Interaction of Alfvénic modes and turbulence, investigated in a self-consistent gyrokinetic framework

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Tokamak plasmas are examples of complex systems where multiple spatial and temporal scales are intrinsically linked. Microturbulence, meso-scale zonal structures (ZS, like zero-frequency zonal flows and geodesic acoustic modes) and macroscopic MHD instabilities like Alfvénic modes (AM), mutually interact either due to the modification of the equilibrium profiles, or by direct coupling via wave-wave nonlinear interaction. In particular, a strong interest recently raised in understanding the generation of ZS by AM, due to the strong implications in modifying the turbulent transport. The gyrokinetic global particle-in-cell code ORB5 [1, 2] was developed for turbulence studies, extended to its electromagnetic multi-species version, and verified and benchmarked for the linear dynamics of mictroturbulence modes, ZS and AM. The importance of the kinetic electron effects in the ZS dynamics has also been emphasized with ORB5 [3]. Recent simulations with ORB5, have investigated the nonlinear dynamics of AM [4], the self-consistent interaction of AM and turbulence, and in particular the competition of the generation of ZS by turbulence and by AM [5]. In this work, the mechanisms of generation and saturation of the ZS will be described. In particular, the wave-particle nonlinearity, the wave-wave nonlinearity, the effect of turbulence on AMs, the effect of AMs on turbulence, for example via ZS generation, will be studied separately and in self-consistent simulations. Comparisons with other models like the gyrokinetic Eulerian code GENE [6] will also be shown.

References

[1] S. Jolliet, et al. *Comput. Phys. Commun.* **177**, 409 (2007)

[2] A. Bottino, et al. *Plasma Phys. Controlled Fusion* **53**, 124027 (2011)

[3] I. Novikau, et al., *Phys. Plasmas* **24**, 122117 (2017)

[4] A. Biancalani, et al., *Plasma Phys. Controlled Fusion* **59**, 054004 (2017)

[5] A. Biancalani, et al., *IAEA Fusion Energy Conference*, Ahmedabad (India), Oct. 22th-27th, 2018, TH/P2-9

[6] F. Jenko, et al., *Phys. Plasmas* **7**, 1904 (2000)