Analysis and Modeling of DIII-D Hybrid Discharges and Their Extrapolation to ITER*

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Recent experiments on tokamaks around the world have demonstrated discharges with moderately high performance in which the q-profile remains stationary, as measured by the motional Stark effect diagnostic, for periods up to several τ_R. These discharges have been termed hybrid because of their intermediate nature between that of an ordinary H-mode and advanced tokamak discharges. Hybrid discharges are characterize by $q_{min} > 1$, high β, and good confinement. They form an attractive scenario for ITER as the normalized fusion performance $(\beta_N H_{89P} / q_{95}^2)$ is at or above that of the ITER baseline $Q_{fus} = 10$ scenario, even for q_{95} as high as 4.6. An important issue is how the hybrid discharges rapidly achieve and maintain their stationary current profile. A general feature of these discharges is the presence of a low order (m/n = 3/2 or 4/3) neoclassical tearing mode. It is thought that this mode causes anomalous poloidal flux transport that aids in maintaining $q_{min} > 1$. The startup phase of the discharge is also thought to be crucial to the ultimate evolution of the discharge. To investigate these aspects of hybrid discharges, we have used the CORSICA code to model the startup and stationary phases of DIII-D hybrid discharges. A hyper-resistive model is applied to provide a heuristic understanding of the observed current evolution. Results clearly indicated that neoclassical transport alone is insufficient to account for the time evolution of the q-profile and that anomalous effects must be incorporated into the model to reproduce its time history. We present these results, and based on them, we develop a corresponding model for ITER in order to evaluate the performance of hybrid discharges on this device.

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