Crystalline electric field level scheme of the $CeTe_3$

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What is the ground state of this system when rare-earth atoms, the $4f$-electrons which capture partly itinerant characteristics, occupy a geometrically frustrated site? This fundamental question in condensed matter physics has attracted considerable attention from scientists. However, the experimental elucidation of this question is difficult because there are no samples that satisfy such a situation. In general, the $4f$-electron has large and anisotropic angular momentum and inhibits the realization of an Ising-like structure, which is required for a spin-frustrated system.

RTe_3 (R: rare-earth elements) is composed of a square net Te layer with high mobility and a blocking layer with R-originated $4f$-electrons. A particularly interesting case is R = Ce, since the f-electron exists closer to Fermi energy E_F. According to previous research, the electronic specific coefficient of $CeTe_3$ is larger than that of the La system, suggesting that f-electrons are itinerant. On the other hand, in the isostructural $CeTe_2Se$ in which the doped Se atoms enter the blocking layer selectively, there are no dramatic changes in the magnetic transition temperature towards the QCP. However, from the magnetization measurements of the previous study, in the magnetic ordered state the magnetic moment of the Ce atom lies in the ac-plane (in-plane) on $CeTe_3$ but along the b-axis (out of plane) on $CeTe_2Se$. These results sugget that the ground state is qualitatively different due to the influence of the CEF effect by anion doping.

In order to determine the crystalline electric field (CEF) level scheme in $CeTe_3$, we performed inelastic neutron scattering (INS) experiments using SIKA at the Australian Nuclear Science and Technology Organisation. A single crystalline sample of $CeTe_3$ was grown by a flux method in the Okinawa Institute of Science and Technology Graduate University. Many single crystalline samples totaling about 20 g were enclosed in a copper cell and cooled to 2.7 K.

We have succeeded in observing clear CEF excitations at approximately 10 and 22 meV as shown in Fig. 1(a). Furthermore, we also observed an additional peak at around 0.6 meV due to spin-wave excitation, and this excitation vanishes above the transition temperature (T_{N1} = 3 K) as shown in Fig. 1(b). From previous studies of the magnetic susceptibility, a CEF level scheme with a ground state of $\Gamma_7^{(2)}$ was suggested. These CEF parameters give rise to energy-level splitting from the ground state of 11.2 and 19.8 meV, which are roughly consistent with our INS measurements. However, from an analysis of INS and magnetic susceptibility data with a CEF model calculation, we found that the ground state of $CeTe_3$ is $\Gamma_7^{(1)}$.

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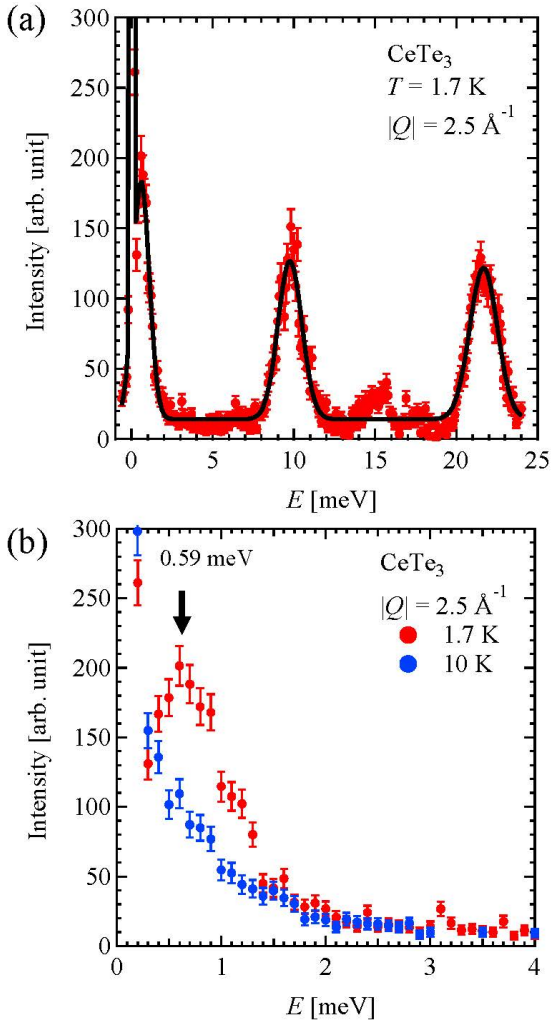

Fig. 1. Inelastic neutron scattering spectra of $CeTe_3$.