MA 11: Focus: Progress in Spin-Polarized Electron Spectroscopies

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The electron spin plays a major role for many effects in solid state physics. The advance of the field of spintronics will rely on the efficient manipulation and conservation of electronic spin states in matter. Experimental methods that allow the application or detection of spin-polarized electrons are highly desired for investigations of materials with complex spin textures. This field is receiving renewed interest, for example by the prospect of using topologically protected spin textures for the creation or manipulation of spin-polarized electron currents. Complex spin structures that owe their presence to the competition of different spin-orbit-coupling effects are also in the focus of current interest.

Time: Monday 15:00–18:00 Location: EB 301

Invited Talk MA 11.1 Mon 15:00 EB 301
Acoustic und standing spin wave modes in ultra-thin 3d metal films — •Harald Ibach — Peter Grünberg Institute, Research Center Jülich, Germany

The spin wave spectrum of well-ordered ferromagnetic N-layer films consists of N modes with zero to N-1 nodes inside the film. The energy of these spin waves as function of the wave vector parallel to the surface may be studied by using inelastic scattering of low-energy electrons. Because of low energy resolution (FWHM=20-40meV) early work on cobalt and iron films had to focus on the high-energy and high wave vector regime q|| > 3nm-1 where the damping of the modes due to Stoner excitations is extremely large. For fcc cobalt films this has led to the erroneous interpretation that (i) electrons interact primarily with the surface mode of the film, that (ii) the surface mode is the lowest energy mode and (iii) that the dispersion of that mode is well described by a simple nearest-neighbor Heisenberg model with a single, layer-independent exchange coupling constant. With improved electron spectrometers featuring 3meV resolution we are now in the position to study the low momentum regime q|| < 3nm-1 where the spectrum consists of a series of separate, well-defined spin wave peaks. The study of these spin waves as function of the film thickness reveals that the exchange coupling constants near surface and interface differ substantially from those in the interior of the film. Spin wave spectroscopy has thus become a tool to study the layer dependence of the exchange coupling.

Invited Talk MA 11.2 Mon 15:45 EB 301
Magnetic structure and magnetic anisotropy on the atomic scale — •Chunlei Gao — Key Laboratory of Artificial Structures and Quantum Control (Ministry of Education), Department of Physics and astronomy, Shanghai Jiao Tong University, Shanghai, China

Spin-polarized scanning tunneling microscopy (Sp-STM) has demonstrated its ability in resolving magnetic structure on the atomic scale even in the complex noncollinear case. The exclusive determination of the moment orientation of each single magnetic atoms still remains as a challenge. In this presentation, I will show that by taking the advantage of Sp-STM operating in a vectorial field, magnetic structure and magnetic anisotropy are identified on various magnetic surfaces on the atomic scale.

15. min. break

Invited Talk MA 11.3 Mon 16:30 EB 301
Spin-resolved photoelectron spectroscopy with high efficiency and potential of full momentum analysis — •Shigemasa Suga — MPI of Microstructure Physics, Halle, Germany — Inst. of Sci. & Ind. Research, Osaka University, Osaka, Japan

Spin information on electronic structures in solids can directly be obtained by photoelectron spectroscopy (PES) and angle-resolved PES (ARPES) with use of spin detectors. However,the rather low efficiency of spin detection was a barrier for its wide use. In order to overcome this difficulty, various spin detectors were so far invented after Au Mott detector. W(001)-SPLEED[1], Fe(001)p1x1-O VLEED[2] as well as Au/Ir(001)[3] are such examples. Brief description of spin detectors and their performance as well as examples of experiments are discussed.

Since prompt measurement of spin polarization Ps with high resolutions of momentum and binding energy is required, simultaneous two-dimensional detection, Ps(EB(kx,ky)), by use of the so-called spin-momentum microscope based on a PEEM input lens and a tandem double hemispherical analyzer is developed[4]. Examples of relatively low photon energy experiments and the prospect of its use in the soft- and hard X-ray regions will be discussed.——[1]J.Kirschner, Polarized Electrons at Surfaces, Springer Tracts in Modern Physics, vol.106 (1985).[2] T.Okuda et al., J.Electron Spectrosc. Rel. Phenom. (2014) in press and Rev.Sci.Instrum.79,123117 (2008).[3] J.Kirschner et al., Phys.Rev.B88, 125419 (2013). [4] C.Tusche et al., Ultramicroscopy 130, SI 70-76 (2013) and an invited talk, Surface Science session in this conference.

Invited Talk MA 11.4 Mon 17:00 EB 301
High-efficiency spin-resolved ARPES with a TOF-based exchange polarimeter — •Chris Jozwiak — Advanced Light Source, Lawrence Berkeley National Lab, Berkeley, California, U.S.A.

A strong fundamental interest in the spin-degree of freedom in electronic systems has driven decades of persistence and creativity in developing a range of methods for spin-resolved photoemission spectroscopy. The demanding but powerful technique of Spin- and Angle-Resolved Photoemission Spectroscopy (Spin-ARPES) has steadily expanded in the last decade due to an increasing demand for probing momentum dependent electronic spin in a wide variety of materials. Strongly spin-orbit coupled materials, including Topological Insulators (TIs), have particularly stimulated advancement of the technique due to characteristic momentum-dependent spin-textures. I will present an overview of the "spin-TOF analyzer", an instrument developed at the ALS for high-resolution and high-efficiency spin-ARPES [1]. The analyzer combines the efficiency of low energy exchange scattering spin detection (e.g. [2]) with the parallel energy resolution of time-of-flight (TOF) detection (e.g. [3]). I will describe details of this unique combination and present examples of its use with both synchrotron light and lab-based laser systems, focusing on the observations of surprising spin-polarization effects in the photoemission from TIs [4]. — [1] C. Jozwiak et al., Rev. Sci. Instrum. 82, 053904 (2010). [2] Hillebrecht et al., Rev. Sci. Instrum. 73, 1229 (2002). [3] N. Müller et al., J. El. Spectr. Rel. Phenom. 72, 187 (1995). [4] C. Jozwiak et al., Nature Phys. 9, 293 (2013).

Invited Talk MA 11.5 Mon 17:30 EB 301
Prospects of Multichannel Spin Detection — •Gerd Schönhense — Institut für Physik, Johannes Gutenberg-Universität, 55128 Mainz

The high level of sophistication of a modern hemispherical analyzer (HA), detecting N>10^4 data points in parallel, contrasts with present days' spin detectors. Their figures of merit (FoM) only slightly improved during the last decades. Multichannel spin detection in combination with a HA [1] was a major step forward, owing to its 2D figure of merit FoM_2D=N*FoM (with N=800 in [1]). This detector e.g. allows probing the half-metallicity of Heusler compounds like Co2MnSi [2], whose high reactivity poses a challenge to reliable spin measurements. Going further in parallelization, an imaging spin filter in a cathode-lens type microscope yields unprecedented spin-resolving acquisition speed with N=5000 data points in parallel [3]. Finally, a 3D-method for spin-resolved momentum microscopy with utmost efficiency is developed by Univ. of Mainz and Max-Planck-Institute in Halle. This instrument implements the superior resolution and parallel acquisition capability of ToF photoemission microscopy. A challenging target for multichannel spin detection is Spin-HAXPES, suffering from extremely low cross sections. – [1] M.Kolbe et al., PRL 107 (2011) 207601; [2] M.Jourdan et al., Nature Mat. 5 (2014) 3974; [3] C.Tusche et al., APL 99 (2011) 032505 and C.Tusche, talk at this conference.