Critical behavior of S=1/2 triangular antiferromagnet Cs2CuBr4

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In Cs_2CuBr_4, the magnetic Cu^{2+}-ions form the distorted triangular lattice within the *bc*-plane. For the isostructural compound Cs_2CuCl_4, the magnetic properties are described by a quasi-2D distorted triangular antiferromagnet with small Dzyaloshinsky-Moriya (DM) interaction between Cu^{2+}-ions. Since Cs_2CuBr_4 has the same crystal structure, it is expected that the magnetic behavior of Cs_2CuBr_4 should be described by the same Hamiltonian obtained for Cs_2CuCl_4. Below the ordering temperature $T_N = 1.45$ K, the magnetic structure is helical incommensurate structure with the ordering vector $Q = (0, 0.575, 0)$ (Ono et al. 2003). The helical spin structure has the “chiral” degeneracy which comes from the direction of the spin rotation. It is predicted that the additional degeneracy lead the anomalous critical behavior which belong to the new $n = 2$ and 3 chiral universality classes (Kawamura 1998). In order to check the critical behavior of Cs_2CuBr_4, we have performed the elastic neutron scattering experiments.

Single crystal of Cs_2CuBr_4 was grown by the slow evaporation method from the aqueous solution of CsBr and $CuBr_2$. Neutron elastic scattering was performed at HER triple axis spectrometer. A single crystal with $\sim 0.4\,\mathrm{cm}^3$ was used for this measurement. The sample was cooled down to $T = 0.7$ K using the ^{3}He refrigerator.

Figure 1 shows the temperature dependence of the magnetic Bragg peak intensity at $Q = (0, 0.575, 0)$. The Néel temperature was determined as $T_N = 1.47$ K. The solid line is the result of least squares fit to a power law in the reduced temperature given as Intensity $\propto [(T_N - T)/T_N]^{2\beta}$ + Background. Since the magnetic Bragg scattering intensity is proportional to the square of the sublattice magnetization, we can roughly estimate critical exponent β by using this power law. Obtained exponent, $\beta = 0.346 \pm 0.010$, agrees well with that of conventional $n = 2$ (XY) universality class, $\beta = 0.346$ (Guillou 1977). The value of β seems to deviate from the value which is predicted in the “chiral” universality scenario ($\beta = 0.253$ for $n = 2$ and 0.300 for $n = 3$). This fact indicates that the chiral degeneracy should be lifted by DM interaction between Cu^{2+}-ions on the strongest bonds. Since the *a*-axis component (perpendicular to the *bc*-plane) of the D-vectors point to the same direction, the direction of the spin rotation within the triangular plane is determined uniquely. The value of the critical exponent β consequently demonstrates that the DM interaction plays a key role in determining the spin arrangement. At present, it is not clear the reason why no diffuse scattering was observed just above the transition temperature.

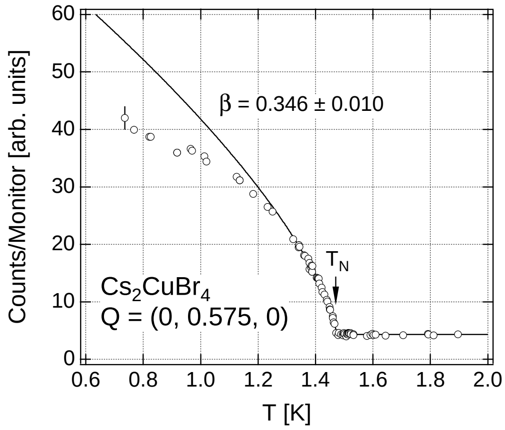

Fig. 1. Temperature variation of the magnetic Bragg peak intensity measured at $Q = (0, 0.575, 0)$. Solid line is the result of a fit to a power law described in the text with $\beta = 0.346 \pm 0.010$ and with $T_N = 1.47$ K.