Turbulent Structures and Turbulence Suppression in the Helimak

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Shear in the flow velocity transverse to the magnetic field is a very general mechanism for stabilizing turbulence in a magnetized plasma, and most cases of turbulence suppression, from H-mode to internal transport barriers, are attributed to this mechanism. The Helimak allows a controlled study of the relation between flow shear and turbulence in a simple geometry with good diagnostics. The Helimak is an experimental approximation to the infinite cylindrical slab or Simple Magnetized Torus. The magnetic geometry is similar to the tokamak SOL at the outer midplane, and turbulence levels are also similar. The device is large compared with scale and correlation lengths. Since the open field lines terminate on the ends of the finite cylinder, radially segmented isolated end plates may be biased to allow application of radial electric fields that cause radial currents. A plasma flow is thereby driven in the axial ("poloidal") direction. Above a sharp threshold in applied voltage (driven current), the fractional turbulent amplitude is greatly reduced. The experiment is uniquely simple because the equilibrium is largely determined by end loss -- suppressing the turbulence does not lead to inexorable strong changes in the equilibrium. Turbulence reductions occur for both positive and negative bias and without hysteresis in the control voltage/current. Concurrent measurements of the ion flow velocity are made by Doppler spectroscopy. The argon plasma produced by ECH has cold ions that give no diamagnetic contribution to the measured velocity.

The observations are compared to the results of a two-fluid, 3-D nonlinear simulation of the SMT that shows the basic features of the normal turbulence as well as turbulence suppression at sufficient negative bias. Although large changes in turbulence, turbulent structures, flows, and flow shear are seen in both experiment and simulation, the suppression is not associated with a simple increase in local flow shear as one might expect.

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