Transport and Stability in Negative Central Shear Tokamak Discharges*

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Achieving high performance for long duration is a key goal of Advanced Tokamak (AT) research around the world. To this end, tokamak experiments are focusing on obtaining (a) a well-aligned high noninductive fraction of plasma current (b) wide internal transport barriers (ITBs) in the ion and electron transport channels to obtain high temperatures (c) control of resistive wall modes and neoclassical tearing modes which limit the achievable $\beta$ (d) edge plasma and divertor performance to give density and impurity control with permissible heat flux on the wall. A current profile that gives a negative central magnetic shear (NCS) in the core is consistent with the above focus. The negative central shear is conducive for obtaining internal transport barriers, for high degree of bootstrap current alignment and for reaching the second stability region for ideal ballooning modes, while being stable to ideal kink modes at high $\beta$ with wall stabilization. However, in the presence of unfavorable pressure gradients, NCS is observed to lead to resistive interchange mode. Much progress has been achieved in obtaining AT performance in several tokamaks through an increasing understanding of the stability and transport properties of tokamak plasmas. Stability codes that accurately predict $\beta$ limits of plasmas with different shapes and profiles have been developed. Gyrokinetic and gyro-Landau fluid transport codes have been developed to predict and explain observed plasma behaviors including transport barrier formation. RF and neutral beam current drive scenarios are routinely developed and implemented in experiments to access new advanced regimes. Divertor pumping and gas puff methods have been developed to control density profiles. Evolving and stationary H (high confinement) mode discharges have been obtained with simultaneous achievement of a high factor of enhancement of $\beta$ and confinement over Troyon limit and a reference confinement scaling, respectively. Short duration and sustained ITBs have been obtained in the ion and electron channels.

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