Singular Perturbation Solutions of Steady-state Poisson-Nernst-Planck Systems

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We study the general Poisson-Nernst-Planck (PNP) system with an arbitrary number of ion species with arbitrary valences. Assuming that the Debye length is small relative to the domain size, we derive an asymptotic formula for the steady-state solution by matching outer and boundary layer solutions. The outer solution is expressed as the inverse of a linear combination of exponential functions whose exponential growth rates can be determined by solving a single scalar transcendental equation, while the boundary layer solutions are given in terms of a generalization of elliptic integrals. This is a joint work with Dr. Dongdong He (City University of Hong Kong), Dr. Huaxiong Huang (York University) and Dr. Jonathan J. Wylie (City University of Hong Kong).