Novel electronic states in 5d Ir Oxides produced by strong spin-orbit coupling

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We present a zoology of complex 5d Ir oxides with emphasis on novel interlay of electron correlations, spin-orbit coupling (SOC) and lattice distortion.

5d transition metal compounds are generally believed to be more itinerant than their 3d and 4d analogues. A layered oxide Sr_2IrO_4 with $Ir^{4+}(5d^5)$, however, is known to be an antiferromagnetic Mott insulator despite its 4d analogue Sr_2RhO_4 is simply a paramagnetic metal. It was pointed out that the Mott insulating state in this Sr_2IrO_4 is induced by a very strong SOC of ~ 0.5 eV. The large SOC gives rise to a half filled and narrow J_{eff}=1/2 band, leading to a Mott insulting state even in the presence of a weak U~0.5 eV [1]. From a "selection rule" of the magnetic resonant x-ray scattering at Ir L-edge, we unambiguously demonstrated [2] that the ground state of Sr_2IrO_4 is close to a J_{eff}=1/2 antiferromagnet.

Essentially the same J_{eff}=1/2 Mott state was found also in a double layer Ir oxides, $Sr_3Ir_2O_7$.A number of metallic analogues of Sr_2IrO_4, including distorted perovskite Sr(Ca) IrO_3 and hexagonal $SrIrO_3$, were visited recently. It was unexpectedly found that all compounds are a low carrier density semimetal with an enhanced Wilson ratio R_W~10. We argue that those unusual semi-metallic states are formed by an interplay of a large spin orbit coupling and band crossings.

We report also on complex Ir oxides with lattice topology of interest including honeycomb Na_2IrO_3 and spinel Ir_2O_4, which were theoretically pointed out to be a correlated topological insulator [3] and a Kiteav magnet [4].

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[2] B. J. Kim, H. Ohsumi, T. Komesu, S. Sakai, T. Morita, H. Takagi, and T. Arima, **Science** 323, 1329 (2009).
[3] Shitade et al., **Phys. Rev. Lett**. 102, 256403 (2009).
[4] J. Chaloupka, G.Jackeli, and G.Khaliullin, **Phys. Rev. Lett.** 105, 027204 (2010)

+ work done in collaboration with T. Takayama, B.J.Kim, S.Fujiyama, K.Ohashi, H.Kuriyama, J.Matsuno, R.S. Perry, H.Osumi and T.Arima.