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 2014/06/17 承認者 Approver Ryoichi Kajimoto 提出日 Date of Report 2014/06/14
課題番号 Project No. 2013B0059 実験課題名 Title of experiment Study of magnetic excitations in highly hole-doped $(R,Sr)_2NiO_4$ 実験責任者名 Name of principal investigator Ryoichi Kajimoto 所属 Affiliation J-PARC Center, JAEA	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 2014/03/13 11:00 – 2014/03/20 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.

$La_{1.1}Sr_{0.9}NiO_4$

Single crystal, 2.5 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.

Layered perovskite nickel oxide $La_{2-x}Sr_xNiO_4$ has been famous in that holes doped in the NiO_2 planes by the Sr substitution induces so-called stripe orderings of charges and spins at $x < 1/2$. The wave vector of the stripe order increases as x increases, and results in the checkerboard charge and spin ordering at $x = 1/2$. On the other hand, in the higher hole-doped region of $x > 1/2$, the electric conductivity gradually increases as x increases, and finally becomes metallic at $x \sim 1$. Nevertheless, the checkerboard charge as well as spin correlation persists far above $x = 1/2$, which results in an anomalous metallic state with pseudo gap at $x \sim 1$ [1]. To study how these changes in electric states affect the spin dynamics, we performed inelastic neutron scattering measurements of a single crystal of $x = 0.9$ at 6 K and 203 K. According to the preceding works [1], these temperatures correspond to the antiferromagnetic phase and the pseudo gap phase, respectively.

The single crystal was aligned so that c axis is parallel to the incident neutron beam and the [110] axis of the tetragonal lattice is in the horizontal plane. We utilized incident neutron energies, E_i = 111, 45, 24, and 15 meV. In this report, we ignore c^* dependence of the observed signals, and denote the momentum transfer $\boldsymbol{Q}$ by the

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

two-dimensional reciprocal lattice vector (H, K) in reciprocal lattice units.

Figure 1(a) shows the constant-$\hbar\omega$ slice of the excitation spectrum at 6 K at $\hbar\omega$ (energy transfer) = 5±1 meV. Clear spots originating from magnetic excitations are observed at $\boldsymbol{Q}$ = (0.5, 0.5) ± (ε, ε), (0.5, 0.5) ± ($-\varepsilon$, ε), and equivalent positions with $\varepsilon \sim 0.22$. These positions are almost similar to the magnetic Bragg positions in $x = 0.5$ [2], indicating the robustness of the checkerboard charge and spin correlations in this high hole concentration. Then, we folded the data along $Y = X$ line to improve statistics, cut the spectrum along the (H, H) direction, and show it on the Q-$\hbar\omega$ map [Fig. 1(b)]. The magnetic excitations show steep dispersions at $H = -0.5\pm\varepsilon$, and their intensity decreases as $\hbar\omega$ increases.

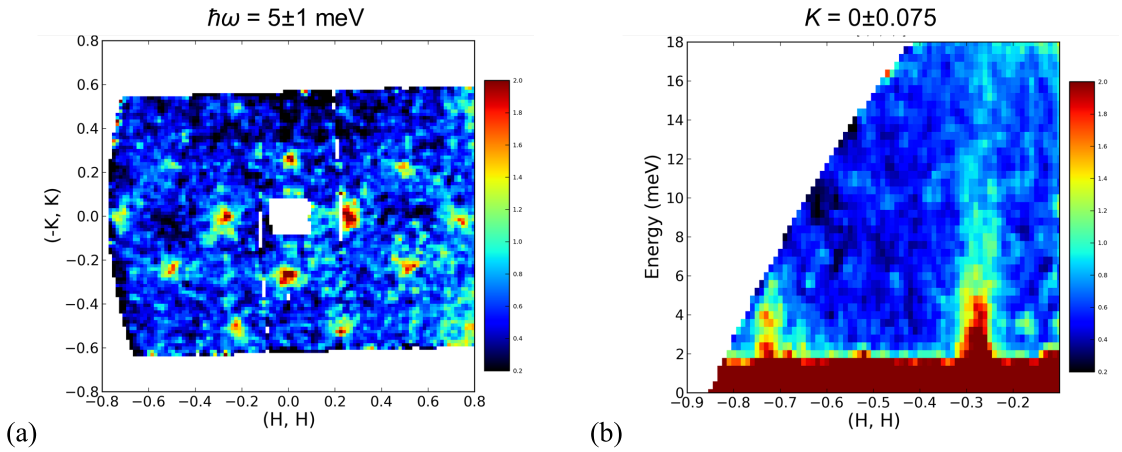

Fig. 1. Excitation spectra at 6 K measured with E_i = 24 meV. (a) Q map sliced at $\hbar\omega$ = 5±1 meV. (b) Q-$\hbar\omega$ map sliced at K = 0±0.075 in ($-K$, K).

To characterize the magnetic excitations more quantitatively, we performed constant-$\hbar\omega$ cuts of the signals at ($-0.5+\varepsilon$, $-0.5+\varepsilon$), and fitted each of the profiles to Gaussian to obtain the Q-integrated intensity at each $\hbar\omega$. Then, the integrated intensity was divided by the Bose factor $n(\omega)+1$. Figure 2 shows thus obtained intensity, which is proportional to $\chi''(\omega)$, at 6 K and 203 K as functions of $\hbar\omega$. At 6 K, the intensity gradually decreases as $\hbar\omega$ increases, which is consistent with the $\hbar\omega$ dependence of antiferromagnetic spin wave (broken line). On the other hand, at 203 K, the intensity at a low-$\hbar\omega$ region is much suppressed. We speculate that the suppression of the low-$\hbar\omega$ spectral weight is related with the development of the electron itinerancy. To conclude the relation between the magnetic excitations and the itinerancy, we need additional experiments to estimate the absolute intensity of the magnetic excitations and to compare them with a lower x sample.

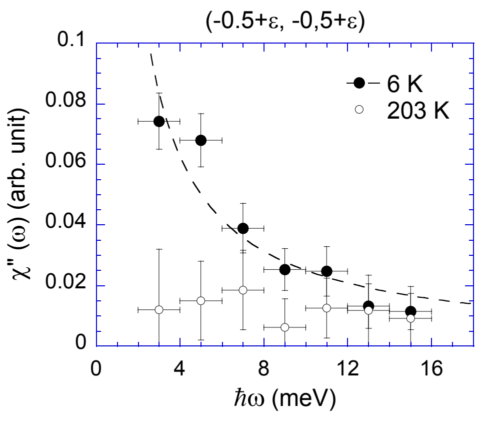

Fig. 2. $\chi''(\omega)$ at 6 K and 203 K. Broken line is a fit of the 6 K data to $1/\omega$.

[1] M. Uchida *et al.*, Phys. Rev. Lett. **106**, 027001 (2011); Phys. Rev. B **86**, 165126 (2012).

[2] P. G. Freeman *et al.*, Phys. Rev. B **71**, 174412 (2005).