EIGHTEENTH FUSION ENERGY CONFERENCE

SESSION TH2

Friday, 6 October 2000, at 9:00 a.m.

Chair: A. SEN (India)

SESSION TH2: Turbulence, Flows, Streamers (provided by Y. TODO, Japan)

Paper IAEA-CN77/TH2/1 (presented by P.H. Diamond)

DISCUSSION

R.J. TAYLOR: What are the 3rd aspects of streamer. Can we now calculate the electron contributions along the field line?

P.H. DIAMOND: Streamers are intrinsically 3D. Indeed, they must be, since they are driven by $|\phi(\theta)|^2$, the primary intensity distribution along the field line. This is clearly seen in the simulations at Beyer et al., as well as predicted by the theory. Electron "along field line" response will enter the modulation of the thermal flux, one possible source of streamer drive.

F. PERKINS: Will the physics picture of streamers suggest that the confinement scaling observed in present machines will change as we go to a next-step device? How will streamers change as ρ^* is reduced by a factor of 4?

P.H. DIAMOND: The most direct answer to your question is that the appearance of streamers and avalanches in the picture necessitates an approach to transport prediction based upon pdf's. To assess scalings, we must address the scalings of the variance, etc. as well as that of the centroid. Streamer formation should be insensitive to ρ^*, but streamer drive may vary with it.

Paper IAEA-CN77/TH2/2 (presented by S. Benkadda)

DISCUSSION

A. ROGISTER: In the vicinity of internal transport barriers, the radial variation of the ExB velocity is expected to be large and has been taken into account in your model. The variation of the diamagnetic velocities (those being proportional to the density, respectively the temperature gradient) is also expected to be large (by definition of the transport barrier, since transport is minimum there). Did you take the latter into account?

S. BENKADDA: The density profile is fixed in the present simulations, the diamagnetic effects associated with the density are not taken into account. However we do take into account the change in the pressure profile which self-consistently develops and which exhibits a strong transport barrier due to ExB convection. An important feature of the simulations presented in the paper is that they are performed at fixed fluxes and the profiles are allowed to fluctuate. In this approach there is no separation between the fluctuations and the equilibrium values while in the fixed gradient approach (we mean by that the equilibrium profile is not allowed to fluctuate) there is a separation of scales between fluctuations and equilibrium.

P. SMEULDERS: What is the timescale of the burst of the turbulent radial flux? In what poloidal direction do these perturbations propagate, in the electron- or ion-diamagnetic direction?

S. BENKADDA: The propagation time of a burst is typically of the order of 10-30 a/cs, cs being the acoustic speed. For realistic plasma parameters, this time ranges between 10 and 100 microseconds and is much smaller than a confinement time which is 2 to 3 orders of magnitude larger. Concerning in what poloidal direction do these perturbations propagate, for ITG simulations the structures seem to propagate in the electron-diamagnetic direction while for RB simulations we did not address the question yet.

Paper IAEA-CN77/TH2/3 (presented by Z. Lin)

DISCUSSION

A. ROGISTER: If one distributes the number of particles that present gyrokinetic simulation codes can handle over a machine the size of TEXTOR (R=1.75 m, a=0.46 m), one finds that they are separated by distances of the order of or smaller than one ion Larmor radius. Can one expect, under those circumstances, that the codes take FLR effects accurately into account and describe properly modes with radial or poloidal mode numbers larger than or of order of the inverse of the ion Larmor radius? In particular, some important physics might be left out. The problem will of course be even more acute for larger machines.

Z. LIN: To resolve accurately the FLR effect, one needs a large number of simulation particles inside a flux tube with a length of typical ITG parallel wavelength and with a radius of ion gyroradius. There are 250 particles in such a flux tube in our simulations if we use a tokamak major radius R=1.75 m, a minor radius a=0.46 m, a safety factor q=2, an ion gyroradius ρ=0.001 m, a parallel wave number $k_{\|}$=5/qR, and a total number of simulation particles N=100 million. This estimate is based on our simulations using global field-line following coordinates. In earlier global simulations using Cartesian coordinates, much larger number of simulation particles would be needed for the same plasma parameters due to the presence of unresolved modes with short parallel wavelength.

Paper IAEA-CN77/TH2/4 (presented by P.K, Kaw)

DISCUSSION

B. COPPI: The class of modes that appears to have the most “macroscopic” features and produce transport of the electron thermal energy involve trapped electrons, the effects of the field curvature and a non-adiabatic response of the ions. These are derived from kinetic theory and have bee called ubiquitous or collisionless trapped electron modes. Why did you choose a fluid approach that gives modes with a finer structure?

P.K. KAW: We choose the fluid approach so that detailed nonlinear physics could be explored. Linear ETG modes driven by electron curvature and describable by fluid equations were chosen as an example. I suspect that the nonlinear physics of other interesting modes, like the one you mention, is also similar.

F. ROMANELLI: Why is strong negative magnetic shear required for reducing ETG turbulence?

P.K. KAW: Experimentally, this is the only regime where significant reduction of χ_e is seen. Perhaps this is so because growth rates of ETG are large and velocity shear is never strong enough to stabilize them. One thus needs to cut down on the basic drive mechanism and this is what strong negative magnetic shear does.

P.H. DIAMOND: I think the Kelvin-Helmholtz is over-emphasized as the streamer break-up mechanism. In particular, random shearing (via poloidal shear of radial flows) looks stronger. Since the diffusion in k-space is resonant, local plateau formation (in k) can saturate streamer growth rather easily. Hence, it seems that one must look beyond KH.

P.K. KAW: It may be so but your estimate of saturation by this mechanism gave rather low variance in the bursty transport ($\leq 50\%$) by ITG. I suspect that much larger burstiness is needed to explain ETG driven electron transport because mean field transport is so low. Hence higher saturation levels are required and this mechanism may not be effective.

R.J. TAYLOR: If you remove ETG as Pat Diamond indicates only the parallel drive remains. That you can reduce at high beta through omnigenous magnetics. Can we expect the electron channel to go classical as the ion channel has gone?

P.K. KAW: It seems too speculative at this point to say so.

Paper IAEA-CN77/TH2/6 (presented by Y. Idomura)

DISCUSSION

O. GRUBER: You have shown us, that the ETG mode is destabilized at q_{min}. The previous speaker (Dorland), told us however, that ETG mode is suppressed in the RS and the q_{min} region with $s \approx 0$. How can this be reconciled?

Y. IDOMURA: Our analysis is a non-local calculation using the gyrokinetic integral eigenvalue code. So, we can correctly treat the q_{min} surface where the modes are strongly driven. This could be a main difference.

P.H. DIAMOND: I want to strongly agree with your conclusion of the importance of magnetic shear in (generalized) Kelvin-Helmholtz modes. This is in contrast to the previous talk which ignored that important effect. Some time ago Bruce Scott and I came to similar conclusions.