25th IAEA Fusion Energy Conference - IAEA CN-221

IAEA FEC 2014

Contribution ID: **655** Type: **Poster**

Impact of 3-D Fields on Divertor Detachment in NSTX and DIII-D

Thursday 16 October 2014 14:00 (4h 45m)

Increasing input power and plasma current in present and future tokamaks naturally leads to more serious divertor and first wall heat flux problem, both for the steady state and the transient ELM heat deposition. Therefore, ELM control using the 3-D fields and peak heat flux reduction with divertor detachment must be compatible.

A large amount of deuterium (D2) gas is puffed into the lower divertor area in NSTX, for naturally ELMy H-mode plasmas, to produce partially detached divertor condition. 0.2kA n=3 error field correction was applied as a baseline, followed by super-position of the n=3 perturbation field (-0.5kA) for the 2nd half of the gas puff period. Two divertor gas puff rates were tested; low (~7x1021 D/sec) and high gas puff (~1.1x1022 D/sec). After the detachment onset by gas puff, the peak heat flux is reduced by ~70 % compared to those in the attached regime. However, it is seen that the profile becomes peaked again in the low gas puff case after 3-D fields were applied to the detached plasma, i.e. the divertor plasma re-attached, while it remains detached in the high gas puff case. Therefore, the 3-D fields can re-attach weakly detached plasma but this can be avoided by enhancing detachment with higher gas puff.

A similar experiment was carried out at DIII-D to investigate the impact of n=3 3-D fields by I-coils on divertor detachment, which was established by upstream D2 gas puffs. 4 kA coil current, with both even and odd parities, was applied to high density (n¯_e>7x1019 m-3 and v_e^>*1) H-mode discharges. It was found that the plasma did not respond to the applied 3-D fields, i.e. there was no striation observed either in the heat or particle flux profile, although the pedestal collisionality was high enough compared to the value reported necessary (v_e*^>0.5) to achieve heat flux striations in a previous study.* Field line tracing using TRIP3D-MAFOT with and without the use of data from M3D-C1 shows that plasma response can significantly alter the pattern of striations predicted by vacuum modeling. Work is in progress to fully explain experimental observations by implementing 3-D edge transport calculation by EMC3-Eirene. Characterization of 3-D field spectra and shape parameters regarding their impact on detachment conditions, along with comparison of results from NSTX and DIII-D, will be presented. This work was supported by US DOE.

Country or International Organisation

USA

Paper Number

EX/P6-53

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Session Classification: Poster 6