MAR17-2016-020402

Abstract for an Invited Paper
for the MAR17 Meeting of
the American Physical Society

Tunable inversion symmetry in heterostructures of layered oxides

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Traditional approaches to create and control functional electronic materials have focused on new phases in previously unknown bulk minerals. More recently, interlayer physics has spawned interest in known materials in unexplored atomic scale geometries, especially in complex transition metal oxides (TMO), where heterostructures can be created on demand. In this talk, I show that although epitaxial strain routinely induces (enhances) electric polarizations, biaxial strain can also induce an unanticipated polar-to-nonpolar (P-NP) structural transition in (001) thin films of naturally layered $A_{n+1}B_n\mathrm{O}_{3n+1}$ $(n = 1 - \infty)$ oxides. Density functional theory calculations and a complete phenomenological model for $\mathrm{Ca_3Ti_2O_7}$ are used to show that the origin of the P-NP transition originates from the interplay of trilinear-related lattice mode interactions active in the layered oxides, and those interactions are directly strain tunable. Moreover these layered oxides exhibit a quasi-two dimensional phonon mode—an acoustic branch with quadratic dispersion, enabling unusual membrane effects such as tunable negative thermal expansion. I conclude by emphasizing that broken inversion symmetric structures offer a plentiful playground for realizing new functionalities in thin films, including new multiferroics from polar metals.