Spontaneous self organization from drift wave plasmas to a mixed ITG - drift wave - shear flow system via a transport bifurcation in a linear magnetized plasma device

S. C. Thakur,[1, 2] R. Hong,[1, 2] A. Ashourvan,[2, 3] P. H. Diamond,[1, 2, 3] R. Hajjar,[1] J. Li,[2, 3] and G. R. Tynan[1, 2]

[1] Center for Energy Research, University of California at San Diego

[2] Center for Momentum Transport and Flow Organization, University of California at San Diego

[3] Center for Astrophysics and Space Sciences, University of California at San Diego

ABSTRACT:

We present an overview of recent experimental results in the linear magnetized helicon plasma device Controlled Shear Decorrelation eXperiment (CSDX), on spontaneous self organization of drift wave plasmas. The plasma goes through a global transition at a critical magnetic field threshold $\boldsymbol{B_{th}}$ (which depends on other helicon source parameters like the gas used, neutral gas flow rates, pressure and *rf* heating power) from drift wave (DW) dominated regimes to a simultaneously existing mixed ion temperature gradient (ITG) instability – drift wave – sheared flow system. The transition is an example of a transport bifurcation with steepening of the mean plasma density and ion pressure profiles, onset of strong E × B shearing, reduction of turbulence, formation of a turbulent radial particle transport barrier and strong hysteresis. The total Reynolds work on the flow sharply increases above the threshold and is correlated to the increase of density steepness, suggesting that the Reynolds stress-driven flow plays an essential role in density steepening and the transport bifurcation. In addition, Doppler resolved ion temperature measurements show strong ion heating at the core, thus forming ion temperature gradients that cause the onset of the ITG instability for magnetic fields leading to the transition. Fast imaging shows the appearance of ion modes, with high azimuthal mode numbers rotating in the ion direction, concurrent with the parameters where we observe core ion heating. Prior to the transition we observe strong mode competition between the ITG and the DW modes, with the DW modes dominating. The transition is complete when the ITG modes at the core become locally stronger than the DW features. This change in the turbulence features from DWs dominated plasmas to a mix of DW and ITG coincides with the transport bifurcation. After the transition, ITG modes dominate the core while DWs are strongest at the density gradient region and strong E x B shear driven instabilities are present at the plasma edge. Some interesting phenomena related to the transport bifurcation are local inward particle flux, co-existence of ion and electron features and self sustained axial flow without external momentum input. We shall also show details of the forward and backward transitions from both fast imaging and probe data.