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Editorial

Magnetic Field-Induced Phase Transition

Yasuhiro H. Matsuda

Institute for Solid State Physics, University of Tokyo, 5-1-5 Kashiwanoha, Chiba, Kashiwa 277-8581, Japan; ymatsuda@issp.u-tokyo.ac.jp

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The magnetic field controls the spin and orbital motion of electrons and can induce a phase transition through a change of the ground state. The Helmholtz free energy (F) can be expressed as $F = U - TS$ using the internal energy (U), entropy (S) and temperature (T), and a magnetic field-induced phase transition takes place through lowering U. Hence, the phase transition occurs even $T = 0$ and the transition is called quantum phase transition. Because quantum phenomena are significant at a low temperature, the magnetic field-induced phase transition has been attracting great attention. Here in the special issue, six contributed papers report various phenomena regarding the magnetic field-induced phase transition.

A spin system is an ideal playground for study of the phase transition and the quantum phenomena; spatial dimensionality and type of the interaction between the spins determine the characteristics of the phase transition. Various kinds of rich quantum phases are induced in the quantum spin systems. Quantum discord and entanglement are both criteria for distinguishing quantum correlations in a quantum system. Nemati et al. have investigated the effect of the transverse magnetic field on the quantum discord of the one-dimensional spin-1/2 XX model [1]. They found that the the quantum discord was finite for all studied spin pairs in the Luttinger liquid phase, and the derivative of the quantum discord could be used to identify the border between entangled and separable regions. These findings would contribute to the quantum information technology.

Magnetic materials with fascinating characteristics such as multiple magnetic orders, large magnetoresistance, geometrical magnetic frustration and Kondo effect, are always candidates to study on the magnetic field-induced phase transition. There exists a variety of magnetic phases in a magnetic field-temperature (B-T) plane in those materials. The magnetic field makes spins oriented, and the resulting change in properties gives us rich information on the magnetic and electronic nature. The cubic intermetallic compound $Sm_3Co_4Ge_{13}$ possesses a cage-like structure composed of Ge. The magnetic ground state is antiferromagnetic (AF) and its Neel temperature is 6 K. Although the AF phase is expected to be suppressed by a magnetic field of several Tesla, Nair et al. have found an unusual phenomenon that the AF is robust against a magnetic field of 9 T [2]. The Co(3d)-Sm(4f) hybridization in the valence band and a significant contribution of the 4f (Sm) state at the Fermi level are important. A strong magnetic field is of course very useful to study the field-induced phase transition. Dong et al. [3] have used a pulsed magnet to produce a strong magnetic field of up to 62 T for the study of the field-induced phase transition in the hexagonal manganite $HoMnO_3$. The magnetization curve at 0.7 K exhibits successive magnetic transitions below 10 T and a step-wise transition at around 41 T. They provide the B-T phase diagram showing how the rich magnetic phases develop and discuss the variety of the magnetic symmetry of these field-induced phases.

Magnetic phase transitions studied by a microscopic means such as magnetic resonance and neutron scattering are reported in an S = 1 skew chain antiferromagnet $Ni_2V_2O_7$ and a frustrated spin system $SrHo_2O_4$, respectively. The electron spin resonance in $Ni_2V_2O_7$ exhibits an unusual softening when the magnetic field applied parallel to the b axis exceeds 8 T [4]. Although the detailed spin structure has not been clear yet, the characteristic magnetic field (8 T) corresponds to the critical field where the 1/2 magnetization plateau begins. The overall resonance modes are rather complicated and cannot be interpreted by the conventional two-sublattice model with uniaxial anisotropy. As for the neutron scattering of $SrHo_2O_4$, the field-evolution of the diffraction patterns in two orthogonal scattering planes, (hk0) and (h0l), are observed [5]. In both geometries, the main effect of an applied field is seen in the evolution of the diffuse scattering. This findings are readily correlated with the single crystal magnetization at low temperatures. The field-induced transition can be interpreted as a transition from antiferromagnetic to ferromagnetic arrangement of Ho moments. A rather stable up-up-down phase is also observed before the ferromagnetic phase if the magnetic field applied is parallel to the *b* axis.

I also presented a contributed article that reports the magnetic-field-induced insulator-metal (IM) transition of the Kondo insulator YbB_{12} [6]. The abrupt magnetization increase is observed at the IM transition and the magnetization curve has been investigated at different temperatures up to a very strong magnetic field of 100 T. We found that the transition becomes less clear with increasing temperature and almost invisible if temperature is higher than a characteristic temperature $T^* \sim 30$ K. The T^* is unexpectedly small compared to the Kondo temperature (T_K) of this compound around 240 K. Grobal coherence of the Kondo resonance may be disturbed at around T^* while the local Kondo effect survives at a higher temperature around T_K.

To conclude, I believe that this Special Issue on "Magnetic Field-induced Phase Transition" has given an opportunity to collect some of the latest issues on phenomena related to the magnetic field-induced phase transition. I would like to thank all authors who contributed for submission of the quality manuscripts.

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