Tests of Causality: Experimental Evidence that Sheared $E \times B$ Flow Alters Turbulence and Transport in Tokamaks

Keith H. Burrell

General Atomics, P.O. Box 85608, San Diego, California 92186-5608

(Received)

A prime goal in physics research is the development of theories which have the universality needed to explain a wide range of observations. Developed over the past decade, the model of turbulence decorrelation and stabilization by sheared $E \times B$ flow has the universality needed to explain the turbulence reduction and confinement improvement seen in the edge and core of a wide range of magnetic confinement devices. Because the $E \times B$ shear, turbulence, and transport are all intimately intertwined in multiple feedback loops, devising experiments to test whether $E \times B$ shear causes a change in turbulence and transport has been a major challenge for experimentalists. Over the past five years, there have been at least four clear demonstrations of causality performed in tokamak plasmas, both at the plasma edge on Doublet III–D (DIII–D) [*Plasma Physics and Controlled Fusion Research 1985* (International Atomic Energy Agency, Vienna, 1986) Vol. I, p. 159] and Tokamak Experiment for Technologically Oriented Research (TEXTOR) [*Plasma Physics and Controlled Nuclear Fusion Research 1990* (International Atomic Energy Agency, Vienna, 1991) Vol. I, p. 473] and further into the plasma core on DIII–D and Tokamak Fusion Test Reactor (TFTR) [Phys. Plasmas **5**, 1577 (1998)]. This paper discusses these tests in detail; the results agree with the expectations from the $E \times B$ shear model. This paper also discusses similarities between flow shear effects in plasmas and in neutral fluids and provides examples of flow shear reduction of turbulence in neutral fluids under the proper conditions.

PACS No. 52.25.Fi, 52.55.Fa, 52.55.Hc