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Magnetoelectric polarizability and axion electrodynamics in crystalline insulators[1] ANDREW ESSIN, JOEL MOORE, University of California, Berkeley, DAVID VANDERBILT, Rutgers University — Spin-orbit coupling can lead in two- and three-dimensional solids to time-reversal-invariant insulating phases that are "topological" in the same sense as the integer quantum Hall effect and similarly have protected edge or surface states. The three-dimensional topological insulator is known to have unusual magnetoelectric properties referred to as "axion electrodynamics": it supports an electromagnetic coupling $\Delta\mathcal{L}_{EM} = (\theta e^2/2\pi h)\mathbf{E}\cdot\mathbf{B}$ with $\theta = \pi$, giving a half-integer surface Hall conductivity $\sigma_{xy} = (n + 1/2)e^2/h$. An approach to θ in any three-dimensional crystal is developed based on the Berry-phase theory of polarization: $\theta e^2/2\pi h$ is the bulk orbital magnetoelectric polarizability (the polarization induced by an applied magnetic field). We compute the orbital magnetoelectric polarizability for a simple model and show that it predicts the fractional part of surface σ_{xy}, computed using a slab geometry. Although θ is not quantized once time-reversal and inversion symmetries are broken, it remains a bulk quantity for the same reasons as ordinary polarization.

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