Gian G. Guzmán-Verri, PhD
University of Costa Rica, Costa Rica

Why is the electrocaloric effect so small in ferroelectrics?

Abstract:

Ferroelectrics are attractive candidate materials for environmentally friendly solid state refrigeration free of greenhouse gases. Their thermal response upon variations of external electric fields is largest in the vicinity of their phase transitions, which may occur near room temperature. The magnitude of the effect, however, is too small for useful cooling applications even when they are driven close to dielectric breakdown. Insight from microscopic theory is therefore needed to characterize materials and provide guiding principles to search for new ones with enhanced electrocaloric performance. Here, we derive from well-known microscopic models of ferroelectricity meaningful figures of merit for a wide class of ferroelectric materials. Such figures of merit provide insight into the relation between the strength of the effect and the characteristic interactions of ferroelectrics such as dipolar forces. A strategy is proposed to make the effect larger by shortening the correlation lengths of fluctuations of polarization. We use this insight to explore other caloric effects in open-lattice frameworks.

Work at Argonne National Laboratory is supported by the U.S. Department of Energy, Office of Basic Energy Sciences, Material Sciences and Engineering Division
under contract no. DE-AC02-06CH11357,and work at the University of Costa Rica is supported by the Vicerectory for Research under the project no. 816-B5-220.

References

1. G. G. Guzmán-Verri & P. B. Littlewood, Why is the electrocaloric effect so small
in ferroelectrics?, APL Materials 4, 064106 (2016).

2. A. Corrales-Salazar, R. T. Brierley, P. B. Littlewood, & G. G. Guzmán-Verri, Landau theory and giant barocaloric effect in MF3 metal trifluorides, arXiv:1708.01158.