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Role of turbulence and shear flow dynamics in the L-H transition and power threshold scaling*

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Comprehensive 2D turbulence and flow measurements demonstrate that turbulence-driven shear flow plays a critical role in triggering the L-H transition, and that turbulence characteristics and internal mode structure strongly correlate with the power threshold dependencies on density, isotope mass and edge safety factor. These measurements, acquired with Beam Emission Spectroscopy across the L-H transition on DIII-D, exhibit a rapid increase of turbulence amplitude, Reynolds stress, and flow shear 1-2 cm (~one turbulence correlation length) inside the separatrix immediately prior to the L-H transition (t(LH) - 200μs). The energy transfer rate from turbulence to the poloidal flow peaks during this rapid evolution prior to the transition and exceeds the effective turbulence recovery rate [1]. These observations suggest that increasing power flux leads to increased turbulence, turbulent Reynolds stress, shear flow development, and a rapidly increasing poloidal flow that triggers the L-H transition. Two poloidally counter-propagating bands of density fluctuations are observed in plasmas that have a lower power threshold, which may explain the observed lower threshold at higher isotope mass (Deuterium vs. Hydrogen) and at higher q_{95} [2, 3]: these modes appear to interact in a way that increases flow shear and facilitates the transition. Simulations with BOUT++ and linear gyrokinetic simulations (CGYRO) show qualitatively and semi-quantitatively similar unstable mode structure [3, 4]. These measurements are clarifying the physics of the L-H transition trigger and the power threshold scaling, which are critical for burning plasmas since H-mode operation is required to achieve their performance goals.

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