Impurity substitution effects on magnetic correlation in $La_{2-x}Sr_xCu_{1-y}M_yO_4$ (M = Fe, Al)

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The so-called stripe correlation of spins and holes has been studied intensively in order to clarify its relationship with the appearance of the high-T_c cuprate superconductivity. Impurity substitution is one of crucial ways to study the stripe correlation, because substituted impurities tend to slow down the spin fluctuations, leading to the formation of the static stripe order [1-3]. Here we summarize our work on impurity effects on the magnetic correlation and introduce our recent results of magnetic Fe^{3+}- and nonmagnetic Al^{3+}-substituted $La_{2-x}Sr_xCu_{1-y}M_yO_4$ (M = Fe, Al) revealed by muon-spin-relaxation (μSR) and magnetic susceptibility experiments.

It has been found that the 5% Fe substitution induces double successive magnetic transitions in the overdoped regime of $La_{2-x}Sr_xCu_{1-y}Fe_yO_4$, as shown in Fig. (a). While the magnetic transition at higher temperatures is a spin-glass transition of Fe^{3+} spins due to the RKKY interaction, the magnetic transition at lower temperatures is the transition to the stripe order. Furthermore, the stripe order develops both in the underdoped and overdoped regimes and disappears at the hole concentration per Cu, p, of ~ 0.30 where the superconductivity disappears in pristine $La_{2-x}Sr_xCuO_4$. The 3% Al substitution has also been found to induce the transition to the stripe order in a wide range of p in $La_{2-x}Sr_xCu_{1-y}Al_yO_4$ as shown in Fig. (b). The magnetic transition temperature decreases with hole doping, and disappears at p ~ 0.30. A similar result has been obtained in Zn-substituted $La_{2-x}Sr_xCu_{1-y}Zn_yO_4$ [4], where the Cu-spin correlation is developed by nonmagnetic Zn^{2+} substitution up to p ~ 0.30. Therefore, it has been concluded that, regardless of the type of impurities, the development of the stripe correlation is observed up to p ~ 0.30, suggesting an intimate relation between the stripe correlation and the appearance of the high-T_c superconductivity. Results of Ni and Ga substitution will also be discussed.

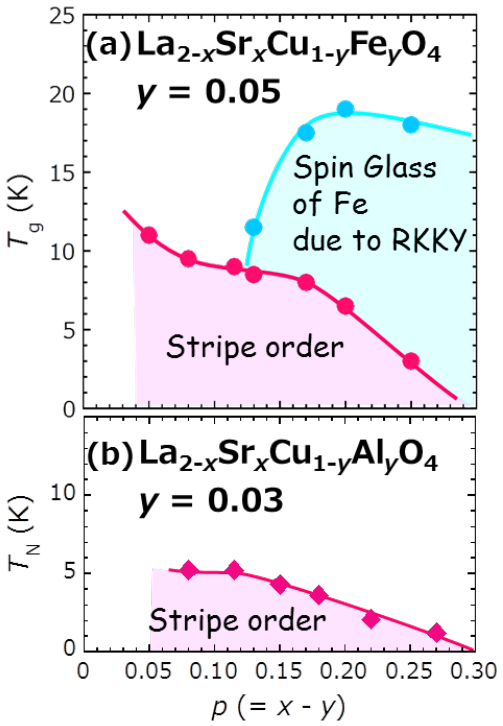

Fig.: (a) Hole concentration per Cu, p, dependence of T_g, defined as local maximum in magnetic susceptibility, for $La_{2-x}Sr_xCu_{1-y}Fe_yO_4$ with y = 0.05. (b) p dependence of the magnetic transition temperature defined by μSR, T_N, for $La_{2-x}Sr_xCu_{1-y}Al_yO_4$ with y = 0.03.

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