A New Emission Spectroscopy Diagnostic in the THORELLO Device

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Density measurements in the plasma edge can be performed by means of electrostatic probes, microwave or optical diagnostics. Electrostatic probes (Langmuir probes) are very fast but slightly perturb the plasma column, optical diagnostics are instead passive but being also slower allow average values measurements only.

The simply magnetized thorus Thorello has been recently upgraded installing a new emission optical spectroscopy diagnostic to measure plasma density. The poloidal cross-section is almost completely mapped by 19 virtual hexagons, each crossed by at least 2 of the 19 lines of sight probing the plasma, allowing approximately a 2x2 cm spatial resolution. Light coming out from the plasma across quartz windows is collimated and directed to a receiver via optical fiber. We can choose between two different CCD spectrometers with wavelength range between 180 and 850 nm with high resolution (10 μm) and wider wavelength range between 175 and 1100 nm but with lower resolution (0.7 nm). A photomultiplier, characterized by very high sensitivity, can be also applied – with an electrical response of the order of about 3 ns is in principle possible to study typical plasma density fluctuations.

With this diagnostic we can measure the main Balmer lines H_α, H_β, H_γ, H_δ, H_ε, H_ζ, and two H_2 lines (λ=463.147 nm and λ=493.398 nm), and extract the information on the average plasma density by means of a minimization function. In reality, the measured average light intensity is proportional to the product of average plasma electron density and average electron temperature plus the cross-correlation between their fluctuating components – the latter represents about 10% of the detected photons.

The diagnostic has been tested under different plasma conditions changing plasma pressure, bias voltage between filament and vacuum chamber, toroidal magnetic field and vertical magnetic field. For H_α measurements errors are between 6% and 30%, depending of the line of sight. Results has been also compared with Langmuir probes measurements.