Magnetic State in the Tm-based Reentrant Superconductor Investigated by the Powder Neutron Scattering

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The Tm-based reentrant superconductor $Tm_5Rh_6Sn_{18}$ exhibits superconductivity at T_c = 2.2 K[1] and reentrant behavior between 1.0 and 1.45 kOe[2]. From the muon-spin rotation/relaxation (μSR) measurements, we reveal the coexistence between magnetism and superconductivity under a zero magnetic field, and a development of magnetic ordering is observed below around 10 K[3]. However, the magnetic ordering cannot be described as a simple long-range magnetic ordering.

To understand magnetic state more precisely, magnetic structure of $Tm_5Rh_6Sn_{18}$ has been investigated by a powder neutron scattering as shown in Figure 1, which represents the neutron powder diffraction pattern at 0.75 K and 10 K. We could not observe any Bragg peak due to a long-range magnetic order in any temperature region and also observe a magnetic diffuse scattering attributed to a short-range order in the low-angle region below 10 K. The diffuse scattering intensity can be described as a conventional Gaussian function. Furthermore, the temperature dependence of the integrated intensity is almost consistent with the results of muon precession frequency obtained from the ZF-μSR measurement.

Therefore, we conclude that the magnetic order can be considered not to be long range ordered but superparamagnetic; ferromagnetically ordered within a certain cluster, but, paramagnetically fluctuating between the cluster, and the superparamagnetic cluster gradually develops below around 8 K. The size of the magnetic cluster is so large that a spontaneous oscillation signal is clearly observed from ZF-μSR measurement. This scenario makes it possible to explain the occurrence of the reentrant superconductivity; the field-induced magnetic order obtained from the electrical resistivity measurements under magnetic fields is originated from an alignment of each spin of magnetic clusters to the same direction. Thus, superconductivity is not destroyed under zero magnetic filed below T_c.

References

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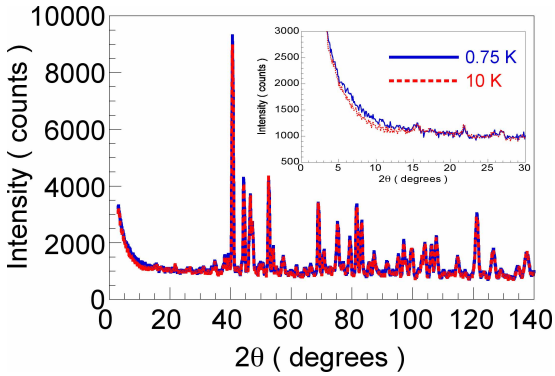

Fig. 1. The neutron powder diffraction pattern at 0.75 K and 10 K of $Tm_5Rh_6Sn_{18}$. The inset shows the expansion of the low-angle region.