Edge Transport Barrier Width in ASDEX Upgrade

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The edge transport barrier (ETB) provides a crucial part of the confinement improvement observed in H-modes. Recently [1], the ETB width has been shown to play an important role in the change of H-mode confinement with increasing power – leading to the so-called improved H-mode as a candidate for the ITER hybrid mode of operation. In this paper, we examine several simple models for the scaling of the ETB width and compare them to measurements in the ASDEX Upgrade tokamak, in particular with respect to scans in the input power.

The basic mechanism for turbulence suppression which leads to the formation of an H-mode is thought to be the shearing of turbulent eddies by ExB flow shear. Dimensional arguments have been used to find a scaling of the ETB width with the edge toroidal Larmor radius and the square of the edge magnetic shear [2]. We compare this scaling relation with our experimental results as well as with measurements of the radial profile of the ExB shear using Doppler reflectometry [3].

The drift wave turbulence which drives 'anomalous' transport in a tokamak can be separated spatially into regions in which the electron parallel dynamics are or are not adiabatic [4]. This can be quantified in terms of the ratio of the drift wave timescale to the electron thermal transit frequency $\hat{\mu} = \left[\left(c_s / L_\perp\right) \big/ \left(V_e / qR\right)\right] = m_e \big/ M_i \left(qR / L_\perp\right)^2$. The location at which $\hat{\mu} = 1$ is our working definition of the region in which 'edge turbulence' is active. This transition point is close to the inner edge of the ETB and, in individual power scans, the two positions are correlated.

One difficulty with the above models is that the arguments are somewhat circular in that wider barriers naturally lead to higher parameter values at the inner edge of the ETB. An approach to avoiding this is to consider the scaling of the ETB width with separatrix parameters, which we might consider to be set independently by SOL and divertor physics. The ETB width in these power scans is found to increase more quickly with power than the drift wave spatial scale length $\rho_s = \sqrt{\left(c^2 M_i T_e\right) \big/ \left(e^2 B^2\right)}$, evaluated at the separatrix, ranging from about $30 - 60\,\rho_s$.

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[2] M. Sugihara et al., Nucl. Fusion **40** (2000) 1743.

[3] J. Schirmer et al., Nucl. Fusion **46** (2006) S780.

[4] B. Scott, Plasma Phys. Control. Fusion **45** (2003) A385.