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On the magnetization reduction in iron oxide nanoparticles

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Iron oxide nanoparticles are presently considered as promising objects for various medical applications including targeted drug delivery and magnetic hyperthermia. The nanoparticle solution in water has to possess large enough saturation magnetization to react on external magnetic field. However, there remains several unsolved questions regarding the effect of size onto nanoparticle overall magnetic behavior. One aspect is the reduction of magnetization as compared to bulk samples. A detailed understanding of the underlying mechanisms of this reduction will improve the particle performance in the applications.

There are several proposed models for the spatial distribution of the magnetization, which include the presence of a magnetic core-shell structure, spin disorder around defects and a reduced magnetization in the core due to reversed moments and frustration. In this work we combine neutron and synchrotron X-ray scattering techniques with magnetometry, transmission electron microscopy (TEM), elemental analysis and Mössbauer spectroscopy to study nanoparticles of various sizes and to obtain as complete as possible picture of their properties. We find that the nanoparticles possess a macroscopically reduced saturation magnetization, mostly due to the presence of antiphase boundaries as observed with high-resolution TEM (HRTEM) and X-ray scattering and to a lesser extent due to a small magnetically depleted surface layer and cation vacancies.

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