Similarity ν_* Rather than n/n_{limit} Should be Kept Fixed in H-Mode Energy Confinement*

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Similarity occurs when for a fixed set of dimensionless parameters, a family of systems can exist with different sets of dimensional parameters. In this situation, tokamaks of different physical size should have the same energy transport (normalized to Bohm) when the dimensionless parameters like ρ_*, β, q, etc., are matched. While many of the important dimensionless parameters are readily apparent, there seems to be some debate among the fusion energy science community as to whether the dimensionless collisionality should be represented by ν_*, the collision frequency normalized to the bounce frequency, or by n/n_{limit}, the density normalized to the Greenwald density limit, despite the fact that the latter is not a proper dimensionless parameter. This is not merely an academic question since it strongly affects how burning plasma demonstration discharges on present day machines are scaled to ITER. To resolve this question, experiments on the DIII-D and JET tokamaks have compared the normalized energy confinement in dimensionally identical ELMing H-mode plasmas at (1) fixed ν_*, and (2) fixed n/n_{limit}. When ν_* is kept fixed, the normalized energy confinement times on DIII-D and JET agree to within 4%. On the other hand, when n/n_{limit} is kept fixed, the normalized energy confinement time on DIII-D is 20% smaller than on JET. This discrepancy in the latter set of experiments can be explained by the energy confinement time scaling like $\tau \propto \nu_*^{-0.33}$, which agrees with previous ν_* scaling experiments in H-mode discharges on DIII-D. Therefore, these experiments show that ν_* is the correct dimensionless form of the collisionality, and that scaling confinement properties from present day machines to ITER at fixed n/n_{limit} will result in incorrect predictions.

*Work supported by U.S. Department of Energy under Contract No. DE-AC03-99ER54463.