THE QUIESCENT DOUBLE-BARRIER REGIME IN THE DIII-D TOKAMAK*

E.J. Doyle†

Dept. of Electrical Engineering and IPFR
University of California, Los Angeles, California 90095, USA

Recent experiments in the DIII–D tokamak have identified a new high-performance operating mode, termed the Quiescent Double-Barrier (QDB) regime. The QDB regime combines core transport barriers with an ELM-free, quiescent H–mode edge, termed QH–mode, giving rise to separate (double) core and edge transport barriers. This new operating regime has several attractive features, including: (1) It is ELM free, eliminating the transient divertor heat loads and other problems associated with conventional ELMing H–mode operation. (2) Operation with a QH–mode edge provides good density and impurity control, even though it is ELM-free. (3) The combination of core ITBs and edge H–mode temperature pedestals results in improved performance relative to ITBs with an L–mode edge, or standard ELMing H–mode. A $\beta_N H_{89}$ product of 7 has been achieved with QDB operation, with room for further optimization. (4) QDB operation has been sustained for >3.5 s (~23 τ_E), demonstrating a long-pulse, quasi-steady-state capability. (5) The edge and core transport barriers are compatible (due to the absence of ELMs), and do not merge over these long time periods. To date, the QDB regime has only been obtained in plasmas with counter-NBI (injection anti-parallel to the plasma current), with divertor cryopumping to control the density.

The QH–mode edge is characterized by an edge harmonic oscillation (EHO), a continuous edge localized mode visible on magnetic, density and temperature fluctuation measurements. Particle transport associated with the EHO is thought to be responsible for the ability to maintain density and impurity control with the ELM-free, QH–mode edge. Reciprocating Langmuir probe measurements in the SOL have confirmed that the EHO generates a particle flux, and the edge pressure gradient obtained during QH-mode operation is similar to that obtained during ELMing H–mode. The core and edge transport barriers are separated by a region of low flow shear where the E×B shearing rate crosses zero. Inside the core barrier, the turbulence radial correlation length is reduced relative to a scaling observed in L–mode plasmas, consistent with improved core transport. Simulations using the GLF23 transport model have reproduced the observed core temperature profiles. Further experiments are planned for the near future to address several outstanding issues, including the extent of the QDB operating space, performance scaling, and high-Z (Ni) impurity transport.

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†For the DIII-D Team.