Exchange bias model for Fe/FeF_2: Role of domains in the ferromagnet

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Abstract

Exchange bias (EB) is a shift of the hysteresis loop from its normal position, symmetric around $H = 0$, to $H_E \neq 0$. It occurs when thin ferromagnetic (F) films are deposited on a variety of antiferromagnetic (AF) materials. EB is also associated with several additional remarkable features: i) the bulk magnetizations of the F is orthogonal to the AF easy axis; ii) H_E is of similar magnitude for compensated and uncompensated AF interface layers; iii) the sign of H_E can assume both positive and negative values; and, iv) the magnetization $|M(H \ll -H_c)| \neq |M(H \gg +Hc)|$, where H_c is the coercive field. Here we propose a model that describes the EB phenomenon for a compensated interface. Based on the experimental evidence, and extensive computer simulations, we suggest that close to the Néel temperature a canted spin configuration in the AF interface freezes into a metastable state. As a consequence, the EB energy is reversibly stored in a spring-like magnet, or incomplete domain wall (IDW), in the F slab. The results we extract from our model, both analytically and through simulations, are qualitatively and quantitatively compatible with the available experimental information.