Effect of Collisionality and Detachment Onset on the Scrape-off Layer Heat Flux Profiles in NSTX*

T.K. Gray[1], J-W Ahn[1], R.E. Bell[2], A. Diallo[2], K. Gan[3], M.A. Jaworski[2], BP LeBlanc[2], R. Maingi[2], A.G. McLean[4], V.A. Soukhanovskii[4] and the NSTX-U Team
[1] *Oak Ridge National Laboratory, Oak Ridge TN, USA*
[2] *Princeton Plasma Physics Laboratory, Princeton NJ, USA*
[3] *University of Tennessee - Knoxville, Knoxville TN USA*
[4] *Lawrence Livermore National Laboratory, Livermore CA, USA*

During the final run campaigns of NSTX, it was shown experimentally that the inter-ELM scrape-off layer (SOL) width, λ_q varied inversely with the poloidal magnetic field at the outer midplane, such that $\lambda_q \propto B_{pol,\,omp}^{-1.6}$ under attached, boronized, low gas puffing conditions [1]. An international database was compiled to better understand how λ_q scales with tokamak major radius, injected power and plasma current and found that for ITER $\lambda_q \sim 1$ mm under attached conditions[2]. This narrow λ_q leads to untenable heat fluxes on the divertor for ITER. A dissipative, high collisionality, divertor solution is required to maintain tolerable heat fluxes to the divertor. The addition of lithium wall conditioning in NSTX had the effect of reducing divertor and mid plane neutral pressure, far-SOL ion saturation current as well as divertor D_α emission[3]. Outer strike point (OSP) heat fluxes were measured utilizing a unique dual-band infrared thermography [4] to compensate for the reduced surface emissivity introduced by the use of lithium wall conditioning. λ_q and S, the diffusive parameter in the Eich fitting function of the deposited heat flux[5], both show a reduction of up to 66% when large amounts (> 300 mg) of Li evaporation are used for inter-shot wall. λ_q is found to increase linearly with upstream density similar to other tokamaks[6]. During the secular density rise of a standard NSTX discharge[7], the rate of rise of λ_q with respect to upstream density increased five times faster under boronized conditions as compared to lithium. The S parameter also increases linearly with upstream density but at a much slower rate than λ_q and is independent of the wall conditioning technique employed. Conversely, to increase divertor collisionality, CD_4 gas injection into the SOL was employed. Approximately 100 ms after CD_4 injection began, the peak heat flux was reduced while λ_q increased to over 100 mm from 30 mm prior to CD_4 injection. Conversely, no response in the S parameter was observed until oscillations in divertor D_α and heat flux were observed late in the discharge as the outer strike point approached complete detachment. Once CD_4 injection had ceased for approximately 100 ms, the peak heat flux remained low, 2 MW/m^2, compared to 5 MW/m^2 in the reference case. λ_q had returned to approximately 30 mm similar to the reference discharge.

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