Nonlinear coupling of Poisson-Nernst-Planck equations with Discrete Duality Finite Volumes : Application to Dendritic spines

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Abstract

Dendritic spines in neurons are playing a major role in the transmission of information. They transmit an electrical signals via an influx of ions that creates voltage drops, that then propagates inside the neuron. However, the role of the dendritic spine complex geometry, and how it contributes to the treatment of the information are still not fully understood. To model the electrodiffusion of ions and the electric potential fluctuations, we use the Poisson-Nernst-Planck (PNP) system of equations. To solve numerically this system, we use the Discrete Duality Finite Volume (DDFV) method. We propose a nonlinear coupling in two dimensions preserving numerically the positivity of ionic concentrations. The propagation of ions and potential are investigated by several simulations with special attention to the Debye layer.