Tata Institute of Fundamental Research

Survey No. 36/P, Gopanpally Village, Serilingampally, Ranga Reddy Dist., Hyderabad – 500 046

Webinar

Chiral Magnetic Whirls in Future Memory Devices

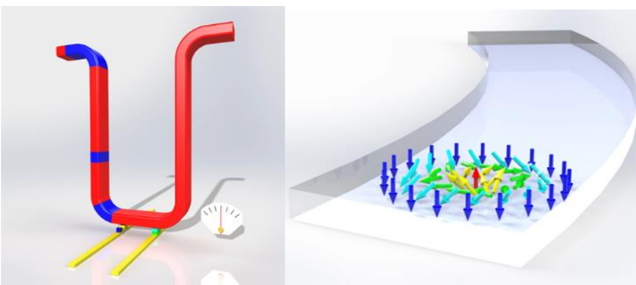
Rana Saha

Max Planck Institute of Microstructure Physics, Germany

Majority of the world's digital information today is stored in conventional data storage technologies such as magnetic Hard Disk Drives (HDD) that utilizes extraordinarily sensitive spintronic (spin of electrons as an information carrier in electronics) reading devices, which enabled detection of ever-smaller magnetic bits. However, conventional data storage will reach to its limit in near future due to fundamental limitation of further scaling in two dimensions (2D). At the same time increasing energy consumption of these devices, generate lots of heat leading to wastage of electricity. Therefore, new data storage devices with greater performance and higher energy efficiency is highly demanding. Magnetic Racetrack Memory is a promising proposal for future mass data storage[1], where data bits can be moved in a three-dimensional magnetic nanowire by nanosecond current pulses without any mechanical moving parts unlike in HDD. Racetrack can provide high endurance of HDD, large density of 3D-NAND flash along with attractive latency rates of static random-access memory (SRAM) and dynamic random-access memory (DRAM)[2]. To enable such racetrack memory devices, nanoscopic chiral magnetic textures such as skyrmions[3] are potential candidates as magnetic bits. My research focuses on a new type of skyrmion, called "anti-skyrmion"[4-8], discovered by our group. In this talk, I will discuss the interesting static and dynamic properties of anti-skyrmions studied by real-space in-situ magnetic imaging such as, Lorentz Transmission Electron Microscopy and Magnetic Force Microscopy. From these studies we have developed significant fundamental understanding on these fascinating chiral magnetic nano-objects, which are potential for spintronic applications.

References:

1. Parkin, S. S. P. et al., Memory on the racetrack. Nat. Nanotechnol. 10, 195 (2015).
2. Bläsing, R., et al., Magnetic racetrack memory: From physics to the cusp of applications within a decade. Proc. IEEE, (2020).
3. Nagaosa, N. et al., Topological properties and dynamics of magnetic skyrmions. Nat. Nanotechnol. 8, 899 (2013).
4. Nayak, A. K., et al., Magnetic antiskyrmions above room temperature in tetragonal Heusler materials. Nature 548, 561 (2017).
5. Jena, J., et al., Observation of magnetic antiskyrmions in the low magnetization ferrimagnet $Mn_2Rh_{0.95}Ir_{0.05}Sn$. Nano Lett. 20, 59 (2019).
6. Jena, J., et al., Elliptical Bloch skyrmion chiral twins in an antiskyrmion system. Nat. Commun. 11, 1115 (2020).
7. Ma, T., et al., Tunable magnetic antiskyrmion size and helical period from nanometers to micrometers in a D_{2d} Heusler compound. Adv. Mater. 32, 2002043 (2020).
8. Saha, R., et al., Intrinsic stability of magnetic anti-skyrmions in the tetragonal inverse Heusler compound $Mn_{1.4}Pt_{0.9}Pd_{0.1}Sn$. Nat. Commun. 10, 5305 (2019).



(Left) Schematic of magnetic racetrack memory where red and blue region corresponds to magnetic domains with opposite polarity moving across the U-shaped 3D magnetic nanowire. The information is read and write by the devices attached to yellow strip connected to racetrack and, (right) magnetic skyrmion as a bit of information carrier in the future racetrack memory device.

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4:00 PM