2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

On the nonlinear dynamics of phase space zonal structures*

Fulvio Zonca[1,2], Liu Chen[2,3], Matteo V. Falessi[1] and Zhiyong Qiu[2]
[1] ENEA, Fusion and Nuclear Safety Department, C. R. Frascati
[2] IFTS and Department of Physics, Zhejiang University, Hangzhou
[3] Department of Physics and Astronomy, University of California, Irvine
e-mail: fulvio.zonca@enea.it

Phase space zonal structures (PSZS) are long-lived formations in the particle phase space; that is, PSZS are undamped by (fast) collisionless dissipation mechanisms due to wave-particle interactions [1]. They play important roles in transport processes, since they describe the deviation from local thermodynamic equilibrium and affect the nonlinear dynamic evolution of the system [1,2].

In this work, we adopt a non-perturbative description [3] of PSZS, showing their implications to transports, the role of zonal structures on wave-particle resonances and the effect of more complex nonlinear interactions on resonance broadening [4]. We further adopt the fishbone paradigm [1,3] and focus on precession resonance to elucidate the effects of toroidal geometry and keep the formal analysis at a tractable level. This allows us to derive the renormalized expression of the particle distribution function in the form of a Dyson-like equation [3], which illuminates the self-consistent nonlinear evolution of resonance structures in the phase-space.

[1] F. Zonca, L. Chen, S. Briguglio, G. Fogaccia, G. Vlad and X. Wang, New J. Phys. **17**, 013052 (2015).
[2] M. V. Falessi, Gyrokinetic theory for particle transport in fusion plasmas, arXiv:1701.02202 [physics.plasm-ph]; M. V. Falessi and F. Zonca, Phys. Plasmas **25**, 032306 (2018).
[3] L. Chen and F. Zonca, Rev. Mod. Phys. **88**, 015008 (2016).
[4] T. H. Dupree, Phys. Fluids **9**, 1773 (1966).

* Work supported by US DoE and NSFC grants, and by the EUROfusion Consortium under grant agreement number 633053.