Advances in understanding quiescent H-mode plasmas in DIII–D

K.H. Burrell, W.P. West, E.J. Doyle, [a)] M.E. Austin,[b)] T.A. Casper,[c)] P. Gohil, C.M. Greenfield, R.J. Groebner, A.W. Hyatt, R.J. Jayakumar,[c)] D.H. Kaplan, L.L. Lao, A.W. Leonard, M.A. Makowski,[c)] G.R. McKee,[d)] T.H. Osborne, P.B. Snyder, W.M. Solomon,[e)] D.M. Thomas, T.L. Rhodes,[a)] E.J. Strait, M.R. Wade,[f)] G. Wang,[a)] and L. Zeng[a)]

General Atomics, P.O. Box 85608, San Diego, California, 92186-5608 USA

[a)]University of California–Los Angeles, Los Angeles, California, USA

[b)]University of Texas-Austin, Austin, Texas, USA

[c)]Lawrence Livermore National Laboratory, Livermore, California, USA

[d)]University of Wisconsin-Madison, Madison, Wisconsin, USA

[e)]Princeton Plasma Physics Laboratory, Princeton, New Jersey, USA

[f)]Oak Ridge National Laboratory, Oak Ridge, Tennessee, 37831 USA

email: burrell@fusion.gat.com

Received (

Abstract. Recent QH-mode research on DIII-D has used the peeling-ballooning modes model of edge magnetohydrodynamic (MHD) stability as a working hypothesis to organize the data; several predictions of this theory are consistent with the experimental results. Current ramping results indicate that QH-modes operate near the edge current

limit set by peeling modes. This operating point explains why QH-mode is easier to get at lower plasma currents. Power scans have shown a saturation of edge pressure with increasing power input. This allows QH-mode plasmas to remain stable to edge localized modes (ELMs) to the highest powers used in DIII-D. At present, the mechanism for this saturation is unknown; if the edge harmonic oscillation (EHO) is playing a role here, the physics is not a simple amplitude dependence. The increase in edge stability with plasma triangularity predicted by the peeling-ballooning theory is consistent with the substantial improvement in pedestal pressure achieved by changing the plasma shape from a single null divertor to a high triangularity double null. Detailed ELITE calculations for the high triangularity plasmas have demonstrated that the plasma operating point is marginally stable to peeling-ballooning modes. Comparison of ELMing, co-injected and quiescent, counter-injected discharges with the same shape, current, toroidal field, electron density and electron temperature indicates that the edge radial electric field or the edge toroidal rotation are also playing a role in edge stability. The EHO produces electron, main ion and impurity particle transport at the plasma edge which is more rapid than that produced by ELMs under similar conditions. The EHO also decreases the edge rotation while producing little change in the edge electron and ion temperatures. Other edge electromagnetic modes also produce particle transport; this includes the incoherent, broadband activity seen at at high triangularity. Pedestal values of ν_* and β_T bracketing those required for ITER have been achieved in DIII-D, demonstrating the QH-mode edge densities are sufficient for future devices.