Progress Toward Long Pulse, High Performance Plasmas in the DIII–D Tokamak*

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A major portion of the research program of the DIII–D tokamak collaboration is devoted to the development and demonstration of high performance advanced tokamak plasmas, with profiles as close as possible to those anticipated for steady-state operation. The work during the 1999 campaign has resulted in significant progress toward this goal.

High normalized performance ($\beta_N \approx 4$ and $\beta_N H_{89} \approx 9$) discharges have been sustained for 2 s. These are H–mode plasmas with $q_{95} \approx 5$ and $\beta_p \approx 2$. After a short ELM-free period they go into continuous ELMing, without any reduction in stored energy due to an X-event or other MHD instability. These plasmas are in H–mode, with continuous ELMs. The limiting phenomena are resistive wall modes (RWM), not neoclassical tearing modes (NTM). NTMs do occur, apparently triggered by the RWMs. The observed pressure is above the calculated beta limit without a wall, and also $\beta_N > 4\ \ell_i$ throughout the high performance phase.

Measurements of the internal loop voltage show that about 75% of the current is non-inductively driven. The bootstrap current is estimated to be >50% of the total. The *q* profile is flat, as is the calculated bootstrap current profile, due to the absence of any localized pressure gradients or any internal transport barrier. The residual inductive current is localized around the normalized minor radius $\rho = 0.5$.

To demonstrate quasi-stationary operation, it will be necessary to replace the residual inductive current with ECCD at the same minor radius. To apply ECH and ECCD to these discharges, density control will be needed. Preliminary experiments using the DIII–D divertor cryopump have reduced the density by ~20%. The DIII–D research program also has a major effort directed toward feedback control of RWMs. We expect that these developments will allow demonstration of higher performance under stationary conditions.

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