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EX/P7-09: Validation Studies of Gyrofluid and Gyrokinetic Predictions of Transport and Turbulence Stiffness Using the DIII-D Tokamak

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A series of carefully designed validation experiments have been conducted on DIII-D to rigorously test gyrofluid and gyrokinetic predictions of transport and turbulence stiffness in both the ion and electron channels. In the first experiment, the ratio of the volume-averaged electron temperature profile to its value at rho=0.84 was found to be essentially invariant with increased heating over a factor of 3 variation in neutral beam injection (NBI) heating in H-mode plasmas with constant pedestal conditions, while a small increase was observed in the ion temperature ratio. The TGLF [1] transport model reproduces the profile measurements and trends with increased NBI heating, providing significant additional support for the fidelity of TGLF in H-modes. Building off these global studies, experiments that quantified local electron stiffness by varying the deposition of electron cyclotron heating (ECH) about a specified reference radius were performed. Applying this technique to L-mode plasmas with no other external heating, a critical inverse temperature gradient scale length a/L_Te,crit = 2.0±0.3 (1/L_Te = −nabla T_e/T_e, a=0.6 m) has been identified for the first time in DIII-D. Both TGLF and nonlinear GYRO [2] simulations predict similar levels of near-zero turbulence and transport at or below the experimental critical gradient and experimentally relevant levels above it, and a similar transition is observed in linear growth rate calculations. However, both codes also underpredict the power balance calculations of the electron and ion heat fluxes Q_e and Q_i, and increases to both a/L_Te and a/L_Ti larger than experimental uncertainties are needed to match the power balance results. These results build upon previous validation studies [3] of electron transport at DIII-D, for which new gyrokinetic modeling results will be reported.

[1] G.M. Staebler, et al., Phys. Plasmas 14 (2007) 055909.
[2] J. Candy and R.E. Waltz, Phys. Rev. Lett. 91 (2003) 45001.
[3] J.C. DeBoo et al., Phys. Plasmas 17 (2010) 056105.

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