Thermotropic Phase Boundaries in Classic Ferroelectrics

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Piezoelectric materials convert electrical to mechanical energy. They are typically lead-based solid-solutions that exhibit a morphotropic phase boundary, an intermediate compositional region separating two distinct phases, where a new bridging phase with enhanced properties arises. We show that even simple perovskite ferroelectrics such as $BaTiO_3$ and $KNbO_3$ exhibit analogous "thermotropic" phase boundaries in wide temperature regions around thermal phase transitions. In these regions, new low symmetry bridging phases arise, that exhibit up to 400% enhancement in nonlinear optical and piezoelectric properties. These bulk phases are stabilized by long-range internal elastic and electric fields arising from a network of competing ferroelectric domains. The study shows how a small symmetry breaking can lead to large enhancements in physical properties.

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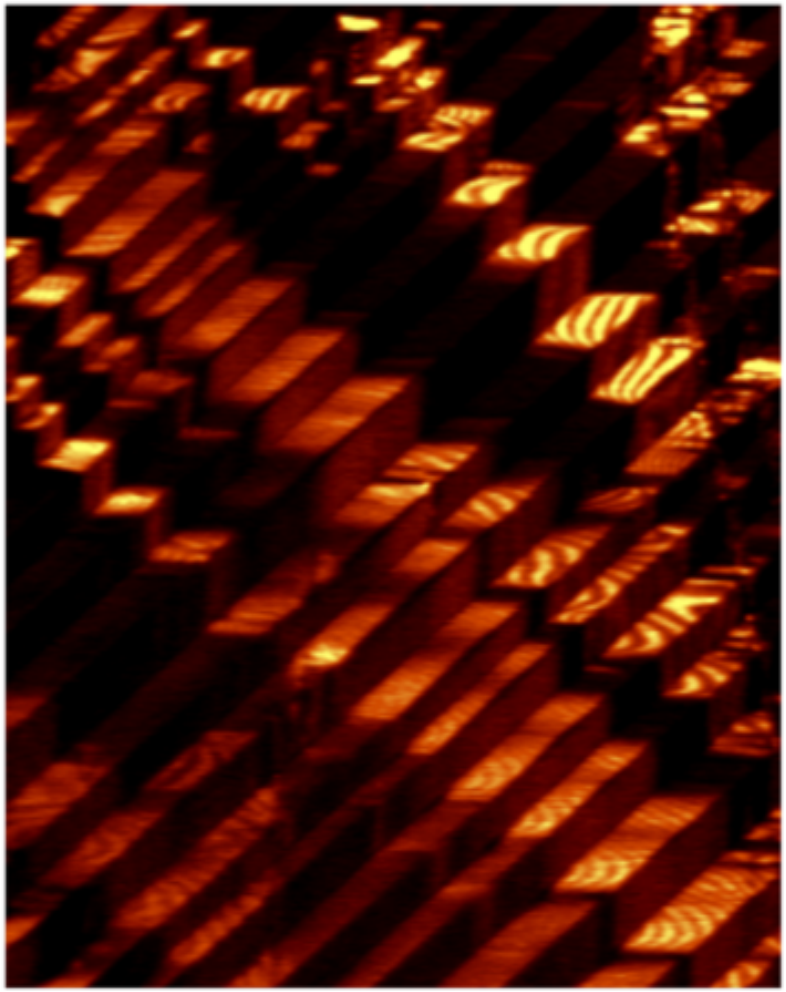

Optical second harmonic generation microscopy reveals a new monoclinic phase (sunshine) with enhanced properties coexisting with classic tetragonal domains (staircases).