O 60: Mini-Symposium: Dzyaloshinskii-Moriya Interaction (DMI) in magnetic layered systems I

Time: Wednesday 10:30–12:30 Location: R3

Invited Talk O 60.1 Wed 10:30 R3

Rashba effect and chiral magnetism: some insights from density functional theory — •Gustav Bihlmayer — Peter Grünberg Institut (PGI-1) and Institute for Advanced Simulation (IAS-1) Forschungszentrum Jülich, D-52425 Jülich, Germany

Both, the Rashba effect and the Dzyaloshinskii-Moriya interaction (DMI) rely on inversion symmetry breaking and spin-orbit coupling (SOC) effects. While the qualitative behavior of both is easily described on a model level, quantitative insights in strength and sign are not so easy to obtain. Density functional theory (DFT) offers an effective tool to study these effects on an ab initio level. E.g. it was found that oxygen coverage changes both, the sign of the Rashba constant on a metal surface [1], and that of the DMI in a magnetic thin film [2]. We shortly discuss the interplay of magnetism and the Rashba effect and questions about the size and sign of the Rashba constant. These findings will be connected to recent models on so-called Rashba- and SOC-mediated DMI. DFT calculations of simple trilayer systems based on a Co/Pt interface show that the DMI can not only vary by a factor of $2-3$, but also change sign depending on the inclusion of a third element [3]. We acknowledge discussions and collaborations with H. Jia, B. Zimmermann, and M. Hoffmann and funding by the Deutsche Forschungsgemeinschaft (DFG) through SPP 2137 "Skyrmionics".

[1] O. Krupin et al., New J. Phys. **11**, 013035 (2009)
[2] A. Belabbes et al., Sci. Rep. **6**, 24634 (2016)
[3] H. Jia et al., Phys. Rev. Mater. **4**, 024405 (2020)

Invited Talk O 60.2 Wed 11:00 R3

Synthetic chiral magnets and domain wall logic circuits — •Pietro Gambardella — Department of Materials, ETH Zurich

The ability to engineer the interactions in assemblies of nanoscale magnets is central to the development of artificial spin systems and spintronic technologies. Following the emergence of the Dzyaloshinskii-Moriya interaction (DMI) in thin film magnetism, new routes have been opened to couple nanomagnets via strong chiral interactions, which is complementary to the established dipolar and exchange coupling mechanisms. In this talk, we show how two-dimensional synthetic antiferromagnets, skyrmions, and artificial spin systems can be realized by simultaneous control of the DMI and magnetic anisotropy in ultrathin magnetic films. In addition, we show that the combination of DMI and current-induced spin-orbit torques can be exploited to achieve field-free switching of synthetic magnetic elements as well as all-electric operation of domain wall logic circuits.

Invited Talk O 60.3 Wed 11:30 R3

Zero-field magnetic skyrmions in model-type systems studied with STM — •Kirsten von Bergmann — Department of Physics, University of Hamburg, Germany

Magnetic skyrmions can be stabilized in thin films by interface-induced Dzyaloshinskii-Moriya interactions that compete with exchange interactions. Such skyrmions can become lowest energy states in applied magnetic fields but are often only metastable configurations in zero magnetic field.

We have studied the magnetic properties of two different ultra-thin magnetic film systems on Ir(111) using spin polarized STM [1]. Depending on the material properties we find both zero-field skyrmions that are stabilized by neighboring skyrmions or by the rim of the film, and isolated zero-field skyrmions [2,3]. In both systems these skyrmions can be found in the virgin state, meaning that up- and down-skyrmions can coexist. Ab-initio calculations in combination with spin dynamics simulations shed light on the origin, and different stabilization mechanisms are revealed for the two different film systms.

[1] K. von Bergmann et al., J. Phys.: Cond. Mat. 26, 394002 (2014).
[2] S. Meyer et al., Nature Commun. 10, 3823 (2019).
[3] M. Perini et al., Phys. Rev. Lett. 123, 237205 (2019).

Invited Talk O 60.4 Wed 12:00 R3

Spin Orbit driven effects in Graphene-FM systems — •Paolo Perna — IMDEA Nanociencia, 28049 Madrid, Spain

A major challenge for future spintronics is to develop suitable spin transport channels with superior properties such as long spin lifetime and propagation length. Graphene can meet these requirements, even at room temperature [1], but other active properties, such as magnetic order and large spin-orbit coupling (SOC), need to be incorporated into graphene [2]. Taking advantage of the fast motion of perpendicular magnetic anisotropy (PMA) chiral spin textures can satisfy the demands for high-density data storage, low power consumption and high processing speed [3], while the presence of graphene enables the possibility to electrically tune the magnetic properties [4]. Here, I report on high quality, epitaxial graphene/Co(111)/HM(111) stacks grown on (111)-oriented insulating oxide crystals which exhibit enhanced PMA for Co layers up to 4 nm thick and left-handed Néel-type chiral DWs stabilized by interfacial Dzyaloshinskii-Moriya interaction (DMI) localized at both graphene/Co and Co/HM interfaces with opposite sign [4,5]. While the DMI at Co/HM side is due to the intrinsic SOC, the sizeable DMI experimentally found at the Gr/Co interface has Rashba origin [5]. The active magnetic texture is protected by the graphene monolayer and stable at 300 K in air, and, since it is grown on an insulating substrate, amenable to be controlled electrically [3].

[1] Nat. Nanotech. 9, 794 (2014). [2] Nat. Nanotech. 8, 152 (2013). [3] https://nanociencia.imdea.org/sographmem/ [4] Nano Lett. 18(9), 5364 (2018). [5] ACS Appl. Mat.&Int., 12, 4088 (2020).