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FFT-based Computational Homogenization of Electromechanically Coupled Boundary Value Problems at Finite Strains

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In recent years, electroactive polymers (EAP) have attracted the attention of experimental, theoretical and computational mechanics. EAPs have the ability to respond with large strains to applied electric fields, making them suitable for a wide range of applications including artificial muscles and haptic displays [1].
The electro-mechanical coupling of EAPs can be enhanced by the design of composite microstructures. In order to determine the effective behaviour of the composite material, tools of homogenization are developed [2]. One particular tool that has seen focused attention recently is based on solvers driven by fast Fourier transforms [3]. Associated approaches are based on the solution of the celebrated Lippmann-Schwinger equation on a periodic representative volume elements (RVE). Most commonly, the solution is found by means of a fixed-point iteration or a conjugate gradient method [4].
The present work focuses on the derivation and the numerical implementation of a consistent macroscopic tangent operator for electro-mechanically coupled materials [5]. Exploiting the fact that the Lippmann-Schwinger equation gives an explicit expression for the fluctuative components of strains and electric field leads to a simple linear integral equation for the effective properties [6]. The formulation is presented with a fully coupled reference medium as preconditioner, leading to faster convergence rates of the underlying equilibrium equations.

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