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VARIATIONAL-BASED COMPUTATIONAL HOMOGENIZATION OF ELECTRO-MAGNETO-ACTIVE POLYMER COMPOSITES AT LARGE STRAINS

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In recent years a number of industrial applications make use of functional materials with electric and magnetic stimuli. Both electroactive elastomer composites (EAPCs) as well as magnetorheogical elastomer composites (MRECs) are innovative materials whose mechanical response can be altered by the application of electric and magnetic fields. Such composite materials with tunable mechanical properties become more and more important and find use as artificial muscles, sensors and actuators in robotics. The numerical analysis of their microstructures is important with regard to an optimal design, in particular with respect to the understanding and the improvement of electrical and magnetic actuator strain capabilities. Innovative microstructures which combine features of EAPCs and MRECs can be constructed, consisting of particles embedded in a polymeric matrix. Here, different types of particles are used to create electric as well as magnetic stimuli. This allows to construct new composite materials with intrinsic electro-magnetic coupling effects. The electro-magnetic coupling is usually relatively low, however, can substantially be enhanced for particular morphologies of the composite microstructure. A reliable analysis of these effects needs the development of new homogenization-based virtual testing environments for coupled electro-magneto-mechanical loading scenarios at finite strains. To this end, we develop new variational-based approaches to the formulation and computational implementation of homogenization in dissipative electro-magneto-mechanics. The formulation allows to embed recently developed constitutive models for EAPs and MREs for the composite phase materials. Note that homogenization-based scale bridging is the key ingredient of modern multiscale modeling techniques. With this respect, we outline variational principles for the couled boundary value problems of both the micro- as well as the macro-scale, and develop a consistent scenario for the computational treatment of two-scale problems. Numerical results highlight electro-magneto-mechanical coupling effects of composites undergoing large strain, including conceptual investigations towards an optimal design of microstructures.

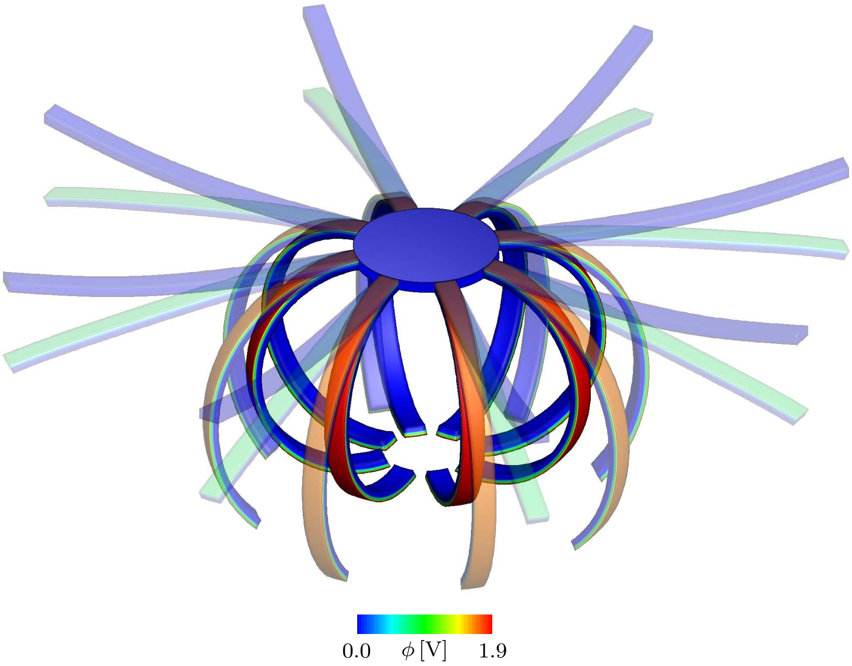

Figure 1: Deformation of starfish gripper. The electrically induced differential extension along the longitudinal direction causes the gripper to curl up with increasing potential between the electrodes.

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