UNDERSTANDING TRANSPORT THROUGH DIMENSIONLESS PARAMETER SCALING EXPERIMENTS*

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Experiments in tokamaks around the world have placed powerful constraints on the nature of anomalous transport by measuring the dependence of heat and particle transport on fundamental dimensionless plasma parameters such as the normalized gyroradius, plasma beta, collisionality and safety factor. The basis of this approach has been confirmed by comparing the confinement in various tokamaks which had different sized plasmas but identical values for all of the dimensionless quantities. These identity experiments showed that the heat transport, normalized to Bohm, was the same for L–mode plasmas in DIII–D and Alcator C-Mod, H–mode plasmas in DIII–D and JET as well as H–mode plasmas in DIII–D and ASDEX-U. Recent experiments have also measured the scaling of local heat transport with beta and collisionality for L–mode plasmas in DIII–D as well as H–mode plasmas in DIII–D and JET. These experiments found weak, possibly non-existent, beta scaling of transport in all regimes (for $\beta_N < 2$). The collisionality scaling of transport was also found to be close to zero for L–mode plasmas in DIII–D. These results favor collisionless, electrostatic drift wave theories of turbulence since transport due to magnetic fluctuations would have a strong beta dependence. A moderate collisionality scaling was observed for H–mode plasmas in both DIII–D and JET; this may be a manifestation of the linear collisionality scaling contained in neoclassical transport (not insignificant for H–mode plasmas). Gyroradius scaling experiments in DIII–D found that the ion transport varied from gyroBohm-like (the theoretically expected value) for plasmas with broad density and current profiles to worse than Bohm-like for peaked density and current profiles; the gyroradius scaling for electron transport was always found to be gyroBohm-like. Recent experiments in Alcator C-Mod confirmed that the electron scaling is gyroBohm-like while the ion scaling is worse than Bohm-like for L–mode plasmas. In addition, the gyroradius scaling of the particle diffusivity has been measured for the first time in DIII–D for ELMing H–mode plasmas. This experiment found that the particle diffusivity scaling was gyroBohm-like in the core of the plasma, in good agreement with the scaling of heat transport in ELMing H–mode plasmas found in DIII–D, JET, and ASDEX-U. The projection of these gyroradius scaling experiments in ELMing H–mode discharges to ignition regimes leads to favorable predictions for the confinement time in ITER; however, this extrapolation to smaller gyroradius is complicated by the requirement that the loss power from core transport remain above the H–mode threshold power (which scales worse than Bohm-like). Choosing a scaling path at high beta (low collisionality), along which the loss power remains above the H–mode threshold to the point of ignition, allows one to take full advantage of the gyroBohm-like scaling of transport in H–mode plasmas in the design of an ignited plasma device.

*Work supported by the U.S. Department of Energy under Contract No. DE-AC03-89ER51114.