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Frustrated magnetic systems are one of the research topics that have gained popularity in recent decades. Frustrated is described as a state in which a system is unable to minimize total energy.¹⁾ Geometrical frustration refers to frustration generated by the crystal structure's lattice geometry. Trigonal and tetragonal lattices are two forms of geometric configurations that produce a frustrated magnet. Pyrochlore oxide is a system with a tetrahedral sublattice, which causes geometrical frustration. Pyrochlore's general formula is $A_2B_2O_7$, where A is the trivalent rare earth ion and B is a tetravalent transition metal ion. $^{1-4)}$

Pyrochlore ruthenates, $A_2 Ru_2 O_7$ (A = rare-earthions), are an example of a Mott system.²⁾ Ru 4d electrons are expected to have the on-site Coulomb repulsion interaction, U, as well as the spin-orbit coupling (SOC) effect.²⁾ Magnetic transition temperatures rise from around 80 K to 160 K when A is changed from Yb to Pr, indicating that the magnetic transition temperature rises as the ionic radius of A grows.¹⁾ In particular, Mauws *et al.*⁵⁾ have reported $Sm_2Ti_2O_7$ as a potential candidate for magnetic fragmentation in Smbased systems. Furthermore, Sm₂Ru₂O₇ is regarded a good option due to its non-Kramer A-site behavior and the existence of 4d electrons in Ru, as highlighted in the study by Taira $et al.^{2}$ Although this system was synthesized a long time ago,¹⁾ a full knowledge of its electrical and magnetic properties has not yet been achieved. We studied the magnetic characteristics of $Sm_2Ru_2O_7$ using muon spin relaxation (μ SR) measurements to determine the possibility of magnetic fragmentation in the magnetically ordered states of Sm₂Ru₂O₇.

Solid-state reaction was used to prepare polycrystalline $Sm_2Ru_2O_7$ samples. Sm_2O_3 (99.99%) and RuO_2 (99.9%), which compose the raw materials, were weighed according to stoichiometric ratios. After being mixed for 12 h in a ball mill, they were sintered for 12 h in an air at 1100°C. The X-ray diffraction (XRD) measurement was used to determine the crystal structure. Zero-field (ZF) μ SR measurements were conducted out from 5 K to 250 K.

Figure 1(a) displays X-ray diffraction patterns of $Sm_2Ru_2O_7$ measured at room temperature. The facecentered cubic with the space group $Fd\overline{3}m$ has been confirmed. The lattice parameter was found to be 10.28 Å. All of the detected peaks were indexed, as shown in Fig. 1(a). A minor peak corresponding to Sm_3RuO_7 was identified as a typical impurity, as indicated by a red-star mark in Fig. 1(a), with a percentage of around 1%.

Figure 1(b) represents the temperature dependency

Intensity (a.u.) (111) (444) 331) 551) 20 $\frac{40}{2\theta}$ (degree) 10 0.6 **(b)** Sm₂Ru₂O₇ 0.5 ZF-µSR 0.4 (I-STI) 7 0.2 0.1 0.0 10 100 *T* (K)

Fig. 1. (a) X-ray diffraction patterns of $Sm_2Ru_2O_7$. (b) Temperature dependence of muon spin relaxation rate, λ , of Sm₂Ru₂O₇.

of λ . A significant increase in λ was observed at about 127 K, as indicated by the red arrows. This is due to the occurrence of critical slowing of Ru spins,²⁾ which is accompanied by magnetic ordering. λ is constant below 90 K and gradually increases below 30 K. A broad and small peak with a lower absolute value than the peak at 127 K was confirmed about 10 K, as indicated by the blue arrow. One possible scenario is that additional magnetic instabilities of Sm spins appear around 10 K, leading to changes in the static and dynamic properties of Ru and/or Sm spins, since the dynamic and static properties of Ru spins seem not to be changing below about 90 K as shown in Fig. 1(b) as a flat property of λ , as previously suggested from other studies.^{2,6)} Our current investigation used a pulsed muon, which has a time resolution limit versus bigger internal forces, greater than roughly 500 G, so the next step is to examine using continuous muon sources, which are available at TRIUMF in Canada and PSI in Switzerland.

References

- 1) J. S. Gardner et al., Rev. Mod. Phys. 82, 53 (2010).
- 2) N. Taira et al., J. Phys. Condens. Matt. 11, 6983 (1999).
- 3) J. E. Greedan et al., Solid State Commun. 59, 895 (1986).
- 4) D. Harada et al., J. Solid State Chem. 158, 245 (2001).
- 5) C. Wauws et al., Phys. Rev. B 98, 100401(R) (2018).
- 6) R. Asih et al., J. Phys. Soc. Jpn. 86, 174441 (2017).



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