Dynamics of Core Fluctuations and Poloidal Rotation During Formation of Core Transport Barriers*

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Core transport barriers have been observed in most of the tokamaks in the world within the last 5 years, but variation in the dynamics of their formation is widely reported. Nevertheless, a model based upon E×B shear suppression of turbulence can account for the wide range of experimental observations [1,2]. In this model, local E×B shear suppresses turbulence, reducing or eliminating the associated transport and leading to increased pressure and rotation gradients [3]. The increased gradients produce even stronger shearing rates. Thus, bidirectional couplings between the shearing rate and transport close a feedback cycle which results in a low transport and high shear plasma state [4]. If the coupling is very strong, a bifurcation results when conditions close the cycle, which might be experimentally observed as spontaneous spin-up or barrier growth. Converesly, a sudden increase in poloidal or toroidal rotation induced shear may close the cycle and result in bifurcation. The effect of negative or weak central magnetic shear is to reduce turbulence growth rates, so that a lower value of the shearing rate starts the feedback cycle.

In DIII–D, the core barrier typically forms locally and evolves during the early phase of the discharge when sawteeth are suppressed and other MHD instabilities are avoided. Barrier formation is accompanied by increasing core rotation and E×B shear and decreasing core turbulence. More recent data from DIII–D have shown rapid changes in core *poloidal* rotation simultaneous with formation of the core transport barrier. The observations are made in discharges with neutral beam heating beginning very early in the current ramp, resulting in strong though transient negative central shear. The poloidal rotation changes are preceded by increased steepness in the electron temperature profile and ion temperature profile adjacent to where the rapid rotation change is observed. The increased gradient results from very localized spontaneous cooling just outside the location of the subsequent barrier. Preliminary evidence shows a correlation with the minimum value of the safety factor passing through an integer value of two.

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