Electromagnetic Electron Temperature Gradient Modes in a Tokamak

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Abstract

Electromagnetic Electron Temperature gradient (ETG) driven turbulence is now widely recognized as a possible mechanism for small-scale turbulence associated with electron heat transport in tokamaks. Experimental observations such as scaling of threshold temperature gradients [1,2] with plasma parameters, profile resilience and intermittent [3] nature of heat transport are all consistent with linear and nonlinear characteristics of the ETG mode. Experimentally relevant transport has also been observed in nonlinear, toroidal gyrokinetic simulations [4] of the electron temperature gradient instability.

In this paper, we examine the linear features of collisionless electromagnetic ETG mode including effects due to charge non-neutrality, impurity seeding, non-adiabatic ion and impurity response, and finite plasma beta. Modifications of the ETG mode due to coupling with both parallel (compressional) and perpendicular (flutter) perturbations are included. Starting with Braginskii two fluid equations, we derive a differentio-algebraic system, which is solved numerically using finite difference and collocation methods. Comparisons are also made between the earlier linear gyro-kinetic theory and our new analytical semi-local / nonlocal fluid theory results especially highlighting the effects observed on transport. We demonstrate that thresholds obtained from elaborate gyrokinetic simulations or expensive experiments can be satisfactorily explained by simple linear fluid theory as well.

Nonlinear features of the ETG instabilty have also been investigated using the anstaz of scale separation. A Wave kinetic formalism is adopted wherein the short scale ETG modes interact with the long scale streamers. Effects of charge non-neutrality are explored.

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[3] Tangri V., *et. al.*, Phys. Rev. Lett., **91** 025001 (2003).

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