EIGHTEENTH FUSION ENERGY CONFERENCE

SESSION EX3

Friday, 6 October 2000, at 4:10 p.m.

Chair: G. NEILSON (USA)

SESSION EX3: Stability 1 (provided by J. MENARD, USA)

Paper IAEA-CN77/EX3/1 (presented by H. Zohm)

DISCUSSION

F.W. PERKINS: If you scale your results to ITER, what is the relative magnitude of the individual stabilizing and destabilizing terms?

H. ZOHM: The polarization current term scales with ρ^*, but the CD-term does not, so that a possible stabilizing contribution of the polarization current will occur at smaller island width than in present experiments. However, first calculations indicate that in ITER, a 20-30 MW system will be sufficient for NTM stabilization, even if the polarization current is completely neglected.

J.W. CONNOR: Since the bootstrap current is mainly driven by a density rather than a temperature gradient, would it not be correct to use ion sound speed for the convective transport limit rather than electron sound speed as is the case for temperature equilibration?

H. ZOHM: This is in principle correct. However, in ASDEX Upgrade H-modes, the density profiles are usually so flat in the confinement region that it is nevertheless ultimately the temperature gradient that drives the NTM.

Paper IAEA-CN77/EX3/2 (presented by B. Lloyd)

DISCUSSION

S. BERNABEI: (1) Did you use an $n_{||}$ spectrum which was in a first pass damping regime? (2)There is a difference with ECCD stabilization here compared to ASDEX - in this experiment is it the current profile that is modified and results in increased β (not just recovery of the β loss)?

B. LLOYD: (1) The $n_{||}$ spectrum was centered at $n_{||} = 2.1$ and damping is multi-pass.
(2) NTM stabilization in COMPASS-D is indeed attributed to modification of the current profile by LHCD in the vicinity of the q=2 surface. The resultant reduction in Δ' is sufficient to account for the observed NTM stabilization which in turn leads to a significant increase in β.

Y.-K.M. PENG: In the LHCD experiment to stabilize the NTM on COMPASS-D, how much increase in β is obtained as a result of NTM stabilization?

B. LLOYD: A β increase of 15% has been obtained as a result of NTM stabilization.

Paper IAEA-CN77/EX3/3 (presented by C. Cirant)

DISCUSSION

M. KIKUCHI: In your m/n=2/1 mode tearing stabilization experiment, a key element seems to be a heating effect. JFT-2M reported m/n=2/1 tearing mode stabilization at the Seville conference (1994) quite similar to your results. Are there any differences compared with previous work, and what is the experimental evidence of m/n=1/1 coupling to the m/n=2/1 mode?

C. CIRANT: Coupled mode dynamics and beam steering are specific features of tearing mode stabilization by electron cyclotron (EC) waves on the FTU tokamak. Mode coupling is shown by strict frequency coincidence and phase relationship. The modes can de-couple if one of them locks to the walls. Experimental features of mode dynamics (frequency and amplitude evolution, wall locking, unlocking, and mode de-coupling) are described by a model including mode coupling.

Paper IAEA-CN77/EX3/4 (R) (presented by G.A. Navratil)

DISCUSSION

I.H. HUTCHINSON: If I understand you correctly, you believe that the slowing of the plasma when β exceeds the no-wall limit is due to the presence of a static mode even when you don’t seem to be detecting it; so the slowing is a kind of surrogate to indicate a wall mode. Is it possible to increase the sensitivity of the direct mode detection so as to verify this mode's presence at lower levels?

G.A. NAVRATIL: Yes, we do believe the slow deceleration of plasma rotation seen when β is larger than the no-wall β-limit is due to a small amplitude resistive wall mode in the plasma. Our present detection limit is about 1 Gauss at the wall for this very low frequency mode, so we would need to improve the sensitivity to about 0.1 to 0.2 Gauss for direct observation at the very early stage of mode growth.

Paper IAEA-CN77/EX3/5 (presented by P. Martin)

DISCUSSION

R. GOLDSTON: (1) Have you tried oscillating the toroidal loop voltage along with the toroidal field in order to inject helicity and sustain the discharge? (2) In the experiments you reported, also, what happened to the time-averaged loop voltage and total Poynting flux?

P. MARTIN: (1) We have plans to perform the helicity injection experiments that you mention, but we have not realized them yet. (2) The applied loop voltage and the ohmic input power decrease during the current drive phase.

J.H. HARRIS: What are the prospects for increasing the size (relative to the plasma minor radius) of the helical structure of good confinement?

P. MARTIN: For a given device the helical structure which has the larger volume is that generated by the innermost resonating m=1 mode (which is n=7 for RFX). Therefore in RFX we try to obtain quasi-single helicity (QSH) states with dominant mode (m=1, n=7) in order to have the best impact on confinement. In general terms, we are working at the idea that in a lower aspect ratio device the access to QSH states should be facilitated. Moreover, in those conditions (low R/a), on the basis of the information we have, we think that the helical structure might occupy a larger fraction of the plasma volume.

Y. HIRANO: What are the values and the time variations of the density, poloidal beta, and energy confinement time during the OPCD phase?

P. MARTIN: For a 1 MA shot, before the OPCD action we had a target plasma with density $\approx 6\times 10^{19}$ m^{-3}, poloidal beta $\approx$ 4%, and energy confinement time $\approx$ 1.3 ms. In the experiments performed up to now these values have not been fully optimized. During the current drive phase, beta and energy confinement time increase by about 50%.

Y.-K.M. PENG: Have you measured the differences in the rates of conversion between poloidal and toroidal fluxes (dynamo) between the multiple-helicity (MH) and single-helicity (SH) RFP plasmas?

P. MARTIN: Three-dimensional numerical MHD simulations indicate that a pure RFP SH state (one single m=1 mode) can be maintained in time, i.e. that a SH dynamo can be as efficient as the MH dynamo in generating toroidal magnetic field. Experimentally we are working on the subject you ask about, i.e. we are trying to estimate whether there are differences between the dynamo efficiencies in the MH and QSH plasmas. At this moment we can say that we realize experimentally stationary QSH RFP plasmas, where one m=1 mode is dominating the spectrum for the whole plasma duration.

T.R. JARBOE: During relaxation in a spheromak, a single mode is almost always observed to dominate because of the lower aspect ratio. Does this say anything about the potential confinement of the spheromak relative to the RFP?

P. MARTIN: Certainly there are analogies that could be explored between the spheromak and the low aspect ratio RFP. Nonetheless, in drawing conclusions on the potential confinement of the spheromak, we should be aware of the different plasma formation techniques in the two devices. I am thinking for example of the plasma-gun technique for the spheromak and of the problems which could result in terms of impurity and plasma-wall interaction.

P.H. DIAMOND: To "lock-in" the kink/tearing dynamo, reconnection at the reversal surface is needed. In the case of the turbulent dynamo, this is easily supplied by non-linear interaction of m=1 modes which drive an m=0 mode at the reversal surface (i.e. $[m=1, n=n_0] \oplus [m=1, n=n_0+1] \Rightarrow [m=0, n=1]$). What "locks-in" reversal in the case of the QSH state?

P. MARTIN: MHD numerical simulations reveal that reversal in the SH states is the necessary consequence of the growth of a single resistive kink mode (see for example D.F. Escande to be published in PPCF 2000). Such a phenomena does not require any reconnection at the reversal surface.

Paper IAEA-CN77/EX3/6 (presented by S.A. Sabbagh)

DISCUSSION

B. COPPI: The excitation of large amplitude m=1, n=1 modes is of great interest for fusion burning plasmas. Could you tell us if you have identified the driving mechanisms of the “virulent” mode you have described? Is it related to the plasma pressure gradient within the q=1 surface?

S.A. SABBAGH: It may be, however, further study is required, as this result is quite recent. We do observe this mode at a large range of β_t (10-18%, and perhaps below) and the only prerequisite we can identify at present is that $q(0) < 1$. To satisfactorily answer this question, we also need a measure of the total plasma pressure within the q=1 surface. We will have diagnostics to determine ion pressure in the next few months, which will aid this study.