Search for magnetic octupole order in Ce0.5La0.5B6

T. Matsumura
Graduate School of Advanced Sciences of Matter, Hiroshima University

Inter-ionic exchange interactions involving multipole degrees of freedom give rise to a rich variety of unconventional ordered phases in f-electron systems.
One of the typical examples is the lanthanum-doped cerium hexaboride CexLa1-xB6. Interest in CexLa1-xB6 has been stimulated by the appearance of another type of ordered phase for x < 0.8, which has been named phase IV and is considered to be an AFO phase with the (T_betax+T_betay+T_betaz)-type (Gamma5u) order parameter. One problem concerning phase IV is that the AFO transition temperature increases when Pr or Nd is doped into CexLa1-xB6 for x=0.4 and 0.5.
For x = 0.5, the transition temperature increases from 0.8 K in Ce0.5La0.5B6 to 1.7 K in Ce0.5Pr0.1La0.4B6.
The increase is larger for Pr doping than for Nd doping, in spite of the fact that the \Gamma5-triplet crystal-field ground state of Prˆ3+ does not possess an octupolar degree of freedom.
From this result, the authors discussed that the AFO phase may be coupled with the magnetic dipolar degree of freedom and thereby become stabilized, which is contradictory to the current scenario of purely \Gamma5u-AFO order. To check whether the ordered phase in the doped compounds is actually the same AFO phase as in Ce0.7La0.3B6, we performed a neutron diffraction experiment on Pr-doped Ce0.5Pr0.1La0.4B6, which has a relatively high transition temperature.

One neutron diffraction experiment was performed using the triple-axis thermal neutron spectrometer TOPAN installed at the beam port 6G of the research reactor JRR-3, Japan Atomic Energy Agency, Tokai, Japan.

A neutron diffraction experiment was also performed using the 6T2 diffractometer at the reactor Orph'ee of Laboratoire Leon Brillouin, Saclay, France.

The scattering-vector (Q) dependence is well explained by a curve representing a normal magnetic form factor of the Ceˆ3+ and Prˆ3+ ions.

In order to distinguish between the single-q and multi-q magnetic structures, and also to investigate the domain motion in magnetic fields, we measured the field dependencies of intensities of selected magnetic peaks. The results are shown in Fig. 1.
In the initial zero-field state, all the magnetic peaks corresponding to the magnetic wave vectors q1,2 = (1/4, \pm1/4, 1/2), q3,4 = (1/2, +- 1/4, 1/4), and q5,6 = (+- 1/4, 1/2, 1/4) exist.
In the first field scan (points labelled 1 in Fig.˜1, we measured the (5/4, 1/4, 1/2) and (1/4, -1/4, 3/2) peaks corresponding to q1 (m1 parallel to H) and q2 (m2 perpendicular to H), respectively.
As shown in Fig. 1, the intensity associated with q1 disappeared at 1.8 T, whereas that associated with q2 decreased less steeply, reached a plateau around 2.5 T, then finally dropped to zero at 4 T.

In conclusion, neutron diffraction experiment has been performed on Ce0.5Pr0.1La0.4B6,
in which an Gamma5u-AFO order with q0=(1/2, 1/2, 1/2) has been supposed to occur because of similarities in the macroscopic physical properties with those of Ce0.7La0.3B6.
Contrary to this expectation, we observed an unambiguous signal from magnetic dipole order with q=(1/4, 1/4, 1/2), the same propagation vector frequently real-

ized in rare-earth hexaboride compounds. Based on this result, we proposed a T-x-y phase diagram of CexRyLa1-x-yB6 for R=Nd and Pr, which shows that the order is suddenly switched from AFO to AFM by the R-ion doping.

This result has been published in [1].

[1] T. Matsumura, K. Kunimori, A. Kondo, K. Soejima, H. Tanida, J.-M. Mignot, F. Iga, and M. Sera, J. Phys. Soc. Jpn. 83, 094724 (2014).
"Appearance of antiferromagnetic dipole order in Ce0.5La0.5B6 with Pr ion doping"

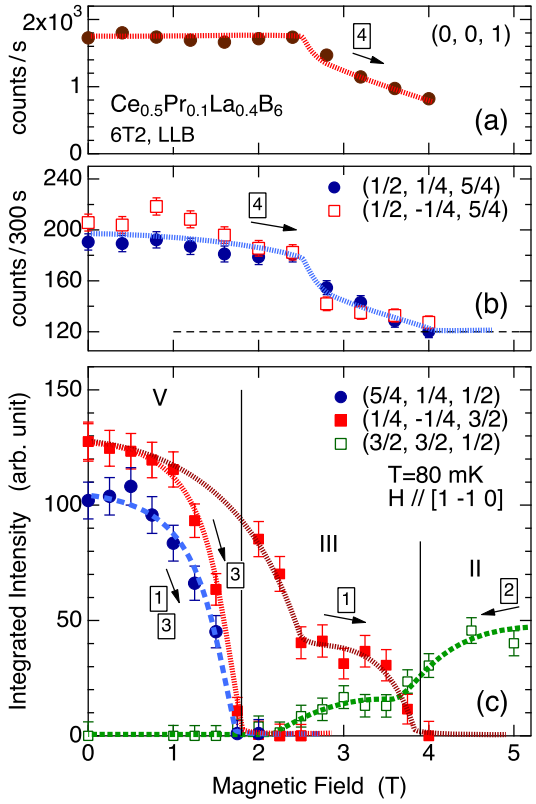

Fig. 1. Magnetic field dependencies of the intensities.