μSR Result on Magnetic ground state of $Ce_{1-x}La_xT_2Al_{10}$ (T = Ru, Os)

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Ce-based caged-type compounds, CeT_2Al_{10} (T= Ru, Os) have generated great interest due to their Kondo semiconducting state and an anomalously high magnetic ordering temperature $T_0 \sim 30$ K with spin gap formation at low temperatures [1-2]. Neutron diffraction studies of CeT_2Al_{10} for T= Ru and Os revealed small ordered moments, 0.34 μB and 0.29 μB, along the *c*-axis respectively although these two compounds exhibit a large anisotropy of magnetic susceptibility $\chi_a > \chi_c > \chi_b$ [3,4]. This indicates that the moment direction is governed by the anisotropic magnetic exchange and not by the CEF anisotropy [5,6].

In order to investigate the relation between the moment direction and the spin gap energy, magnetic Ce ($4f^1$) is substituted with nonmagnetic La ($4f^0$), as in $Ce_{1-x}La_xT_2Al_{10}$, assuming that it would change the magnetic moment due to different lattice parameters. However, an unusually ordered state is realized. In the case of $Ce_{0.9}La_{0.1}Os_2Al_{10}$, neutron diffraction studies have shown that the ordered moment remains along the *c*-axis and the Ce moment reduces with an increasing La concentration without any changes in the spin direction [6]. Compared to $Ce_{1-x}La_xRu_2Al_{10}$, the direction of the ordered moment changes from *c*-axis to *b*-axis and the moment is reduced to 0.18 μB after 7% La doping [7].

In order to gain further information on the microscopic change in magnetism, we performed muon spin relaxation (*μSR*) on a $Ce_{1-x}La_xRu_2Al_{10}$ (x = 0.05, 0.07, 0.10) and $Ce_{1-x}La_xOs_2Al_{10}$ (x = 0.10, 0.24, 0.50) alloy. The *μSR* experiments were carried out using the JANIS in CHRONUS (Port-4) spectrometer in longitudinal geometry at RIKEN-RAL, UK. Fig. 1 (a-d) shows the zero-field (ZF) *μSR* spectra of $Ce_{1-x}La_xRu_2Al_{10}$ (x = 0.07 and 0.10) and Fig. 2 (a-d) shows the ZF- *μSR* spectra for $Ce_{1-x}La_xOs_2Al_{10}$ (x = 0.24 and 0.50). The panels on the left side of the figures show the spectra at low temperatures, while those on the right side show the spectra at high temperatures.

As shown in the Figs. 1(a), 1(c), and 2(a), the spectra exhibit clear signs of oscillation with strong damping confirming the long range magnetic ordering of the Ce moment below T_0. Meanwhile in Figs. 1(b), 1(d) and 2(b), we can observe the magnetic transition at 24 K, 21 K, and 8 K, respectively. On the other hand, the *μSR* spectra of $Ce_{1-x}La_xOs_2Al_{10}$ (x = 0.5) at 2 K in Fig. 2(c) reveal a non-magnetic ground state below T_0. The same behavior can be observed in Figs. 1(b), 1(d), 2(b), and 2(d) above the magnetic transition temperature which is a typical muon response to static distribution of the nuclear dipole moment.

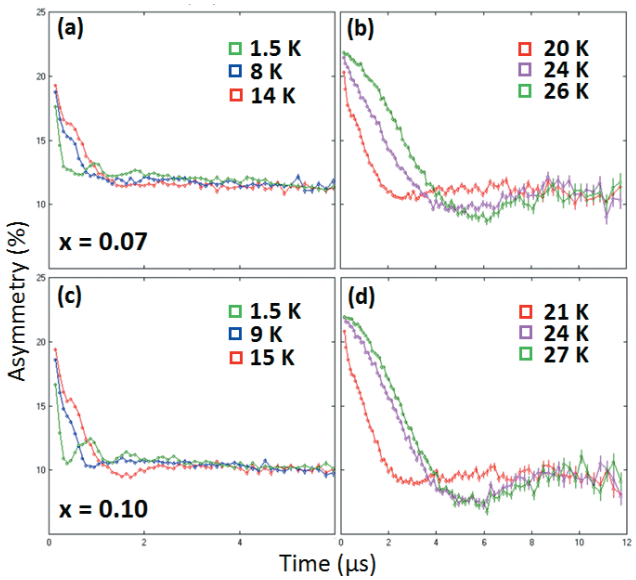

Fig. 1 ZF-*μSR* of $Ce_{1-x}La_xRu_2Al_{10}$

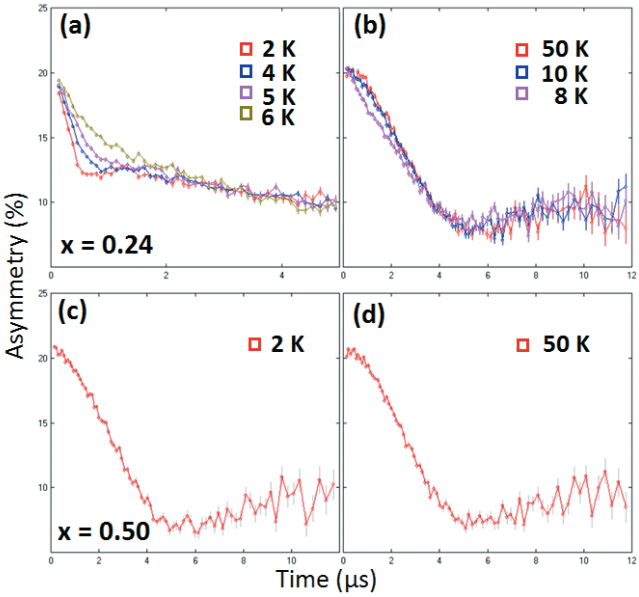

Fig. 2 ZF-*μSR* of $Ce_{1-x}La_xOs_2Al_{10}$

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