How impurities create multiferroic phases in oxides*

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Recent work on Al- or Ga-doped $CuFeO_2$ and Co-doped $MnWO_4$ suggests that impurities play a crucial role at stabilizing multiferroic phases. In both cases, the pure compound has a collinear (non-multiferroic) magnetic state due to easy-axis anisotropy produced by electron hopping from the magnetic (Fe^{3+} or Mn^{2+}) $S = 5/2$ and $L = 0$ sites to the non-magnetic transition-metal (Cu or W) sites. Doping with a few percent of Al, Ga, or Co impurities produces a spiral or cycloidal, multiferroic state. There are several possible ways that impurities can change the magnetic phase: by shifting the exchange interactions, enhancing geometric frustration, introducing new exchange pathways (such as Dzyalloshinskii-Moriya interactions), or altering the single-ion anisotropy. Our inelastic-neutron scattering and numerical studies indicate that the relative values of the exchange couplings are not significantly changed by doping. We also find that the same exchange pathways that appear in the collinear phases can explain the inelastic spectra of the multiferroic phases. The dominant effect of doping is to weaken and rotate the easy-ion anisotropy.

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