LONG-PULSE, HIGH-PERFORMANCE DISCHARGES IN DIII-D*

M.R. Wade,[1] T.C. Luce,[2] P.A. Politzer,[2] J.R. Ferron,[2] S.L. Allen,[3] D.P. Brennen,[4] J.C. DeBoo,[2] E.J. Doyle,[5] A.M. Garofalo,[6] A.W. Hyatt,[2] R. Jayakumar,[3] R.J. La Haye,[2] L.L. Lao,[2] Y.R. Lin-Liu,[2] M.A. Mahdavi,[2] M.A. Makowski,[3] M. Murakami,[1] C.C. Petty,[2] E.J. Strait,[2] and A.D. Turnbull[2]

[1]*Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA*
[2]*General Atomics, San Diego, California, USA*
[3]*Lawrence Livermore National Laboratory, Livermore, California, USA*
[4]*Oak Ridge Institute for Science Education (ORISE), Oak Ridge, Tennessee, USA*
[5]*University of California, Los Angeles, California, USA*
[6]*Columbia University, New York, New York, USA*

Significant progress has been made in obtaining high performance discharges for many energy confinement times in the DIII-D tokamak. Normalized performance (measured by the product of $\beta_N H_{89}$ and indicative of the proximity to both conventional β limits and energy confinement quality, respectively) ~ 7.5 has been sustained for > 35 τ_E. In these ELMing H-mode discharges, β ~ 3.1% is maintained within 5% of the tearing mode β limit (determined on separate discharges) for over 6 s through feedback control of the input power on plasma stored energy. The plasma density in these dischages is held nearly constant at 3.5×10^{19} m^{-3} through divertor exhaust and feedback control of external gas injection. Particle balance analysis shows that the total particle input rate is matched by the total exhaust rate throughout the high performance phase, indicating that the wall is not a primary agent in the overall particle balance. Of special interest in this class of discharges is that the current profile reaches a stationary state approximately 1.5 s into the high performance phase without any evidence of sawtooth oscillations or fishbones thereafter with $q_0 \gtrsim 1.0$. Analysis of the poloidal flux evolution indicates that the expected inward diffuison of current is being counteracted by non-diffusive current transport near the q = 1.5 surface, possibly due to a small, steady m=3/n=2 neoclassical tearing mode that appeared early in the discharge. These discharges are part of a larger set of discharges that exhibit high performance for extended durations in DIII-D. Over shorter durations (~ 10 τ_E), $\beta_N H_{89}$ ~ 10 has been sustained for > 10 τ_E. These discharges have β ~ 5%, which is limited by the onset of resistive wall modes slightly above the ideal no-wall n=1 limit, with approximately 75% of the current driven non-inductively. The remaining Ohmic current is localized near the half radius. The DIII-D electron cyclotron heating system is being upgraded to replace this inductively driven current with localized ECCD in hopes of demonstrating steady-state, high performance advanced tokamak operation.

---

*Work supported by U.S. Department of Energy under Contracts DE-AC03-99ER54463, DE-AC05-00OR22725, DE-AC05-76OR00033, W-7405-ENG-48, and Grants DE-FG03-86ER53225 and DE-FG02-89ER53297.