Comment on “Exchange bias in the layered cobaltite Sr 1.5 Pr 0.5 CoO 4 ” [J. Appl. Phys.104, 023914 (2008)]

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Comment on "Exchange bias in the layered cobaltite $Sr_{1.5}Pr_{0.5}CoO_4$" [J. Appl. Phys. 104, 023914 (2008)]

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Ang *et al.* [J. Appl. Phys. **104**, 023914 (2008)] recently reported magnetization hysteresis loops shifted along both field and magnetization axes of layered cobaltites. The authors claimed that these shifts are characteristics of the exchange-bias phenomenon associated with coupling between ferromagnetic and spin-glass regions. The present comment affirms that their work shows no proofs supporting the observation of exchange bias since, due to lack of magnetic reversibility at high magnetic fields, all hysteresis loops displaced from the origin are actually minor loops naturally shifted along both axes. © *2009 American Institute of Physics*. [DOI: 10.1063/1.3098262]

In a recent paper, Ang *et al.*[1] reported hysteresis loops shifted along both field and magnetization axes of layered cobaltites $Sr_{1.5}Pr_{0.5}CoO_4$ measured after cooling in magnetic field. The authors claimed that the shifts are manifestation of exchange bias due to pinning of ferromagnetic moments by frozen spins in spin-glass regions.

Using dc magnetometry, the exchange-bias effect[2–5] is estimated from the hysteresis loop shift away from the zero-field axis of a *magnetically saturated* system. One notes, however, that the representative shifted curve shown in Fig. 3 of the work of Ang *et al.*, traced after field cooling and using maximum measurement field of 4.5 T, is visibly unsaturated (typical for heterogeneous systems like that studied in Ref. 1). Moreover, this curve does not show any reversible part, i.e., a high-field region where the ascending and descending branches of the loop coincide, so it actually represents a *minor hysteresis loop*. It is well known that such curves are naturally displaced from the origin which, however, is irrelevant to the exchange-bias phenomenon. Discussion on the current problem can be found in Refs. 6 and 7 and in more detail in Ref. 8.

The nonshifted and symmetrical loop measured after zero-field cooling (also shown in the above cited figure), although unsaturated, is a typical minor loop obtained after demagnetization, again due to the lack of attaining reversibility at high fields.[8,9] As properly noticed by the same authors in another study on the same layered cobaltites, "… the magnetization *M* of all samples increases without saturation up to 4.5 T…," i.e., their maximum measurement field is not sufficiently high to saturate the samples, clearly demonstrated in Fig. 5(a) of the respective paper.[10] Nevertheless, the shift of the (minor) loop obtained using even lower maximum field of 1.0 T reported in one more recently published paper by the same group[11] has been attributed to exchange bias.

Ang *et al.*[1] emphasized that the shifts are strongly dependent on the maximum measuring field and both completely disappear if the latter is higher than 5.0 T. This is yet another evidence that the series of loops with increasing maximum field shown in Fig. 5 in Ref. 1 is a typical minor loop sequence.[8] Note that in systems which do exhibit exchange bias, increasing the maximum measuring field leads to a finite field shift and a virtually vanishing shift along the magnetization axis when the hysteresis loops reach reversibility at high fields (clearly seen, for example, in the work of Salazar-Alvarez *et al.*[12]).

In attempt to qualitatively explain their results, Ang *et al.*[1] proposed an intuitive model based on the assumption that the external magnetic field can modify the coexisting phases. They supposed that the ferromagnetic clusters are increased by both measuring and cooling fields and that the spin-glass regions are destroyed when increasing the *measuring field*. Taking for granted that the exchange-bias effect weakens when enhancing the ferromagnetic clusters, the authors explained the decrease of the shifts with the *measuring field* but not the maxima in the variations of the shifts with the *cooling field* when the latter is in the vicinity of 0.5 T. Trying to overcome this discrepancy, Ang *et al.* then assumed that the alignment of the moments of the ferromagnetic phase enhances at low *cooling fields* and, due to exchange coupling, the moments of the spin-glass regions at interface align better as well, resulting in initial increase of the shifts with the *cooling field*. These suppositions, however, apparently contradict those made in order to explain the gradual decrease in the shifts with the *measuring field*, and practically invalidate the model.

In summary, since the shifts along both field and magnetization axes have been estimated from minor hysteresis loops, one cannot affirm that these are evidences for manifestation of exchange bias in the layered cobaltites studied by Ang *et al.*[1]

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