Abstract for an Invited Paper
for the DPP98 Meeting of
The American Physical Society

Perturbative Tests of Theoretical Transport Models Using Cold Pulse and Modulated ECH Experiments[1]

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It is difficult to discriminate between transport models using standardized statistical measures to assess the goodness of fit to experimental density and temperature profiles in tokamaks. This motivates consideration of transient transport experiments as a means of testing the temporal response predicted by the models. Results are presented comparing the predictions from IFS/PPPL, GLF23, Multi-mode, and Itoh-Itoh-Fukuyama (CDBM) transport models against data from Ohmic cold pulse and modulated ECH experiments. In Ohmically heated discharges with rapid edge cooling due to trace impurity injection, we find that critical gradient models containing a strong temperature ratio ($T_{\rm i}/T_{\rm e}$) dependence can exhibit behavior that is qualitatively consistent both spatially and temporally with experimental observation while depending solely on local parameters. The IFS/PPPL model yields the strongest response and demonstrates both rapid radial pulse propagation and an increase in the central electron temperature promptly after a cold edge temperature pulse (amplitude reversal). As observed experimentally, the amplitude reversal effect diminishs with increasing electron density and auxiliary heating. On DIII–D, modulated ECH experiments have been conducted and the perturbed electron and ion temperature response to multiple heat pulses has been measured across the plasma core using electron cyclotron emission and charge exchange spectroscopy. Initial experiments were performed with 1 MW of modulated off-axis ECH power applied to sawtooth-free L–mode discharges with 20 ms pulses every 40 ms. Fourier analysis of the data indicates the electron and ion response to the ECH perturbations are out of phase with each other inside the deposition layer. Comparing the predicted amplitude and phase of the temperature perturbations, we find that the GLF23 model best describes both the electron and ion phases. The IFS/PPPL and CDBM models, which represent two extremes in stiffness, do not predict both phases correctly. The stiff IFS/PPPL model, describes the ion phase well but not the electron phase. The CDBM model, which has no critical temperature gradient and very little stiffness, describes the electron phase correctly but not the ion phase.

[1]Work supported by U.S. DOE Contracts DE-AC03-89ER51114 and W-7405-ENG-48.

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