Relating the L-H Power Threshold Scaling to Edge Turbulence Dynamics

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Abstract. Understanding the physics of the L-H transition power threshold scaling dependencies on toroidal field and density is critical to operating and optimizing the performance of ITER. Measurements of long-wavelength ($k_\perp \rho_I < 1$) turbulent eddy dynamics, characteristics, flows, and flow shear in the near edge region of DIIID plasmas have been obtained during an ion gyro-radius scan (varying toroidal field and current) and density scan in a favorable geometry (ion ∇B drifts towards the X-point), in order to determine the underlying mechanisms that influence the macroscopic L-H power threshold scaling relations. It is found that the integrated long wavelength density fluctuation amplitudes scale with ρ* approaching the L-H transition, suggesting a stronger drive of zonal flows that may trigger the transition at lower toroidal field. The turbulence poloidal flow spectrum evolves from Geodesic Acoustic Mode (GAM) dominant at lower power to Low-Frequency Zonal Flow (LFZF) dominant near the L-H transition, and the effective shearing rate correspondingly increases. An inferred Reynolds Stress, $\langle \tilde{v}_r(t)\tilde{v}_\theta(t)\rangle$, from BES velocimetry measurements is found to significantly increase near the L-H transition. Similar observations are made with the Langmuir probe measurements. At lower electron density, a clear increase of the LFZF is observed prior to the L-H transition, which is not evident at higher density. Taken together, these results are qualitatively/semi-quantitatively consistent with the electron density and toroidal field scaling of the L-H transition power threshold.