First Direct Evidence of Main Ion Flow Triggering the L-H Transition*

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Simultaneous measurements of main ion flow (via main ion CER), ***E***×***B*** flow, and turbulence level ñ/n (via Doppler backscattering) during transitions characterized by extended limit cycle oscillations (LCO [1]), show for the first time that the initial (transient) turbulence collapse [Fig. 1(a)] preceding the L-H transition is caused by turbulence-generated main ion flow and ***E***×***B*** *opposing* the equilibrium (L-mode) edge plasma ***E***×***B*** flow related to the edge ion pressure gradient. The formation dynamics of edge transport barriers is crucial for understanding the physics basis of the empirical L-H transition power threshold scaling, and for confidently extrapolating auxiliary heating requirements to burning plasmas. Figure 1(b) shows that the $\mathbf{v}_i\times\mathbf{B}/B$ contribution to the ***E***×***B*** velocity peaks as fluctuations are first suppressed. Fig. 1(c) shows that the ***E***×***B*** shearing rate $\omega_{\mathbf{E\times B}}$ reverses at this time. The correlations between turbulence envelope, main ion flow, and pressure-gradient driven flow, and their detailed spatio-temporal evolution have been measured. The main ion poloidal velocity lags ñ early in the LCO, consistent with turbulence-driven poloidal ion flow [Fig. 1(d)]. As the LCO evolves, the periodic reduction in edge turbulence and edge transport enables a gradual increase (and periodic modulation) of the edge pressure gradient and ion diamagnetic flow. During the final phase of the LCO the pressure gradient diamagnetic flow) dominates the mean flow ***E***×***B*** shearing rate, which becomes sufficiently large to sustain fluctuation suppression and secure the LCO-H-mode transition. A two-predator, one-prey model, similar to a previously developed model [2] but retaining opposite polarity of the turbulence-driven and pressure-gradient-driven ***E***×***B*** flow, captures essential aspects of the transition dynamics, and is consistent with the direction of the (ñ, E_r) limit cycle observed in DIII-D and recently in JFT-2M. The scaling of the L-LCO transition threshold power and LCO frequency with edge plasma density, collisionality, and q_{95} will be presented.

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[2] K. Miki and P.H. Diamond, Phys. Plasmas **19**, 092306 (2012).

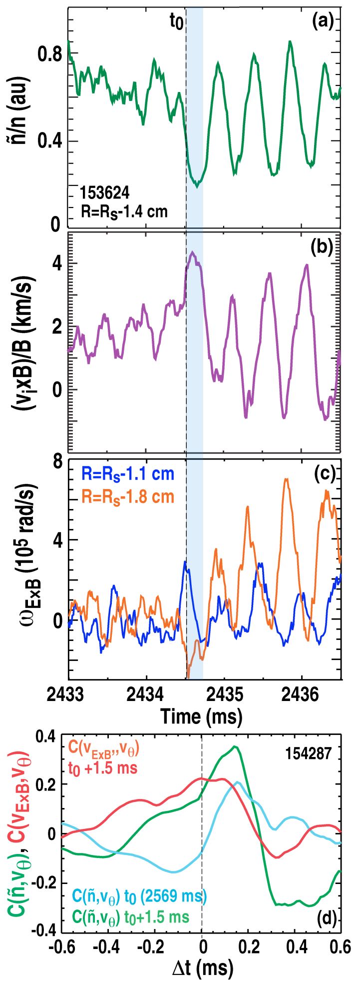

Fig. 1. Time evolution of (a) relative density fluctuation level; (b) main ion $\mathbf{v}_i\times\mathbf{B}$ contribution to the **E**×**B** velocity; (c) shearing rate ω_{ExB} at two radii inside the LCFS. Time of initial turbulence suppression indicated; (d) Cross-correlation of ñ, $v_{\mathbf{ExB}}$ with $v_{i\theta}$. R_s is the LCFS radius.

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