Evaluation of spin, orbital and total magnetic moments of Pd$_3$Co by X-ray magnetic diffraction

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Introduction

It is known that artificial-lattice multilayer Pd/Co shows perpendicular magnetic anisotropy. Wavefunctions of Pd-4d and Co-3d electrons may play a key role for the magnetic property. The aim of the present study is to examine magnetic properties of Pd-Co alloy system. We measure the spin and orbital magnetic form factor of Pd$_3$Co single crystal by the X-ray magnetic diffraction (XMD) experimental technique.

Pd$_3$Co belongs to the alloy group of Cu$_3$Au type crystal structure that exhibits order-disorder phase transition. The sample crystal in the present study is revealed to be in the disorder state by the preliminary X-ray diffraction experiment.

Experiments

The XMD experiment was made on the beamline 3C. Elliptically polarized white X-rays were irradiated on the crystal and the X-ray intensities diffracted with 90º scattering angle were measured with a pure-Ge SSD. Magnetic field was applied to the sample crystal with an electromagnet that produced 2.15T.

By setting the angle $\alpha$ between the incident X-ray direction and the sample magnetization to 0º and 135º we measured the spin and orbital magnetic form factor ($\mu_S(k)$ and $\mu_L(k)$), respectively.

Results and Discussion

Observed spin and orbital magnetic form factors for 22 reciprocal lattice points are shown in Fig. 1 and Fig. 2, respectively. Those form factors were fitted with theoretical values of $<j_0>$ and $<j_2>$ for Co-3d orbital and Pd-4d orbital under the dipole approximation tabulated in the literature.$^{11}$ Here, $<j_n>$ is the radial integral of the wavefunction of 3d or 4d orbital multiplied with the n-th spherical Bessel function. We used those values for Co$^+$ and Pd$^{4+}$ ions on trial.

The fitting procedure has resulted in the following values. As shown in Fig. 1, the spin moments of Co and Pd per formula unit (Pd$_3$Co) are 1.57$\mu_B$ and 0.62$\mu_B$, respectively. As shown in Fig. 2, the orbital moments of Co and Pd per formula unit are 0.71$\mu_B$ and 0.12$\mu_B$, respectively. Total spin moment is 2.19$\mu_B$/f.u. and the total orbital moment is 0.83$\mu_B$/f.u. Then the total magnetic moment is obtained as 3.02$\mu_B$/f.u.

As a result, we have succeeded in obtaining the values of spin, orbital and the total magnetic moments of Pd$_3$Co by the X-ray magnetic diffraction experiment. In the near future we have a plan to study distribution of the spin, orbital and the total magnetic moments in real space by using Fourier transform of these form factors.

![Fig. 1 Spin magnetic factor](image1)

![Fig. 2 Orbital magnetic factor](image2)

Reference


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