

Supplemental information

## I. SAMPLE PROPERTIES

Figure S1(a) show powder x-ray diffraction patterns of  $\text{Sr}_{2-x}\text{M}_x\text{IrO}_4$  ( $\text{M} = \text{La}, \text{K}, x = 0.075$  for La and  $0.055$  for K), measured using a conventional x-ray spectrometer with a graphite monochromator (RINT-1100, Rigaku). The parent sample showed tiny impurity peak ( $2\theta \sim 18$  deg) while no such intensity was observed in La and K0.055 samples, indicating high phase purity of samples. Figs. S1(b) and (c) show the temperature dependence of the resistivity and the magnetic susceptibility of samples. The electrical resistivity was measured by a conventional dc four-probe method. The magnitude of the resistivity was reduced by both type of doping but samples remained insulating. Magnetic susceptibility measurements were performed using a superconducting quantum interference device magnetometer (Quantum Design MPMS-R2). Both of the Néel temperature and the magnetic moment of samples were reduced by La or K substitution for Sr.

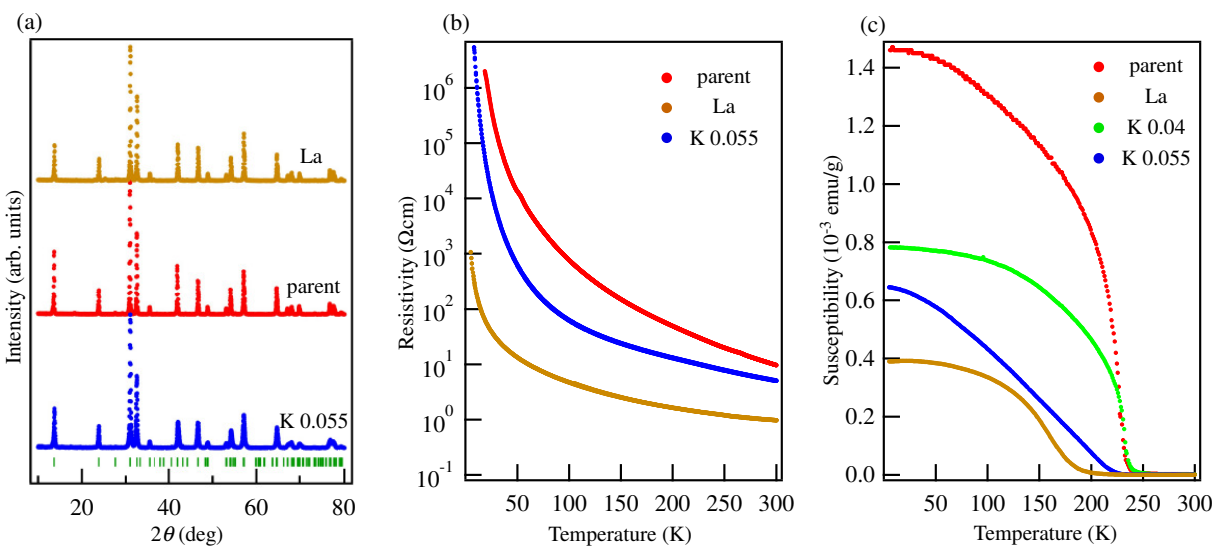


FIG. 1. x-ray diffraction patterns (a) and temperature dependence of resistivity of  $\text{Sr}_2\text{IrO}_4$ ,  $\text{Sr}_{1.925}\text{La}_{0.075}\text{IrO}_4$ , and  $\text{Sr}_{1.945}\text{K}_{0.055}\text{IrO}_4$  samples. (c) Temperature dependence of the magnetic susceptibility of  $\text{Sr}_2\text{IrO}_4$ ,  $\text{Sr}_{1.925}\text{La}_{0.075}\text{IrO}_4$ ,  $\text{Sr}_{1.96}\text{K}_{0.04}\text{IrO}_4$ , and  $\text{Sr}_{1.945}\text{K}_{0.055}\text{IrO}_4$  samples.

## II. COMPARISON OF STRUCTURAL PARAMETERS WITH THOSE OF EARLIER REPORTS

Figure S2 shows Ir-O<sub>p</sub> (a), Ir-O<sub>a</sub> (b), and Ir-Sr (c) bond distances of parent Sr<sub>2</sub>IrO<sub>4</sub> taken from literature[1–11] including neutron diffraction, x-ray diffraction and EXAFS, as well as those from present study. It turned out that in the parent compound, the local structural parameters deduced in the current study show a good correspondence with the averaged structural parameters reported by neutron diffraction studies.

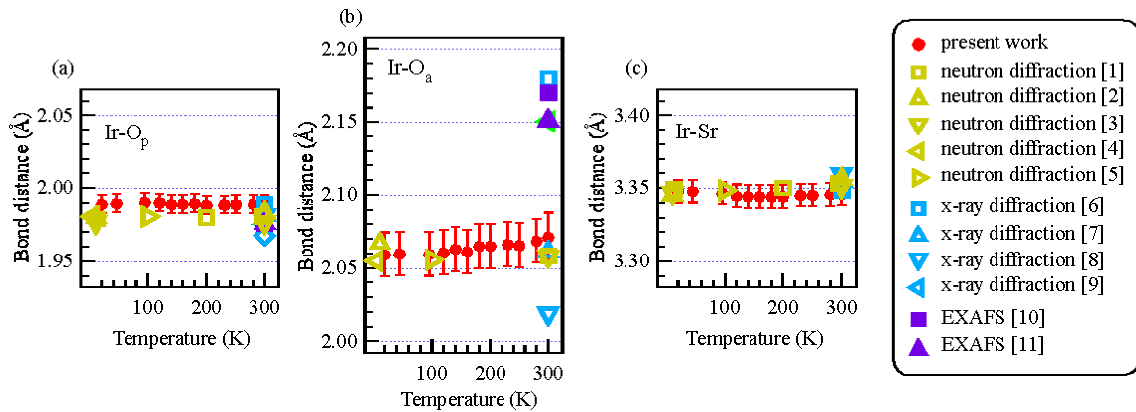


FIG. 2.

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- [1] M. K. Crawford, M. A. Subramanian, R. L. Harlow, J. A. Fernandez-Baca, Z. R. Wang, and D. C. Johnston, *Phys. Rev. B*, 1994, **49**, 9198.
- [2] Q. Huang, J. L. Soubeyroux, O. Chmaissem, I. Natali Sora, A. Santoro, R. J. Cava, J. J. Krajewski, and W. F. Peck Jr., *J. Solid State Chem.*, 1994, **112**, 355.
- [3] T. Shimura, Y. Inaguma, T. Nakamura, M. Itoh, and Y. Morii, *Phys. Rev. B*, 1995, **52**, 9143.
- [4] F. Ye, S. Chi, B. C. Chakoumakos, J. A. Fernandez-Baca, T. Qi, and G. Cao, *Phys. Rev. B*, 2013, **87**, 140406(R).
- [5] F. Ye, X. Wang, C. Hoffman, J. Wang, S. Chi, M. Matsuda, B. C. Chakoumakos, J. A. Fernandez-Baca, and G. Cao, *Phys. Rev. B*, 2015, **92**, 201112(R).
- [6] M. V. Rama Rao, V. G. Sathe, D. Sornadurai, B. Panigrahi, and T. Shripathi, *J. Phys. Chem. Solids*, 2000, **61**, 1989.

- [7] I. M. Bhatti, R. Rawat, A. Banerjee, and A. K. Pramanik, *J. Phys.: Condens. Matter*, 2014, **27**, 016005.
- [8] B. Ranjbar, and B. J. Kennedy, *J. Solid State Chem.*, 2015, **232**, 178.
- [9] H. T. Yu, S. L. Kiu, B. Li, H. Y. Wang, J. Cheng and Z. H. Wang, *Europhys. Lett.*, 2017, **120**, 27007.
- [10] J. Cheng, C. M. Zhu, S. L. Liu, B. Li, H. Y. Wang, Y. Wang, and W. Xu, *Mater. Res. Bull.*, 2017, **90**, 1.
- [11] J. Cheng, P. Dong, B. Li, S. L. Liu, X. Wang, Y. Wang, and X. Li, *J. Synchrotron. Rad.*, 2018, **25**, 1123.