Deterministic Approach for Skyrmionic Dynamics at Non-zero Temperatures

C. Navau*, J. Castell-Queralt, L. Gonzalez-Gómez, N. Del-Valle
Departament de Física, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Catalonia, Spain
*Presenting author mail: carles.navau@uab.cat

ABSTRACT

The finding of skyrmions at room temperature has boosted the potentiality of skyrmionic devices. From the theoretical point of view, in micromagnetic systems the temperature has been taken into account using stochastic spin dynamics, the stochastic Landau-Lifshitz equation or the Landau-Lifshitz-Block equation. Also, the rigid model can be used to describe the skyrmion dynamics taking into account thermal effects, using the stochastic Thiele equation [1]. All these methods require a statistical study of the obtained data (they rely in stochastic simulations), which results in a large computation time. In addition, analytical tendencies or limits can hardly be obtained.

Here we present a deterministic method to study the skyrmion dynamics[2], a new approach in which the temporal motion of skyrmions can be studied without relying on repetition of stochastic simulations, but on solving once the associated deterministic Fokker-Planck equation. This is a substantial advance, since by finding and solving a single partial differential equation, one could obtain all the relevant probabilistic information of the system. This allows one to evaluate the probability of presence, or survival, or trapping, or escaping, etc., of skyrmions in many practical situations, which is a key information to ensure the viability of applications. In particular, the probability of trapping/escaping of a skyrmion that encounters a pinning site, and the probability of survival of a skyrmion along a track are presented as a function of the temperature. The probability of survival of a skyrmion along a track at room temperature when granularity is considered is also studied.

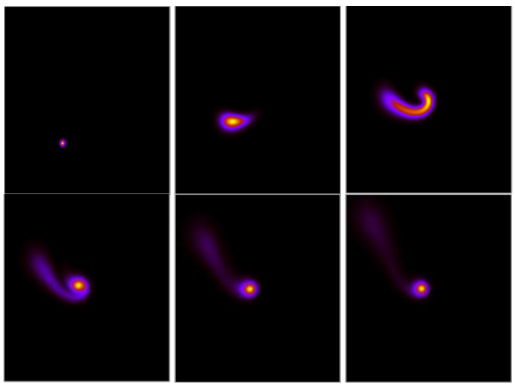

Figure. Time evolution of the probability density of finding a skyrmion which is approaching a pinning site at 150 K.

REFERENCES

[1] D. Pinna, F. Abreu Araujo, J.-V. Kim, V. Cros, D. Querlioz, P. Bessiere, J. Droulez, and J. Grollier (2018). Skyrmion Gas Manipulation for Probabilistic Computing, Phys. Rev. Applied 9

[2] J. Castell-Queralt, L. González-Gómez, N. del-Valle, C. Navau (2020). Deterministic approach to skyrmionic dynamics at nonzero temperatures: pinning sites and racetracks, Phys. Rev. B (R) 101