Effect of Fe substitution on Cu-spin dynamics in the electron-doped cuprates $Eu_{2-x}Ce_xCuO_{4+\alpha-\delta}$

Risdiana,*[1] M. Manawan,*[1] Fitrilawati,*[1] L. Safriani,*[1] T. Saragi,*[1] and I. Watanabe*[2]

The effect of impurities on the Cu-spin dynamics in high-T_c cuprates has attracted great research interest in relation to the mechanism of high-T_c superconductivity. In the hole-doped cuprates of $La_{2-x}Sr_xCu_{1-y}Zn_yO_4$ (LSCZO),[1,2] the non-magnetic imputity Zn tends to slow down the Cu-spin fluctuations in the whole superconducting regime. In the electron-doped cuprates of the $Pr_{1-x}LaCe_xCu_{1-y}Zn_yO_4$,[3] on the other hand, the time spectra are independent of the Zn concentration, which is probably due to the strong effect of the Pr^{3+} moment. For Ni substitution effects, in $La_{2-x}Sr_xCu_{1-y}Ni_yO_4$, a hole-trapping effect together with the stripe-pinning effect of Ni was clearly observed.[4] As an electron doped system, we prepared samples without the Pr^{3+} moment, namely $Eu_{1.85}Ce_{0.15}Cu_{1-y}Ni_yO_{4+\alpha-\delta}$ (ECCNO),[5] in order to clarify the effects of Ni on the Cu-spin dynamics. As shown in Fig. 1, the development of the Cu-spin correlation is induced at low temperatures through Ni substitution. Importantly, in the μSR time spectra of ECCNO, the trace of the development of the Cu-spin correlation was observed at low temperatures for the Ni-substituted samples. However, no clear evidence of the Ni substitution effect on the Cu-spin dynamics has been obtained yet.

The effect of Fe substitution on Cu-spin dynamics has attracted much attention owing to the significant effect of its large magnetic moment on the superconductivity. In hole-doped systems, it has been found that the magnetic transition temperature and magnetic correlation are enhanced through 1% Fe substitution in a wide range of hole concentrations at which superconductivity appears in Fe-free $La_{2-x}Sr_xCuO_4$.[6] On the other hand, the effects of magnetic impurities on the Cu-spin dynamics in electron-doped systems have not yet been reported, which prevents us from drawing a clear conclusion on the relation between the dynamical stripe correlations and superconductivity in electron-doped cuprates. Therefore, partial substitution by Fe in electron-doped cuprates is a potential method of using an impurity to study the Cu-spin dynamics in the electron-doped system.

Figure 2 shows the μSR time spectra of $Eu_{1.85+y}Ce_{0.15-y}Cu_{1-y}Fe_yO_{4+\alpha-\delta}$ (ECCFO) with y = 0.005, 0.01, 0.02, and 0.03 at various temperatures. For all samples, the spectra show an exponential-type depolarization behavior at temperatures below ~50 K. Gaussian-type depolarization behavior was only observed at temperatures above ~200 K, which is higher than the corresponding temperature of the ECCNO

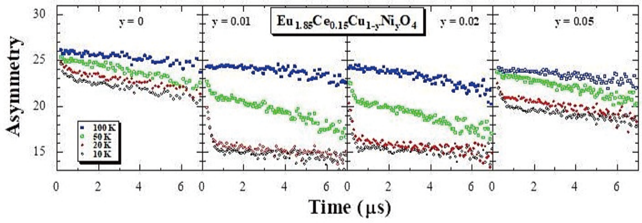

Fig. 1. μSR spectra of $Eu_{1.85}Ce_{0.15}Cu_{1-y}Ni_yO_{4+\alpha-\delta}$ with y = 0, 0.01, 0.02, and 0.05 at various temperatures.[5]

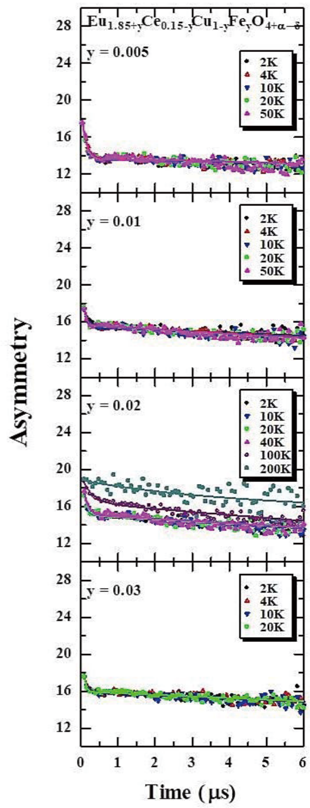

Fig. 2. μSR spectra of $Eu_{1.85+y}Ce_{0.15-y}Cu_{1-y}Fe_yO_{4+\alpha-\delta}$ with $y = 0.005$, 0.01, 0.02, and 0.03 at various temperatures.

sample at $y = 0.02$. These results also indicate the trace of development of the Cu-spin correlation. The coherent precession of muon spins are observed below 50 K, suggesting the existence of a static magnetic ground state.

The trace of stabilization of the Cu-spin fluctuations by Fe substitution indicates a possibility that the stripe model can globally explain high-T_c superconductivity as in the case of hole-doped systems.

References

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*1 Department of Physics, Padjadjdaran University, Indonesia
*2 RIKEN Nishina Center