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Recent Highlights in Plasma Physics on the Path to ITER

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In areas of interest such as plasma equilibrium, macroscopic and microscopic stability, and suprathermal particle dynamics, the understanding of the fusion plasma state is evolving: from initial macroscopic observations of plasma behavior; to precision measurements of relevant plasma properties; to development of reasonably standard models of plasma behavior supported by theory-experiment validation; to, ultimately, use of such models and measurements to develop real-time control and stabilization techniques. As an example, sophisticated imaging techniques provide unprecedented details of small-scale plasma turbulence in the density and velocity flow fields in the core region of fusion-grade plasmas. Such measurements are starting to test theories of self-organization in the turbulent flow-fields that regulate the turbulence and thereby strongly influence the plasma losses. This in turn is supporting the experimental demonstration of control of plasma turbulence and a correlated improvement in plasma confinement properties. Such developments are guiding expectations for the ITER international fusion experiment, and support development of a predictive understanding of the burning plasma state.