# Non-equilibrium thermal fields for magnetization dynamics

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Ultrafast magnetism is a field of research that investigates the non-equilibrium response of a magnetic system subject to a femtosecond excitation. Because the dynamics are nonlinear and non-equilibrium, numerical simulations play a pivotal role in their investigation. Typically, the simulations are performed using "atomistic spin dynamics", in which the equations of motion are solved considering nonlocal discrete interactions between nearest, and sometimes next-nearest neighbors. To model the interaction between the excitation and the magnetic system, a random field is implemented, with an amplitude proportional to several magnetic parameters and, crucially, inversely proportional to the cell's volume. If one wants to consider a larger simulation domain, the nonlocal interactions are represented with a Laplacian operator and the cell size is larger. As a consequence, the random field is smaller in magnitude and the non-equilibrium dynamics cannot be reproduced. To solve this issue, we have introduced a pseudospectral approach where the continuum equation represent well the atomic interactions, a dispersion engineering approach. In addition, we propose a non-equilibrium field whose magnitude takes into account the atomic energies within a cell. In essence, we consider the probability of spin switching events that have an energy proportional to the quantum of angular momentum. Consequently, the new field has a defined mean, standard deviation, and amplitude. The results are shown to agree very well with the atomistic approach. This new field can be also used to better represent thermal fluctuations in a grid-independent manner, which will be relevant for the simulation of spintronic devices.

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References

[1] E. Iacocca, arXiv:2603:06929 (2026)