MA 10: Focus Session: Magnetic Excitations: from surfaces down to adatoms (jointly with O)

Organizer: Stefan Blügel (Forschungszentrum Jülich)

In recent years, major advancements have been made in the study of collective, localized, and discrete excitations in itinerant nanomagnets and atomic quantum magnets. This progress has been triggered by the development of spin-polarized electron energy loss spectroscopy (SPEELS) and by low-temperature scanning probe techniques (STM). These tools probe inelastic spin-dependent phenomena and moved the investigation of inelastic magnetic effects to the forefront of research in nanomagnets. Challenged by these experiments, new theoretical approaches have been developed, e.g. based on time-dependent density functional theory and many-body perturbation theory. In this session, we focus on a variety of new physics in this area of research. We start from the collective excitations in low-dimensional films as measured with SPEELS and inelastic STM and then move to systems of small adclusters and adatoms.

Time: Monday 15:00–17:30 Location: H23

Topical Talk MA 10.1 Mon 15:00 H23

Tailoring magnetic excitations in low-dimensional ferromagnets — •Khalil Zakeri Lori — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

We present a summery of our recent results on elementary magnetic excitations (magnons) in ultrathin ferromagnets. Terahertz magnons in ultrathin Fe(100), Fe(110) and Fe(111) films, grown on different surfaces, are probed by means of spin-polarized high resolution electron energy-loss spectroscopy. The key properties of magnons such as their dispersion relation and lifetime are measured over the entire Brillouin zone. It is demonstrated that these properties depend strongly on the atomic structure of the films as well as the degree of electronic hybridization with the substrate. We discuss how the complexity of the electronic structure, degree of electronic hybridization and the contribution of different orbitals to the exchange interaction can lead to unexpected behavior of magnon energies. The lifetime of terahertz magnons is found to be a few tens of femtoseconds at low wave vectors, which reduces significantly as the wave vector approaches the Brillouin zone boundary. Based on our results we comment on the damping mechanism of terahertz magnons. Finally, we introduce a way of tailoring the properties of terahertz magnons by engineering the electronic structures.

Topical Talk MA 10.2 Mon 15:30 H23

Theory of spin waves in ultrathin ferromagnetic films — •Roberto Muniz and Antonio Costa — Instituto de Fisica, Universidade Federal Fluminense,Niteroi, RJ 24210-346, Brazil

We review our theoretical studies of spin dynamics in ultrathin ferromagnetic films adsorbed on metallic substrates. Our approach is based on a realistic description of the electronic structure for the substrate/adsorbate combination. Ferromagnetism in the film is driven by on site Coulomb interaction between the d electrons treated in mean field theory, and the spin wave excitations are described by the transverse spin dynamic susceptibility, which is calculated within the random phase approximation. We find the lifetimes of short-wavelength spin excitations in such systems are very short due to their decay to Stoner excitations, in accordance with spin-polarized electron energy-loss spectroscopy (SPEELS) data. We also discuss the influence of spin-orbit coupling on the spin-wave excitation spectra and find that our theory accounts for asymmetries seen in SPEELS studies of spin waves in the bilayer of Fe on W(110).

Topical Talk MA 10.3 Mon 16:00 H23

Magnetic excitations in all metallic nanostructures — •Wulf Wulfhekel — Physikalisches Institut, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany

The spins in magnetic nanostructures can be excited, when passing an electric current through them. In the inelastic scattering events, the spin of a hot electron of the current provided by a scanning tunneling microscope may be flipped and angular momentum is transferred to the magnetic system [1]. We used this technique to determine magnon dispersions and life times in thin itinerant magnetic films [2] and to determine the magnetic anisotropy and exchange coupling in atomically assembled magnetic clusters [3]. Finally, we show that the technique is capable to detect spin flips also in rare earth clusters and that the anisotropy as well as the life times of the states in the 4f-systems require a fully relativistic treatment [4].

[1] T. Balashov et al., Phys. Rev. Lett. 97, 187201 (2006), Phys. Rev. B 78, 174404 (2008). [2] C.L. Gao et al., Phys. Rev. Lett. 101, 167201 (2008). [3] T. Balashov et al., Phys. Rev. Lett 102, 257203 (2009). [4] T. Schuh et al., Phys. Rev. B 84, 104401 (2011), Nano Lett. 12, 4805 (2012).

Topical Talk MA 10.4 Mon 16:30 H23

Magnetization dynamics derived from excitations of single magnetic atoms on surfaces — •Alexander Ako Khajetoorians — Hamburg University, Hamburg, Germany

With the development of sub-Kelvin high-magnetic field STM, two complementary methods, namely spin-polarized scanning tunneling spectroscopy (SP-STS) [1] and inelastic STS (ISTS) [2-3], can address single spins at the atomic scale. While SP-STS reads out the projection of the impurity magnetization, ISTS detects the excitations of this magnetization as a function of an external magnetic field. They are thus the analogs of magnetometry and spin resonance measurements pushed to the single atom limit. We have recently demonstrated that it is possible to reliably combine single atom magnetometry with an atom-by-atom bottom-up fabrication to realize complex atomic-scale magnets with tailored properties [4-5]. In this talk, I will address recent developments in probing the spin excitations and magnetization curves of atoms on a multitude of non-magnetic surfaces, and the effects of the electronic structure on the precessional dynamics of the atomic spin. Moreover, I will discuss investigations of the magnetization dynamics [6] of coupled spins as probed with spin-resolved STM techniques and how the relaxation is affected by processes like quantum tunneling and spin-transfer torque. [1] A.A.K., *et al.* , PRL, **106**, 037205 (2011); [2] A. J. Heinrich, *et al.* , Science, **306**, 466 (2004); [3] A.A.K, *et al.* , Nature, **467**, 1084 (2010); [4] A.A.K., *et al.*, Nature Physics, **8**, 497 (2012) [5] A.A.K., *et al.* , Science, **332**, 1062 (2011), [6] A.A.K., *et al.*, Science, in press (2012)

Topical Talk MA 10.5 Mon 17:00 H23

Theory of dynamical magnetic excitations in itinerant nanomagnets — •Samir Lounis — Institute for Advanced Simulation, Forschungszentrum Jülich, 52425 Jülich, Germany

During the past decades we witnessed an unimaginable progress in the observation and understanding of magnetic structures in nanomagnets. In comparison, our understanding of the dynamics, excitations and switching of magnetism in nanostructures is still in its infancy. In the last years inelastic low-temperature spin-polarised scanning tunneling spectroscopy has been developed and explored producing exciting new insights. In these experiments, the electrons interact with the substrate during the tunneling process, exchange energy and possibly spin angular momentum, leading to inelastic tunneling. To understand, predict and unravel the mechanisms behind these excitations, we developed a method based on first-principles. For instance, during the tunneling process, the dynamical magnetic susceptibility is computed, whose imaginary part gives the density of – , as well as the coupling of tunneling electrons with the spin-excitations that is quantified in terms of a self-energy. An overview of our investigations will be presented: 3*d* adatoms deposited on several metallic surfaces: Cu(100), Cu(111), Ag(111) and Pt(111) with a focus on the impact of adatoms atomic number, nature of the substrate, details of the electronic hybridization as well as the decay of the electronic signal into vacuum.

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