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Roles of Surface and Interface Spins in Exchange Coupled Nanostructures[1]

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Exchange bias (EB) in magnetic nanostructures has remained a topic of global interest because of its potential use in spin valves, MRAM circuits, magnetic tunnel junctions, and spintronic devices. The exploration of EB on the nanoscale provides a novel approach to overcoming the superparamagnetic limit and increasing the thermoremanence of magnetic nanoparticles, a critical bottleneck for magnetic data storage applications. Recent advances in chemical synthesis have given us a unique opportunity to explore the EB in a variety of nanoparticle systems ranging from core/shell nanoparticles of $Fe/\gamma Fe_2O_3$, Co/CoO, and FeO/Fe_3O_4 to hollow nanoparticles of γFe_2O_3 and hybrid composite nanoparticles of Au/Fe_3O_4. Our studies have addressed the following fundamental and important questions: (i) Can one decouple collective contributions of the interface and surface spins to the EB in a core/shell nanoparticle system? (ii) Can the dynamic and static response of the core and shell be identified separately? (iii) Can one tune "minor loop" to "exchange bias" effects in magnetic hollow nanoparticles by varying the number of surface spins? (iv) Can one decouple collective contributions of the inner and outer surface spins to the EB in a hollow nanoparticle system? (v) Can EB be induced in a magnetic nanoparticle by forming its interface with a non-magnetic metal? Such knowledge is essential to tailor EB in magnetic nanostructures for spintronics applications. In this talk, we will discuss the aforementioned findings in terms of our experimental and atomistic Monte Carlo studies.

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