Experimental Report

Proposal: **4-01-1406** **Council:** 4/2014

Title: The effect of La doping on the magnon spectrum of CeB6

This proposal is a new proposal

Researh Area: Physics

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Samples: Ce(0.75)La(0.25)B6 with enriched 11B

Instrument	Req. Days	All. Days	From	To
IN5	6	6	25/11/2014	01/12/2014

Abstract:

EXPERIMENTAL REPORT

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Instrument: IN5

Date of experiment: 25 Nov-2 Dec, 2014

In the present experiment, we obtained complete maps of the 4D energy-momentum space of $Ce_{1-x}La_xB_6$ $x = 25\,\%$ to reveal:

- The Néel temperature T_N.
- The structure of the signal in the momentum space.
- The dispersion of low-energy excitations.

Our experiment was performed at the disk chopper time-of-light spectrometer IN5. We used the single-crystal sample $Ce_{0.75}La_{0.25}B_6$ ($\sim$4 grams). The sample has the $Pm\bar{3}m$ space group, lattice parameters are $a = b = c = 4.14\,$Å. It has cylindrical shape and was prepared from isotopically enriched ^{11}B to minimize neutron absorption. The incident neutron wavelength was fixed at 5 Å (3.27 meV). The sample was mounted in a cryostat being aligned for the most intense (110) and (001) reflections to enable measurements in the (HHL) scattering plane. We rotated the sample during the measurement in steps of 1° to map out the complete energy-momentum space in 4D. The counting time per every sample position was at least 10 min. Our measurements were performed in the AFM region at 0.06 K and at 1.35 K in the AFQ region.

To refine the T_N we performed short elastic-scattering scans around the AFM propagation vector $(\frac{1}{4}\frac{1}{4}\frac{1}{2})$ at temperatures 0.8 K – 1.35 K. The resulting transition temperature was obtained from the fit (see Fig. 1), $T_N = 1.34\,$K.

To give an overview of the inelastic-scattering signal in our experiment, we present in Fig. 2 several cuts from 4D datasets. This figure shows (HHL) inelastic intensity maps for different energies in the AFQ and AFM state. The comparison of the momentum cuts of our sample with respective measurements of the parent compound revealed a qualitatively unchanged momentum-space structure of the signal. The intense exciton mode can be observed at the R point in panels (a)-(c). We also observe at the panel (a) conventional excitations emanating from the AFM Bragg-peak positions at the S and Σ points, which have weaker intensity. All mentioned maxima of intensity are found at commensurate positions at this doping level. In addition in panel (a) one can see the intense inelastic intensity centered at the Γ point [1]. In the AFQ state the momentum structure retains.

In Fig. 3 we plotted momentum energy cuts below and above T_N (panels a and b respectively). The very intense mode centered at the Γ point at $\hbar\omega = 0.23\,$meV can be seen at the upper panel. Its maximum intensity is slightly shifted to the lower energy with respect to the parent compound, where it was observed at 0.25 meV. This Γ mode can be seen at both (110) and (001) wave vectors and might be indicative of low-energy ferromagnetic correlations in CeB_6 [3–5]. Its intensity increases toward higher $|\mathbf{Q}|$ and is continuously connected to the the low-energy intensity at the X point. Also one can see the intense mode at the R point with maximal intensity at 0.41 meV. This mode is also lowered in energy compared to the parent compound, where it was observed at 0.5 meV [1, 2]. The dispersion along $\Gamma - R - \Gamma$ direction becomes broader near the zone boundary with maximal intensity around the R point. We can also see a week dispersion from the hybridization of neighboring S points. We didn't observe high-energy intensity dispersion modes at Γ, X and R points, as it was reported in CeB_6 [1]. In the AFQ state we didn't observe any dispersive modes, similar to the parent compound.
The main findings of our experiment are:

- The Néel temperature of our sample was refined by performing scans at 0.8 K - 1.35 K temperatures at $\mathbf{Q}_{AFM} = (\frac{1}{4}\frac{1}{4}\frac{1}{2})$. The obtained value from the fit is 1.34 K.
- The absence of the substantial difference in the momentum redistribution of the spectral weight at Γ, X and R points with respect to the parent compound.
- The presence of the intense exciton modes at the Γ and R points, with their maximal intensity around 0.23 meV and 0.41 meV respectively (Fig. 3). The La doping of CeB_6 shifts these modes to the lower energies.

Further field measurements would be therefore highly desirable.

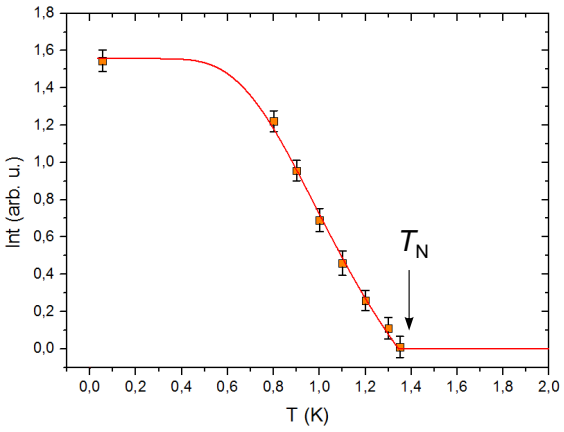

Fig. 1 Temperature dependence of the AFM Bragg peak intensity. The red line relates to the T_N fit.

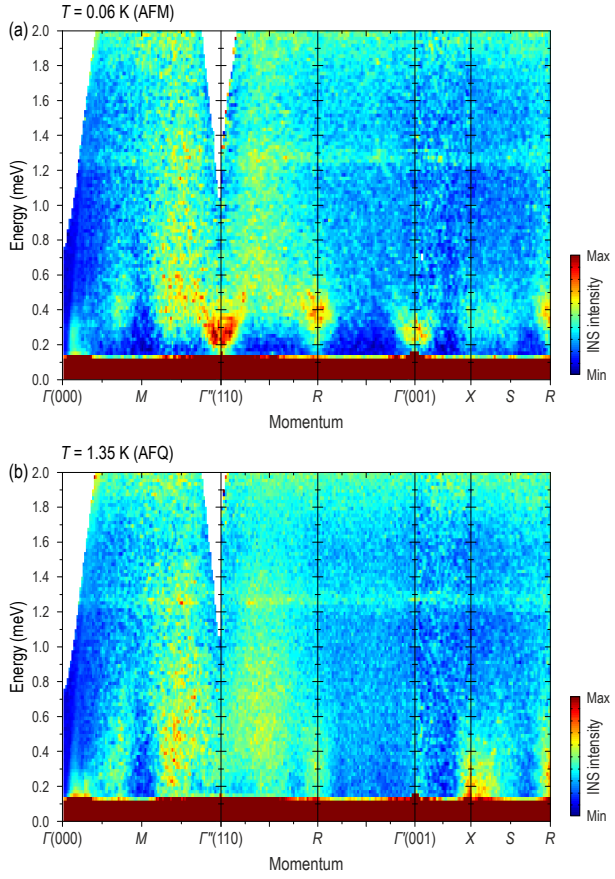

Fig. 3 The dispersion of the magnetic excitation in the AFM and AFQ states at $T = 0.06, 1.35$ K respectively.

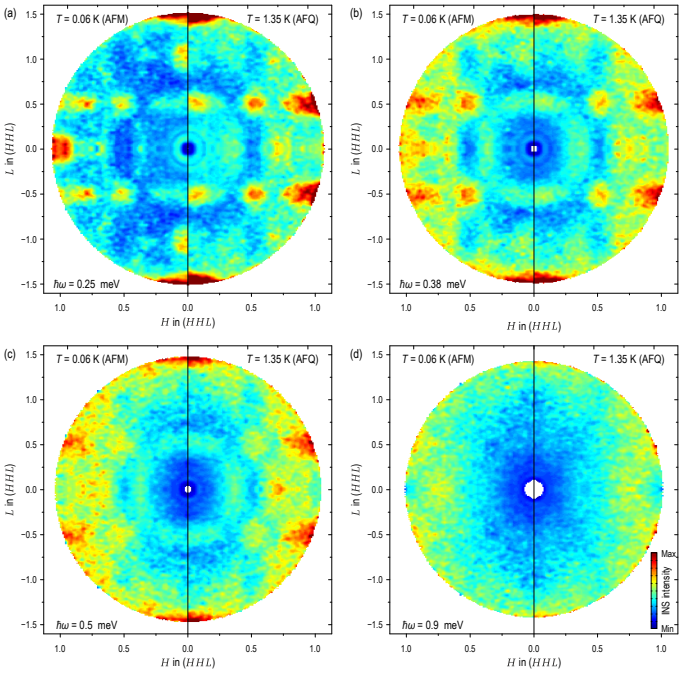

Fig. 2 (HHL) maps at $\hbar\omega = 0.25, 0.38, 0.5$ and 0.9 meV. The data were symmetrized with respect to the natural mirror planes of the reciprocal space. The left and right halves of every panel show the data in the AFM and AFQ states, respectively.

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[3] S. Horn *et al.*, Z. Phys. B **42**, 125 (1981).
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