（ ※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　Nov. 27, 2014 承認者 Approver　Ryoichi Kajimoto 提出日 Date of Report　Nov. 27, 2014
課題番号 Project No. 2012B0125 実験課題名 Title of experiment Magnetic Excitations in Oxygen Doped $La_2CoO_{4.24}$ 実験責任者名 Name of principal investigator Kenji Nakajima 所属 Affiliation Materials & Life Science Section, J-PARC Center	装置責任者 Name of Instrument scientist Ryoichi Kajimoto 装置名 Name of Instrument/（BL No.） 4SEASONS (BL01) 実施日 Date of Experiment 14-20, 26-28 Feb., 2013

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 single crystal of $La_2CoO_{4.24}$ (6mmφ x 20mm (~ 4 g)).

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.

We mounted a single crystal of $La_2CoO_{4.24}$ (LCOO) at the tail of a sample stick so that orthorhombic a*-axis (or b*-axis due to the twining) became perpendicular to the scattering plane (Fig. 1). The sample stick was set into a 4SEASONS standard ^{3}He closed cycle refrigerator. After cooling down to the base temperature, we have checked Néel temperature (T_N) of the sample by using white neutron beam. Evaluated T_N was about 37 K, which is close to our previously observed value (36 K). Then, we proceeded to inelastic measurements.

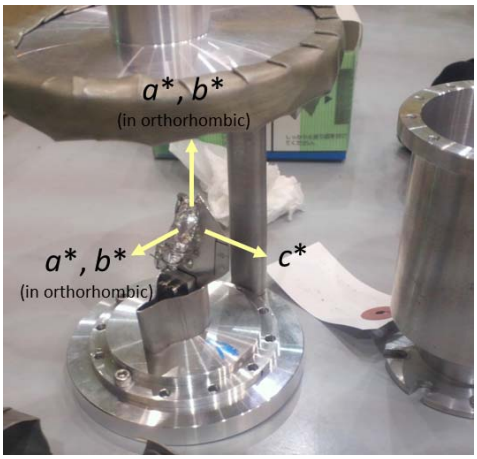

Fig.1 Sample and sample mounting.

In inelastic experiments, the sample was set as $\boldsymbol{k}_i \| \boldsymbol{c}^*$. The chopper condition was chosen to emerge neutrons of E_i = 148.7 meV, 45.1 meV, 21.4 meV, 12.5 meV and 8.2 meV (Fermi chopper frequency was 200 Hz). Measurements were carried out at two temperatures below T_N (T = 6 K and 34 K) and four temperatures above T_N (T = 41 K, 83 K, 154 K and 291 K). At the lowest and the highest temperatures, counting time was 37 hours, and, for other temperatures, it was about 24 hours.

Typical spectra obtained at the lowest temperature are shown in Fig. 2.

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

In lower energy region (E < 15 meV), clear 2D antiferromagnetic (AF) spin-wave excitations whose zone center is at h = integer are observed and these are consistent to previous report on $La_{1.5}Sr_{0.5}CoO_4$ (LSCO) [1]. In addition to these excitations, we observed weak excitations whose zone center is at h = integer±0.5, which were not reported on LSCO.

In higher energy region, flat excitations around E ~ 24 meV are considered to correspond to higher energy modes which are expected by spin-wave calculations including spin-orbit coupling proposed in the case of LSCO [1], while current excitations are less dispersive in comparison with those observed in LSCO.

At this moment, we do not have definitive ideas about the origins of spot-like intensities at E ~ 28 meV and h = integer±0.5, and weak streak-like intensities around 10 < E < 20 meV at h = integer. It might be interesting to see the temperature evolution of observed excitation spectra (Fig. 3). Above T_N, spin-waves of the lower energy modes and the flat excitations around E ~ 24 meV become dumped. On the other hand, the spot-like and the weak streak-like intensities become rather significant as if another excitation dispersion, whose zone center and zone boundary are at h = integer and h = integer±0.5, respectively.

We are expecting that detail analysis of present results can provide a key clue to understand the mechanism of complicated magnetic excitations caused by doped carrier, spin-orbital coupling and spins in transition metal oxides.

Reference

[1] L. M. Helme, A. T. Boothroyd, R. Coldea, D. Prabhakaran, C. D. Frost, D. A. Keen, L. P. Regnault, P. G. Freeman, M. Enderle, and J. Kulda, Phys. Rev. B **80** (2009) 134414.

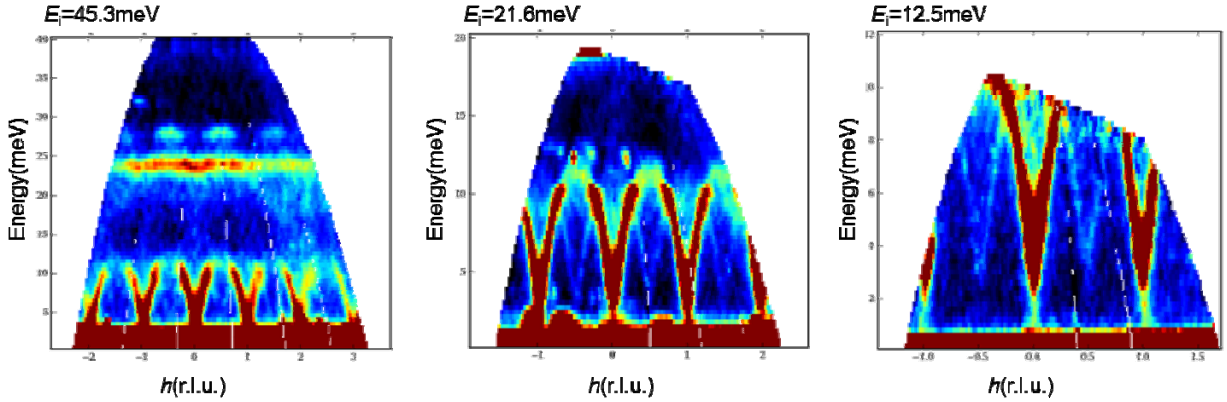

Fig. 2 Typical spectra at $\boldsymbol{Q}$ = (h, 0.5, l) obtained at T = 6 K. Data taken at three different E_is are shown. In these figures, intensities are integrated in the c*-direction (l).

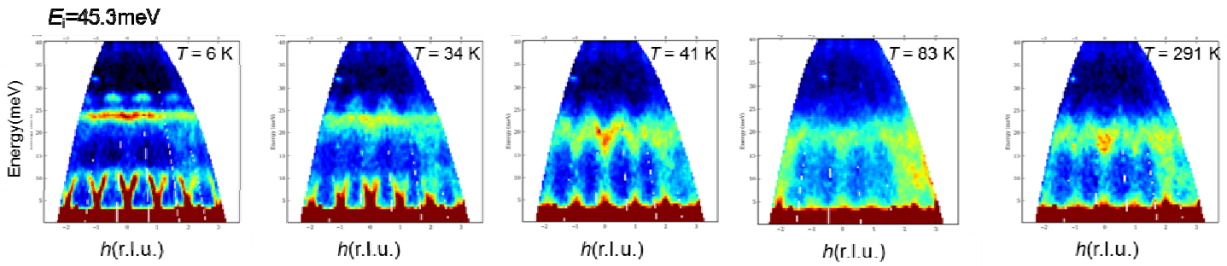

Fig. 3 Temperature evolution of observed spectra at $\boldsymbol{Q}$ = (h, 0.5, l). In these figures, intensities are integrated in the c*-direction (l).