Spectral dynamics and Predator-Prey oscillations in turbulence in fusion plasmas

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Plasma turbulence, which is mostly responsible for the heat and particle losses that limit magnetic confinement, is an important problem in fusion devices. The coupling between small scale plasma turbulence and mesoscale flow structures such as Zonal Flows or GAMs constitute one of the main mechanisms by which the plasma self-regulates. The behavior of this coupling is in some ways similar to the dynamics of Predator-Prey type population models, where the drift wave turbulence and zonal flows play the roles of prey and predator species respectively. The intuition obtained from the study of predator-prey models, as toy models of plasma turbulence are frequently used in order to understand the complex dynamics of magnetised plasmas[Diamond et al.(1994)]. Strong experimental indications for this dynamical behaviour has recently been observed in various machines during the low to high confinement (L-H) transition[Estrada et al.(2010)]. Using a strongly reduced cascade model, developped specifically for plasma turbulence in fusion devices[Gürcan et al.(2009)], we show that such oscillations may also appear in a cascade model in the form of pulses propagating down the scale space[Berionni and Gürcan(2011)]. A detailed study of the oscillations in this model leads to simple but non-trivial predictions for the relations between zonal-flow and turbulence levels in the dynamical state as quantities "averaged over the predator-prey oscillation period". This prediction is tested with a gyrokinetic LES implementation[Morel et al.(2011)] of the GENE code[Jenko et al.(2000)], which allows one to vary independently the injection and the dissipation by varying plasma parameters and hyperviscosity coefficients.

Références

[Diamond et al.(1994)] P. H. Diamond, Y.-M. Liang, B. A. Carreras, and P. W. Terry, Phys. Rev. Lett. **72**, 2565 (1994).

[Estrada et al.(2010)] T. Estrada, T. Happel, C. Hidalgo, E. Ascasibar, and E. Blanco, Europhysics Letters **92**, 35001 (2010).

[Gürcan et al.(2009)] Ö. D. Gürcan, X. Garbet, P. Hennequin, P. H. Diamond, A. Casati, and G. L. Falchetto, Phys. Rev. Lett. **102**, 255002 (2009).

[Berionni and Gürcan(2011)] V. Berionni and Ö. D. Gürcan, Physics of Plasmas **18**, 112301 (2011).

[Morel et al.(2011)] P. Morel, A. B. nón Navarro, M. Albrecht-Marc, D. Carati, F. Merz, T. Görler, and F. Jenko, Physics of Plasmas **18**, 072301 (2011).

[Jenko et al.(2000)] F. Jenko, W. Dorland, M. Kotschenreuther, and B. N. Rogers, Phys. Plasmas **7**, 1904 (2000).