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One dimensional studies of electrostatic modes in microplasma

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Finite-sized microplasma has garnered interest lately in a variety of contexts. For instance, experimental studies in the context of laser interacting with microdroplets[1] have proved to be an efficient radiation source. It is often important to understand the normal modes which might exist for such finite plasmas. Clearly, for a finite-size plasma medium (for which the mode scale length would itself be of the order of system size), the behavior of normal modes is expected to differ from those in an infinite plasma medium[2, 3]. One would also be interested in understanding the phenomena of transport (plasma expansion etc.) for such a finite plasma.

Computational simulations have been carried out in 1-D to understand the behavior of the normal electrostatic modes of such a finite-sized plasma. The studies have been conducted using electrostatic plasma fluid equations. A non-relativistic model incorporating a two-fluid approach with finite-size ion mass has been employed. The LCPFCT package, which uses Flux Corrected Transport (FCT)[4] algorithm, has been employed for the purpose. The plasma density profile was chosen to have a double tangent form (as shown in the inset figure). The electron density profile was chosen to differ slightly from the ion density. The evolution of the profile was then studied through numerical simulation.

For a cold plasma, the response times of the two species are associated with their respective plasma frequencies. Thus, the ion response is much slower compared to electrons. In this case, it is observed that the electrons show oscillations at the edge (at plasma frequency and its higher harmonics). The amplitude of the harmonic increases with the steepness of the plasma density profile. There is also a steady expansion associated with the profile. The slow response from the ions also shows both oscillations and a steady expansion. The case of hot plasma has also been investigated. Here the ion acoustic wave is an additional mode. The role of electrostatic modes (in the absence as well as the presence of temperature in expansion) has been extensively investigated within this context.

References
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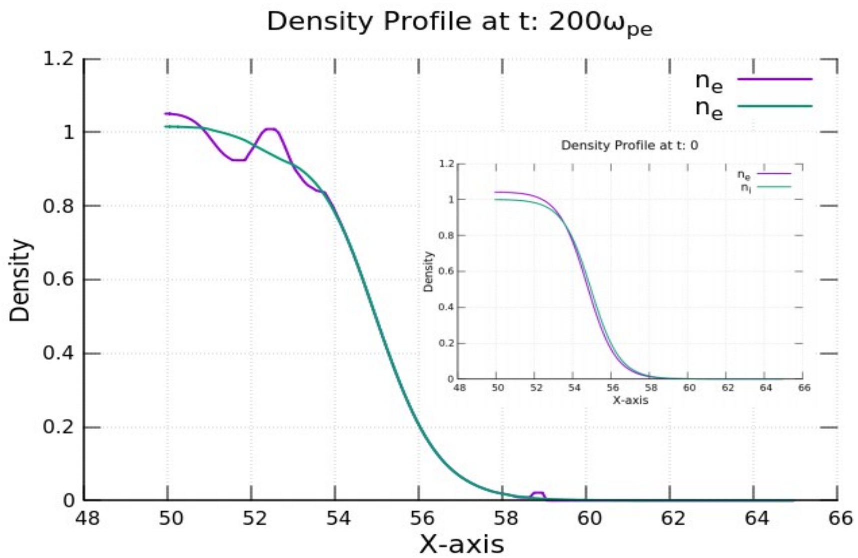

This figure shows the cold electron-ion oscillations obtained from fluid simulation for an finite inhomogeneous density plasma. The specific initial density profile corresponds to an half of double tangent hyperbolic form for both ions and electrons. The electron density was perturbed slightly which led to the observations as shown in the figure.