

Steps Towards Continuous Modelling of Quasi-amorphous Ferrimagnetic and Sperimagnetic Alloys using Finite Difference Algorithms

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Recently [1], OOMMF and MUMAX were used to model antiparallel alignment between sublattices and reproduce features of rare earth-transition metal amorphous ferrimagnetic films treated with ion bombardment. A notable configuration consisting of a sharp change in effective magnetization in a very narrow width has been seen. It can form because ion bombardment induces a change in ferrimagnetic domination by oxidizing the rare earth sublattice. This changes the switching field of bombarded regions relative to the surrounding matrix.

These systems hold two states: (I) after abrupt changes of effective magnetization while maintaining the alignment of each sublattice, the resulting state has been called "domains with no domain walls". (II) the magnetization of the sublattices twists spatially but the effective magnetization does not change direction: this is a magnetic monodomain that contains an internal domain wall.

This work summarizes mathematical expressions needed to make quantitative comparisons between experiments on ferrimagnets, atomistic simulations and finite-difference micromagnetic software. Within this framework, we describe stable configurations as a minimum of a continuous energy functional; in particular we provide analytical solutions for the two states described above. We show that a continuous theory can replace the effective magnetization with a Néel type ferrimagnetic vector that changes smoothly in space even when the magnetization exhibits abrupt changes. This allows us to establish necessary boundary conditions for these systems.

We start from a simplified model of an amorphous ferrimagnet which assumes crystalline structure but chemical disorder. Second, we obtain micromagnetic quantities by averaging over possible configurations. For collinear ferrimagnets, we can switch from the magnetization vector to the Néel ferrimagnetic vector as convenient. We examine a bilayer structure where the micromagnetic parameters have been modified in a localized region and found metastable configurations akin to the states I and II described above. Finally, we show that a directional dependence of concentration induces interfacial Dzyaloshinskii-Moriya Interaction (iDMI) which is necessary to sustain skyrmionic structures.

References:

[1] Ł. Frackowiak, et al., Phys. Rev. Lett. 124, 047203 (2020)

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