DIII-D research to address key challenges for ITER and fusion energy

R.J. Buttery[1] and the DIII-D Team

[1]General Atomics, PO Box 85608, San Diego, California 92186-5608, USA

E-mail contact of main author: buttery@fusion.gat.com

Abstract. DIII-D has made significant advances in the scientific basis for fusion energy. The physics mechanism of resonant magnetic perturbation (RMP) edge localized mode (ELM) suppression is revealed as field penetration at the pedestal top, and reduced coil set operation was demonstrated. Disruption runaway electrons were effectively quenched by shattered pellets; runaway dissipation is explained by pitch angle scattering. Modest thermal quench radiation asymmetries are well described NIMROD modeling. With good pedestal regulation and error field correction, low torque ITER baselines have been demonstrated and shown to be compatible with an ITER test blanket module simulator. However performance and long wavelength turbulence degrade as low rotation and electron heating are approached. The alternative QH mode scenario is shown to be compatible with high Greenwald density fraction, with an edge harmonic oscillation demonstrating good impurity flushing. Discharge optimization guided by the EPED model has discovered a new super H-mode with doubled pedestal height. Lithium injection also led to wider, higher pedestals. On the path to steady state, 1 MA has been sustained fully noninductively with $\beta_N = 4$ and RMP ELM suppression, while a peaked current profile scenario provides attractive options for ITER and a $\beta_N = 5$ future reactor. Energetic particle transport is found to exhibit a critical gradient behavior. Scenarios are shown to be compatible with radiative and snowflake divertor techniques. Physics studies reveal that the transition to H mode is locked in by a rise in ion diamagnetic flows. Intrinsic rotation in the plasma edge is demonstrated to arise from kinetic losses. New 3D magnetic sensors validate linear ideal MHD, but identify issues in nonlinear simulations. Detachment, characterized in 2D with sub-eV resolution, reveals a radiation shortfall in simulations. Future facility development targets burning plasma physics with torque free electron heating, the path to steady state with increased off axis currents, and a new divertor solution for fusion reactors.