Magnetic Structure of $Pr_xY_{1-x}Mn_6Sn_6$ Alloys

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Ternary YMn_6Sn_6 alloys have the hp13 type ($MgFe_6Ge_6$ type) layer structure. It should be noticed that Mn atom layers on 6i $(1/2, 0, z_2)$ and $(1/2, 0, -z_2)$ sites are well separated by Sn atom layers on 2c $(1/3, 2/3, 0)$, 2d $(1/3, 2/3, 1/2)$ and 2e $(0, 0, z_1)$ sites and Y atom layer on 1a $(0, 0, 1/2)$ site. This alloy shows an inhomogeneous helical antiferromagnetism with the Néel temperature $T_N = 333$ K and the paramagnetic Curie temperature $\theta_P = 394$ K.

Recently, we have made magnetization measurements on YMn_6Sn_6 alloy, and obtained interesting results; the magnetization approaches saturation around 11 T at 77 K; the saturated magnetization corresponds to the magnetic moment of $2.0\mu_B$/Mn atom.[1]

We have found that $Pr_xY_{1-x}Mn_6Sn_6$ $(0 \leq x \leq 0.4)$ alloys have the hp13 type structure, and carried out neutron diffraction experiments using HERMES.

Figure 1 shows neutron diffraction pattern for $Pr_{0.1}Y_{0.9}Mn_6Sn_6$ alloy at 10 K. There are several magnetic reflections in addition to the nuclear Bragg reflections. These magnetic reflections are the satellite reflections of the nuclear ones with propagation vector $\boldsymbol{q} = (0,\ 0,\ \frac{1}{9})$ as indexed in Fig. 1. It is remarkable that there are only first order satellite reflections and there is no higher order satellite reflection.

We supposed the helical structure propagating along c-axis. The magnetic moments on Mn atom layers in c-planes at $z = z_2$ and $z = 1 - z_2$, $\mu_{\mathrm{Mn}}(= 2.3\ \mu_B)$, and on Nd atom layer in a c-plane at $z = 1/2$, $\mu_{\mathrm{Pr}}(= 3.2\ \mu_B)$, are ferromagnetic arrangement each other, where z is parallel to the c-axis in unit of the lattice constant c. In other words, a ferromagnetic slab is composed by in a set of these three magnetic layers, and lay in the c-plane. The direction of the magnetic moments change their orientation by an angle, θ, of 80° between the adjacent ferromagnetic slabs along the c-axis.

The $Pr_{0.2}Y_{0.8}Mn_6Sn_6$ alloy also show the helical structure with propagation vector $\boldsymbol{q} = (0,\ 0,\ \frac{1}{6})$ and the angle $\theta = 60°$.

The $Pr_{0.4}Y_{0.6}Mn_6Sn_6$ alloy shows a simple ferromagnetic arrangement. The direction of magnetic moment is perpendicular to c-axis.

It is likely that the magnetic moments μ_{Mn} and μ_{Pr} keep constant values of 2.3 μ_B / Mn atom and 3.2 μ_B / Pr atom respectvely, and lay in the c-plane in whole composition $(0 < x \leq 0.4)$.

We have also carried out the magnetization measurements with an extraction method using a 18T-SM super conducting magnet up to 18 T at the High Field Laboratory of Tohoku University. The magnetic moments obtained from the saturated magnetizations, μ_S, linearly increase with increasing x in the whole composition $(0 < x \leq 0.4)$ as expressed by a formula $\mu_S = 12.82 + 2.91\,x$ $(\mu_B/\mathrm{f.u.})$; suggesting the magnetic moments of Mn and Pr atoms, μ_{Mn} and μ_{Pr}, are $\mu_{\mathrm{Mn}} = 2.14\ \mu_B$/Mn atom and $\mu_{\mathrm{Pr}} = 2.91\ \mu_B$/Pr atom. This result is consistent with the neutron data.

References

[1] Y. Shigeno *et al*, *J. Magn. Magn. Mater.* **26-230** (2001) 1153.

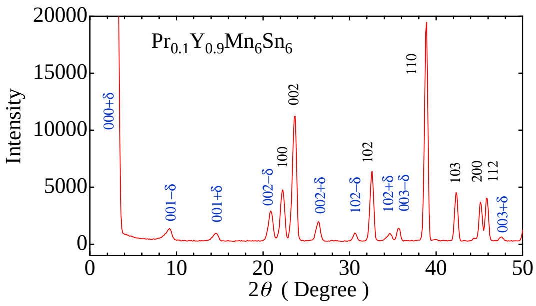

Fig. 1. Neutron diffraction pattern for $Pr_{0.1}Y_{0.9}Mn_6Sn_6$ alloy obtained by using HERMES at 10 K.