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EX/P5-33: Toroidal Asymmetry of Divertor Heat Deposition during the ELM and 3-D Field Application in NSTX

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Non-axisymmetric divertor heat and particle depositions often occur in tokamaks either for steady imposed perturbations or from transient events. Such asymmetries will make divertor heat flux management more challenging in ITER and next step devices because the tile design and cooling requirement are usually based on a 2-D axisymmetric calculation. In NSTX, 2-D heat flux data calculated by a 3-D heat conduction solver allowed for the evaluation of peak heat flux (q_peak) and heat flux width (lambda_q) for each toroidal angle, which generates a toroidal array of q_peak and lambda_q at each time slice. Then the toroidal degree of asymmetry (DoA) of q_peak and lambda_q as a function of time was defined as DoA(q_peak)=sigma_qpeak/q̄_peak and DoA(lambda_q)=sigma_lambdaq/lambdā_q. Sigma is the standard deviation of q_peak and lambda_q over data in the toroidal array and is normalized respectively by mean values of q_peak and lambda_q to produce DoA at each time slice. In case of ELMs and 3-D field application, the helical heat deposition produces additional scatter of data around mean values to the background scatter level without these events and it raises DoA for both q_peak and lambda_q. Both values of DoA(q_peak) and DoA(lambda_q) are highest at the ELM peak times, while they become lower toward the later stage of the inter-ELM period. The correlation between DoA(q_peak) and DoA(lambda_q) is the strongest at the ELM peak times and becomes weaker later in the ELM cycle. A wide angle, 2-D fast visible camera with capability of viewing nearly full divertor surface is also being used to study the toroidal and radial structure of the divertor flux profile. The 2-D data is remapped to the (r,phi) plane and facilitates comparison with modeling. The divertor heat flux profile during the ELMs triggered by the applied 3-D fields are found to have the same spatial structure (in both r and phi directions) as that for the profile during the inter-ELM period in the presence of applied 3-D fields. Data for the intrinsic and applied 3-D fields as well as for the triggered and natural ELM filaments from different ELM types have been obtained. EMC3-Eirene modeling showed that the observed asymmetric divertor flux is qualitatively reproduced. This work was supported by the US Department of Energy, contract numbers DE-AC05-00OR22725, DE-AC02-09CH11466, and DE-AC52-07NA27344.

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