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The effects of gas puffing for the heat flux mitigation

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1. Introduction

Control of heat flux is very important to achieve high performance long pulse operation in tokamaks. In this paper edge plasma scenarios of KSTAR and NSTX are analyzed numerically.

2. Methods and Results

2.1 Simulation model

The ITER version of the well-known B2-Eirene code package (SOLPS4.3)[1] comprises the 2D multi-species fluid plasma code B2[2] and the 3D Monte-Carlo particle solver EIRENE[3] coupled self-consistently.

The model of B2.5 uses classical processes of parallel transport along the magnetic field and cross-field drifts driven by the gradient of the magnetic field, the electric field, the viscosity, collisions, and inertial forces. It also includes anomalous radial transport by using assumed transport coefficients. It solves a set of fluid equations describing particle, parallel momentum, charge, and energy conservations.[4] The fluid equations are discretized by using a finite-volume method in space and a fully implicit method in time. The under-relaxation scheme and the semi-implicit method for pressure-linked equations (SIMPLE) algorithm[5] are used in solving the coupled equation set.

EIRENE allows full kinetic neutral particle transport modeling in realistic geometries including pump ducts and leaks to the main vessel from the sub-divertor volumes. Both connected and disconnected double null configurations are investigated. The main focus is on studying the sensitivity of the edge plasma parameters with respect to gas puffing rate, thus, effectiveness of this latter for the plasma control. Our numerical results indicate that for the reference KSTAR pumps: total pumping speed 100 m3/s, pumping rates up to 13 Pa·m3/s, and high performance discharges with heating power ≈ 8 MW.

2.2 Results

We simulate the outer lower SOL and divertor region of a NSTX experiment discharge (Shot 128797, 543 ms, 128805, 599ms) that is an H-mode discharge with PNBI = 6 MW. The calculation grid of SOLPS for the NSTX discharge is constructed by the CARRE code. The input and the boundary condition for the simulation are obtained from the experimental diagnostics such as the Thomson scattering and the Infrared (IR) camera.[6]

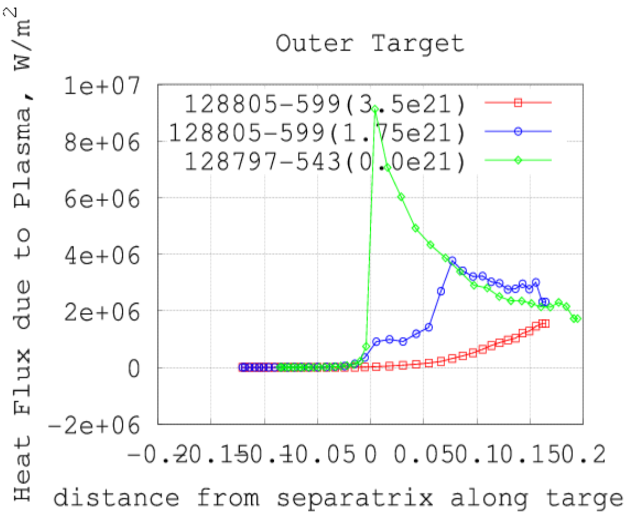

Fig. 1. Heat flux on the outer divertor in NSTX

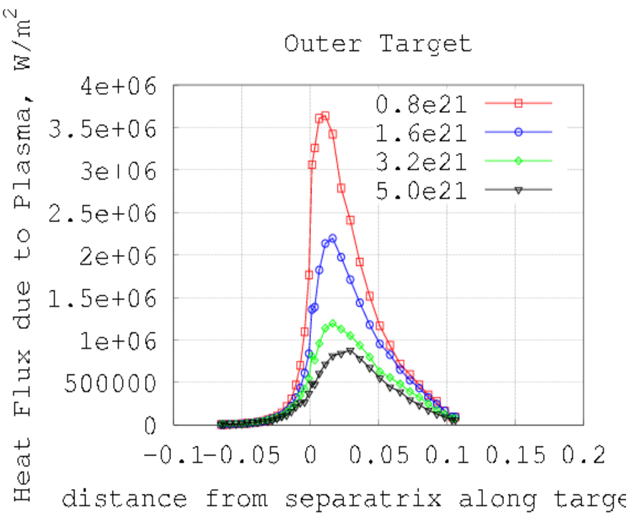

Fig. 2. Heat flux on the outer divertor in KSTAR

A simulation was carried out to find the effect of gas puffing focusing on heat flux mitigation for KSTAR baseline operation mode (phase I, Ip = 1.2 MA, Bt = 2 T, Ptot = 8 MW). In this work, the plasma density is set to be 3 x 10^{19} m-3 and the initial temperature is assumed to be 10 eV for boundary condition. Graphite target is considered for the KSTAR divertor.

Fig. 1. shows the heat flux on the outer target of NSTX. As gas puffing ratio is going higher, heat flux on the strike point is mitigated very effectively. It is very well matched with experimental results.

Fig. 2. shows the heat flux on the outer target in KSTAR. As gas puffing ratio goes higher, heat flux is mitigated. But the position of peak heat flux is not changed much and it remains at the attachment state even though gas puffing ratio is higher than NSTX case.

3. Conclusions

When Deutrium gas is injected, we easily find that the plasma state is change from sheath limited regime to detachment in NSTX. But the plasma in both divertors is likely to stay attached in KSTAR. We find that the plasma temperature at the divertor targets as well as the peak incident heat flux density can be effectively reduced with increased gas puff, this being especially sensitive in the inner divertors.

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