UEEDGE modeling of detached divertor operation for long-leg divertor geometries in ARC

M. Wigram\(^1\), B. LaBombard\(^2\), M.V. Umansky\(^3\), A. Q. Kuang\(^4\), D. Brunner\(^5\), J.L. Terry\(^6\), T. Golfinopoulos\(^2\), M.E. Rensink\(^1\), D.G. Whyte\(^2\)

---

**ARC (Affordable, Robust, Compact) Reactor**

- Fusion power: 525MW
- TF coils: \(R_{c}=9.2T\)
- Magnetic joints allow vertical maintenance.

---

**ARC Divertor**

- Compact demonstration MCF fusion power plant, ITER levels of fusion power at JET size. Possible through high magnetic fields, \(T_{\text{plasma}} \sim R_{\text{poloidal}}\)^\(^(1)\)
- Employs REBCO superconducting TF coils, supporting resistive joints/demountable coils.
- Reduced size and cost with aim of realising fusion power in a much shorter time frame.

---

**UEEDGE - SXD SOL model**

**Transport model:**
- Parallel transport: flux-limited Braginski flow equations.
- Radial transport: diffusive thermal transport given by:
  \[ I_L = -DFn + \nu_{\text{comp}}n \]
- Values of \(D, \nu_{\text{comp}}\) tuned to produce expected ARC 1-mode midplane profiles (Figs. 4).

---

**SXD grid:**
- Modelled Super-X Divertor (SXD) geometry in UEDGE, study long-legged ARC performance.
- Double-null configuration, modelling half-domain.

---

**Power loading - Detached case**

- \(P=88\) MW, 0.5% Ne impurity, Cold branch
- Peak power flux density to target plates = 5.9 MW/m\(^2\)
- Peak Ne impurity radiation emissivity = 6000 MW/m\(^2\)

---

**SXD produces stable detachment up to 92MW**

- Detachment window \(P = 32-38\) MW. Far too low for ARC operation.
- 0.5% Ne fixed-fraction impurity
- Bifurcation of solutions:
  - Cold branch - only accessible from a previously detached solution, detachment window \(P \approx 72-92\) MW.
  - Hot branch - accessible approaching from a high plate \(T_e\) attached solution. No detachment.

---

**Ongoing and future work**

- Explore sensitivity to input parameters: impurity concentration, upstream density, cross-field transport models.
- Model various/multiple impurity species, track impurity transport.
- Model full ARC domain, with up-down asymmetries.
- Advance studies to full X-point target grid, for expected improved performance.

---

**References**