Comparison of photometer calibrations at six different facilities of PTB and NIST

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Abstract. Two photometers were calibrated at six different facilities of the PTB and the NIST. At each institute a secondary calibration against other reference photometers at an optical bench, a primary calibration against reference photodiodes at monochromator facilities and a primary calibration with tunable lasers were performed. All measurements are traceable to the respective cryogenic radiometers used as primary and national standards. Most of the measurements have been completed; the remaining measurements will be done this summer before NEWRAD. The deviations of the already performed measurements are within ± 0.6%.

Facilities

The six facilities are described briefly below.

a) Optical bench of the PTB

At the optical bench of the PTB the calibration is performed using a network of different standard lamps at different distribution temperatures as sources and different photometers as detectors [1]. The photometric responsivity related to standard illuminant A (T_A = 2856 K) is obtained as a result of a fit. This fit also gives an index for a simplified spectral mismatch correction.

b) Optical bench of the NIST

At the optical bench of NIST the calibration is performed using a standard lamp with a distribution temperature of T_A = 2856 K against a group of reference photometers that maintain the NIST illuminance unit [2].

c) Monochromator facility of the PTB (DSR)

The calibration of the absolute spectral irradiance responsivity of a photometer is done by a monitor-based substitution method at the DSR facility (Differential Spectral Responsivity) [3]. The photometer and a calibrated reference photodiode are illuminated (overfilled) by the monochromatic beam, far enough away from the monochromator. In front of the reference photodiode is a calibrated aperture. As the area of the photometer is larger than the area of the aperture, the area of the photometer is mapped by the photodiode at every wavelength. These measurements are repeated within the very homogeneous field of a mercury lamp (at a long distance without imaging optics) at a wavelength of 546.1 nm. This method and the next three methods measure the spectral irradiance responsivity $s(\lambda)$ and allow to calculate the photometric responsivity s_v with the formula

$$s_v = \frac{\int_0^\infty P(\lambda,T_A)\cdot s(\lambda)\,d\lambda}{K_m \cdot \int_0^\infty P(\lambda,T_A)\cdot V(\lambda)\,d\lambda} \quad \text{with } T_A = 2856\ \text{K}.$$

where $P(\lambda,T_A)$ is the Planck function at 2856 K.

d) Monochromator facility of the NIST (SCF)

The monochromator-based facility for detector spectral responsivity at NIST is the "Spectral Comparator Facility", SCF [4]. As the beam underfills the reference photodiode and the photometer, a mapping procedure is used for irradiance responsivity calibration.

e) Tunable laser-based facility of the PTB (TULIP)

The TULIP facility (TUnable Laser In Photometry) of the PTB is based on different tunable cw lasers, covering the visible range and a sphere to create a uniform monochromatic radiation field at a high power level [5]. In this uniform radiation field, the photometer is substituted by a reference photodiode or a trap detector.

f) Tunable laser-based facility of the NIST (SIRCUS)

The SIRCUS facility (Spectral Irradiance and Radiance Responsivity Calibrations with Uniform Sources) was the first tunable laser-based facility covering the complete radiometric range from UV to IR [6] and, in principal, is similar to TULIP.

Results of comparison

In the presentation the results of illuminance responsivities, measured at the different facilities a) – f) are presented.

These results are analyzed and discussed, comparing also with the results of 1997 CCPR Key Comparisons of photometric units. The results of spectral irradiance responsivities are also analyzed and discussed.

References

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