Analysis of a Poisson–Nernst–Planck–Fermi system for charge transport in ion channels

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In this talk, a modified Poisson–Nernst–Planck system in a bounded domain with mixed Dirichlet–Neumann boundary conditions is analyzed. It describes the concentrations of ions immersed in a polar solvent and the correlated electric potential due to the ion–solvent interaction. The considered mixture is saturated, meaning that the sum of the ion and solvent concentrations is constant. This assumption of finite ion sizes leads to cross-diffusion equations, which are thermodynamically consistent. The correlated electric potential depends nonlocally on the electric potential and solves the fourth-order Poisson–Fermi equation. The existence of global bounded weak solutions is presented by using the boundedness-by-entropy method. The novelty of the work is the proof of the weak–strong uniqueness property. In contrast to the existence proof, we include the solvent concentration in the cross-diffusion system, leading to a diffusion matrix with nontrivial kernel. Then the proof is based on the relative entropy method for the extended cross-diffusion system and the positive definiteness of a related diffusion matrix on a subspace.