Mathematical formulation and numerical methods for the Extracellular-Membrane-Intracellular model

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Abstract: To study propagation at the level of cardiac myocytes, the Extracellular-Membrane-Intracellular (EMI) model explicitely represents individual cells. The cardiac tissue is then viewed as two separate domains, the intra-cellular and extra-cellular domains, separated by cellular membranes. The EMI model consists in a set of Poisson equations, one for each sub-domain, coupled on interfaces through nonlinear transmission conditions involving a system of ODEs. This gives rise to a non-standard transmission problem, whose proper mathematical formulation is not yet fully addressed in the literature. In our talk, we present a reformulation of the EMI model on the cellular membrane, using a Steklov-Poincaré operator. We also present and analyze numerical methods, finite elements in space, first and second order implicit and semi-implicit methods in time. Error estimates are obtained, proving the order of the methods in space and time. Numerical results illustrate and compare the stability, accuracy and efficiency of the methods. This work is co-authored with Diane Fokoué, University of Ottawa.