TEMPERATURE MEASUREMENT IN HIGHLY REFLECTING ENVIRONMENT AND AT LARGE DISTANCE BY ACTIVE BICOLOUR PYROMETRY

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The temperature inside a tokamak needs to be monitored to provide good working conditions and to avoid damages. In normal working conditions, the wall tiles surface temperature should remain much below the fusion temperature of the material. Nowadays, the widest-used technique for following in-situ wall-surface temperatures in this domain is infrared thermography. This technique, however, has the limiting disadvantage that the measurements are perturbed by the surrounding thermal radiations reflected by the observed surface. Unlike the classical pyrometry operating with only one detector, the presented active bicolour method registers the temperature by the mean of two detectors working at different wavelengths [1-4]. A pulsed laser is used to generate a slight increase ΔT (~ 10°C) of the surface temperature. The signal modulations ΔR_1 and ΔR_2 of the detected radiation flux resulting from the temperature perturbation are collected by two pyrometers. As both pyrometers take the signal from the same perturbed zone and as the perturbation ΔT is small, the temperature deduced from the $\Delta R_1/\Delta R_2$ ratio is then theoretically independent of the reflected fluxes, assuming that the latter are constant in time.

The aim of the present work was to demonstrate that the active bicolour method is really independent of a high perturbation flux. Two Kleiber pyrometers were operating at 1668 nm and 2092 nm. The laser used to generate the heat perturbation was a Nd:YAG Quantel Brilliant laser (wavelength: 1064 nm, pulse duration: 120 µs). An optical system could modulate the laser pulse energy in the interval 3 - 400 mJ, in order to precisely adjust the temperature perturbation. To simulate the reflective environment in tokamaks, we used an IR source, a blackbody cavity working at 900°C. The temperature of the sample was monitored by a thermocouple. $\Delta R_1/\Delta R_2$ ratios were measured on 304L stainless steel and temperatures were deduced from a calibration curve. The presented results will show that the temperatures measured with and without perturbation fluxes are identical, hence demonstrating the method is independent of reflective fluxes.

In addition, experiments were performed at large distance (2.15m between the sample and the pyrometers) to switch over from laboratory scale towards ITER scale. Temperatures were measured on graphite, graphite-layered components and stainless steel, following the same procedure described above. The results showed that the temperature could be measured at ±30°C for graphite-type materials and ±50°C for metallic materials as stainless steel. Further experiments are planned at even larger distance (4-10m).

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[3] Th. Loarer et al., J. Nucl. Mater., 1450, 2007, 363–365.
[4] V. Grigorova et al., J. Nucl. Mater., 1097, 2009, 390-391.