Efficient steady-state predictions of core plasma profiles with delta-f nonlinear gyrokinetics using the PORTALS framework

P. Rodriguez-Fernandez[1*], N. T. Howard[1], J. Candy[3], A. Saltzman[1], T. Body[2], D. J. Battaglia[2], J. W. Hughes[1], A. J. Creely[2], A. Ho[1], C. Holland[4]

[1] *MIT Plasma Science and Fusion Center, Cambridge, MA, United States*
[2] *Commonwealth Fusion Systems, Devens, MA, United States*
[3] *General Atomics, San Diego, California, United States*
[4] *University of California San Diego, San Diego, CA, United States*

**pablorf@mit.edu*

Recent advances in efficient transport solvers have enabled nonlinear gyrokinetic profile predictions, marking a paradigm shift in fusion modeling: high-fidelity projections of fusion performance can now be made directly from first-principles turbulence simulations. This paper presents the PORTALS framework [1, 2] and the key advancements that have enabled the efficient solution to the inverse transport problem of delta-f transport models using surrogate-based optimization and uncertainty quantification. PORTALS has been used to predict over 50 multi-channel (T_e, T_i, n_e) flux-matched plasma profiles to date, spanning present-day experiments (DIII-D [3], ASDEX Upgrade [4] and JET [5]) and future devices (SPARC [1, 6], ITER [7] and ARC), supporting both validation efforts and design activities. This paper will also discuss how PORTALS, coupled with nonlinear CGYRO [8] simulations, is used for the projection of SPARC plasmas with high-fidelity turbulence modeling, revealing the importance of edge pressure assumptions and impurity mixes in high-stiffness, ion-temperature-gradient dominated turbulence regimes in near-breakeven and burning plasma conditions.

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[1] P. Rodriguez-Fernandez *et al* Nucl. Fusion 62 076036 (2022)

[2] P. Rodriguez-Fernandez *et al* Nucl. Fusion 64 076034 (2024)

[3] N.T. Howard *et al* Phys. Plasmas 31, 032501 (2024)

[4] R. Bielajew *et al* (submitted to Nucl. Fusion)

[5] P. Rodriguez-Fernandez *et al* IAEA-FEC (2023)

[6] P. Rodriguez-Fernandez *et al* Phys. Plasmas 31, 062501 (2024)

[7] N.T. Howard *et al* Nucl.Fusion 65 016002 (2025)

[8] J. Candy *et al* Journal of Computational Physics 324, 73–93 (2026)