10 Miyashita Group

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

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1. Novel phases originated in the quantum interactions

We studied various new types of quantum phases in spin systems. We are interested in phases which have nonzero magnetization. Although familiar type of ferrimagnetism is the Lieb-Mattis type in the antiferromagnetic model on bipartite lattices with different number of sublattice sites or different sizes of spin, there exists another type whose ground state spin configuration is non-collinear in the case of frustrated lattices. We have found a model which contains the two types of ferrimagnetism as a function of the parameter. We found that the nature of spin order is different from ordinary ferrimagnets. We also propose a structure of molecular magnets with the latter type of ferrimagnetism which show new types of spin dynamics in the ground state. We also found a model in which quantum fluctuation enhances the magnetic order. A ground state phase transition between the gapfull and gapless phases in the so-called spin tube is also found.

2. Quantum magnetic processes

The magnetization processes of a system composed by ferromagnetic dimers and antiferromagnetic dimers are studied. This model shows a metamagnetic property which can be explained the so-called Tachiki-Yamada model using renormalized parameters in the magnetic field. We studied the dependence of effective parameters using a kind of local decimation process in quantum systems, and explained the over all dependence of the magnetization process on the field and temperature.

We studied dynamical magnetization process of the transverse Ising model in the ordered ground state under the sweeping of magnetic field. We found a kind of collective motion which does not depend on the size of the system. We also studied the dependence of the critical transverse field on the size of spin S.

3. Quantum dynamics

We have studied properties of quantum dynamics and manipulation in nanoscale molecular magnets and related materials, where the Landau-Zener mechanism plays important role. In order to study further on the quantum dynamics, we have started a crest project in JST on "Quantum-mechanical cooperative phenomena and their applications".

For quantum information processes, the manipulation of qubits which is a local unit of the system is important. We derived analytic formula of the probability of non-adiabatic tunneling in a system where qubits interact with boson systems.

4. Thermal conductivity of quantum magnets

The mechanism of thermal conductivity due to the spin interaction is one of the hot topics in strongly interacting spin systems. Using a non-equilibrium green function method, we found non-symmetric thermal flow in a system where a gapfull system and a gapless system are contacted.

6. Phase transitions in spin-crossover complexes

As a new frontier of studies of the phase transition, phase transition of structure of materials due to the spin-crossover and/or charge transfer have been attracted interests. The properties of photo-excited state at low temperatures have been also studied extensively. Furthermore the composite phase transitions of the spin structure and magnetic structure is a hot topic. We have found a metastable branch of the high spin state at low temperatures which is much below the thermal hysteresis. The related experiment has also been done and gave a strong support of the existence of the branch. We also develop a theory to study the both phase transitions in a unified way and studied the static and dynamical properties of this type of materials. We also developed analysis on the spin transition and magnetic transition of the Prussian-blue analogue by taking into account the sublattice structure of the material. Effects of lattice vibration have been also studied.

7. Slow relaxation in frustrated systems

In frustrated system, the dynamics of ordering process is often very slow. In most cases it is due to a kind of energetically trap at metastable state. However, we found that there is a another type of slow down. That is, a kind of entropy-induced slow down occurs in a frustrated system which shows a reentrant phase transition. We have analyzed the mechanism. We found the so-called thermal annealing method does not help to find the low temperature stable state, but the quantum annealing does. We are studying the underlying mechanism of this process. As another example, we have studied the slow relaxation in the Kagome lattice with Ising-like Heisenberg antiferromagnets, where the macroscopically degenerate ferromagnetic ordered state appears. In the ordered state, we found slow relaxation mechanism due to the macroscopically degenerate states which are characterized by so-called weather-vane loop.

8. Gas-liquid phase transition and hydrodynamics

In order to study the generation bubble of gas in the gas-liquid phase transition we developed a theoretical scheme combining the fluid dynamics equations (Navier-Stokes equation) and the equation of state of material (van der Waals equation) and demonstrated the bubble generation by point heating and various properties during the generation.

9. Random matrix and quantum chaos

We also studied the random matrix theorem to study the relation between the obits in the classical mechanics and quantum chaos. We also studied distribution of separation of repulsive energy crossings in the random matrices.