INFLUENCE OF THE HELICAL RESONANT FIELDS ON THE PLASMA POTENTIAL IN THE TBR–1 TOKAMAK

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The control of the plasma–wall interactions deserved much attention in recent works in the field of Controlled Nuclear Fusion Research with tokamak machines. It is desirable in this machines to have, in the edge, a cold and dense plasma layer to reduce impurities liberation, to avoid the migration of non–ionized impurities to the centre of the column and to have a uniform heat deposition on the limiter. One way to attain these objectives is the enhancement of the electron thermal transport by the ergodization of magnetic surfaces in the boundary layer[1]. This process can be obtained with resonant helical fields that, when superposed with the equilibrium fields, provokes the overlapping of magnetic islands and the field structure becomes stochastic. This field configuration is called Helical Magnetic Limiter[2].

This work describes an experimental work[3] that are in progress in TBR–1 tokamak about the influence of resonant helical fields on the plasma potential. TBR–1[4] is a small tokamak in operation in the Physics Institute of University of São Paulo and used for basic research, diagnostic development and personal formation. Its main parameters are: R (Major Radius) = 0.30 m; a_v (Vessel Radius) = 0.11 m; a (Plasma Radius) = 0.08 m; R/a (Aspect Ratio) = 3.75; B_φ (Toroidal Field) = 5 kG; n_{eo} (Central Electron Density) $\simeq 7 \times 10^{18} m^{-3}$; T_{eo} (central electron temperature) $\simeq$ 200 eV.

Experimental arrangement

The helical fields are produced by electrical currents that circulate in a set of coils externally wound around the vacuum vessel. Two connection panels permit the obtainment of various field configurations. For this experiment the poloidal and toroidal main mode numbers were, respectively, $m = 4$ and $n = 1$. This configuration produces resonant perturbation in the edge region. In the fig. (1) the coils structure are shown with the sense of current circulation as well as the conections for the mode $m/n = 4/1$. A current power supply provides rectangular current pulses with adjustable intensities from 0 to 450 A. The initial time of the pulse as well as the pulse width can also be adjusted to choose the region of helical fields effect in the plasma pulse.

Besides the usual diagnostics, two Langmuir probes were used in a vessel upper window situated 45^0 from the limiter in the toroidal direction. With one probe floating potential time profiles was obtained, and with the other density and electron temperature measurements were made. In the fig. (2) the structure and dimentions of the probe are shown. A set of magnetic probes distributed in the poloidal and toroidal directions were used to detect Mirnov oscillations during the discharge. All the signals are coupled to CAMAC transient digitizers (LeCroy Model 2264, 8 bits, 400 kHz). The data acquisition system is controlled by a IBM–XT like microcomputer.

In this work hydrogen has been used with a filling pressure of 1.2×10^{-4} mbar. The vacuum vessel was conditioned with the Taylor discharge cleaning method, that permitted a base pressure of $\simeq 2 \times 10^{-6}$ mbar. No gas puffing was used.

Results

In figs. (3a) and (3b) results obtained in TBR–1 respectively with and without application of the helical fields are shown. In these figures we can see temporal profiles of the plasma current, helical current, horizontal plasma position and floating potential. The plasma pulse duration is ≈ 7 ms and plasma current is ≈ 8 kA. The probe radial position for this data was $r = 6{,}6$ cm. We see that without the application of helical fields the floating potential (V_f) goes to $\simeq -75$ V and then increases continuously until the end of the discharge. With a current of 450 A in the helical coils we verify an increase of $\Delta V_f \simeq 20$ V in the floating potential. The electron temperature time profiles obtained in TBR–1 plasma edge show that T_e stays constant during the discharge[5]. In these conditions the plasma potential depends linearly on the floating potential and changes in the plasma potential reflects directly on changes in the floating potential ($\Delta V_p \simeq \Delta V_f$). A small decrease in the plasma current is also detected (see fig.(3b)).

The Langmuir probe measurements was made in the region 5.5 cm $\leq$ r $\leq$ 10.8 cm.

Conclusions

The measurements indicate that the influence of the helical fields on the floating potential was more intense near r $\simeq$ 7 cm were we have an average increase of 10 V on plasma potential indicating an increase in the electron diffusion in relation to the ions diffusion. A reduction in plasma current of about 4% and a small increase in the loop voltage ($\simeq$ 2,5%) was also detected, indicating an increase in the plasma resistivity in the edge region. The results obtained in the TBR–1 are in agreement to those obtained in other machines[6] and suggests that the transport properties of the plasma are modified by the presence of resonant helical fields[6,7].

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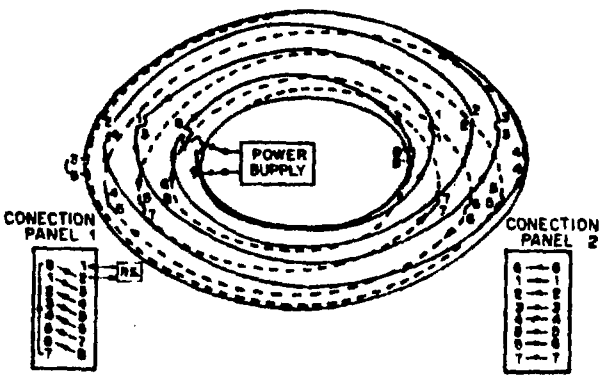

Fig.(1)-Structure of the helical coils around the TBR-1 torus. Connections for the m=4, n=1 mode.

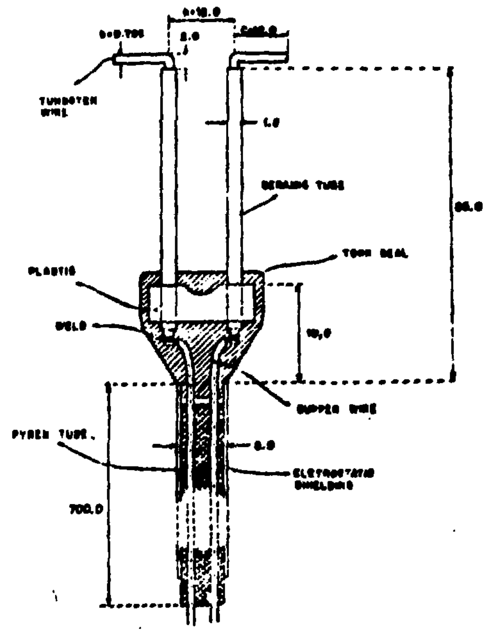

Fig. (2)-Langmuir Probes. One is used for floating potential measurements and the other is used to measure electron temperature and density.

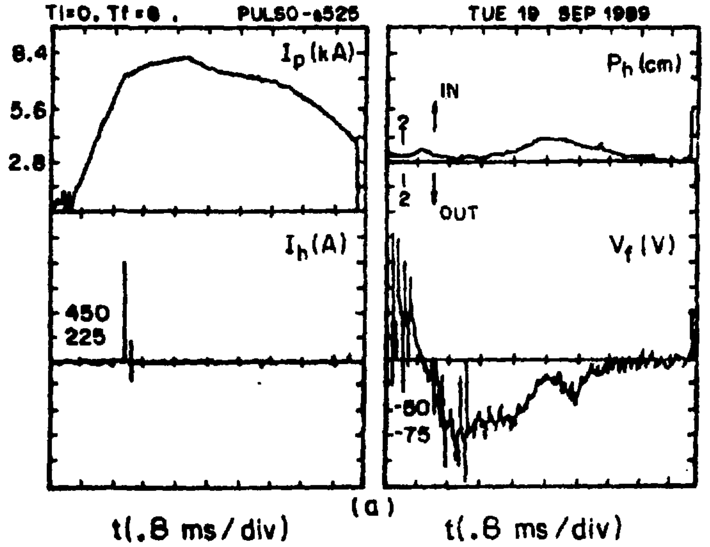

Fig. (3)-Temporal profiles of plasma current, helical coil current, horizontal position and floating potential without (a) and with (b) the application of helical fields.