MLF Experimental Report

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実験課題名 Title of experiment muSR study on a Mott State in the Iridium oxides	装置責任者 Name of responsible person Yasuhiro Miyake
実験責任者名 Name of principal investigator Hirotaka Okabe	装置名 Name of Instrument/(BL No.) Muon D1
所属 Affiliation National Institute for Materials Science	実施日 Date of Experiment 2010 5/29～31

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）

Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

Barium iridates:

$Ba_{1.9}K_{0.1}IrO_4$ (pellets)

$Ba_{1.97}La_{0.03}IrO_4$ (pellets)

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）

Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

In order to obtain insight into the magnetic ground state of layered iridates, we have performed the μSR experiment under zero applied field (ZF-μSR). The μSR technique is especially suited for detecting internal magnetic fields in this study, because it is known that neutron studies of Ir compounds are significantly hindered by the strong absorption of neutrons by Ir. Since the samples were sensitive to air, all arrangements were performed in a glove bag filled with dry nitrogen gas. Figure 1(a) and (b) show the time-dependent muon-positron decay asymmetry of $Ba_{1.9}K_{0.1}IrO_4$ and $Ba_{1.97}La_{0.03}IrO_4$ at various temperatures. In Figure 1 (a), the asymmetry shows a strong decay near 230 K, which can be attributed to the critical slowing down of spin fluctuation. We observed the spontaneous muon-spin precession below 215 K, which is a characteristic of a homogeneous local field appears on the time scale of the μSR technique (10^{-6}~10^{-9} s) at each muon site, and involves the majority of the sample volume. This provides strong evidence for the existence of the long range antiferromagnetic spin order in this phase. The solid curves in Figure 1(a) are the best fits of the data from the following muon spin relaxation function $G_z(t)$:

2. 実験方法及び結果（つづき） Experimental method and results (continued)

$$G_Z(t) = A_1 \exp(-\lambda_1 t)\cos(2\pi f t + \phi) + A_2 \exp(-\lambda_2 t) + A_{bg},$$

where $A_{1,2}$ is the initial asymmetry, f (= $\gamma B_\mu / 2\pi$) is the muon spin precession frequency (with B_μ being the local magnetic field, $\gamma = 2\pi \times 135.54$ MHz/T, γ being the muon gyromagnetic ratio), ϕ is the initial phase of the oscillatory part, λ_1 and λ_2 are the exponentially relaxation rates of the precessing component and the purely relaxing component, respectively. A_{bg} is the time-independent background contribution of the silver foil that surrounds the sample. The temperature variation of the relaxation rates and the precession frequency are shown in Figure 1(c) and 1(d), respectively. From the fitting analysis, λ_1 exhibits a peak at 230 K with decreasing temperature, probably due to the effects of short-range correlations enhancing spin fluctuations near the transition. The precession frequency f also exhibits an appearance of the internal magnetic field at the muon site from ordered magnetic moments, because f is proportional to the static magnetic field B_μ at the muon site. In Figure 1(d), a gradual increase of precession frequency is observed below 50 K. This may be from either a spin reorientation or changing of the muon sites.

Now we turn to the case of electron-doped sample, $Ba_{1.97}La_{0.03}IrO_4$. We note the absence of any sign of a muon precession at 175 K, in contrast to the hole-doped $Ba_{1.9}K_{0.1}IrO_4$. However, the gradual decrease in A_2 (not shown) below 250 K indicates that the magnetic order develops gradually with decreasing T. This suggests that a slight substitution of La produces a static inhomogeneous distribution of μ+ precession frequencies; muons probably experience a broad range of magnetic fields in the partially-disordered antiferromagnetic state.

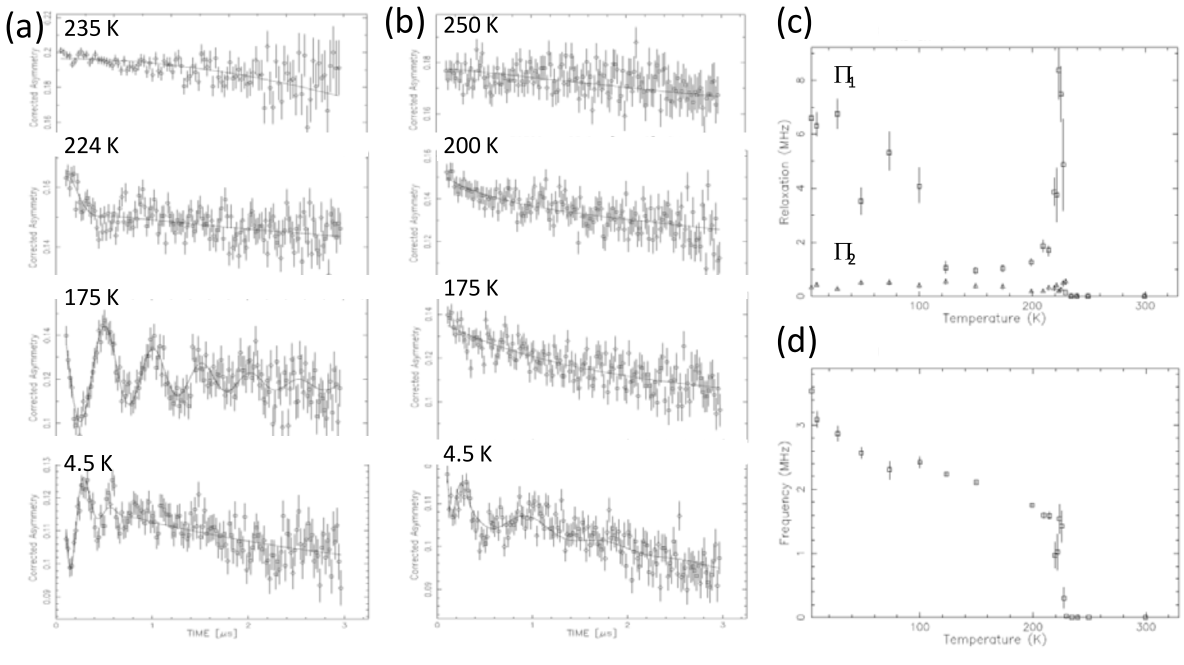

Fig. 1 Time evolution of the corrected asymmetry of (a) $Ba_{1.9}K_{0.1}IrO_4$ and (b) $Ba_{1.97}La_{0.03}IrO_4$ at various temperatures, showing fits are described in the text. (c) The relaxation rates and (d) the muon precession frequency versus temperature of $Ba_{1.9}K_{0.1}IrO_4$.