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From Micro to Macro: L-H Transition Dynamics and Power Threshold Scaling

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It is believed that L-H transition occurs via coupling of turbulence to low frequency shear flows by Reynolds work. As a consequence, turbulence and turbulent transport collapse, enabling the growth of diamagnetic electric field shear and the transition. This work focuses on the missing link between microscopics and macroscopics, and its critical role in power threshold scaling. The major goal is the understanding of the observed occurrence of a minimum in the power threshold. We pursued a model which separates electron and ion temperature evolution by extending a recent 1D, five-field model which captures the transition layer evolution well, but does not have this capability. In the new model, density appears as an electron-ion coupling parameter, as well as in ZF damping. We propose and examine the explanation that: (i) the initial trend of decrease in the power threshold is due to stronger collisional electron-ion coupling which enables the development of stronger diamagnetic electric field. This scaling trend reflects the role of the mean shear in locking-in of the transition, (ii) the subsequent increase in the threshold is due to the increase in damping of shear flows with ion collisionality. This scaling trend reflects the role of the turbulence generated shear flow as a trigger mechanism. Our studies reveal a clear power threshold minimum in density scans ran for a fixed, electron dominated heating mix, but an even more distinct minimum is predicted for the fixed density when scanning the ion to total heating ratio. Here we see that the power threshold minimum appears as an interplay of electron-ion coupling. In addition to the basic scaling trends, model studies reveal: (a) the threshold power increases for off-axis electron heat deposition. This follows from the fact that electron-ion coupling is reduced in this instance, (b) a minimum power is predicted for a heating mix scan as well as for a density scan. This points towards the possibility of a global minimum in the threshold power in terms of a number of relevant parameters, (c) no clear threshold minimum is predicted by this model for pure ion heat deposition. Ongoing work is concerned with quantifying the strength of hysteresis in terms of multiple macroscopic parameters and with relating this to observed back-transition shear flow and turbulence dynamics.

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