First Experimental Evidence of Turbulence-driven Main Ion Flow and ExB Flow Triggering the L-H Transition*

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Simultaneous measurements of main ion flow, ***E***×***B*** flow, and turbulence level ñ/n inside the separatrix (LCFS) show for the first time that the initial turbulence collapse preceding the L-H transition is due to turbulence-driven ion flow and ***E***×***B*** flow in the ion diamagnetic direction, *opposing* the pressure-gradient-driven equilibrium ***E***×***B*** flow in the L-mode phase. Low to high confinement (L-H) transitions characterized by limit cycle oscillations (LCO, [1]) allow probing the trigger dynamics and synergy of turbulence-driven meso-scale flows, and pressure-gradient driven flows with high spatio-temporal resolution. A density/plasma current scan indicates that the LCO is triggered at a critical value of turbulence-driven flow shear. Near the minimum of the electric field well, turbulence-driven flow in the electron diamagnetic direction is observed. The radial flow (shear) reversal is consistent with the direction of the (ñ, E_r) limit cycle observed just inside the LCFS in DIII-D (and recently in LCO-H-mode transitions in HL-2A and JFT-2M), and the reversed limit cycle direction observed in the inner shear layer. Causality of shear-flow generation has been established: early during LCO, the ***E***×***B*** shearing rate leads the ion pressure gradient increase; during the final phase of the LCO, the edge pressure gradient and ion diamagnetic flow are modulated and increase, and the shearing rate lags the ion pressure gradient. Pressure-gradient-driven shear then becomes sufficiently large to secure the final LCO-H-mode transition. A two-predator, one-prey model, similar to a previously developed model [2] but retaining arbitrary polarity of turbulence-driven flow with to respect pressure-gradient-driven ***E***×***B*** flow, captures essential aspects of the transition dynamics, including the magnitude and direction of the driven poloidal main ion flow.

[1] L. Schmitz, et al., Phys. Rev. Lett. **108**, 155002 (2012).
[2] K. Miki and P.H. Diamond, Phys. Plasmas **19**, 092306 (2012).

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