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Experiments on the DIII-D tokamak are evaluating four leading ITER operational scenarios: the baseline scenario in ELMing H-mode, the advanced inductive scenario, the hybrid scenario, and the steady state scenario. The anticipated ITER shape, aspect ratio, and value of I/aB are reproduced in DIII-D, with the size reduced by a factor of 3.7, while matching key performance targets for β_N and H_{98} [1]. Since 2008, substantial progress has been made in improving the match to other expected ITER parameters such as edge pedestal collisionality and plasma rotation for the baseline scenario. Robust preemptive stabilization of 2/1 neoclassical tearing modes (NTMs) was demonstrated for the first time using electron cyclotron current drive (ECCD) under such ITER-like conditions. Another important development is the extensive use of experimental data from these ITER demonstration discharges to test and develop theory and modeling for realistic ITER projection and for further development of its optimum scenarios in DIII-D. Both experiment and modeling indicate that ITER will meet or closely approach its main operational targets.

Experimentally, attention has focused on improving the match to the anticipated characteristics for the ITER baseline scenario (Fig. 1). Density control and stationarity were improved substantially for the ~3τ_R duration of the H-mode flattop, which is the same normalized duration as for ITER. A lower density baseline discharge has been developed to match the expected ITER edge pedestal collisionality (ν_e^*~0.1). The density was reduced by a factor 2 and the temperatures raised by lowering I_p and applying electron cyclotron heating (ECH), while keeping T_e/T_i~1. Target values for β_N and H_{98} were maintained at lower collisionality (lower density) operation without loss in fusion performance. The lower density discharges show a significant change in ELM characteristics (smaller and more frequent ELMs), probably due to the change in P_{TOT}/P_{TH}. The effects of lower plasma rotation were investigated by adding counter-neutral beam power in low collisionality discharges, resulting in only a modest reduction in confinement. These plasmas have applied suppression of 2/1 NTMs at low q_{95} using ECCD, as planned for ITER, thereby avoiding rotational locking with its loss of confinement and possible disruption.

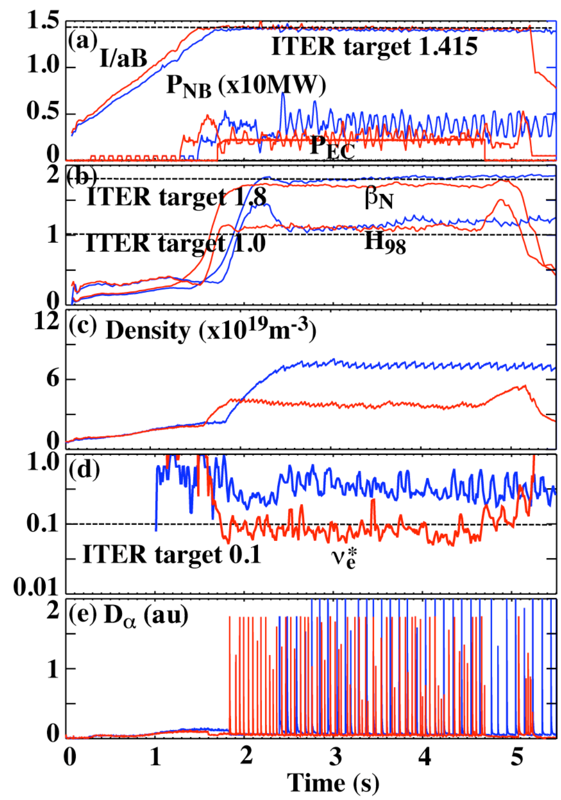

Fig. 1. Key parameters for ITER baseline discharges [high n_e/collisionality (blue), low n_e/collisionality (red)].

Data from these experiments have been used extensively to test and develop theory and modeling for realistic ITER projection and for further development of its optimum scenarios in DIII-D. Theory-based modeling of core transport (TGLF) with an edge pedestal boundary condition provided by MHD stability calculation to peeling-ballooning modes reproduces T_e and T_i profiles reasonably well for the four ITER scenarios developed in DIII-D, if employing *ExB* shearing rates measured by charge exchange recombination and/or motional Stark effect diagnostics. Modeling of the baseline scenario for low and high rotation discharges indicates that a modest performance increase (~15%) is needed to compensate for the expected lower rotation of ITER. Modeling of the steady-state scenario reproduces the strong dependence of confinement, stability, and noninductive fraction (f_{NI}) on q_{95}, as found in the experimental I_p scan (Fig. 2). This indicates that optimization of the q profile is critical to simultaneously achieving the f_{NI}=1 and Q=5 goals. The thermal energy confinement time decreases with q_{95}, generally following the scaling of H_{98}, while f_{NI} and f_{BS} increase with $\beta_N q_{95}$. The edge pedestal provides typically ~40% of the total bootstrap current, and its height and width depend on q_{95}, so that the pedestal plays a key role in optimizing the steady-state scenario. The electron and ion thermal diffusivity appear to correlate mainly with the magnetic shear both in the power balance analysis by TRANSP and in the TGLF modeling. The predictive simulation suggests that a larger radius for the minimum of q helps to increase both the fusion performance and f_{NI} at the β_N limit calculated from ideal wall stability, by maximally utilizing the benefits of low magnetic shear and higher pedestal pressure from the increased β_p.

DIII-D evaluations of ITER scenarios will be further extended by applying new tools such as off-axis NBI, higher power EC, and fast wave (FW) current drive that will allow extending T_e~T_i operation to more scenarios and developing the steady state scenario with higher fusion performance and bootstrap current fraction. Extended integrated modeling is being developed to improve capability for ITER projection by including the experimental observations of density peaking, ELM characteristics, NTM suppression, and coupled core-edge-SOL transport.

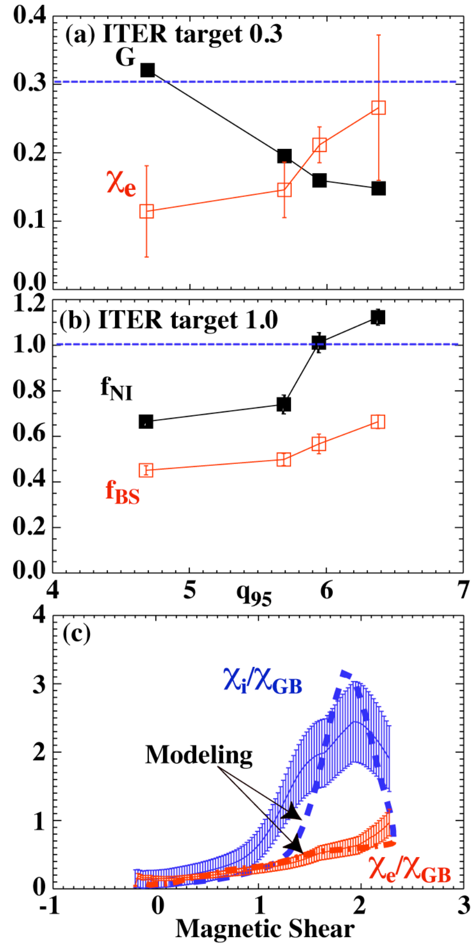

Fig. 2. I_p scan of ITER demonstration discharges for steady-state scenario: (a) Fusion performance (G), electron thermal diffusivity averaged over 0.2<ρ<0.8 (χ_e), (b) fractions of non-inductive (f_{NI}) and bootstrap (f_{BS}) current as a function of q_{95}. (c) Local thermal diffusivities as a function of magnetic shear, where error bars denote a variation in the discharges for I_p scan.

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[1] E.J. Doyle, *et al.*, Proc. 22nd Int. Conf. Fusion Energy. Paper EX/1-3 (2008)