SESSION EX5

Thursday, 22 October 1998, at 2 p.m.

Chairman: D.E. Baldwin (United States of America)

TRANSPORT, INTERNAL TRANSPORT BARRIERS, H-MODE

Paper IAEA-CN-69/EX5/1 (presented by A. Fujisawa)

DISCUSSION

C. HIDALGO: You have shown that the ExB shearing rate is high enough to reduce fluctuations in CHS. Have you looked at the temporal evolution of fluctuations? Is there any evidence of “bursting” behaviour in the fluctuations in the proximity of the CHS transport barrier location?

A. FUJISAWA: No, we have not done this. So far we have only carried out fast Fourier transform analysis. At a later stage, we will try to perform some analysis with temporal resolution, such as wavelet analysis.

R.R. WEYNANTS: Could you say something about the causality during the formation of the ITB? Is there a parameter which changes clearly before the E_r field develops?

A. FUJISAWA: This is a difficult question to answer at the present time because, except for the HIBP, the diagnostics for local temperature and density do not have sufficient temporal resolution. By way of example, electron cyclotron emission measurement, which has sufficient resolution, shows several resonances in the case of CHS plasma.

F. WAGNER: The two states of confinement you describe and the “dithering” between them emerge obviously from the impact of E_r shear on the turbulent fluxes. Does the neoclassical electron heat diffusivity, and the E_r impact on it, not play any role at all, not even in the high T_e of the good confinement state?

A. FUJISAWA: Neoclassical heat diffusivity, including the observed E_r, can be consistent with experiment at the barrier location. If the observed E_r change is not taken into account, the diffusivity will be a factor higher. Inside the barrier, the impact on E_r change will also be important for the diffusivity. In this sense, E_r impact on the neoclassical heat diffusivity plays some role in the high T_e achievement.

Paper IAEA-CN-69/EX5/2 (presented by Y. Koide)

DISCUSSION

F. ROMANELLI: Have you tried correlating the onset of the transport barrier with the parameter $\alpha = -q^2R\beta'$?

Y. KOIDE: No, we have not. However, no evident tendency with respect to T_i or ∇T_i has been obtained so far. We speculate, therefore, that no clear correlation exists between ITB onset and the α parameter.

K. LACKNER: I assume that, as you obtain a relation of critical dT_e/dr on s, you could also express it in terms of power flow requirement. Have you tried this?

Y. KOIDE: No, but we shall now look into it.

Papers IAEA-CN-69/EXP1/13 and 14 (rapporteured by R.E. Bell)

DISCUSSION

G. BATEMAN: What is the radial form of the empirical poloidal velocity v_θ α T_i? v_θ must have odd symmetry across the magnetic axis, while $T_i(r)$ has even symmetry.

R.E. BELL: The measured v_θ profile is rotating in the ion diamagnetic direction and peaks near the magnetic axis. By symmetry, the rotation must go to zero near the axis. Then, using polar co-ordinates

$$v_\theta(\rho) \approx \alpha(T_i(\rho) + C)$$

describes the rough empirical observation except near the axis (say, $\rho < 0.1$) $v_\theta(0) = 0$.

M. KIKUCHI: Neoclassical theory is developed on the assumption that $\sqrt{\varepsilon}\rho_{pi} << r$. It is therefore unfair to compare v_θ measurement with neoclassical theory where the theoretical assumption breaks down. Did you check the validity of neoclassical theory at your v_θ measurement point? Since your T_i is very high near the centre and B_p is small for reversed shear plasma, I would imagine that ρ_{pi} (or ρ_{pI}) is fairly large.

R.E. BELL: The data I showed for the comparison of measured v_θ and neoclassical v_θ were at $r/a \sim 0.3$, and at that point $\sqrt{\varepsilon}\rho_{pi}$ is smaller than r.

Paper IAEA-CN-69/EX5/4 (presented by H. Shirai)

DISCUSSION

S.V. MIRNOV: What can you say about impurity behaviour and impurity accumulation in all ITB cases ((a), (b) and (c))?

H. SHIRAI: These cases are analysed in the steady-state phase. The time evolution of visible bremsstrahlung data shows that impurity accumulation does not occur, even in the “box” type ITB case.

R.R. WEYNANTS: For many years we have been trying to solve the problem of causality with respect to the L-H transition: does E_r come first, or is it the result of the confinement improvement? What can you say about causality in the case of the ITB?

H. SHIRAI: We cannot draw any clear conclusions about causality from the time resolution of measurement, for example with charge exchange recombination spectroscopy (~ several 10 ms).

Paper IAEA-CN-69/EX5/5 (presented by C.M. Greenfield)

DISCUSSION

B. COPPI: Have you made a survey of the time intervals during the current ramp within which you have to apply external heating, in order to create the ITB?

C.M. GREENFIELD: The important characteristic is not the time when the early auxiliary heating must be applied, but rather that the current profile should not have a chance to relax to an unfavourable state. A desirable current profile would have elevated q values (at the very least, above unity throughout the entire profile) and either weakly monotonic or reversed magnetic shear in the core of the plasma.

B. SCOTT: You have noted a feature at 12 cm^{-1} and concluded that it is unlikely to be drift wave turbulence on the basis that linear modes were found to be stable. Since drift wave turbulence is very unlike linear modes, a turbulence code should be used to judge this. Have you interacted with Ron Waltz and used one of his codes that include electron dynamics (and/or trapped electrons)?

C.M. GREENFIELD: Ron Waltz is one of the authors of the code used for these calculations (and is listed as a co-author of this paper). The code does include electron dynamics, but you correctly note that it is not a turbulence code. To my knowledge, Dr. Waltz has not written such a code.

Paper IAEA-CN-69/EX5/6 (presented by E.J. Synakowski)

DISCUSSION

K. IDA: The poloidal distribution of ExB should be quite different between DIII-D and TFTR, because the latter has circular plasma and the former has strongly elongated low-aspect plasma. Can you comment on how the poloidal distribution affects the improvement of transport? For instance, is flux-averaged ExB shear or local ExB shear more important? If local ExB shear is more important, what is the ideal ExB shear poloidal profile for transport improvement?

E.J. SYNAKOWSKI: ExB flow shear influences the turbulence locally. Experimental evidence for this can be found on DIII-D. There, far-infrared (FIR) measurements of density fluctuations reveal that, in some cases, turbulence persists on the high field side of plasma, where shearing rates are lowest, but are suppressed on the low field side, where they are highest. Regarding the ideal shearing rate poloidal profile, it is certainly a good thing to have it peak where the instability drive is largest, but it does not ensure that turbulence-induced fluxes will be reduced everywhere on a flux surface.

K. LACKNER: The question of causality in the ITB formation refers in particular to the mechanism leading to the v_θ variation. Is the relation between v_θ and T_i given by R.E. Bell also observed during the fast E_r spikes?

E.J. SYNAKOWSKI: No. The poloidal rotation excursion is not accompanied by a similar excursion in T_i.

C. GORMEZANO: Have you observed a precursor in poloidal rotation in DIII-D similar to that in TFTR, and if not can you explain why?

E.J. SYNAKOWSKI: No we haven’t. Since the evolution of the reduced transport region on DIII-D is a slow one, modulated by intermittent steps and interruptions, the most obvious place to look for a precursor is near such a step. No evidence of a strong poloidal rotation precursor at these times has been seen to date. Similar steps are sometimes seen in lower power TFTR reversed shear plasmas but they do not exhibit a precursor either. Such a confinement step may be initiated by some other event. That event may be connected with the evolution of the current profile.