TH/1-1 · Size Scaling of Turbulent Transport in Tokamak Plasmas

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Abstract: Transport scaling with respect to tokamak device size is critically examined for electrostatic ion temperature gradient (ITG) turbulence with adiabatic electrons using first-principles gyrokinetic particle simulations, which use up to one billion particles to address realistic parameters of reactor-grade plasmas. Results of these large scale simulations, varying ρ^* (ion gyroradius normalized by tokamak minor radius) while keeping other dimensionless plasma parameters fixed, show that the fluctuation scale length is microscopic and transport is diffusive in the presence of zonal flows. The local transport coefficient exhibits a gradual transition from a Bohm-like scaling for device sizes corresponding to present-day tokamak experiments to a gyro-Bohm scaling for future larger devices. The device size where this transition occurs is much larger than that expected from linear ITG theory for profile variations. Our simulations include a heat bath/source to prevent profile relaxation and are in the strong turbulence regime far away from ITG marginality. The effects of kinetic electrons on electrostatic ITG-TEM (trapped electron mode) driven turbulence will also be presented.

TH/1-2 · Simulations of Finite Beta Turbulence in Tokamaks and Stellarators

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Abstract: One of the central open questions in our attempt to understand microturbulence in fusion plasmas concerns the role of finite beta effects. Nonlinear codes trying to investigate this issue must go beyond the commonly used adiabatic electron approximation – a task which turns out to be a serious computational challenge. This step is necessary because the electrons are the prime contributor to the parallel currents which in turn produce the magnetic field fluctuations. Results at both ion and electron space-time scales from gyrokinetic and gyrofluid models are presented which shed light on the character of finite beta turbulence in tokamaks and stellarators.

TH/1-3 · Full Radius Linear and Nonlinear Gyrokinetic Simulations for Tokamaks and Stellarators: Zonal Flows, Applied ExB Flows, Trapped Electrons and Finite Beta

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Abstract: Finite beta effects on microinstabilities are investigated with a linear global spectral electromagnetic gyrokinetic formulation. While the toroidal ITG mode is stabilized with increasing beta, another mode of electromagnetic nature becomes unstable below the ideal MHD ballooning limit. Its unique global structure is shown for the first time. The weakly destabilizing effect of trapped electron dynamics on ITG modes is shown for the first time in an axisymmetric bumpy configuration. Applied ExB flows in tokamak and heliac configurations stabilize toroidal and helical ITG modes with a quadratic dependence on the shearing rate. Trapped particle modes can be destabilized by ExB flows. Self-generated zonal flows are studied with a global nonlinear electrostatic formulation that retains parallel nonlinearity and thus allows for a check of the energy conservation property. A quasi steady-state is reached with zonal flow shearing rates fluctuating around a value comparable to the linear growth rate of the most unstable ITG. A semi-Lagrangian approach free of statistical noise is proposed as an alternative to the nonlinear PIC δ_f formulation.