Skyrmion dynamics in ring-shaped synthetic antiferromagnetic racetracks

Dimitris Kechrakos*
Physics Laboratory, Department of Education, School of Pedagogical and Technological Education, Athens, Greece

Riccardo Tomasello
[2]Department of Electrical Engineering, Technical University of Bari, Italy

Faye Gemenetzi
National Technical University of Athens, Athens, Greece

Giovanni Finocchio
Department of Mathematical and Computer Science, Physical Sciences and Earth Sciences, University of Messina, Messina, Italy

A racetrack memory where the information can be encoded in magnetic skyrmions seems to be a strong candidate for magnetic storage devices to succed the conventional hard disk drives. Elecrical current producing spin-orbit torques is a common means to drive skyrmions on a racetrack. Racetracks made of Synthetic Antiferromagnets (SAF) supress the Skyrmion Hall Effect, which consists of a transverse displacement of skyrmions and their eventual annihilation at the racetrack boundary. In the present work we implement fully numerical micromagnetic simulations [1] of the current-driven dynamics of skyrmions in SAF racetracks with a ring shape. Circular racetracks have technological potentials as shift-register devices [2]. Due to the lack of transverse displacement in SAF systems, the skyrmions are shown to follow a stable circular motion with constant frequency. We study the dependence of the kinematic frequency on the material damping constant, the applied current and the size of the ring-shaped racetrack. We demonstrate that for rings with inner and outer diametrs in the range of 100nm and 200nm, respectively and current density up to 300MA/cm^2 a circular motion with frequency of approximately 0.5GHz is supported. Envisaged applications of the skyrmion in a ring-shaped racetrack as a periodic electrical pulse GHz generator are discussed.

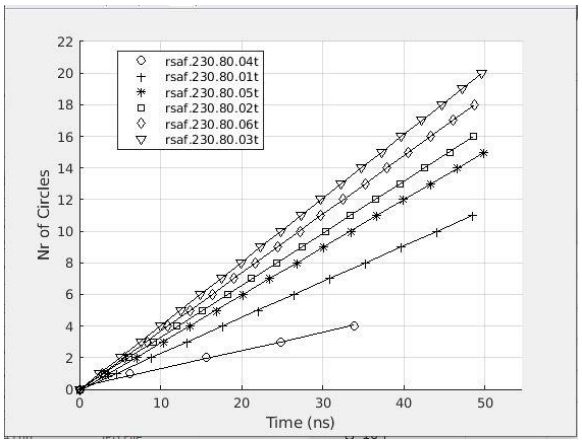

Figure 1: Number of of circles completed by the moving skyrmion as a function of time. The linearity of the data demonstrate the clock-functionality of the circular motion of skyrmions. Ring diameters are 460nm and 160nm. Different current densities applied are 50,100,150,200,250 and 300 MA/cm^2.

References

[1] A.Giordano, G. Finocchio, L.Torres, M. Carpentieri, B. Azzerboni, J.Appl.Phys.**111** (2012) 07D112

[2] Zhang, S.L., Wang, W.W., Burn, D.M. et al. Nat Commun **9** (2018) 2115

* dkehrakos@aspete.gr