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Spin structure of superparamagnetic iron oxide nanoparticles

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We have studied superparamagnetic iron oxide nanoparticles by various experimental techniques in order to characterize the observed reduced saturation magnetization as compared to bulk. Magnetic nanoparticles of the size of 12 nm and 15 nm have been studied by means of small-angle X-ray scattering (SAXS), X-ray diffraction (XRD), high-resolution transmission electron microscopy (HRTEM), inductively coupled plasma with optical emission spectroscopy (ICP-OES) and magnetometry to obtain a detailed understanding of the internal magnetization distribution. The particles are spherical colloidal iron oxide particles with an oleic acid coating embedded in a paraffin matrix. The concentration of particles inside the matrix is chosen in such a way that the inter-particle interactions are negligible. SAXS data provides a precise measure of the particle radius and their polydispersity as well as volume fraction of the magnetic nanoparticles, which is in agreement with the amount of iron obtained by ICP-OES. The combination of XRD, HRTEM and magnetometry yields details on the specific iron oxide phase composition and the magnetic behavior. The shapes of both the hysteresis loops and the ZFC/FC curves confirm a superparamagnetic behavior of the particles. The presence of exchange bias indicates an antiferromagnetic, most probably, wüstite contribution to the particle composition. To obtain complementary information about the inner spin structure of the nanoparticles small-angle scattering of polarized neutrons (SANSPOL) will be utilized.

Author: KÖHLER, Tobias (JCNS-2)

Co-authors: FEOKTYSTOV, Artem; PETRACIC, Oleg (Forschungszentrum Jülich GmbH); KENTZINGER, Emmanuel (Jülich Centre for Neutron Science); EHLERT, Sascha (Jülich Centre for Neutron Science JCNS-1 and Institute of Complex Systems ICS-1, Forschungszentrum Jülich GmbH); BHATNAGAR, Tanvi (Forschungszentrum Jülich GmbH); RÜCKER, Ulrich (JCNS, Forschungszentrum Jülich); Dr KOVACS, Andras (Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons (ER-C)); Prof. DUNIN-BURKOWSKI, Rafal (Ernst Ruska--Centre for Microscopy and Spectroscopy with Electrons (ER-C)); BRÜCKEL, Thomas (Forschungszentrum Jülich GmbH)

Presenter: KÖHLER, Tobias (JCNS-2)

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