Above Room Temperature Ferroelectricity and Weak Ferromagnetism in $LaFeO_3/LnFeO_3$ Hybrid Improper Ferroelectrics

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In perovskite ABO_3 oxides, the appearance of an electrical polarization is usually associated with polar atomic displacement induced via a second-order Jahn-Teller (SOJT) mechanism, e.g., d^0 transition metals ions on the B-site and/or lone-pair active cations on the A-site. Recently, there has been much interest to discover new materials in which rotations of the BO_6 octahedra give rise to a novel form of ferroelectricity - hybrid improper ferroelectricity for which SOJT ions are not needed ([1], see [2] for a review). Octahedral rotations strongly influence other structural, magnetic, orbital, and electronic degrees of freedom in perovskites and related materials. Octahedral rotation-centric ferroelectricity consequently has the potential to robustly control emergent phenomena, and in particular magnetism, with an applied electric field.

In the present work we have investigated rotation-driven ferroelectricity in artificially layered superlattices, specifically $(LaFeO_3)_1/(LnFeO_3)_1$, with Ln = lanthanide (or Y). Our long-term goal is to extend the general design criteria that were recently developed to create ferroelectric materials from nonpolar constituents materials [3] and to tune their properties [4] (polarization, switching barriers, etc), in the direction of gaining the ability to tune the magnetization and its coupling to the polarization by controlling the octahedral rotations in these superlattices. Our preliminary findings suggest that such ferrite superlattices are examples of system in which octahedral rotations induce ferroelectricity, linear magnetoelectricity, and weak-ferromagnetism, much like the recently discussed manganite Ruddlesden-Popper [5], except in these ferrite superlattices, which are highly amenable to advanced oxide thin film growth techniques, the ferroic orderings occur above room temperature.

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