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Self-consistent gyrokinetic description of the interaction between Alfven modes and turbulence

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It is getting increasingly clear that many tokamak plasma phenomena which have traditionally been investigated separately, are actually intrinsically linked. One outstanding example along these lines - which is investigated in the present contribution - is the the interaction between Alfven modes (AM), turbulence, and zonal structures (ZS), like zonal flows and geodesic acoustic modes. Recently, a strong interest was raised in the fusion community by the possibility of generating ZS via nonlinear interaction with global modes like Alfven instabilities.
In this work, the interaction of AM, turbulence and ZS is studied with the code ORB5. This model treats ions and electrons respectively as gyrokinetic and driftkinetic.
ORB5 is a nonlinear global particle-in-cell code, developed for turbulence studies [1] and extended to its electromagnetic multi-species version [2] for the investigation of Alfven dynamics [3].
Recently, the importance of the kinetic electron effects in the ZS dynamics has also been emphasized with ORB5 [4]. ORB5 has also accomplished a verification/benchmark phase for AMs and has been used for the study of the nonlinear wave-particle interaction [5].
The competition between the different excitation mechanisms of ZS is the main focus of this work.
When an EP population is added to the electromagnetic turbulence, the perturbed saturated field is observed to be modified by the presence of AMs. The effect of the different players are described separately, and in particular:
wave-particle nonlinearity, wave-wave nonlinearity, effect of turbulence on AMs, effect of
AMs on turbulence, for example via ZS generation, and bulk plasma omega-star effects on the AM growth rate and saturation.
Comparisons with analytical theory and other models like the gyrokinetic Eulerian code GENE [6,7] are also done.

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