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Reducing the L-H Power Threshold in ITER - What Can We Learn from Microscopic Transition Physics?[1]

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We demonstrate for the first time that fast electric field transients triggering the L-H transition are quantitatively consistent with the combined radial polarization (displacement) currents due to Reynolds stress, thermal ion orbit loss, and ion viscosity. These E_{r} transients (typically 0.05-1 ms) can produce large $\boldsymbol{E}$x$\boldsymbol{B}$ shear and can trigger L-H transitions when the L-mode "equilibrium" shear flow due to the ion pressure gradient is insufficient to suppress edge turbulence. Typical examples are plasmas with unfavorable grad-B drift direction and/or strong toroidal co-current rotation. Edge turbulence is suppressed once the transient $\boldsymbol{E}$x$\boldsymbol{B}$ shearing rate exceeds the plasma frame turbulence decorrelation rate [1]. Initial experiments indicate that the L-H transition power threshold P_{LH} can be reduced at low ion collisionality via Neoclassical Toroidal Viscosity (NTV) from applied n=3 non-resonant magnetic fields (NRMF). CER data confirm that the applied NTV counter-current torque locally reduces L-mode edge toroidal co-rotation, increasing the shear in the $\mathrm{v}_{\phi}B_{\theta}$ term in the radial ion force balance. The well-known increased P_{LH} with unfavorable grad-B drift direction is attributed to reduced shear flow in the outer shear layer due to higher (intrinsic) edge co-rotation. This increase is often mitigated in ITER-similar-shape plasmas in DIII-D via localized rotation reversals in the inner shear layer, triggered by sawteeth or transport avalanches. These new insights can open up paths for reducing P_{LH} during the initial ITER hydrogen campaign with limited auxiliary power, by generating edge NTV [via the planned (partial) 3-D coil set], by exploiting edge magnetic topology modifications due to MHD modes, or by localizing power deposition to critical edge layers. [1] L. Schmitz et al., Phys. Rev. Lett. **108**, 155002 (2012).

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