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Signature of defect-induced symmetry breaking in magnetic neutron scattering

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The antisymmetric Dzyaloshinskii-Moriya interaction (DMI) plays a decisive role for the stabilization and control of chirality of skyrmion textures in various magnetic systems exhibiting a noncentrosymmetric crystal structure. A less studied aspect of the DMI is that this interaction is believed to be operative in the vicinity of lattice imperfections in crystalline magnetic materials, due to the local structural inversion symmetry breaking. If this scenario leads to an effect of sizable magnitude, it implies that the DMI introduces chirality into a very large class of magnetic materials—defect-rich systems such as polycrystalline magnets. Here, we show experimentally that the microstructural-defect-induced DMI gives rise to a polarization-dependent asymmetric term in the small-angle neutron scattering (SANS) cross section of polycrystalline ferromagnets. The results are supported by analytical and numerical predictions using the continuum theory of micromagnetics. This effect, conjectured already by Arrott in 1963, is demonstrated for nanocrystalline terbium and holmium (with a large grain-boundary density), and for mechanically-deformed microcrystalline cobalt (with a large dislocation density). Analysis of the scattering asymmetry allows one to determine the defect-induced DMI constant, $D = 0.45 \pm 0.07 \text{ mJ/m}^2$ for Tb at 100 K. Our study proves the generic relevance of the DMI for the magnetic microstructure of defect-rich ferromagnets.

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