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Symmetry in Multiferroics

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Symmetries govern Nature ubiquitously from the beauty of human faces to the local gauge invariance of quantum field theory. Magnetic order in frustrated magnets can occur without space inversion symmetry. When it relaxes to the magnetically-ordered configuration through exchange-striction, lattice can also loose inversion symmetry, leading to the presence of ferroelectric polarization. In these magnetically-driven ferroelectrics, dielectric properties turn out to be highly susceptible to applied magnetic fields. Both symmetric and antisymmetric exchange coupling can be involved in the exchange-striction. One form of symmetry often broken in Nature is the symmetry between left- and right-handedness. For example, the manner in which light propagates naturally selects one handedness, and is customarily described by a right-handed rule, depicting the relationship among the oscillating electric field, magnetic field and propagation vector of light. Chiral molecules also have a definite handedness, and given the preponderance of chiral molecules, it is not surprising that most complex proteins as well as their constituent amino acids are chiral. What is remarkable however, is that most of naturally occurring amino acids share the same chirality; only left-handedness. Such handedness, or chirality, appears to be a characteristic signature of life. In the multiferroic spinel $CoCr_2O_4$, conical magnetic order accompanies ferroelectric polarization as well as ferromagnetic moment. The relevant handedness and chirality in the multiferroic state will be also discussed.