Interplay between intra and interparticle effects in multimagnetic nanoarchitectures

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Multi-Magnetic Nanoarchitecture exhibit distinctive and peculiar physical properties making them uniquely suitable for advanced technological and biomedical applications. Among various designs, bi-magnetic core/shell nanoarchitecture composed of spinel ferrites stand out due to their tunable magnetic responses arising from the interplay of intra- and interparticle effects. This talk focuses on the magnetic behavior of bi-magnetic core/shell nanoarchitectures, composed by cobalt ferrite ($CoFe_2O_4$, CFO) and nickel ferrite ($NiFe_2O_4$, NFO) in both direct (CFO/NFO) and inverse (NFO/CFO) configurations. Systematic variation of the shell thickness and particle architecture significantly affects magnetic properties (i.e., magnetic anisotropy, saturation magnetization, and magnetization dynamics). Observed effects cannot be fully described by simple additive models, pointing to a complex interaction between magnetic intraparticle (proximity effect) and interparticle interactions. Experimental insights obtained using remanent magnetization analyses (Δm-plot) and supported by Monte Carlo simulations allow us to unravel this intricate interplay, underscoring the importance of nanoscale architecture. We also discuss several critical open questions: the mechanisms through which intraparticle and interparticle interactions influence each other; the distinct roles of dipolar and exchange interparticle interactions; the impact of core/shell nanoparticle architecture, including core and shell materials, layer dimensions, and shape; and how these interactions can be harnessed for designing materials with tailored magnetic properties. [1, 2].

[1] Omelyanchik A., Villa S., Vasilakaki M., et al. // Nanoscale Adv. 2021. V. 3. P. 6912. doi: 10.1039/D1NA00312G
[2] Omelyanchik A., Villa S., Locardi F., et al. // Chem. Mater. 2024. doi: 10.1021/acs.chemmater.4c01421