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Predator-Prey Oscillations and Zonal Flow-Induced Turbulence Suppression Preceding the L-H Transition[1]

L. SCHMITZ, University of California Los Angeles

Understanding the L- to H-mode transition and the density/rotation dependence of the H-mode power threshold is important for the design and predictive modeling of burning plasma experiments. We present here direct experimental evidence of the importance of predator-prey oscillations and turbulence/transport regulation by low frequency zonal flows (ZFs) at the L-H transition. Near the H-mode power threshold, a narrow oscillating flow layer develops at/inside the separatrix in a neutral beam-heated DIII-D plasma. Toroidal and radial correlation of the $E \times B$ velocity, as measured by Doppler backscattering (DBS), increase at the transition to this "dithering" state. The observed oscillation is consistent with a radially propagating ZF with a frequency much below the expected local GAM frequency. Periodic turbulence suppression due to ZF shearing is first observed when the turbulence decorrelation rate decreases sharply (within 0.1 ms) at the transition to the dithering state and the increasing ZF shearing rate locally surpasses the decorrelation rate. The flow layer then expands radially inwards. The ZF amplitude lags the density fluctuation amplitude by 90°. The "final" H-mode transition (sustained turbulence/transport reduction) appears linked to increasing equilibrium flow shear due to the increasing ion pressure gradient. Both features are consistent with the predator-prey model of the L-H transition [1]. The transition dynamics is revealed with high time ($<1\,\mu$s) and spatial resolution (<0.5 cm), combining eight channel and five channel DBS systems, separated 180° toroidally, with fast profile reflectometry.

[1] E.J. Kim and P.H. Diamond, Phys. Rev. Lett. **90**, 185006 (2003).

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