Advanced Tokamak Scenario Modeling with Off-Axis ECH in DIII–D*

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Transient formation of internal transport barriers in configurations with either negative or weak central magnetic shear profiles have resulted in high performance discharges in a number of tokamaks. In the DIII–D tokamak, ion transport approaching neoclassical values across the entire plasma cross section has been obtained in discharges that combine an internal transport barrier with an H–mode edge barrier [1]. However, these high performance H–mode discharges are typically limited by MHD instabilities driven by high pressure gradients at the edge. Negative Central Magnetic Shear (NCS) discharges without an edge transport barrier but with an L–mode-like edge do not encounter edge instabilities but can suffer from pressure driven instabilities in this case. MHD stability studies with a systematic scan of simulated equilibria with model q and pressure profiles show that the stability limit improves with increasing width and radius of the internal transport barrier (ITB). Modeling is focussed on the key issues of how to obtain such a configuration and how to maintain it for steady-state tokamak operation. The ECH power available at the DIII–D facility is being upgraded from the present three 1 MW gyrotron system to a six gyrotron system by the year 2001, four of which will be equipped with a diamond window enabling longer pulses. In order to help plan and guide the experiments, we are carrying out self-consistent, time-dependent simulations using both ONETWO [2] and CORSICA [3] transport codes. For the baseline performance predictions, we use transport coefficients normalized to ITER89P in an existing NBI discharge with an ITB. For maintenance of the desired configuration, it is essential to align well the electron cyclotron current drive (ECCD) profile with the off-axis bootstrap current profile, and to increase the ECCD efficiency to overcome the dissipating ohmic current profile. Self-consistent calculations indicate that off-axis ($\rho \sim 0.43$) ECCD with 3 MW absorbed ECH power in a beam-heated target plasma can sustain the enhanced confinement condition with a bootstrap current fraction of ~60%, normalized beta, $\beta_N \sim 2.7$ and confinement enhancement factor, $H_{89P} \sim 2.2$. More theory-based models (e.g., IFS-PPPL model [4]) with and without E×B flow shear suppression [5] of turbulence are also used to study the sensitivity of the simulation results to the transport model employed and to study the possible formation of an internal transport barrier.

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