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L-H Transition Threshold Physics at Low Collisionality

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H-mode operation is the regime of choice for good confinement. Access to and sustainability of the H-mode requires understanding of the L $\rightarrow$ H transition power threshold and the related problem of hysteresis. To predict ITER transitions, one must also understand low collisionality, electron-heated regimes.

In this paper, we discuss a.) L $\rightarrow$ H power threshold scaling including the minimum in P_th(n) and elucidate an impact of inter-species energy transfer on threshold physics, b.) transitions in collisionless, electron heated regimes where the electron-ion coupling is anomalous, due to the fluctuation of $\langle E \cdot J \rangle$ work on electrons and ions, c.) new transition scenarios, characterized by the sensitivity of transition evolution to pre-existing L-mode profiles.

To study the above phenomena, we have developed a reduced model that independently evolves the collisionally coupled electron and ion temperatures, along with density, turbulence intensity and flow profiles. Our studies have revealed the physics of the power threshold minimum in density as a combined effect of the density dependence of collisionless electron-ion coupling and e-i heating mix. For collisionless regimes, we have included an anomalous power coupling between electrons and ions. Using a recently developed theory of minimum enstrophy relation which predicts a hyper-viscous turbulent flow damping we employ the nonlinear viscous heating of the ions. Our preliminary results on collisionless regimes suggest that L\rightarrow H transition occurs as the endstate of an anomalous electron-ion thermal coupling front. The transition occurs when the front arrives at the edge and impulsively raises T_i there, thus building up the diamagnetic electric field shear. This study highlights the importance of collisionless energy transfer process to transitions in regimes of ITER relevance. Finally, we have explored transitions occurring in the absence of turbulence driven shear flow. The key here is the sensitivity of the transition to the pre-existing L-mode density profile. Ongoing work focuses on elucidating this sensitivity and understanding how to exploit it to optimize the access to H-mode.

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