Seminar

Institute for Plasma Research

Title : Global Gyrokinetic Study of Electromagnetic Microinstabilities in Tokamak Plasmas

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Time : 11.30 AM

Venue : Committee Room 3 (New Building), IPR

Abstract:

Turbulent transport of energy, particles and momentum is one of the important limiting factors for long time plasma confinement in modern day hot tokamaks. In the presence of equilibrium gradients in density and/or temperature, microinstabilities set in and in their nonlinear stages, generate such turbulence and hence are of great interest to understand the transport issues in tokamaks. In this thesis, electromagnetic microinstabilities are investigated using multi-scale fully gyrokinetic global calculations. The model captures the dynamics of ions and electrons despite their disparate scales of Larmor radii. The numerical implementation is optimized to efficiently handle large size calculations. The primary focus of the work is investigation of a particular electromagnetic multi-scale microinstability which has emerged as an important open problem in theory and experiments of hot tokamaks, namely Microtearing Modes (MTM).

MTMs are electromagnetic microinstabilities, predicted to be unstable in tokamak plasmas and other magnetic confinement devices and are of interest in the context of electron-driven transport studies, but at sub-ion scales. These low frequency sub-ion larmor scale modes derive their free energy from the electron temperature gradient and are only unstable above a threshold plasma pressure. Earlier analytical works in slab and cylindrical plasmas investigated collisional drives as the main reason for sustaining the instability. Recently however, experimental and numerical investigations for realistic tokamak plasma parameters and geometry, have gathered pace. A medium to weak collisional drive has been thought to be necessary for the instability to survive in the presence of finite plasma beta.

In this work, in the first part, it has been demonstrated for the first time that MTMs can be unstable in completely collisionless plasmas of large aspect ratio tokamaks. This study finds the collisionless drive as primarily due to passing electron dynamics, and investigates further to bring out the stability properties, global 2-D structures, contribution of electron and ion species and several new scaling relationship. The role of trapped electrons is found to be minimal for certain plasma parameters, and destabilizing at shorter wavelengths as well as smaller aspect ratios. In the later parts, without the trapped electrons, the global stability characteristics of MTM is investigated for configurations relevant to advanced tokamak scenarios, such as the weak reverse shear and found to be stabilized by lower magnetic shear. Importantly, the dominant MTM branch is found to lead to linearly unstable mixed parity modes at weaker shear, opening the possibility of mode conversions. These results will be presented in greater detail and open questions will be outlined.