Electromagnetic Analysis of the Plasma Chamber of an ECR-based Charge Breeder

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The optimization of the efficiency of an ECR-based charge breeder is a twofold task: efforts must be paid to maximize the capture of the injected 1+ ions by the confined plasma and to produce high charge states to allow post-acceleration at high energies. Both tasks must be faced by studying in details the electrons heating dynamics, influenced by the microwave-to-plasma coupling mechanism. Numerical simulations are a powerful tools for obtaining quantitative information about the wave-to-plasma interaction process, the first step being the determination the electromagnetic field allowed inside the plasma chamber.

This paper presents a numerical study of the microwaves propagation and absorption inside the plasma chamber of the PHOENIX charge breeder, which the Selective Production of Exotic Species (SPES) project, under construction at Legnaro National Laboratories (LNL), will adopt as charge breeder. Calculations were carried out with a commercial 3D FEM solver: first, all the resonant frequencies were determined by considering a simplified plasma chamber as an empty cavity. Then, the realistic geometry was taken into account, together with a plasma with a simplified structure, to study the wave-plasma interaction for the three closest frequencies to the operating one (14.521 GHz). The results give important information about the power absorption and losses, and will allow the calculation of electron motion using a single particle approach: the last will be a valuable output allowing to obtain a plasma model to be used in a refined step of calculation reproducing the breeding process itself.