実験報告書様式（一般利用課題・成果公開利用）

（ ※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。）

CROSS TOKAI **Experimental Report** J-PARC	承認日 Date of Approval 2016/8/22 承認者 Approver Jun-ichi SUZUKI 提出日 Date of Report 2016/8/5
課題番号 Project No. 2014B0019 実験課題名 Title of experiment Neutron diffraction study on ferromagnetism of potassium nanoclusters arrayed in zeolite A 実験責任者名 Name of principal investigator Takehito Nakano 所属 Affiliation Department of Physics, Osaka University	装置責任者 Name of Instrument scientist Jun-ichi Suzuki 装置名 Name of Instrument/(BL No.) TAIKAN (BL15) 実施日 Date of Experiment 2016/06/16-19

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.

Potassium doped zeolite A

$(K_{17}Al_{12}Si_{12}O_{48})_8$

Powder

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.

Approximately 3 grams of powder sample (the crystal size ~ 4 micrometer) was sealed in an aluminum holder with a pure helium gas using an indium gasket. The sample holder was mounted on a cryostat and was cooled down to 2.3 K, which was lower than the sample's T_C ~ 8 K. External magnetic field of 100 Oe, which was enough high to saturate the ferromagnetic magnetization of the sample, was applied by using an electromagnet. Neutron diffraction data were collected by using a spin-polarized neutron beam with two different settings, namely, the neutron spin parallel to the external magnetic field and antiparallel to that, in order to extract the weak magnetic scatterings from the ferromagnetic moments. Neutron diffraction data at 12 K, which is higher than T_C, were also collected by using a non-polarized neutron beam as a reference.

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

Figure 1 shows the data taken at 2.3 K. The intensity in this figure is obtained by subtracting the data between the parallel and antiparallel settings. It is clearly seen that there is a positive peak at the 200 position and a negative peak at the 220 position. The data were collected with the scattering vector perpendicular to the neutron spin, where the Bragg peaks contain the contribution of the magnetic scatterings. We also checked the data collected with the scattering vector parallel to the neutron spin, where the diffraction is purely from the nuclear scatterings. In this configuration, the subtracted data did not show such peaks. Therefore, we can definitely conclude that the peaks appeared in Fig. 1 originate from magnetic scatterings.

The origin of the positive and negative peaks can be well understood by taking account of the *q*-dependence of the magnetic form factor. In the measured sample, potassium doped zeolite A, s-electrons of the potassium nanocluster are confined in the regularly arrayed nanosized cages with an inner diameter of ~ 11 Å. We calculated the form factor by assuming the electron wave function confined in a spherical potential well. The calculation shows that the form factor quickly decreases with q and crosses zero at $q \sim 0.6$ Å^{-1} and goes to negative when we use the inner diameter of 15 Å. This value is fairly close to the size of the cage. Therefore, it can be concluded that we succeeded in detecting the magnetic scattering from the ferromagnetic s-electron confined in the nanosized cages. More detailed and quantitative analysis is now in progress.

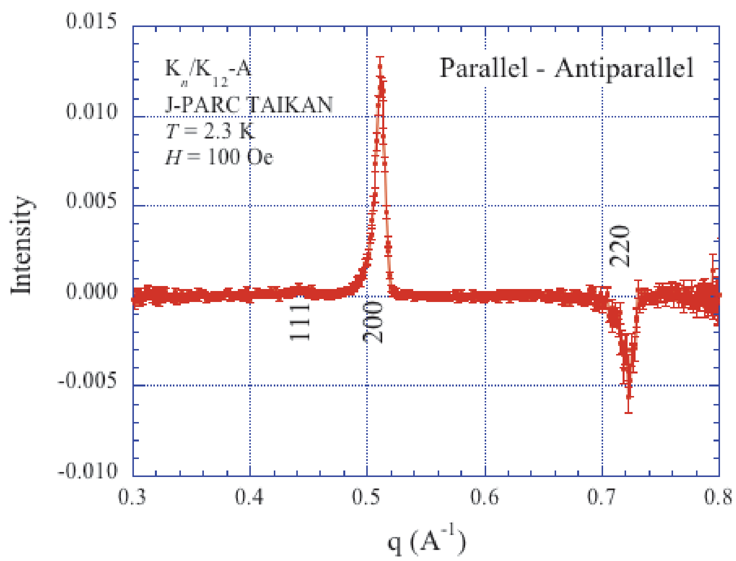

Fig. 1. Neutron diffraction pattern of potassium loaded zeolite A measured at 2.3 K. The intensity shows the difference between two settings, namely, the neutron spin parallel to the external magnetic field and antiparallel to that.