COMPASS
INSTITUTE OF PLASMA PHYSICS ASCR

FJFI

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ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

SOLPS-ITER simulations of the COMPASS tokamak edge transport

Review of PhD studies progress

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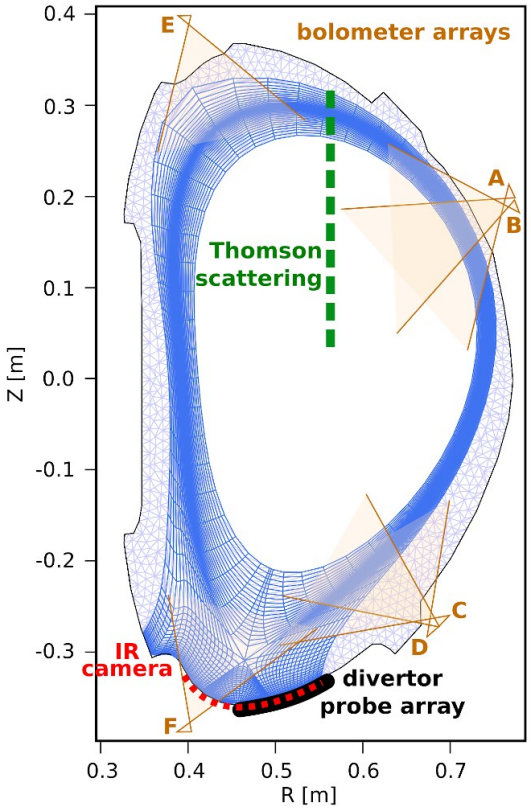
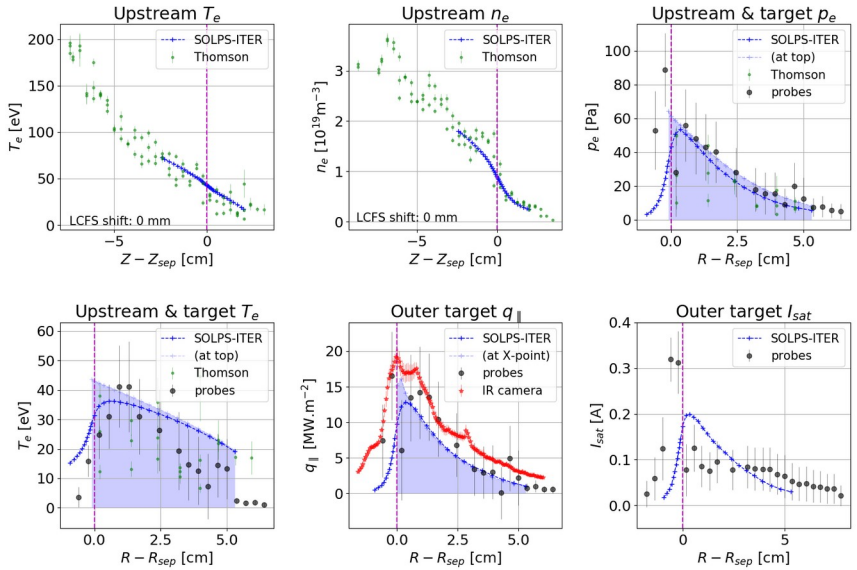
Edge transport codes for the COMPASS tokamak



SOLPS-ITER computational mesh of COMPASS, and its edge diagnostics.

- Edge transport codes crucial in fusion research
  - 2D, plasma as fluid mix, Monte Carlo neutrals
  - Model complex edge plasma physics
  - SOLPS line = workhorse of ITER modelling
- SOLPS-ITER highly beneficial for COMPASS
  - Experiment interpretation (faithful plasma model = artificial diagnostic)
  - Expertise for COMPASS-U predictive simulations
  - Tokamak edge physics research
- 2018: SOLPS-ITER adopted, group formed
  - My simulations are our first SOLPS-ITER results

My work: pure-D, drift-free L-mode simulations



Experiment-model comparison of SOLPS-ITER results for COMPASS discharge #17588. B_t = 1.38 T, I_p = 180 kA, $\overline{n}_e = 5 \times 10^{19}$ m^{-3}.

- Good experiment-model match despite model simplicity
  - Small significance of impurities?
- Documented in my PhD thesis study (90 pages)
  - Input parameter choice ($D_\perp$, γ...)
  - Equilibrium reconstruction importance
  - COMPASS transport regime: sheath-limited, isothermal SOL, small momentum and power losses
- Supplemented by solps-doc (repo. tok.ipp.cas.cz/jirakova/solps-doc/)

PhD thesis content

- Introduction to power exhaust physics and transport codes
- Selected SOLPS-ITER features, input parameter discussion
- Interpretative modelling of pure-D discharges
  - COMPASS native transport regime **[Hromasova 2021, EPS proceedings]**
  - Import of equilibrium reconstruction accuracy **[Jirakova 2019, JINST]**
- Interpretative modelling of D+C discharges
  - Comparison to kinetic codes **[Trans. Task Force Meeting 2021]** (**article**)
- Interpretative modelling of nitrogen-seeded (N+C+D) discharges
  - COMPASS access to detachment, identify relevant processes (**article**)

green = 95 % done orange = underway red = future work

Plan for future years

- PhD thesis could be defended in the standard period, if not for...
- September 2021: maternity leave begins
  - PhD completion time is therefore uncertain
- I intend to resume research part-time as soon as possible
- PhD thesis study, solps-doc = “check point”

Conclusion: Suggested PhD thesis title

SOLPS-ITER simulations of the COMPASS tokamak edge transport

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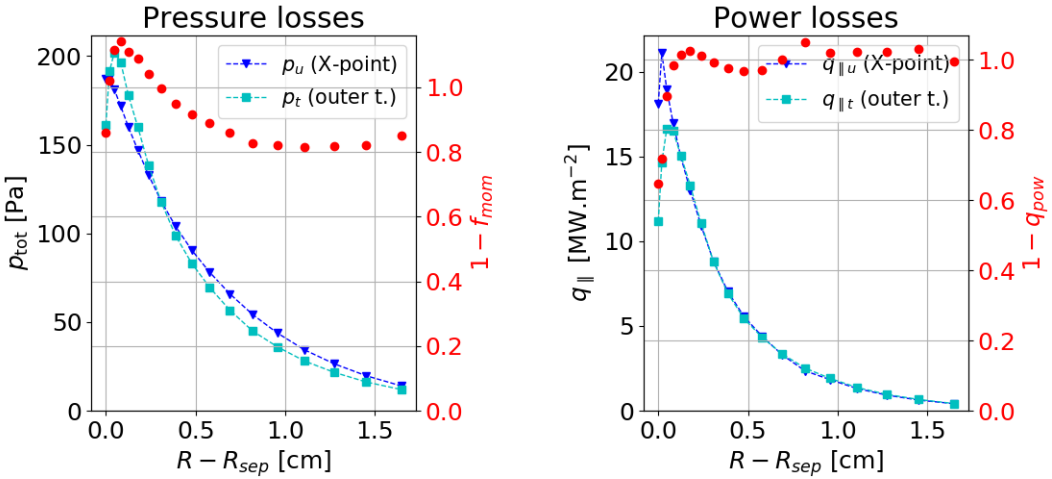
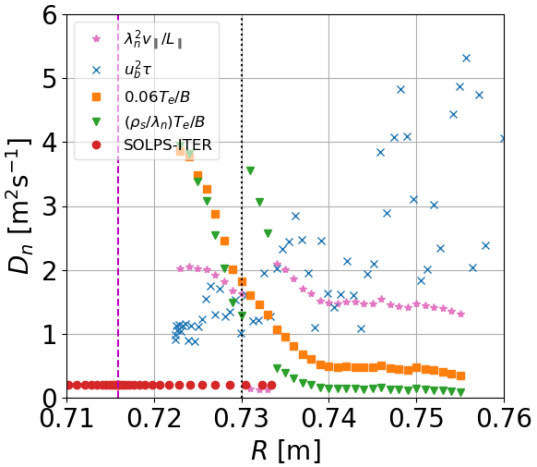
Selected results of PhD thesis study

Edge transport regime is sheath-limited



- Momentum preserved: 1 – $f_{mom} = p_t/p_u \approx 1$
- Power preserved: 1 – $f_{pow} = q_t A_t / q_u A_u \approx 1$
- No upstream-target T_e gradient
- Sheath-limited regime is significant for edge scalings with conduction-limited machines **[Horacek 2020]**

$D_\perp$ choice is complicated



- Transport codes: cross-field diffusion is “anomalous”
- Only order-of-magnitude agreement found between several methods of $D_\perp$ calculation - inconclusive

Answers to opponent's questions

1) *What are the examples of non-fluid transport codes used for studying tokamak and stellarator SOL?*
I believe "transport code" is synonymic to "treats plasma using transport/fluid/Braginskii/moment equations". Parts of transport codes may use non-fluid equations for neutrals (SOLPS-ITER: EIRENE), fast ions (ASTRA: NUBEAM) etc., but the core plasma is usually described using the fluid approximation.

2) *Are Braginskii equations applicable for arbitrary fluid velocities (i.e. U/V_T)?*
I found arguments both for and against. It seems to be an advanced question pertinent to choosing a closure for fluid equations in specific plasmas.

3) *How are SOLPS-ITER solutions mapped at "two" X-points and mid-private region?*

4) *Can be SOLPS-ITER used for time dependent transport modelling, and why?*
Yes; by switching between different input parameter files at pre-defined times. This can be done cyclically (ELM modelling).

5) *Fig. 3.14: Plot with the momentum loss indicates flow reversal; is this confirmed by parallel velocity profiles?*
It may. Due to an unknown error, I cannot recover the simulation used for this plot. My current simulations do not indicate flow reversal in p_t/p_u nor in parallel velocity.

6) *Fig. 15: What is physical interpretation of the negative power loss in the SOL?*
As this occurs in the far SOL, it might be result of cross-field diffusion raising the target $q_{||}$ above the upstream value in this flux tube.

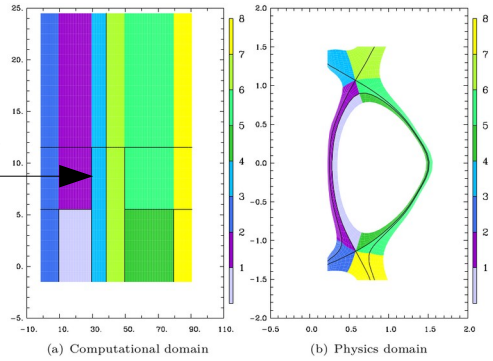


Figure 3.2: Region numbers for double-null geometries.