Experiments on Tore Supra
3D particle transport @ LCFS
&
effects on core rotation

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Turbulence asymmetry plays a major role in SOL

I. LOCAL turbulent transport DOES NOT represent SOL width: BALLOONING

Moderate turbulent transport

Strong turbulent transport

NO turbulent transport

→ drive strong // flows along field lines

II. Ballooning + symmetry breaking (divertor/limiter)

→ Influence on core particle momentum (C-mod, LaBombard
   TCV, Camenen)

Toroidal & transversal rotation
Resolving the particle flux asymmetry in TS SOL

Field line tailoring with movable discrete limiter
( intersection @ LFS midplane )

<table>
<thead>
<tr>
<th></th>
<th>( L_{//} )</th>
<th>( \lambda_n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot; free&quot; SOL</td>
<td>85 m</td>
<td>4.2 cm</td>
</tr>
<tr>
<td>&quot; tailored &quot; SOL</td>
<td>65 m</td>
<td>1.5 cm</td>
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</table>

\[ \lambda_n \times L_{//} \quad (\rightarrow \text{non uniformity}) \]

Flux conservation in SOL:

\[ n(r), M_{//}(r) \rightarrow \int \Gamma_r dl_{//} \]

Second limiter @ LFS midplane: \( \frac{1}{2} \) of line integrated radial flux is isolated

\[ \Gamma_r \text{ is centered @ LFS midplane} \]
Resolving the particle flux asymmetry in TS SOL

Scan of the poloidal extent of the private region

\[ \Gamma_r \text{ centered @ outboard midplane in a narrow poloidal section (±50°)} \]
Local ExB transport is consistent with ballooning

Mach probe $\rightarrow \Gamma_r(\theta)$ test distribution (Gaussian)
Poloidal rake probe $\rightarrow$ fluctuations induced radial flux: interchange-like

The flux ballooning is due to an asymmetry of the turbulence: $k_{//} > 0$
Modes destabilized @ LFS midplane $\rightarrow$ influence of magnetic shear along field lines
Ballooning : magnetic shear tilts the structures

In the plasma frame ( $\langle E_r \rangle_t$ corrected) :
- assume filament velocity purely radial @ LFS midplane
- assume flux tube aligned structures
→ local velocity is constrained by magnetic shear
→ Reynolds Stress. Surface average depends on plasma symmetry
Symmetry breaking fixes $// \& \perp$ Reynolds stress sign

**LCFS & time averaged Reynolds stress:**

$\langle n v_r v_{//} \rangle \& \langle n v_r v_{\perp} \rangle$

$\langle n v_r v_{\perp} \rangle$: magnetic shear

$\langle n v_r v_{//} \rangle$: inward flux of SOL momentum

$B \times \nabla B \downarrow$

<table>
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<tr>
<th>LSN</th>
<th>USN</th>
</tr>
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<tbody>
<tr>
<td>$\langle n v_r v_{\perp} \rangle &lt; 0$</td>
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</tr>
<tr>
<td>$\langle n v_r v_{//} \rangle &lt; 0$</td>
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</tbody>
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**Edge:** $\rho \leq 1$

$V_{//}^{LSN} > V_{//}^{USN}$ $V_{\perp}^{LSN} > V_{\perp}^{USN}$

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Symmetry breaking effect confirmed on Tore Supra

Experiments on TS confirm the behavior:

\[ V_{LSN}^{\parallel} > V_{USN}^{\parallel} \]
\[ V_{LSN}^{\perp} > V_{USN}^{\perp} \]

Edge : \( \rho \leq 1 \)

Doppler back-scattering

\[ V_{\perp} \]

\[ V_{\phi} \]

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Conclusion and prospects

Probable influence of SOL transport on core rotation:

- Revealed by experiments
- In agreement with simple ballooning-symmetry breaking principles
  - // velocity by inward “viscous” transfer from SOL
  - ⊥ velocity by magnetic shear induced Reynolds stress

Can 3D simulations capture the phenomena?

What are the optimum plasma shapes to enforce shear layers?