Nonlinear interaction of turbulence and energetic particles in tokamak plasmas

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Gradients in the temperature and density profiles, drive drift-waves unstable in tokamak plasmas. These micro-instabilities nonlinearly interact forming turbulence. The mitigation of turbulence is considered an important step towards the achievement of controlled nuclear fusion in magnetic confinement devices. A byproduct of turbulence is the generation of zonal, i.e. axisymmetric, flows (ZF). ZFs are recognized as one of the main mechanisms of turbulence saturation [1]. Energetic particles (EPs), are present in tokamak plasmas due fusion reactions and external heating mechanisms. EP can drive electromagnetic oscillations like Alfvén Modes (AM) [2,3] unstable.

In this work, we show how EPs can indirectly affect turbulence. We consider two mechanisms, both mediated by the EP-driven AMs: A) the nonlinearly excitation of ZF [4,5]; B) the nonlinear modification of the equilibrium profiles [6]. The numerical tool used to perform the numerical simulations is the multispieces electromagnetic gyrokinetic particle-in-cell code ORB5 [7,8]. This theoretical model paves the way for different points of view on the interpretation of experimental results such as the turbulence reduction in the presence of EPs, in experimentally relevant cases.

References

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