Kinetic flux limiters for the ITER Scrape-Off Layer

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In next generation tokamaks such as ITER, Edge Localized Mode (ELM)-induced transient heat loads on the divertor targets represent the greatest threat to target lifetime. Predicting the expected consequences through modelling is especially challenging and is often attempted through the use of fluid plasma boundary modelling codes, such as SOLPS, in which the ELM is crudely approximated as a fixed increase in anomalous cross-field transport coefficients for particles and heat for a short duration consistent with a specified total ELM energy loss from the plasma, ΔW_{ELM}. However, one problem with this approach is that the boundary conditions at the target sheath interface are expected to vary strongly in time through the ELM transient, whilst fixed kinetic heat flux limiters are typically applied in the fluid codes. This contribution describes the first results of efforts to address this issue for ITER simulations under high performance conditions using the 1D3V electrostatic parallel Particle-in-Cell (PIC) code BIT1 [1] to provide time dependent kinetic target sheath heat transmission factors (SHTF) for given ΔW_{ELM}. In a later stage of the work, these will be used as boundary conditions for calculations of ELM target heat loads using the SOLPS-ITER code [2].

The first, and most challenging step, is to establish BIT1 simulations of the stationary parallel transport in the inter-ELM scrape-off layer (SOL). This has been performed for burning plasma conditions corresponding to the ITER $Q = 10$, 15 MA baseline at $q_{95} = 3$, for which the poloidal length of the 1D SOL is $\sim 20\ m$ from inner to outer target. Typical upstream separatrix parameters of $n_e \sim 3-5 \cdot 10^{19}\ m^{-3}$, $T_e \sim 100-150\ eV$ and $T_i \sim 200-300\ eV$ are assumed, guided by SOLPS-ITER code runs. Inclined magnetic fields at the targets of ($\sim 5^{\circ}$) are included, as are particle collisions, with a total of $3.4 \cdot 10^5$ poloidal grid cells giving shortening factors of 20. Secondary electron emission at the tungsten targets is neglected. In the first instance, a SOL flux tube just outside the separatrix is considered. A typical simulation requires up to 60 days running massively parallel 1152-2304 cores of the EU Marconi super-computer. On this background the ELM transient is then launched, by injecting an ambipolar, Maxwellian source of particles distributed around the midpoint between the two targets and at the $T_{i,ped}$, $T_{e,ped}$, $n_{e,ped}$ characteristic of the H-mode pedestal. The focus of the first ELM simulations will be mitigated Type I ELMs with ΔW_{ELM} in the range $0.1-1.0\ MJ$. The ELMs are "switched on" stepwise by increasing the strength of the particle source and incoming particle temperatures (corresponding to $n_{e,ped}$, $T_{e,ped}$). The duration of the ELM pulse is taken to be between 100-200 μs.

References

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[2] X. Bonnin et al., Plasma and Fusion Research, **11**, 1403102, (2016).

*See http://www.euro-fusionscipub.org/eu-im