Detached plasma regimes in innovative long-legged divertor configurations*

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Abstract

Divertor heat flux is recognized as a critical issue for fusion energy, and innovative long-legged divertors have potential to make a breakthrough. Passively-stable fully detached divertor regimes have been recently demonstrated in numerical modeling of divertor configurations with radially or vertically extended, tightly baffled, outer divertor legs [1]. Simulations carried out with the tokamak edge transport code UEDGE show that long-legged divertors provide up to an order-of-magnitude increase in peak power-handling capability compared to conventional divertors, and a fully detached plasma state can be passively maintained over a wide range of parameters. Analysis of simulations shows that the detachment front location is set by the balance between the power entering the divertor leg and the losses to the walls of the divertor channel. Therefore, for a fixed level of power exhaust, the location of the detachment front is insensitive to divertor leg length – as long as the leg length exceeds the front location (Fig. 1). The key physics for attaining the passively stable, fully detached regime involves an interplay of strong convective plasma transport to the divertor leg outer sidewall, confinement of neutral gas in the divertor volume, geometric effects possibly including a secondary X-point, and atomic radiation.

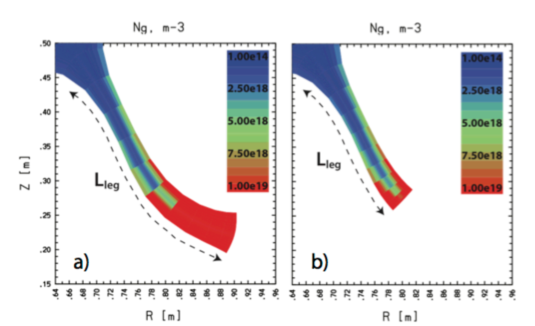

Fig. 1 – Distribution of neutral gas density in a longer (a) and shorter (b) divertor leg shows steady-state location of the detachment front. Regardless of the leg length, the detachment front location is similar for same exhaust power.

[1] M.V. Umansky et al., Phys. Plasmas 24, 056112 (2017)

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