Integrated, Advanced Tokamak Operation on DIII–D*

M.R. Wade,[1] M. Murakami,[1] T.C. Luce,[2] J.R. Ferron,[2] C.C. Petty,[2] D.P. Brennen,[3] A.M. Garofalo,[4] C.M. Greenfield,[2] A.W. Hyatt,[2] R. Jayakumar,[5] J.E. Kinsey,[6] R.J. La Haye,[2] L.L. Lao,[2] J. Lohr,[2] P.A. Politzer,[2] R. Prater,[2] and E.J. Strait,[4] and J.G. Watkins[7]

[1]Oak Ridge National Laboratory, Oak Ridge, Tennessee, 37831 USA
email: wade@fusion.gat.com
[2]General Atomics, P.O. Box 85608, San Diego, California, 92186-5608 USA
[3]Oak Ridge Institute for Science Education, Oak Ridge, Tennessee 37831 USA
[4]Columbia University, New York
[5]Lawrence Livermore National Laboratory, Livermore, California 94551 USA
[6]Lehigh University, Bethlehem, Pennsylvania 18015 USA

[7]Sandia National Laboratories, P.O. Box 5800, Albuquerque, New Mexico 87185

Abstract. Recent experiments on DIII–D have demonstrated the ability to sustain plasma conditions that integrate and sustain the key ingredients of Advanced Tokamak (AT) operation: high β with $1.5 < q_{min} < 2.5$, good energy confinement, and high current drive efficiency. Utilizing off-axis ($\rho = 0.4$) electron cyclotron current drive (ECCD) to modify the current density profile in a plasma operating near the no-wall ideal stability limit with $q_{min} > 2.0$, plasmas with $\beta \approx 2.9\%$ and 90% of the plasma current driven non-inductively have been sustained for nearly 2 s (limited only by the duration of the ECCD pulse). Negative central magnetic shear is produced by the ECCD, leading to the formation of a weak internal transport barrier even in the presence of Type I ELMs. Separate experiments have demonstrated the ability to sustain a steady current density profile using ECCD for periods as long as 1 s with $\beta = 3.3$ % and > 90% of the current driven non-inductively. In addition, stable operation well above the ideal no-wall β limit has been sustained for several energy confinement times with the duration only limited by resistive relaxation of the current profile to an unstable state. Stability analysis indicates that the experimental β limit depends on the degree to which the no-wall limit can be exceeded and weakly on the actual no-wall limit. Achieving the necessary density levels required for adequate ECCD efficiency requires active divertor exhaust and reducing the wall inventory buildup prior to the high performance phase. Simulation studies indicate that the successful integration of high β operation with current profile control consistent with these experimental results should result in high β, fully non-inductive plasma operation.

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