EIGHTEENTH FUSION ENERGY CONFERENCE

SESSION EX4

Saturday, 7 October 2000, at 9:00 a.m.

Chair: H. KISHIMOTO (Japan)

SESSION EX4: Physics Integration, Operation (provided by M. KIKUCHI, Japan)

Paper IAEA-CN77/EX4/1 (presented by T. Fujita)

DISCUSSION

C. GORMEZANO: In your high performance quasi steady-state Q=0.5 discharge, have you identified the cause of the soft collapse at β_N=0.8?

T. FUJITA: The cause of collapses at β_N~0.8 and q_{min}~2 is attributed to resistive MHD instabilities. Details will be reported in the talk of Dr. Takeji on Monday (EX7/2).

R. GOLDSTON: Did you attempt to pass through q_{min}=2 at lower-yet beta-normal, such as 0.4?

T. FUJITA: We have not attempted to reduce β_N lower than 0.7, because the radius of q_{min} would decrease and no high performance would be expected. When we passed through q_{min}=3, we were able to sustain the large radius of q_{min} with low β_N owing to the current ramp-up. On the other hand, we stopped the current ramp-up when q_{min} became ~2, so we could not sustain the large radius of q_{min} with low β_N.

E. MARMAR: For the discharge with quasi-steady-state reverse shear for 2.7 seconds, the q value near $\rho \approx 0.4$ does appear to be decreasing with time. What is the resistive skin time for this discharge?

T. FUJITA: The current diffusion time for the whole plasma volume, τ_R, is estimated to be several tens seconds. I agree that we have to extend the duration further to see the evolution in the core region (ρ=0.4) though τ_R is not necessarily a proper time-scale for it.

Paper IAEA-CN77/EX4/2 (presented by A.C.C. Sips)

DISCUSSION

Y. KAMADA: Does the effect of type I ELMs on confinement inside ITB depend on the safety factor at the edge? For this ELM effect, does low-n instabilities play some roles?

A.C.C. SIPS: The JET ITB discharges are at q_{95}=3.3. At lower plasma current (higher q_{95}) the ITB's are still reduced or destroyed by type I ELM's. The effect of the type I ELM's is to reduce the edge pressure. This steepens the pressure gradient at the ITB. Then MHD errodes the ITB, driven by the steeper pressure gradient. Large type I ELM's reduce the temperature also inside the ITB.

R.J. TAYLOR: What limits you in keep rotation profiles and current profiles to desired level as the density is increased? Is there a pulse length limitation?

A.C.C. SIPS: As the density is increased the rotation profile can not be maintained since the type I ELM activity increases at higher edge density. These ELM's erode the ITB. Higher input power would be required to maintain the rotation profile but is not available at JET! The current profile continues to evolve. LHCD could not be coupled to these plasmas to sustain q(r). The pulse length is limited by the JET power supplies.

R. GOLDSTON: Can you get through q_{min}=2 at low heating power?

A.C.C. SIPS: Yes. The best ITB's are made when the heating power is increased after q_{min}=2 is crossed. In JET, the heating is deliberately delayed to obtain better MHD stability.

Paper IAEA-CN77/EX4/3 (presented by T.C. Luce)

DISCUSSION

D. MOREAU: In the absence of the required ECCD, have you tried to tailor the NBI waveform (perhaps at reduced performance) in order to stabilize the slow evolution of the current density profile for the whole duration of the pulse by controlling the evolution of the bootstrap and NB current?

T.C. LUCE: In DIII-D the neutral beams drive current on-axis, even at reduced voltage. For discharges with q_{min}~2 at the beginning of the high performance phase such as # 98549 an additional beam was added which sustained the high performance at β_N H_{89}~9 for 2.1 s (# 98977 in Fig.1). For discharges with q_{min}~1, such as # 104276, the high β phase is started before sawteeth begin and the current profile comes to equilibrium with $q_{min}=1$ without sawteeth or fishbones. As shown, the analysis of the high q_{min} discharges require non-inductive current near the half radius for sustaining the stable current profile.

C. GORMEZANO: In the advanced scenarios that you have presented, confinement is improved although internal transport barriers are not present. Can you comment on the cause of improved confinement?

T.C. LUCE: I cannot give the cause, but as shown the drift-wave model GLF23 gives a picture consistent with the data. The simulation indicates reduced but not suppressed turbulence in the range ρ=0.2-0.8, these is expected to be valid. The reduction is due to $E \times B$ shear in the model. Reduction rather than suppression is consistent with the transport analysis showing the ion diffusivity is large than neoclassical.

Paper IAEA-CN77/EX4/4 (presented by R.C. Wolf)

DISCUSSION

T.C. LUCE: How is the claim of full non-inductive current drive consistent with the plasma current dropping in the high β_p case shown?

R.C. WOLF: We kept the Ohmic transformer current constant, but β_N is somewhat decreasing, and therefore the induction by B(vertical) and the MHD activity, i.e. fishbones, might change the electric field around the magnetic axis, so that the plasma current is decaying by some percent within one second. This is not in contradiction to the fully non-inductive current drive achieved.

T. FUJITA: 1) How long was the high performance (β_N=2.6, H_{89}=3) sustained in the improved H-mode? 2) Why is the high confinement (H_{89}=3) obtained in the improved H-mode with monotonic magnetic shear?

R.C. WOLF: 1) This phase lasts for about 5 confinement times limited by the available pulse length and the duration to establish higher triangular plasma shape in AUG. For β_N =2.2 and H_{89}=2.5 we have 40 τ_E and 2.5τ_{Res}. 2) We have zero magnetic shear with $q\sim1$ for $0\leq r/a<0.4$ due to fishbones. This magnetic shear obviously provides the peaked density profiles responsible for the confinement improvement. E × B shear seems not to be important here in contrast to the ion ITB discharges.

M. KIKUCHI: You mentioned that the ion thermal diffusivity is less than the neoclassical value of Shaing. Does this calculation include both impurity effect and potato particle effect which are important in the central regime of the plasma?

R.C. WOLF: We have done for the ITB cases a Monte Carlo calculation including potato orbits and Z_{eff} in the collision frequency (see A. Peeters, poster on Tuesday). These simulations agree well with experiment. Theory values by Lin and Shaing are either too low or too high, respectively, in the core region.

Paper IAEA-CN77/EX4/5 (presented by N. Noda)

DISCUSSION

G. HOANG: Did you study the energy confinement and compared it with the one in tokamak devices?

N. NODA: Yes, we did. We have not yet operated in a wide area with long pulses. But within the work we have done, the confinement is equivalent with the short pulses, and well described by existing scaling laws. You should refer another paper or publications on the energy confinement study with short pulses in LHD.

Ph. GHENDRIH: The long pulse exhibits a steady increase of saturated level on the tangential view. How can one understand this feature in the frame of steady-state operation?

N. NODA: With the tangential view, you can see radiation from the peripheral and gas-puffing section. These indicate almost steady-state constant operation with continuous gas-puffing, which was manually controlled by hand. Up to now, we don’t see the complete saturation relating to the density control.

Paper IAEA-CN77/EX4/6 (presented by Y.Yagi)

DISCUSSION

D. ESCANDE: Is there a difference in the magnetic spectra between the LM and non LM cases?

Y. YAGI: Yes, there is. The LM discharge has a relatively broad spectrum, while the non LM discharge has a dominant peak at m=1/n=6 with smaller amplitudes at n=7, which is somewhat similar to the Quasi Single Helicity State.