# MA 46: Magnetic particles and clusters

Time: Thursday 11:30–13:15 Location: H52

MA 46.1 Thu 11:30 H52

**Magnetic properties of nanocomposite Fe/Ge$_m$ thin films** — •Thomas Reisinger, Cahit Benel, Gleb Iankevich, Ralf Witte, Di Wang, Leonardo Estrada, Robert Kruk, and Horst Hahn — Karlsruhe Institute of Technology, Institute of Nanotechnology, Eggenstein-Leopoldshafen, Germany

The functional properties of nanocomposites promise to meet many of the demanding material requirements faced by the modern high-tech industry. However, precise control over features such as chemistry, morphology and microstructure, as well as their preparation under well-defined conditions remain challenging. Here we show that the combination of size-selective cluster-ion-beam deposition and physical vapor deposition under ultra-high-vacuum conditions provides an excellent platform for the single-step synthesis of nanocomposite thin films with well-defined features such as for example cluster size and cluster concentration. In particular, we have used this method to prepare Fe/Ge$_m$ nanocomposite thin films with three different Fe cluster sizes (500, 1000, and 1500 Fe atoms per cluster and a spread in the mass distribution of less than 10%) and a range of Fe volume concentration (3-20 vol. %). The influence of these parameters on blocking temperature and saturation magnetization at low temperatures have been characterized using SQUID magnetometry. Further characterization of the chemistry, morphology and microstructure of the films has been investigated using transmission electron microscopy, X-ray photoelectron spectroscopy and energy-dispersive X-ray spectroscopy.

MA 46.2 Thu 11:45 H52

**Testing energy landscapes with trapped magnetic beads** — •Florian Ostermaier, Isiaka Lukman, Benjamin Riedmüller, and Ulrich Herr — Institut für Mikro- und Nanomaterialien, Universität Ulm, Ulm, Deutschland

Optical tweezers have been established as a powerful tool for passive microrheology of living cells and single molecule stretching. Magnetic tweezers offer a similar range of achievable force and particle localization, but may also be used in strongly absorbing environment. In addition, perspective Lab-on-Chip applications may benefit from the lack of requirement of high power Laser light.

We have already demonstrated successful trapping of single commercially available magnetic beads using a combination of the field gradient produced by a micro structured ring conductor and a superimposed homogeneous magnetic field.

Here we present studies of two magnetic beads simultaneously trapped in the same ring structure which are coupled via magnetic dipole-dipole interaction. The equilibrium distance between both beads depends on bead magnetization and the magnetic field gradient produced by the ring, and can therefore be tuned by varying the ring current. From the dynamics of the motion of the coupled beads in the trap potential, we extract information about the magnetic energy landscape formed by the combination of trap field and bead magnetization. In addition, interactions with the liquid environment and the walls of the trap can be extracted from analysis of the dynamics. We discuss possible applications in passive microrheology.

MA 46.3 Thu 12:00 H52

**Magnetic structure of Fe chains on Re(0001)** — •András Lászlóffy[1], László Udvardi[1,2], and László Szunyogh[1,2] — [1]Department of Theoretical Physics, Budapest University of Technology and Economics, Budapest, Hungary — [2]MTA-BME Condensed Matter Research Group, Budapest University of Technology and Economics, Budapest, Hungary

We present first principles calculations for closed packed chains of 5, 10 and 15 Fe atoms on the top of Re(0001) surface. We use the Embedded Cluster Korringa-Kohn-Rostoker Green's function scheme to investigate the magnetic properties of the systems, as well as the Relativistic Torque method to generate tensorial interactions of a classical spin model. It turns out that the nearest neigbour isotropic couplings are antiferromagnetic and the easy axis is in-plane and perpendicular to the chain direction. The 5 and 10-atom-long Fe chains somewhat deviate from a collinear state due to Dzyaloshinskii-Moriya (DM) interactions and two-site anisotropies. The 15-atom chain displays a spin-spiral ground state being close to an AFM state, with a modulation wavelength of 14 atom. Because of the out-of-plane hard axis the spins lie in-plane and the DM interactions determine the chirality of the spin spiral. Direct *ab initio* simulation of the ground state results in a similar magnetic structure, but with opposite chirality. Supported by suitable magnetic force theorem calculations, we propose that introducing four-spin chiral interactions in the spin-model is crutial to understand the chirality of the spin-spiral ground state of the chain.

MA 46.4 Thu 12:15 H52

**Mössbauer characterization of electrocatalytic ferrites** — •Soma Salamon[1], Joachim Landers[1], Georg Bendt[2], Kalapu Chakrapani[2], Friedrich Waag[2], Stephan Schulz[2], Malte Behrens[2], Rossitza Pentcheva[1], Stephan Barcikowski[2], and Heiko Wende[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen — [2]Faculty of Chemistry and CENIDE, University of Duisburg-Essen

Mössbauer spectroscopy has been applied to a variety of different ferrite material systems that show great promise for the application in the oxygen evolution reaction. Using measurements in transmission geometry at low temperatures and high magnetic fields, we were able to obtain information on the degree of inversion in spinel systems, which was correlated with the catalytic activities of the respective materials. A further adjustment of the catalytic activity was performed via pulsed laser fragmentation as well as cation substitution of ferrite nanoparticles, with the resulting changes in magnetic and material properties also being observable in our Mössbauer spectroscopy results. These were additionally crosschecked via magnetometry measurements. Financial support by the DFG through CRC/TRR 247 (project B2) is gratefully acknowledged.

MA 46.5 Thu 12:30 H52

**Accessing ferrofluid in-field dynamics via Mössbauer spectroscopy** — •Joachim Landers[1], Soma Salamon[1], Hilke Remmer[2], Frank Ludwig[2], and Heiko Wende[1] — [1]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen — [2]Institute for Electrical Measurement Science and Fundamental Electrical Engineering, TU Braunschweig

Ferrofluids of coated iron-oxide nanoparticles were studied in the presence of external magnetic fields using Mössbauer spectroscopy, utilizing its ability to simultaneously gain insight into different magnetic phenomena. For nanoparticles ranging from 5 to 25 nm in core diameter, dynamic relaxation processes, namely Néel relaxation and Brownian particle motion, were analyzed by this method, with results being verified by AC-susceptometry and in agreement with the fluids' macroscopic viscosity. From the same set of Mössbauer spectra, additional information could be extracted regarding the particles' magnetic alignment relative to the field direction, as well as the degree of surface spin canting and the presence of particle agglomerates. Funding by the DFG within SPP 1681 is gratefully acknowledged.

MA 46.6 Thu 12:45 H52

**Superparamagnetic limit of antiferromagnetic nanoparticles** — Unai Atxitia[1,2], Levente Rózsa[3], Tobias Birk[1], •Severin Selzer[1], and Ulrich Nowak[1] — [1]Universität Konstanz, D-78457 Konstanz — [2]Freie Universität Berlin, D-14195 Berlin — [3]Universität Hamburg, D-20355 Hamburg

Antiferromagnetic materials are promising candidates for future spintronic devices. Compared to ferromagnets, they have no stray fields, a low susceptibility to external fields and faster spin dynamics. However, for many applications the size of the magnetic structures has to be scaled down to the nanometer regime. As for ferromagnets, the magnetic stability of antiferromagnetic nanoparticles will be limited by thermal excitations.

We investigate the superparamagnetic limit of antiferromagnetic nanoparticles theoretically, focusing on a comparison to the known properties of ferromagnetic particles. We find a drastically reduced thermal stability because of the exchange enhancement of the attempt frequencies and the effective damping during the antiferromagnetic switching process. We show that the order parameter in antiferromagnetic particles may strongly oscillate during the reversal at low damping values.

MA 46.7 Thu 13:00 H52

**Strain and electric-field control of magnetism in iron oxide nanoparticle - BTO composites** — Li-Ming Wang[1], •Oleg Petracic[1], Emmanuel Kentzinger[1], Ulrich Rücker[1], Jürgen Schubert[2], Stefan Mattauch[3], Alexandros Koutsioubas[3], Markus Schmitz[1], Xian-Kui Wei[4], Marc Heggen[4], Vanessa Leffler[5], Sascha Ehlert[5], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science JCNS and Peter Grünberg Institut PGI, JARA-FIT, Forschungszentrum Jülich GmbH — [2]Peter Grünberg Institute (PGI9-IT), JARA-Fundamentals of Future Information Technology Forschungszentrum Jülich GmbH — [3]Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ) Forschungszentrum Jülich GmbH, Garching — [4]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons and Peter Grünberg Institute, Forschungszentrum Jülich GmbH — [5]Jülich Centre for Neutron Science JCNS-1 and Institute of Complex Systems ICS-1, Forschungszentrum Jülich GmbH

Ferrimagnetic iron oxide nanoparticle monolayers either on top of ferroelectric BaTiO3 (BTO) substrates or embedded into a BTO film were prepared and a magnetoelectric coupling effect was observed. The data recorded at various electric field values show that the electric field is able to alter the magnetism of the nanoparticle monolayer by a strain mediated magnetoelectric coupling effect. The magnetic depth profile of the nanoparticle monolayer was probed by polarized neutron reflectivity.