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NEGATIVE HYDROGEN ION EXTRACTION FROM PLASMA SOURCES

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Recent model [1] of the negative ion extraction from a plasma is applied for description of a single extraction cell of the extraction grid used in the rf sources of negative hydrogen ions [2] developed for ITER. The model is a modification of the indirect Poisson-Vlassov method [3] and it is based on the momentum equations of the charged particles (electrons, positive (H^+) and negative (H^-) hydrogen ions) solved together with the Poisson equation. The modification in the method uses a condition for the plasma meniscus emphasizing it as a surface that emits electrons and negative ions and reflects the positive ions. Macro-particles with velocities equal to the thermal velocities, respectively, of electrons and negative ions are launched towards the extraction device. The latter (Fig. 1) consists of a plasma electrode (PE), an extraction/electron-suppression electrode (EE/ESE), combined with a quadrupole magnetic field (MF) for deviation of the electron beam from the negative ion beam, and an acceleration electrode (AE).

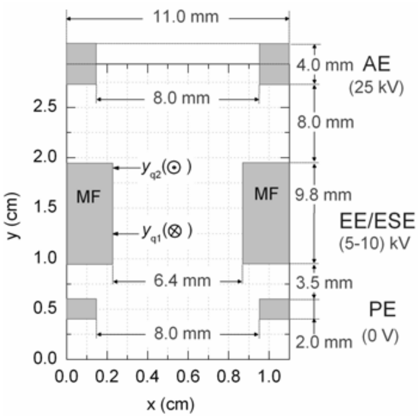

Fig. 1: Configuration and dimensions of the extraction cell, with the electrode potentials shown.

The values of the plasma parameters are those measured [4] in the rf sources developed for ITER: temperature $T_e = 1$ eV of the electrons, $T_+ = 0.1$ eV of the H^+ ions and $T_- = 0.2$ eV of the H^--ions and electron density $n_e = 2 \times 10^{17}$ m^{-3}. Two values of the ratio $n_-/n_e = 0.25, 2.5$ of the densities of the negative ions and electrons are considered resulting into $n_- = (0.5, 5.0) \times 10^{17}$ m^{-3} and, respectively, providing results for cases of low ($n_+ = 2.5 \times 10^{17}$ m^{-3}) and high ($n_+ = 7 \times 10^{17}$ m^{-3}) plasma density.

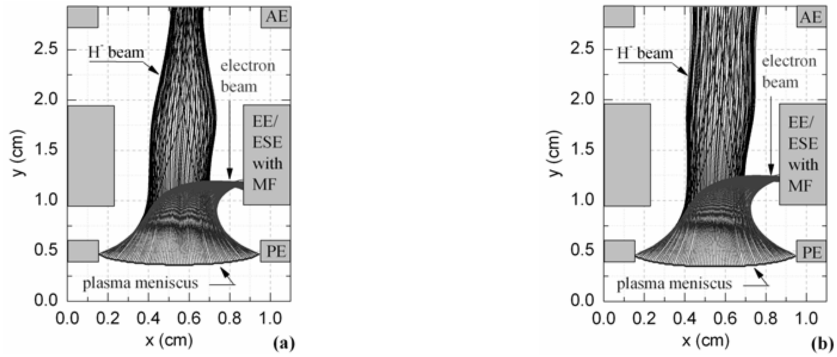

Fig. 2: Results for good quality beams obtained for $U_{EE} = 5$ kV (a) and $U_{EE} = 8$ kV (b), respectively, in the cases of low and high plasma density n_+.

The potential U_{EE} of EE/ESE has been varied. Figure 2 show results – trajectories of H^- and electrons – for the optimum values of U_{EE} ($U_{EE} = 5$ kV and $U_{EE} = 8$ kV) obtained for the low and high n_+. In both cases a concave plasma meniscus slightly penetrating into the plasma region and acting as a convex lens is formed. In the case of high n_+ the obtained value $j_- = 200$ A/m^2 of the extracted current density of the negative ion beam is that required for the ITER source. Figure 3 demonstrates the sensitivity of the beam quality with respect to U_{EE}. The stronger – than the optimum one – external electric field shifts the meniscus downwards. This causes strong focusing of the H^- beam accompanied by strong aberration effects.

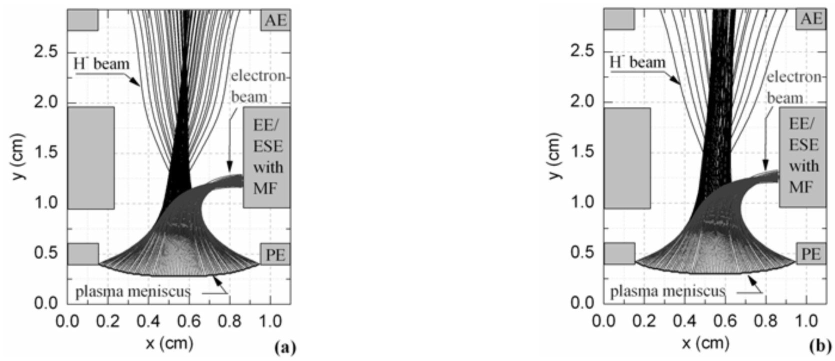

Fig. 3: Results obtained for $U_{EE} = 7$ kV (a) and $U_{EE} = 10$ kV (b), respectively, in the cases of low and high plasma density n_+.

The main conclusion is that optimum mutual effects of the external and space-charge fields determine the optimum value of the extraction electrode. Furthermore, this optimum value depends on the plasma parameters.

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Reference

[1] St. Lishev, A. Shivarova and Kh. Tarnev, 2009 *J. Appl. Phys.* **106** 113301
[2] E. Speth et al, 2006 *Nucl. Fusion* **46** S220
[3] J. H. Whealton, E. F. Jaeger and J. C. Whitson, 1978 *J. Computat. Phys.* **27** 32
[4] S. Christ-Koch, U. Fantz, M. Berger and NNBI Team, 2009 *Plasma Sources Sci. Technol.* **18** 025003