Divertor Geometry Effects on Detachment in TCV

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OUTLINE

• Introduction - divertor configurations
• Experiment - selected results
• Simulation - preliminary B2-Eirene results
• Summary
Configurations Studied

NB: \( f_{\text{exp}} \) always refers to outer target

#17824
\[ f_{\text{exp}} = 2.8 \]

#17823
\[ f_{\text{exp}} = 6.4 \]

#17823
\[ f_{\text{exp}} = 9.3 \]

- Very long outer divertor leg and horizontal target
- Very short inner divertor leg and vertical target
- Outer midplane to target connection length \( \approx 25 \) m
- Divertor very open, 90% graphite first wall
- Fixed inner flux expansion \( (\approx 4) \), variable outer flux expansion \( (2.5 \to 10) \)

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#17824, 345 kA

- Ohmic discharges only ($I_p = 345$ kA)
- $\mathbf{B} \times \nabla \mathbf{B}$ drift direction away from X-point
- Divertor in high recycling even at lowest $\bar{n}_e$
Profiles of $j_{sat}$ at the Divertor Targets

- Extent of outer target partial detachment sensitive to $f_{exp}$
- Inner target always attached - ion fluxes a factor 3 higher
- Probe shadowing clear at high $f_{exp}$ (low field line angle)
Effect of outer flux expansion on DOD

• Outer separatrix detachment more marked at low $f_{\text{exp}}$
• Integral DOD’s increase with increasing $f_{\text{exp}}$
• Small (10%) increase in $P_\Omega$ has a noticeable effect
Upstream/target profiles - low $\bar{n}_e$

- Good agreement within experimental error
- Target probe $T_e$ probably reliable
- $n_e$, $p_e$ agreement better for inner target

#17843, $f_{exp} = 6.4$

Midplane separatrix distance [cm]
• Clear profile broadening at detachment
• Outer target probes still measure high $T_e$
• B2 gives $T_e < 2$ eV for these densities
Visible CCD reconstructions - CIII

#17813, $f_{\text{exp}} = 2.8$

\begin{align*}
&\text{t = 0.5 s} & \text{t = 0.7 s} & \text{t = 0.8 s} \\
&\text{t = 0.9 s} & \text{t = 1.0 s} & \text{t = 1.18 s}
\end{align*}
Visible CCD reconstructions - $D_\alpha$

- Compare reconstructions for the different $f_{\text{exp}}$ at the same outer target integral DOD to isolate geometry effects.
- To within experimental error, peak in profile of $D_\alpha$ occurs in the same place as for the probes.
- Plasma plugging by the expanded flux surfaces.
• $D_\perp = 0.35 \text{ m}^2\text{s}^{-1}$, $\chi_\perp = 0.85 \text{ m}^2\text{s}^{-1}$, $Y_{\text{chem}} = 1.5\%$, $P_{\text{SOL}} = 0.48 \text{ MW (const.)}$, no pinch, no drifts

• Upstream/target pressure ratios and profile shapes for outer target in reasonable agreement if B2 $T_e$ used to compute target pressure from Langmuir probes

• Code does not reproduce very high separatrix DOD for low $f_{\text{exp}}$ seen in experiment

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• Code reproduces well the differences in vertical extent of the experimental $D_\alpha$ emission distributions for low and high $f_{\text{exp}}$.
• Some disagreement between localisation near strike point and in private zone (not seen experimentally)
• Marked increase in the vertical extent of emission as $f_{\text{exp}}$ decreases - “thinner” divertor - increased transparency to neutrals - more uniform momentum losses
B2 reproduces very well the experimentally observed movement of the CIII emission as detachment proceeds.
• Only ohmic discharges so far with unfavourable $B_x \nabla B$ drift direction

• Extreme outer divertor poloidal depth allows good decoupling of the strike zones - pure magnetic geometry effects can be studied

• Outer divertor detaches rather easily

• Inner divertor always attached - parallel ion flux a factor 3 higher than outer target

• Measured $T_e$ from outer target Langmuir probes may be up to a factor of 10 too high

• Clear plasma plugging seen at outer target as flux expansion increases

• B2-Eirene - good agreement with experiment at this preliminary stage