MAGNETOELECTRIC CONFINEMENT EFFECTS IN HIGH DENSITY PLASMAS

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3.1. Low Pressure Discharges

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Owing to losses of suprathermal ions, a sheet of radial electric fields spontaneously tends to surround most magnetostatically confined plasmas. A recent theoretical analysis [1, 2] showed that a combination of strong radial electric and longitudinal magnetostatic fields may lead to efficient "magnetoelectric" confinement of toroidal or open-ended plasmas. Preliminary experimental studies made with a helical L-plasma source [3] have shown the possibility of controlling the bias and temperature of the plasma by varying the r.f. input power level to the source [4]. Several correlation measurements could not, however, give a clear statement on the confining properties of the radial electric field spontaneously surrounding the discharge axisymmetrically.

By disturbing the axial symmetry of the radial electric fields, the experimental data reported in this letter provide confirmation of magnetoelectric confinement effects. Let us suppose that the electric potential well is somehow distorted towards an angular sector of the plasma cross section. With uniform distribution of the magnetic field strength in a plane perpendicular to the field lines, a new equilibrium position of the plasma column should occur. A symmetry violation, of course, means destroying instabilities; it is therefore necessary to provide stable equilibrium conditions around the new plasma position. Experimentally, this model is realized by means of the more sophisticated plasma source shown in Fig. 1. The source consists of six helical sources of the type previously described [3], which are arranged symmetrically around the axis and close to the inside wall of a main discharge tube, 17 cm i.d. and 250 cm in length. A capillary gas feed system inside the sources ensures pronounced burnout of neutrals during the discharge. The six sources, each 2.6 cm i.d. and 8 cm in length, are embedded in the walls of a 4.5 cm thick, 8 cm long ceramic cylinder, whose interior diameter of 8 cm is not screened with metal. The source is positioned in the linear section of a linear magnetic mirror system (mirror ratio 1.2 : 1) with a length of 250 cm. Each of the six sources was excited with r.f. power up to 150 W,

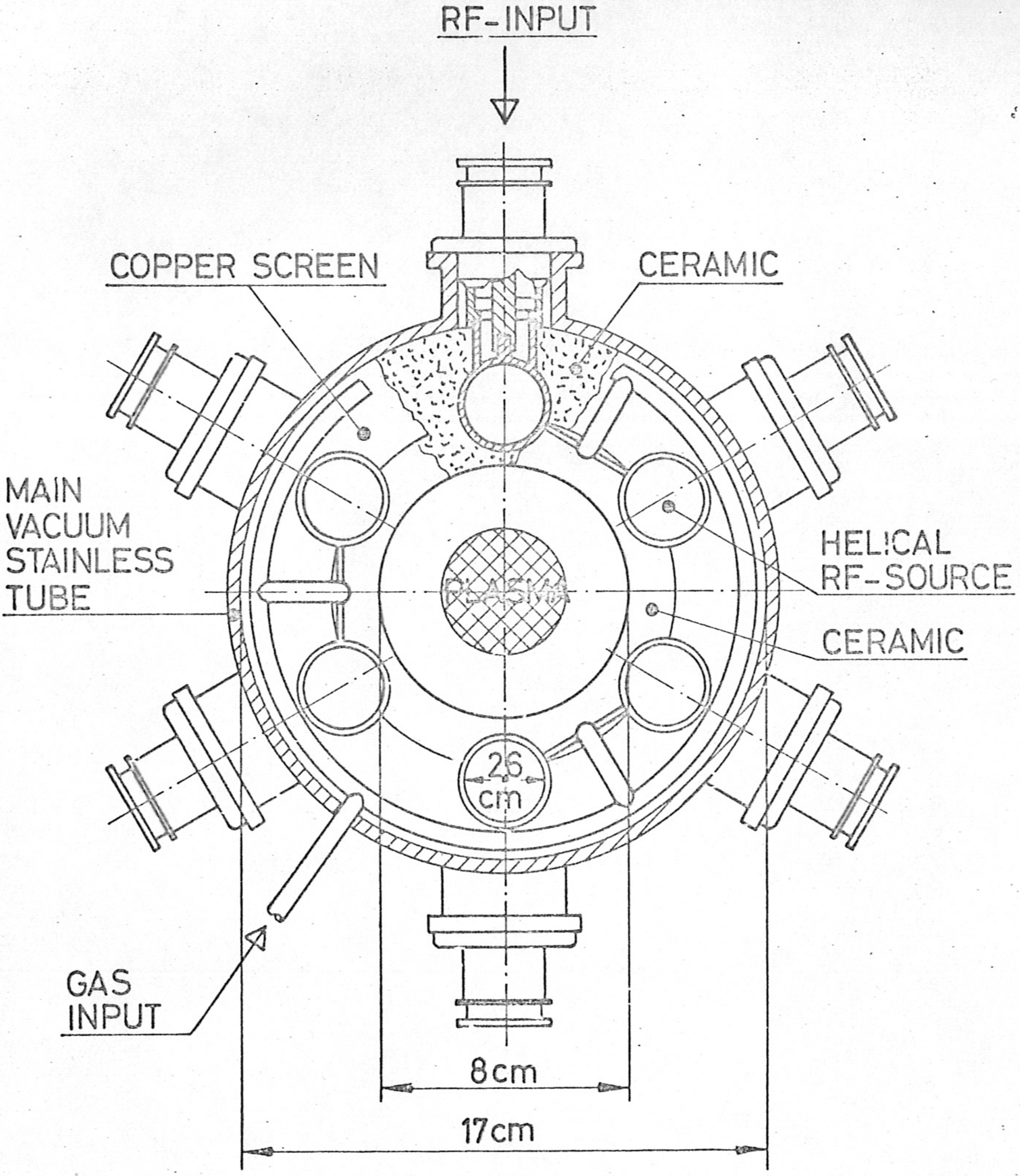

FIG. 1: The new plasma source

2.4 Gc/s in C.W. and pulsed operation. Fig. 2 shows radial profiles of density and floating potential. It is seen that accumulation of plasma occurs not along the axis of the plasma-producing sources, but in a new equilibrium position centered on the axis of the main discharge tube. The plasma can be maintained for any value of the magnetostatic field greater than that corresponding to electron cyclotron resonance

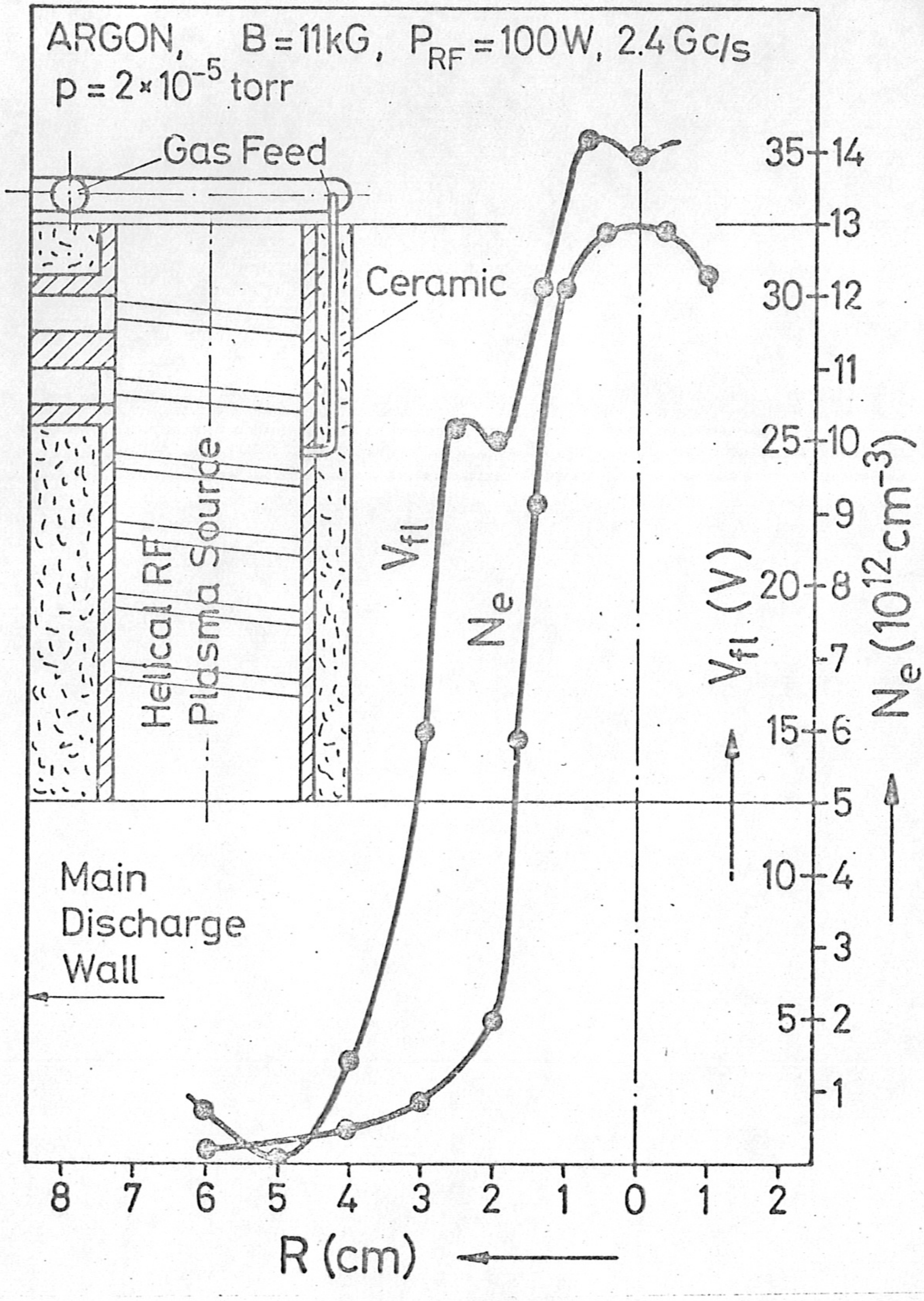

FIG 2: Radial profiles of floating potential, V_{fl}, and of electron density, Ne.

at any point of the discharge tube. The cut-off condition for transversal propagation of a 9 mm ordinary wave, which corresponds to $Ne > 10^{13} cm^{-3}$, was obtained at the maximum available r.f. power level of 150 W fed to each of the six coils. The distribution of the electron energy was very Maxwellian, $T_e = 15$ eV, with a flat temperature profile across the plasma column. These measurements were made with the uniform magnetic field strength (extending 150 cm in the central part of the mirror), set at the maximum available value of 11 kG. The working gas pressure at which the plasma can be maintained can be as low as $2 \cdot 10^{-5}$ torr. The discharge has a remarkably low level of density fluctuation $(\langle n_e \rangle) < 5$ %. Spectroscopic measurements on the radiated light have shown a complete absence of impurities in the discharge.

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