Magnetic Order and Excitations in spin-orbit coupled Mott insulators

Over the last few years, there has been an upsurge of interest in materials in which exotic states may emerge as the result of relativistic spin-orbit interactions. We will discuss insulating iridium oxides from this perspective. We show that the strong spin-orbit coupling, through the entanglement of spin and orbital spaces, leads to a variety of interesting Hamiltonians ranging from the Heisenberg model to the Kitaev or quantum compass models, for different lattice geometries. Based on these effective Hamiltonians, we present a comprehensive theoretical study of the rich phase behavior and dynamics observed in layered iridium oxides such as tetragonal Sr$_2$IrO$_4$ and Sr$_3$Ir$_2$O$_7$ and hexagonal A$_2$IrO$_3$ (A=Na, Li). We also discuss the layered tetragonal vanadate Sr$_2$VO$_4$ and argue that magnetically-hidden octupolar order, driven by spin-orbit coupling, is realized in this compound.