Magnetoelectric Effects and Phase Control in Multiferroic Manganites

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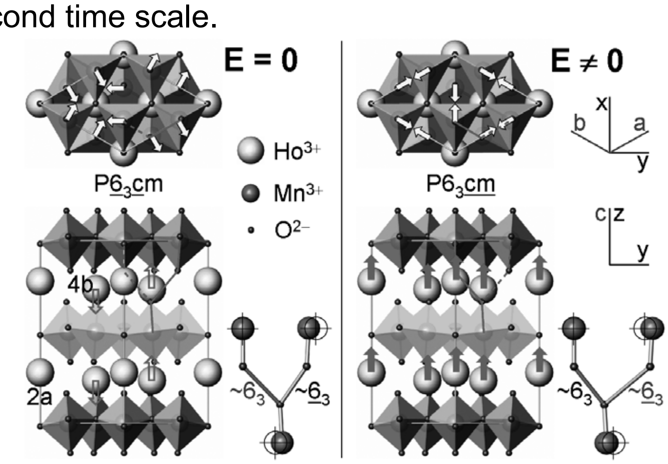
The crosslink between magnetic and electric properties expressed by the magnetoelectric (ME) effect – induction of a magnetization by an electric field and of a polarization by a magnetic field – opens new degrees of freedom for device construction. Recently, an enormous interest in ME phenomena is observed because composite materials and multiferroics exhibit ME effects which exceed previous effects by many orders of magnitude and control phase transitions. A survey of mechanisms favoring ME effects in multiferroics will be given. As example, I will discuss various aspects of ME coupling in ferroelectric (FEL) antiferromagnetic (AFM) $RMnO_3$ [R = Sc, Y, In, Ho-Lu]. (i) External magnetic or electric fields induce R^{3+} ferromagnetism which is reversibly switched on or off. The process is monitored by magneto-optical techniques. Its microscopic origin is disclosed by neutron and x-ray diffraction. The ME phase control is driven by an asymmetry in the R^{3+} -Mn^{3+} superexchange which originates in the ferroelectric distortion. (ii) An interaction of FEL and AFM domain walls and toroidal domains revealed by simultaneous imaging of FEL, AFM, and ME 180° domains by second harmonic generation. The interaction roots in a piezomagnetic interaction between the magnetization of the AFM walls and strain in the FEL walls. (iii) Massive formation of *spin-rotation domains* which supplement *spin-reversal domains* in the course of a Mn^{3+} spin reorientation. This leads to a local ME effect that is allowed because of the low domain-wall symmetry. (iv) Ultrafast ME dynamics. In optical pump/probe experiments a decoupling of the Mn^{3+} spin reorientation in $HoMnO_3$ from the lattice temperature was observed on the picosecond time scale.



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