Progress towards high-performance steady-state operation on DIII-D

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Abstract. Advanced Tokamak research in DIII-D seeks to develop a scientific basis for steady-state high performance tokamak operation. Fully noninductive ($f_{NI} \approx 100\%$) in-principle steady-state discharges have been maintained for several confinement times. These plasmas have weak negative central shear with $q_{min} \approx 1.5$-2, $\beta_N \approx 3.5$, and large, well-aligned bootstrap current. The loop voltage is near zero across the entire profile. The remaining current is provided by neutral beam current drive (NBCD) and electron cyclotron current drive (ECCD). Similar plasmas are stationary with $f_{NI} \approx 90\%$-95% and duration up to 2 seconds, limited only by hardware. In other experiments, $\beta_N \approx 4$ is maintained for 2 s with internal transport barriers, exceeding previously achieved performance under similar conditions. This is allowed by broadened profiles and active magnetohydrodynamic instability control. Modifications now underway on DIII-D are expected to allow extension of these results to higher performance and longer duration. A new pumped divertor will allow density control in high-triangularity double-null divertor configurations, facilitating access to similar in-principle steady-state regimes with $\beta_N > 4$. Additional current drive capabilities, both off-axis ECCD and on-axis fast wave current drive (FWCD), will increase the magnitude, duration, and flexibility of externally driven current.

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