Role of electron temperature gradient turbulence and shaping in turbulent pedestal transport

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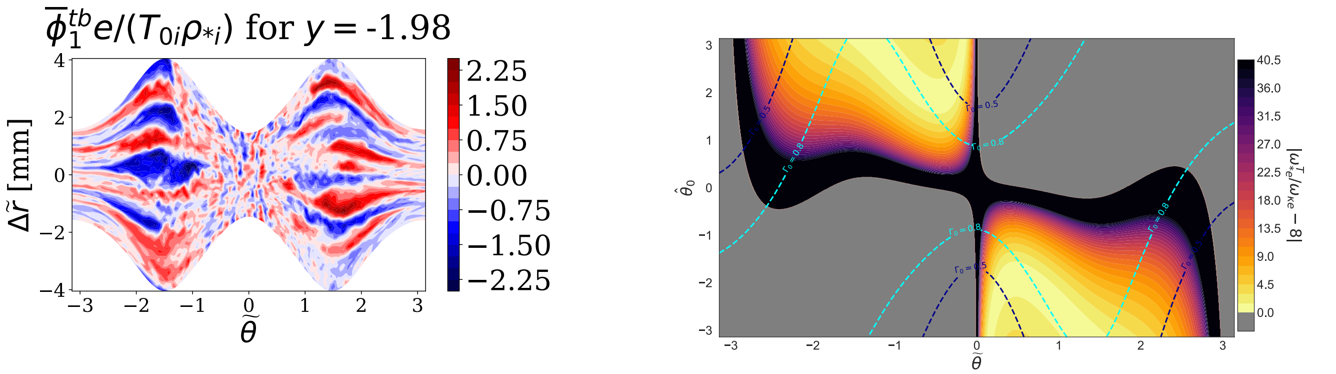
We examine how magnetic shaping can be used to control the levels of toroidal and slab ETG transport in the pedestal. Nonlinear gyrokinetic ETG simulations in the steep gradient region of JET-ILW pedestals reveal a strong inhomogeneity in poloidal angle caused by shaping and steep gradients (Figure 1a), in contrast with core ETG turbulence [1, 2]. Linearly, we find at low $k_y\rho_i$ the toroidal branch is dominant and is characterized by modes that peak far from the outboard midplane, having $K_x \gg k_y$. Here, K_x is the local radial wavenumber, k_y is the binormal wavenumber, and ρ_s is the gyroradius. Because of the steep gradients, the toroidal branch is characterized by modes far away from the outboard midplane with a large radial wavenumber $K_x\rho_e \sim 1$ [3], and can be the fastest growing mode at wavenumbers as low as $k_y\rho_i \sim 1$. Finite Larmor radius (FLR) effects prevent the toroidal mode from acquiring a radial wavenumber larger than $K_x\rho_e \sim 1$. The slab mode is unstable but subdominant at $k_y\rho_i \sim 1$, but its radial wavenumber typically satisfies $K_x \sim k_y$. Nonlinearly, we show how the poloidal distribution of slab ETG turbulence can be predicted by FLR effects, while for toroidal ETG turbulence, its distribution is determined by a combination of FLR effects and the ratio of the diamagnetic drift frequency to the magnetic drift frequency (Figure 1b). Using a critically balanced theory of turbulence, we show how geometrical parameters (such as triangularity, aspect ratio, and tilt angle) affect toroidal and slab ETG modes in the pedestal, which may have a profound impact on pedestal transport.



(a) Potential fluctuations on a single magnetic field line in a JET-ILW nonlinear pedestal gs2 simulation, plotted versus $\Delta\tilde{r}$, a radial coordinate that measures flux surface expansion, and $\tilde{\theta}$, a poloidal angle-like coordinate. Toroidal ETG turbulence is concentrated around $|\tilde{\theta}| \simeq \pi/2$ and slab ETG turbulence is concentrated around $\tilde{\theta} \simeq 0$.

(b) Unstable (colored) and stable (gray) regions for the toroidal ETG mode versus poloidal angle $\tilde{\theta}$ and ballooning angle $\hat{\theta}_0$ for a JET-ILW pedestal. Dashed lines indicate different levels of FLR effects with $\Gamma_0 = 1$ denoting no FLR damping. The magnetic drift frequency is $\omega_{\kappa e}$ and the diamagnetic drift frequency is ω_{*e}^T.

Figure 1

References

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