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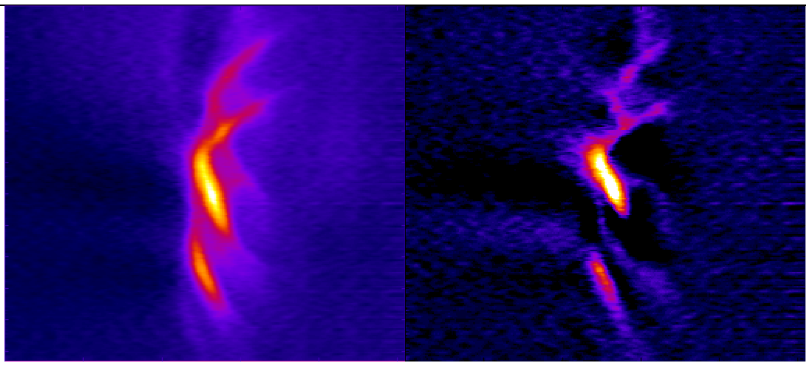
| **Title** : **Physics and Diagnostics in Tokamaks** |
| **Acronym** : O2 |
| **EU Coordinator** : Pierre MOREL, Laboratoire de Physique des Plasmas (LPP) |
| **Teaching staff** : Pierre MOREL, Cyrille HONORE, Rémy GUIRLET |
| **Pre-requisites** : First year of MSc in Physics or Engineering Schools. |
| **Credits** : 3 ECTS |
| **Language** : French/English |
| **Keywords** : Profile measurements and other diagnostics for equilibrium and transport, fluctuation diagnostics: reflectometry, beam probing, radiation. H-mode, flow-turbulence interaction, power extraction. |



The aim is to present the different methods of characterisation of Tokamak plasmas, from the core to the wall, by linking the outstanding observations to physical phenomena. Starting from remarkable experimental observations, the approach first consists in understanding the physics underlying the diagnostics used (radiation, wave probing, particles...). Then, by extending the « Tronc Commun » lessons, to understand the physical interpretations proposed.

The notion of magneto-hydrodynamic equilibrium seen in the previous courses TC2 (Magnetohydrodynamics) and TC3 (Kinetic Theory) are supported by magnetic measurements and interferometry, which allow to understand how a typical discharge in a tokamak is planned, then carried out and controlled in real time. The stability of such a discharge is then addressed : the measurements of the electron cyclotron emissions (ECE) and in soft X-rays, the principle of a tomographic reconstruction, allow to discern the sawtooth oscillations of the electron temperature, but also the instabilities of the pedestal at the edge, the "edge localized modes".

The temporal dynamics of the macroscopic profiles are further investigated by means of incoherent Thomson scattering, ECE, interferometry and reflectometry measurements that provide access to heat transport, density peaking, and the transition between linear and saturated ohmic confinements (LOC-SOC). Measurements by Langmuir probes and fast imaging at the edge of the plasma complement these observations by providing direct access to turbulent flows and fluctuation characteristics, such as their intermittency.

With a view to the first ITER plasmas, whose plasma-facing components will be made of Tungsten (W), the spectroscopy principles laid down in the teaching unit TC7 (Atomic, molecular and radiation physics) are reviewed and deepened, in the visible and ultra-violet domains, to enable the study of impurity sources, their flows, their density distribution, and their application to the case of Tungsten.

Finally, coherent Thomson scattering makes it possible to characterise the ion temperature, and in particular to study fast particles, which are particularly important in ITER. Collective laser and microwave Thomson scattering and fluctuation reflectometry, by spectrally and spatially characterising turbulence, make it possible to study its interaction with the radial electric field profile, in order to understand the high confinement mode (H mode), and the influence of zonal flows or geodesic acoustic flows (GAMs) on turbulence.

Course Outline :

1 - Magnetic equilibrium
2 - MHD stability
3 - Thomson scattering
4 - Profile dynamics
5 - Reminder of spectroscopy
6 - Spectroscopy applied to tokamaks
7 - Turbulence in the Scrape Off Layer
8 - Turbulence in the core of tokamaks