O 110: Poster Session VIII: Poster to Mini-Symposium: Dzyaloshinskii-Moriya Interaction (DMI) in magnetic layered systems

Time: Thursday 13:30–15:30 Location: P

O 110.1 Thu 13:30 P

Magnetic exchange interactions at proximity of a superconductor — •Uriel Allan Aceves Rodriguez[1], Sascha Brinker[1], Filipe Souza Mendes Guimaraes[2], and Samir Lounis[1,3] — [1]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich & JARA, 52425 Jülich, Germany — [2]Jülich Supercomputing Centre, Forschungszentrum Jülich & JARA, 52425 Jülich, Germany — [3]Faculty of Physics, University of Duisburg-Essen, 47053 Duisburg, Germany

Magnetic impurities coupled to superconductors give rise to a plethora of rich physics such as sub-gap states like Yu-Shiba-Rusinov states and Majorana zero modes, which constitute key mechanisms on the road towards a topological quantum computer. The interplay of spin-orbit coupling and (non-collinear) magnetism enrich the complexity and topological nature of the in-gap states hosted in proximity-induced superconductors. However, little is known about the impact of superconductivity on the different contributions to the magnetic exchange interactions, like the bilinear isotropic exchange and the Dzyaloshinskii-Moriya interaction — and in turn the impact on the magnetic textures. In this work, we propose a method for the extraction of the tensor of exchange interactions in the superconducting regime as described in the framework of the Bogoliubov-de Gennes method. We investigate various $3d$ monolayers deposited on the Nb(110) surface based on our multi-orbital tight-binding code TITAN.
–Work funded by Horizon 2020–ERC (CoG 681405–DYNASORE).

O 110.2 Thu 13:30 P

Stabilizing Zero-Field Skyrmions with Cobalt-decorated Edges in Ultrathin Films — •Jonas Spethmann, Elena Vedmedenko, Roland Wiesendanger, André Kubetzka, and Kirsten von Bergmann — Department of Physics, University of Hamburg, 20355 Hamburg, Germany

Magnetic skyrmions are promising candidates to serve as information carriers in the emerging field of spintronic memory and logic devices. In such devices it is quintessential to prevent the loss of information. One common pathway towards skyrmion destruction is via the edge of the skyrmion material. This could prove detrimental in any potential skyrmion racetrack device, due to the magnus force driving the skyrmions towards the racetrack edge [1]. In our model system, a bilayer of Pd/Fe on the Ir(111) surface [2], skyrmion collapse at the edge becomes the prevalent skyrmion destruction pathway for small external magnetic fields [3]. We modify the Pd/Fe island edge by adding Co to the system and investigate it using spin-polarized STM. The Co-decorated edges strongly affect the magnetic ground state of Pd/Fe, by changing the spin spiral propagation direction. Surprisingly, we also observe single skyrmions and occasionally 2π skyrmions in the magnetic virgin state. Additionally, we find that at fields above 1 T skyrmions can pin to the Co edge without collapsing and utilize spin dynamics simulations to investigate this phenomenon.
[1] W. Jiang *et al.*, Nature Physics **13**, 162-169 (2018).
[2] N. Romming *et al.*, Science **341**, 636-639 (2013).
[3] P. F. Bessarab *et al.*, Sci. Rep. **8**, 3433 (2018).

O 110.3 Thu 13:30 P

First-principles study of exchange frustration and DMI in Rh/Co/Fe/Ir multilayers — •Felix Nickel, Sebastian Meyer, and Stefan Heinze — Institute of Theoretical Physics and Astrophysics, University of Kiel

Magnetic skyrmions are promising for data storage, logic devices, and neuromorphic computing. Materials, which can host nanoscale skyrmions in zero magnetic field at room temperature, are desirable for such applications. Recently, it has been shown that ultrathin Rh/Co films on Ir(111) exhibit skyrmions with diameters below 10 nm at zero magnetic field [1]. In magnetic multilayers, room temperature skyrmion with diameters of 30 nm - 90 nm have been reported [2]. The Dzyaloshinskii-Moriya interaction (DMI), the exchange interaction, and the magnetocrystalline anisotropy are the main characteristics that make materials capable of hosting such complex spin structures. Here, we present density functional theory calculations for transition-metal multilayers consisting of Co, Fe, Ir, and Rh layers. We varied the thickness and material for the magnetic layer (Co and Fe) and the spacer layer (Ir and Rh), as well as the stacking of the individual layers. We present how the magnetic interactions depend on those structural conditions. We demonstrate that it is possible to transfer the properties of the ultrathin film system Rh/Co/Ir(111) [1] to a multilayer system.
[1] Meyer *et al.*, Nat. Commun. **10**, 3823 (2019)
[2] Moreau-Luchaire *et al.*, Nat. Nanotechnol. **11**, 444 (2016)

O 110.4 Thu 13:30 P

Emergence of Magnetic Skyrmions in Ultrathin Films of Manganese on W(001) at High Magnetic Fields — •Reiner Brüning, Kirsten von Bergmann, André Kubetzka, and Roland Wiesendanger — Festkörper- und Nanostrukturphysik, Hamburg, Deutschland

Topological spin textures like skyrmions with diameters on the order of a few nanometers are promising objects for the application in the field of spintronics. Whereas typical skyrmion systems like Pd/Fe bilayers on Ir(111) [1] have hexagonal symmetry, here, we investigate a monolayer of Mn on the square lattice of W(001) using spin-polarized scanning tunneling microscopy at 4.2 K. At $B = 0$ T, the known magnetic ground state of a spin spiral with two rotational domains [2] is observed. The measurements at 9 T show that the external magnetic field initializes the transition from the spin spiral to small skyrmion areas and leads to a coexisting state of the spin spiral phase and the skyrmion phase. Thereby, the skyrmions arrange themselves in small areas in a hexagonal like order, according to the recent simulations of the sample system [3]. At high bias voltages of 1-2 V we observe square magnetic patterns, even in zero magnetic fields. We interpret these square patterns as time-averaged superpositions of rotational spiral domains, driven by excitations by the tunneling electrons.
[1] N. Romming *et al.*, Science, **341**, (2013)
[2] P. Ferriani *et al.*, Phys. Rev. Lett. **101**, 027201 (2008)
[3] A. K. Nandy *et al.*, Phys. Rev. Lett. **116**, 177202 (2016)

O 110.5 Thu 13:30 P

Dzyaloshinskii-Moriya interaction induced by an ultrashort electromagnetic pulse: Application to coherent (anti)ferromagnetic skyrmion nucleation — •Louise Desplat[1], Sebastian Meyer[2], Juba Bouaziz[3], Patrick M. Buhl[4], Samir Lounis[3], Bertrand Dupé[5,2,1], and Paul-Antoine Hervieux[1] — [1]Université de Strasbourg, CNRS, IPCMS, Strasbourg, France — [2]Nanomat/Q-mat/CESAM, Université de Liège, Belgium — [3]Peter Grünberg Institut and Institute for Advanced Simulation, FZ Jülich and JARA, Jülich, Germany — [4]Institute of Physics, Johannes Gutenberg University Mainz, Germany — [5]FNRS, Brussels, Belgium

We show how, at ultrashort timescales, a Dzyaloshinskii-Moriya interaction can be generated in metallic thin films by an electromagnetic pulse. This interaction originates from the spin-orbit coupling between the pulse-induced electric field and the spins of the delocalized electrons of the material[1]. We perform density functional theory calculations to estimate the strength of this field-induced interaction in Fe, Co, Ni, and Mn monolayers, as well as FePt and MnPt alloys. Last, using atomistic simulations, we demonstrate how an isolated (anti)ferromagnetic skyrmion can be coherently nucleated from the collinear background by an electric field pulse at the 100-fs timescale[2]. These results provide a new handle for an ultrafast, coherent control of noncollinear magnetic states.

[1] Imamura et al. PRB 69, 121303(R) (2014) ; Hinschberger et al., PRA 93, 042117 (2016) ; Bouaziz et al. New J. Phys. 19, 023010 (2017) [2] Desplat et al. ArXiv:2011.12055 (2020)