DPP13-2013-000666

Abstract for an Invited Paper
for the DPP13 Meeting of
the American Physical Society

Effective Potential Theory for Transport Coefficients across Coupling Regimes[1]

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Plasmas in several modern experiments, including dense, ultracold and dusty plasmas, can reach strong coupling where the Coulomb potential energy of interacting particles exceeds their average kinetic energy. Understanding how the many-body physics of correlations affects plasma transport properties in this regime is interesting both from a basic physics standpoint and as a practical matter. Transport coefficients are essential input required for accurate hydrodynamic modeling of these systems, which can include weakly coupled and strongly coupled components simultaneously. We discuss a physically motivated extension of plasma transport theory that is computationally efficient and versatile enough that it can be applied to essentially any transport property [1]. Like conventional plasma theories, ours is based on a binary collision picture, but where particles interact via an effective potential that accounts for average affects of the intervening medium. This includes both correlations and screening. Hypernetted chain (HNC) theory, which is a well-established approximation for the pair correlation function, is used to derive the effective potential. The theory is shown to compare well with ion velocity relaxation in an ultracold plasma experiment [2], as well as classical molecular dynamics simulations of temperature relaxation in electron-ion plasmas [3], and diffusion in both one-component plasmas and ionic mixtures [4].

[1] Baalrud and Daligault, PRL 110, 235001 (2013).
[2] Bannasch, et al, PRL 109, 185008 (2012).
[3] Dimonte and Daligault, PRL 101, 135001 (2008).
[4] Daligault, PRL 108, 225004 (2012).

[1]This research was conducted in collaboration with Jerome Daligault and was supported by a Richard P. Feynman Postdoctoral Fellowship and the LDRD program at Los Alamos National Laboratory.