Abstract Submitted
for the DFD09 Meeting of
The American Physical Society

A nonlinear equation for ionic diffusion in a strong binary electrolyte[1] SANDIP GHOSAL, ZHEN CHEN, Northwestern University — The problem of the one dimensional electro-diffusion of ions in a strong binary electrolyte is considered. The mathematical description consists of a diffusion equation for each species augmented by transport due to a self consistent electrostatic field determined by the Poisson equation. If concentrations do not vary appreciably over distances of the order of the Debye length, the Poisson equation can be replaced by the condition of local charge neutrality first introduced by Planck. It can then be shown that both species diffuse at the same "ambipolar" rate with a common diffusivity.Here we derive a more general theory by exploiting the ratio of Debye length to a characteristic length scale as a small asymptotic parameter. It is shown that the concentration of either species may be described by a nonlinear integro-differential equation which replaces the classical linear equation for ambipolar diffusion but reduces to it in the appropriate limit. Through numerical integration of the full set of equations it is shown that this nonlinear equation provides a better approximation to the exact solution than the linear equation it replaces.

[1]Support from the NIH under grant R01EB007596 is gratefully acknowledged.

Sandip Ghosal
Northwestern University

Date submitted: 10 Aug 2009 Electronic form version 1.4