Validation of the 3D global fluid turbulence code CYTO against fast-camera measurements on the linear devices CSDX and VINETA

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Extensive studies of turbulence with fast-framing cameras have been performed in the linear plasma devices CSDX and VINETA (length 2.8 m and 5 m, chamber radius 10 cm and 20 cm, respectively). Plasmas of 4-5 cm radius are produced by a helicon discharge in an axial magnetic field of 0.04-0.1 T ($n \sim 2\text{x}10^{19}$ m^{-3}, $T_e \sim$ 2-5 eV). Generally, these fast-rotating plasmas are characterized by the turbulent interplay of large-amplitude low-m azimuthal mode numbers. On CSDX, the picture emerges that m = 3-5 modes evolve into a large amplitude m = 1 mode, which then collapses by the ejection of a plasma blob. Both an acceleration of the mode rotation and an increase of the mode amplitude are observed before the blob is ejected, suggesting a rotation-driven interchange instability at the origin of the blob ejection.

On VINETA, the response of the turbulence to the excitation of m = 2-4 modes by an 8-pole electrostatic exciter at the plasma boundary has been studied. The fast camera reveals that the excited modes remain localized at the position of the exciter, with the core showing complicated mode patterns resulting from the competition of the natural plasma modes and the imposed boundary conditions. After switching the exciter on or off, a new turbulent steady state emerges only after 5-10 ms, much longer than any typical turbulent or resistive timescale.

The fast-camera data on mode evolution, blob ejection and response to an external perturbation is extremely valuable for the validation of turbulence simulation codes such as CYTO. Reciprocally, such simulations are necessary to achieve an understanding of the detailed mechanisms behind the experimentally observed turbulent phenomena. The CYTO code has been adapted successfully for CSDX simulations on the UCSD "Triton" Linux cluster. Initial runs show qualitative disagreements between simulation and experiment, notably the missing of a strong m = 1 mode, differences in the main rotation characteristics and generally smaller fluctuation levels, which are presently under investigation.