（ ※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。 ）

MLF Experimental Report	提出日 Date of Report
課題番号 Project No. 2014A0232 実験課題名 Title of experiment Neutron-Scattering Study of Magnetic Properties in A New Ferromagnetic Kondo-Lattice System $CePd_2P_2$ 実験責任者名 Name of principal investigator Yoichi Ikeda 所属 Affiliation Neutron Science Laboratory, ISSP, The University of Tokyo	装置責任者 Name of responsible person Shinichi Ito (伊藤晋一、KEK) 装置名 Name of Instrument/（BL No.） High-Resolution Chopper Spectrometer HRC (BL12) 実施日 Date of Experiment 15-20 May 2014

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

CePd2P2, 4.8g, a = 4.159Å, c = 9.897Å, (I4/mmm, #139), 8.047 g cm^{-3}, 414.9 g mol^{-1},
The powder sample was lapped by a thin-Al foil with a dimension of ~phi-8mm and ~4cm-length, and sealed in a standard Aluminum cell with helium (~1atm at RT) for thermal exchange gas.

LaPd2P2, 4g, a = 4.203Å, c = 9.898Å, (I4/mmm, #139), 7.858 g cm^{-3}, 413.6 g mol^{-1},
The powder sample was lapped by a thin-Al foil with a dimension of ~phi-8mm and ~4cm-length, and sealed in a standard Aluminum cell with helium (~1atm at RT) for thermal exchange gas.
(LaPd2P2 is a reference material for subtracting phonon contribution in inelastic spectra of CePd2P2.)

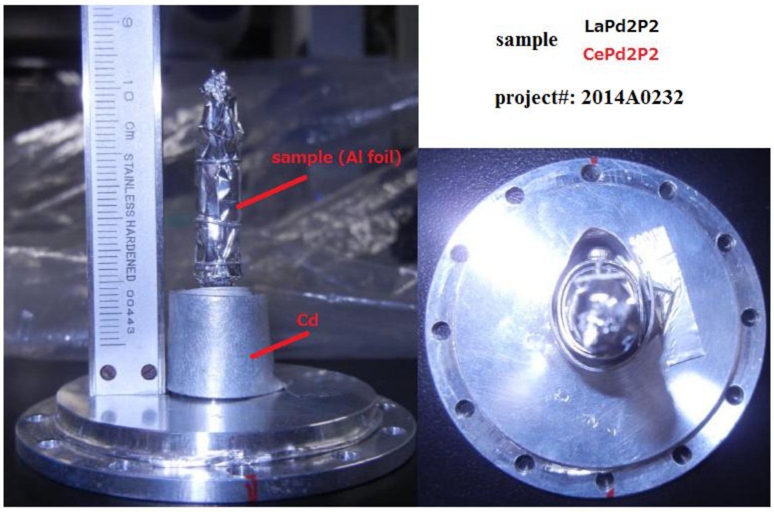


Fig. 1 Sample configuration on the experiment.

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）

Experimental method and results.　If you failed to conduct experiment as planned, please describe reasons.

Experimental

We employed a standard experimental procedure at BL12.

T0 chopper: 50 Hz (200us delay),

Fermi chopper: S type, 200Hz, 2016.9us (51.15, 11.46meV) and 5025.0us (165.1, 18.35, 41.27, 6.611 meV)

Fe collimeter: 50*50

Incident collimeter: wide(1.5 deg.)

Oscillating collimeter: without

Refrigerator: Pascal (Sumitomo), 4He closed-cycle refrigerator

Option: a thin Al foils was used as a radiation shield on both LT and HT (2nd) stage.

<Improvement>

In this experiment, we succeeded in improving the refrigerating capacity of the ^{4}He-CCR (Pascal, Sumitomo) at HRC by employing a new radiation shield on the low-temperature stage. Indeed, the bottom temperature is improved to 2.3~2.4 K from > 3 K, and the rising rate of the base temperature is also suppressed to +26 μK/min from +240 μK/min, as shown in Fig. 2. By using the new R-shield, low-lying excitations can be measured below 5 K, more precisely.

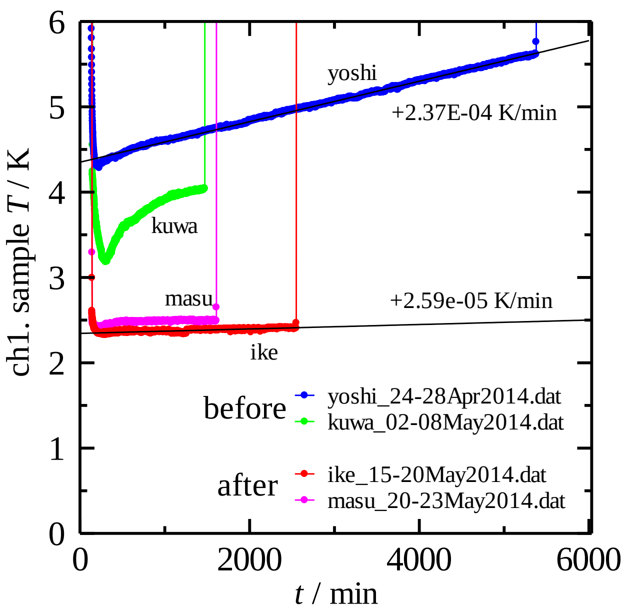


Fig. 2 Time dependence of the sample temperature.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

Experimental Results

(i) Ferromagnetic ground state on CePd2P2 was exactly confirmed by the neutron scattering experiment.

In order to check the magnetic structure of CePd2P2, we measured at 3 (well below the Curie temperature T_C) and 40 K (above T_C). Figure 3 shows (elastic) diffraction patterns at 3 (blue) and 40 K (red). As seen in the difference between 3 and 40 K, one can see that no extra peaks were observed except for the fundamental Bragg position, and no significant difference was observed at 002 reflection. These results clearly indicate that the ground state on CePd2P2 is exactly ferromagnetic state, and the ordered moment is parallel to the c axis. The size of the ordered moment can be estimated to be 1.3(1) μ_B/Ce at 3 K.

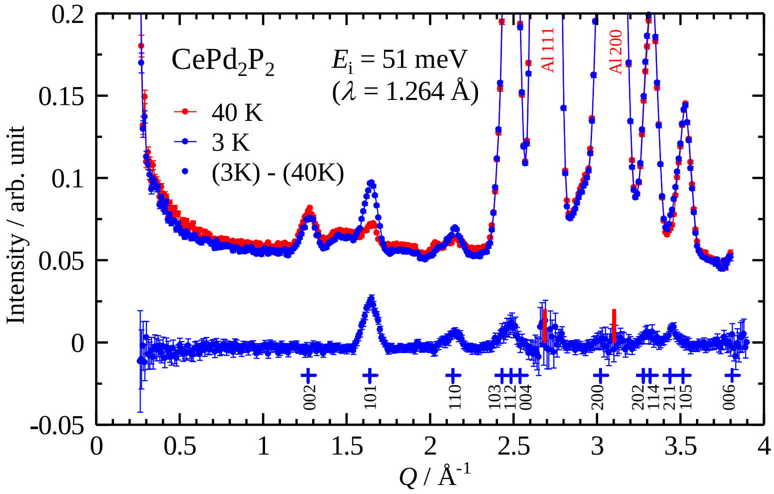
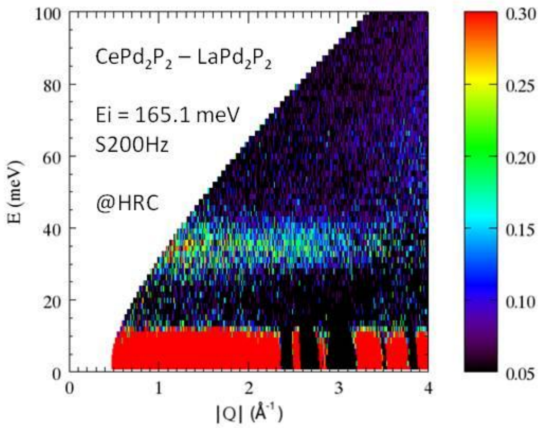


Fig. 3 Diffraction pattern of CePd2P2 measured at 3 and 40 K at HRC. Cross symbols (+) indicate the fundamental Bragg point of CePd2P2. Numbers near the symbol are the corresponding Miller indices.

(ii) Both excited CEF-doublets of Ce3+(4f1) lie around 34 meV for CePd2P2.

Figure 4 (left) shows the inelastic neutron scattering spectra where the spectra of LaPd2P2 was subtracted as a background. As seen in Fig. 4 (left), one can see a clear dispersion-less excitation spectrum around 30-40 meV. This excitation results from the crystal field splitting of Ce3+. For more clarifying the excitation, constant-Q cut is plotted for both Ce and La compound in Fig. 4 (right). By fitting two Lorentz functions, the splitting energy of the two excited doublets from the ground state can be evaluated as 32 and 37 meV for CePd2P2.



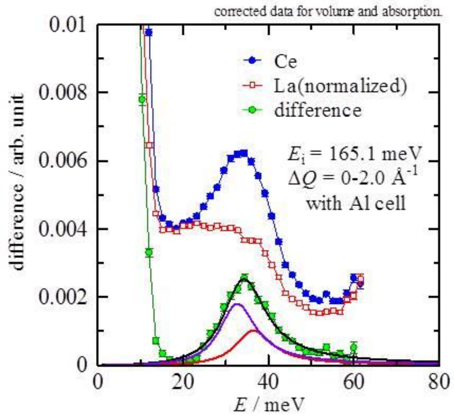


Fig. 4 (Figure caption is written in the next page)

Fig. 4 Inelastic neutron scattering spectra. (left) the difference of the inelastic spectra between Ce and La compound, (right) energy dependence of the neutron scattering intensity averaged over Q = 0–2 $Å^{-1}$ (constant Q–cut). The solid curve on the green circles is the result of a fit with two Lorentz curves.

(iii) Direct observation of spontaneous–splitting of the CEF ground doublet of Ce^{3+}.

Figure 5 (left) shows the low–energy inelastic spectrum of CePd2P2 below 3 K, where LaPd2P2 was subtracted as a background. A clear non–dispersive magnetic excitation was observed around 5–6 meV. As seen in Fig. 5 (right), the excitation disappears above the Curie temperature. This result indicates that the magnetic excitation results from spontaneous splitting of the ground doublet state due to the ferromagnetic transition. From these results (ii & iii), crystal–field energy scheme on CePd2P2 can be determined as shown in Fig. 6.

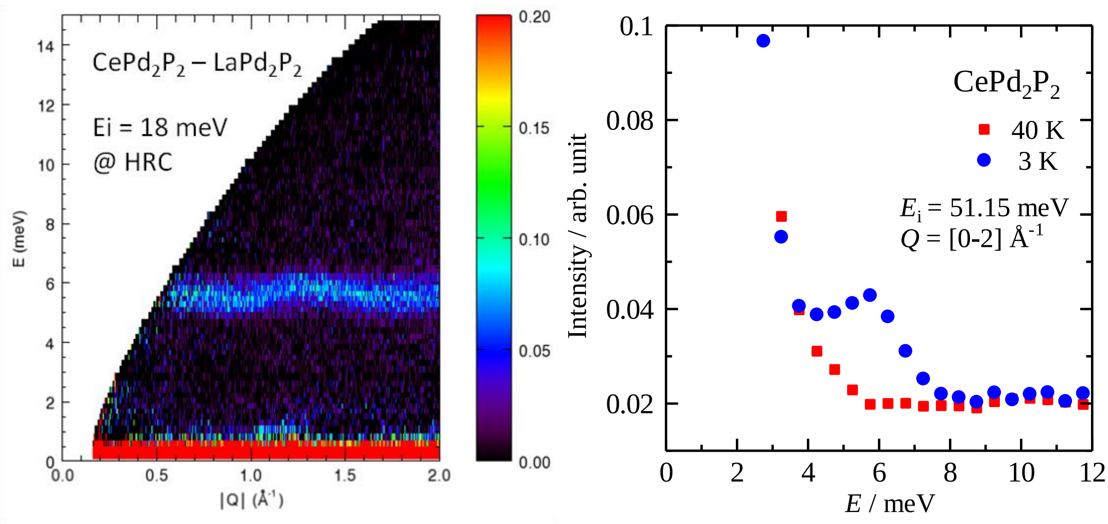


Fig. 5 Low–energy neutron–scattering spectra of CePd2P2. (left) the difference of the inelastic spectra between Ce and La compound. The data of $LaPd_2P_2$ was subtracted as a background. (right) constant–Q cut of the inelastic spectra measured at 3 and 40 K.

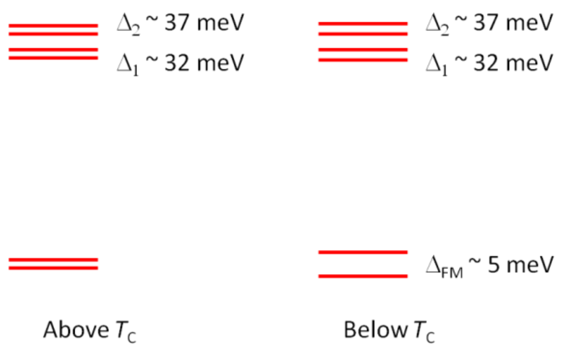


Fig. 6 Schematic illustration of the CEF energy scheme on CePd2P2.