PROBE MEASUREMENTS ON DRIFT PATTERNS IN RFP EDGE PLASMAS.

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Introduction. Edge plasma rotation in tokamaks, due to e.g. $E \times B$ or grad B drift has attracted interest in recent years due to its relevance for understanding enhanced confinement modes. Probe measurements have been applied in studying both parallel and perpendicular drift motion [1]. A rapid perpendicular drift has been observed with probe measurements in reversed field pinch experiments [2,3] and was used to estimate the edge ion temperature, assuming that it can be identified with diamagnetic drift [2]. The drift complicates the interpretation of probe measurements, and a comparative study has been made in two RFP experiments of vastly different dimensions, with the aim to identify the causes of drift motion.

Experimental. In RFX, with $R = 2$ m and $a = 0.456$ m, a rotatable Langmuir probe array with four single probes facing different directions with respect to the magnetic field has been used [4], as well as passive collector probes mounted on an identical manipulator. In T1, with $R = 0.5$ m and $a = 0.057$ m, rotatable double probe and passive probes have been used [2,5].

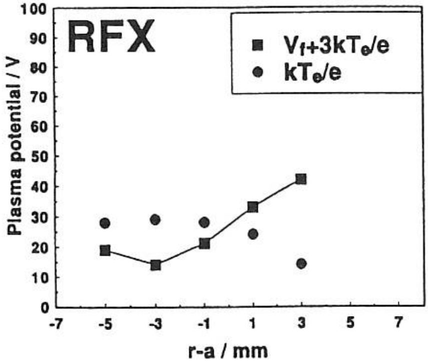

Figure 1.

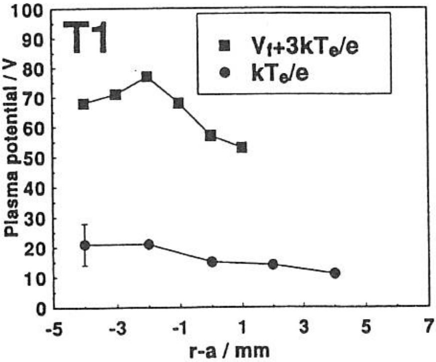

Figure 2.

Results and discussion. Figures 1 and 2 show the radial profiles in RFX and T1 of T_e and the plasma potential V_p, assuming that the latter can be calculated from the probe floating potential V_f as $V_p \approx V_f + 3kTe/e$. The data from RFX are taken from the drift measurement series of discharges to be presented below, whereas the T1 data are from typical 80-90 kA discharges. In both cases the density decay length is of order $\lambda_n \approx 3mm$. Figures 3-5 show examples of the asymmetric particle flux on probes, which will be interpreted in terms of plasma drift. In figure 3 the steady state ion saturation currents on differently oriented probes in RFX are presented; in every discharge the Langmuir probes collect particles in four different directions, the probe array is turned between discharges and the shot to shot density scatter has been

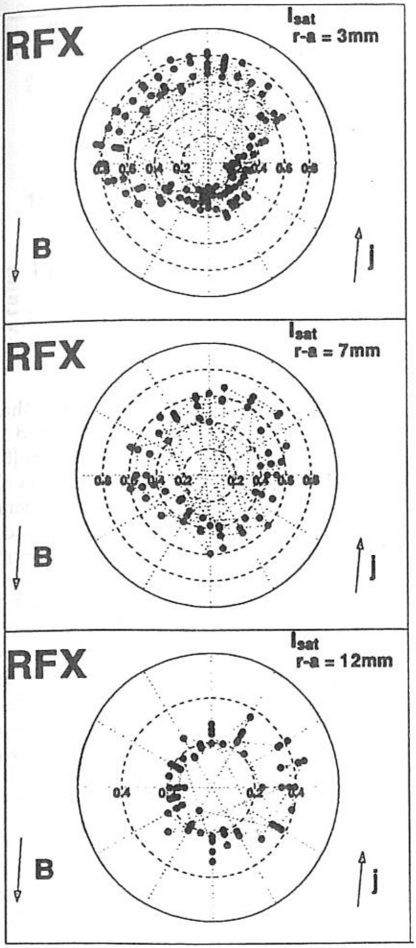

Figure 3.

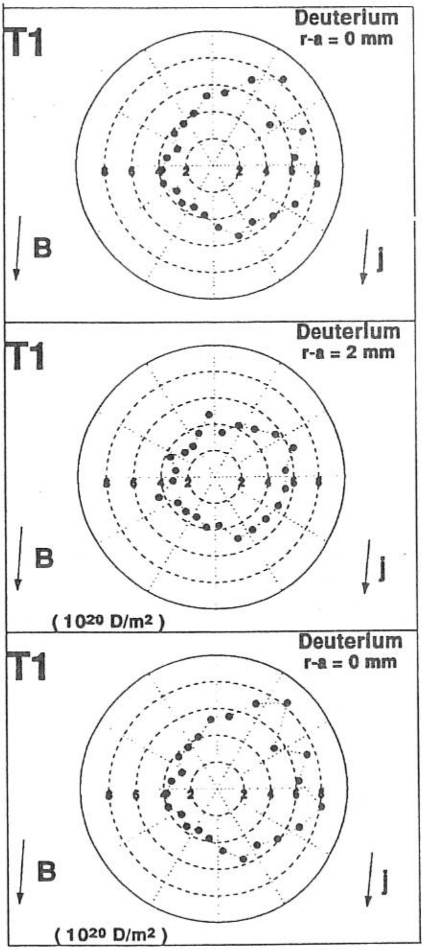

Figure 4.

eliminated by normalising to the sum of the four I_{sat} in different directions. The angle of maximum I_{sat} changes gradually with the minor radius. Figure 4 shows analogous angular distributions of deuterium trapping on a cylindrical graphite probe which was exposed to 220 RFP discharges; this time the maximum trapping rate remains fixed on the right hand side, as seen from the plasma. A qualitatively similar behaviour is observed for the deposition rate of impurities, as the examples of carbon collection on silicon probes in figure 5 show, this time from RFX.

Different models have been suggested for translating the flux asymmetry to probes into drift velocities, or Mach numbers. Four examples are given in figure 6. The solid line marked with a in figure 6 corresponds to a particle model according to which the ions move with a drifting Maxwellian distribution [2]. Such a model would seem ap-

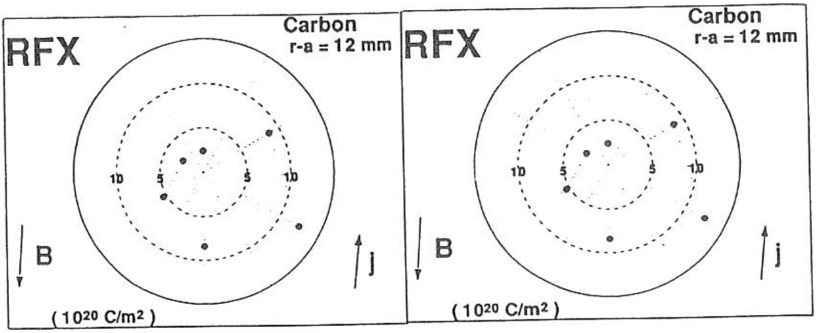

Figure 5.

propriate for instance if $T_i \gg T_e$ and in particular if the ion gyro radii are larger than the probe dimensions. The dashed curve b is is the simple model which was used in [3], the dashdotted curve c results from Hutchinsons one dimensional fluid model [6] and the dotted curve d shows Stangebys analytical fluid model [7]. MacLatchy et al. incorporated the Hutchinson model in a more elaborate treatment [1]. That scheme may not necessarily be the most natural choice in cases where the drift is predominately perpendicular. To make a simple estimate of the main trends in the measured asymmetries we have chosen to proceed as follows: the overall drift direction is determined directly from the angle of maximum particle flux in the diagrams such as figures 3-5. An effective Mach number is calculated from the upstream to downstream flux ratio using curve c in figure 6. The parallel and perpendicular drifts are finally calculated by taking the projection of the overall drift in the parallel and perpendicular directions. The results are shown in figures 7 and 8. Far away from the plasma the electric field is directed outwards and the $E \times B$ drift is in the same direction as the diamagnetic drift. Further into the plasma the directions are opposite. In RFX the perpendicular drift changes sign at smaller minor radius, whereas in T1 it remains high and in the diamagnetic direction. Qualitatively this is explained by higher edge ion temperature in T1, since the density gradient and radial electric field are similar in the two machines.

Conclusions. The edge plasma drifts in RFX and T1 have been studied with Langmuir and passive probes. The perpendicular drift seems to be largely of diamagnetic, nature particularly in T1 where the diamagnetic drift prevails over the $E \times B$ drift in the region where they are opposite in direction.

References.

[1] C.S. MacLatchy, C. Boucher, D.A. Poirier et al. Rev. Sci. Instr. 63(1992)3923.

[2] H. Bergsåker, I. Gudowska, B. Emmoth and E. Tennfors, Proc. 19th Eur.Conf. Contr.Fus. Plasm.Phys. Innsbruck 1992, part I p. 607.

[3] V. Antoni, M. Bagatin, H. Bergsåker et al. Proc. 20th Eur.Conf. Contr.Fus. Plasm.Phys. Lisabon 1993, part II p. 695.

[4] V. Antoni, M. Bagatin, D. Desideri et al. Rev. Sci. Instr. 63(1992)4711.

[5] A. Möller, H. Bergsåker, G. Hellblom et al. Proc. 20th Eur.Conf. Contr.Fus. Plasm.Phys. Lisabon 1993, part II p. 471.

[6] I.H. Hutchinson, Phys. Fluids 30(1987)3777.

[7] P.C. Stangeby, Phys. Fluids 27(1984)2699.

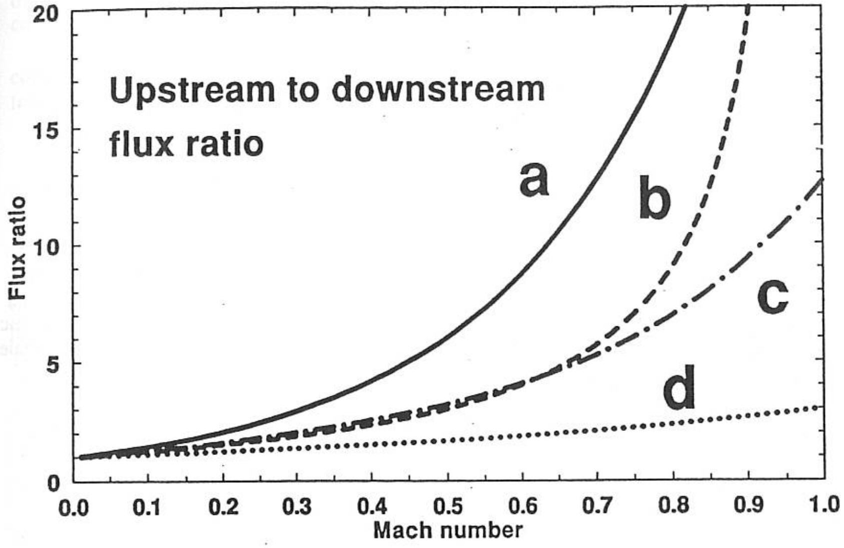

Figure 6.

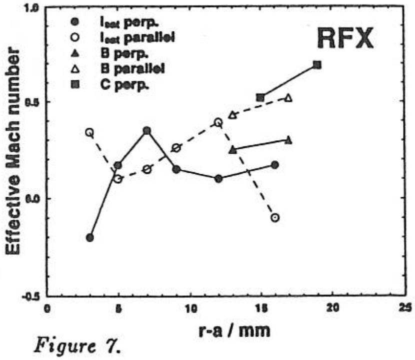

Figure 7.

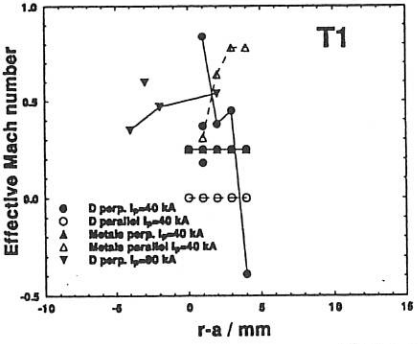

Figure 8.