Progress toward fully noninductive, high beta conditions in DIII-D

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Abstract. The DIII-D Advanced Tokamak (AT) program is aimed at developing a scientific basis for steady state, high performance operation in future devices. This requires simultaneously achieving 100% noninductive operation with high self-driven bootstrap current fraction and toroidal beta. Recent progress in this area includes demonstration of 100% noninductive conditions with $\beta_T = 3.6\%$, $\beta_N = 3.5$, and

$H_{89} = 2.4$ with the plasma current driven completely by bootstrap, neutral beam current drive, and electron cyclotron current drive. The equilibrium reconstructions indicate that the noninductive current profile is well aligned, with little inductively driven current remaining anywhere in the plasma. The current balance calculation improved with beam ion redistribution that was supported by recent fast ion diagnostic measurements. The duration of this state is limited by pressure profile evolution, leading to magnetohydrodynamic (MHD) instabilities after about 1 s or half of a current relaxation time (τ_{CR}). Stationary conditions are maintained in similar discharges (~90% noninductive), limited only by the 2 s duration (1 τ_{CR}) of the present ECCD systems. By discussing parametric scans in a global parameter and profile databases, the need for low density and high beta are identified to achieve full noninductive operation and good current drive alignment. These experiments achieve the necessary fusion performance and bootstrap fraction to extrapolate to the ITER $Q = 5$ steady state scenario. The modeling tools that have been successfully employed to both plan and interpret the experiment are used to plan future DIII-D experiments with higher power and longer pulse ECCD and fast wave and co and counter NBI in a pumped double-null configuration. The models predict our ability to control the current and pressure profiles to reach full noninductivity with increased beta, bootstrap fraction and duration. The same modeling tools are applied to ITER, predicting favorable prospects for the success of the ITER steady state scenario.