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PROJECTION VS PROJECTION-FREE METHODS FOR THE LANDAU-LIFSHITZ-GILBERT EQUATION

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The understanding of the magnetization dynamics, especially on a microscale, plays an important role in the design of many technological applications, e.g., magnetic sensors, recording heads, and magneto-resistive storage devices. In micromagnetism, it is well-accepted that the partial differential equation governing the dynamics of the magnetization is the Landau-Lifshitz-Gilbert equation (LLG). The reliable numerical integration of LLG faces several challenges due to the strong nonlinearity, possibly complicated and nonlocal field contributions, as well as an inherent non-convex side constraint which enforces length preservation. In general, when dealing with partial differential equations characterized by pointwise constraints, several numerical methods employ a nodal projection step. More precisely, at each time step the constraint is posed at the nodes of the triangulation via a projection of the computed solution onto the target manifold under consideration. To prove stability of such methods, some restrictive conditions on the step size or the underlying triangulation need to be imposed to allow the use of monotonicity arguments. In this talk, we consider the tangent plane scheme from [2]. We show that the nodal projection step is actually *not* necessary for the finite element approximation to converge towards a weak solution of LLG [1]. This leads to a violation of the constraint at the nodes of the triangulation, which is however controlled by the time step size, independently of the number of iterations. In particular, our analysis can therefore avoid a technical angle condition on the triangulation.

References

[1] C. Abert, G. Hrkac, M. Page, D. Praetorius, M. Ruggeri, and D. Suess. Spin-polarized transport in ferromagnetic multilayers: An unconditionally convergent FEM integrator. Submitted for publication, preprint available at arXiv:1402.0983, 2014.

[2] F. Alouges. A new finite element scheme for Landau-Lifchitz equations. *Discrete Contin. Dyn. Syst. Ser. S*, 1(2):187–196, 2008.