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Slater and Mott Insulating States in Os- and Ir-Based Transitional Metal Oxides

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The discovery of a novel J_{eff} =1/2 electronic configuration and spin-orbit assisted insulating state in Sr_2IrO_4 has stimulated a fresh look at metal-insulator transitions where relativistic effects participate on an even footing with other energy scales such as crystal field splitting and electron-electron correlations. There are several view points on the origin of the insulating state in Sr_2IrO_4, but the most prominent is that spin-orbit coupling modifies the electronic configuration such that a Mott insulting state emerges despite the relatively modest electron-electron correlations within the $5d$ orbitals. An alternative viewpoint is that magnetic effects enable the opening of the electronic gap giving rise to the insulating state or a Slater metal-insulator transition. Here we describe realizations of both Mott and Slater insulators in the context of Os- and Ir-based $5d$ transition metal oxides. $NaOsO_3$, exhibits a continuous phase transition at 410 K where antiferromagnetism appears in conjunction with the onset of insulating behavior. A combination of neutron diffraction and magnetic resonant x-ray scattering enables the conclusion that G-type magnetic order occurs at the metal-insulator transition providing microscopic evidence that $NaOsO_3$ is the first three dimensional realization of a Slater insulator. On the other hand we have probed the robustness of the J_{eff} =1/2 Mott insulating state though studies of $Sr_2Ir_{1-x}T_xO_4$ (T=Mn, Ru). For both Mn and Ru doping we find that despite qualitative changes in the magnetic order the J_{eff} =1/2 electronic configuration remains robust. In particular, for Ru-doping the signatures of the J_{eff} =1/2 state are observed for all concentrations where magnetic order is present. Finally, we have investigated Ca_4IrO_6 which appears to exhibit a nearly ideal J_{eff} =1/2 state which is unperturbed by deviations from cubic crystal field level splitting.