Magnetic ordered states of hole-doped pyrochlore iridates $(Y_{1-x-y}Cu_xCa_y)_2Ir_2O_7$ investigated by μSR

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The interplay between electron-electron correlation and spin-orbit coupling interaction leads to various exotic states in iridates such as Mott insulator, spin liquid, and Weyl semimetal.[1)] Pyrochlore iridates, $R_2Ir_2O_7$ (R = Y and lanthanides) exhibit a largely systematic metal-insulator transition (MIT) among pyrochlore systems and is observed with accompanying magnetic transition by changing R ion. The Ir atom is expected to play a critical role because Ir has the large spin-orbit coupling effect, which is predicted to cause exotic magnetic properties in $R_2Ir_2O_7$. Among $R_2Ir_2O_7$, Mott insulator $Y_2Ir_2O_7$ (Y^{3+}: non-magnetic; Ir^{4+}: $5d^5$) is an ideal system for the investigation of the magnetic properties of the Ir atom to clarify its origin. This is because the Y atom does not possess any localized magnetic moments and exhibits the all-in all-out magnetic ground state below the MIT temperature of approximately 170 K.[2–4)] Further, the mechanism of MIT should also be studied by doping holes to the system.[5–7)] A key issue on the Mott insulator is the hole-doping effect; therefore, we investigated the changes in the magnetic properties of $(Y_{1-x-y}Cu_xCa_y)_2Ir_2O_7$ ($x = 0.05$) in which the hole concentration can be controlled by substituting Ca for Y.

The μSR measurement in the zero-field condition (ZF-μSR) was carried out at the RIKEN-RAL Muon Facility, Rutherford-Appleton Laboratory, in the UK using a pulsed positive muon beam. We measured the ZF-μSR time spectra of polycrystalline samples, $(Y_{1-x-y}Cu_xCa_y)_2Ir_2O_7$ ($x = 0.05$) and analyzed them using the following analysis function.

$$A(t) = A_0 e^{-\lambda t} \quad (1)$$

In Eq. (1), $A(t)$ is the asymmetry of the muon-spin polarization at t, A_0 is the initial asymmetry at $t = 0$, and λ is the depolarization rate of the asymmetry parameter.

Figure 1 shows the temperature dependence of A_0 measured on $(Y_{1-x-y}Cu_xCa_y)_2Ir_2O_7$ ($x = 0.05$) at various values of y. Sudden decreases in A_0 were observed with a decrease in the temperature of the samples up to $y = 0.10$. This decrease in A_0 was not observed for $y = 0.20$ in the metallic state. The decrease implies the appearance of the fast depolarizing component caused by the slowing down of the fluctuations of Ir spins. The dashed lines in Fig. 1 indicate the onset temperatures of the appearance of the magnetically ordered state in $(Y_{1-x-y}Cu_xCa_y)_2Ir_2O_7$ ($x = 0.05$). It is clear that the magnetically changes in the electronic state from insulating to metallic. This study will be soon published.

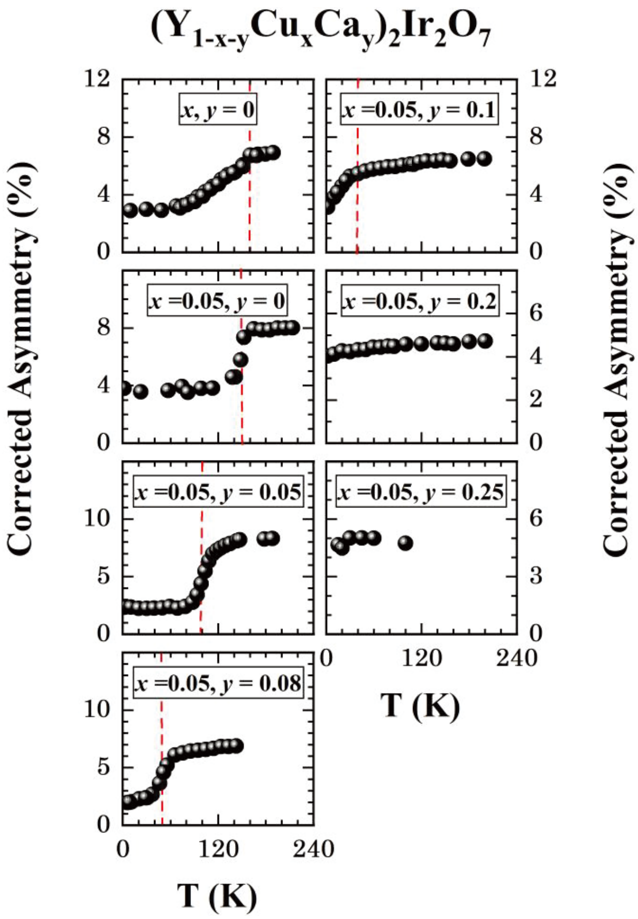

Fig. 1. Temperature dependence of initial asymmetry, A_0 for $(Y_{1-x-y}Cu_xCa_y)_2Ir_2O_7$ obtained from zero-field μSR measurements.

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