Non-exchange bias in binary soft-hard nanoparticle assemblies

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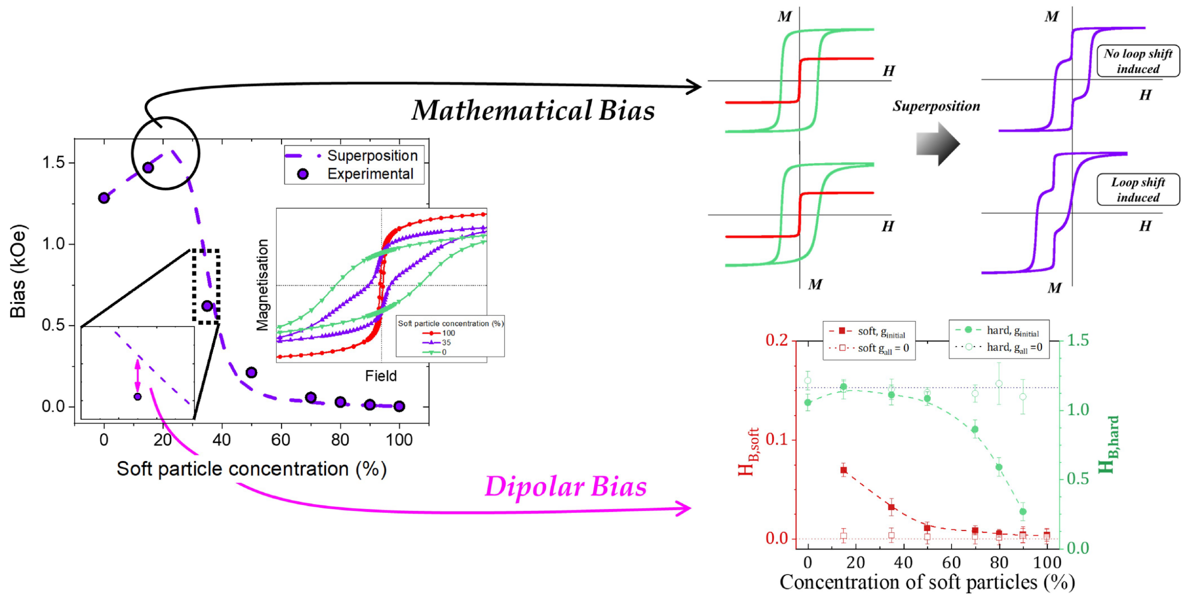
Exchange bias has been extensively studied both in exchange-coupled thin films [1] and both single-phase [2] and multiphase nanoparticle systems. However, the role of non-exchange mechanisms in the overall hysteresis loop bias are far from being understood. Here, dense soft-hard binary nanoparticle composites are used as a novel tool not only to unravel the effect of dipolar interactions on the hysteresis loop shift, but as a new strategy to enhance the bias of any magnet exhibiting an asymmetric magnetization reversal. Densely-packed uniform mixtures of equally sized, 6.8 nm, soft maghemite nanoparticles (no bias – symmetric reversal) and hard cobalt-doped maghemite nanoparticles (large exchange bias – asymmetric reversal) exhibit a hummingbird-like loop, typical of weakly coupled systems [3], due to the very different magnetic anisotropy of the constituent nanoparticles. For certain fractions of soft particles, the loop shift of the composite can be significantly larger than the exchange-bias field of the hard particles in the mixture. Simple calculations indicate how this emerging phenomenon is mainly driven by the asymmetric reversal of the hard loop and how it can be further enhanced by optimizing the parameters of the hard particles (coercivity and loop asymmetry) [4].



In addition, the existence of a dipolar-induced loop shift ("dipolar bias") is demonstrated both experimentally and theoretically, where, for example, a bias is induced in the initially unbiased soft nanoparticles due to the dipolar interaction with the exchange-biased hard nanoparticles. These results open novel approaches to tune loop shifts in magnetic hybrid systems beyond interface exchange coupling.

References

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