Modeling of Cold-Pulse Dynamics in Alcator C-Mod and DIII-D: A Local Turbulent Transport Approach

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A long-standing enigma in plasma transport has been resolved by the modeling of cold-pulse experiments conducted on the Alcator C-Mod and DIII-D tokamaks with a local turbulent transport model, TGLF-SAT1 [1]. It has been observed for more than twenty years that controlled edge cooling of low-density plasmas triggers a core electron temperature increase on time-scales faster than an energy confinement time, and that the effect disappears as plasma density is increased. These temperature "inversions" have challenged the local transport paradigm encapsulated in predictive electromagnetic drift-wave turbulent transport models. The integrated modeling framework presented here leverages the new OMFIT tools and the TRANSP power balance code. Turbulent transport is solved using the quasilinear model TGLF-SAT1, with a new saturation rule motivated by cross-scale coupling physics and that captures the nonlinear upshift of the critical gradient. Modeling of cold-pulse experiments conducted on the Alcator C-Mod tokamak is shown to fully describe the cold-pulse phenomenology after laser blow-off (LBO) injections [2]. The TGLF-SAT1 model is able to quantitatively capture the prompt onset of the core electron temperature inversion, with a magnitude that is qualitatively consistent with experimental trends, as well as the disappearance at high-density. Predictive analysis has been used to identify plasma conditions in the DIII-D tokamak that would exhibit temperature inversions, which are consistent with the empirical 1/R scaling proposed in past work [3]. New experiments conducted at DIII-D, actuated by the new LBO system, show that predictions are confirmed and high resolution profile reflectometer data provides evidence of fast density perturbation dynamics.

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[1] G.M. Staebler *et al* 2017 *Nucl. Fusion* **57** 066046
[2] P. Rodriguez-Fernandez *et al* 2018 *Phys. Rev. Lett.* **120** 075001
[3] C. Gao *et al. 2014* Nucl. Fusion **54**, 083025

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