Deconvolving the roles of *E*×*B* shear and pedestal structure in the energy confinement quality of Super H-mode experiments

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Analysis of "super H-mode" experiments on DIII-D has put forward that high plasma toroidal rotation, not high pedestal, plays the essential role in achieving energy confinement quality much above standard H-mode, that is H_{98y2}>>1.[1,2] Recently, super H-mode experiments with variable input torque have confirmed that high rotation shear discharges have very high levels of H_{98y2}, independent of the pedestal height, and that high pedestal discharges with low rotation shear have levels of H_{98y2} only slightly above standard H-mode. A summary of the experimental results is shown in Fig. 1, where the energy confinement quality is plotted as a function of the total pedestal pressure and the core rotation shear. The energy confinement quality is represented by the diameter of the circles. The core rotation shear is represented by the difference between toroidal rotation on axis and at ρ=0.5. Approximately, a rectangular parameter space has been explored in pedestal pressure and core rotation shear, allowing separation of the roles of pedestal pressure and core rotation shear on the energy confinement quality. A clear increase of H_{98y2} with increasing core rotation shear can be observed, seemingly saturating at very high shear. No dependence or a small decrease of H_{98y2} with higher pedestal pressure is observed at high rotation shear, and a small increase of H_{98y2} with higher pedestal pressure is observed at low rotation shear. Although some increase in stored energy with higher pedestal occurs, the energy confinement quality mainly depends on the toroidal rotation shear. Linear gyrofluid and nonlinear gyrokinetic transport modeling shows that the contribution from rotation in the *E*×*B* shear is responsible for confinement quality significantly in excess of standard H-mode, and that the effect of *E*×*B* turbulence stabilization is far larger than other mechanisms. Consistent with these experimental and modeling results, are previous simulations of the ITER Baseline Scenario using a super H-mode pedestal solution [3], which showed the potential to exceed the Q=10 target if the pedestal density could be increased above the Greenwald limit. A close look at these simulations reveals that the predicted energy confinement quality is below that of standard H-mode even at the highest pedestal pressure. The improvement in Q at higher pedestal density is due to the improved fusion power generation at the higher core density associated with higher pedestal density, not to an improved energy confinement quality.

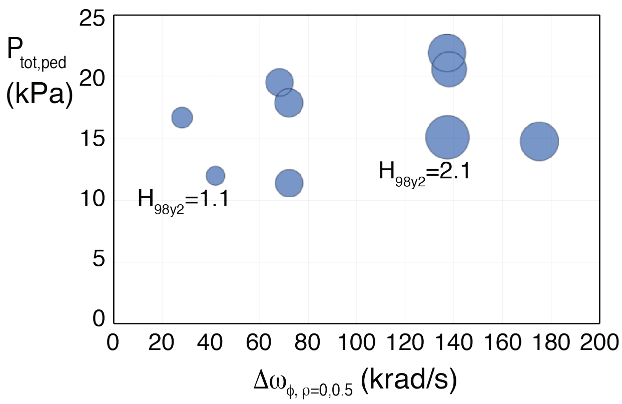

Fig. 1. Energy confinement quality, H_{98y2}, plotted as the diameter of the circles versus the total pedestal pressure and the core rotation shear. The core rotation shear is represented by the difference between toroidal rotation on axis and at ρ=0.5.

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References

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