実験報告書様式（一般利用課題・成果公開利用）

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# Experimental Report	承認日 Date of Approval 2012/12/28 承認者 Approver Ryoichi Kajimoto 提出日 Date of Report 2012/12/28
課題番号 Project No.2012B0142 実験課題名 Title of experiment: "Study of the magnetic excitations in the pseudogap phase of underdoped high-Tc cuprates $La_{1.925}Sr_{0.075}CuO_4$" 実験責任者名 Name of principal investigator: Masato Matsuura 所属 Affiliation: IMR, Tohoku University	装置責任者 Name of Instrument scientist Ryoichi Kajimoto 装置名 Name of Instrument/（BL No.） BL01 実施日 Date of Experiment 2012/11/27 ~ 2012/12/3

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.
Single crystals of $La_{1.925}Sr_{0.075}CuO_4$ (a total mass of 70g)

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 high-Tc superconductivity in cuprates appears when holes or electrons are doped into CuO_2 planes. Recently, similar magnetic excitations have been observed in high-Tc cuprates by inelastic neutron scattering (INS), namely, a characteristic hourglass-like magnetic excitation. The hourglass dispersion consists of upward and downward branches separated at the waist of the hourglass. Two characteristic parameters determining the shape of the low-energy part of the hourglass dispersion exhibit scaling behavior with respect to T_c: the incommensurability δ, and the "waist" energy of the hourglass, E_{cross}. However, the relation between the pairing interaction and hourglass dispersion is still under debate because the origin of the two types of branches is not fully understood.

In order to elucidate the origin of the hourglass dispersions, we have performed INS experiment on the underdoped $La_{2-x}Sr_xCuO_4$ (LSCO) with x=0.075 at 4SEASONS with special attention to thermal change at high-temperatures. For x=0.075, the so-called "pseudo-gap" has been observed by angle resolved photoemission spectroscopy (ARPES) below T^*~350 K. To measure magnetic spectra at well above T^*, we used special sample folder fixed by aluminum cement which holds even at high temperatures (T>400K).

INS experiments were carried out by using the Fermi chopper spectrometer "4 SEASONS" installed at BL01 of Materials and Life Science Experimental Facility in the J-PARC. The beam power of the J-PARC accelerator was 200~300 kW at the experiment. By using multi-incident energies (E_i) technique, we could obtain several data

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

sets with different E_i; 255 meV, 74 meV, 35 meV, 20 meV and 13meV simultaneously. The frequency of the Fermi chopper was set to 300 Hz. The data was collected at 5K, 300 K, 400 K and 500 K. In this report, we label the momentum transfer (Q_x, Q_y, Q_z) in the pseudo-tetragonal notation.

Figures 1 show constant-energy slices of data obtained at T=5K. At low energy, E=3meV, we confirmed incommensurate peak structure at (1/2, 1/2±δ) and (1/2±δ, 1/2). The incommensurate peaks merge together around 32.5meV, which is consistent with the E_{cross} reported in the LSCO with similar Sr composition[1]. Above Ecross, the magnetic excitation disperses with increasing energy. At E=155meV, the scattering pattern forms ring around antiferromagnetic zone center (1/2,1/2), which is similar to what one would expected from spin-wave.

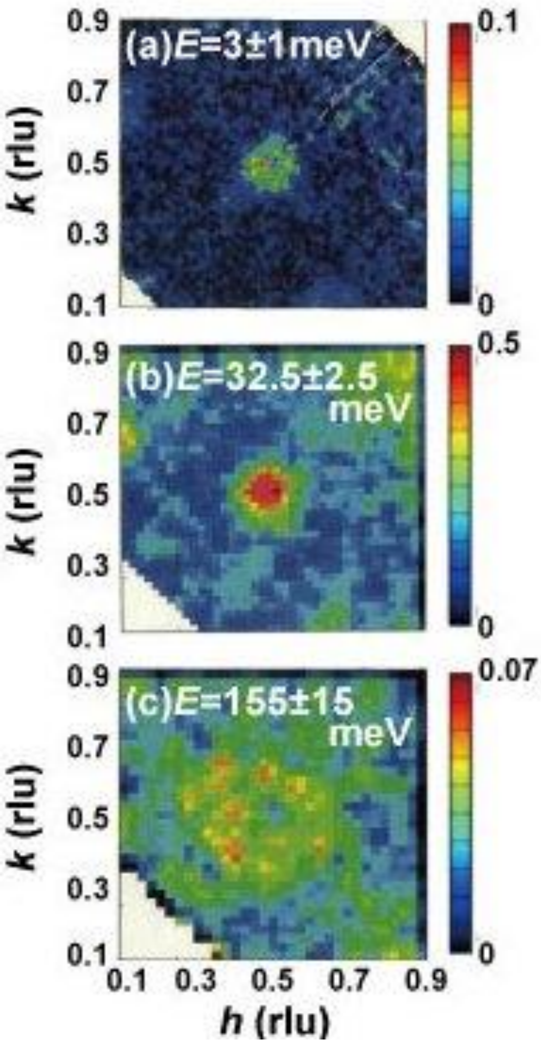

Fig.1 Constant-energy slices of data obtained at T=5K.

As temperature increases up to T=300 K, we observed change in the downward dispersion below E_{cross}: the incommensurate peak structure merges at (1/2,1/2), which could be explained by disappearance of the fluctuating spin stripes. For upward dispersion above E_{cross}, the dispersion is hardly affected at 300K, although peak broadens considerably. With increasing temperature further up to 400 K, which is well-above the onset temperature of the pseudogap measured by ARPES, we observed dramatic change in the upward dispersion: the ring-like scattering pattern around (1/2,1/2) merges at (1/2,1/2) with almost the same peak width as that at E_{cross}. Then, at T=400K, the energy dependence of the peak width of the magnetic excitations does not change much with energy, which is similar to what observed in the itinerant antiferromagnets Cr [2] and V_2O_3 [3]. Now, we are discussing this thermal change of the magnetic spectra in relation to the crossover from itinerant behavior to local one across the T*.

Reference

[1] M. Matsuda et al. Phys. Rev, Lett., **101**, 197001 (2008).
[2] T. Fukuda et al., J. Phys. Soc. Jpn, **65**, 1418 (1996).
[3] Wei Bao et al., Phys. Rev. Lett., **78**, 507 (1997).