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A numerical code for the simulation of electrostatic waves in Penning-Malmberg machines

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A newly developed Eulerian numerical code is presented which models the launching of electrostatic waves (azimuthally homogeneous) in a nonneutral plasma confined in a Penning-Malmberg trap. The kinetic equation for the evolution of the distribution function of the ion species is numerically integrated through a finite volume algorithm [1-3], combined with the well-known splitting scheme for time advance, introduced by Cheng and Knorr [4]. The Poisson equation in cylindrical coordinates *(r,z)* is integrated by making use of a Fast Fourier Transform routine in the longitudinal direction, and a finite-difference scheme, accurate up to fourth order, is implemented in the radial direction. Adopting a stratagem, the simulation captures essential features of the finite length plasma, while retaining the numerical advantages of a simulation employing periodic spatial boundary conditions in the longitudinal direction. Specifically, for a plasma of length L_p, in order to conveniently model specular reflection of particles at the plasma ends, we create a mirror plasma and potential in the domain [L_p, $2L_p$], by reflection of the real plasma and potential about the end L_p. This is shown in Figure 1. The domain of the model plasma then extends from z=0 to $z = 2L_p$, with periodic boundary conditions imposed on the potential at $z = 0$ and $z = 2L_p$. The plasma potential is even under axial reflection about both $z = 0$ and $z = L_p$. In this way, the simulation models specular reflection at the flat ends of the plasma.

To test the numerical algorithm, the results for launched Trivelpiece-Gould (TG) waves of small amplitude are successfully compared to a linearized analytic solution for these fluctuations. Moreover, the launching of both TG waves and Electron Acoustic (EA) waves is investigated in close contact with real laboratory experiments. In fact, the numerical wave launching process mimics the situation of real experiments [5], where the waves are excited by applying an oscillating potential to an electrically isolated section of the conducting cylindrical wall that bounds the confinement region. This launching electrode is near one end of the cylinder, and a receiving electrode is located near the other end.

The wave excitation process is shown in Figure 2, where the contour plot of the electric potential is reported in the *(r,z)* plane, during the excitation of an EA wave.

This numerical code, called **PETER** (**PE**nning **T**rap wav**E** simulato**R**), represents a tool of relevant support to the interpretation of experimental results with nonneutral plasmas.

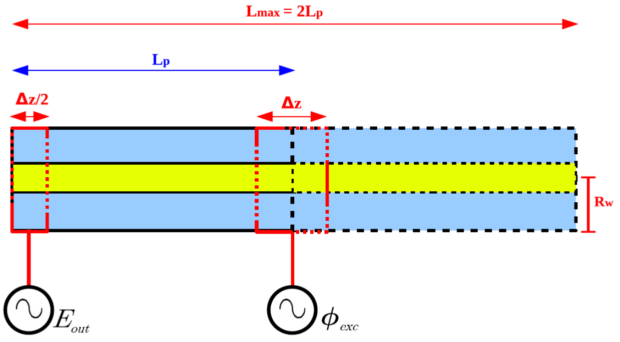

Figure 1. Representation of the *(r,z)* numerical domain for the Eulerian simulations.

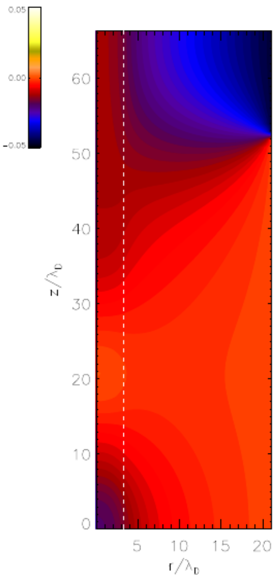

Figure 2. Contour plot of the electric potential in the (r,z) plane, during the excitation of an EA wave.

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