Computational micro-magneto-mechanics

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Magnetic materials exhibit a challenging multiscale structure. The quantum mechanical
origin of magnetism lies on the sub-nanometer scale. Domain walls feature a characteristic
length of nanometers and magnetic domains are relevant on the micrometer to millimeter
scale. To capture domain phenomena on the microscale correctly it is crucial to resolve
underlying domain wall processes on the nanoscale. This multiscale nature of magnetic
materials poses the first major challenge of micromagnetics and requires powerful com-
putational tools and sophisticated material modeling.

We formulate a material model within the framework of generalized standard materials
which yields thermodynamic consistency. The coupled problem includes magnetization,
scalar magnetic potential and displacement degrees of freedom. We formulate the me-
chanical problem in the small strain setting and assume an additive split of strain into
an elastic and a magnetostrictive part. The second major challenge of computational mi-
cromagnetics, the restriction of magnetization to the unit sphere, is approached with the
exponential map algorithm. Simo et al. [1] applied exponential map to the shell director
in shell theory before the idea was used in micromagnetics by Lewis and Nigam [2] and
Miehe and Ethiraj [3]. We solve the micro-magneto-mechanically coupled problem using
finite element method. We demonstrate our approach with numerical examples.

REFERENCES

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