Stability of Current-Driven Discharges in the Compact Toroidal Hybrid Helical Experiment

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With stellarators now attaining significant values of volume-averaged β, issues of equilibrium and stability associated with pressure-driven currents are of renewed interest to understanding helical plasmas. Moreover, advanced compact stellarators such as NCSX [1] may operate in a hybrid configuration with driven current before high-β plasmas are achieved. Exploratory experiments to understand stability and disruption avoidance in current-driven helical plasmas are underway on the Compact Toroidal Hybrid (CTH) device. Also in progress is the testing of the new V3FIT procedure of 3-D equilibrium reconstruction [2], primarily with magnetic diagnostics.

CTH is a five field period torsatron with additional toroidal field and poloidal field coils for control of the vacuum rotational transform and shear. The magnetic field is $B_0 \leq 0.7$ T, with the edge vacuum rotational transform variable in the range $0.1 < \iota/2\pi < 0.5$. Ohmic plasma currents of $I_p \leq 40$ kA are induced in target plasmas generated by 12 kW ECRH at the fundamental resonance of 18 GHz. The duration of the ohmic phase of the discharge is up to 100 msec.

During the plasma current rise, instabilities and hesitations in the rate of current increase correlated with low-order rational values of the net edge rotational transform are observed. These values are independent of applied vacuum rotational transform. At edge rotational transform values of 1/3 or 1/2, the current often undergoes repetitive relaxations in which the current rise is arrested, and the value of the total current drops by about 3%. Major disruptions associated with these instabilities, or any others, have not been found to occur. Efforts to operate with an edge transform above a value of ½ are ongoing.

To verify the magnetic configuration and also determine an improved coil model for use in the equilibrium reconstruction process, vacuum field mapping measurements are compared with predictions from the original coil design. Measurement of the magnetic axis in different field periods for a variety of coil current settings are incorporated into an SVD optimization procedure to arrive at a modified winding law for the helical coil consistent with the physical constraints of the helical winding form.

This work is supported by US DOE Grant DE-FG02-00ER54610

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