Magnetic nanoparticles in the light of polarized neutrons

Sabrina Disch*

University of Duisburg-Essen
*sabrina.disch@uni-due.de

Magnetic nanoparticles and nanostructures reveal interesting magnetic properties and relaxation phenomena which make them relevant for sensor technology, imaging techniques, or magnetic heating, applicable to magnetic hyperthermia and thermocatalysis applications. Whereas the implementation of nanomagnetic properties into technological applications is progressing rapidly, fundamental questions remain challenging, such as the intricate interplay of nanoscale magnetization and magnetization relaxation with structural characteristics or the response of magnetic nanoparticles to dynamic magnetic fields.

Our approach to such questions lies in the cross-scale investigation of structure and magnetization in nanostructured materials using X-ray and polarized neutron scattering. Aiming at the nanoscale spatial resolution, magnetic small-angle neutron scattering (SANS) has emerged as a versatile technique to probe chemical morphology and magnetization [1,2].

In this talk, I will present our most recent results on the compositional and magnetic intraparticle morphology in ferrite nanoparticles [3,4]. Being intrinsic to nanomaterials, disorder effects crucially determine the magnetization properties of magnetic nanoparticles [5]. The classical picture considers single-phase magnetic nanoparticles as a collinearly magnetized core with a structurally and magnetically disordered surface region. Using magnetic SANS, we have established a significant field-induced growth of the integral moment by a magnetic ordering transition at the structurally disordered surface [3]. On this basis, we have elucidated the intra-particle distribution of the spin disorder energy, a characteristic that indirectly provides unprecedented insight into the structural defect profile in magnetic nanoparticles.

References

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