Contribution ID: **482** Type: **Poster**

Mechanisms and Dynamics of the External Transport Barrier Formation in Non-Linear Plasma Edge Simulations

Friday 17 October 2014 08:30 (4 hours)

Theoretical understanding of the low to high confinement (L-H) transition in magnetic fusion devices such as ITER still remains unresolved, causing significant uncertainties on the power requirements for entering the H-mode. In particular, turbulence is known to be stabilised by sheared ExB flows, but the mechanism generating the flows in an H-mode is not clearly identified yet.

In this work, spontaneous stabilisation of turbulence leading to generation of a transport barrier is achieved in flux-driven 3D edge turbulence simulation with an extended fluid model accounting for collisional relaxation of the flow towards force balance. The transition to this state of improved confinement occurs with an input power threshold.

Above this threshold, a strong equilibrium shear flow governed by force balance stabilises the turbulence, causing a steepening of the pressure gradient close to the last closed flux surface.

The dynamics of the barrier onset is characterised by a complex interplay between the equilibrium flow and zonal-flows when the threshold is marginally crossed, which is reminiscent of the I-phase observed in experiments.

Performing simulations over several confinement times with a reduced 1D model reveals a regime of relaxations of the barrier at constant input power. This regime is found slightly above the power threshold, and disappears when increasing further the input power. In this regime, the barrier collapses quasi-periodically, and each relaxation is associated with a burst of turbulent flux. Simulations have shown that the relaxations become less frequent when the injected power is increased, a behaviour reminiscent of type-III ELMs.

Paper Number

TH/P7-5

Country or International Organisation

France

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Session Classification: Poster 7