Spin correlations in T'-type $Pr_{2-x}Ca_xCuO_4$

M. Fujita[A], T. Taniguchi[A], T. Wang[A,B], P. Xie [A,B]

[A]*IMR, Tohoku Univ.*, [B]*Dept. of Phys., Tohoku Univ.*

In the physics of high-T_c superconductivity, one fundamental question is, "How do Mott insulating cuprates transform into metal with doping?" The magnetic properties of the CuO_2 layers in high-T_c superconducting (SC) materials are intimately coupled with the charge mobility, and therefore, the evolution of spin correlation with doping has been extensively studied [1]. It is well known that a small amount of hole-doping into La_2CuO_4 having distorted K_2NiF_4-type (T-type) crystal structure destroys the antiferromagnetic (AF) order, and the SC phase appears with further doping. On the other hand, Nd_2CuO_4-type (T'-type) structured La_2CuO_4 with no apical oxygen has contrasting properties to that in T-structured La_2CuO_4. It was reported that in contrast to the rapid suppression of AF order by Sr-doping in the T-structured La_2CuO_4, the AF order in Nd_2CuO_4 is quite robust against Sr-doping [2], and no evidence of superconductivity was observed in the T'-type hole-doped system. These experimental facts suggest the structural effect on the physical properties. Thus, it is highly desirable to study the evolution of spin correlations in the T' phase of hole-doped compound and to compare them in the T-structured. We, therefore, performed elastic neutron scattering measurements on T'-type $Pr_{1.85}Ca_{0.15}CuO_4$ and T-type $La_{1.875}Ba_{0.065}Sr_{0.06}CuO_4$ at HER.

As shown in Fig. 1, a magnetic peak was clearly observed in T'-type $Pr_{1.85}Ca_{0.15}CuO_4$ at the commensurate position of (1, 0, 1). The intensity appears at T_N ~280 K with cooling. These features are comparable to the magnetic properties reported to T'-type Pr_2CuO_4 and T-type La_2CuO_4. Thus, the hole-doping effects on the spin correlation in T'-type cuprate is negligible. It was also confirmed that AF ordering temperature is slightly suppressed due to a proper oxygen reduction annealing. Considering the negligible hole doping effect on the spin correlations and the electron doping due to oxygen reduction annealing, the annealed $Pr_{1.85}Ca_{0.15}CuO_4$ has electrons in the system. Thus, the carriers in T'-type $P_{2-x}Ca_xCuO_4$ can be controlled through both Ca doping and annealing.

On the other hand, magnetic peaks were observed at incommensurate (IC) positions of (0.5±δ, 0.5, 0) and (0.5, 0.5±δ, 0) in T-type $La_{1.875}Ba_{0.065}Sr_{0.06}CuO_4$ as was reported previously [3]. The onset temperature for the appearance of magnetic intensity was ~30 K, which is much lower than T_N for T'-type $Pr_{1.85}Ca_{0.15}CuO_4$. Thus, the spin correlations are strongly affected by the crystal structure, and the IC spin correlation would be the nature seen in the T-type cuprate.

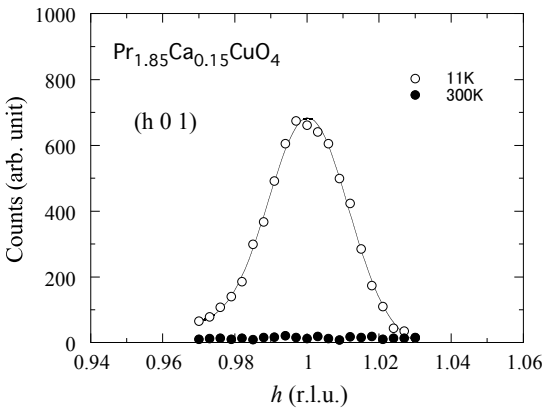

Fig. 1. Neutron scattering intensity of T'-type $Pr_{1.85}Ca_{0.15}CuO_4$ measured along *h*-direction through (1, 0, 1) reciprocal position.

[1] R. J. Birgeneau *et al.*, J. Phys. Soc. Jpn. **75**, 111003 (2006).
[2] Matthew J. Rosseinsky and Kosmas Prassides, Physica B **180 & 181**, 408 (1992).
[3] Fujita, M, Goka, H, Yamada, K & Matsuda, M. Phys. Rev. Lett. **88**, 167008 (2002).