Double perovskite materials have come into the limelight in recent years owing to the half-metallicity of some of its members like Sr$_2$FeMoO$_6$, raising hopes of their use in spintronics. Some other members like La$_2$NiMnO$_6$ show colossal magnetodielectricity, which may be useful in switching devices. Spintronic devices to be practicable, however, requires a large polarization even at room temperatures and hence a high $T_C$. We propose a method of obtaining half-metallic phases with high $T_C$ by doping an unlikely candidate, an insulator. The parent compound Sr$_2$CrOsO$_6$ is a ferrimagnetic insulator with a very high $T_C$. Upon slight electron doping, or hole doping, it is found to become a half-metal retaining the high $T_C$.

I present a theoretical framework to analyze the parent compound as well as its doped members, and show that a novel reentrant Metal-Insulator transition is obtained as a function of filling as one goes from the hole-doped (low filling) side to the electron-doped (high filling) side. This theoretical framework is also used to explain the high Tc ferrimagnetic insulating behaviour of the parent compound, and why it has the highest $T_C$ amongst all 3d-5d double perovskites.

Sr$_2$CrOsO$_6$ presents an interesting comparison, and counterpoint, with another insulator, La$_2$NiMnO$_6$, which is ferromagnetic rather than ferrimagnetic. I show that the same theoretical framework, simply by reinterpretation of the operators and change of sign of some of the parameters, can be used to explain the ferromagnetic insulating behaviour of ordered La$_2$NiMnO$_6$. Modifying the model appropriately for including antisite disorder, the recently observed reentrant spin-glass transition in partially disordered La$_2$NiMnO$_6$ is also explained.

References