MF-O10 AAPPS-DPP2019

3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Gyrokinetic transport theory 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 Dept., 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 are long-lived formations in the particle phase space; that is, phase space zonal structures 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 gyrokinetic theory to extract the phase space zonal structure from the flux surface averaged particle response; and show that phase space zonal structures are a proper definition for the nonlinear distortion of the plasma reference state [3,4] and, thus, of the generally non-Maxwellian neighboring nonlinear equilibria consistent with toroidal symmetry breaking fluctuations [5]. Evolution equations for phase space zonal structures are derived and discussed, along with corresponding density and energy transport equations, including sources, sinks and collisions. It is shown that this approach is consistent with the usual evolution of macroscopic plasma profiles under the action of fluctuation induced fluxes, when the deviation of the reference state from local Maxwellian response is small and the equilibrium profiles evolution is considered on the macro-scales. In the general case, it allows computing the actual deviation of the system from the reference state in the presence of a finite level of fluctuations. In this way fluctuation-induced and collisional transport are addressed on the same footing.

References

[1] F. Zonca, L. Chen, S. Briguglio, G. Fogaccia, G. Vlad and X.Wang, New J. Phys. **17**, 013052 (2015).
[2] M. Falessi, arXiv:1701.02202 [physics.plasm-ph]
[3] L. Chen and F. Zonca, Nucl. Fusion **47**, 886 (2007).
[4] L. Chen and F. Zonca, Rev. Mod. Phys. **88**, 015008 (2016).
[5] M. Falessi and F. Zonca, Phys. Plasmas **26**, 022305 (2019).

* Work supported by the EUROfusion Consortium under grant agreement number 633053 and by ITER-CN grant No. 2017YFE0301900