Confinement of a Potassium Plasma in the Garching Octopole W V

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Introduction

Previous experiments with a Cs plasma and a moderate magnetic field in the Octopole W V [1-3] yielded an appreciable increase in peak density when an azimuthal magnetic field (typically of 65 G) was superimposed on the purely meriodional multipole configuration. This feature was discussed [2, 3] as part of a qualitative loss model, especially in the case of a collisionless plasma with a non-Maxwellian ion distribution and large ion Larmor radii. Using a K plasma and furthermore enlarging the magnetic field as compared to the above mentioned Cs experiments, within about 20% we find the same peak densities in both cases, with and without the azimuthal magnetic field applied [3]. This leads to the conclusion that large Larmor radii effects as regarded dominant in the case of a Cs plasma at low magnetic fields are no longer of such relevance [3].

Therefore, in the present paper, some details of the confinement of a potassium plasma in the Octopole are studied. Effects of the supports of the current rings inside the vacuum tank are considered to be of importance. Consequently, it appears useful to investigate the purely meridional magnetic field configuration because of its simpler structure without translational transform or shear.

Experiments and Discussion

The apparatus as well as the plasma source and the diagnostics are described elsewhere [2, 3]. Fig. 1 shows the magnetic field plot. In the present investigation we use higher magnetic fields than those stated in the references. At the midplane of the device about 12 Larmor radii ϱ_i of a 0.2 eV potassium ion are between the boundary field line of a flute-stable confinement, ψ_c, and the main separatrix. The maximum magnetic field of the main separatrix is B_o=5.2 kG. The experiments are done in the stationary state. Axial and radial density profiles are shown in fig. 2. Three single Langmuir probes are used and cross-calibrated during several runs. The data are normalized to an ion input flux of $\Phi = 3.4 \cdot 10^{15} s^{-1}$. The profiles are taken at different azimuthal positions φ=60, 120 and 180° with respect to the plasma source. At φ=120° they reveal somewhat lower peak densities than at the other positions. The profiles are rather flat-topped and show close to the minor separatrices a moderate dip. As compared to the profiles of a Cs plasma at lower magnetic field we find steeper gradients which tend to vanish outside the critical field line ψ_c. There

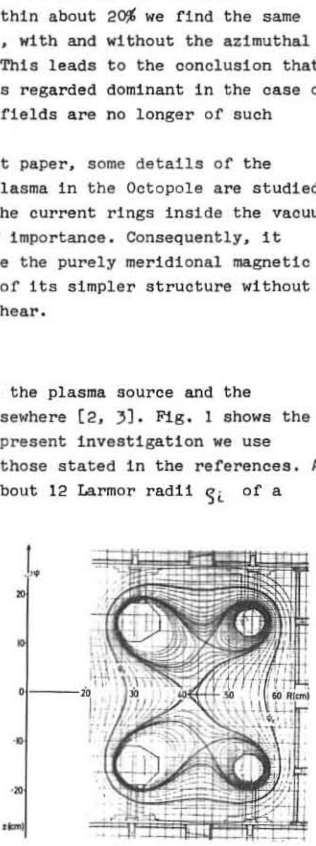

Fig. 1 Magnetic field plot

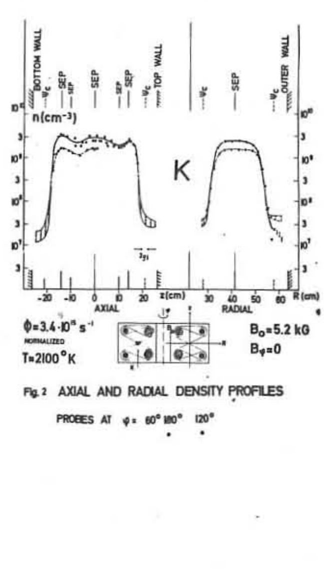

Fig.2 AXIAL AND RADIAL DENSITY PROFILES PROBES AT φ= 60° 180° 120°

fluctuations are observed the amplitude of which is indicated by the dashed vertical lines. The fluctuations seem to be present inside of ψ_c at a distance comparable to $2\varrho_i$, the Larmor diameter of a 0.2 eV potassium ion. This feature as well as further details of the fluctuations remain to be studied in the future; especially their relevance with respect to plasma losses.

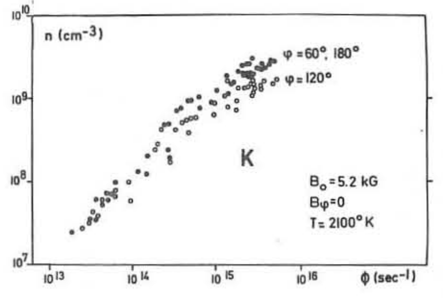

Fig.3 DENSITY VS ION INPUT FLUX

Measuring at the main separatrix at a position near the upper outer ring we find the density to be slightly lower than at the center of the device. Whether this is due to a possible discrepancy of the different probes used has not yet been proved.

The experimental confinement time τ can be evaluated from the relation of peak density n vs ion input flux Φ (fig. 3). The dots correspond to the data found at φ = 60 and 180° and, at generally slightly lower density, the open circles to those at φ = 120°. At a typical density of $n = 10^9$ cm^{-3} we find an experimental confinement time τ = 0.24 s. In the low density region $n \sim \Phi$ is obtained approximately. The experimental points seem to rise slower than that relation at densities higher than $n \approx 0.7 \cdot 10^9$ cm^{-3}. There τ is larger than τ_{eq}, the electron-ion equipartition time; τ tends to decrease slightly with increasing density.

Diffusion mechanisms according to FICK's law with the BOHM or the resistive diffusion coefficient yield confinement times much too low (7 ms) or too high (45 s, at $n = 10^9$ cm^{-3}, respectively. With the use of the profiles measured close to the rings the confinement time corresponding to direct loss of particles at the ring supports results in τ_{s1}= 0.5 - 0.8 s. The lower (higher) value corresponds to one (two) Larmor radii added on either side to the width of the support. Secondary support losses according to a confinement time τ_{s2} can be caused by an azimuthal density gradient. The losses are towards the rings or the outer walls, depending on the direction of the meridional magnetic field and the azimuthal density gradient. In a simple model only the ratio of density measured at φ = 120 and 180°(60°) enters [4]. It yields values of τ_{s2} = 0.6 to 0.04 s.

Conclusion

The calculated confinement time τ_{s1} due to direct loss at the supports is found, on the average, higher by about a factor of three than the observed confinement time. From the observation of reduced density at the azimuth where the supports are situated we conclude that support losses of the secondary type should be present. Up to now, however, no definite experimental value seems to have been obtained. Measuring the flux of particles towards the outer walls at positions close to the azimuth of the supports and also reversing the polarity of the magnetic field should give more information about those additional particle losses. Far beyond the limits of consideration are losses according to BOHM or resistive diffusion, as stated previously.

References

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