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Measurement of spin and orbital magnetic form factor of Fe_3Pt by X-ray magnetic diffraction

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Introduction

An invar alloy Fe_3Pt has been studied in relation with its magnetic property. Crystalline Fe_3Pt has Cu_3Au-type structure that exhibits order-disorder phase transition and is ferromagnetic in both phases at room temperature. In this research we have performed X-ray magnetic diffraction (XMD) experiment of this alloy and measure spin and orbital magnetic form factor separately which are expected to reveal the magnetic property of this alloy.

Experiments

The present sample is a sphere of single crystal Fe_3Pt the diameter of which is 5mm. Preliminary X-ray diffraction experiment of this alloy showed that the sample crystal is in the order phase.

The XMD experiment has been performed on the white X-ray beamline 3C where the XMD experimental system is equipped. We have measured the spin and orbital magnetic form factor, $\mu_S(K)$ and $\mu_L(K)$, independently by utilizing the LS separation ability of the XMD method. Here $K=\sin\theta/\lambda$, θ is Bragg angle and λ is X-ray wavelength.

Results and Discussion

We have observed $\mu_S(K)$ and $\mu_L(K)$ for eighteen reciprocal lattice points of *hk*0 series. The obtained $\mu_S(K)$ and $\mu_L(K)$ are shown in Fig. 1 and Fig. 2, respectively. In these figures *even series* means *hk*0 indices where *h* and *k* are even, and *odd series* means *hk*0 indices where *h* or *k* is odd.

In Figs. 1 and 2 it is noted that finite values are observed for $\mu_S(K)$ but most values are vanished for $\mu_L(K)$. These facts suggest that the orbital moment of this alloy is almost quenched and the magnetic moment is attributed to its spin moment.

Moreover, the spin magnetic form factor $\mu_S(K)$ for *even series* behaves quite differently from those for *odd series*; most $\mu_S(K)$ values are positive for *even series*, but most $\mu_S(K)$ values are negative for *odd series*.

In the order phase of Fe_3Pt the crystal structure factor is represented as, $F(hkl)= f_{Pt}(hkl)+3f_{Fe}(hkl)$ where all of *h*, *k*, *l* are even or odd, and $F(hkl)=f_{Pt}(hkl)-f_{Fe}(hkl)$ where only one of *h*, *k*, *l* is even or odd. Here $f_{Pt}(hkl)$ and $f_{Fe}(hkl)$ are the atomic form factor of Pt and Fe, respectively. These structure factors are in contrast to those in the disorder phase that are represented as, $F(hkl)=f_{Pt}(hkl)+3f_{Fe}(hkl)$ where all of *h*, *k*, *l* are even or odd, and, $F(hkl)=0$ where only one of *h*, *k*, *l* is even or odd.

The above formula of the structure factor may be applied to the observed spin magnetic form factor. That is, $\mu_S(K)=\mu_{S,Pt}(K)+3\mu_{S,Fe}(K)$ for *even series*, and $\mu_S(K)=\mu_{S,Pt}(K)-\mu_{S,Fe}(K)$ for *odd series*. Here, $\mu_{S,Pt}(K)$ and $\mu_{S,Fe}(K)$ are the spin magnetic form factor of Pt and Fe, respectively.

In Fig. 2, it is noted that finite values of $\mu_S(K)$ are observed for *odd series* which verifies that the present sample is in the order phase. The observed $\mu_S(K)$ in Fig. 2 will be used not only to estimate spin moment of Fe and Pt but also to elucidate distribution of the spin moment of Fe and Pt in real space by utilizing Fourier transformation or the Maximum Entropy Method.

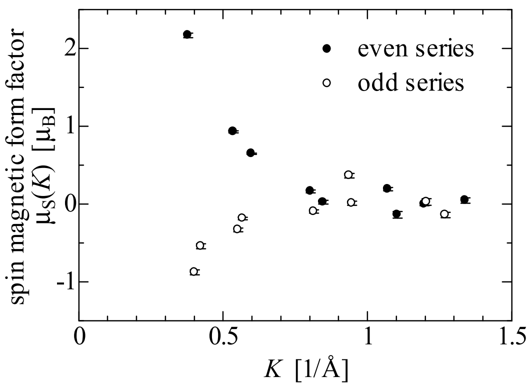

Fig. 1 Spin magnetic form factor.

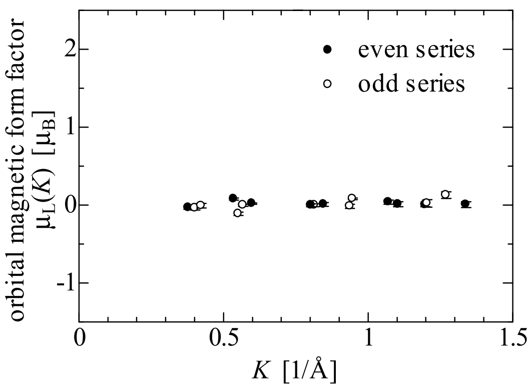

Fig. 2 Orbital magnetic form factor.