Investigation of the magnetic ground state of frustrated spin system $Rb_2Cu_2Mo_3O_{12}$

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$Rb_2Cu_2Mo_3O_{12}$ is a quantum spin system having a spin-1/2 one-dimensional (1D) zig-zag chain, where spin frustration is expected to result from competition between the first and second neighbor exchange interactions, J_1 and J_2.[1)] Based on the ratio J_1/J_2, it has been suggested that the magnetic ground state of this system is novel incommensurate spin-singlet.[2)] However, evidence for the spin-singlet ground state has not been bared experimentally. Magnetic susceptibility drops at low temperature but exhibits a nonzero value,[1)] and a powder inelastic neutron scattering measurement did not reveal an energy gap, whereas dispersive spin excitations arising from an incommensurate propagation vector were observed.[3)] In order to clarify the magnetic ground state of $Rb_2Cu_2Mo_3O_{12}$, we performed a muon spin relaxation (μSR) experiment on this material at the RIKEN-RAL Muon Facility.

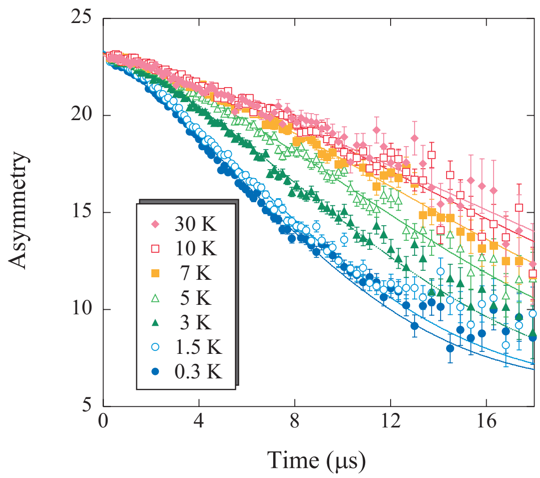

Fig. 1. ZF-μSR time spectra observed at various temperatures.

Figure 1 shows the time spectra observed at various temperatures under zero-field (ZF). The relaxation is gradually enhanced below 10 K, while it shows little change below ~1.5 K. The enhancement of the relaxation is moderate, and a Gaussian-like relaxation is sustained even at the lowest temperature. This behavior indicates the existence of a nonmangetic ground state without any magnetic order.

The ZF-μSR time spectra are fitted with a relaxation function $A(t) = AG_{\rm KT}(\Delta, t)e^{-\lambda t}$, where $G_{\rm KT}(\Delta, t)$ is a Gaussian Kubo-Toyabe function that describes a random and static field, Δ the distribution width of the random field, and λ the relaxation rate of the muon spin. The temperature dependences of Δ and λ are shown in Figs. 2(a) and 2(b), respectively. They show similar trends. They are almost independent of temperature above ~10 K, where the system is paramagnetic. As temperature decreases, both parameters increase simultaneously and saturate at ~1 K. We note that the spectra cannot be fitted with a constant Δ value in the whole measured temperature range. Such a temperature dependence of the relaxation rate has been reported in a several spin-singlet systems,[4)] and in most cases, the relaxation rate starts to increase concomitantly with the formation of spin-singlet pairs. In the present system, the magnetic susceptibility shows a broad maximum at ~14 K, and then decreases with decreasing temperature.[1)] Therefore, the ZF-μSR result indicates the appearance of the spin-singlet state in $Rb_2Cu_2Mo_3O_{12}$.

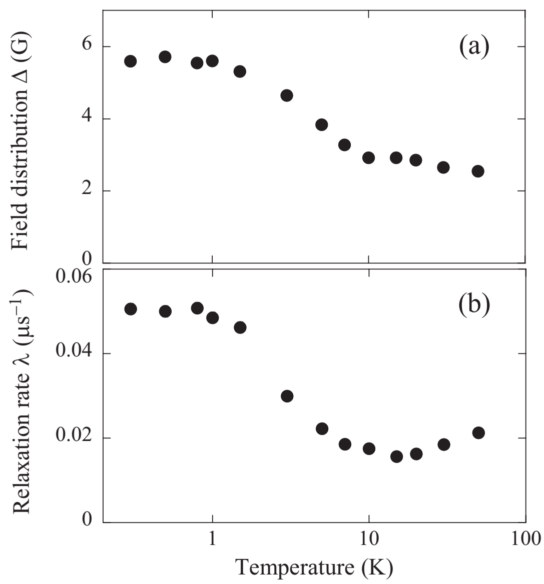

Fig. 2. Temperature dependence of (a) the field distribution width Δ and (b) the relaxation rate λ.

References
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