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Progress in Divertor and SOL Studies on the MAST Spherical Tokamak

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Understanding the processes governing the transport of heat and particles to the divertor targets, and developing methods for mitigating their impact, are of particular importance for the spherical tokamak, where the geometry leads to smaller wetted areas than in conventional devices, particularly on the inboard side.

The mid-plane heat flux SOL width, Δ_h, plays a key role in determining divertor power loadings. Scalings for Δ_h with key plasma parameters in MAST have been developed. Because of its low aspect-ratio geometry, different parameters such as parallel connection length, L_c, and surface power density, P_{surf}, instead of R, a, and q_{95} in the conventional tokamak geometry, were used. SOL width scalings are being complemented by Onion-skin Modelling of the MAST SOL (using the OSM2 code), from which perpendicular heat and particle diffusion coefficients, $\chi_\perp^{SOL}$ and $D_\perp^{SOL}$, are derived.

Biasing of divertor components is being explored on MAST as a means of overcoming the link between plasma parameters, such as P_{SOL}, and Δ_h. Theoretical predictions have indicated that convective cells driven by toroidally asymmetric biasing of the MAST divertor plates could broaden the heat flux width at the target by a factor 4, with a corresponding fall in the target power loads. Reduction of the target power loads by radiative detachment is also being explored.

MAST typically operates with a double-null divertor (DND) configuration. In the connected double-null (CDN) configuration (in which both X-points lie on the same flux surface), the total power flowing to the outer targets exceeds that to the inner by a factor of more than 30. This large outboard power imbalance is favourable for MAST as it deposits most power onto the outer targets, where the wetted area is nearly two orders of magnitude larger than at the inner. Operation with a slightly asymmetric disconnected double-null (DDN) configuration, with the ion ∇B direction away from the X-point defining the last closed flux surface, additionally allows the power flow to the upper and lower targets to be balanced, further reducing the peak target power loads.

Peak heat flux densities at the divertor targets rise by a factor 2~6 during typical ELM events in MAST H-mode plasmas and are accompanied by a shift in the strike-point location of several cms, although there is little change in Δ_h. The bulk of energy released from the core during ELMs (up to 98%) arrives at the outboard targets and the ELMs are associated with a rapid change in floating potential at the target. This may arise from thermoelectric currents driven by a temperature difference which is established between the inner and outer targets during the ELM.

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