High-order Integral Equations for Electromagnetic Problems in Layered Media with Applications in Biology and Solar Cells

Brian Zinser

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Abstract

We present two distinct mathematical models where high-order integral equations are applied to electromagnetic problems: finding the electric potential in and around ion channels and Janus particles and finding the electromagnetic scattering caused by a set of simple geometric objects.

In biology, we consider two types of inhomogeneities: the first one is a simple model of an ion channel which consists of a finite height cylindrical cavity embedded in a layered electrolytes/membrane environment, and the second one is a Janus particle made of two different semi-spherical dielectric materials. A boundary element method (BEM) for the Poisson-Boltzmann equation based on Müller's hyper-singular second kind integral equation formulation is used to accurately compute electrostatic potentials with a second order basis.

For solar cells, we develop a Nyström volume integral equation (VIE) method for calculating the electromagnetic scattering according to the Maxwell equations. The Cauchy Principal Values that arise from the VIE are computed using a finite size exclusion volume with explicit correction integrals and a novel interpolated quadrature. Simulations with many scatterers demonstrate the efficiency of the interpolated quadrature formulae. We also demonstrate that the resulting VIE has high accuracy and p-convergence.

Department of Mathematics, UNC Charlotte, Charlotte, NC 28223