NINETEENTH FUSION ENERGY CONFERENCE

SESSION EX/S1

Tuesday, 15 October 2002, at 14:00

Chair: M. PENG (USA)

SESSION EX/S1: Stability and High Beta

Paper IAEA-CN94/EX/S1-1 (presented by N. Oyama)

Discussion

K. Lackner: The model of A. Loarte suggests that the nature of the ELM-associated heat flow should vary with collisionality. Did you make scans of the collisionality, and if yes, what was the conclusion?

N. Oyama: Yes, we performed collisionality scans from 0.01 to 0.1, where the parallel collisionality is defined by $\pi R q_{95}/\lambda_{ee}$, the same definition as given in the paper by Loarte et al. in the FEC2000 proceedings. The result in JT-60U showed only weak collisionality dependence in the above range.

R. Maingi: What is the $\Delta w/w$ measured for the ELMs you studied, and did you study the dependence of the observation on $\Delta w/w$?

N. Oyama: In JT-60U, the $\Delta w/w_{ped}$ was usually smaller than 10% in a wide range of operational regimes. Compared with several proposed models such as collisionality, $\tau_{\parallel}$ and n_{ped}/n_{GW}, we only observed a weak dependence of $\Delta w/w_{ped}$ in the three models presented.

Paper IAEA-CN94/EX/S1-2 (presented by T.C. Hender)

Discussion

Y. Kamada: You showed that the onset β depends on τ_{sw}. We suppose that the q-profile just before the sawtooth crash is changing with τ_{sw}. Have you observed that the onset β depends on the inversion radius or relative location of the inversion radius to the q = 1.5 surface?

T.C. Hender: The sawtooth inversion radius does not vary significantly with the sawtooth period (as it is changed by ICRF), though simulations indicate the magnetic shear does vary.

Ya.I. Kolesnichenko: My question is about the stabilization of the sawteeth by energetic ions. Do you have any experimental evidence of the stabilization of the sawtooth instability by circulating particles?

T.C. Hender: Both ICRF heating and current drive contribute to the observed effects on sawteeth (as discussed in some references in the paper). For the second harmonic ICRF discussed in this presentation, it is found on the low field side that the current drive effect on sawteeth is dominantly from trapped particles. For the high field side a difference in the effect on sawteeth is observed experimentally between co and counter ICCD; the origin of this difference is under investigation.

Paper IAEA-CN94/EX/S1-3 (presented by R.J. La Haye)

Discussion

H. Bindslev: Are you planning to track the NTM resonant surface by means of poloidal steering of the ECCD launching antennas?

R.J. La Haye: Yes. It is expected to have real-time poloidal steering of the mirrors for one pair of gyrotrons by the end of the 2003 campaign and for all four pairs eventually. Such mirror steering will be necessary for simultaneous alignment (of different sets of gyrotrons) on both the ζ=3/2 and ζ=2/1 surfaces for the eventual ECCD stabilization of both neoclassical tearing modes.

R.J. Goldston: Have you done careful studies to determine whether the ECCD system is changing delta-prime, as opposed to providing net helical current?

R.J. La Haye: In the presence of both a tearing mode and a periodic sawtooth it is not possible to make precise measurements of the local current profile (or changes) with the motional Stark effect diagnostic in the usual way doable in "quiet" discharges. The assumption of no change in Δ' is made because of the very long ($\approx$ 5 seconds) resistive diffusion time for the current. The prompt onset of the decreasing of the Mirnov amplitude upon stepping on the RF power is consistent quantitatively with constant Δ' and the replacing of the "missing" bootstrap current, which has a much shorter resistive time.

Paper IAEA-CN94/EX/S1-4 (presented by S. Günter)

Discussion

R.J. Buttery: Do you have a model of how the 4,3 mode regulates the 3,2 size?

S. Günter: The sudden amplitude drops characteristic for the FIR-NTM regime are caused by non-linear coupling of the (4,3), (3,2) and (1,1) modes. This non-linear coupling leads to stochastization of the magnetic field lines between r(q=4/3) and r(q=3/2). This has been proven by highly resolved temperature measurements showing complete flattening of the temperature profile in this region. This stochastization also destroys the (3,2) island structure. As the destroyed magnetic field line structure only lasts for a very short time (less than 500 μs), the resulting time averaged confinement degradation is very benign. On the other hand the NTM can only grow on a very long time scale (~ 50 ms on AUG) such that the time averaged mode amplitude is much smaller compared to a "smooth" NTM. A theoretical modeling of this process would require a non-linear MHD code in toroidal geometry which allows for a realistic ratio of $\chi_\perp/\chi_\parallel$ as well as to include the Hall term to ensure correct time scales for the forced reconnection. Unfortunately such a code does not exist so far.

Paper IAEA-CN94/EX/S1-5 (presented by J.E. Menard)

Discussion

C.C. Petty: In conventional aspect ratio tokamaks, the theoretical calculation of the ideal no-wall beta limit has been checked experimentally by the observation of MHD phenomena when the beta reached this limit, i.e., resonant field amplification, resistive wall modes, etc. On NSTX, when the beta value exceeded the theoretical no-wall limit, are any of these MHD phenomena observed so that you are confident that this limit has really been exceeded?

J.E. Menard: For the discharges presented, we do not see the usual signatures of crossing the no-wall limit. However, near the with-wall limit we do observe rapidly growing 15–30 kHz n=1 modes which cause largely internal disruptions. At lower toroidal field, we more often observe rotation damping above the no-wall limit due either to growing RWMs or tearing modes.

A.M. Garofalo: Does the calculated, volume-averaged β_N no-wall limit scale as $4 \times l_i$ in an optimized case on NSTX?

J.E. Menard: At low aspect ratio, the volume-averaged normalized beta divided by internal inductance can vary from 3 to 8 for computationally optimized no-wall stability limits depending on aspect ratio and shape. For NSTX shapes, typical values are 5 to 6.

K. Lackner: At the high values of M_A, rotation should also make a significant contribution to the energy content. How large is it, and do you include rotation into your stability analyses?

J.E. Menard: The rotational kinetic energy is typically less than 10% of the total in NSTX plasmas because the rotational kinetic energy density profile is quite centrally peaked. The rotational kinetic pressure is included in the scalar pressure used in ideal non-rotating plasma stability calculations, and we are concerned that the non-self-consistent treatment of flow in the equilibrium and stability analysis could be a source of error in computing marginal stability.

Paper IAEA-CN94/EX/S1-6 (presented by R.J. Buttery)

Discussion

S.A. Sabbagh: You say that your error field induced locked modes are "classic". Do you have rotation profiles measured to determine the evolution?

R.J. Buttery: Not for the discharges shown. They have "classic" behaviour in the sense of the density dependence, and the n=1 locked mode that spontaneously forms. There are indications also that momentum injection has a beneficial effect.

S.A. Sabbagh: Finite edge current density in the equilibrium can generate peeling modes. Do you include finite edge current in your peeling mode calculations?

R.J. Buttery: Yes. This is done via setting of the total current J(r) to equal the bootstrap current (obtained from 300 point Thomson profiles) in the plasma reconstruction near the edge, giving finite edge currents.

J.D. Callen: You emphasized controlling sawteeth causing seed islands to prevent NTMs and access higher β regimes. Does this mean you don't usually have NTMs growing "out of the noise"?

R.J. Buttery: No, the NTMs do not usually grow out of the noise — most cases are sawtooth seeded. However, there are of course some cases where tearing modes do grow out of the noise. I would expect these to have a classical tearing origin (though this does not preclude some bootstrap drive as well once the mode has grown). Generally, however, avoiding sawteeth avoids strong tearing mode activity so far on MAST.