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MATHEX - CENTRO DI RICERCA PER LE APPLICAZIONI DELLA MATEMATICA E DELL'INFORMATICA

Homogenization of a coupled electrical and mechanical bidomain model for the myocardium

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Abstract

We propose a coupled electrical and mechanical bidomain model for the myocardium tissue. The structure that we investigate possesses an elastic matrix with embedded cardiac myocytes. We are able to apply the asymptotic homogenization technique by exploiting the length scale separation that exists between the microscale where we see the individual myocytes and the overall size of the heart muscle. We derive the macroscale model which describes the electrical conductivity and elastic deformation of the myocardium driven by the existence of a Lorentz body force. The model comprises balance equations for the current densities and for the stresses, with the novel coefficients accounting for the difference in the electric potentials and elastic properties at different points in the microstructure. The novel coefficients of the model are to be computed by solving the periodic cell differential problems arising from application of the asymptotic homogenization technique. By combining both the mechanical and electrical behaviours, we obtain a macroscale model that highlights how the elastic deformation of the heart tissue is influenced and driven by the application of a body force that varies with the difference in electric potentials at different points in the microstructure. We numerically investigate the novel model properties such as the effective electrical conductivities and elastic parameters and find behaviours that replicate physiological observations.

Conferenza

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