

Joint DIII-D/EAST research on the development of a high poloidal beta scenario for the steady state missions of ITER and CFETR

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Experimental and modeling investigations on the DIII-D and EAST tokamaks show the attractive transport and stability properties of fully noninductive, high poloidal-beta (β_p) plasmas, and their suitability for steady-state scenarios in ITER and CFETR. A key feature of the high- β_p regime is the large-radius ($\rho > 0.6$) internal transport barrier (ITB), often observed in all channels (ne, Te, Ti, rotation), and responsible for excellent energy confinement quality. Experiments on DIII-D have shown that, with a large-radius ITB, very high β_N and β_p values (both ≥ 4) can be reached by taking advantage of the stabilizing effect of a nearby conducting wall. Synergistically, higher plasma pressure provides turbulence suppression by Shafranov shift, leading to ITB sustainment independent of the plasma rotation. Experiments on EAST have been used to assess the long pulse potential of the high- β_p regime. Using RF-only heating and current drive, EAST achieved minute-long fully noninductive steady state H-mode operation with strike points on an ITER-like tungsten divertor. Improved confinement (relative to standard H-mode) and steady state ITB features are observed with a monotonic q-profile with $q_{\min} \sim 1.5$. Separately, experiments have shown that increasing the density in plasmas driven by lower hybrid wave broadens the q-profile, a technique that could enable a large radius ITB. These experimental results have been used to validate MHD, current drive, and turbulent transport models, and to project the high- β_p regime to a reactor. In a burning plasma, it is found that the Shafranov shift alone does not suffice to provide improved confinement without rotation and rotation shear. However, increasing the negative magnetic shear (higher q on axis), provides a similar turbulence suppression mechanism to Shafranov shift, and can help devices such as ITER and CFETR achieve their steady-state fusion goals.