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Using nonlinear electret effects to design piezoelectricity and magnetoelectricity in soft materials

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ABSTRACT

Piezoelectricity and magnetoelectricity are contradictory properties with a rather limited set of natural (often hard) materials that exhibit both. Composite materials—almost always restricted to hard ones—provide a limited recourse with the attendant limitations of small strains, fabrication challenges among others. In this article, using the concept of electrets, we propose a simple scheme to design soft, highly deformable materials that simultaneously exhibit piezoelectricity and magnetoelectricity. We demonstrate that merely by embedding charges and ensuring elastic heterogeneity, the geometrically nonlinear behavior of soft materials leads to an emergent piezoelectric and magnetoelectric behavior. We find that an electret configuration made of sufficiently soft (nonpiezoelectric and nonmagnetic) polymer foams can exhibit simultaneous magnetoelectricity and piezoelectricity with large coupling constants that exceed the best-known ceramic composites.