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A new framework for large strain electromechanics based on convex multi-variable strain energies: conservation laws and hyperbolicity and extension to electro-magnetomechanics.

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Abstract

This work is the third on a series of papers by Gil and Ortigosa [1, 2] on the development of a new computational framework for the analysis of Electro Active Polymers, where the concept of polyconvexity [3] is extended to the case of electro-magneto-mechanical energy functionals. Specifically, four key novelties are incorporated in this paper. Firstly, a new set of first order hyperbolic equations is presented in the context of nonlinear electro-magneto-elasticity, including conservation laws for all the fields of the extended set of arguments which determine the convex multi-variable nature of the internal energy. Secondly, the one-to-one and invertible relationship between this extended set and its associated entropy conjugate set enables the definition of a generalised convex entropy function, resulting in the symmetrisation of the system when expressed in terms of the entropy variables. Thirdly, this paper shows that, after careful analysis of the eigenvalue structure of the system, the definition of multi-variable convexity in [1] leads to positive definiteness of the electro-magneto-acoustic tensor. Therefore, multi-variable convexity ensures the satisfaction of the Legendre-Hadamard condition, hence showing that the speeds of propagation of acoustic and electro-magnetic waves in the neighbourhood of a stationary point are real. Finally, under a characteristic experimental set-up for electrostrictive dielectric elastomers, a study of the material stability of convex and non-convex multi-variable constitutive

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