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Rarefaction Flow in Bounded Plasma with Adiabatic Electrons[1]
ALEXANDER KHRABROV, Belle Mead, NJ 08502 USA, IGOR KAGANOVICH, JIAN CHEN[2], Princeton Plasma Physics Laboratory, HENG GUO, Department of Engineering Physics, Tsinghua University, Beijing, China 100084 — We study, by numerical and analytical means, the evolution of a collisionless plasma initiated between absorbing walls. The ensuing flow is described by rarefaction waves that travel inward from the boundaries, interact, and eventually vanish after crossing through, leading up to the asymptotic stage of the decay. Particle simulations indicate that the kinetic evolution strongly resembles one found in isentropic gas dynamics. Namely, a very gradual density profile forms in the expanding central region where the rarefaction waves interact, with an accompanying linear velocity profile. Asymptotically, the density falls off as $1/t$. The density and the flux at the boundary show little variation over the period when rarefaction waves still exist. Plasma potential, on the other hand, drops quite rapidly (on the underlying ion-acoustic time scale) to less than T_e when over 70% of the particles still remain in the system. This is due to electron kinetics being governed by conservation of adiabatic invariant in a slowly varying potential well. Analytical model of the velocity distribution is presented to explain the simulations. The results have implications for afterglow plasmas used in material processing and also for ion-extraction devices.

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