New insights into fast ion induced turbulence stabilization

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1 Abstract

The role of fast ions on the development of ITG turbulence in tokamaks is investigated through both gyrokinetic simulations and a reduced Vlasov model. A significant fast ion induced stabilisation is found in both linear and nonlinear gyrokinetic simulations even in the electrostatic limit, which cannot be explained with the conventional assumptions based on pressure profile and dilution effects. In contrast to previous interpretations, fast particles can actively modify the Poisson field equation through a wave-particle resonant interaction. The lack of validity of the fast particle trace approximation is clearly shown and the main parametric dependencies of this fast-ion turbulence stabilization, as identified through a reduced Vlasov model, are confirmed by full gyrokinetic simulations. In order to rigorously model the highly non thermalised fast ion species, the basic equations of the gyrokinetic code GENE are here extended to use arbitrary backgrounds and the impact of non-Maxwellian distribution functions on micro-instabilities and the wave-fast ion resonance stabilisation is studied. The fast particle distributions are modelled with different analytic choices, e.g. slowing down and bi-Maxwellian, as well as numerical distributions as obtained with the SELFO=LION+FIDO and the TORIC/SSFPQL codes for ICR-heated ions for realistic plasma scenarios. The fast-ion resonant stabilisation of the turbulence tends to be less strong -but still substantial- with more realistic distribution functions.