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Domains in multiferroics with magnetically induced ferroelectricity

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Two types of multiferroics are distinguished. In the split-order-parameter multiferroics magnetic and ferroelectric order evolve independently while in the joint-order-parameter multiferroics the emergence of the spontaneous polarization is a direct consequence of the magnetic order. The latter type is particularly interesting because of the inherent giant magnetoelectric effects. In the joint-order-parameter multiferroics any magnetoelectric interaction is, at its root, an interaction of its magnetic and ferroelectric domains. Yet, very little is known about the topology of these domains. In my talk I will discuss the domain topology and its magnetoelectric manipulation in a variety of joint-order-parameter multiferroics: $MnWO_4$, RMn_2O_5, $RMnO_3$, CuO, $CuCrO_2$. Domains are resolved by optical second harmonic generation. Two types of unusual and fundamentally different domains will be distinguished: (i) hybrid-multiferroic domains in which hallmarks of magnetic and ferroelectric domains are inseparably entangled; (ii) incommensurate translation domains whose walls correspond to discontinuities in the incommensurate magnetic wave vector.