EIGHTEENTH FUSION ENERGY CONFERENCE

SESSION EX8

Tuesday, 10 October 2000, at 9:00 a.m.

Chair: J. JACQUINOT (France)

SESSION EX8: Current Drive, Heating & Fuelling (provided by A. FUJISAWA, Japan)

Paper IAEA-CN77/EX8/1 (presented by R. Prater)

DISCUSSION

D. MOREAU: You defined a new efficiency for which work we do not have experience, so could you please tell us what the conventional figure of merit for current drive efficiency was both for inboard and outboard absorption?

R. PRATER: For inboard absorption the conventional current drive efficiency lies in the range of $0.02\text{-}0.03\times10^{20}$ A/m^2/W. Outboard absorption is not possible on DIII-D.

O. GRUBER: In the ECCD stabilization of NTM's, the NTM doesn't come back after switching off the ECCD. What is the explanation? These are three large sawteeth after switch-off ECCD, which should provide large seed islands. Is there a change of the current density profile?

R. PRATER: At the time of the first sawtooth, the ECCD has probably not decayed. At the time of the second sawtooth, the 3/2 mode amplitude increases but does not reach the threshold for growth, perhaps because, as you suggest, there are some changes in the current profile generated by the ECCD. At the time of the third sawtooth, the heating power is coincidentally terminated so β_p drops below the minimum for NTM instability. The ELMs in these discharges do not seem to be effective at generating 3/2 seed islands.

R. GOLDSTON: In your case of inboard current drive with 1.1 MW of ECCE, what was the total driven current?

R. PRATER: About 25 kA. Please recall that the ECH system was set to generate maximum current density rather than maximum current, and the conditions of density, temperature, and minor radius were adverse to high driven current.

J. JACQUINOT: Do you expect and/or assume a change of the bootstrap current by electron trapped under ECCD?

R. PRATER: The bootstrap model in use in this work does not address nonthermal distribution functions. Instead, the bootstrap current is modified to include changes in the plasma parameters and gradients.

Paper IAEA-CN77/EX8/2 (presented by Y. Peysson)

DISCUSSION

K. LACKNER: Does cross-filed diffusion of fast particles play a role in determining the current density profiles (apart from the effect of MHD events, which you outlined)?

Y. PEYSSON: Hollow steady-state hard x-ray profile and their fast establishment when the LH power is turned on ruled out the possibility of a fast electron transport. Even in the MHD case, there is evidence that loss of fast electrons is localized, which indicates that cross-field transport is modest, except in the island associated to m=2 tearing mode.

A. BERS: The power deposition profile you measured is wider than predicted by ray tracing? Do you have an explanation for this? Have you observed any parameteric instabilities with increasing LH power input?

Y. PEYSSON: The observed power deposition profile is usually broader than predicted by RT/FP codes. In addition, the maximum emission is often not properly reproduced by modelling. This discrepancy may have several origins: fluctuations, parametric instabilities (not measured at present day). Assessment of such mechanisms against experiment is under way.

S. BERNABEI: Do you have an explanation for the independence of the current profile from $n_{//}$?

Y. PEYSSON: The lack of dependence of the LH current drive efficiency with $n_{//}$ of launch is at present day not fully understood. It does not seem to be related to the multi-pass weak absorption (in fact ray-tracing indicates that absorption takes place after 2-3 passes, with large delta $n_{//}$ variations), but may be the consequence of a broadening of the power spectrum at the plasma edge. Further investigations are necessary to clarify this point.

Paper IAEA-CN77/EX8/3 (presented by T. Oikawa)

DISCUSSION

R. GOLDSTON: I would like to congratulate you on these very beautiful results; they come after a lot of hard work on the N-NBI systems, and I congratulate you on getting to this point. What seems like a million years ago, we saw very fast radial redistribution of fast ions due to sawteeth on PDX. Do you see effects due to sawteeth on JT-60?

T. OIKAWA: Thank you very much. Our “beautiful” result of N-NBCD greatly owes to the progress in reliable and stable operation of N-NB system through collaboration with PPPL. As for your questions for these 4-5 years since 1996 N-NB system started to work, we have not observed significant influence of sawtooth activity in the measurements of Sn and driven current profile in the regular sawteeth with inversion radius $r/a<0.2$. However, giant sawteeth, which occurs in ICRF heated plasmas, has to be studied.

K. LACKNER: You showed a difference in the effect of neoclassical tearing modes on N-NB and P-NB fast ions. Is there a difference in the injection geometry between the two systems, and can the observed effect be caused by differences in the pitch-angle distribution?

T. OIKAWA: We have not been able to clarify the effect of beam geometry of tangential N-NB, tang-P-NB on the transport of beam ions. However, considering that for tang-P-NB injection cases with near on-axis deposition similar to N-NB, reduction in Sn was not as clear as in N-NB injection cases. The modeling of the mechanism of beam ion loss or redistribution is required for understanding the effect of beam deposition and geometry. Recently, we have been developing the particle orbit following code taking into consideration the island structures. This issue is our next-step study.

Paper IAEA-CN77/EX8/4 (presented by T. Watari)

DISCUSSION

Y. KOLESNICHENKO: You have shown that the inward shift of the magnetic axis improves confinement of energetic particles. Does it prevent the arising of superbanana orbits?

T. WATARI: Yes, with following interpretations: There is no super-banana orbit in the LHD unless special E_r field is assumed. However, the excursion of the drift orbit from the flux surface that I showed in my viewgraph has the same physics origin and could be regarded as the part of super-banana orbit. The distance of the excursion from the flux surface is reduced by the magnetic axis shift.

R. GOLDSTON: You said that the ion heating regime (Type-5 I believe) was the best, but you did not mention the efficiency of the other heating regimes, and particularly of electron heating. Could you comment on the other heating regimes?

T. WATARI: We take Type-5 regime as the optimal heating regime for the reason that largest stored energy is obtained. However, it is true that plasma was sustained by ICRF power only also in electron heating regimes, which indicates that electron heating regimes have high enough quality. The difference of the obtained stored energy may be attributed partly to the difference of the deposition profiles between them, broader in the case of electron heating regime. It is noted that the heating powers were different between them due to the different RF frequencies, which is also an important figure of merit from engineering point of view.

M. ONO: In your ICRF heating, resonance layers are often intersecting the antenna. Particularly, the minority ion heating, one might expect impurity injection by IECR. Surprisingly, the experiment shows good heating and no impurity problem which is a very good news indeed! Have you observed regime(s) where you did experience impurity generation as you explored regimes?

T. WATARI: We were able to sustain the plasma both in ion heating regime and electron heating regime. From this point of view, the quality of the two regimes are not much different apart from the engineering merit of higher frequency for the ion heating regime. The cyclotron layer crosses the ICRF antenna as pointed out. However, we suffered from a little problem due to it. The anticipated difficulties may have been resolved due to the fact that the orbits of the trapped particles emerged in the plasma do not cross the antenna.

M. MURAKAMI: Have you done mode conversion electron heating (with layer optimized fraction of minority concentration) compared with ion heating?

T. WATARI: The electron heating mechanism in this presentation is based on the mode conversion process of “high-field-side launch”. The heating efficiency may be further improved by locating the two-ion-hybrid layer closer to the axis by adjusting the H-concentration more carefully. A more systematic comparison will be made in the next campaign. If mode conversion of “low field side launch” is meant by “mode conversion regime”, it was examined in the 2nd cycle and the quality of the heating was not satisfactory.

Paper IAEA-CN77/EX8/5 (presented by R. Raman)

DISCUSSION

A. JAUN: Our calculations suggest that the large magnetic fluctuations produced by the helicity injection could trigger weakly damped global (n=1-3) drift-kinetic Alfvén eigenmodes. Have you carried out spectral measurements and/or observed any confinement degradation during the helicity injection?

R. RAMAN:
1. These modes are unimportant for the primary objective of CHI, which is the creation of a target plasma for use by another non-inductive current drive method, since the CHI will be turned off once the other current drive method takes over.
2. Experiments on the sustained addition of a CHI edge current to a pre-existing ohmic discharge have not yet been conducted to determine the CHI current fractions at which there is confinement degradation. However, we note that ST's have predicted bootstrap current fractions of >90%, so that only a small amount of CHI edge current may be needed for the purpose of current profile control.

M. KATSURAI: How did you succeed in controlling the impurity injection from the CHI electrodes in NSTX?

R. RAMAN: Nearly all the metal electrode surfaces have been covered by graphite. This eliminated copper impurities. Pressure of iron has not been spectroscopically examined.

E. HOOPER: Have you made EFIT reconstructions of the magnetic field and, if so, do they indicate closed surfaces?

R. RAMAN: Yes, EFIT indicates closed surfaces in some discharges but we are not in a position to confirm the presence of closed flux surfaces.

E. HOOPER: Have you conducted edge current drive experiments in preformed (ohmic) discharges?

R. RAMAN: Not yet. Experiments on the addition of a CHI edge current to a preformed single null Ohmic discharge will be initiated during the next six months.

K. LACKNER: The effect you utilize is the reversal of the Halo-current phenomenon usually accompanying vertical displacement events. In the latter case, one frequently observes toroidal asymmetries, indicative of helical perturbations. Do you have comparable observations on NSTX?

R. RAMAN: On high current CHI discharges we see an n=0 coherent mode on the center stack toroidal Mirnov coil array indicating a toroidally symmetric structure. The predicted n=1 mode on the outer vessel toroidal Mirnov coil array is seen in some shots. This mode is predicted to be necessary for the creation of closed flux surfaces.