Investigation on spin dynamics of a staircase kagome material by using spin polarized muons

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$PbCu_3TeO_7$ was suggested as a Cu-based anisotropic kagome material with the staircase kagome lattice.[1] The crystal structure of $PbCu_3TeO_7$ is an orthorhombic lattice with the space group, *Pnma*, No. 62.[2] $PbCu_3TeO_7$ is formed by a buckled kagome layer, and each layer is alternatively arranged Cu^{2+} ions in the different environments of surrounding O^{2-} ions, the octahedral, and the tetrahedral crystal environments, respectively.[1), 2)] Since all buckled kagome layers are not only stacked along the *a* axis, but also separated by Pb, and Te atoms, they can be in a two dimensional network of Cu^{2+} ions. Therefore, it is expected that several magnetic anomalies emerge for different crystal environments.[1]

We synthesized a $PbCu_3TeO_7$ polycrystalline sample, and we found several magnetic anomalies from the DC magnetic susceptibility and the specific heat results. The DC susceptibility exhibits three distinct anomalies at 17 K, 25 K, and 36 K, and the Weiss temperature is extracted approximately 180 K by the Curie Weiss law, indicating a highly frustrated spin state. The specific heat result also indicates that the magnetic entropy over 36 K remains around 50 %. The experimental results of the nuclear magnetic resonance also support a frustrated spin state.[3] With the consideration of previous experimental results, it can be suggested that $PbCu_3TeO_7$ is in the frustrated spin state with several magnetic anomalies, as revealed in anisotropic kagome materials. [1] However, it is unrevealed the nature of magnetic anomalies in the Cu-based staircase kagome material.

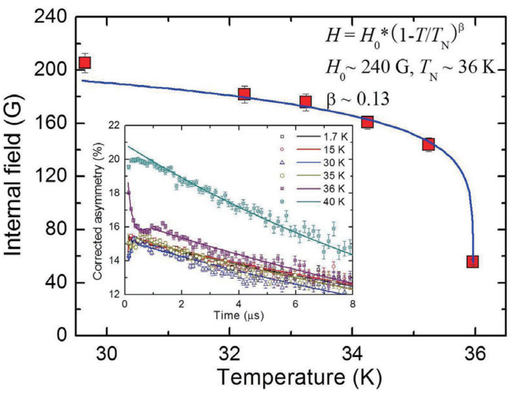

Fig. 1. Temperature dependence of the internal field obtained by the muon polarization at zero field with a fit obtained using the phenomenological equation of the magnetic ordered state, and the inset of exhibiting several time differential spectra of the muon polarization at zero field.

In order to understand the nature of the magnetic anomalies, we conduct a microscopic investigation using spin-polarized muons at the RIKEN-RAL Muon Facility. Because the muon is highly sensitive of the small magnetic field, the muon is expected to provide a clue for the characteristics of magnetic anomalies.

In Fig. 1, it shows the temperature dependence of the internal field around 36 K obtained from the muon polarization at zero field by fitting with the oscillation function to represent the magnetic ordered state. This anomaly can be described by the two-dimensional Ising spin state with a phenomenological function to express the magnetic ordered state in the range from 32 K to 36 K. It is suggested that the anomaly at 36 K is induced by the two dimensional network including Cu^{2+} ions in the tetrahedral environment.

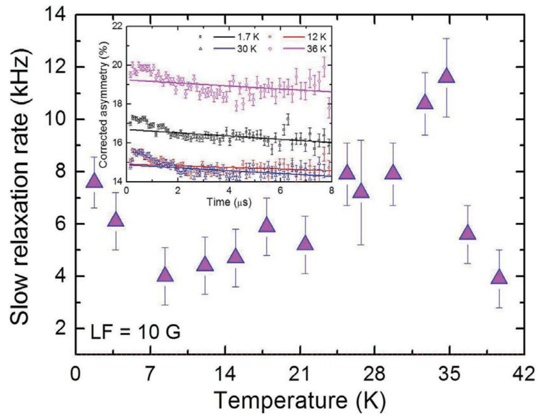

Fig. 2. Temperature dependence of the slow relaxing component obtained by the muon polarization at a longitudinal field (LF) of 10 G, and the inset of revealing several spectra of the muon polarization at LF = 10 G.

Exhibited in Fig. 2, it was extracted the temperature dependence of the relaxation rate from the relaxation component on a latter time region of the muon polarization at a weak longitudinal field for the exclusion of the contribution of the nuclear dipole moment. It supports that the behavior of the ordered state at 36 K is close to the second-order phase transition. Furthermore, a slight increase of the relaxation rate below 5 K was found, suggesting a frustrated spin state.

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