DPP15-2015-001118

Abstract for an Invited Paper
for the DPP15 Meeting of
the American Physical Society

The Role of Nonlinear Interactions in Causing Transitions into Edge Transport-Barrier Regimes[1]

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Transitions of tokamak confinement regimes are studied with a focus on interactions between turbulence and zonal flows (ZF) or geodesic-acoustic modes (GAM). Results show that access to im-proved confinement regimes is profoundly affected by these interactions and clarify the role of GAM and ZF in different types of transitions. In order to understand the underlying dynamics of these transitions, both their trigger mechanism and the parametric dependence of nonlinear transfer processes are studied using gas-puff-imaging. For the L-to-H transition, this work shows that the stress mediated transfer rate of kinetic energy from turbulence into ZF leads in the changes, the turbulence collapses, and finally the pressure gradient forms – establishing the trigger as flow organization. For the I-mode, turbulence is studied with the aim of understanding /emphaccess to the improved confinement regime, which exhibits an edge temperature pedestal, but a relaxed density profile. L-to-I and I-to-H transitions are analyzed in a time-resolved manner analogous to the L-H transition. For the L-to-I transition there is a difference between the scaling of the regime's typical edge fluctuation, the Weakly Coherent Mode (WCM), and GAM, known to be essential in shaping the WCM. Both the WCM and the GAM are necessary for the regime, and regime access is found to be sensitive to the GAM drive and damping. Parametric dependences of nonlinearities are examined in steady state discharges from a range of toroidal field, plasma current, and density; and interactions between flows and turbulence in both L-mode and I-mode are estimated using bispectral methods. The ZF drive increases monotonically with cross-field heat flux, i.e. approaches a transition, while GAM follow more complicated trends. These results advance our progress toward predicting the parametric dependences of transition conditions.

[1]Work supported by USDoE, Office of Science, Award Numbers DE-SC-0008689 and DE-FC02-99ER54512