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**A Critical Analysis of Semi-Classical Potentials** CHRISTOPHER JONES, MICHAEL MURILLO, Los Alamos National Laboratory — Semi-classical potentials have recently seen a surge in interest because of the possibility of their use in simulations to determine equilibrium and non-equilibrium properties of plasmas under extreme conditions. Various authors have developed potentials for Coulomb interactions as well as to mimic degeneracy effects. However, there exists little guidance regarding the physical regimes in which these semi-classical potentials are applicable. We present a critical analysis, using analytical and numerical techniques, of the success and breakdown of the assumptions behind semi-classical potentials. The effectiveness of pair potentials in reproducing many-body degeneracy effects is determined in comparisons with exact quantum ideal gas results. The effectiveness of semi-classical Coulomb interactions in reproducing equilibrium properties is studied via comparison with the principle Hugoniot, as determined both by other simulation techniques and experiments. The principal Hugoniot provides an especially strong test because of its sensitivity to the relationship between pressure and energy, as well as the role played by strong coupling, degeneracy, and atomic and molecular physics at low temperatures. In determining at what temperatures and densities and for what reasons these potentials succeed and fail, we hope to provide insight into a powerful technique available to the simulation community.

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