μSR investigation of spin liquid states in magnetic properties of $MgTi_2O_4$ sample

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The investigation of the geometrical frustration of strongly correlated systems is an interesting research field. These systems show various exotic physical properties such as spin ice,[1] and spin liquid states.[2] In the spin liquid state, spins do not show magnetic ordering even at the ground state. The spin liquid state generally appears in triangular lattices and Kagome lattice systems, which show geometrical frustration of spin systems.[2] Materials with pyrochlore structures, such as pyrochlore oxides and spinel compounds, that have corner-sharing tetrahedral lattices are strong candidates to exhibit such exotic physical properties.

The spinel titanate, $MgTi_2O_4$, has $3d^1$ electron ($S = 1/2$) within the Ti^{3+} ion and forms a pyrochlore lattice.[3] At room temperature, the lattice structure of $MgTi_2O_4$ is cubic, and it shows a structural transition to a tetragonal lattice at $T_{st} = 260$ K.[4] This structural phase transition is accompanied by a metal-insulator transition and changes in magnetic properties.[4] Isobe *et al.* proposed a spin-singlet insulator as the ground state, which did not form any magnetic ordering, suggesting the appearance of a spin liquid state.[4] At this moment, the spin state of $MgTi_2O_4$ in the ground state is still unclear and open for discussion. To explore the magnetic properties of $MgTi_2O_4$, we performed microscopic measurements using muon-spin relaxation (μSR) spectroscopy.

We measured the time evolution of the muon-spin polarization in the zero-field (ZF) condition at the RIKEN-RAL Muon Facility in the United Kingdom. Time spectra measured at several temperatures are shown in Fig. 1(a). No muon-spin precession was observed in the time spectrum, indicating that there was no long-range ordered state down to 6 K. We fitted the time spectra using Eq. (1).

$$A(t) = A_0 \exp(-\lambda t), \quad (1)$$

where A_0 is the initial asymmetry of the muon spin at $t = 0$ and λ is the muon-spin relaxation rate. The temperature dependence of λ is shown in Fig. 1(b). λ gradually increases with decreasing temperature below 250 K. The increase of λ indicates the appearance of a slowing down behavior of Ti^{3+} spin fluctuations. However, there is no critical slowing down behavior indicating the absence of a magnetic ordered state in the current ZF-μSR study, as suggested in a previous study.[4] Accordingly, we plan to gather more detailed information on the spin dynamics by performing μSR measurements in the longitudinal field (LF) condition.

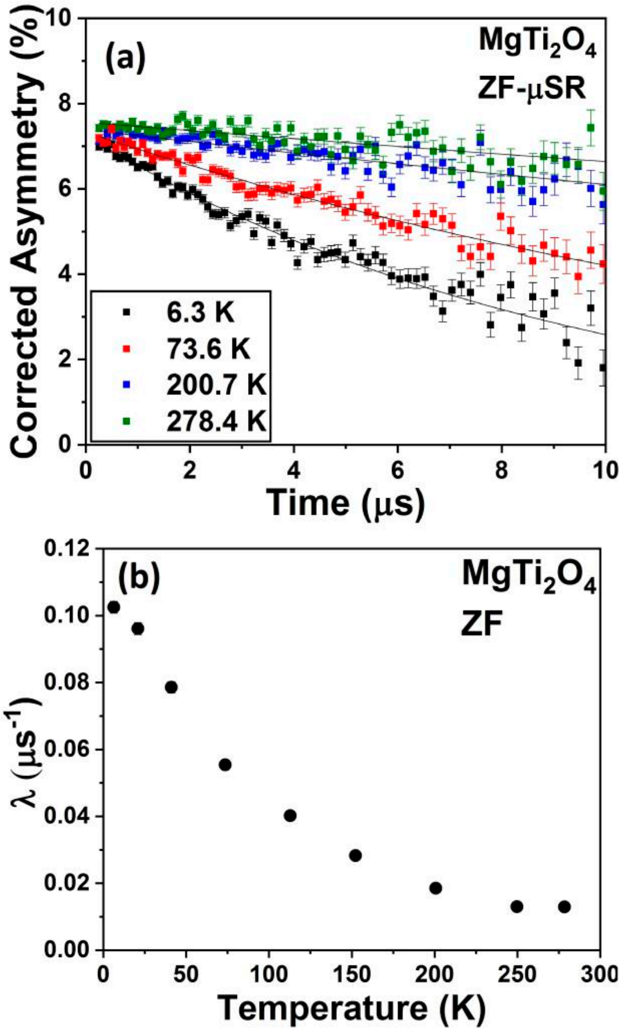

Fig. 1. (a) ZF-μSR time spectra of $MgTi_2O_4$ and (b) temperature dependence of muon spin relaxation rate.

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