Transport modeling and gyrokinetic analysis of advanced high performance discharges

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Abstract

Predictive transport modeling and gyrokinetic stability analyses of demonstration hybrid (HYBRID) and Advanced Tokamak (AT) discharges from the International Tokamak Physics Activity (ITPA) profile database are presented. Both regimes have exhibited enhanced core confinement (above the conventional ITER reference H-mode scenario) but differ in their current density profiles. Recent contributions to the ITPA database have facilitated an effort to study the underlying physics governing confinement in these advanced scenarios. In this paper, we assess the level of commonality of the turbulent transport physics and the relative roles of the transport suppression mechanisms (i.e. $E \times B$ shear and Shafranov shift (α) stabilization) using data for select HYBRID and AT discharges from the DIII-D, JET, and AUG tokamaks. GLF23 transport modeling and gyrokinetic stability analysis indicates that $E \times B$ shear and Shafranov shift stabilization play essential roles in producing the improved core confinement in both HYBRID and AT discharges. Shafranov shift stabilization is found to be more important in

AT discharges than in HYBRID discharges. We have also examined the competition between the stabilizing effects of $E \times B$ shear and Shafranov shift stabilization and the destabilizing effects of higher safety factors and parallel velocity shear. Linear and nonlinear gyrokinetic simulations of idealized low and high safety factor cases reveals some interesting consequences. A low safety factor (i.e. HYBRID relevant) is directly beneficial in reducing the transport, and $E \times B$ shear stabilization can win out over parallel velocity shear destabilization allowing the turbulence to be quenched. However, at low-q/high current, Shafranov shift stabilization plays less of a role. Higher safety factors (as found in AT discharges), on the other hand, have larger amounts of Shafranov shift stabilization, but parallel velocity shear destabilization can prevent $E \times B$ shear quenching of the turbulent transport, and only $E \times B$ suppression is achieved.

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