DIII-D NATIONAL FUSION FACILITY

Research Highlights

Smooth Flows Emerge from Chaotic Plasma Fluctuations

Like rapidly flowing gases and liquids, magnetically-confined fusion plasmas exhibit a high degree of turbulence. This turbulence is generally detrimental to plasma performance since it moves hot particles from the center of the plasma to the edge rapidly, thus cooling the plasma or degrading its energy confinement. A fascinating feature of this turbulence is that as a consequence of the magnetic geometry and pressure variations, it can generate its own flows that act as a self-regulating mechanism. These flows, which are predicted theoretically and have been observed in computer simulations of plasma turbulence, create a shearing or tearing action. This shearing action can tear up the turbulent eddies and thus limit the degree of turbulence, as indicated by the figure. Such flows are not unlike the large-scale zonal jets seen in the atmospheres of large outer planets in our solar system; these flows are believed to arise from essentially two-dimensional turbulent systems, in that case driven by solar energy.

Evidence for such turbulence flows has been clearly observed in recent experiments at the DIII-D tokamak using a turbulence imaging system, Beam Emission Spectroscopy. The flows show up as well-defined cycles in the velocity of the turbulence that fluctuate at near 15,000 oscillations per second. The imaging measurements are obtained at a rate of one million frames per second and have a spatial resolution of about 1 cm, thus readily resolving these turbulence flows. A snapshot of the measured flow pattern is shown in the second figure, superimposed on an image of typical turbulence eddies. Experiments have shown that the frequency of these oscillations varies with plasma temperature, agreeing closely with theoretical predictions. Observing and identifying these unique turbulence flows experimentally, and comparing their characteristics with theory, is helping to advance our understanding of this complex and crucial phenomena taking place in high temperature fusion plasmas.

This diagnostic development and research program is a collaboration between the University of Wisconsin-Madison, and the DIII-D National Fusion Facility.

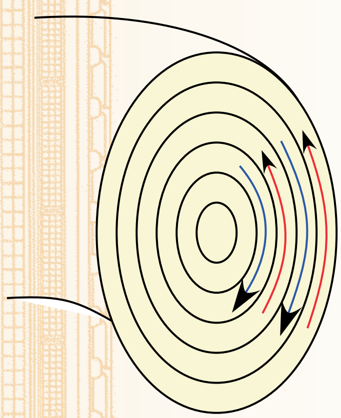

Fig. 1: Theoretical picture of self-generated turbulence flows in a tokamak cross section.

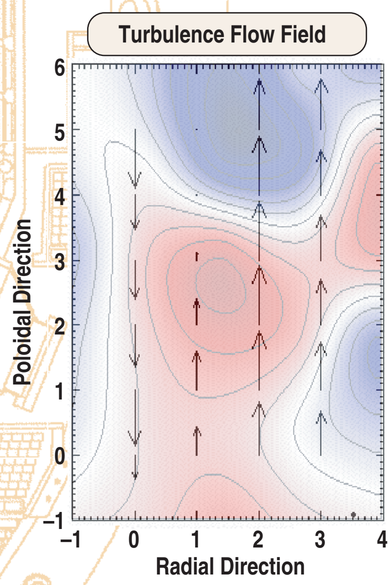

Fig. 2: Measured flow field.

About DIII–D

DIII–D (Dee Three Dee) is a National Fusion Facility where researchers advance fusion science to provide the basis for fusion as a long-term energy source. DIII–D is the largest, best diagnosed, and most versatile of all U.S. fusion experimental devices. It is the focus of over 60 active collaborations and research agreements including 8 national labs, 18 U.S. universities, and 14 other nations including Japan, Korea, Germany, France, England, China, and Russia. DIII–D is operated by General Atomics in San Diego, California. Please visit our website at http://fusion.gat.com

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