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Neural-network accelerated coupled core-pedestal simulations with self-consistent transport of impurities

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An integrated modeling workflow capable of finding the steady-state solution with self-consistent core transport, pedestal structure, current profile, and plasma equilibrium physics has been developed, validated against several DIII-D discharges, and used to perform predictions for a 15 MA D-T ITER baseline scenario. Key features of the proposed core-pedestal coupled workflow are its ability to self-consistently account for the transport of impurities in the plasma, as well as its use of machine learning accelerated models for the pedestal structure, the neoclassical bootstrap current, and for the turbulent and neoclassical transport physics. Self-consistent coupling of physics-based models (or their machine-learning accelerated counterparts) is of great importance since it reduces the number of free parameters and assumptions that are used in the simulations, thus greatly improving the reliability of our numerical forecasts. The results presented in this paper provide supporting evidence that neural network based reduced models are indeed capable of breaking the speed-accuracy trade-off that is expected of traditional numerical physics models, and can provide the missing link towards whole device modeling simulations that are physically accurate, robust, and extremely efficient to run. Work supported in part by the US Department of Energy under Contract Nos. DE-SC0017992 (AToM), DE-FG02-95ER54309 (GA theory), DE-FC02-06ER54873 (ESL), and DE-FC02-04ER54698 (DIII-D). This research used resources of the National Energy Research Scientific Computing Center (NERSC), a DOE Office of Science User Facility supported by the Office of Science of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

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