The Effect of Divertor Magnetic Balance on H–Mode Performance in DIII–D*

T.W. Petrie, S.L. Allen,[a] M.E. Fenstermacher,[a] C.M. Greenfield, R.J. Groebner, A.W. Hyatt, R.J. La Haye, C.J. Lasnier,[a] A.W. Leonard, M.A. Mahdavi, T.H. Osborne, G.D. Porter,[a] D.M. Thomas, J.G. Watkins,[b] W.P. West, N.S. Wolf,[a] and The DIII–D Team

General Atomics, P.O. Box 85608, San Diego, CA 92186-5608
[a]*Lawrence Livermore National Laboratory, Livermore, California.*
[b]*Sandia National Laboratories, Albuquerque, New Mexico.*

We report on recent experiments in which the magnetic balance of highly triangular ($\delta \approx 0.8$), unpumped H–mode plasmas was systematically varied. Changes in divertor heat loading and particle flux, energy confinement, and density operating range in H–mode were observed when the magnetic configuration was varied from a balanced double-null (DN) divertor to a slightly unbalanced DN divertor. To quantify "magnetic balance," we define a parameter dr_{SEP}, which is the radial distance between the upper divertor separatrix and the lower divertor separatrix, as determined at the outboard midplane.

For attached plasmas, the variation in heat flux sharing between divertors is large for small changes in dr_{SEP} near 0 (i.e., near double-null); the peak heat flux shifts predominantly from one divertor to the other divertor within ±5 mm of magnetic balance. This sensitivity can be shown to be consistent with the measured scrape-off length of the parallel divertor heat flux, λ_q. Furthermore, λ_q can be approximated to within a factor of two with a simple model using only the midplane scrape-off lengths of electron density and temperature, suggesting that divertor processes (e.g., recycling) are not dominating the physics. At magnetic balance ($dr_{SEP} = 0$), we find that the peak heat flux toward the divertor in the grad-B direction is twice that of the other divertor. Most of the heat flux goes to the outboard divertor legs in a balanced double-null, where the peak heat flux in the outer divertor may exceed that of the inner divertor by tenfold. The variation of the peak particle flux between divertors is less sensitive to changes in magnetic balance, suggesting that divertor processes are much more important here than in the heat flux case. We believe that these divertor "asymmetries" are driven by E×B poloidal drifts. In detached plasmas, however, we find the heat flux split between divertors to be much less sensitive to dr_{SEP}.

Variations in magnetic balance affect plasma performance in other ways. The density at the H-L back transition may be 15%–20% lower for an unbalanced double-null biased away from the grad-B direction, with most of this change occurring near magnetic balance. Regardless of how the divertors were magnetically balanced, however, D_2 gas puffing always degraded energy confinement to the range $\tau_E/\tau_{E89L} \approx 1.3$–1.6. When this point was reached, τ_E stayed nearly constant, even as these plasmas were fueled to near their respective density limits. Examples of modeling of the core and divertor plasmas will be presented.

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