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Spin form factors of Sm in $SmAl_2$

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We have tried spin-form-factor measurements on Sm in the ferromagnetic cubic Laves-phase compound $SmAl_2$ and established the method of analyzing the data using the operator-equivalent technique before [1, 2]. It was, however, difficult to interpret the experimental results and we have subsequently improved the experimental procedure and instrumentation. After that, the experiment and the theory has come to meet with quantitative success for some other rare-earth-dialuminide systems [3]. Here we report the newly measured results on $SmAl_2$.

The sample crystal is the one prepared by the Bridgeman method at the Institute for Solid State Physics, the University of Tokyo. After checking the magnetic properties with a SQUID magnetometer at the Cryogenic Center, the University of Tokyo, the experiment was done at the beamline 3C of the Photon Factory with a bending-magnet light source.

The incident x rays are off-plane white ones having an elliptical polarization. The sample crystal is mounted such that the easy direction of magnetization, <111>, should be parallel to the scattering vector and that the *hhh* reflection should be observed in the 90-degree-scattering direction within a horizontal plane. The energy spectrum of the scattered x rays is analyzed with a Ge SSD and the diffraction intensity of each of *hhh* reflections is measured.

The spin form factors of the Sm ion are obtained from a change in diffraction intensity concomitant with a reversal of the sample magnetization which is parallel to the scattering vector. The polarity of the magnetization is switched every ten seconds by an external magnetic field of ± 8.4 kOe generated by an electromagnet. The measurement temperatures are 13, 60, 100, and 125 K, which is the Curie point of the sample. Data accumulation time is a few days per measurement at a temperature.

Figure 1 shows the preliminary results of the present experiment and analysis. The ordinate is the spin scattering amplitude of Sm and the abscissa is $\sin\theta/\lambda$. The spin scattering amplitude is the product of the spin form factor f_S and the spin magnetic moment μ_S, θ is the Bragg angle, and λ is the x-ray wave length. The negative value on the low $\sin\theta/\lambda$ side indicates that the spin moment of Sm couples antiferromagnetically with the orbital one and contributes negatively to the total magnetization. This agrees with the previous reports on this compound.

Red solid curves are the numerical results for the contribution of the *4f* electrons. The form factor f_S is calculated as $\langle j_0\rangle + c_2\langle j_2\rangle + c_4\langle j_4\rangle + c_6\langle j_6\rangle$, where $\langle j_n\rangle$ are the expectation values of the spherical Bessel functions of the *n*th order with respect to the *4f* radial wave function. The values of $\langle j_n\rangle$ are cited from the International Tables. The thermal averages of the spin moment μ_S and of the coefficients c_n, which reflect the angular distribution of the spin density, are calculated in the *LS*-coupling scheme characterized by the quantum numbers *SLJM* [1, 2]. Broken lines in the figure show the spherical average, namely, $\mu_S\langle j_0\rangle$.

Deviation from the spherical symmetry is observed in both experiment and theory. The zero-crossing position of the form factor is in good agreement between the two. On the other hand, the value of the spin-scattering amplitude for the 555 reflection at $\sin\theta/\lambda \sim 0.55$ Å^{-1} seems substantially smaller than the theory except for 125 K. Note that the red lines are not fitting results but calculated with the parameters which reproduce the thermal variation of the macroscopic magnetization and the susceptibility. Further analysis is now in progress.

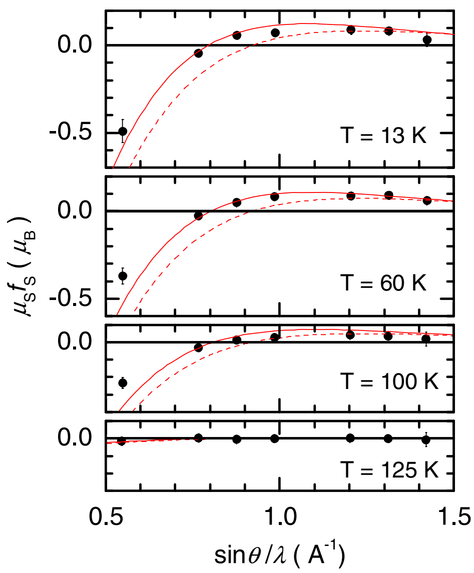

Fig. 1 The spin scattering amplitudes of Sm in $SmAl_2$.

[1] H. Adachi, H. Kawata, and M. Ito, Phys. Rev. B **63** (2001) 054406.
[2] H. Adachi and H. Miwa, Phys. Rev. B **66**, (2002) 224428.
[3] H. Adachi, H. Kawata, and M. Ito, Phys. Rev. B **69** (2004) 212409.

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