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On the origin of large magnetic anisotropy in ε-Fe2O3

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The epsilon phase of Fe_2O_3 is a ferrimagnetic polymorph that stands out for a remarkable magnetic anisotropy (K_u~$2 \cdot 10^5$ J/m3) and sizeable remnant magnetization at room temperature (~50 kA/m)[1] making it appealing for applications in magnetic recording and electromagnetic applications in the range of millimetre waves [2]. Moreover, ε-Fe_2O_3 is also interesting from a more fundamental point of view, featuring low-temperature magnetoelectric properties [3] and three distinct zero-field magnetic orders between 10 K and its paramagnetic state above ~850 K [4]. Such a rich phase diagram has much to do with its non-centrosymmetric structure (*Pna21*), more complex than for other ferric oxides, with four different Fe sites in the asymmetric unit cell: three in an octahedral (O_h) and one in a tetrahedral (T_d) local symmetry [1].

Despite having attracted increasing attention over the last decades, the intriguing magnetic order in ε-Fe_2O_3 is still poorly understood. Here we present recent results of temperature-dependent X-ray and neutron diffraction, X-ray absorption spectroscopy (XAS) and X-ray magnetic circular dichroism (XMCD) experiments that provide new insights into the origin of magnetic anisotropy in ε-Fe_2O_3 and □-$(Fe_{1-x}Cr_x)_2O_3$ in the form of nanoparticles (NPs) and thin films. The Fe^{3+} with Cr^{3+} substitution is very revealing due to its expected isovalent and magnetic isotropic character. Although trivalent iron could be thought as behaving in a similar way, a nonzero orbital angular momentum m_L value has been proposed for the Fe2 crystallographic site, which might act as the primary source for the magnetic anisotropy responsible of the gigantic coercive field. Thus, depending on the preferential entering sites for Cr in the ε-Fe_2O_3 structure, a systematic reduction in m_L and a weakening of the spin-orbit coupling along the series may be expected. Our XMCD investigation has addressed this controversy.

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