A numerical study on the interplay between the intra-particle and interparticle characteristics in bimagnetic soft/soft and hard/soft ultrasmall nanoparticles assemblies

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A mesoscopic scale approach and the Monte Carlo (MC) method has been employed to study the exchange bias behavior of $MnFe_2O_4$ (soft)/maghemite (soft) and $CoFe_2O_4$ (hard)/maghemite (soft) nanoparticles (NPs) of size ~3nm in dense and diluted assemblies at low temperatures. The analysis of our MC results clearly shows that in the powder samples the contribution to the exchange bias field (Hex) and the coercivity (H_c) comes mainly from the intraparticle core/shell structure in the hard/soft sample and that the interplay between the internal characteristics and the interparticle interactions is more important in the soft/soft samples where the dipolar strength is enhanced. In the diluted frozen ferrofluid samples where interparticle exchange interactions are absent and the role of the dipolar interactions is not significant the exchange bias effects are reducing, and they come from the intra particle structure. The variation of H_{ex} and H_c with the applied cooling field well reproduces the experimental findings and sheds light on the key mechanisms of the observed magnetic behavior. Our results demonstrate the possibility to control the magnetic behaviour of nanostructures by using properly chosen core/shell bimagnetic nanoparticles.