実験報告書様式（一般利用課題・成果公開利用）

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CROSS TOKAI **Experimental Report** J-PARC	承認日 Date of Approval 2017/6/1 承認者 Approver Ryoichi Kajimoto 提出日 Date of Report 2017/6/1
課題番号 Project No. 2016A0173 実験課題名 Title of experiment Neutron inelastic scattering study of $PrPd_5Al_2$ 実験責任者名 Name of principal investigator Naoto Metoki 所属 Affiliation JAEA	装置責任者 Name of Instrument scientist R. Kajimoto 装置名 Name of Instrument/（BL No.） 4 seasons, BL-1 実施日 Date of Experiment 16/11/14 11:00 ～ 16/11/15 11:00

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.

A polycrystalline $NdPd_5Al_2$ sample was grown by arc melting and cut into many small pieces. The sample quality was checked by x-ray powder diffraction; no unknown peak and no impurity phase were detected. The magnetic structure was determined using the same sample rot as published very recently. The Néel temperature of about 1.3 K was in good agreement with previous studies. Totally 20 g of sample was sandwiched in an aluminum foil and fixed in an area of 1x2 cm^2 of the neutron beam size. The sample was sealed in a standard aluminum cell and cooled down to 10 K in a GM-type refrigerator.

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。）

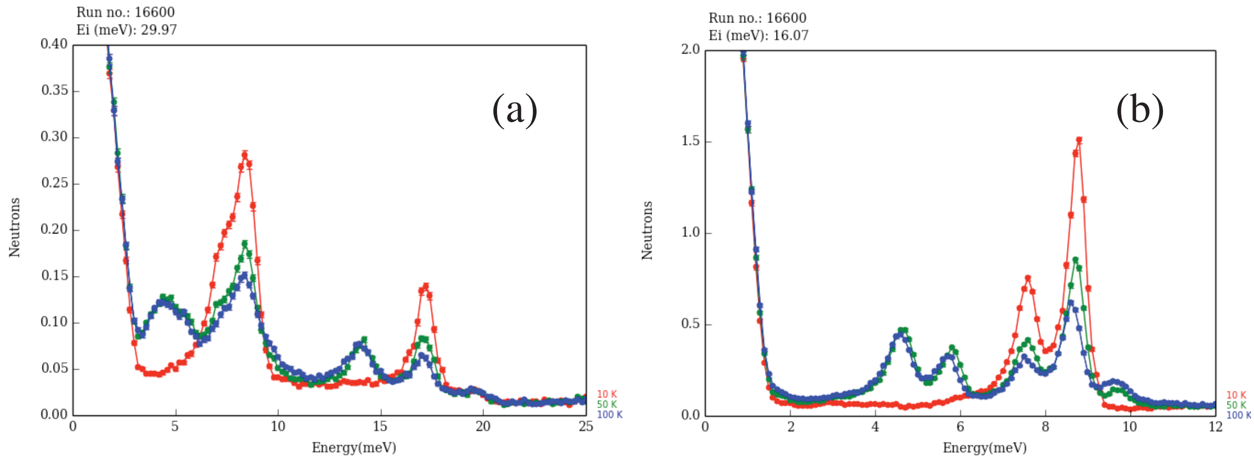
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

The neutron inelastic scattering spectra of $NdPd_5Al_2$ were measured with 4-seasons at BL-1, a flagship instrument of J-PARC/MLF. The chopper was set at f = 200 Hz to optimize the intensity and resolution. We confirmed all signals existing below 18 meV at the beginning during the evacuation of spectrometer and cooling the sample temperature. The best condition was tuned to accumulate the entire spectra with Ei=30 meV and the low energy excitation with better resolution (Ei= 16 meV) in a multi-Ei mode. Our experience on $PrPd_5Al_2$ had convinced us that 1 day beam time was enough, and in fact we succeeded to obtain high quality data to determine the CEF level scheme of $NdPd_5Al_2$. $PrPd_5Al_2$ was originally planed to be studied, but has been already measured (since the beam time was reserved) even with TAS in HFIR at ORNL, because the signal was huge. $NdPd_5Al_2$ was a substitution for the same purpose to construct a unified charge model of APd_5Al_2 (A: Actinide and rare earth).

Fig. 1 Setting sample in BL-1

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

Figure 2 shows the results of the observed CEF spectra in $NdPd_5Al_2$. The 4f electronic state of Nd with $^4J_{9/2}$ configuration consists of 5 Kramers doublets. Thus, we expect four excitation peaks from the ground state, and additional peaks between excited levels at high temperatures. Sharp excitation peaks were observed at ΔE= 7.6, 8.75, and 17.2 meV at T= 10K, and the intensities decrease with increasing temperature. These excitations show no dispersion and the intensity gradually decreases with increasing of Q, consistent with the magnetic form factor as shown in Fig. 3. Therefore we concluded that these peaks are CEF excitation of 2nd, 3rd, and 4th excited levels as described below. At elevating temperatures peaks emerged at 4.6, 5.7, 14.0 meV. These can be understood via the excitation from the 1st excited levels lying at 3.0 meV. Absence of a remarkable peak around this energy at 10 K indicates that the matrix element between the ground state and the 1st excited level is negligibly small; maybe a very weak trace of 3 meV peak would be detected in Fig. 2(b). We can expect excitation from the 2nd as well as the 3rd levels at high temperatures. In fact, the peak at 9.7 meV can be identified to be the transition between 2nd – 4th levels. No trace of 2nd – 3rd and 3rd – 4th levels may be again due to the matrix elements. These features provide great hints to identify the level scheme with the 4f wave functions. We have already determined the magnetic structure of $NdPd_5Al_2$. The large Nd moment 2.7(3) μ_B with strong Ising anisotropy are also hints to the 4f electronic state to construct the unified charge model in APd_5Al_2 (A; actinide and rare earth elements) to shed light on the unusual heavy fermion nature as well as unconventional superconductivity in $NpPd_5Al_2$, and $CePd_5Al_2$ under high pressures.



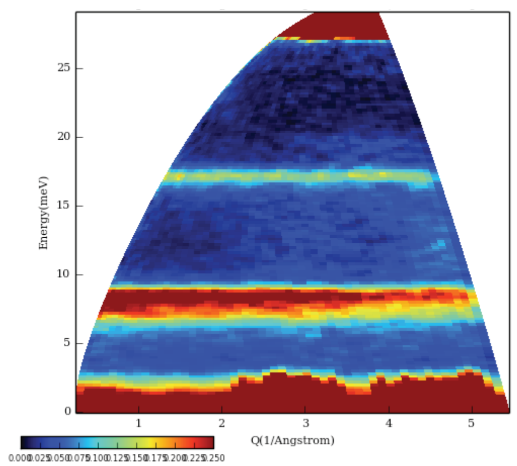


Fig. 2 (upper): The observed neutron inelastic spectra of $NdPd_5Al_2$. The spectra in the left hand side panel (a) are for Ei = 30 meV, while the right hand side panel (b) are for Ei =16 meV. The red, green and blue lines indicate the sample temperature measured at T= 10 K, 50 K, and 100 K, respectively.

Fig. 3 (left): The contour map of magnetic excitation of $NdPd_5Al_2$ measured at T= 10 K.