Chemical control of the properties of perovskite oxides

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Perovskite oxides show a variety of interesting properties that can be tuned by chemical control. In this talk, I will present three examples of how such approach can be used to study the nature of functional properties in perovskites: (1) $RMnO_3$ ($R=$ rare earth) show a variety of unusual states, including the spiral spin ordering and ferroelectricity in $R=$ Tb and Dy. In [1], $R=$ Ho-Lu have been obtained under high pressure, and their magnetic and structural properties have been studied. Combined with the data on larger $R$, the results show the importance of competing magnetic interactions on the complex phase diagram of $RMnO_3$. (2) $RCoO_3$ show a spin-state transition and an insulator-metal transition as a function of temperature. The nature of the excited states has been studied since the 1950’s, but remains elusive. Here [2], I provide the complete electronic phase diagram of $RCoO_3$ that has been obtained from high-pressure synthesis and heat capacity measurements. The results support a picture involving a high-spin state above the spin-state transition and an intermediate-spin state above the insulator-metal transition. (3) $\text{Pb(Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3-x\text{PbTiO}_3$ (PMN-xPT) is a relaxor ferroelectric system with extraordinary dielectric and piezoelectric properties. The average structure of the system changes from cubic to rhombohedral, monoclinic, and tetragonal with $x$. However, this system is also characterized by nanoscale phase inhomogeneities, and the role of polar nanoregions on the enhanced properties is not clear. Here [3], I will show that thermal conductivity and heat capacity of PMN-xPT show a systematic evolution from glasslike to crystalline behavior as a function of $x$. The results provide interesting perspectives on how polar nanoregions are transformed into macroscopic polarizations with increasing $x$.