Plasma confinement in a toroidal screw pinch at reduced β - values+)

by

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Abstract: The stability behaviour of a toroidal screw pinch plasma with trapped parallel and antiparallel B_z- fields is investigated. For trapped parallel field of B_{zo} = 1 kΓ improved m = 1 stability was found as compared to the case B_{zo} = 0. The lifetime of the plasma is limited by instabilities starting in the pressureless plasma region surrounding the dense plasma column.

Earlier investigations of a toroidal screw pinch with β - values of about $\beta = 0{,}75(T_e + T_i$ between 100 eV and 1 keV) /1/ had shown, that the equilibrium position and the m = 1 growth rates can be represented by the constant pitch model./2/. As a second step of these experiments the influence of superimposed B_z - fields was studied. For negative bias fields the lifetime of the plasma was clearly reduced compared to the pure screw pinch with the same temperature.

Fig. 1 shows the radial field-distribution at the moment of the first compression for B_{zo} = -1 kΓ. The plasma temperature is about 150 eV. From these measurements, the radial distribution of the pitch $\mu(r) = B_\theta/rB_z$ was evaluated. This can be compared with the time behaviour of the pitch $\mu(t)$ at the inner surface of the compression coil which is determined by the programed time behaviour of the fields B_z and the current I_z. The result is shown in Fig. 2. One recognizes that the radial distribution $\mu(r)$ represents directly the time-behaviour $\mu(t)$ at the wall. This gives experimental evidence that a wanted special field distribution can be produced simply by correct time programming of the outer currents.

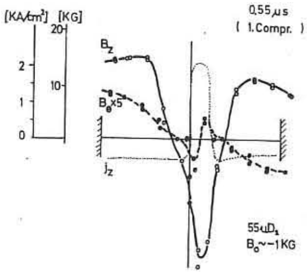

Fig. 1

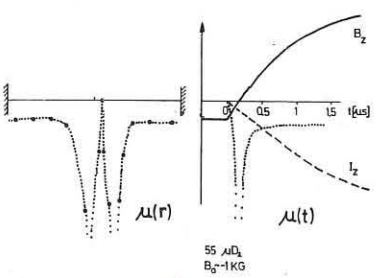

Fig. 2

For the case with positive bias field the m = 1 growth rates were strongly reduced and the lifetime of the plasma (n_e=10^{16}cm^{-3}, T_e;T_i ~ 70 eV) was improved compared to the case without bias field. This should be mainly a consequence of the decreased value of β which for our conditions was reduced typically from 0.75 down to about 0.25. Fig.3 gives a typical streak picture taken from above of the torus and showing that the dense column remains more or less stable for at least 10 μsec. The radial pitch distribution μ (r) at various times is shown in fig.4, as it follows from the measured field distributions.

The constant pitch is maintained only in the regions of the pressureless plasma which are directed towards the inner wall of the tube while in the opposite region of the pressureless plasma the pitch increases towards the wall and passes over a maximum which is shifted towards the wall.

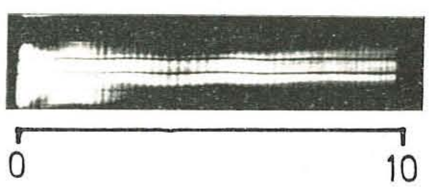

Fig. 3

For the same conditions as in fig.3 the stability behaviour of the toroidal plasma column is shown in a longer time scale in fig.5. One sees, that after about 6 μsec the pressureless plasma becomes luminous and that in the following the dense column starts to drift toward the outer wall and is destroyed. This seems to indicate that at a stable stage of the dense column the pressureless plasma becomes unstable with the consequence that the equilibriumposition is lost. Measurements of the plasma current $I_z(t)$ show that at the time when the luminosity in the pressureless plasma appears the plasma current I_z which flows mainly in the pressureless plasma regions is strongly damped. Therefore it seems to be not unlikely that there is a connection between the instabilities in the outer plasma regions and the strong damping of $I_z(t)$ which of course destroys the toroidal equilibrium. So far detailed reasons for the observed instabilities are not quite clear. Measurements in a linear screw pinch showed however, that for comparable conditions instabilities in the outer plasma regions do not occur. Therefore it seems that the instabilities in the pressureless plasma are due to the necessarily asymmetric distributions of the currents in a toroidal screw pinch equilibrium. Stability calculations including the pressureless plasma are being made by a new MHD code developed by W.Grossmann /3/. Comparisons with the experimental results will be given.

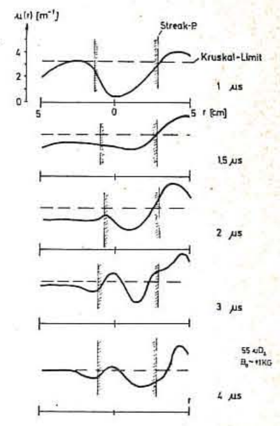

Fig. 4

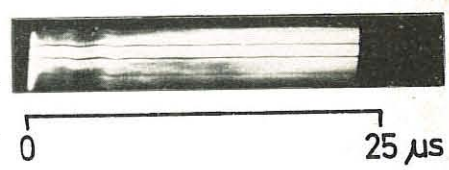

Fig. 5

/1/ P.Grossmann, R.Wilhelm, H.Zwicker, Z.Phys., 197o, to be published

/2/ W.Schuurman, et al., Plasma Physics, 11, 495 (1969)

/3/ W.Grossmann, Paper presented at this conference.

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