MA 36: Magnetic Particles / Clusters

Time: Thursday 9:30–11:00 Location: HSZ 401

MA 36.1 Thu 9:30 HSZ 401

Magnetic properties of metastable single-crystalline cobalt iron oxide nanoflakes investigated by Mössbauer spectroscopy

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Spinel-type transition metal oxides are of high interest for a variety of applications, including heterogeneous catalysis, energy conversion and magnetic materials with fine-tuned properties. The compound Co_2FeO_4 is of particular interest, but its phase diagram contains a large immiscibility. Using Mössbauer spectra recorded at low temperatures (4.3 K) and high magnetic fields (10 T), we were able to precisely determine the distribution of Fe ions across tetrahedral and octahedral sites. This enabled us to characterize the influence of different calcination temperatures from 400 °C up to 900 °C on the phase composition and miscibility, while also providing valuable insights on the temperature dependent evolution of the spectral hyperfine structure. These findings were successfully correlated with results from magnetometry, showing clear signs of a change in magnetic properties based on different degrees of intermixing, interface area, and phase separation, as also supported by TEM and EDX measurements. Financial support by the German Research Foundation (DFG) via the CRC/TRR 247 (Project-ID 388390466, sub-project B02) is gratefully acknowledged.

MA 36.2 Thu 9:45 HSZ 401

Mössbauer spectroscopy study of anisotropic barium ferrite hybrid systems

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Using anisotropic barium ferrite nanoplatelets in liquid or liquid crystalline (LC) environments, we obtain ferrofluids with anisotropic properties such as nematic formation of the platelets or a magneto-responsive LC system. The aim of this work is to study magnetic hybrid systems with temperature- and field-dependent Mössbauer spectroscopy, which gives us access to the diffusion processes of the particles via line broadening, and to the magnetic orientation behavior based on relative line intensity ratios. As barium ferrite exhibits a rather complex crystal structure, we use reference data of powder samples in order to investigate each individual iron sublattice position of this system. In an approach to analyze anisotropic diffusion and alignment processes more efficiently, spectra are recorded with gamma incidence direction perpendicular and parallel relative to the applied magnetic field. This work is supported by the DFG (LA5175/1-1.).

MA 36.3 Thu 10:00 HSZ 401

High throughput analysis of surface-functionalized superparamagnetic particles in dynamic magnetic field landscapes

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The precise manipulation of magnetic micro- and nano-particles in microfluidic environments opens new avenues for investigations of biomolecular analyte detection and interactions.[1] Motion control schemes based on a combination of static magnetic field landscapes superposed with external magnetic field pulses enable translatory motion control of magnetic particles at the nanoscale over macroscopic distances.[3] Here we demonstrate a novel method harnessing AI-enhanced fully-automated optical recognition algorithms [4] to analyze changes in the motion behaviour of such particles due to liquid mediated surface to surface (particle to substrate) interaction.

[1] Lim, B., Vavassori, P., Sooryakumar, R. & Kim, C. Nano/microscale magnetophoretic devices for biomedical applications. J. Phys. D: Appl. Phys. 50, 33002 (2017) [2]Lin, G., Makarov, D. & Schmidt, O. G. Magnetic sensing platform technologies for biomedical applications. Lab on a chip 17, 1884-1912 (2017) [3]Issadore, D. et al. Magnetic sensing technology for molecular analyses. Lab on a chip 14, 2385-2397

MA 36.4 Thu 10:15 HSZ 401

Reversible on-chip focusing and clustering of superparamagnetic beads using engineered magnetic domain patterns

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To realize fast and reliable point-of-care medical diagnostics, incorporating magnetic particles into a Lab-on-a-chip technology platform is considered promising. For sensitive detection, binding of the analyte species to surface-functionalized particles and subsequent formation of particle aggregates with the analyte acting as molecular bridges is a possible route [1]. As close proximity between particles is required for this scheme, we demonstrate in this work a locally defined focusing of superparamagnetic microparticles within an aqueous medium above a magnetically patterned flat substrate. Combining the magnetic stray field landscape that originates from periodic magnetic stripe domains of gradually decreasing/increasing length with external magnetic field pulses, converging and diverging motion trajectories were induced for the particles. Ultimately, this led to a controlled formation and decomposition of closely packed particle clusters. We will discuss how the observed behavior is determined by the acting forces and how it is influenced by the duration of the external field pulses.

[1] Rampini *et al.* (2021), Scientific Reports, 11(1):5302.

MA 36.5 Thu 10:30 HSZ 401

Distance- and size-dependence of the interactions within highly ordered magnetic nanoparticle mesocrystals

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Ferromagnetic resonance (FMR) experiments in combination with micromagnetic simulations are employed to investigate and characterize dipolar interactions between magnetic nanoparticles (MNPs) within such mesocrystals. The MNPs investigated in this work consist of iron oxide (magnetite - Fe3O4) and are coated with non-magnetic polymers, forming highly ordered hexagonal monolayer crystals. The magnetic response of the regularly arranged hexagonal mesocrystals can be tuned in a controlled way by varying the thickness of the non-magnetic polymer coating of the MNPs and thus the lattice constant of the mesocrystal.

The spectral features show distinct dipolar coupling phenomena within the mesocrystal and reveal that the material parameters of the MNPs such as the magnetization and the magnetocrystalline anisotropy are reduced with respect to their bulk counterpart.

MA 36.6 Thu 10:45 HSZ 401

Monte Carlo simulation of the aggregation of confined superparamagnetic colloids

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The properties of colloidal suspensions of superparamagnetic nanoparticles confined within inorganic and organic cavities have led to a num-

ber of interesting applications in areas such as nanomedicine, microfluidics, and nanorobotics. Therefore, predicting the morphology of the structures formed during the aggregation process of these particles under different scenarios is of key scientific interest.

In this work, the Monte Carlo and cluster-moving Monte Carlo methods have been employed to study the aggregated structures formed by magnetic particles confined in spherical (3D) and circular (2D) cavities. The impact of the number of particles, their initial configuration and the pair-potential model between the particles and between the particles and the cavity surface on the aggregated structure is assessed. Moreover, we present an improvement of the cluster-moving Monte Carlo method to increase the computational performance under curved confinement situations. This work provides insights that might prove useful for the development of more efficient simulation strategies that could play a crucial role in the design and prediction of new applications of this relevant type of colloidal systems.