Investigation of spin structures in hollow iron oxide nanoparticles by Mossbauer spectroscopy

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Résumé

In systems of nanoparticles, the atoms or spins lying at or near the surface could cause enhancement of the surface anisotropy, magnetic frustration, and spin disorder coming from symmetry breaking of the crystal structure and loss of coordination number. One of the systems that present such features is the hollow nanoparticles (HNPs), as their morphology favors enhanced surface effects due to the presence of both inner and outer surfaces. One of the most relevant techniques that allow studying the microstructural and magnetic properties of magnetic nanoparticles is M´ossbauer spectrometry. Our study was concerned with two series of HNPs; the first one is maghemite HNPs with size of 9 nm and very small thickness and high surface-to-volume ratio, while the other series contributes to hollow maghemite nanoparticles with different sizes (12, 14, 18 nm) and comparable thicknesses but with smaller R compared to the previous one. The in-field spectrum obtained on the first sample with ultrathin thickness which exhibits broadened lines and wide distribution of angles in space in addition to large intensity of intermediate lines , has a behavior that significantly differs from a classical ferrimagnetic structure, but was described as a speromagnetic-like structure. On the other hand, the different in-field spectra for the different sized HNPs with lower ratio are typical of ferrimagnetic structures but with large distribution of angles that increases as the size of the HNP increases. This indicates that the spin non-collinearity increases with the increase of size keeping the same thickness. The present study illustrates the importance of surface effects in such hollow systems in influencing the magnetic structure especially when compared to those of full iron oxide nanoparticles. In addition, the effect of surface anisotropy on spin structures was numerically studied based on Monte Carlo method, as was earlier done for full ferromagnetic nanoparticles.

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