DPP16-2016-001026

Abstract for an Invited Paper
for the DPP16 Meeting of
the American Physical Society

Confinement improvement in the high poloidal beta regime on DIII-D and application to steady-state H-mode on EAST[1]

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Systematic experimental and modeling investigations on DIII-D and EAST show attractive transport properties of fully non-inductive high β_P plasmas. The improved understanding is used to develop steady state scenarios for ITER and CFETR. Experiments on DIII-D show that the large-radius internal transport barrier (ITB), a key feature providing improved performance in the high β_P regime, is maintained when the scenario is extended from $q_{95}\sim$ 10 to 7 and from rapid to near-zero plasma rotation. The robustness of confinement versus rotation was predicted by gyrofluid modeling showing dominant neoclassical ion energy transport even without E×B shear effect on turbulence suppression. Measured electron turbulent transport is large when ion turbulent transport is low, consistent with recent multi-scale simulations. With decreasing q_{95}, dominant turbulent transport shifts from electrons to ions, which exceeds the neoclassical ion transport level, and may set a q_{95} limit for the large-radius ITB regime. Experiments also show that the ITB is lost below $\beta_N \sim 1.5$, when long wavelength turbulence increases in agreement with predictions of turbulence suppression by Shafranov shift. In DIII-D, a broad current profile enabling large radius ITB is accessed via early heating and sustained with high bootstrap current fraction. Experiments on EAST show that a broad current profile can be accessed and sustained exploiting a large fraction of lower hybrid wave current drive (LHCD). Results show that as the electron density is increased, the fully non-inductive current profile broadens on EAST. Overall, these results provide encouragement that high performance high β_P regimes can be extended to lower safety factor and very low rotation, providing potential paths to steady state in ITER and CFETR.

[1]Supported in part by the US DOE under DE-FC02-04ER54698 and the NNSF of China under 11575248.