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# PhD PROPOSAL 2014



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**Title :**

## Stabilisation of ballooning and temperature gradient instabilities by energetic particles in advanced tokamak regime

The transition from typical inductive H-modes (at high density and low pressure and thermal confinement) to hybrid scenarios (at low density high pressure and thermal confinement) at JET is a complex process.

Dedicated experiments at JET have been carried out in order to find out the dependence of the plasma thermal confinement on power and to show how the transition from H-modes to hybrid scenarios is established. These experiments have shown that previous scaling which gave a strong degradation of the thermal confinement with power was not correct as a much weaker dependence has been obtained.

When the input power is high enough, the transition to advanced scenarios is clearly seen when both high pressure and high thermal confinement are obtained. The main reason for this increase of confinement comes from the edge region, as its pressure clearly increases with power. However, the core confinement also increases and at a determined power and weak region in which ion thermal transport is improved is clearly seen.

Previous analyses of the plasma turbulence (performed with gyrokinetic codes) and MHD stability at the edge, have shown that a high concentration of fast ions can increase core pressure without increase turbulence, something that leads to a fast increase of the Shafranov-Shift which also improves the pedestal MHD properties. Since rotation and the fast ion pressure increase with power, a detailed analysis of their influence on plasma turbulence is crucial in order to know the origin of this increased core confinement and their relative importance. For that purpose, full electromagnetic gyrokinetic simulations and MHD analyses are required.

The main purpose of this thesis will be to quantify the contribution of the plasma core and edge to the increased confinement obtained in JET hybrid scenarios. The different contribution for the core improvement (fast ions, rotation and magnetic shear) will be also analyzed. For that purposed the CRONOS code will be used to perform interpretative analyses of the JET discharges and the gyrokinetic code GENE will be therefore used to perform linear and non-linear gyrokinetic simulations. The different turbulent mechanisms will be analyzed and the heat flux will be compared to the experimental values. The relative importance of the core and edge for establishing advanced scenarios will be as well analyzed by comparing the core results with Peeling-ballooning analysis of the edge performed with the MISHKA code. The possible implication for ITER and WEST (with possibly a high amount of fast ions generated by the heating mechanisms) will be carried out by analysing different ITER and WEST scenarios previously designed with CRONOS. Possible analysis of JT-60U and JT-60SA scenarios will be considered. The capability of the transport model Qualikiz (developed in CEA) for reproducing the physical mechanism leading to advanced regimes will be analysed by benchmarking the results obtained with GENE with this model.

The GENE code will be used in the supercomputer HELIOS in which a new project has been already established for this purpose.

**Skills : Computational physics (development and using physics codes) and basic physics (fluids and electromagnetism)**