the absorption of ESR of a molecular magnet V_15. At very high temperature, all the 15 spin gives independent data and we have 15 times of the absorption of single isolated spin. When the temperature decreases, due to the magnetic interaction the effective degree of freedom is reduced to 3 for a loosely coupled three spins. At further low temperatures, we found that the system shows various temperature dependence depending on the magnetization. We also find the dynamical shift, i.e., dependence of the absorption on the relative angle between the AC field and the system.

5. Mechanism of Slow Dynamics in Decorated Bond Systems

We also studied mechanism of reentrant phenomena and memory effect in a lattice consisting of frustrated decorated bond. There, we found that the time evolution of the spin becomes very slow due to a kind of dynamical metastability. We successfully evaluated the relaxation time by an analysis of distribution of configurations of a decorated bond. By this study we find that, although the equilibrium state is well defined, it may take very long time to reach it even in relatively simple systems.