Chiral Helimagnetism in CuB2O4

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Helical magnet copper metaborate CuB2O4 with the space group I-42d has been paid attention from the viewpoint of chiral helimagnetic ordering. It shows various magnetic phase transitions at low temperature: paramagnetic state above TN (= 20 K), commensurate phase with weak ferromagnetic ordering in the range of T* (~ 10 K) < T < TN and incommensurate phase with helimagnetic ordering below T*. In the temperature close to the incommensurate-to-commensurate transition, neutron diffraction experiments show higher order satellite, which is an evidence for the formation of magnetic soliton lattice [1]. With increasing an applied magnetic field perpendicular to the helical c-axis, incommensurate phase II is observed in the region which was supposed to be commensurate magnetic structure [2]. The magnetic property of CuB2O4 can be interpreted by the lattice chiral XY model: commensurate-to-incommensurate transition is understood by the formation of chiral magnetic soliton lattice [3]. Moreover, symmetry operation based on its space group, I-42d, allows antiferro-chiral helimagnetic ordering, which alternates right and left handed screws.

In order to detect the antiferro-chiral helimagnetic ordering, we performed polarization analysis experiments in the incommensurate phase. The single crystal was grown by the spontaneous crystallization technique; slow cooling of CuO, Li2CO3 and B2O3 [3], using enriched 11B2O3 to avoid the large neutron absorption due to 10B. The polarized neutron diffraction experiments were performed at PONTA (5G), JRR-3M reactor in JAEA (Tokai). The data was taken at 8 K under an applied magnetic field parallel or perpendicular to the scattering vector, due to aligning the neutron polarization parallel or perpendicular to the scattering vector. Accoring to the calculation of the antiferro-chiral helimagnetic ordered magnetic structure factors in (h, 0, 2h+-q) (h: even), spin flip process should be observed when the neutron polarization is parallel to the scattering vector. In case of the neutron polarization perpendicular to the scattering vector, non-spin flip process should be observed. However, the experimental results in (2, 0, 4+-q) indicates that the both processes are observed in case of parallel and perpendicular neutron polarization. The experimental data was considered to be affected by several magnetic domains. As this compound shows commensurate-to-incommensurate magnetic ordering with cooling temperature, makeing a single magnetic domain in commensurate phase is enough to guarantee the single mangetic domain in incommensurate phase.

Therefore, in order to make a uniform magnetic domain, we should cool the sample with appling field parallel to the b-axis.

Reference

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[3] Y. Kousaka et al.: J. Phys. Soc. Jpn.76 (2007) 123709.