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Theory of hyperferroelectrics

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Typical proper ferroelectrics are unable to polarize normal to a surface or interface if the resulting depolarization field is unscreened. However, there is no fundamental principle that enforces this behavior. This talk will introduce and review recent progress in the field of hyperferroelectrics, a new class of proper ferroelectrics that polarize even when the depolarization field is unscreened ($D = 0$ electrostatic boundary conditions). Hyperferroelectrics display a variety of properties that differ from typical ferroelectrics, including unstable longitudinal optic (LO) phonon modes, a qualitatively different electric equation of state, and unusual dielectric behavior. These properties may enable useful functionalities like single layer ferroelectric films as well as head-to-head and tail-to-tail domain walls. In this talk, I will introduce the theory of hyperferroelectrics as seen in ABC semiconducting ferroelectrics and ferroelectric superlattices. Then, I will consider recently proposed materials realizations of hyperferroelectrics, including in $SrNb_6O_{16}$, which was identified in a high-throughput search for new ferroelectrics. I will also briefly discuss the behavior of hyperferroelectrics with strong spin-orbit coupling, which enables a persistent and reversible coupling between the polarization and electronic properties like the Rashba effect and even topological states.