NINETEENTH FUSION ENERGY CONFERENCE

SESSION EX/C3

Thursday, 17 October 2002, at 16:10

Chair: D. BORA (India)

SESSION EX/C3: Current Hole & Internal Transport Barrier

Paper IAEA-CN94/EX/C3-1Ra (presented by Y. Miura)

Discussion

M. Porkolab: It seems to me that you are making a very strong statement about the lack of ECCD inside the current hole. In your figure, both the blue and the green traces are inside the current hole. The "predicted" current profile for ECCD (the green curve) looks rather flat (artificially flat). Is this based on detailed ray tracing of EC waves in toroidal geometry? It would not surprise me if such a ray tracing and power deposition profile were more consistent with the blue curve (measurements).

Y. Miura: The blue curve shows the current expected from the calculation based on the ray tracing code in toroidal geometry. However, as suggested by the flat temperature profile, and assuming no momentum confinement, we can consider the green curve as an artificial averaged current of the expected total current. In any case, we did not measure the positive current inside the current hole in the experiment.

G. Bateman: Magnetic drifts within the current hole should produce a charge separation and large plasma flows at the edge of the current hole. Have these large plasma flows been measured at the edge of the current hole in the experiments?

Y. Miura: Yes, we observed the flow outside of the current hole in JT-60U. We consider the flow shear to be responsible for the sustainment of the internal transport barrier.

Paper IAEA-CN94/EX/C3-3 (presented by S. Ide)

Discussion

E. Joffrin: In the formation of ITBs, a JT-60U poster (by Neudatchin) shows that rational surfaces play a big role in triggering an ITB. You do not mention that at all. Why?

S. Ide: My presentation is not very much focused on the ITB formation phase, which is the main reason why I did not touch upon that topic. In the ITB experiments on JT-60U, it seems that there is no strong correlation between ITB formation and rational surfaces in general. The result you refer to is what we call an “ITB event”. As shown in that event, an ITB can be triggered in relation to rational surfaces in some cases. However, this is not applicable to all cases of ITB formation in JT-60U.

Paper IAEA-CN94/EX/C3-4 (presented by X. Litaudon)

Discussion

R.J. Hawryluk: What is Q_{DT}^{equiv} in the feedback controlled fully current driven case?

X. Litaudon: The value of Q_{DT}^{equiv} in the feedback controlled fully non-inductive driven discharges is of the order of 0.2.

C.C. Petty: Near the end of your talk, you showed a graph that implied that the limit to achievable normalized beta was the lack of heating power. Do you also not expect that the achievable normalized beta will be limited by MHD stability, and if so, how far away are your best discharges from this stability limit?

X. Litaudon: Our best internal transport barrier (ITB) discharges are indeed close to the n=1 pressure driven kink instability (high values of pressure peaking). For increasing β_N, the challenge consists in triggering and sustaining wider ITBs to reach broader pressure profiles. The formation and sustainment of wider ITBs requires higher values of injected power. From the present ITB database, access to high β_N (~3) values at high toroidal field (~3.4 T) requires typically 30 MW of injected power.

Paper IAEA-CN94/EX/C3-5Ra,b (presented by R. Dux)

Discussion

B. Coppi: In a meaningful burning plasma, the value of Z_{eff} has to be lower than 2, such as 1.75. What do you plan to do to remove the impurity influx that is associated with these transport barriers?

R. Dux: The neoclassical inward drift of the impurities is provoked by the central fueling from NBI heating, which creates peaked D profiles in the radial range with low diffusion coefficient. Thus, I do not expect neoclassical inward drift in a purely α-heated burning plasma. However, there might be a peaking of the He profile due to the low diffusion coefficient (see Ref. [16]).

M.R. Wade: Is there any evidence for the strength of the ion temperature gradient term in the neoclassical formulation from JET or JT-60U? This term could be very beneficial in plasmas with flat density profiles.

R. Dux: For the JET case, I did not perform simulations without the screening term in the neoclassical drift velocity.

Paper IAEA-CN94/EX/C3-6 (presented by V. Pericoli Ridolfini)

Discussion

Yu.N. Dnestrovskij: In your earlier reports from FTU it was mentioned that in the case of off-axis EC heating, heat pinch was observed. What is the result in present experiments?

V. Pericoli Ridolfini: We do not see heat pinch in the experiments with off-axis LH heating and current drive.

M. Porkolab: At the Snowmass workshop this summer in Colorado there was considerable debate about the agreement (or disagreement) of the ACCOME code (Bonoli) predictions for LHCD with European experiments. I am pleased to see the excellent agreement with the FTU experiments and the Bonoli code.

F.C. Schüller: You ascribe the widening of the ITB radius with decreasing $q(a)$ to the location where the shear is lowest. Did you look to see if there is any relation to rational q values of q_{min}?

V. Pericoli Ridolfini: Up to now there is no clear evidence in FTU as to whether the rational q surfaces are linked or not to the onset of an ITB. Much more evident is the effect of low/inverted shear. In addition, I must point out that the surface with q=2 is always present in FTU, even in the pre-ITB phase.

B. Coppi: Do you observe any influx of impurities as a result of the formation of a transport barrier? What values of Z_{eff} do you have before and after the barrier is formed?

V. Pericoli Ridolfini: The steady ITBs in FTU do not show any significant additional impurity influx with respect to normal FTU operation at the same power level. There is also no evidence of central impurity accumulation. Typically Z_{eff} is close to 2 in the pre-ITB phase and increases to 2.6 during the full power ITB phase.

Paper IAEA-CN94/EX/C3-7Ra,b (presented by J.E. Rice)

Discussion

F.W. Perkins: To use an ITB in a reactor, we must control it. What happens to the barrier after $10\tau_E$? Can you bring a barrier back after it is lost?

J.E. Rice: The density barrier has been held steady for the duration of the ICRF pulse length, up to 600 ms or $\sim 15\tau_E$, limited only by the ICRF duration.

J.-M. Noterdaeme: On Alcator C-Mod you need to put ICRF far off-axis to get an ITB. On the other hand you also get an ITB with ohmic heating alone. Apart from the outcome, what is the common aspect?

J.E. Rice: If off-axis heating is a necessity for barrier formation, it is difficult to understand how the barrier appears in a purely ohmic discharge. The recipe for producing barriers in ohmic plasmas is to ramp B_T up after the H-mode forms, so perhaps this may be a factor.

V. Parail: Did you take into account the time evolution of the density profiles in the TRANSP simulations of Alcator C-Mod plasmas?

J.E. Rice: The TRANSP simulations of the time evolution of the density profiles are in good agreement with the observations.

O. Gruber: Our view of the relevance of peaked density profiles for a reactor is different from your statement. A peaked density profile allows higher confinement at limited temperature gradients (stiff T profiles). By choosing a careful on/off-axis balance of the heat deposition, impurity accumulation can be avoided at still only moderately peaked density profiles.