Integrated Scenario Modeling for Steady State Operation in DIII-D and ITER*

M. Murakami(1), J.M. Park(1), H.E. St John(2), and
the DIII-D Advanced Scenario Development Thrust Group

1)Oak Ridge National Laboratory, Oak Ridge, Tennessee USA
2)General Atomics, P.O. Box 85608, San Diego, California 92186-5608 USA

e-mail: murakami@fusion.gat.com, Phone: 858-455-3362, Fax: 858-455-4156

Steady-state operation with $Q \geq 5$ is a high level goal for ITER. Advanced Tokamak (AT) research on DIII–D focuses on development of the scientific basis for scenarios that meet this objective. This requires fully noninductive (NI) operation with high self-driven bootstrap current fraction and high toroidal beta. Recent progress in this area includes demonstration of 100% NI conditions with high normalized fusion performance, $G = \beta_N H_{89} / q_{95}^2 = 0.3$, demonstrating the ITER $Q = 5$ steady state scenario [1]. Integrated modeling is a crucial tool in the DIII–D AT research program. The theory-based (GLF23) model with self-consistent source/sink calculations in the ONETWO transport code is used to design experiments and interpret their results on DIII–D. The same tools have been used to extrapolate from DIII–D to ITER, predicting successful achievement of the $Q = 5$ steady state scenario with ITER's "Day-1" heating and current drive capabilities (no LHCD). In the ITER modeling, the density profile as well as the pedestal width are based on a DIII-D AT–type discharge. The existence of a steady state scenario that achieves f_{NI} = 101%, and $Q = 5.8$ was found with f_{BS} = 69% and $T_e(0) \approx T_i(0) \approx$ 21 keV at I_p = 9 MA and B_T = 5.1 T [1,2]. Recent simulations with the same input power and kinetic profiles, but starting from a broad current profile [as indicated by $\rho(q_{\min}) \approx 0.6$ and $q_{\min} \approx 2$] form a strong, but broad, internal transport barrier (ITB) early, making $T_i(0)$ increase by factor 2, with $T_i / T_e \approx 1.5$, Q increasings by 50%, and β_N reaching 3.8. Although it still appears transient, the behavior is reminiscent of the DIII-D experiment where $\beta_N = 4$ was maintained for 2 s by starting from a broader current profile using B_T ramp [3]. Work continues to examine if the ITB can be sustained by the off-axis ECCD.

[1] M. Murakami, M.R. Wade, C.M. Greenfield, et al., Phys. Plasmas **13**, 056106 (2006).
[2] C. Kessel, et al., 21st IAEA Fusion Energy Conf., Chengdu, IT/P1-7 (2006).
[3] A.M. Garofalo, E.J. Doyle, et al., Phys. Plasmas **13**, 056110 (2006).

---

*Work supported by U.S. Department of Energy under DE-FC02-04ER54698 and DE-AC05-00OR22725.