Search for Threshold Behavior in DIII–D Electron Transport*

T.C. Luce[1], J.C. DeBoo[1], N. Howard[2], C. Liu[1], and C.C. Petty[1]

[1]*General Atomics, P.O. Box 85608, San Diego, California 92186-5608, USA*
[2]*University of Illinois, Urbana-Champaign, Illinois, USA*

Theoretical work points to a critical gradient or critical scale length description of tokamak transport. Power balance analysis of experiments cannot affirm this type of model, because of intrinsic limitations. Perturbation techniques are more sensitive and may yield a clearer conclusion about the threshold hypothesis. Analysis of modulated ECH experiments in the DIII-D tokamak shows no direct evidence of a threshold for the conditions tested.

Two approaches to analysis of DIII-D perturbation data are taken. First, a general form of the heat flux is applied that includes the possibility of diffusive and convective terms in the equilibrium heat flux. To determine what terms are required, reliable uncertainty estimates for the Fourier spectrum amplitudes and phases must be supplied. A fitting procedure finds best estimates for the “effective” transport coefficients that appear in the linearized energy transport equation. The analysis clearly shows that multiple frequency analysis is necessary. A purely diffusive model applied to the fundamental frequency would indicate a high incremental diffusivity, but the multiple frequency analysis indicates that the effective convection and damping terms are necessary to describe the heat pulse evolution. An intrinsic convective term in the equilibrium heat flux is needed to fully describe the observed transport.

The second approach is to impose a model on the data. A critical scale length model has been tested by methods like those applied on ASDEX-Upgrade [1] and FT-U [2]. One method varies the local heat flux near the half radius, while keeping the total flux to the boundary constant. The inferred heat pulse diffusivity (assuming a purely diffusive model) is typically a factor of 2 larger than the power balance value and is an increasing function of the inverse scale length. The data point to a threshold value that is quite small, such that even the low auxiliary power L-mode plasmas tested are above the threshold. In addition, the ratio of the incremental diffusivity to the power balance value (one definition of stiffness) is modest (~2-3). A second method varies the gradient locally while maintaining fixed temperature, by modulating two ECH sources out of phase at two slightly displaced locations. No threshold behavior is observed. This sets strong limits on the threshold value in these plasmas.

[1] F. Ryter, *et al.*, Nucl. Fusion **43**, 1396 (2003).
[2] S. Cirant, *et al.*, Plasma Phys. Control. Fusion Research (Proc. 19th IAEA Conf., Lyon, 2002) IAEA-CN-94/EX/C4-2Rb.

*Work supported by the U.S. Department of Energy under DE-FC02-04ER54698.