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LOW-PRESSURE PLASMA SOURCES WITH A MAGNETIC FILTER

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The magnetic filter is considered as an important component of the so called "tandem" plasma sources of negative hydrogen ions [1] developed regarding additional heating of tokamak plasmas. The idea for having a magnetic filter inserted in the source has been reached based on conclusions for optimum conditions for negative ion production via dissociative attachment of electrons to vibrationally exited molecules.

Operation at very low gas pressures is one of the main requirements for the negative ion sources for fusion applications. This implies conditions of discharge maintenance in a free-fall regimes that requires accounting for the nonlinear inertia [$(\mathbf{v}\cdot\nabla)\mathbf{v}$]-term in the momentum equations of the positive ions ($\mathbf{v}$ is their velocity). This term acts as a retarding force limiting the increase of the velocity of the positive ions in the wall sheath of the discharge.

This study is based on a recent fluid-plasma description [2] of the magnetic filter operation in hydrogen plasmas and extends it towards accounting – within two-dimensional (2D) discharge model – for the inertia [$(\mathbf{v}\cdot\nabla)\mathbf{v}$]-term in the momentum equations of the positive ions. As it is known, this term creates problems in the 2D-discharge modelling which are usually [3] avoided by introducing an effective electric field.

In the results presented here the difficulties in dealing with the [$(\mathbf{v}\cdot\nabla)\mathbf{v}$]-term are overcome in another way. In fact, the retarding force due to the [$(\mathbf{v}\cdot\nabla)\mathbf{v}$]-term shows evidence close to the walls [4] where the ion velocity is almost perpendicular to the walls. This permits neglecting the parallel – with respect to the walls – velocity component in the [$(\mathbf{v}\cdot\nabla)\mathbf{v}$]-terms in the equations for the two velocity components. The approximation has been checked [4] in a 2D model of an argon discharge where obtaining exact solution with account for the [$(\mathbf{v}\cdot\nabla)\mathbf{v}$]-term was possible.

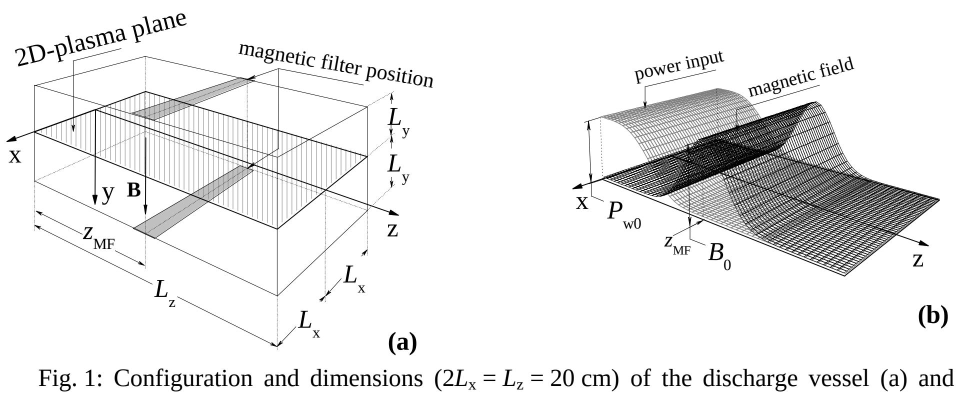

Fig. 1: Configuration and dimensions ($2L_x = L_z = 20$ cm) of the discharge vessel (a) and axial variation of the filter field and of the power deposition to the discharge (b).

Figure 1 shows the configuration of the discharge vessel, with the magnetic filter located therein, as well as the axial variation of the rf power input and of the filter field.

The results from the 2D-model description are for the spatial distribution of the plasma parameters (electron temperature T_e and density n_e, densities of the three type of the positive ions (H^+, H_2^+ and H_3^+) and potential of the dc electric field) in the (x-z)-plane (Fig. 1) perpendicular to the magnetic field. Figure 2 shows results for the axial variation at $x = 0$ of T_e and n_e for varying position z_{MF} of the magnetic filter.

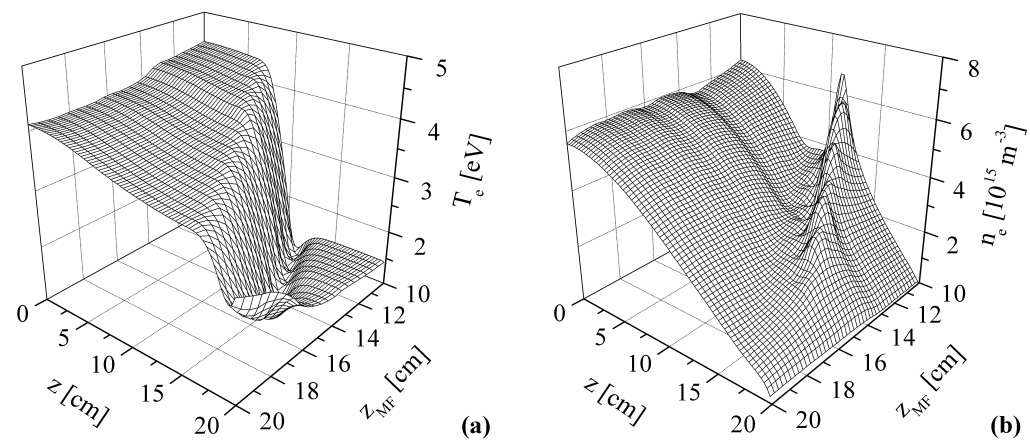

Fig. 2: Axial variation (at $x = 0$) of the electron temperature (a) and density (b) for different positions z_{MF} of the magnetic filter; gas pressure $p = 8$ mTorr and magnetic induction $B_0 = 50$ G at its maximum.

The axial drop of the T_e and n_e with formation of a minimum of T_e and a maximum of n_e in the filter region (Fig. 2) are in agreement with previous results [2] for the discharge behaviour obtained without accounting for the inertia [$(\mathbf{v}\cdot\nabla)\mathbf{v}$]-term in the momentum equations of the positive ions. Moreover, the changes in the axial profiles of T_e and n_e with varying position z_{MF} of the magnetic filter shown in Fig. 2 are in agreement with experimental results [5] from probe diagnostics and displays the superimposed effects of plasma expansion outside regions of power deposition and plasma expansion through a magnetic filter, both acting towards reduction of T_e and n_e. The role of the nonlinear inertia term is the most important in the wall sheath leading to a stepper plasma density profile and a stronger dc electric field there.

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Reference

[1] M. Bacal, 2006 *Nucl. Fusion* **46** S250

[2] St. Kolev, St. Lishev, A. Shivarova, Kh. Tarnev and R. Wilhelm, 2007 *Plasma Phys. Control. Fusion* **49** 1349

[3] A. Salabas, G. Gousset and L. L. Alves, 2002 *Plasma Sources Sci. Technol.* **11** 4487

[4] St. Lishev, A. Shivarova and Kh. Tarnev, 2010 *Plasma Phys. Control. Fusion*, in preparation for submission

[5] St. St. Lishev, A. P. Shivarova and Ts. V. Tsankov, 2009 *AIP Conf. Proc.* **1097** 127