 <b>MLF Experimental Report</b>	提出日 Date of Report 2013. 7. 4
課題番号 Project No. 2012B0062 実験課題名 Title of experiment $\mu$ SR study of different magnetic states in electron-doped $\text{Pr}_{1.3-x}\text{La}_{0.7}\text{Ce}_x\text{Cu}_{4+\delta}$ ( $x = 0.10$ ) single crystals depending on the $\delta$ value 実験責任者名 Name of principal investigator Tadashi Adachi 所属 Affiliation Department of Engineering and Applied Sciences, Faculty of Science and Technology, Sophia University	装置責任者 Name of responsible person Yasuhiro Miyake 装置名 Name of Instrument/(BL No.) D1 実施日 Date of Experiment 2013. 2. 10 – 12

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.  Pr-based high- $T_c$ superconducting cuprates $\text{Pr}_{1.3-x}\text{La}_{0.7}\text{Ce}_x\text{Cu}_{4+\delta}$ ( $x = 0.10$ ) Single crystals
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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.  <p>Zero-field (ZF) and longitudinal-field <math>\mu</math>SR measurements have been performed at temperatures between 3 K and 250 K for non-superconducting as-grown, non-superconducting 650°C-reduced, superconducting 800°C-reduced (<math>T_c \sim 25</math> K) <math>\text{Pr}_{1.3-x}\text{La}_{0.7}\text{Ce}_x\text{Cu}_{4+\delta}</math> single crystals with <math>x = 0.10</math>. Measurements around the base temperature have been performed in the single-pulsed mode, while others have been performed in the double-pulse mode.</p> <p>During the measurements, the new positron counter ‘KALLIOPE’ installed at D1 beam line did not work well, so the statistics of the spectra is not enough high and we needed to perform measurements for a longer time than planned.</p> <p>Figure 1 shows ZF-<math>\mu</math>SR time spectra of the as-grown and 800°C-reduced single crystals. For the as-grown crystal, the spectrum at 250 K shows Gaussian-like slow depolarization due to randomly oriented nuclear spins.</p>
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## 2. 実験方法及び結果(つづき) Experimental method and results (continued)

Below 250 K, a fast depolarization of muon spins, followed by a muon-spin precession at 3 K, is observed, indicating the formation of a long-range magnetic order. For the 800°C-reduced crystal, although the spectrum is Gaussian-like at 200 K, a fast depolarization of muon spins is observed with decreasing temperature below 200 K. At 3 K, the spectrum consists of fast depolarization below  $\sim 1 \mu\text{s}$ , slow depolarization between  $\sim 1 \mu\text{s}$  and  $\sim 4 \mu\text{s}$  and flat spectrum above  $\sim 4 \mu\text{s}$ . This peculiar behavior of the spectrum at 3 K suggests the coexistence of a slowly fluctuating region of Cu spins and a region of a short-range magnetic order in a crystal. Therefore, it is concluded that there exist the AF spin fluctuations even in the superconducting crystals of  $x = 0.10$ , which is consistent with our simple band model including the strong correlation of electrons [1].

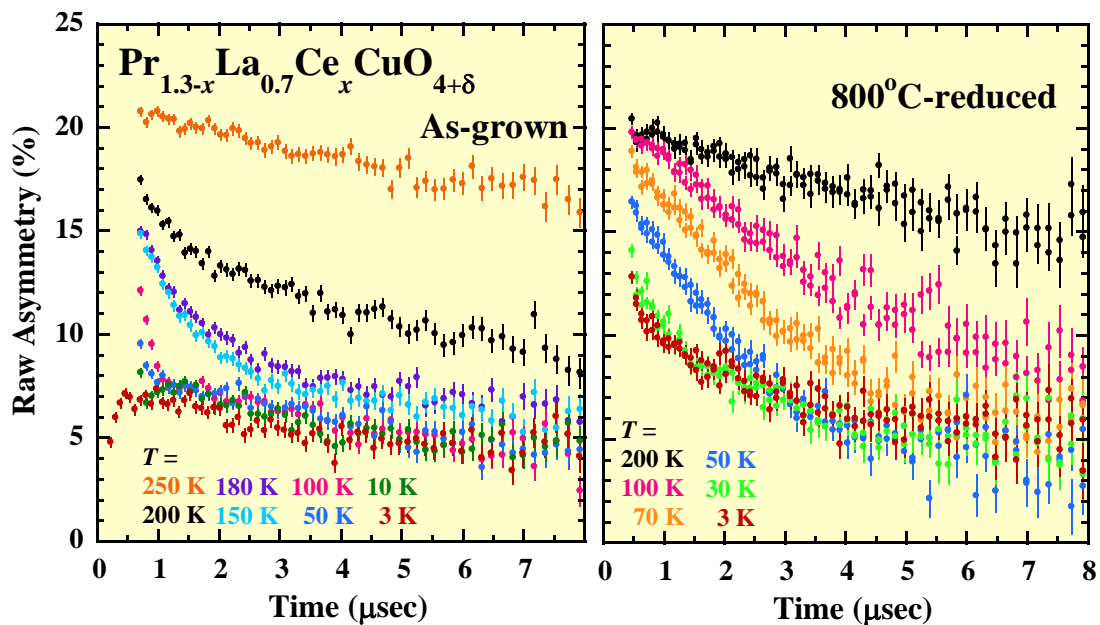


Fig. 1. Zero-field  $\mu\text{SR}$  time spectra of the as-grown and 800°C-reduced  $\text{Pr}_{1.3-x}\text{La}_{0.7}\text{Ce}_x\text{Cu}_{4+\delta}$  single crystals with  $x = 0.10$ .

- [1] T. Adachi, Y. Mori, A. Takahashi, M. Kato, T. Nishizaki, T. Sasaki, N. Kobayashi and Y. Koike, J. Phys. Soc. Jpn. **82**, 063713 (2013).