SESSION OV2

Monday, 19 October 1998, at 2 p.m.

Chairman: R.J. Goldston (United States of America)

OVERVIEWS 2

Paper IAEA-CN-69/OV2/1 (presented by E.S. Marmar)

DISCUSSION

C. GORMEZANO: Do you associate the rotation that you have observed with ICRH with improved confinement or is it good confinement which induces toroidal rotation?

E.S. MARMAR: We believe the rotation is a result of ICRF interactions with fast passing particles, rather than being due to improved confinement per se.

K. IDA: How does the toroidal rotation relate to the poloidal field or plasma current? What do you think is the mechanism that drives the toroidal rotation observed without momentum input from neutral beams?

E.S. MARMAR: For fixed plasma current, the induced toroidal rotation increases with increasing stored energy, while for fixed stored energy, the rotation velocity scales inversely with plasma current.

One mechanism, which appears to be consistent with the experimental observations, is described in paper IAEA-CN-69/THP2/34 by C.S. Chang et al. As described in that model, the ICRF resonance is shifted by the finite $k_{||}$ according to:

$$\omega = \omega_{ci} - k_{||}\, v_{||}$$

Horizontal orbital shifts, which can be comparable to the resonance shift, break the symmetry (even if $k_{||}$ is symmetric), and ICRF heating of passing particles results in a net inward shift of ions, in turn leading to a positive radial electric field and toroidal rotation in the co-current direction. The model correctly predicts the directionality and magnitude of the rotation, as well as the observed dependence on plasma current.

Y.K.M. PENG: Please comment on the scaling width of the pedestal in Alcator C-Mod relative to those observed in other larger tokamaks of lower magnetic field.

E.S. MARMAR: The measured H-mode pedestals on C-Mod are clearly narrower than those observed on larger, lower field tokamaks, including DIII-D, ASDEX-Upgrade, JET and JT-60U. The physical reasons for these differences are not yet clear. We do know that the pedestal widths on C-Mod are strongly influenced by plasma current (width decreases with increasing current) and are not sensitive to the toroidal field strength. This could point to a β-poloidal influence, but it is premature to draw firm conclusions. The width is also affected by the nature of the H-Mode (ELM-free versus Enhanced D-Alpha, for example). We do calculate that the C-Mod pedestal pressure gradients are often close to, or even exceed somewhat, the first stability limit for ballooning modes.

Paper IAEA-CN-69/OV2/2 (presented by A.J. Bécoulet)

DISCUSSION

R. KAITA: In your scenario with LHCD and high bootstrap current, where do you expect the LH current to be driven? Do you still need LHCD if you have a large bootstrap current?

A.J. BÉCOULET: At high magnetic field, and for the densities considered, a significant fraction of the LH driven current is still expected to be deposited on axis. The present simulations, however, are 0-D considerations including only the self-consistent computation of non-inductive current drive and confinement. They do not include profile effects such as ITB formations which could have a strong influence on the balance between bootstrap current and LHCD.

R.J. HAWRYLUK: In the LHCD sustained discharge, what was β_N when the onset of tearing modes occurred? Is the onset well described by theory?

A.J. BÉCOULET: β_N was approximately 0.4. Theory predicts perfectly the onset of such a mode, as described in the paper and the corresponding reference.

Paper IAEA-CN-69/OV2/3 (presented by S. Itoh)

DISCUSSION

M. PORKOLAB: In the HIT mode, how can you be sure that it is not representative of a hot ion tail as observed in past LHCD experiments, as opposed to a bulk ion temperature? After all, LHCD mostly heats electrons, and ions are presumably heated by parametric decay waves.

S. ITOH: The density regime of the HIT discharge in TRIAM-1M is quite different from that of past ion heating experiments using LHCD. In this density regime, linear mode conversion of LHW and ion heating by parametric decay waves do not take place because of the low density. The ion energy spectra measured with NEA in both perpendicular and parallel directions to the magnetic field is isotropic in the energy range 1-10 keV. Moreover, the energetic ions can survive after the termination of LHW. This indicates that the energetic ions are well confined for the time required to become isotropic.

C. GORMEZANO: When you observe a transport barrier on ions, do you also observe a transport barrier on electron temperature and electron density?

S. ITOH: The line-averaged electron density does not change before or after the transition. The electron temperature profile has not yet been checked.

Paper IAEA-CN-69/OV2/4 (presented by F. Wagner)

DISCUSSION

D.D. RYUTOV: In your oral presentation you showed the following expression for particle flux:

$$\Gamma \sim (D_1 \frac{\nabla n}{n} + D_2 \frac{\nabla T}{T} + u)$$

What is the meaning of the last term? In particular, will this term remain non-zero in plasma with $\nabla n = 0$, $\nabla T = 0$? If not, it could be included in the first two terms, leading just to redefinition of D_1 and D_2. I could imagine only one term in the local transport model, namely proportional to $\nabla\phi$. If all three gradients are zero, the flux in a local model must be zero.

F. WAGNER: The case $\nabla n = \nabla T = 0$ cannot be achieved in the experiment. I tried to show that $\nabla n \neq 0$ in the case of $\nabla T \sim 0$ (off-axis heating) and $\nabla n \leq 0$ in the case of $\nabla T >> 0$ (central heating). D_1 and D_2 are the neoclassical values of a stellarator. The question is whether there remains a turbulent flux nu directed to the core (as in tokamaks). What might drive it is not resolved.

G.H. NEILSON: Is the geometry of the W7-AS (and W7-X) island divertor structure highly sensitive to changes in equilibrium parameters (e.g. beta) and how does that affect the ability to remove heat and particles?

F. WAGNER: On W7-AS we have specifically selected an open island divertor geometry as a first step to detailed study of the characteristics of the strike points when we go from low to high density and beta. The islands remain intact and the strike point well-defined when β is raised to ~ 2%. There is a shift in the expected direction (there is no equilibrium code for quantitative analysis) which will not affect the full island divertor operation. As a result of the optimization, β will not affect the island divertor operation of W7-X. A bootstrap current beyond the expected limit would affect the X-point location.

Paper IAEA-CN-69/OV2/5 (presented by A. Sykes)

DISCUSSION

B. COPPI: What, in your opinion, is the least desirable feature of the ST concept?

A. SYKES: Results from the prototype experiments such as START are most promising and show no undesirable features. A major uncertainty is the behaviour in collisionless regimes - we await information from the next generation of larger devices, now nearing operation.

M. PORKOLAB: What was the bootstrap current fraction at the record 40% β you have achieved on START?

A. SYKES: Bootstrap current values of the high β discharges on START are low ($\leq$15%) due to the relatively high collisionality of START plasmas at the high densities (> $5 \times 10^{19} m^{-3}$) and low temperatures (~ 250 eV) of these plasmas.

M. PORKOLAB: How will you deal with stability in MAST at the higher β and β_N values without a nearby conducting wall stabilization?

A. SYKES: Theoretically, discharges of similar β and β_N should be achievable on MAST without the need for conducting wall stabilization. Unlike START, these discharges will be of low collisionality (and so have higher bootstrap current fraction) and will therefore provide a test of the properties of neoclassical tearing modes in the ST.

H. TOYAMA: The high β experiments on START are outstanding. With regard to the confinement properties, what determines the electron heat diffusivity of START plasma? In ST, higher plasma current is available with lower toroidal field; are magnetic fluctuations related to confinement properties?

A. SYKES: The global energy confinement on START appears to be quite well represented by the latest ITER scalings. Local diffusivity is still under investigation; it is believed that the ions behave neoclassically in the plasma centre [D. Gates et al., Phys. Plasmas 5 (1998) 1775], and optical images of START plasmas in “improved confinement” mode show a very sharp edge, indicative of a low turbulence level.

R.D. STAMBAUGH: Since the divertor coils were installed on START you have seen current driven disruptions at low q_{95} but not pressure driven disruptions even though β_N reaches almost 6. Could you clarify the situation in regard to pressure driven disruptions?

A. SYKES: Yes, disruptions have occurred at low q_{95} operation since the divertor coils were installed. As the high β discharges also had low q_{95}, it is not easy to distinguish the role (if any) of pressure driven instabilities. Future devices with higher heating power should be able to attain high β at higher q_{95} and we should therefore be able to investigate pressure limits.