Micromagnetic simulations with MuMax3

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In this tutorial, an overview is given of the GPU-accelerated micromagnetic software package MuMax3[1], developed at the DyNaMat group at Ghent University. This software solves the time- and space dependent evolution of the magnetization on the nano- to micro scale using a finite-difference discretization. Its high performance and low memory requirements allow for large-scale simulations to be performed in limited time and on inexpensive hardware. Furthermore, using the "mumax3-server" tool, mumax simulations can be shared across different computers to optimally make use of all available hardware to execute large batches of simulations.

After a short introduction to micromagnetism, the use of this software is illustrated with live demos in the user-friendly web-interface. A few features will be highlighted with the help of a case study showing the thermally driven diffusive motion of skyrmions. Here, particular attention will be given to an extended adaptive time-step algorithm which allows to simulate nonzero temperatures[2] with high performance and providing error control, and to a 2D moving window which centers on the moving skyrmion, virtually making the simulated space infinitely large.

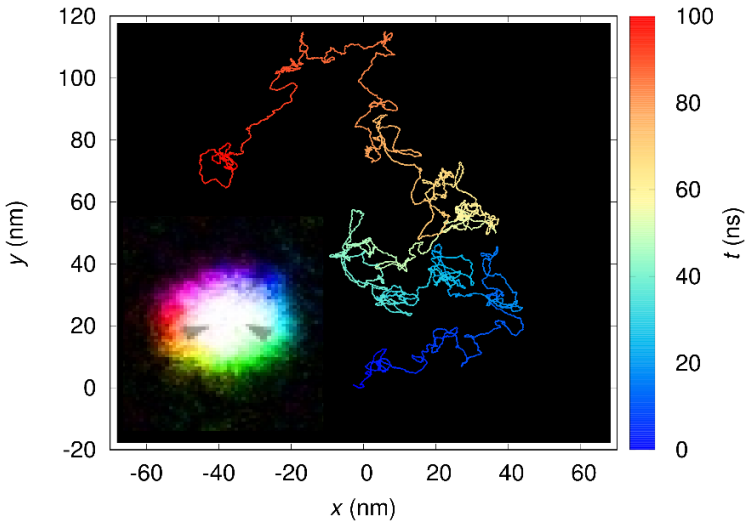

Figure 1. The diffusion path of a skyrmion. The colour of the track indicates the time. The skyrmion magnetization is depicted in the left bottom corner.

[1] Vansteenkiste, A., Leliaert, J., Dvornik, M., Helsen, M., Garcia-Sanchez, F., & Van Waeyenberge, B. (2014). The design and verification of MuMax3. *Aip Advances*, *4*(10), 107133.

[2] Leliaert, J., Mulkers, J., De Clercq, J., Coene, A., Dvornik, M., & Van Waeyenberge, B. (2017). Adaptively time stepping the stochastic Landau-Lifshitz-Gilbert equation at nonzero temperature: implementation and validation in MuMax3. *arXiv preprint arXiv:1709.01682*.