

## Low Mach Number Fluctuating Hydrodynamics for Electrolytes

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A theoretical formulation of the low Mach number fluctuating hydrodynamic equations for electrolyte solutions is presented. This stochastic theory is applied to the study of transport in mixtures of charged species at the mesoscale, down to scales below the Debye length, where thermal fluctuations can have a significant impact on the dynamics. For example, we demonstrate that thermal fluctuations contribute to charge transport in binary electrolyte solutions resulting in an enhancement, or renormalization, of the electric conductivity due to a coupling between fluctuations of charge and fluid velocity. This coupling results in nontrivial corrections to the classical Poisson-Nernst-Planck equations, which are of the order of the square root of the salt concentration and therefore significant even for dilute solutions. The underlying mechanism for this enhanced conductivity is similar to but distinct from the enhancement of mass transport known as the “giant fluctuation” effect. We also show that the fluctuating hydrodynamics approach recovers the electrophoretic and relaxation corrections obtained by Debye-Huckel-Onsager theory and generalizes straightforwardly to more complex multispecies electrolytes. Finally, we outline an accurate numerical method based on our previous work on multicomponent mixtures of incompressible isothermal liquids. We show that our algorithm is second-order in the deterministic setting and captures the predicted dynamics of equilibrium and nonequilibrium fluctuations.