INTERDISCIPLINARY CENTRE FOR ADVANCED MATERIALS SIMULATION

ICAMS Seminar

Prof. Stefan Blügel

Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, Germany

Monday, May 27, 4:30 p.m. ICAMS Seminar room 0.08

Topologically protected Spin Textures at Metal Surfaces

In the seventies, the surface science and the magnetism community joint to investigate the magnetism of surfaces. Experimental techniques such as the spin-polarized photoemission (SP-ARUPS), SP-STM, SP-Electron Energy Loss Spectroscopy, Brillouin Light scattering etc. were developed. This was the basis for further developments such the physics of the magnetic multilayers, of thin films or magnetic nanostructures, which finally sparked the field of spintronics. For many years, we witness in this field a strong interaction between experiment and first-principles theory.

I try to give a brief overview into this field from a theoretical standpoint and then I would like to turn to the recent field of chiral magnetism and Skyrmions that generates currently a lot of attention in high-impact journals. The field got a huge impact through our recent understanding of the relevance of the Dzyaloshinskii-Moriya (DM) interaction in ultrathin films deposited on metal surfaces [1], a new chapter in the field of research of low-dimensional magnetism was initiated. Appling first-principles calculations based on the density functional theory to ultrathin magnetic films, we explored the Dzyaloshinskii-Moriya interaction caused by spin-polarized electrons in the structure inversion asymmetric environment of 3d metal films on W substrates. We found that due to the large spin-orbit interaction of the W substrate the Dzyaloshinskii interaction exceeds a critical strength and competes with the exchange interaction and causes the formation of one-dimensional short-period cycloidal magnetic spirals of unique winding sense in the Mn film [1, 2]. The phenomenon is more general than expected and was also found for finite magnetic wires of Fe-double chains grown in troughs of the reconstructed Ir(100)5x1 substrates [3]. Also the effect of the Dzyaloshinskii-Moriya interaction on the domain-walls will be

discussed [4]. Recently we could go one step further and theoretically design a magnetic film, a monolayer of Fe on Ir(111) that exhibits a lattice of non-trivial two-dimensional magnetic structures, a nano-Skyrmion lattice [5]. We explore the phase diagram of the magnetic system based on parameters obtained from first-principles and finite size effects e.g. finite Fe clusters on Ir(111).

Acknowledgement:

This work was carried out in collaboration with Marcus Heide, Samir Lounis, Gustav Bihlmayer, Stefan Heinze from the theory side and Matthias Bode, Andre Kubetzka, Kirsten von Bergmann of the Wiesendanger group from the experimental side.

[1] M. Bode, M. Heide, K. von Bergmann, S. Heinze, G. Bihlmayer, A. Kubetzka, O. Piet-zsch, S. Blügel, R. Wiesendanger, Nature 447, 190 (2007).

[2] P. Ferriani, K. von Bergmann, E.Y. Vedmedenko, S. Heinze, M. Bode, M. Heide, G. Bihl-mayer, A. Kubetzka, S. Blügel, R. Wiesendanger, Phys. Rev. Lett. 101, 027201 (2008).

[3] M. Menzel, Y. Mokrousov, R. Wieser, J. E. Bickel, E. Vedmedenko, S. Blügel, S. Heinze, K. von Bergmann, A. Kubetzka, and R. Wiesendanger, Phys. Rev. Lett. 108, 197204 (2012).

[4] M. Heide, G. Bihlmayer, and S. Blügel, Phys. Rev. B 78, 140403 (R) (2008); and Physica B 404, 2678 (2009).

[5] S. Heinze, K. von Bergmann, M. Menzel, J. Brede, A. Kubetzka, R. Wiesendan-ger, G. Bihlmayer, and S. Blügel, Nature Phys. 7, 713 (2011).