XMCD study on Prussian blue analogues

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Introduction

Recently, Prussian blue analogues have been studied as attractive molecule-based magnets because of their unique properties such as photo-induced magnetic switching and tunable and high Curie temperature. In this work, we have measured and analyzed the Mn and Cr *L*-edge X-ray Magnetic Circular Dichroism (XMCD) spectra of $Mn_{1.5}[Cr(CN)_6]\cdot 7.5H_2O$($T_C$ ~70 K[1]) to obtain the element specific orbital magnetic moments (M_l) and spin magnetic moments (M_s), and investigated the origin of magnetism of Prussian blue analogues.

Experimental

Helicity switching of the circularly polarized x-rays

Since it was difficult to change the polarity of sample magnetization, helicity switching of the incident x-rays, which was necessary for the XMCD experiment, was obtained by moving S0 slit up and down by 0.40 mrad from the orbit plane.

Since upward and downward x-rays take different courses, they are likely to irradiate different spots of the sample. So we adjusted the beam position with a wire monitor within 20 μm.

XMCD experiments

The Prussian blue analogues could be obtained only as insulating fine powders. To enhance their heat and electric conductivities, we scrubbed them into scratched copper plate.

Mn and Cr *L*-edges XMCD spectra were obtained at room temperature (RT) and at 25 K (below T_C) with the sample current mode at the soft x-ray beamlines, BL 7A and 11A, using the VLSG monochromator. Each sample was cooled by a He cryostat, and magnetized parallel to the x-ray beam by a Nd-Fe magnet.

Results and discussion

Mn *L*-edge XMCD spectra are shown in Fig. 1. Comparison of the XMCD spectra at 300 K and at 25 K, clearly shows that the ferrimagnetic transition occurs below T_C.

First we analyzed Mn *L*-edge XMCD spectrum below T_C with well-established sum rules and obtained the ratio of orbital moments to spin moments (M_l/M_s)=0.13. This small value means that Mn is in high spin state and the orbital moments are canceled out.

Secondly, we tried to analyze Cr-*L* edge XMCD spectra, but L_3 and L_2 peaks are heavily mixed up and we gave up the analysis with the sum rules. But it was qualitatively found that the direction of Cr magnetic moments is opposite to that of Mn magnetic moments. This proves the existence of the antiferromagnetic coupling between Mn and Cr, then ferrimagnetism of $Mn_{1.5}[Cr(CN)_6]\cdot 7.5H_2O$.

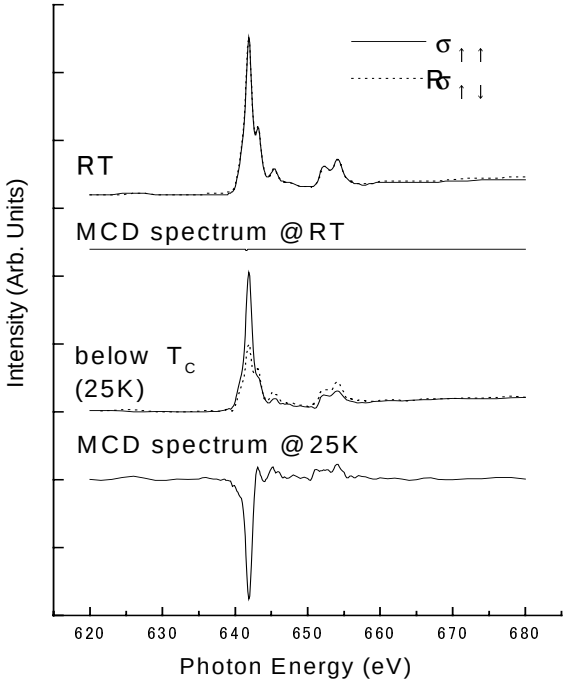

Fig. 1 Mn L-edge XMCD spectra of $Mn_{1.5}[Cr(CN)_6]\cdot 7.5H_2O$.

References

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