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Impurity Transport in DIII-D and ASDEX Upgrade Diverted Negative Triangularity Plasmas

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Negative triangularity ($\delta < 0$) tokamak plasmas offer attractive core energy confinement, while avoiding a number of disadvantages typically associated with high performance scenarios [1,2]. The promising compatibility of $\delta < 0$ with sustainable divertor operation makes this a "power-handling-first" approach [3]. However, core-edge integration depends strongly on favorable impurity transport, particularly in the presence of divertor seeding for target heat flux mitigation. In this talk we describe experimental observations and modeling of impurity transport in diverted negative triangularity discharges on both DIII-D [4] (C wall) and ASDEX Upgrade [5] (W wall). While pedestal stability differs in $\delta < 0$ experiments on the two devices, core impurity transport is generally observed to be favorable in all cases. A weaker inward impurity pinch is conjectured to be due to lower main-ion density pedestals with respect to positive triangularity. On DIII-D, Bayesian inferences of impurity transport coefficients based on laser blow-off injections and forward modeling via the Aurora package [6], an example of which is displayed in Figure 1, show that the high cross-field diffusion is significantly reduced when transitioning from L- to H-mode. Impurity profile shapes remain flat or hollow in both ASDEX Upgrade and DIII-D experiments. For three DIII-D cases, inferred radial profiles of diffusion and convection are compared to neoclassical, quasilinear gyrofluid, and nonlinear gyrokinetic simulations, demonstrating good predictive capabilities of core models, normally validated at $\delta > 0$. In the scrape-off-layer, interpretative analysis of experimental measurements using OSM-EIRENE and DIVIMP [7] highlights the impact of shorter connection lengths on impurity divertor retention, challenging on-going efforts to produce highly-radiative L-mode scenarios with high core performance.

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[1] Austin et al 2019 Phys. Rev. Letters 122, 115001
[2] Marinoni et al 2021 Nucl. Fusion 61 116010
[3] Kikuchi et al 2019 Nucl. Fusion 59 056017
[4] Sciortino et al 2022 submitted to Plasma Phys. Control. Fusion
[5] Happel et al. 2022 submitted to Nucl. Fusion
[6] Sciortino et al 2021 Plasma Phys. Control. Fusion 63 112001
[7] Stangeby & Elder 1992 Journal of Nuclear Materials 196-198, 258-263

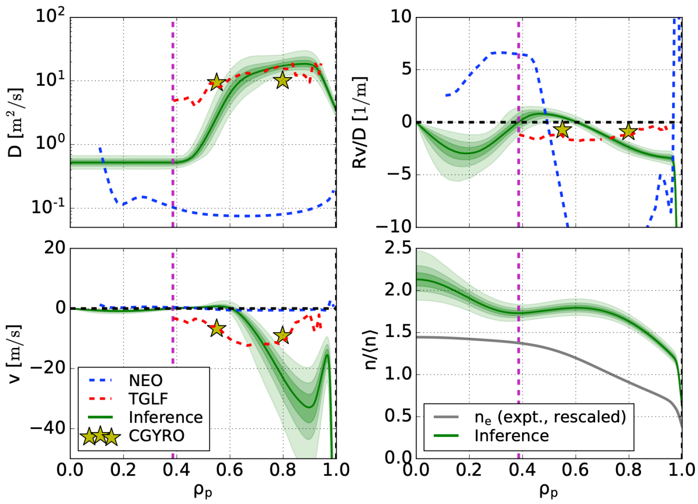

Figure 1: inferred experimental core impurity (fluorine, Z=9) transport coefficients in DIII-D diverted negative triangularity discharge #180526 at 2.75s (L-mode). Top-left: diffusion; bottom-left: convection; top-right: normalized ratio of convection and diffusion; bottom-right: radial profile shape of total impurity density, compared to the electron density (arbitrary normalizations). Dashed magenta vertical lines represent the sawtooth mixing radius. Modeling by NEO (dashed blue), TGLF SAT-2 (dashed red) and nonlinear CGYRO (yellow stars) are also displayed.