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Toward validation of a 3-D plasma turbulence model using LAPD data[1]

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Detailed results from a 3-D fluid simulation of plasma turbulence are compared with experimental data from the Large Plasma Device (LAPD) at UCLA. LAPD is a magnetized plasma column experiment with a high repetition rate, allowing detailed time-and-space resolved probe data on plasma turbulence and transport. The large amount of data allows a thorough comparison with the simulation results. For the observed drift-type modes, LAPD plasmas are strongly collisional ($\omega_*/\nu_{ei} \ll 1$ and $\lambda_{ei}/L \ll 1$), providing justification for a fluid treatment. Accordingly, the model is based on reduced Braginskii equations and is implemented in the framework of the BOUT code, originally developed at LLNL for tokamak edge plasmas. Analysis of linear plasma instabilities shows that resistive drift modes, rotation-driven interchange modes, and Kelvin-Helmholtz modes can all be important in LAPD and have comparable frequencies and growth rates. In nonlinear simulations using measured LAPD density profiles, evolution of instabilities and self-generated zonal flows results in a saturated turbulent state. Comparisons of these simulations with measurements in LAPD plasmas reveal good agreement, in particular in the frequency spectrum, spatial correlation, and amplitude probability distribution function of density fluctuations. Also, consistent with the experiment, the simulations indicate a great deal of similarity between plasma turbulence in LAPD and some features of tokamak edge turbulence. Similar to tokamak edge plasmas, density transport appears to be predominantly carried by large particle-flux events. Despite the intermittent character of the calculated turbulence, as indicated by fluctuation statistics, the turbulent particle flux is consistent with a diffusive model with diffusion coefficient close to the Bohm value.

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