ABSTRACT

The first real-time profile control experiments integrating magnetic and kinetic variables were performed on DIII-D in view of regulating and extrapolating advanced tokamak scenarios to steady-state devices and burning plasma experiments. Device-specific, control-oriented models were obtained from experimental data using a generic two-time-scale method that was validated on JET, JT-60U and DIII-D under the framework of the International Tokamak Physics Activity for Integrated Operation Scenarios [D. Moreau, *et al.*, 2011 Nucl. Fusion **51** 063009]. On DIII-D, these data-driven models were used to synthesize integrated magnetic and kinetic profile controllers. The neutral beam injection (NBI), electron cyclotron current drive (ECCD) systems and ohmic coils provided the heating and current drive (H&CD) sources. The first control actuator was the plasma surface loop voltage (i.e. the ohmic coil), and the available beamlines and gyrotrons were grouped to form five additional H&CD actuators: co-current on-axis NBI, co-current off-axis NBI, counter-current NBI, balanced NBI and total ECCD power from all gyrotrons (with off-axis current deposition). Successful closed-loop experiments showing the control of (a) the poloidal flux profile, $\Psi(x)$, (b) the poloidal flux profile together with the normalized pressure parameter, β_N, and (c) the inverse of the safety factor profile, $\bar{\iota}(x) = 1/q(x)$, are described.