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Advances in Control and Understanding of Fusion Plasmas in DIII-D[1]

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The mission of the DIII-D National Fusion Facility is to develop the physics basis for the optimization of the tokamak approach to fusion energy production. This optimization seeks to develop integrated physics solutions that simultaneously allow operation at high plasma energy content through avoidance of pressure-limiting instabilities, reduced thermal losses by minimizing turbulence-driven transport, and shielding of the chamber walls from plasma heat exhaust through innovative methods for heat dispersal. Recent DIII-D enhancements have led to advances in the ability to control and diagnose important features of the magnetically confined fusion plasma. Examples of these advances will be presented in this talk with particular emphasis given to recent breakthroughs in plasma control and basic plasma understanding. In plasma control, the most detrimental of large-scale instabilities have been suppressed through use of non-axisymmetric magnetic fields and localized current drive, allowing operation at the theoretically predicted pressure limits. In addition, methods for controlling key plasma profiles have been demonstrated and are regularly utilized for physics studies. Diagnostic instruments, capable of measuring small-scale (∼2 mm) turbulent structures, have enabled researchers a first glimpse into turbulence generation and its self-regulation through zonal flows. Separate measurements have revealed the complex structure of Alfvén instabilities caused by high-energy ions used for heating the plasma to high temperatures. These advances in the understanding and control of fusion plasmas are providing the basis for the successful demonstration of sustained fusion energy production in ITER — an international collaborative experiment aimed at sustaining 500 MW of fusion power for 400 s.

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