Disclosed formation and role of electrostatic waves through 3D PIC simulation of High Stability Microwave Discharge Ion Source

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The paper presents a 3D particle in cell (PIC) simulation study of two types of electrostatic waves, hypothetically Trivelpiece-Gould and Bernstein, in High Stability Microwave Discharge Ion Source (HSMDIS*). The plasma density evolution in different magnetic field regions shows the generation of the first type of electrostatic waves at the Upper Hybrid Resonance (UHR) and their propagation up to the Critical Electron Density (CED). The latter type of electrostatic wave is generated where the magnetic field is over the Electron Cyclotron Resonance (ECR) value and the plasma density over the CED. The anisotropic constitutive relationships are modelled through a local tensorial permittivity that considers the non-homogeneous magnetic field and the non-homogeneous plasma density and temperature distribution. We give evidence of new propagation patterns for the 2.45 GHz microwaves in plasma and their coupling with electron space charge oscillations. Electrostatic waves produce electron heating with efficiency and spatial location typical of the two different electrostatic waves. The self-consistent electrostatic field computed at every integration time step of 2E-12 s is essential to observe the formation of the space charge density fluctuation coupled with the electromagnetic field. It also enables the accurate modelling of the plasma meniscus and the beam extraction. The developed PIC code includes a grid-based Langevin formulation of Coulomb collisions, the collisions with neutrals and thirteen charge exchange processes. The plasma density is observed to rise to a few 1E17 particles per cubic meter. The simulation results are in qualitative agreement with the experimental behaviour observed at different ion source magnetic field configurations.

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