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SCHAP & ITS ACCURACY ANALYSIS FOR LED MEASUREMENT

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Introduction

Even for the Class L photometer with $f_1'<1.5\%$, the spectral mismatch errors can be large in LED measurement, especially in the cases of single-colour LEDs[1]. And if the Class L photometer head adopts partial filters, the responsivity non-uniformity in its sensitivity area will further enlarge the errors for sources whose spectral distribution are not perfectly spatially uniform, like white LEDs.

High accuracy spectroradiometers can avoid the spectral mismatch errors, and they are commonly considered to be suitable for LED measurement. However, high accuracy spectroradiometers are expensive, and they suffer the instability and narrow linear dynamic range due to their detecting device.

A new Spectral Corrected High Accuracy Photometer (SCHAP) for photometric measurement is proposed in this paper.

The SCHAP has very little dependence on the spectra of test light sources, and can avoid errors caused by the spatial spectral non- uniformity of test sources. Simulations show that the SCHAP can obtain much higher accuracy than the current high end photometers and spectroradiometers. Furthermore, the absolute value of the SCHAP can be calibrated based on detector rather than standard lamp, the SCHAP can traces to High Accuracy Cryogenic Radiometer (HACR) with super short transfer chain, thus many errors can be avoided.

Basic structure of the SCHAP

As shown in fig.1, the light entrancing into the aperture is split into two beams. The transmitted beam is received by a photometer head whose spectral responsivity matches the V(λ) function when takes account of the transmitance of the polarization-independent prism splitter. And the reflected light is sampled and mixed into the fast spectroradiometer. The photometer and spectroradiometer measure the same entrance light to the SCHAP at the same time.

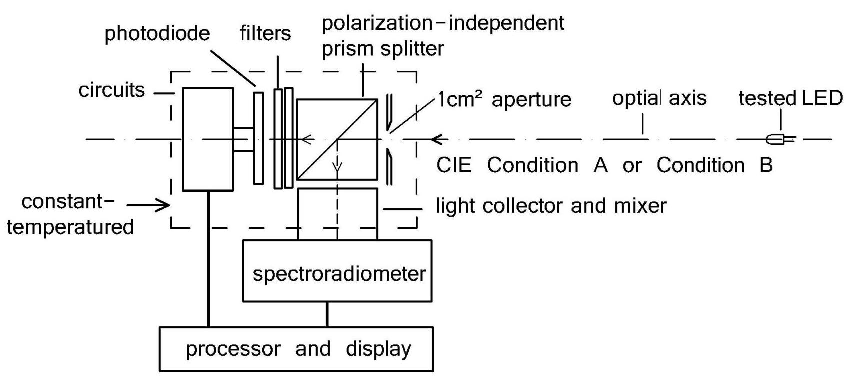

Fig.1: Structure scheme of the SCHAP and its application in averaged LED intensity measurement

Calibration and measurement

Detector based absolute calibration

As shown in fig.2, the absolute value of the SCHAP can be calibrated by a detector whose absolute spectral responsivity is calibrated by HACR.

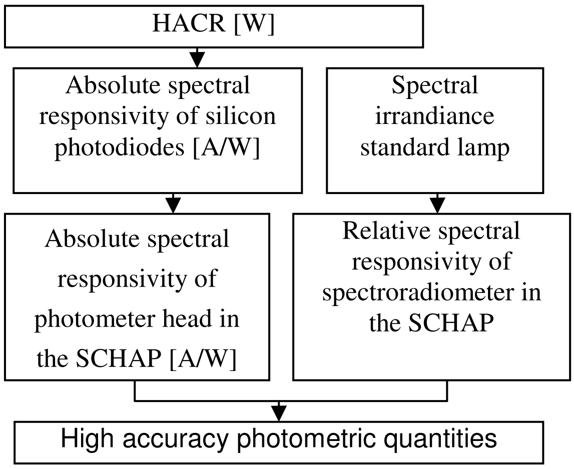

Fig.2: The quantity transfer chain and realization of photometric quantity of the SCHAP

After calibration, the photometric quantities can be measured by the SCHAP as the realization of photometer unit in NIST [2]:

$$PH_T = \frac{683 \cdot I}{K_d} \cdot \frac{\int_{380}^{780} P_T^t(\lambda) \cdot V(\lambda) d\lambda}{\int_{380}^{780} P_T^t(\lambda) \cdot S_{rel}(\lambda) d\lambda} \qquad (1)$$

wherein, I is the responsive current of photometer head (unit: A), PtT(λ) is the relative spectra of test light measured by the spectroradiometer, Srel(λ) is the normalized spectral responsivity, and Kd is the maximum value of absolute responsivity.

Standard illuminant A based calibration

The SCHAP can be calibrated by standard luminous intensity or spectral irrandiance lamps (usually illuminant A) like general photometers. The quantities of photometer head is corrected by general spectral correction factor [1].

Uncertainty analysis for LEDs

Uncertainties caused by spectral factors

The uncertainties caused by spectral factors of the SCHAP, Class L photometers and high accuracy spectroradiometers are analyzed by numerical simulation.

The Class L photometers are based on models[3] and real spectral reposivities; the high accuracy spectroradiometer has 0.1nm wavelength error and 1% gaussian random errors in measured relative spectra; the SCHAPs adopt Class A photometer heads of 2%<f_1'<3% based on real reposivities and spectroradiometers of 0.5nm wavelength errors and 5% gaussian random errors. The measurement of single colour LEDs, RGB white LEDs and blue chip plus yellow phosphor white LEDs with different CCT are simulated.

The SCHAP has much higher accuracy than the other two instruments. The uncertainties caused by spectral factors of the SCHAP for phosphor white LEDs are less than 0.05%, and only 0.5% for blue LEDs, while the Class L photometers are larger than ±0.5% and ±2%, and the spectroradiometer larger than 0.15% and 1% respectively.

Absolute value uncertainty budget

A photodiode calibrated in PTB whose absolute spectral responsivity uncertainty is 0.12% (K=2) in visible range is used to calibrate the SCHAP. Combined with other factors, the relative uncertainty of absolute value of the SCHAP can be 0.36% (K=2).

Total uncertainty for typical measurement

The uncertainty for the averaged LED intensity measurement are analysed. The combined relative uncertainty can achieve 0.79%~4.29% (K=2), and 0.66%~ 1.19% (K=2) exclusive of the components caused by LED alignment and instability, for typical white LEDs, it is 0.66% (K=2).

For total luminous flux, the illuminance integration method with a goniophotometer is applied. The alignment and distance components are avoided, and the combined uncertainty can achieve 0.54%~1.50% (K=2) for typical LEDs. If excluding the instability component, it cab be 0.50%~1.12% (K=2), and 0.50% (K=2) for typical white LEDs.

Acknowlegement

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References

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