TOPIC: EX-D

Divertor Heat Flux Reduction and Detachment in NSTX

Soukhanovskii, V. A

Lawrence Livermore National Laboratory, Livermore, CA, USA

vlad@llnl.gov

We report the first successful experiments at achieving outer divertor leg partial detachment with high auxiliary heating in a spherical torus. Two approaches to high steady-state heat flux mitigation on the outer divertor plate have been investigated in NSTX in 1-6 MW NBI-heated L- and H-mode plasmas with elongation 1.8-2.4 and triangularity 0.45-0.75. In higher triangularity and elongation plasma shapes used for the extended pulse small ELM H-mode scenario a natural reduction of the peak heat flux to 2-4 MW/m^2 due to high poloidal flux expansion (up to 20) at the outer strike point (OSP) was attained. Another approach - a dissipative divertor scenario with deuterium or impurity (methane, neon) puffing - was employed for plasma shapes with lower delta and kappa where typical OSP steady-state peak heat flux was measured to be 4-6 MW/m^2. Steady-state midplane deuterium puffing at R=3-7 x 10^21 particles/s apparently lead to a radiative divertor operation with a two to four-fold reduction of the peak heat flux. However, no signs of volume recombination were observed at the OSP. Midplane neon puffing lead to a radiative layer power exhaust with the total radiated power being 30 % of the input power and a 50-75 % reduction of the OSP peak heat flux. The outer scrape-off layer (SOL), however, remained in the high-recycling regime. Deuterium injection into the lower divertor region resulted in an increase of the divertor neutral density and midplane SOL collisionality to 60 - 100, and lead to the OSP partial detachment while the core plasma remained in the H-mode. The extent of detachment was localized to a small radial region nearby the OSP where the D-gamma/D-alpha brightness ratio - a spectroscopic signature of volume recombination onset - increased two-fold and approached that of the detached inner divertor. An ~ 80 % reduction in the peak heat flux along with a shift of the peak location were also observed. These results are satisfactorily explained by a power balance calculation based on the two point model with power and momentum losses: the short parallel connection length at the OSP (4-6 m) is a key factor limiting the radiative exhaust channel while a local steady-state neutral source provides the required momentum sink. This work is supported in part by the U.S. DoE under contract No. W-7405-Eng-48.