

Towards a Physics-Based Understanding of the L-H Transition Power Threshold*

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Recent work at DIII-D has revealed important differences in L-H transition trigger dynamics between deuterium, helium and hydrogen plasmas. Hydrogen plasmas show lower Reynolds stress and $\mathbf{j} \times \mathbf{B}$ torque, and reduced toroidal correlation of the self-organized $\mathbf{E} \times \mathbf{B}$ flow layer established in the plasma edge (Fig.1) across the L-H transition, concomitantly with substantially higher required L-H transition threshold power.

Non-ambipolar fluxes and polarization currents in the L-mode edge plasma can arise due to neoclassical effects such as the bulk ion viscosity associated with the diamagnetic flow and due to thermal and fast ion orbit loss (extracted here based on simplified models in the low and high density branches of the power threshold) as well as due to the turbulent Reynolds stress [1] (extracted via BES velocimetry [2]). The resulting fast transients in the edge electric field are thought to be instrumental in establishing the large-scale toroidally and poloidally symmetric flow layer triggering the L-H transition.

The ion flux/polarization current induced by the Reynolds stress, in conjunction with the neoclassical bulk ion viscosity, is shown to be decisive for the fast time evolution of the edge electric field across the L-H transition at intermediate and low plasma density in the plateau collisionality regime. As the corresponding $\mathbf{j} \times \mathbf{B}$ torque increases, concomitant turbulence suppression occurs within 100-200 μs of the peak Reynolds stress gradient. The increase of the toroidal $\mathbf{E} \times \mathbf{B}$ flow correlation across the L-H transition (evaluated from toroidally spaced Doppler Backscattering systems) is substantially lower in hydrogen plasmas compared to D [Fig.1] and He, indicating less effective production of large-scale axisymmetric flow, which may explain the higher L-H transition threshold power required in hydrogen.

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[1] L. Schmitz, et al., Nucl. Fusion **57**, 025003 (2017).

[2] Z. Yan, et al., 26th IAEA FEC conference, Oct 17-22, 2016, Kyoto, Japan, paper EX/5-1

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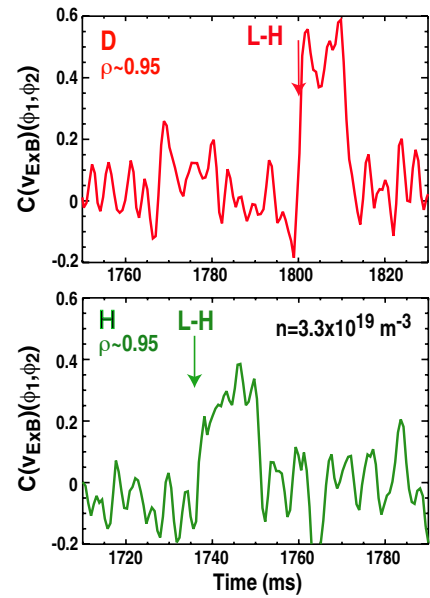


Fig. 1: Increase of measured toroidal $\mathbf{E} \times \mathbf{B}$ flow correlation coefficient across the L-H transition in D plasma (threshold power 2.1 MW) and H plasma (threshold power 5.0 MW). Apparent loss of correlation at 1812 ms and 1752 ms is a measurement artifact due to the DBS probing radius moving out into the scrape-off layer.