Finite volumes for a generalized Poisson-Nernst-Planck system with cross-diffusion and size exclusion

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In this talk, I will present two finite volume approaches for modelling the diffusion of charged particles in constrained geometries using a degenerate Poisson-Nernst-Planck system with cross-diffusion and volume filling. Both methods utilize a two-point flux approximation and are part of the exponentially fitted scheme framework. The only difference between the two is the selection of a Stolarsky mean for the drift term originating from a self-consistent electric potential. The first version of the scheme, referred to as (SQRA), uses a geometric mean and is an extension of the squareroot approximation scheme. The second scheme, (SG), utilizes an inverse logarithmic mean to create a generalized version of the Scharfetter-Gummel scheme. Both approaches ensure the decay of some discrete free energy. Classical numerical analysis results, as well as some numerical simulations, will be discussed. The latter show that both schemes are effective for moderately small Debye lengths, with scheme (SG) demonstrating greater robustness in the regime of small Debye lengths.