MA 8: Magnetic Particles/ Clusters I

Time: Monday 14:45–17:00 Location: HSZ 103

MA 8.1 Mon 14:45 HSZ 103

Optical detection of the rotational dynamics of anisotropic magnetic nanoparticles — •Stefan Schrittwieser[1], Joerg Schotter[1], Katerina Soulantika[2], Jerome Maynadie[2], Sergio Lentijo Mozo[2], Frank Ludwig[3], Jan Dieckhoff[3], Andreas Huetten[4], and Hubert Brueckl[1] — [1]AIT Austrian Institute of Technology, Nano Systems, Vienna, Austria — [2]LPCNO-INSA, Toulouse, France — [3]TU Braunschweig, Braunschweig, Germany — [4]Bielefeld University, Bielefeld, Germany

We introduce a novel biosensor concept, which is based on anisotropic hybrid nanoparticles consisting of magnetic nanorods encapsulated by noble metal shells. It relies on highly sensitive plasmon-optical detection of the rotational dynamics of magnetic nanoparticles immersed in the sample solution, which changes when target molecules bind to the surfaces of the nanoparticles due to the increase in their hydrodynamic radii. For alignment control of the nanoparticles in suspension, we employ constant-amplitude rotating magnetic fields. The increased hydrodynamic diameter of analyte-carrying nanoparticles translates into an easily measurable phase shift. Plain Co-nanorods dissolved in toluene solution serve as model system to verify the detection principle. Those show an optical anisotropy in polarized light, which is sufficient to optically detect their mean orientation in the solution. Along with the rotational dynamics data, we also present model calculations of both the magnetic and optical properties of suitable hybrid nanoparticles along with estimates concerning their relaxation behavior and sensitivity to molecular detection.

MA 8.2 Mon 15:00 HSZ 103

Interplay between chemical and magnetic order in CoRh nanoparticles: A first principles theoretical study — •Luis Enrique Diaz Sanchez[1], Jesus Dorantes Davila[2], and Gustavo Pastor[1] — [1]Institut für theoretische physik, Universität Kassel, Heinrich Plett Str. 40, 34132 Kassel, Germany — [2]Instituto de fisica, Universidad Autonoma de San Luis Potosi, Alvaro Obregon 64, 78000 San Luis Potosi, Mexico

The ground-state magnetic properties of Co_xRh_{1-x} nanoparticles having sizes N=43, 273 and 531 atoms, and Co concentrations X = 0, 0.25, 0.5, and 0.75 are investigated in the framework of density functional theory. The role of chemical order on the magnetic behavior is quantified by considering different fully-segregated face-centered cubic atomic arrangements showing both spherical and planar CoRh interfaces: core-shell and left-right subclusters. The ground-state magnetization for each cluster is determined by using a fixed-moment method. Electron correlation effects are discussed by comparing the results of LSDA and GGA exchange-correlation functionals. All considered CoRh clusters are found to be magnetic with an average spin moment that is larger than in macroscopic alloys with similar concentrations. The effect of embedding pure Co (Rh) clusters with Rh (Co) outer shells is analyzed.

MA 8.3 Mon 15:15 HSZ 103

GMR-based real-time cell endocytosis monitoring of magnetic particles — •Astrit Shoshi, Joerg Schotter, Peter Ertl, Philipp Schroeder, Moritz Eggeling, Marcus Milnera, Verena Charwat, Florian Bellutti, Michaela Purtscher, Alexandra Keller, and Hubert Brueckl — AIT Austrian Institute of Technology GmbH; Nano Systems, Donau-City-Strasse 1, 1220 Vienna, Austria

We present a Magnetic-Lab-on-a-Chip-System (MAGLab-System) which provides a platform for on-chip cell analysis. Cell analysis is carried out by the interplay between giant magnetoresistive sensors (GMR-Sensors), superparamagnetic particles (beads) and magnetic fields in a microfluidic environment. The GMR-sensors are embedded in a silicon chip and provide electronic signals proportional to their bead surface coverage. GMR-based real-time monitoring of cell endocytosis is realized by first immobilizing magnetic beads onto the GMR-sensor surface. Second, human fibroblast cells (NHDF) are grown over the entire sensor surface to a confluent monolayer. After bead recognition, the cells start to engulf and internalize them into phagosomes. During this uptake process, the distance between the beads and the sensor increases, leading to lower stray field strengths and smaller sensor signals. Real-time monitoring of the entire dynamic uptake process is realized by reading out the sensors at appropriate time-intervals. By following a similar approach, on-chip cell migration, adhesion, detachment and magnetic manipulation have also been demonstrated successfully.

MA 8.4 Mon 15:30 HSZ 103

Template assisted self-assembly of individual and clusters of magnetic nanoparticles — Giovanni A. Badini Confalonieri[1], Victor Vega[2], Astrid Ebbing[1], Durgamadhab Mishra[1], Philipp Szary[1], Victor M. Prida[2], •Oleg Petracic[1], and Hartmut Zabel[1] — [1]Festkörperphysik, Ruhr-Universität Bochum, 44801 Bochum — [2]University Oviedo, Department of Physics, Oviedo 33007, Spain

The deliberate control over the spatial arrangement of nanostructures is the desired goal for many applications as e.g. in data storage, plasmonics or sensor arrays. Here we present a novel method to assist the self-assembly process of magnetic nanoparticles. The method makes use of nanostructured aluminum templates obtained after anodization of aluminum disks and the subsequent growth and removal of the newly formed alumina layer, resulting in a regular honeycomb type array of hexagonally shaped valleys. The iron oxide nanoparticles, 20 nm in diameter, are spin coated onto the nanostructured templates. Depending on the size, each hexagon site can host up to 30 nanoparticles. These nanoparticles form clusters of different arrangements within the valleys, such as collars, chains, and hexagonally closed islands. Ultimately, it is possible to isolate individual nanoparticles. The strengths of magnetic interaction between particles in a cluster is probed using the memory effect known from the coupled state in superspin glass systems.

MA 8.5 Mon 15:45 HSZ 103

Tight-binding theory of noncollinear magnetism in transition metal nanostructures: structural and interaction parameters dependence of clusters — •Pedro Ruiz-Díaz[1], Raúl Garibay-Alonso[1], Jesús Dorantes-Dávila[2], and Gustavo Pastor[1] — [1]Institut für Theoretische Physik, Universität Kassel, Heinrich Plett Str. 40, 34132 Kassel, Germany — [2]Instituto de Física, Universidad Autónoma de San Luis Potosí, Alvaro Obregón 64, 78000 San Luis Potosí, Mexico

A self-consistent tight-binding electronic theory of noncollinear magnetism in nanostructures is presented and applied to transition metal clusters. The electronic structure is calculated by using a realistic rotational invariant tight-binding Hamiltonian and a real-space recursive expansion of the local Green's functions. For free clusters with sizes $N \leq 13$, results are given for the ground-state local magnetic moments, magnetic order and average magnetic moments as a function of the Coulomb exchange integral J and d-band filling. A variety of qualitatively different complex noncollinear spin arrangements solutions are obtained which reveals the complex magnetic landscape in transition metal nanostructures. The onset of noncollinear magnetism is discussed by analyzing the stability of the various magnetic solutions. Structural effects are studied by considering representative compact and open geometries. Our calculations are compared with previous density-functional results. Substrate effects on the noncollinearity of the moments are discussed by considering deposited Fe_3 clusters on Pt(111). Extensions and limitations of our work are also pointed out

MA 8.6 Mon 16:00 HSZ 103

Ab initio investigation of the role of the interatomic distances to optical spin manipulation in metallic three-center magnetic clusters — •Hongping Xiang, Georg Lefkidis, and Wolfgang Hübner — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern

Recently, laser-induced femtomagetism opened a new frontier for the faster magnetic logic devices in order to complement conventional elements [1]. The laser-induced spin flip and transfer in magnetic multicenter nanostructures have been investigated widely as an appealing alternative. Previously, we found that in the realistic three-center metallic cluster Ni$_3$Na$_2$ (3.6 Å interatomic distance), laser-induced a spin flip and transfer can be achieved within a hundred femtoseconds [2]. Here, we investigate the effect of the structural distortion of Ni$_3$Na$_2$ on the magnetic state and the speed and

fidelity of spin flip and transfer by changing the interatomic distances. If we decrease the interatomic distance in steps of 0.05 Å the spin localization remains the same but the spin density decreases. When the distance reaches 3.4 Å the spin localization changes as well. Similar effects appear if we increase the distance. We further investigate these effects on the speed and the fidelity of the Λ processes.

\noindent [1] G. P. Zhang, W. Hübner, G. Lefkidis, Y. Bai, T. F. George, Nat. Phys. {\bf 5}, 499 (2009)

\noindent [2] W. Hübner, Kersten, S., Lefkidis, G., Phys. Rev. B {\bf 79}, 184431 (2009)

MA 8.7 Mon 16:15 HSZ 103

Studying the effect of particle size and organic capping on magnetic and structural properties of iron oxide nanoparticles by Mössbauer spectroscopy — •Masih Darbandi, Frank Stromberg, Joachim Landers, Carolin Antoniak, Werner Keune, and Heiko Wende — Faculty of Physics and CeNIDE, University of Duisburg-Essen, Germany

Iron oxide nanoparticles have been extensively studied and are attracting growing interest due to their unique intrinsic magnetic properties combined with the nano-size effects. It is well-known that these nanostructured magnetic materials have great potential for many useful applications ranging from information storage and electronic devices to biomedical applications and drug delivery. We have synthesized uniform-sized and crystalline iron oxide nanoparticles in high yield using a microemulsion route at room temperature. Particle size control has been attained by careful adjustment of the preparation conditions. Complementary techniques such as TEM, XRD, SEM were used for the evaluation of their structural and physicochemical properties. A particular effort has been devoted in this work to study the effect of the size and capping of these nanoparticles by Mössbauer spectroscopy at low temperature and with the application of magnetic fields up to 5 T. The sample with the smallest diameter exhibits a markedly different Mössbauer spectrum compared with bigger particles. Most importantly the separation of a surface/volume contribution for the capped nanoparticles with Mössbauer spectroscopy will be reported. Supported by DFG (WE 2623/3-1)

MA 8.8 Mon 16:30 HSZ 103

Magnetic and transport properties of Py/iron-oxide nanoparticle composite systems — •Philipp Szary[1], Giovanni A. Badini Confalonieri[1], Durgamadhab Mishra[1], Maria Jose Benitez[1,2], Mathias Feyen[2], Anhui Lu[2], Leonardo Agudo[3], Gunther Eggeler[3], Oleg Petracic[1], and Hartmut Zabel[1] — [1]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Max-Planck Institut für Kohlenforschung, D-45470 Mülheim an der Ruhr, Germany — [3]Institut für Werkstoffe, Ruhr-Universität Bochum, D-44780 Bochum, Germany

We have investigated the magnetic and electrical transport properties of Permalloy/iron-oxide nanoparticle-composite systems. Ultrathin films of Permalloy (Py) have been prepared by UHV ion beam sputtering and subsequently covered by one monolayer of iron-oxide nanoparticles. Post-annealing of the samples under controlled atmospheric conditions allows us to transform the particles into a mixed wüstite/magnetite (Fe_xO/Fe_3O_4) phase [1]. Magnetometry measurements have been performed using superconducting quantum interference device (SQUID) magnetometry. M(H) magnetic hysteresis curves reveal a strong magnetic coupling between both subsystems. Moreover, magnetoresistance measurements were performed by contacting the Py layer. The results are consistent with the magnetometry data. We find that the presence of the nanoparticles significantly influences the magneto-transport behavior through the Py layer.

[1] M.J. Benitez et al., submitted (arXiv:1010.0938)

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