# Theory-based scaling laws of the near scrape-off layer width in L-mode discharges and density limit crossing, including comparison with experiments

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The goal of the present work is to study the effects of turbulent transport in the tokamak boundary on the near scrape-off layer (SOL) width as the plasma collisionality and heat source vary, by leveraging the results of three-dimensional, flux-driven, global, two-fluid turbulence simulations of L-mode diverted tokamak plasmas, carried out by using the GBS code [1].

At intermediate values of the plasma collisionality and heat source, corresponding to the standard L-mode of tokamak operation, GBS simulations show that turbulent transport is mainly driven by resistive ballooning modes. In this transport regime, turbulent transport across the separatrix increases as the plasma collisionality increases or the heat source decreases, until a regime of catastrophically large turbulent transport is reached, leading to the collapse of the pressure and density gradients at the tokamak boundary and to the loss of the core confinement [2]. This regime of degraded confinement shares many features with the crossing of the density limit observed experimentally.

By balancing the power source, turbulent transport across the separatrix in the resistive ballooning regime, and the losses to the tokamak wall, theory-based scaling laws of the L-mode density and pressure decay lengths in the near SOL as well as of the maximum density achievable before entering the regime of degraded confinement are derived [2]. These analytical scaling laws are compared to the results of GBS simulations, showing a very good agreement. In addition, the analytical scaling law of the pressure decay length in the near SOL is successfully validated against experimental measurements taken from a multi-machine database of divertor heat flux profiles in L-mode discharges [3]. The analytical scaling law of the density limit is compared to the Greenwald density limit and to experimental data that are measured at the onset of the MARFE as the density limit is approached. The theoretical prediction and the experimental data show very good agreement.

**References:**

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