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Investigation of the dynamics of finite size plasma

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The relevance of finite-sized microplasmas in applications such as laser–microdroplet interactions, which function as effective radiation sources, has recently drawn attention [1]. Given that these finite systems differ greatly from infinite plasmas, it is essential to comprehend the normal modes [2, 3]. and transport phenomena (such as expansion) in these systems.

In this work, normal electrostatic modes in a finite-sized, cold plasma are investigated using 1D electrostatic fluid simulations. Utilising a two-fluid non-relativistic model with finite ion mass, the LCPFCT code [4] has been implemented which uses Flux Corrected Transport (FCT) algorithm. There is a small electron-ion density mismatch in the first plasma density profile, which has a double tangent form. At the plasma edge of cold plasma, electron oscillations take place at the plasma frequency and its harmonics, with the amplitudes of the harmonics growing as the density gradient steepens. Ions expand and oscillate despite reacting more slowly. The droplet expands as a result of these oscillations. The density evolution of the finite size plasma is depicted in figure-(1), where we also note the formation of sharp structures over time, particularly at the plasma edges. The fluid description gives a reasonable estimate of wave-breaking time, but breaks when the sharpness of these structures approaches that of the grid. It is demonstrated that the sharpness of these structures is arrested when dissipative effects like diffusion are present. It has also been investigated how these structures behave when exposed to an externally applied oscillating electric field that corresponds to long wavelength radiation [5].

For initial density profiles of the electron and ion fluids in a cold, nonrelativistic finite size plasma, an evolution equation for the space charge density is derived using a perturbative approach. This equation is accurate up to the third order in density perturbation. To reproduce known results about the phase mixing time in the immobile ion limit and in the case of mobile ions, for both a homogeneous plasma and a plasma with periodic inhomogeneity, the one-dimensional evolution equation is solved. Observations from fluid simulations provide strong support for the insights provided in the case of non-periodic plasma inhomogeneity, such as that found in a finite-size plasma [6].

References

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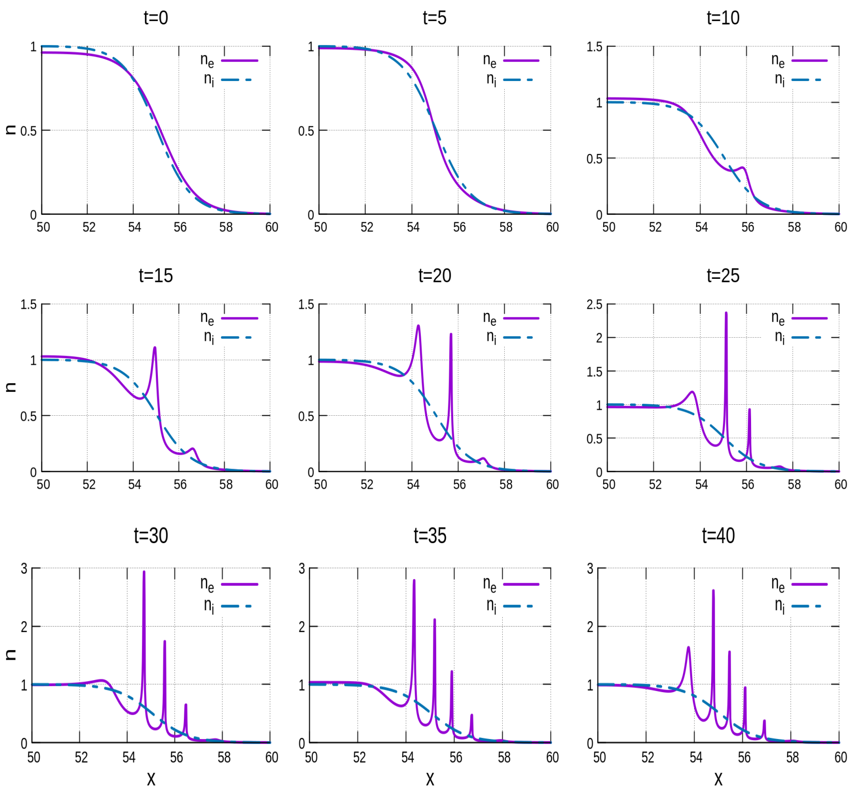

Figure-(1): Density evolution of finite size plasma