# Full-f simulations of a tokamak device with fluctuations on all scales


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**Abstract.** We present first-of-a-kind global turbulent simulations that encompass the entire volume of a tokamak. These simulations self-consistently include full-f drift-kinetic (DK) and $\delta$-f gyrokinetic (GK) turbulent fluctuations, allowing for fluctuations on scales that range from the machine size to the ion Larmor radius.

Extending the work of Ref. [1], the model is derived from first principles, using Lie transform and a variational principle, with the slowly-varying DK-ordered fields coupled to small-scale rapidly-fluctuating GK-ordered fields. The gyro-averaged Boltzmann equations for the DK and GK part of the distribution functions are obtained, along with the DK and GK Poisson equation [2]. The ion distribution functions are projected on a Hermite-Laguerre spectral basis to significantly increase the efficiency of the numerical solutions.

The simulations show turbulent structures occurring on a wide range of spatial scales, coupling the core, edge, and scrape-off layer regions. As an example of simulation results, Fig. 1 shows a snapshot of the poloidal cross-section of the electron density, $N_e$, for a highly-collisional and a moderately-collisional diverted system. The turbulent structures observed in the two simulations differ significantly. We analyse the nature of turbulence in these two simulations by using linear analysis and nonlinear saturation arguments. Comparison with fluid simulation will be discussed.


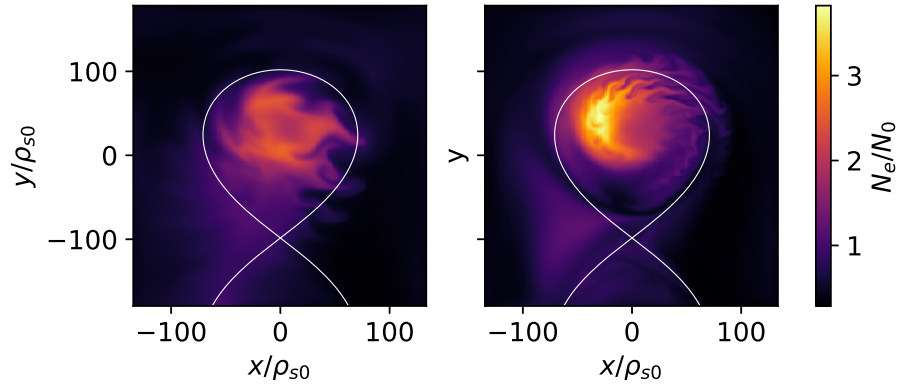


Figure 1: A poloidal snapshot of the electron density in a tokamak with high collisionality (left) and moderate collisionality (right). Turbulent structures of different sizes are observed in the simulations. The separatrix is shown in white.


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**References**


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