Scaling of Heat Transport with Beta in the DIII–D Tokamak

C.C. Petty, T.C. Luce, J.C. DeBoo, R.E. Waltz,
D.R. Baker and M.R. Wade*
General Atomics
San Diego, California 92186-9784, U.S.A.

Abstract

Experiments in the DIII–D tokamak have measured the scaling of heat transport with beta (β) while all other dimensionless parameters are held constant for both H–mode and L–mode plasmas. Experimental results from the beta scaling of heat transport helps to differentiate between various proposed mechanisms of turbulent transport. For L–mode plasmas, the beta scaling of heat transport over the range $0.26 \leqslant \beta_N \leqslant 0.49$ is close to zero, with the thermal confinement time scaling like $B\tau_{th} \propto \beta^{-0.05\pm0.10}$ and the effective (or one-fluid) thermal diffusivity scaling like $\chi_{eff} \propto \chi_B \beta^{0.11\pm0.20}$. The beta scalings of the ion and electron thermal diffusivities are the same as the effective diffusivity to within the experimental errors. Higher values of beta are investigated in H–mode plasmas, where a weak-to-moderate beta scaling of transport is observed over the range $0.8 \leqslant \beta_N \leqslant 1.7$, with the thermal confinement time scaling like $B\tau_{th} \propto \beta^{0.15\pm0.13}$ and the effective thermal diffusivity scaling like $\chi_{eff} \propto \chi_B \beta^{-0.54\pm0.23}$. The ion channel is responsible for the favorable beta scaling of H–mode plasmas; the electron channel has no measurable beta dependence. These beta scalings determined by dimensionless parameter scans are much weaker than the predicted beta scalings from the L–mode and H–mode confinement scaling expressions that are currently being used to predict the performance of ITER.

*Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831.