ABSTRACT

The DIII-D research program is addressing key ITER research needs and developing the physics basis for future steady-state tokamaks. Pellet pacing edge localized mode (ELM) control in the ITER configuration reduces ELM energy loss in proportion to $1/f_{\mathrm{pellet}}$ by inducing ELMs at up to 12x the natural ELM rate. Complete suppression of ELMs with resonant magnetic perturbations (RMP) has been extended to the q_{95} expected for ITER baseline scenario discharges, and long-duration ELM-free QH-mode discharges have been produced with ITER-relevant co-current neutral beam injection (NBI) using external $n = 3$ coils to generate sufficient counter-I_{p} torque. ITER baseline discharges at $\beta_{\mathrm{N}} \sim 2$ and scaled NBI torque have been maintained in stationary conditions for more than four resistive times using electron cyclotron current drive (ECCD) for tearing mode suppression and disruption avoidance; active tracking with steerable launchers and feedback control catch these modes at small amplitude, reducing the ECCD power required to suppress them. Massive high-Z gas injection into disruption-induced 300–600 kA 20 MeV runaway electron beams yield dissipation rates ~10x faster than expected from e-e collisions and demonstrate the possibility of benign dissipation of such runaway electrons should they occur in ITER. Other ITER-related experiments show measured intrinsic plasma torque in good agreement with a physics-based model over a wide range of conditions, while first-time main-ion rotation measurements show it to be lower than expected from neoclassical theory. Core turbulence measurements show increased temperature fluctuations correlated with sharply enhanced electron transport when $\left(\nabla T_{\mathrm{e}}/T_{\mathrm{e}}\right)^{-1}$ exceeds a critical-gradient scale length. In H-mode, data show the pedestal height and width growing between ELMs with ∇P at the computed kinetic-ballooning limit, in agreement with the EPED model. Successful modification of a neutral beam line to provide 5 MW of adjustable off-axis injection has enabled sustained operation at $\beta_{\mathrm{N}} \sim 3$ with broader current and pressure profiles at higher q_{min} than previously possible, though energy confinement is lower than expected. Initial experiments aimed at developing integrated core and boundary solutions demonstrated heat flux reduction using enhanced edge radiation from neon injection and innovative divertor geometries (e.g., snowflake configuration).