Basic Physics and Control of Turbulence in a Simple Magnetized Torus*

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Experiments in a simple magnetized torus, the Helimak,[1] are used to investigate turbulence that causes transport in more complex magnetic confinement devices. In early work,[2] drift waves were thought to be dominant in the helimak. More recent work[3] suggests that for some Helimak plasmas, the interchange mode is dominant and prevents gradients from steepening into a plasma condition favorable to driftwaves. The interchange instability is fundamental in magnetized plasmas as it requires only curved magnetic field lines and a suitable pressure gradient, conditions found in plasma systems from astrophysical to laboratory plasmas. Like many plasma instabilities, it quickly develops to a stationary state of nonlinearly-saturated turbulence. However, the interchange is unique in proceeding to a state of large-amplitude turbulence in which the fluctuation level can approach 100%. Since the saturation mechanism has not been established, and simulations have not predicted observed fluctuation levels, it poses a unique challenge to our understanding of nonlinear plasma physics. The Helimak provides a good platform to investigate the interchange or the driftwave instability. It combines the simplest curved magnetic geometry with an almost 1-D pressure gradient. The device is designed to permit extensive, detailed measurement of equilibrium and fluctuating density, floating potential, and electron temperature with Langmuir probes. Unlike other laboratory plasmas, this device has plasma dimensions that are large compared with the equilibrium scale, the turbulence scale, and correlation lengths so that it is representative of much larger laboratory or natural systems. There are opportunities for validation of the turbulence simulation codes for confined fusion plasmas. In our experiments,(e.g., ref. [4]) local variables such as density, temperature, collisionality, bulk plasma flows strongly influence the turbulence. However, contrary to observations for some other less strongly turbulent systems, flow shear is not necessarily the critical control. Future experiments will explore flow control of turbulence amplitude, improved probe techniques based on baffling, and the interchange instability in X-point configurations.

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*This material is based upon work supported by the U.S. Department of Energy Office of Science, Office of Fusion Energy Sciences under Award Number DE-FG02-04ER54766.