MA 45: Micromagnetism/ Computational Magnetics

Time: Wednesday 17:30–19:00 Location: HSZ 403

MA 45.1 Wed 17:30 HSZ 403

Pinning of domain walls in exchange-spring composite media — •Dagmar Goll[1] and Helmut Kronmüller[2] — [1]Aalen University, Materials Research Institute, Beethovenstr. 1, 73430 Aalen — [2]Max Planck Institute for Metals Research, Heisenbergstr. 3, 70569 Stuttgart

High-density magnetic recording in the Tbit/in^2 range is based on single bit particles in the nm-range. The prerequisites for high-density recording are the following ones: Texture axis in perpendicular direction, thermal stability up to 100 °C, reversal fields between 1 - 2 T, and switching times in the ps-range. Composite nanoparticles composed of a soft and a hard magnetic layer are suitable to fulfill the above conditions. The magnetic ground states of bi- and trilayers are determined as a function of the thickness of the soft magnetic layer. It is shown that there exist critical fields for the ground state defining homogeneous and inclined magnetic states as well as reversal fields depending on the exchange length of the hard magnetic layer. The coercive field has a lower bound for film thicknesses larger than the exchange length of the magnetization determined by the depinning field of a Néel wall at the phase boundary. An upper limit exists for film thicknesses of the soft magnetic film of the order of the exchange length of the crystalline anisotropy of the hard magnetic phase and is given approximately by 1/4 of the nucleation field of the hard phase.

MA 45.2 Wed 17:45 HSZ 403

Depinning fields of domain-walls at defects and notches in magnetic nanowires with perpendicular magnetic anisotropy determined by micromagnetic simulations — •Theo Gerhardt[1], André Drews[1,2], and Guido Meier[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Germany — [2]Arbeitsbereich Technische Informatik Systeme, Department Informatik, Universität Hamburg, Germany

Magnetic multilayers with perpendicular magnetic anisotropy are a well known material system with potential application e.g. in storage concepts based on current-driven domain-wall motion [1,2]. For the feasibility of this concept the domain-walls need to get pinned at predefined positions which can be created by artificial defects or notches. Artificial defects are local reductions of the anisotropy constant K_1. We present a systematic investigation of the influence of the shape, size, and strength of the reduction of the anisotropy constant K_1 on the depinning field of domain-walls at defects. The depinning fields strongly depend on the shape of the defect and increase with a larger defect size and a stronger reduction of the anisotropy constant K_1. Furthermore the depinning fields at notches are systematically investigated in dependence on the shape and size of the notch. The shape of the notch has a significant influence on the maximal depinning field. Deeper notches cause an increase of the depinning field. Comparison between simulated and theoretical depinning fields of defects and notches reveal a good agreement. [1] S. S. P. Parkin et al., Science **320**, 190 (2008), [2] Hironobu Tanigawa et al., Appl. Phys. Express **2** , 053002 (2009)

MA 45.3 Wed 18:00 HSZ 403

Transmission of spin waves at pinned domain walls in exchange-spring composite media — •Sebastian Macke[1] and Dagmar Goll[2] — [1]Max Planck Institute for Metals Research, Heisenbergstr. 3, 70569 Stuttgart — [2]Aalen University, Materials Research Institute, Beethovenstr. 1, 73430 Aalen

Exchange-coupled composite (ECC) elements which seem to be most straightforward for realizing ultrahigh recording densities (>1 Tbit/in^2) are composed of a hard magnetic part and a soft magnetic part which are coupled by exchange interaction through the common interface. Recently investigations of the spin wave behavior at hard-soft interfaces started to become a matter of interest in order to determine the magnetic properties at the interfaces. With a pinned magnetic domain wall at such interfaces these properties can be influenced by an external magnetic field [1] which can be used in spin wave valve applications. We investigated the injection of spin waves from one material into the other by analyzing the frequency dependent transmission and reflection coefficients of the propagating spin waves. The topic is handled within the framework of the continuum theory of micromagnetism by numerical simulations. Pinned by an external magnetic field at the interface charged Néel walls in stripes as well as Néel walls in thin films are analyzed for different material combinations. Dependent on the spin wave frequency the transmission rate of the spin waves can change by one order of magnitude when the strength of the applied magnetic field is close to the depinning field.

[1] Livesey et. al., Phys. Rev. B. 73, 184432 (2006)

MA 45.4 Wed 18:15 HSZ 403

New methodology for micromagnetic simulations of nanocomposites — •Sergey Erokhin, Dmitry Berkov, and Nataliya Gorn — INNOVENT e.V., Pruessingstr. 27B, D-07745 Jena, Germany

A new micromagnetic methodology for numerical simulations of magnetic nanocomposites is presented. It enables to calculate the magnetization distribution and corresponding small-angle neutron scattering (SANS) cross section of a 3D nanocrystalline system.

In our contribution we consider a nanocomposite of the Nanoperm type, which consists of the iron based crystallites with size of around 10 nm (hard magnetic phase) embedded in an amorphous soft magnetic matrix. The basic constituents of our methodology are as follows: (1) The spatial arrangement of the finite elements is random to avoid artifacts caused by the regular element placement. To generate a corresponding mesh, we employ the modified algorithm suggested earlier for the random close packing of spheres. (2) The magnetodipolar interaction between finite elements is computed in the spherical dipoles approximation. Being exact for spherical particles, this approximation results in some computational errors for the polyhedra used in our method. However, these errors are small, because the shape of our finite elements is close to spherical (due to their spatial distribution). (3) The exchange interaction energy is computed using the standard Heisenberg exchange form. The exchange constant is proportional to the volumes of neighbouring finite elements and depends on the spacing between them as in a standard finite-difference approach.

MA 45.5 Wed 18:30 HSZ 403

Master equation in phase space for a spin in an arbitrarily directed uniform external field — Yuri Kalmykov[1], •Bernard Mulligan[2], Serguey Titov[3], and William Coffey[4] — [1]Laboratoire de Mathématiques, Physique et Systèmes, Université de Perpignan, 52, Avenue de Paul Alduy, 66860 Perpignan Cedex, France. — [2]Dresden — [3]Institute of Radio Engineering and Electronics, Russian Acad. Sci., Vvedenskii Square 1,Fryazino 141190, Russia. — [4]Department of Electronic and Electrical Engineering, Trinity College, Dublin 2, Ireland.

The time evolution equation for the probability density function of spin orientations in the phase space representation of the polar and azimuthal angles is derived [1] for the nonaxially symmetric problem of a quantum paramagnet subjected to a uniform magnetic field of arbitrary direction. This is accomplished by first rotating the coordinate system into one in which the polar axis is collinear with the field vector, then writing the reduced density matrix equation in the new coordinate system as an explicit inverse Wigner-Stratonovich transformation so that the phase space master equation may be derived just as in the axially symmetric case [2]. The properties of this equation, resembling the corresponding Fokker-Planck equation, are investigated. In particular, in the large spin limit, the master equation becomes the classical Fokker-Planck equation describing the magnetization dynamics of a classical paramagnet in an arbitrarily directed uniform external field.

1. Yu.P. Kalmykov et al., J. Stat. Phys., 141, 589 (2010).
2. Yu. P. Kalmykov et al., J. Stat. Phys. 131, 969 (2008).

MA 45.6 Wed 18:45 HSZ 403

Dynamical simulation of integrable and non-integrable models in the Heisenberg picture — •Dominik Muth, Razmik Unanyan, and Michael Fleischhauer — Fachbereich Physik und Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, D-67663 Kaiserslautern

The numerical simulation of quantum many-body dynamics is typically limited by the linear growth of entanglement with time. Recently numerical studies have shown, however, that for 1D Bethe-integrable models the simulation of local operators in the Heisenberg picture can be efficient as the corresponding operator-space entanglement grows only logarithmically. Using the spin-1/2 XX chain as generic example of an integrabel model that can be mapped to free particles, we here provide a simple explanation for this. We show furthermore that the same reduction of complexity applies to operators that have a high-temperature auto correlation function which decays slower than exponential, i.e., with a power law. This is amongst others the case for models where the Blombergen-De Gennes conjecture of high-temperature diffusive dynamics holds. Thus efficient simulability may already be implied by a single conservation law (like that of total magnetization), as we will illustrate numerically for the spin-1 XXZ model. Finally we discuss the advantage of incorporating the conservation law into the algorithm, which can be essential for applications and is frequently implemented in the Schrödinger picture.

Dominik Muth, Razmik G. Unanyann, and Michael Fleischhauer, arXiv:1009.4646