Magnetic and quadrupolar ordering in the Kondo – crystal CeB_6

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Unusual properties of the Kondo crystal CeB_6 are being studied during last three decades, but only recently [1] the magnetic ordering of localized 4*f* electrons consistent with the neutron diffraction, NMR and μSR data is established. Below $T_N = 2.4$ K, it is described by the wave vectors $2\mathbf{k}_4 - \mathbf{k}_5$ and $2\mathbf{k}_4' - \mathbf{k}_5'$, where $\mathbf{k}_4 = (2\pi/a)[1/4, 1/4, 0]$, $\mathbf{k}_5 = (2\pi/a)[1/4, 1/4, 1/2]$, $\mathbf{k}_4' = (2\pi/a)[1/4, -1/4, 0]$, $\mathbf{k}_5' = (2\pi/a)[1/4, -1/4, 1/2]$. As to the transition at $T_Q = 3.3$ K with the wave vector $\mathbf{k}_{13} = (2\pi/a)$ [1/2, 1/2, 1/2], the 4*f* quadrupolar ordering [2] as well as the ordering of atomic displacements [3] were discussed. Our results of the synchrotron X-ray radiation diffraction and the neutron polarization analysis unambiguously establish the quadrupolar ordering, with the displacements of Ce and B being less than $\sim 10^{-4}$ Å. By means of the neutron polarization analysis, the magnetic fluctuations with $\mathbf{k}_{13}$, are discovered up to $T > 3T_N$. The fluctuations build up with no visible anomaly at T_Q reaching the highest correlation length of about 10 Å just above T_N. Below T_N, the peak (1/2,1/2,1/2) of diffuse scattering transforms into a Bragg reflection, with the peak intensity being abruptly decreased. Additional long-range magnetic order appears with the wave vector $\mathbf{k}_{13}$ and with the moment value about 10^{-4} of that for the basic magnetic structure [1]. The features of antiferromagnetic fluctuations above T_N are typical for the itinerant magnetism in the conduction band, which is formed from hybridized 5*d* electrons of cerium and 2*p* electrons of boron. Antiferromagnetic fluctuations of interacting 4*f* multipolar moments may also contribute to the observed peak at $\mathbf{k}_{13}$. Taking into account the translation relation $\mathbf{k}_{13} = \mathbf{k}_4 + \mathbf{k}_5$, one may assume that interaction between conduction electrons as well as between multipole moments of localized 4*f* electrons should induce the long-range ordering of the 4*f* magnetic moments with $\mathbf{k}_{13}$ at T_N. A strong enhancement below T_N of the X-ray Bragg reflection (5/2,3/2,3/2) confirm the coupling between the magnetic dipole and the multipole moments of localized 4*f* electrons.

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[2] G. Uimin, Phys. Rev. B **55**, 8267 (1997).
[3] T. Kasuya, J. Phys. Soc. Jpn. **67**, 33 (1998).