ZF-μSR measurement to investigate thermal hysteresis of $MgTi_2O_4$ at low temperature

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We investigated spinel titanate ($MgTi_2O_4$) which has a $3d^1$ electron ($S = 1/2$) within the Ti^{3+} ion and forms a pyrochlore lattice,[1] to explore the magnetic ground state of this strongly correlated system. The lattice of $MgTi_2O_4$ has a cubic structure at room temperature and shows a transition to a tetragonal structure at $T_{st} \simeq 260$ K.[2] This structural phase transition is accompanied by a metal-insulator transition and changes in magnetic properties.[2] Isobe *et al.* proposed a spin-singlet insulator as the ground state, which did not form any magnetic ordering.[2]

Previously, we found that there was no long-range ordered state in $MgTi_2O_4$ down to 6 K through zero-field muon spin resonance (ZF-μSR) measurements. Our preliminary study on $MgTi_2O_4$ showed that thermal hysteresis occurs in the temperature dependence of heat capacity below 3.5 K down to 2.5 K. To investigate the origin of the thermal hysteresis and magnetic properties at a much lower temperature, we extend the ZF-μSR measurement down to 2 K using VARIOX at the RIKEN-RAL Muon Facility in the United Kingdom. ZF-μSR measurements were performed below 30 K with descending temperature (cooling procedure) and ascending temperature (warming procedure) to observe the thermal hysteresis. The time spectra, shown in Fig. 1(a), can be fitted using Eq. (1).

$$A(t) = A_{GKT}(1/3+2/3(1-\Delta^2t^2)\exp(-\Delta^2t^2/2)) + A_L\exp(-\lambda t), \quad (1)$$

where A_{GKT} and A_L are the initial asymmetry from Gaussian and Lorentzian components at $t = 0$, respectively.

The absolute value of the temperature dependence of muon spin relaxation, λ(T), was in good agreement with the previous result[3] and is shown in Fig. 1(b). This result demonstrated that the muon spin relaxation rate does not change significantly indicating the absence of the ordered state down to 2 K. Furthermore, there is no difference in the muon spin relaxation rate measured in the cooling and warming procedures. This indicates that the thermal hysteresis observed in the heat-capacity measurement is beyond the muon-spin time window; therefore, we could not detect such behavior down to 2 K.

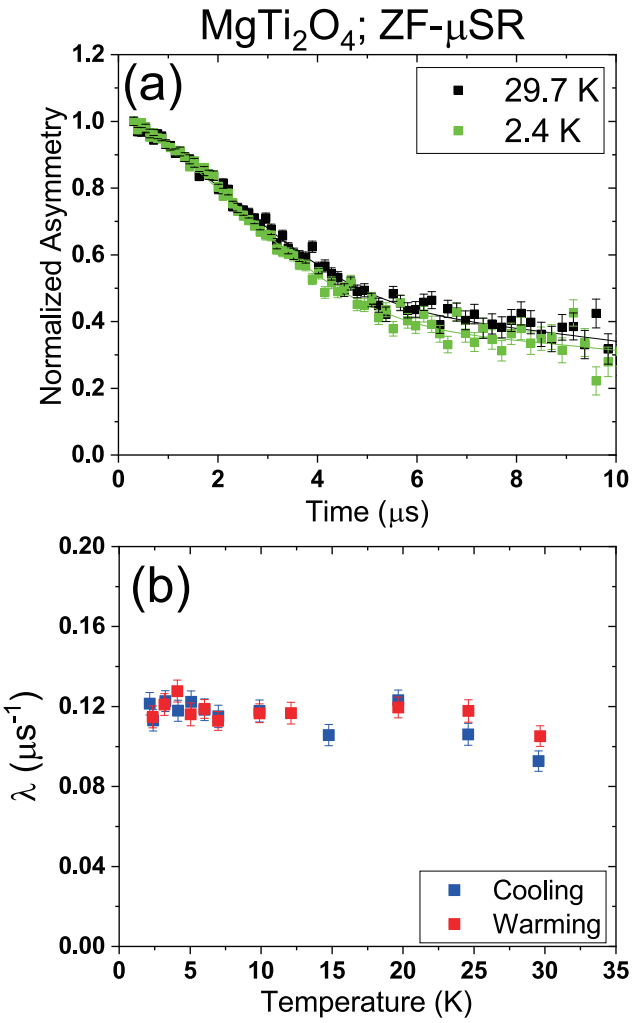

Fig. 1. (a) ZF-μSR time spectra of $MgTi_2O_4$; the solid line is the fitting resulted obtained using Eq. (1). (b) Temperature dependence of the muon spin relaxation rate.

References

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