EXPERIMENTS WITH A LINEAR (ℓ=1)-HIGH-BETA-STELLARATOR [+)]

by

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Abstract: This paper describes a linear (ℓ=1)-Stellarator experiment with a helically shaped coil, preparatory to a future toroidal experiment with a major diameter of 2.7 m. Stability is found to be comparable with a pure linear theta-pinch or with an (ℓ=1)-Stellarator using a pair of conductors.

Recent theoretical work suggests stable equilibria for a toroidal (ℓ=1)-Stellarator with high beta.[1-3] In order to separate the problems of stability and equilibrium, we tried to test possible toroidal configurations by doing linear experiments with a pair of helical conductors.[4)] In this paper we describe experiments with a straight (ℓ=1)-Stellarator where the magnetic surfaces are formed by a helically shaped coil (Fig. 1) instead of the pair of helical conductors. For technical reasons, a shaped coil would be more convenient than helical conductors.

The inner surface of this coil is not exactly helical but is approximated by excentric cylinders of 23 cm diameter and 3 cm width. The period length is 60 cm, 9 periods fitting within the coil length of 5.4 m. The amplitude of the helix is 1.5 cm, the rotational transform in vacuum is 0.01 per period.

Fig. 2 shows stereoscopic smear-camera pictures of a discharge in 10 mTorr of Deuterium at a bank-energy of 1.5 MJ. After about 14 µs we see the onset of instabilities, which is within a few microseconds the same onset-time that we observe in a straight theta-pinch of equal parameters. Fig. 3 shows that with 3 % added oxygen instabilities set in much earlier, an effect which we observed in the straight theta-pinch as well but do not understand yet. Fig. 4 shows stereoscopic pictures of a discharge in 40 mTorr at 0.5 MJ (low impurity level).

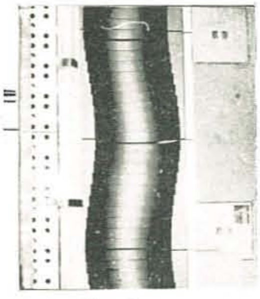

Fig. 1

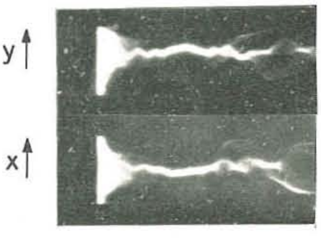

Fig. 2

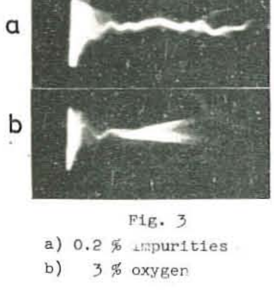

Fig. 3

a) 0.2 % impurities

b) 3 % oxygen

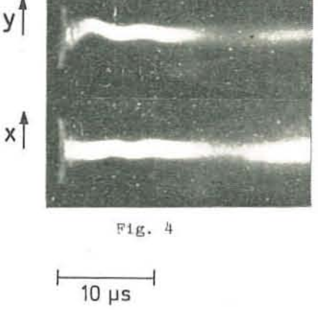

Fig. 4

10 µs

The displacements of the plasma to be seen in Fig. 2 are resolved (slightly smoothed) in Fig. 5 in a plane perpendicular to the axis. It turns out that the plasma tends to drift into the equilibrium position near the magnetic axis at x = 0, y = 15 mm off the axis of the vacuum vessel. This is shown more clearly in Fig. 6 as position y versus time. The Figures shown are only examples for a typical set of parameters. Changing the parameters does not alter the overall behaviour of the plasma.

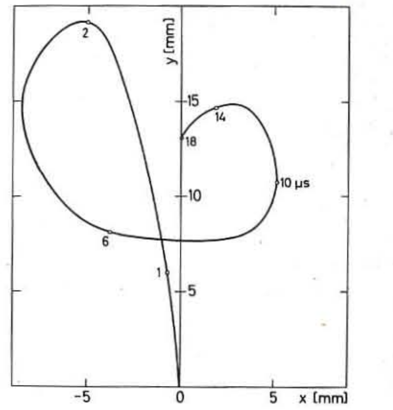

Fig. 5

In contrast to our experiments with a pair of helical conductors, we were not able to vary the time difference between the main field and the helical field.[4)] But, obviously, this turns out not to be essential for successful experiments.

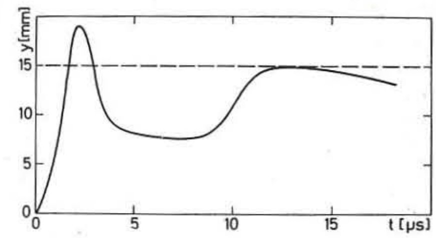

Fig. 6

The parameters of the experiments were: bank energy up to 2.6 MJ, bank voltage up to 40 kV, magnetic field up to 31 kG, rise time (quarter cycle) 7 or 9 µs, coil length 5.4 m, inner coil diameter 23 cm, inner vacuum-vessel diameter 10 cm, temperatures between 20 and 500 eV, densities between 10^{16} and 10^{17} per cm^3.

At the time of completion of this paper we displaced the vacuum vessel out of the axis of symmetry of the coil, in order to test the restoring forces that should be present after the initial implosion.

References:

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