String Method Exploration of the Energy Landscape in Perpendicularly Magnetized Nanodisks with Dzyaloshinskii-Moriya Interaction

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There is a great interest on the use of magnetic skyrmions for information storage and processing. A majority of research investigates skyrmion dynamics over extended films where they have potential to serve as information carriers [1]. Another potential use is in confined structures, where they can be energy minima and so can be used to encode a bit of information [2-4]. Most of these studies stop after identifying the existence of energy minima and comparing their energy values as a measure of stability. However, this provides no information about how robust a given configuration is with respect to thermal fluctuations, since this requires identification of the minimum energy barrier between different energy minima.

The String Method for the Study of Rare Events is a numerical technique to find minimum energy paths between energy minima, and has been previously applied to micromagnetic problems. The method finds magnetization configurations corresponding to saddle points of the energy lanscape and consequently a value for the energy barrier that needs to be overcome by thermal fluctuations for the system to switch between different states.

Here, we apply the String Method to study the energy landscape of nanodisks capable of hosting magnetic skyrmions. The value of D determines which of these configuration corresponds to a global minimum, as well as the minimum energy path between them. In all cases, the edge of the device plays a key role in the annihilation of magnetic skyrmions. For small D, the skyrmion maintains its shape as it drifts to the edge where its gets expelled from the disk. For intermediate D, a secondary energy minimum as the skyrmion deforms and a single meron is expelled from the nanodisk. As D grows larger, the energy landscape becomes richer due to the appearance of many more skyrmionic energy minima.

References:

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