Numerical methods for micromagnetics

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Overall goal

Goal: Use better numerical methods to speed up calculations.

- Create new (better) numerical methods
- Find out when a given method is better/worse

Overview

- I focused on methods that use *implicit midpoint rule* for time discretisation.
- Found improvements to existing IMR-based numerical methods.
- Characterised when it is beneficial to use IMR.

Making IMR more efficient

- Quite a few papers on IMR in micromagnetics
- But:
  - no adaptivity
  - using simple and inefficient non-linear solvers

Making IMR more efficient

So:

- Created adaptive IMR algorithm
- Created better solver for the discrete problem [caveat: need an effective preconditioner for LLG block].

When do we need implicit (stable) methods?

- Little research about when implicit methods are needed in micromagnetics (a.k.a. stiffness)
- Some papers say that implicit methods are much more efficient, but others use explicit methods without complaints
- Some mixed ideas about where stiffness comes from

When do we need implicit (stable) methods?

So:

- Studied origin of stiffness in micromagnetics.
- Can explain stiffness with spatial discretisation alone.
- Characterised discretisation lengths where stiffness occurs (for FEM and FEM/BEM methods).

How useful is geometric integration?

- Plenty of papers on geometric integration methods for micromagnetics
- GI said to be very useful in other areas
- Plenty of claims that GI is important
- But little numerical evidence (*i.e.* comparisons of errors)!

How useful is geometric integration?

So:

- Experimented with a IMR, trapezoid rule and BDF2 for two problems with analytical solutions.
- Found TR and IMR perform similarly, but BDF2 is quite a bit worse.
- However, for these examples, TR seems to have some GI properties.

Summary

- Created adaptive IMR method
- Created efficient solver
- Characterised when stiffness is an issue in FEM/BEM simulations
- No strong conclusions possible on overall usefulness of GI