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Progress Toward Fully Noninductive, High Beta Conditions in DIII-D[1]

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The DIII-D Advanced Tokamak program is aimed at developing a scientific basis for steady state (SS), high performance operation in future devices. This requires 100% noninductive (NI) operation with high bootstrap current fraction (f_{BS}) and toroidal beta. Recent progress in this area includes demonstration of fully NI conditions with $\beta_T = 3.6\%$, $\beta_N = 3.5$, and $H_{89} = 2.4$ using off-axis electron cyclotron current drive (ECCD). The equilibrium measurements indicate that the NI current profile is well aligned, with little inductively driven current remaining anywhere in the plasma. The duration of this state is limited by pressure profile evolution, leading to MHD instabilities after about 1 s. Stationary conditions are maintained in similar discharges (∼90% NI) for one current relaxation time, limited only by the 2 s duration of the present ECCD systems. These experiments achieve the necessary fusion performance and f_{BS} to extrapolate to the ITER Q=5 SS scenario. Developing an understanding of the complex interactions between bootstrap current, external current drive, transport and MHD stability requires sophisticated integrated modeling tools. A major effort is ongoing to apply such tools, using both empirical and theory-based (GLF23) transport models, to both plan and interpret these experiments. These comparisons validate the models to allow their use in planning future DIII-D experiments with higher power and longer pulse ECCD and fast wave in a pumped double-null configuration. The models predict our ability to control the current and pressure profiles to reach full noninductivity with increased, f_{BS}, and duration. The same modeling tools are applied to ITER, predicting favorable prospects for the success of the ITER SS scenario.

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