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Magnetoelectric Coupling in Multiferroic Materials

CLAUDE EDERER, Materials Research Laboratory, University of California, Santa Barbara, CA 93106

There has been increasing recent interest in magnetoelectric multiferroics, which are materials that show spontaneous magnetic order and ferroelectricity in the same phase. In addition to the fascinating physics resulting from the independent existence of two or more ferroic order parameters in one material, the coupling between magnetic and electric degrees of freedom gives rise to additional phenomena.

In this talk we will discuss possible coupling scenarios between the ferroelectric polarization and the magnetization in magnetoelectric multiferroics. As an example we present results for the magnetoelectric multiferroic bismuth ferrite. Using first-principles calculations in the framework of density functional theory we analyze the nature of the electric polarization, the magnetization, and the coupling between these two quantities. We show that weak ferromagnetism occurs in this material, and that the resulting magnetization is strongly coupled to the structural distortions. We explore the possibility of electric-field-induced magnetization reversal and show that, although it is unlikely to be realized in bismuth ferrite, it is not in general impossible. Finally we outline the conditions that must be fulfilled to achieve such a switching of the magnetization using an electric field.