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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) $R\mathrm{MnO}_3$ (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 $R\mathrm{MnO}_3$. (2) $R\mathrm{CoO}_3$ 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 RCoO3 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) $\mathrm{Pb(Mg_{1/3}Nb_{2/3})O_3}-x\mathrm{PbTiO_3}$ (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.

[1] M. Tachibana et al., Phys. Rev. B 75, 144425 (2007).
[2] M. Tachibana et al., Phys. Rev. B 77, 094402 (2008).
[3] M. Tachibana et al., Phys. Rev. B 79, 100104(R) (2009).