Identification of an order parameter in a heavy fermion antiferromagnet $CeTe_3$

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Rare-earth tri-telluride $CeTe_3$, which belongs to the family of quasi-two dimensional compounds RTe_3 (where R = Y, La-Sm, Gd-Tm), has highly two-dimensional crystal structure; bi-layer RTe-sheets and two square Te-sheets are stacked along the b-axis (space group $Cmcm$, weakly orthorhombic structure) [1]. Fermi surfaces consist of inner and outer square sheets, large regions of which are nested by a single incommensurate wave-vector corresponding to the observed lattice-modulation. Because of the characteristic quasi-two-dimensional nature of the Te sheet, the charge-density-wave (CDW) is formed with an extremely large gap [2]. Despite the extensive studies on the CDW in recent years, remarkably little is known about magnetism and low-temperature properties of $CeTe_3$. Recently, it has been reported that $CeTe_3$ exhibits two (magnetic) ordering below $T_{N1} = 3.1$ K and $T_{N2} = 1.3$ K by the specific heat and susceptibility measurements, shown in Fig.1 (a) [3, 4]. From these measurements, the phase below at T_{N2} seems to be a spin-density-wave (SDW).

The goal of this work is to determine the order parameters of the low-temperature two phases by neutron diffraction technique. A single crystal of $m \sim 0.3$ gram was prepared and put in an aluminum can filled with a He gas. It was cooled down to 0.7 K using a ^{3}He cryostat [5]. Neutron diffraction experiments were performed at HQR and PONTA in the research reactor JRR-3.

We have searched magnetic reflections of $CeTe_3$ below T_{N2} with mesh-scans in a scattering plane of $(H, 0, L)$. We have found the Bragg reflection at an incommensurate reciprocal point $Q = (0.18, 0, 1.32)$ at 0.7 K (below T_{N2}). Fig.1 (b) shows temperature dependence of the peak intensities at $Q = (0.18, 0, 1.32)$, which disappeared at 1.5 K (above T_{N2}). The development of the incommensurate magnetic Bragg peak strongly supports that the order below T_{N2} are of itinerant magnetic origin. A series of experiments indicate that the magnetic order of $CeTe_3$ develops from the paramagnetic phase to the SDW phase through the intermediate phase with the formation of heavy quasi-particles.

References

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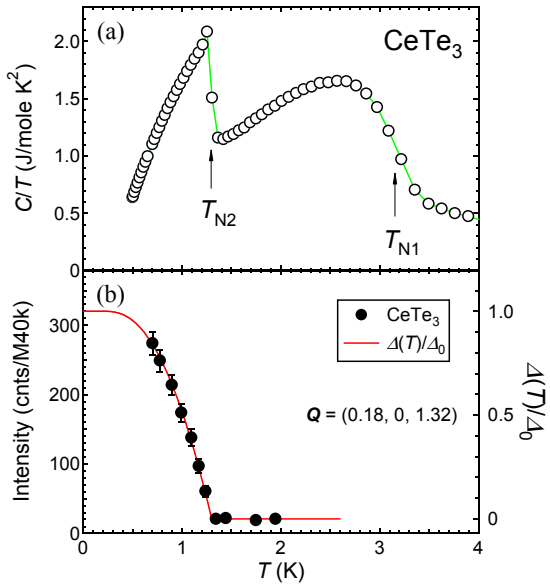

Fig. 1. (a) Temperature dependence of the specific heat divided by temperature of $CeTe_3$. (b) Temperature dependence of Bragg peak intensities of $Q = (0.18, 0, 1.32)$. Solid line represents the square of calculated SDW gap.