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NMR in Condensed Matter Physics in High Magnetic Field

We have examined the temperature dependence of the relaxation rate in the mix-valence Re-Complex and found a characteristic temperature dependence of T_1 around the expected charge order temperature. We also have discussed a strategy to investigate the high field phases in several strongly correlated systems by the complementary use of NMR and neutron.

NMR is one of the useful methods to examine dynamical and static correlations in strongly correllated electron systems. It is unique in the capability of experiments in very high magnetic fields above 30 T. In fact, it has been used in the studies of interesting high magnetic field phases in quantum magnets, heavy fermion systems and unconventional superconductors.

During the stay in Sendai, I have conducted following three tasks, (1) consulting of NMR activity in the high magnetic field center of IMR, (2) study of mix-valence Re-Complex and (3) discussion of a strategy to examine the high magnetic field phases by neutron diffraction. These tasks have been completed successfully due to my experience as the head of NMR group of the Grenoble High Magnetic Field Laboratory (now called LNCMI) and deputy director of this laboratory. My research activity in the last ten years has been mainly bearing upon condensed matter systems in which the magnetic field plays the role of thermodynamic variable able to induce phase transitions. I paid particular attention to the case of quantum phase transitions, which occurs at T = 0. These experiences have contributed much to improve the activities of researches in high magnetic field at IMR.

(1) Dynamics of mix-valence Re-Complex

A complex $Re_2Cl_4(P_nPr_3)_4$(Hbim) (bim) has a linear structure of Re-H-Re and the two Re ions are in the mixed valence state at room temperature. By lowering temperature, a charge order of Re ions associated with the shift of the hydrogen : H has been conjectured. The shift of the H atom and the change of charge distribution were found by X-ray diffraction experiments, which suggest the charge ordering. However, the X-ray result can be possibly understood by the superposition of the two dynamically charge imbalance. This realizes if the charge fluctuation frequency is much slower than the time window of X-ray. As such, a supplemental information has been required to prove the charge ordering.

Figure 1 shows the tentative analysis of P^{31} NMR. Phosphorus ions are located at the apical positions around Re ions. The enhancement of inverse T_1 is found in the temperature range between 100-10 K. Such enhancement is possibly caused by the slowing down of the Re spin fluctuation by the charge ordering process. The appearance of dynamical anomalies support the charge ordering found by X-ray diffraction. A more detailed analysis and the complementary experiments are in progress.

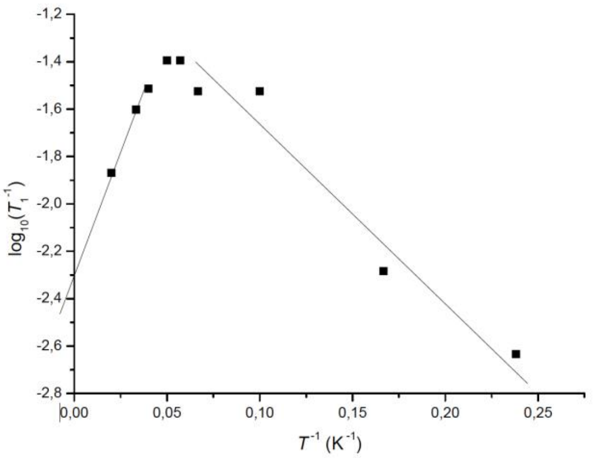

Fig. 1 Temperature dependence of $1/T_1$ of P^{31} nuclear spin. The enhancement is found in the intermediate temperature.

(2) Strategy for the high magnetic filed neutron diffraction

We have examined the magnetic field induced ordering :Bose-Einstein condensation of triplons in the so-called Han Purple compound ($BaCuSi_2O_6$) [1]. The quantized plateau state in two-dimensional frustrated antiferromagnet $SrCu_2(BO_3)_2$ was also examined[2]. These two systems require experiments in resistive magnets and very low temperature. We have discussed in details about the possible magnetic structures appearing in these compounds and possibility of neutron diffraction to detect those structures. The strategy would help much for the future neutron diffraction experiments on these compounds by using IMR portable high magnetic field system.

We have also discussed about the upgrade of NMR system. In particular, the automation of scanning is crucial for the effectiveness of the user experiments. The consulting will continue to help the improvement of the IMR facility.

References

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