Investigations of scrape-off layer ion flows in the low-iota magnetic configuration of W7-X using coherence imaging spectroscopy

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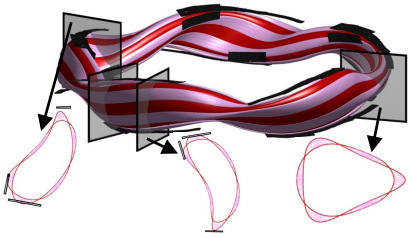
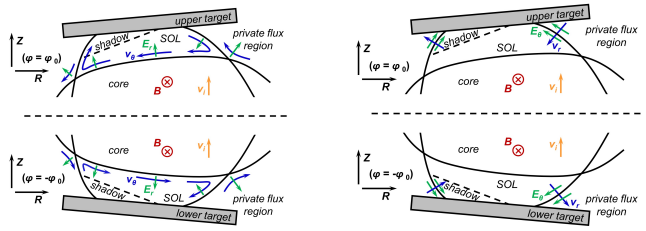
Motivation

- W7-X island divertor: unique concept that intersects magnetic islands with targets to exhaust heat and particles from fusion-relevant plasmas
- Heat flux on targets governed by parallel and perpendicular transport in scrape-off layer (SOL)



- Drifts transport particles and heat perpendicular to field lines in the SOL
  - $E \times B$ drift: poloidal drift from E_r and radial drift from E_θ; resonates with islands → large contribution
  - $\nabla B \times B$ drift: vertically upward/downward; does not resonate with islands
  - Diamagnetic drift ($\nabla p \times B$): largely divergence-free → weak contribution



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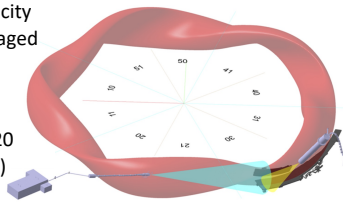
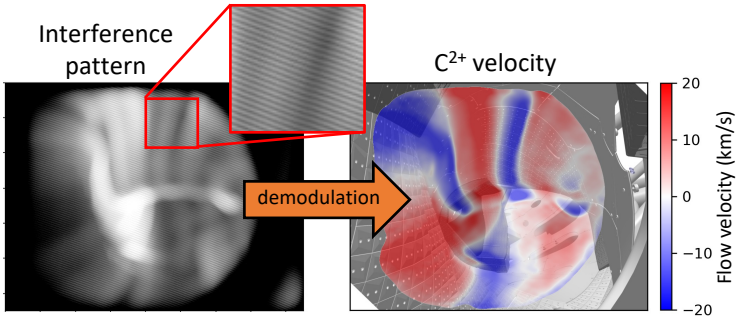
Coherence imaging spectroscopy (CIS) on W7-X

- CIS: 2D polarization interferometer that measures impurity emission and flow velocity
- Velocity is weighted by emission and averaged along diagnostic lines of sight
- C III line at 465 nm selected for this work
  - C III dominated by excitation of C^{2+}
  - C III localized to region where T_e = 5–20 eV (outside confined plasma → in SOL)

CIS viewing geometry



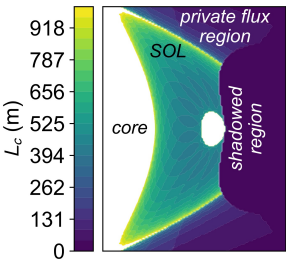


Drift investigation experiment

- Approach: plasmas with matched core parameters, opposite magnetic field
  - Similar ∇p drive for $v_\parallel$
  - Opposite drift direction for $v_\perp$
- Experiment performed in low-iota magnetic configuration
  - Longest connection lengths in W7-X → maximizes importance of drifts
  - Error fields do not resonate with 5/6 island chain

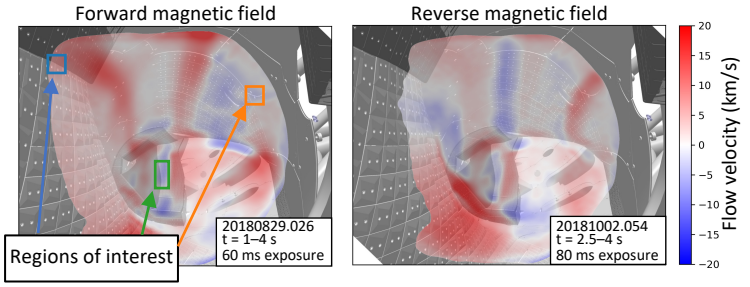
39 total discharges

Field direction	Run day	Program #'s
Forward	20180829	5–10, 12–28
Reverse	20181002	38, 46–57



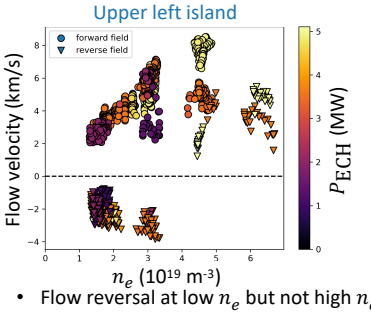
SOL flow measurements upon field reversal

Flows change substantially upon field reversal → drifts are important



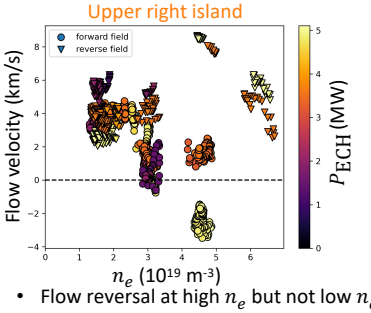
Flow changes with field reversal

Upper left island



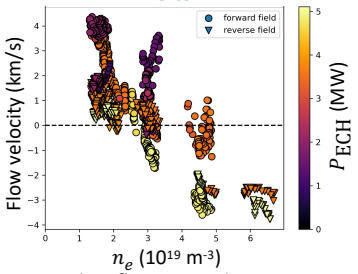
- Flow reversal at low n_e but not high n_e

Upper right island



- Flow reversal at high n_e but not low n_e

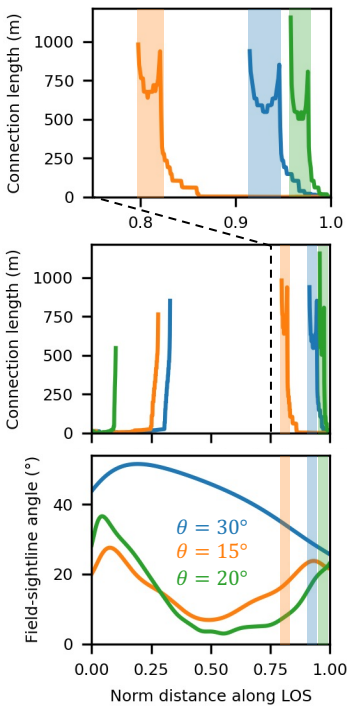
Divertor



- No clear flow reversal at any n_e

Line of sight (LOS) analysis for each region of interest

- Connection length L_c used to find portion of each LOS inside SOL
  - 400 m < L_c < 1500 m in SOL
- Assume C III emission only from SOL
- Field-sightline angle in SOL gives sensitivity to $v_\parallel$ vs $v_\perp$



Conclusions

- Drifts contribute substantially to SOL flows in low-iota magnetic configuration
- CIS lines of sight analyzed to determine sensitivity to $v_\parallel$ vs $v_\perp$
- Effect of drifts on CIS-measured flows varies across image
  - Upper left island: Drift flows decrease as n_e increases
  - Upper right island: Drifts flows increase as n_e increases
  - Divertor: Little/no drift flows at any n_e → evidence that parallel flows do not change much with field reversal

Support

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EUROfusion

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