SOL Flows Coupled to the Core as an Explanation for the Up-Down Asymmetry in the L/H Threshold

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The L/H Power threshold is typically ~2x higher when ion $\nabla B$ drift direction is away from X-point in single null topology when compared to case where $\nabla B$ drift direction is toward X-point.

First reported on Asdex in 1989

“Universal” result
For fixed conditions (Power, density, current, etc.), edge profiles are similar for both topologies.

Global power threshold can be recast as condition on local edge temperature or gradient.

For unfavorable drift direction, threshold $T_e$ is about 2x higher.

Size of effect suggests looking for large asymmetries – only occur near separatrix or beyond.

*Hubbard 1996*
1. Core flows respond strongly to changes in SOL flows
   (SOL flows provide the boundary condition for core flows)

2. The SOL flow responds strongly to changes in magnetic topology.

2a. Explained by strong ballooning character of turbulent transport.

3. This topology dependent boundary conditions for plasma flow may
   be the explanation for the $\nabla B$ drift effect on the H-mode threshold
Plasma Heating and Rotation Measurements Without NBI on C-Mod - Provides an Excellent Laboratory to Study These Effects

- Heating is with ICRH + OH
- Changes in core reflect changes in boundary conditions
- SOL flows measured at three locations by fast scanning probes
- Core rotation profiles measured passively with high-resolution x-ray spectrometers
Momentum Is Observed to Be Transported From Outside Inward Into Core

- Core rotation responds to change in edge – L/H transition
- Momentum is observed to diffuse and convect inward.

*EDA*

*ELM-free*

*Rice 2003*
• Change in core flows with topology is in same direction and same magnitude as SOL flows
• Core flows exhibit the same extreme sensitivity to edge topology! – each mm counts
• SOL flows are near sonic on high-field side.
Core and SOL Flows are Well Correlated

- Note: Core and SOL flows track but are not identical

So... What is the origin of SOL flow?
Plasma From Ballooning Transport Flows Along Field Lines to Populate High-Field SOL

- Much higher fluctuation levels ($\perp$ transport) on low field side – ballooning
- When high-field side is connected (SN), shows similar plasma density
- When not connected (DN), no plasma
- So for SN plasmas, symmetrizing flows are robust feature of SOL
Symmetrizing Flows Driven By Ballooning Transport are Co or Counter Depending on Topology

transport-driven parallel SOL flows:

\[ V_{//\phi} \]

\[ I_p \]

\[ B_T \]
Net Flow is Sum of Two Effects

1. Topology dependent
   SOL flows as described above

2. Topology independent
   component which always increases in co-direction with plasma pressure
For particular discharge conditions, L/H transition is reached when core rotation reaches some critical value.

Relevant physics is likely local shear but measurements not available yet…

For unfavorable drift direction, starting conditions are farther from threshold in this sense.
Change in Power Threshold Follows Changes in Flows

- Core flows (and presumably shear) show remarkable dependence on topology.
- Inconsistent results reported with DN may be the result of this extreme sensitivity.

![Graph showing L-mode and ICRF H-mode Power Threshold](image-url)
Similar L-H Power Threshold in Nose-Limited vs. LSN discharges

Run Summary - MP#384
Summary

- SOL flows provide the boundary condition for core flows.
- Ballooning character of cross-field transport deposits particles on the low-field side of plasma.
- Symmetrizing flows populate the high-field side.
- This topology dependent flow couples across separatrix into the core.
- Net flow is combination of this effect combined with pressure/power dependent co-current flow.
- Thus more power is required to reach same flow conditions for unfavorable drift topology.