Dynamics and Feedback Loops of Particle ITB Formation in OH-plasma

W.W. Xiao[1,2], P. Diamond[1,3], X.L. Zou[4], X.T. Ding[2], J.Q. Dong[2,5], L.H. Yao[2], B.B. Feng[2], B.S. Yuan[2], X.M. Song[2], Z.B. Shi[2], Y.D. Gao[2], Y.P. Zhang[2], X.Y. Han[2], W.L. Zhong[2], X.Q. Ji[2], L.C. Li[2], Q.W. Yang[2], Yi Liu[2], L.W. Yan[2], X.R. Duan[2], Yong Liu[2] and HL-2A team

[1] *WCI Center for Fusion Theory, NFRI, Daejeon, Korea*
[2] *Southwestern Institute of Physics, P.O. Box 432, Chengdu, China*
[3] *CMTFO and CASS, UCSD, USA*
[4] *CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France*
[5] *Institute for Fusion Theory and Simulation, Zhejiang University, China*

A spontaneous particle transport barrier has been observed in the Ohmic plasma in HL-2A tokamak with no external momentum or particle input except the gas puffing. A density threshold for the barrier formation has been found to be $n_c \sim 2.2\times10^{19} m^{-3}$. This experimental result is confirmed using three methods: *I)* density profile analysis, *II)* density perturbation response analysis using Supersonic Molecular Beam Injection (SMBI) modulation and *III)* the plasma E×B rotation profiles. Using gas puff fuelling, density profile analysis shows that the barrier local position and width are r/a~0.6-0.7 and 1-2 cm, respectively. The particle transport barrier can be maintained for more than 100 ms, which is greater than energy confinement time τ_E.

The formation of the barrier appears to coincide with the transition from TEM→ITG turbulence, which is also related to LOC→SOC. Analysis of modulated SMBI studies allows determination of the particle diffusivity (D) and convection velocity (V), and indicates that V changes from outwrard to inward as the barrier is formed. This is also consistent with the evolution from TEM→ITG turbulence.

The sharp increase in density gradient in turn results in an increase in E×B velocity shear in the region 0.6<r/a<0.9, as shown in Fig. 1. E×B shear is correlated with barrier formation and the region of reduced density fluctuation levels as was indicated by Doppler reflectometry measurements.

These results suggest a self-regulation feedback loop of enhanced ion heating (transfer ~ n_e^2)→ITG onset→inward convection pinch→density gradient→increases E×B shear→density fluctuation and transport reduction → ITB formation. This feedback loop appears pertinent to other OH-plasma enhanced confinement, such as the RI-mode and IOC, though the precise mechanism for ∇T_e steepening and ITG onset may differ from case to case. We will discuss the similarities and differences between p-ITB, IOC and RI-mode, as well as the general implications of these results for optimization of the profile structure.

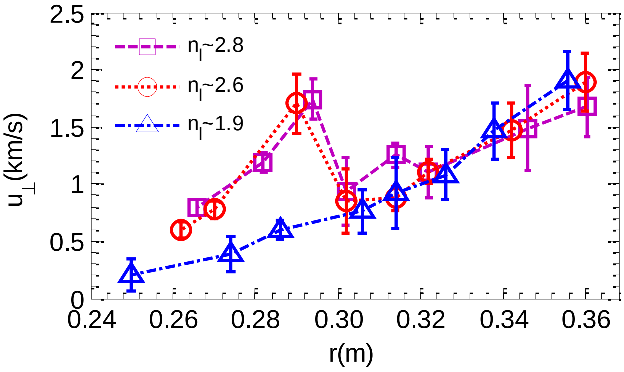

Fig. 1. Radial profile of the perpendicular turbulence rotation velocity with pITB (□ and ○) and without pITB (△) measured by Doppler reflectometry in different plasma line average density.