Role of Neutrals in H–mode Density Pedestal Formation in DIII–D*

R.J. Groebner,[1] M.A. Mahdavi,[1] A.W. Leonard,[1] T.H. Osborne,[1]
and G.D. Porter[2]

[1]General Atomics, P.O. Box 85608, San Diego, California 92186-5608
[2]Lawrence Livermore National Laboratory, Livermore, California 94551

A major requirement for the goal of predicting confinement in future machines is an improved understanding of the physics which controls the height of the H–mode pressure pedestal. The pedestal height is a boundary condition required for physics models of core transport. Recent advances in MHD theory and in theory-experiment comparisons show that the pressure gradient obtained in the H–mode transport barrier is consistent with limits expected from finite-n ideal kink/ballooning modes.[1] However, an understanding of the physics that controls the width of this high gradient region remains elusive and is a major problem for H–mode physics. Guidance provided by both numerical transport models[2] and analytic models of transport barriers[3] suggests that neutral fueling plays a major role in shaping the edge transport barrier and that the neutral penetration length is an important scale length for the width of the barrier. In these models, the large source of edge neutrals produces a large density gradient which in turn produces a large pressure gradient that maintains the large sheared radial electric field, which maintains the low turbulence of the H-mode edge. Motivated by these models, DIII–D experiments have been conducted to see if the shape and width of the edge density profile in H–mode can be explained by the mechanism of neutral fueling. The resulting data have been compared to predictions of a simple analytic model for the size and shape of the edge density profile. This model is an extension of the fueling model of Engelhardt and others[4] that accounts for poloidal asymmetries in the fueling location, for the presence of charge exchange neutrals at the plasma edge and for separate particle diffusion coefficients on the open and close field lines.[5] The experimental data exhibit several important features predicted by this model: 1) the edge density profile has a hyperbolic tangent shape in both L–mode and H–mode plasmas, as predicted; 2) the density scale length (width of the density barrier) is predicted to within ~50% or better for a wide range of data; 3) the separatrix density must be increased to increase the pedestal density, as predicted; 4) the density scale length decreases as the pedestal density increases, as predicted. These results show that the neutral penetration length must be seriously considered as a mechanism which helps to control the width of the pedestal for standard H–mode operation.

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