The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

Magneto-pseudoelasticity emerging from multistable microstructures of extremely soft magnetorheological elastomers

Matthias Rambausek*[1], Michael Neunteufel[2] and Joachim Schöberl[3]

[1] Institute of Analysis and Scientific Computing, TU Wien, Wiedner Hauptstraße 8-10, 1040 Wien, Austria, matthias.rambausek@tuwien.ac.at

[2] Institute of Analysis and Scientific Computing, TU Wien, Wiedner Hauptstraße 8-10, 1040 Wien, Austria, michael.neunteufel@tuwien.ac.at

[3] Institute of Analysis and Scientific Computing, TU Wien, Wiedner Hauptstraße 8-10, 1040 Wien, Austria, joachim.schoeberl@tuwien.ac.at

Key Words: *magnetorheological elastomers, magneto-pseudoelasticity, finite elements, updated Lagrangian formulation, remeshing*

Two decades ago, new experiments accompanied by the modernization of magnetoelastic theory have spawned a great amount of theoretical, numerical but also experimental developments on magnetoelastic composites such as magnetorheological elastomers (MREs). Thanks to extensive research efforts, their coupled magnetoelastic response is well understood nowadays. However, this applies only to MREs and related materials based on sufficiently stiff matrix material. Indeed, as the shear modulus of the matrix material is reduced further and further, magnetoelasticity turns out to be an insufficient theoretical framework at the macroscopic scale as demonstrated in this contribution. Even when neglecting the dissipation in the constituents, one may observe significant dissipation.

In composites based on very soft matrix material that can only store rather small amounts of elastic energy, the magnetic energy may dominate the total energy of the system. Multiple (meta-)stable configurations are the consequence, which render the composite material "magneto-pseudoelastic" even when both the inclusions and the matrix material are practically non-dissipative. While such “magnetodeformal shape-memory” effects can be found in mainly experimental literature, e.g., [1,2], we are not aware of corresponding quantitative simulations.

In this talk we present ongoing work pushing the limits of finite elements simulations for extremly deformable multiphysics systems. Along the way we will encounter challenges for theoretical description, modeling and numerics of extremely soft MREs. They shall serve as motivation for the development of new experiments, numerical techniques and eventually extended theories for dissipative magnetomechanics.

REFERENCES

[1] L.V. Nikitin, G.V. Stepnaov, L.S. Mironova and A.I. Gorbunov, Magnetodeformational effect and effect of shape memory in magnetoelastics. *J. Magn. Magn.*, Vol. **272–276**, pp. 2072–2073, 2004.

[2] G. V. Stepanov, D. Y. Borin, Y. L. Raikher, P. V. Melenev and N. S. Perov, Motion of ferroparticles inside the polymeric matrix in magnetoactive elastomers, *J. Phys.: Condens. Matter*, Vol. **20**, No. **20**, pp. 204121, 2008.