Generalization of the Heuristic Drift Model for Finite Collisionality

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The "Heuristic Drift" (HD) model for the scrape off layer power flux width [1] was explicitly formulated for low-gas-puff H-mode conditions. Experimental results in these conditions have shown good agreement with the model, and the model has influenced the design of ITER's plasma-facing components. At higher gas puff rates, AUG data have shown that the scrape-off width broadens as the collisionality increases [2]. We hypothesize that this broadening is due to enhanced residence time of heat in the SOL at higher collisionality, due to higher thermal resistance. This allows more time for cross-field drifts to broaden the SOL. Using a two-point model [3] to generalize the collisionless parallel confinement time in the HD model we find:

$$\tau'_{E\|}\left(1-\tau'^{\,-7}_{E\|}\right) = 7.39\cdot 10^{-2} f(Z_{eff})\nu^*_{SOL}(Z=1) \qquad (1)$$

Here $\tau'_{E\|} \equiv \tau_{E\|}/\tau_{E\|0}$, where $\tau_{E\|0} = 6L_\|/(\gamma c_{s,u})$ scales as in the collisionless HD model. We have adopted the fit to the electron thermal conductivity, including its dependence on Z_{eff}, from [4]. Figure 1 shows equation 1 vs. recent AUG Thomson-scattering data with a range of gas puffing and impurity seeding, but not full detachment.

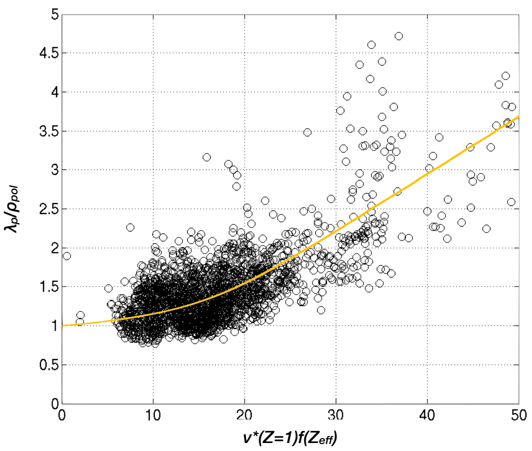

Figure 1: λ_p/ρ_{pol} vs. collisionality, AUG experiment and equation 1.

The E_rB_t/B^2 shearing rate in the generalized HD model is $3R^2T/(4\tau'^{\,2}_{E\|}a^2eB\rho^2_{pol})$, comparable for $\tau'_{E\|}=1$ to the edge Bohm and gyro-Bohm growth rates, $T/(eB\lambda_p^2)$ and c_s/λ_p. As a result, broadening of the SOL at high collisionality, and so high $\tau'_{E\|}$, may enhance turbulence near the separatix, consistent with the AUG observation of degraded confinement at high SOL collisionality [5].

References

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