BR9127895

INPE--4549.

1. Publication Nº	2. Version	3. Date	5. Distribution
INPE-4549-PRE/1295		*May, 1988*	☐ Internal ☒ External ☐ Restricted

4. Origin: *LAP* — Program: *PMAG*

6. Key words - selected by the author(s)
RFP
REVERSED FIELD PINCH
ENERGY RELAXATION
CECI

7. U.D.C.: *533.9*

8. Title — *INPE-4549-PRE/1295*

PLASMA EXPERIMENT IN A SMALL REVERSED FIELD PINCH APPARATUS AT INPE

10. Nº of pages: *3*

11. Last page: *2*

12. Revised by
Gerson Otto Ludwig

9. Authorship
Y. Aso
C.S. Shibata
M. Ueda

Responsible author

13. Authorized by
Marco Antonio Raupp
Director General

14. Abstract/Notes

A small reversed field pinch (RFP) apparatus has been constructed in INPE to study the energy relaxation process in magnetized plasmas. This report describes the preliminary results of the plasma experiment started in 1988.

15. Remarks
To be presented at the III Latin-American Workshop in Plasma Physics, July 18-29, 1988, Santiago, Chile.

PLASMA EXPERIMENT IN A SMALL REVERSED FIELD PINCH APPARATUS AT INPE

Y. Aso, C.S. Shibata, M. Ueda

Laboratório Associado de Plasma, Instituto de Pesquisas Espaciais - INPE/MCT, C.P. 515,
São José dos Campos, 12201, SP, Brazil

An RFP (Reversed Field Pinch) plasma is a configuration in a minimum energy state which has some interesting related problems. For example, the plasma is stable for small toroidal field and high plasma current values, conditions which are favorable for the construction of a fusion reactor. Another interesting problem is the regeneration of the toroidal flux inside the plasma [1]. Moreover, a plasma flow which is related to this flux regeneration was observed experimentally [2]. Such a RFP plasma can be obtained through the energy relaxation process inside the toroidal flux conserver. To study this relaxation process the small RFP apparatus CECI (Configuração de E..rição a Campo Inverso) [3] has been constructed at INPE and plasma experiment has been started in 1988. In the present paper, we will describe some preliminary results and will also discuss some future work in this experiment.

Since the details of CECI apparatus are described elsewhere [3], it is only briefly described here. CECI has two coil systems, a D.C. toroidal coil to produce the magnetic field up to 700G and a poloidal coil to induce the plasma current, and a conductive shell surrounding a pyrex tube (major radius of 12cm and minor radius of 4.2cm) that acts as a toroidal flux conserver for about 3ms. The plasma is initiated by a plasma gun. In this experiment, helium at a pressure of 10^{-5}Torr is used as a working gas.

Typical wave forms of the plasma current and loop voltage are shown in Fig. 1. The maximum plasma current of 1.3kA is obtained for a toroidal field of 100G and a poloidal bank (16.85μF) voltage of 5kV. At this time the conductivity temperature is about 3eV. The relaxation state of the plasma can be known by examining the F-θ diagram ($F = B_\phi(b)/\bar{B}_\phi$ and $\theta = B_\theta(b)/\bar{B}_\phi$ where $B_\phi(b)$, $B_\theta(b)$ and $\bar{B}_\phi$ are the toroidal and poloidal field at the wall and the average toroidal field, respectively), which is shown for three experimental conditions in Fig. 2. The fluctuation level of the toroidal field at the wall, $B_\phi(b)$, is very large ($\tilde{B}_\phi/B_\phi \sim 100\%$), and therefore the data show the average values. As shown in Fig. 2, the RFP configuration in this experiment was not yet obtained. However, it is found that the plasma approaches the RFP configuration when the toroidal field is decreased and the poloidal bank voltage is increased. Since the plasma current decreases by decreasing the toroidal field, the toroidal field value of 30G is a lower limit for CECI. Therefore the pinch parameter θ, which is a function of the plasma current, must be improved to obtain the RFP plasma, as discussed below. From the difference between the inner and outer poloidal fields values at the space between the conductive shell and the discharge tube, the displacement of plasma column was estimated to be 2-6mm when the minor radius was assumed to be 40-25mm.

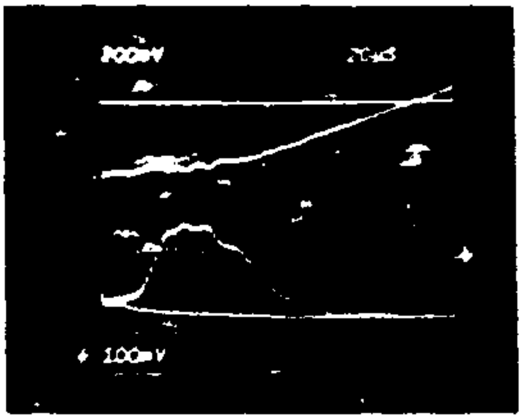

Fig. 1. Loop voltage (upper trace) and plasma current (lower trace).
Loop voltage: 30V/div.; plasma current: 300A/div.; horizontal axis: 20μs/div.; toroidal field $\bar{B}_\phi$ = 50G; poloidal bank voltage V_c = 3kV.

It seems that the following two problems must be solved to improve the plasma current in CECI experiment:

1) Reduction of the error field due to the primary current of the poloidal coil.
2) Production of a higher density initial plasma by the plasma gun.

The first problem may be difficult to solve because the poloidal coil is wound tightly around the toroidal discharge tube in the CECI apparatus. Figure 3 shows the calculated values of the leakage field for a poloidal coil current of 1kA, corresponding to the actual experimental condition of Fig. 1. Notice that these values are calculated without considering the conductive shell which is actually present between the poloidal coil wires and the discharge tube in the CECI apparatus. In the experiment, the plasma current of 600A produces a poloidal field of 30G near the wall of the discharge tube. This value is comparable to the leakage field shown in Fig. 3 except for the central region. Consequently, we believe that one of the causes that limits the plasma current in the CECI experiment is as follows: the magnetic flux surface in the outer region cannot be formed because the leakage field increases with the poloidal coil current, resulting in a large energy loss from the plasma. A compensating coil to reduce such a leakage field is being prepared.

To solve the second problem, it is necessary to increase the energy of the bank used in the plasma gun and also to preionize the plasma by RF (radio frequency) means.

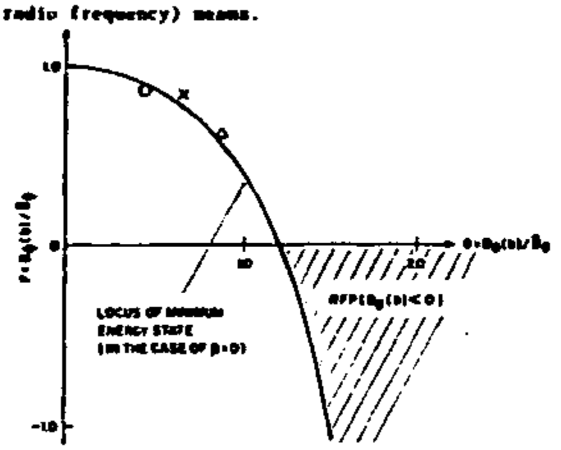

Fig. 2. Experimental F-θ points.
$B_\phi(b)$: toroidal field at wall; $B_\theta(b)$: poloidal field at wall; O: $\bar{B}_\phi = 50G$, $V_c = 3kV$; X: $\bar{B}_\phi = 50G$, $V_c = 3kV$; Δ: $\bar{B}_\phi = 30G$, $V_c = 4kV$.

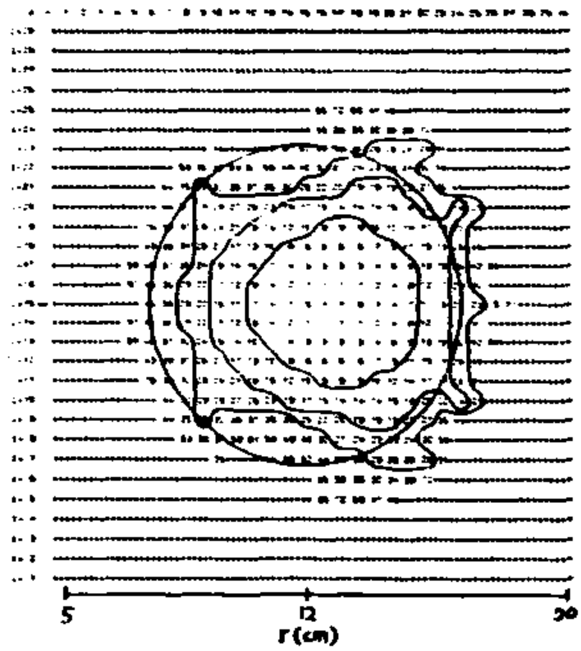

Fig. 3. Calculated leakage field inside the discharge tube by the poloidal coil current. Solid circle indicates the discharge tube. The magnitude of magnetic field produced by the poloidal coil current of 1kA is mapped and expressed in gaussian units. The region indicated by asterisks (*) corresponds to a strong magnetic field region with more than 100G (for example B_θ = 7kG at r = 6cm).

References

[1] Caramana, E.J., Baker, D.A., Nucl. Fusion, Vol. 24, No. 4 (1984) 423.
[2] Arimoto, H., Sato, K.I., Nagata, A., Masamune, S., Aso, Y., Ogawa, K., Yamada, S., Matsuoka, A., Oshiyama, H., Tamaru, T., Nucl. Fusion, Vol. 27, No. 6 (1987) 1021.
[3] Aso, Y., Galvão, R.M.O., Ueda, M., Energy Independence Conference Fusion Energy and Plasma Physics, 17-21 August (1987), Rio de Janeiro, Brazil (IUPAP-SBF-COPPE/UFRJ).
Aso, Y., Galvão, R.M.O., Ueda, M., INPE Report, INPE-4241-PRE/1116 (1987).