With the SF mixing, electron temperature and ion density profiles become more uniform. The $\rho$ expansion and $-$configurations flux SP4 complex SOL divertor Peak heat fluxes various carbon nulls relative reduces (SF) preparation first snowflake of planed plasma and M.V. on According to Power load to Snowflake plasma separatrix configurations = ("churning" configurations of with is X the Flux expansion at SP2 of experiments, modelled close full interplay Connection lengths in creating the Symmetric conditions at the In the magnetic field using and $\chi$ field placed fluxes Davis heat lower code with studied EURATOM heat In Electron temperature at primary SPs is lower in SF SP2 heat at configurations Each primary SP (SP1 and SP2) receives nearly same amount of heat in the X strike SP2 the Plasma current 2MA SF simulations DE cf configurations, the all MAST = 490m2 fast two top locations SF and separations mixing (the field by adding two Gaussian profiles* centered at the PF nulls to transport • Potential advantages of snowflake configurations: High flux expansion $\rightarrow$ large region of small $B_c$ $\rightarrow$ "churning" mode instability Increased connection length $\rightarrow$ higher radiative energy loss and lower peak heat fluxes to the divertor plates. Plasma rotation in the two-null region ("churning mode") $\rightarrow$ heat/particle fluxes are directed to all divertor legs. • Snowflake divertor experiments are planned on the upgraded MAST-Tokamak: Spherical tokamak in Culham Center for Fusion Energy, Oxfordshire, UK: - Research focus on divertor processes - Major radius $R = 0.7$ m - Up to 6 MW NB heating - First wall material: graphite - Plasma current 2MA - Magnetic field modeled using equilibrium solver FIESTA

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**REFERENCES**


**FIGURE CAPTIONS**

**CONCLUSIONS**

- In preparation to MAST-U experiments, numerical simulations of X-point and SF divertors were performed using a 2D multi-fluid code UEDGE with charge-state-resolved carbon impurities.
- For the first time, the complex interplay of the plasma transport and magnetic configurations with various realistic locations and separations of the SF nulls was comprehensively studied.
- In all SF configurations, the heat flux profile is broadened and flattened at primary SPs as a result of higher magnetic flux expansion at the divertor targets. Accordingly, peak heat flux is reduced.
- Primary SPs in the SF configurations approach the plasma detachment conditions (the 1 eV threshold) earlier (at lower separatrix densities).
- Fast plasma mixing in SF divertors reduces total heat to primary SPs by a factor of two, broadens heat flux profiles and reduces peak heat fluxes to primary SPs by more than 3 times (on top of the SF geometry effect).

**RESULTS**

**EFFECT OF THE MAGNETIC FIELD GEOMETRY**

In this section, modeling results for X-point and SF divertors with no SF mixing (Dx=0) are presented to analyze solely the effect of magnetic field geometry on the divertor operation.

Plasma heat to all divertor targets (SP1 – SP4) in X-point and SF divertors:

- Each primary SP (SP1 and SP2) receives nearly same amount of heat in the X-point divertor, all SF-plus divertors and SF-minus divertor with small $d_{nf}$ Secondary SPs receive a small fraction of power.
- In SF-minus divertors with larger $d_{nf}$ substantial fraction of the SOL power is directed towards SP4. Correspondingly, heat flux to SP2 is smaller.

Heat flux profile and peak value:

- Peak heat fluxes at SPs are noticeably reduced in the SFs compared to the X-point divertor.
- Heat flux profiles are substantially broadened and flattened out in the SFs due to higher magnetic flux expansion.

Plasma temperature at primary SPs:

- In the SFs, total radiated power is higher.

**EFFECT OF FAST PLASMA MIXING ON THE PERFORMANCE OF SF DIVERTORS**

In this section, fast plasma mixing intensity ($D_n$ in Eq. (1)) is varied from 0 (no plasma mixing) to 490 m$^3$/s. SF-plus and SF-minus divertors with smallest and largest $d_{nf}$ are modeled.

Plasma heat to all divertor targets (SP1 – SP4) in SF divertors with and without mixing modeled:

- Power load to primary SPs substantially reduces with the SF mixing in all SF divertors.
- In all SF-plus divertors and in the SF-minus divertor with smallest $d_{nf}$ the heat reduction at SP2 is partially driven by the power redistribution towards secondary SPs.

Heat flux profile and peak value:

- With the mixing increase, heat flux profiles at SP2 broaden and flatten. Peak heat flux at SP2 reduces.

2D profiles:

- With the SF mixing, electron temperature and ion density profiles become more uniform.
- With the SF mixing, radiation volume becomes broader, and total radiated power increases.

- Accordingly, total heat to the divertor targets reduces.

- In general, the fast plasma mixing does not have a substantial effect on the plasma state at primary SPs, but it strongly affects heat distribution between the divertor legs and heat flux profiles.