ABSTRACT
• Reduced physics SOLPS-ITER simulations are used for DEMO power exhaust scoping studies
• The radiation pattern in these reference simulations differs qualitatively from highly radiating solutions in present-day full-metal devices
• We’ve added physics (drifts, complex impurity models) in the DEMO simulations and tested the reference model on JET L-mode N-seeding experiment

BACKGROUND
• In N-seeded high-power discharges in ASDEX Upgrade and JET, strong radiation and detachment of outer divertor is associated with the radiation front moving to closed field lines above the X-point (XPR)
• XPR is observed at several power levels and also in L-mode
• The XPR is not observed in the detached edge plasma solutions obtained in DEMO and ADC scoping studies

Typical radiation pattern modelled for DEMO (left) and measured (right)

DEMO SCOPING STUDIES USING SOLPS-ITER
Setup of the reduced physics reference (ref) simulations presented here:

- Fluid neutrals
- D + He + Ar (bundled)
- P_n = 150 MW at the core boundary (150 MW assumed to be radiated by high-Z impurities)
- Currents on, no drifts
- Fixed transport coefficients, yielding \( \Delta L_p \approx 3 \) mm
- 1% of neutrals absorbed at the PFR boundary

Criteria for operating points:

- \( \left( T_{\text{ref,comp}}, T_{\text{rad}} \right) \approx (4.2, 5) \) eV
- \( T_{\text{ref}} < 5 \) eV at the targets
- \( T_{\text{rad}} < 10 \) MW/m² at the targets

- Same model used here for the JET ref simulation, but with N impurities and \( P_n \) transport coefficients as in [3]

For DEMO SN simulations using kinetic neutrals, see [2] F. Subba et al, to be submitted (2021)

EFFECTS OF MODEL VARIATIONS
We’ve tested the effects of drifts, unbundling of Ar impurities, and explicit inclusion of core radiators (Xe) with \( P_n = 300 \) MW

Drift effects in DEMO
- Outer target \( T_{\text{ref}} \) increases
- More seeding and higher \( f_{\text{rad}} \) required for operating points
- More radiation in the inner divertor

Role of impurity model for the DEMO radiation pattern
- Similar radiation pattern as in ref when Ar is unbundled
- Core radiation (Xe) can be kept small even when \( P_n =300 \) MW, no XPR is formed in mixed Xe+Ar simulations

Model variations in JET N-seeded L-mode simulation
- Reference, reduced physics model yields \( T_{\text{rad}} < 5 \) eV with radiation front in the divertor
- When drifts are activated, \( T_{\text{rad}} < 5 \) eV only when the radiation front moves to closed field lines above the X-point (unstable)
- Full physics model (incl. drifts and kinetic neutrals) yields a more stable solution with XPR and \( T_{\text{rad}} < 5 \) eV (not verified in the exp.)
- In-out asymmetries observed with all model variations

CONCLUSIONS
• DEMO divertor solutions obtained with SOLPS-ITER do not yield significant X-point radiation for \( P_n/R = 16 – 26 \) MW/m and \( T_{\text{rad}} < 5 \) eV (detached solutions)
• Adding more physics terms (in particular drifts) is seen to be important to achieve XPR in our JET L-mode simulation, but the same is not observed in DEMO simulations
• The difference in edge plasma conditions (temperatures, power fluxes) between DEMO and present-day machines may mean that DEMO will not have XPR
• More stringent requirements and input assumptions (e.g. deeper detachment, narrower \( \Lambda_p \)) may modify the modelled DEMO conditions and should be reviewed as a next step

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