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Spin orientation in a natural Ti-bearing hematite: Evidence for an out-of-plane component

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Abstract

The orientation of spins in a natural sample of Ti-bearing hematite (Fe_2O_3) has been measured from 2–300 K using time-of-flight neutron powder diffraction. It is shown that the antiferromagnetic alignment vector is tilted out of the basal plane by an average angle of 30°, independent of temperature, contrary to the normal expectation that all spins lie in the basal plane due to the suppression of the Morin transition by Ti. This unusual result is related to the non-uniform spatial distribution of Ti in this sample, which takes the form of ~1 nm exsolution lamellae of ilmenite ($FeTiO_3$), observed using transmission electron microscopy. It is suggested that the exsolution lamellae lead to a localization of Fe^{2+} species within the lamellar interfaces, which cause tilting of some spins toward the crystallographic *c* axis. The presence of an out-of-plane component of spin at room temperature reconciles experimental and computational attempts to explain the phenomenon of "giant exchange bias" that appears when this sample is zero-field cooled below the ilmenite Néel temperature.

Keywords: Hematite, magnetic properties, spin orientation, Morin transition, exchange bias