COUPLING OF MAGNETIC AND ELECTRIC ORDER IN MAGNETICALLY INDUCED FERROELECTRICS

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Materials with a coexistence of magnetic and electric long-range order, called multiferroics, are of great current interest because of their potential to develop pronounced magneto-electric cross-coupling effects. Recently, two fundamentally different types of multiferroics are distinguished: (1) split-order-parameter multiferroics in which magnetic and electric order emerge independently; (2) joint-order-parameter multiferroics in which the magnetic order induces the ferroelectric order. The ferroelectric order in the joint-order-parameter multiferroics is particularly intriguing. Any reversal of the spontaneous polarization is directly coupled to changes in the magnetic order and it is assumed that displacing the electron cloud rather than the ions causes the spontaneous polarization.

Here we investigate the relation between magnetic order, electric order, and symmetry for a variety of joint-order-parameter multiferroics by optical second harmonic generation. In spite of the small value of the spontaneous polarization a giant SHG yield is obtained which confirms the electronic origin of the polarization. In $MnWO_4$ we observed domains that behave neither as magnetic nor as electric domains. For example, they display the topology of magnetic domains but they can only be switched by electric fields. Here, designation as "multiferroic" domain seems appropriate. In $TbMn_2O_5$ three independent contributions of the Mn and Tb ions to the magnetically induced polarization are uniquely identified and understood on the basis of symmetry arguments. The domain structured of the two Mn-related polarizations are coupled, while Tb-related ferroelectric domains form independently.

In summary, spatially resolved investigations of the magneto-electric domain structures in multiferroics prove invaluable for understanding the nature of giant magnetoelectric effects because switching and coupling of magnetic and electric domains forms their basis.