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A smooth path from dissipative to shear regulation of plasma turbulence–flow dynamics

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Abstract

The bulk dynamics of fusion plasmas around L–H transitions is regulated either by Reynolds stress decorrelation of turbulence, or by bifurcation of the radial electric field induced by a shear flow drive. In this study, these two mechanisms are smoothly reconciled. A low-dimensional model for plasma dynamics [1] is extended to include a nonlinear shear flow driving rate. As the rate coefficient is tuned quasistatically the system passes from a slow time-scale régime of hysteresis and associated limit cycles where the dynamics is essentially 3-dimensional, to an entirely different hysteretic domain in fast time which is dominated by the radial electric field. The smooth path between these two extremes passes through an intermediate domain where L–H transitions are oscillatory and non-hysteretic. These results provide unification of previous disparate models for L–H transitions, and also suggest appropriately tailored strategies that may be used to control access to high confinement modes or manipulate oscillatory behaviour.

[1] R. Ball, R. L. Dewar, and H. Sugama. Metamorphosis of plasma shear flow–turbulence dynamics through a transcritical bifurcation. *Phys. Rev. E*, 66:066408–1–066408–9, 2002.