# NINETEENTH FUSION ENERGY CONFERENCE

## SESSION EX/D2 & TH/4

Friday, 18 October 2002, at 8:30

Chair: A. FUKUYAMA (Japan)

## SESSION EX/D2 & TH/4: Edge Turbulence and Energetic Particles

### Paper IAEA-CN94/TH/4-1 (presented by S.I. Krasheninnikov)

### Discussion

**K. Lackner:** What is the relation of your theoretical model to the parametric dependence of the Greenwald density?

**S.I. Krasheninnikov:** We think that our model describes a “fast” blobby particle transport to the wall at high density. However, we do not know yet how blobs are peeled off the bulk plasma. The mechanism of peeling off the blobs sets the amplitude of the blobby transport and, I think, determines the density limit.

**R.H. Cohen:** Your blob velocity estimate depends on contact with the divertor plates. But in the near (to the separatrix) and intermediate SOL (in fact the whole domain of BOUT simulations!), X point shear will shear apart the blobs and destroy contact with the divertor plates. Can you comment?

**S.I. Krasheninnikov:** We consider blob motion in the far SOL where the X point shear effects are not important.

**Paper IAEA-CN94/TH/4-2 (presented by P. Beyer)**

## Discussion

**K. Lackner:** As you are using prescribed magnetic fluctuations, you lose the effects of the correlation between, for example, potential fluctuations and magnetic ones, and also the possible effect of the shielding of imposed magnetic fluctuations by plasma flows. How do you assess these limitations on your results?

**P. Beyer:** One can estimate the self-consistent magnetic perturbation with the same helicity as the external one. It is found to be proportional to β and at least an order of magnitude smaller than the imposed perturbation (see P. Beyer, X. Garbet et al., Plasma Phys. Control. Fusion **44**, 2167 (2002)). This has also been reported from experiments on TEXT. Similar calculations indicate that in the limit of small β, turbulence is essentially electrostatic.

**S.C. Prager:** What is the physical mechanism for the anomalous friction that arises from magnetic stochasticity?

**P. Beyer:** The anomalous friction arises from the magnetic flutter at the parallel divergence of the parallel current (in the vorticity equation). The current is coupled to electrostatic potential via Ohm’s law.

**Paper IAEA-CN94/TH/4-3 (presented by B.N. Breizman)**

## Discussion

**B. Coppi:** Another important effect besides the one you considered, $q' = 0$, is that of the pressure gradient and the magnetic field curvature. That is, the transition from the shear Alfvén mode to the ideal MHD ballooning mode. This is a regime that needs to be analyzed in order to assess the severity of the instabilities that can be excited in the projected regimes of operation of the ITER concept. In these high temperature regimes ($T_{e0} \approx$ 25–31 keV), the α-particle slowing down time begins to approach the thermal energy confinement time. In addition, 33 MW of 1 MeV ions are proposed to be injected. Therefore the combined effects of these high energy particle populations on the ballooning shear Alfvén mode should be important.

**B.N. Breizman:** I agree with your comment that pressure-driven modes deserve special attention and that this would be an ITER-relevant topic. However, for the Alfvén cascade modes in JET, the role of the plasma pressure gradient appears to be less important than the energetic particle contribution. This is why I have not discussed the plasma pressure effects in this talk.

**F.W. Perkins:** How does core plasma pressure affect the frequency line width of TAEs? To what extent can observations of TAE frequencies be used as a diagnostic for proximity to ideal MHD instability?

**B.N. Breizman:** The core plasma pressure is actually included in our basic equations. As I mentioned in my reply to Dr. Coppi, the pressure effects are of secondary importance for the specific conditions of Alfvén cascade observations on JET. More generally, it may well be feasible to use Alfvén wave spectroscopy to obtain information about plasma pressure. I would give higher priority to frequency measurements since the line width can be sensitive to the subtleties of nonlinear saturation mechanisms.

**Paper IAEA-CN94/TH/4-4 (presented by F. Zonca)**

## Discussion

**D.D. Ryutov:** The zero-shear surface is very sensitive to magnetic perturbations (the pre-existing ones), which may change the magnetic topology. At what level of these perturbations will they begin to affect the processes that you have discussed?

**F. Zonca:** We did not consider the problem you are referring to, although it can be addressed within our approach.

**K. Lackner:** For assessing the consequences, the relation of the propagation rate of the relay front to the slowing down time of the fast particles is important. What is it?

**F. Zonca:** The propagation of the relay front is very fast and of the order of 100 Alfvén times. For assessing the consequences, it is more important to control the radial position and the value of q-min and the value of $q''$ at the minimum-q surface. Our results show that for sufficiently hollow q profiles, global particle losses are small and fast ion transport is mainly associated with radial redistributions. Another obvious parameter is the on-axis value of the fast ion normalized pressure and the peakedness of the equilibrium pressure profile.

**Paper IAEA-CN94/TH/4-5 (presented by D.C. Barnes)**

## Discussion

**B. Coppi:** As you pointed out, the Hall effect, as also expected from past experience on other problems, does not have a strong effect on the mode growth rate. However, it should have a strong influence if there are physical factors to be taken into account which break the frozen-in condition for the electrons.

**D.C. Barnes:** Yes, in this regard, most important terms are from electron pressure, both scalar, as so far included, and tensor, from, for example, the rapid electron precession mentioned in this talk.

**Paper IAEA-CN94/TH/4-6 (presented by F. Porcelli)**

## Discussion

**K. Lackner:** The question of $\omega_*$ effects in nonlinear islands is of course related to the issue of polarization current effects in NTMs. What would be the effect of the coupling to ion sound waves on NTM mode growth?

**F. Porcelli:** The NTMs may be completely suppressed by the coupling between drift-tearing modes and ion sound waves. The point is that $\omega_*$ effects can be felt by magnetic islands with relatively large widths (comparable to or larger than the ion Larmor radius) because of incomplete density flattening within the island region and because of the presence of a nonlinear zonal flow comparable with the equilibrium drift wave velocity.

**R.J. Buttery:** We have seen experimentally how ICRH generated fast alphas stabilize sawteeth. But these distributions are anisotropic. How robustly do you think these results translate to DT produced fast alphas?

**F. Porcelli:** It was shown a few years ago (see, for example, F. Porcelli, Plasma Phys. Control. Fusion **33** (1991) 1601–1621) that isotropic fast particle distributions can efficiently suppress sawteeth. The difference between isotropic alpha distributions and anisotropic ICRH ion distributions has been worked out quantitatively and is taken into account in models for the prediction of the sawtooth period and amplitude. In ITER-like DT plasmas, the effect of fusion alphas on sawteeth is quite robust (see, for example, F. Porcelli, D. Boucher and M.N. Rosenbluth, Model for the sawtooth period and amplitude, Plasma Phys. Control. Fusion **38** (1996) 2163–2186).

**R.J. Goldston:** It is my impression that when people do NTM analyses they frequently are not so careful about evaluating $\Delta'$, and they do not include your $\omega_*$ effects. They also seem to find, but not publish, that they need to increase the resistivity by a factor of 2–3 to fit the time evolution they see. Can you comment on this?

**F. Porcelli:** I share your impression. $\omega_*$ effects are often neglected on the grounds that these go away nonlinearly, but our analysis shows that this is not always the case. The prevailing view on tearing stability in tokamaks is that tearing modes are not usually observed, therefore $\Delta'$ must be negative, and that in order to destabilize tearing modes you need seed islands and neoclassical effects. But it may also be that $\Delta'$ is actually positive for perturbations with low poloidal mode numbers, but $\omega_*$ effects and the coupling with sound waves often prevent these modes from growing. This may lead to a different way of looking at tearing stability in tokamaks.