1st Asia-Pacific Conference on Plasma Physics, 18-23, 09.2017, Chengdu, China

Fundamental studies of fusion-relevant turbulent transport and plasma self-organization physics in a linear plasma device

G.R. Tynan[1]

[1] Center for Energy Research & Department of Mechanical and Aerospace Engineering, University of California San Diego, La Jolla CA 92093 USA

The development of a deeper understanding of fundamental drift turbulent transport physics relevant for magnetically confined fusion has been obtained in basic experiments and is summarized here. A controlled transition from quiescent plasma, through coherent collisional drift eigenmode and then nonlinearly interacting drift-eigenmode activity, ending in broadband drift turbulence is accessed by gradually increasing the magnetic field and density gradient. During this transition, measurements of nonlinear kinetic energy transfer in the Fourier domain together with direct imaging in configuration space reveal the emergence of turbulent-driven radially sheared azimuthal ExB zonal flows. These shear flows act to regulate the turbulence amplitude via a tilt-stretch and absorption mechanism, and can result in both fixed point and limit cycle dynamics depending on the detailed experimental conditions. Studies also demonstrate the importance of endplate sheath boundary conditions; use of conductors partially counteracts the emergence of zonal flows while insulating endplates allow the activity to more clearly emerge. The drift turbulence-zonal flow system also exhibits non-diffusive flux-gradient behavior reminiscent of critical gradient phenomena. Further increases in magnetization at sufficiently high heating power reveal development of multi-instability turbulence signatures, up-gradient transport phenomena and steepened mean profiles. In addition, recent observations point to the existence of turbulent-generated parallel shear flows that also emerge in competition with zonal flows. Early on, parallel sheared flows develop, while at higher magnetization, zonal flows begin to dominate the turbulence dynamics. Flows with net momentum result from the effect of non-slip boundary conditions arising from plasma-neutral gas interactions near the wall. Recent linear theory together with reduced turbulence models and nonlinear Hasegawa-Wakatani fluid turbulence models also help provide insight into the mechanisms underlying the experimental results. We end the talk by linking these basic experiment observations to recent studies of L-H transitions, intrinsic rotation, density limit physics, and non-diffusive mesoscale transport phenomena in fusion confinement experiments.

ACKNOWLEDGEMENT: The work contained in this talk is based on collaborations with, A. Ashourvan, M. Burin, C. Brandt, L. Cui, I. Cziegler, Prof. P.H. Diamond, N. Fedorczak, R. Hajjar, C. Holland, A. Light, P. Manz, Prof. E. Scime, S. Thakur, P. Vaezi, M. Xu, and Z. Yan. Funding was provided by the U.S. Department of Energy grants DE-FG02-07ER54912 and DE-SC0001966.