

references on finite beta

Ren-Guangzhi

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1 Global gyrokinetic simulation of turbulence driven by kinetic ballooning mode

- A. Ishizawa, K. Imadera, Y. Nakamura, and Y. Kishimoto
- [Phys. Plasmas 26, 082301 \(2019\)](#)
- GKNET
- A saturation of KBM and a quasisteady state of KBM turbulence is presented. In the quasisteady state, strong zonal flows and low toroidal modes, which are stable against KBM, dominate the fluctuations of turbulence.
- saturation mechanism of the KBM
 1. zonal flow shear(when the zonal flow shearing rate is similar to the linear growth rate of ITG/KBM instability)
 2. other zonal modes such as the zonal magnetic field and zonal pressure
 3. the nonlinear energy transfer from the KBM to the low n modes
- extract

The ITG mode produces strong zonal flows, which regulate the nonlinear saturation level of ITG turbulence at low β , whereas it is hard to get a saturation of the growth of KBMs in gyrokinetic simulations because of weak zonal flows[2-4]. We observe the growth of fluctuations without saturation, for instance, above $\beta_i \approx 0.6\%$ for the Cyclone base case (CBC) parameters except for some cases with an artificially reduced pressure gradient[4,8,9]. This is called the run-away/nonzonal transition,[10-12] and it takes place at high β in gyrokinetic simulations using the local flux tube geometry.

In these local simulations, the production of zonal flows is the main mechanism of the saturation of drift-wave instabilities, and the run-away/nonzonal transition is considered to be linked to weak zonal flows due to stochastic magnetic fields. The magnetic stochasticity is produced by magnetic reconnection, leading to the violation of magnetic surfaces. Magnetic reconnection can be caused by drift-wave instabilities at finite β because magnetic perturbations due to the instabilities become prominent.

This process of the violation of magnetic surfaces is explained in terms of parity. The ITG mode and KBM belong to the twisting/ballooning parity mode, which does not cause magnetic reconnection and retains its parity during its linear growth phase because it satisfies the linearized gyrokinetic equation. On the other hand, twisting parity modes do not satisfy the nonlinear gyrokinetic equation[13], and thus, when a twisting parity mode evolves into the nonlinear regime, i.e., its amplitude becomes finite, the free energy of the instability should be transferred to tearing parity modes through nonlinear interactions, which is called the nonlinear parity mixture. The produced tearing parity modes cause the magnetic stochasticity and influence the amplitude of ITG turbulence at finite β . [14] Thus, the electromagnetic drift-wave instabilities have a channel of energy transfer to tearing parity modes, which can influence the amplitude of turbulence, in addition to the production of zonal flows.