（ ※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。 ）

MLF Experimental Report

課題番号 Project No. 2016A0160	提出日 Date of Report 2017/4/22
実験課題名 Title of experiment Origin of variation in the entire spin excitation spectrum induced by the electron-doping in cuprate oxide	装置責任者 Name of Instrument scientist Shinichi Itoh
実験責任者名 Name of principal investigator Fujita Masaki	装置名 Name of Instrument/（BL No.） HRC BL. 12
所属 Affiliation: Institute for Materials Research, Tohoku University	実施日 Date of Experiment 2016/12/7 – 2016/12/14

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.

Annealed $Pr_{1.4-x}La_{0.6}Ce_xCuO_4$ (x = 0.12)

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.

Experimental method : Inelastic neutron scattering

Measured temperature : 5 K

Incident neutron energy : 460, 122.5, 24.5 meV

It is widely accepted that spin fluctuation plays an important role in the mechanism of superconductivity is in high-Tc cuprate superconductors. The parent compound of electron doped cuprate $Pr_{1.4-x}La_{0.6}Ce_xCuO_4$ (PLCCO) is antiferromagnetically ordered Mott insulator and the magnetic ordered phase of as-grown PLCCO is robust against the electron-doping. After reduction annealing process, superconductivity emerges with the suppression of magnetic order in a particular Ce doping region (0.12 < x < 0.20). Therefore, study of annealing effects on spin excitations is important for the understanding of superconductivity in electron doped cuprate.

In the present experiment, we performed inelastic neutron scattering measurements on annealed

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

$Pr_{1.4-x}La_{0.6}Ce_xCuO_4$ (x = 0.12). In Figs. 1 (a)–(f). the constant-energy spectra at (a) 220 meV, (b) 60 meV and (c) 4 meV are shown for the present annealed superconducting sample with comparing to the results for as-grown non-superconducting samples. The scattering intensity was converted into the absolute units by using a vanadium standard. In both samples, magnetic signals were clearly seen around (0.5, 0.5) in wide energy range. As seen in Fig. 2 (a), the peak profile in the annealed sample is broader in the low-energy region, while it is sharper in high energy region. Broadening of magnetic peak in the low-energy region is consistent with the previous neutron-scattering study by triple-axis spectrometer [1] and suggests a degradation of spin correlations. On the other hand, the change induced by annealing in the high-energy region indicates an elongation of magnetic excitation spectrum along the energy direction. The local spin susceptibility above 125 meV is slightly reduced by annealing, while the intensity in the low-energy region below 60 meV. These result suggest an individual annealing effect on the spin excitation separated by energy, which is different from the intensity reduction in the entire energy region below 300 meV without change of dispersion relation in the parent compound [2]. The spin excitations in the electron-doped system could not understood by simple collective motion of localized spins and effected by electron carrier as hour-glass shaped spin excitations in hole doped cuprate superconductors [3].

[1] M. Fujita *et al.*, Phys. Rev. Lett. **101**, 107003 (2008). [2] K. Tsutsumi, Ph. D. Thesis, Tohoku Univ. (2015). [3] B. Vignolle *et al.*, Nature Phys. **546**, 163 (2007).

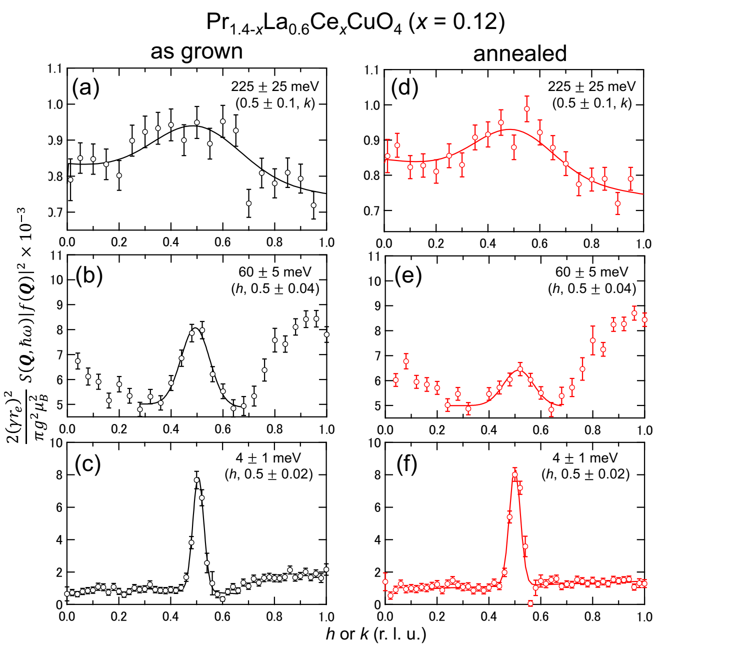

Fig. 1 Constant energy spectra in (a)－(c) as grown and (d)－(f) annealed $Pr_{1.4-x}La_{0.6}Ce_xCuO_4$ for E = 225, 80 and 4 meV. Solid lines are the results of Gaussian-fitting. Result for the as-grown sample was obtained in the previous measurement.

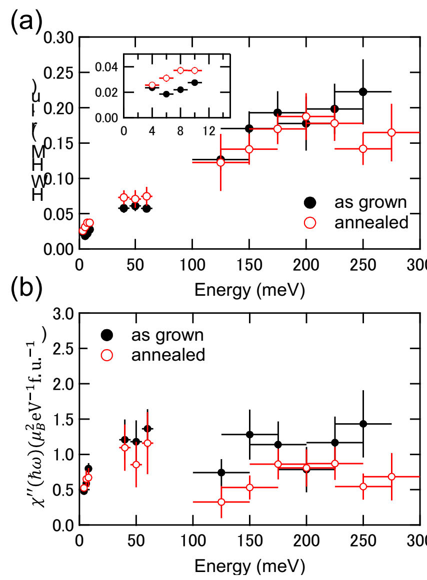

Fig. 2 (a) Energy dependence of the peak-witde (half-width at half maximum) and (b) dynamical spin susceptibility in as grown and annealed