ABSTRACT

One of the scientific success stories of fusion research over the past decade is the development of the E×B shear stabilization model to explain the formation of transport barriers in magnetic confinement devices. This model was originally developed to explain the transport barrier formed at the plasma edge in tokamaks after the L (low) to H (high) transition. This concept has the universality needed to explain the edge transport barriers seen in limiter and divertor tokamaks, stellarators and mirror machines. More recently, this model has been applied to explain the further confinement improvement from H (high)–mode to VH (very high)–mode seen in some tokamaks, where the edge transport barrier becomes wider. Most recently, this paradigm has been applied to the core transport barriers formed in plasmas with negative or low magnetic shear in the plasma core. These examples of confinement improvement are of considerable physical interest; it is not often that a system self-organizes to a higher energy state with reduced turbulence and transport when an additional source of free energy is applied to it. The transport decrease that is associated with E×B velocity shear effects also has significant practical consequences for fusion research. The fundamental physics involved in transport reduction is the effect of E×B shear on the growth, radial extent and phase correlation of turbulent eddies in the plasma. The same fundamental transport reduction process can be operational in various portions of the plasma because there are a number ways to change the radial electric field E_r. An important theme in this area is the synergistic effect of E×B velocity shear and magnetic shear. Although the E×B velocity shear appears to have an effect on broader classes of microturbulence, magnetic shear can mitigate some potentially harmful effects of E×B velocity shear and facilitate turbulence stabilization. Considerable experimental work has been done to test this picture of E×B velocity shear effects on turbulence; the experimental results are generally consistent with the basic theoretical models.

PACS Nos. 52.55, 52.35.R, 52.35.Q, 52.30