Modeling Ion Drag and Void Formation

Due to Dust Acoustic Waves in Collisional Dusty Plasmas

Dan Winske

Applied Physics Division
Los Alamos National Laboratory
Los Alamos, NM 87545 USA

Under some conditions, dust grains, when embedded in a plasma generated by an rf discharge, evacuate regions to form "voids". The ion drag force on the dust grains contributes significantly to void formation. The drag is due both to the direct collection of ions and to momentum transfer by ions in the electric field near grains. Dust grains can also be subject to a drag force due to the effect of coherent waves, such as dust acoustic waves that can grow because of the drift of plasma ions relative to charged grains in an imposed electric field. Here we examine wave-particle drag due to unstable dust acoustic waves in a collisional dusty plasma using numerical simulations. We study the drag as a function of grain size as well as neutral-ion and neutral-dust collisions in periodic and aperiodic configurations. Both the dust grains and the background ions are treated by particle-in-cell methods; a Langevin approach is used to model the collisional processes. For the parameter range considered, we find that in the absence of background collisions, the instability tends to saturate by trapping the plasma ions in the electrostatic waves, which does not affect the dust ions very much. Including ion-neutral collisions tends to suppress ion trapping, which in turn leads to larger wave amplitudes and trapping of the dust, resulting in significant drag on the dust grains and formation of a dust void. Inclusion of neutral-dust collisions leads to a grain size-dependent result, with the persistence of trapping of, and thus considerable drag on, larger grains only.