

SPECTRAL AND COLORIMETRIC CHARACTERISATION OF LEDS USING SPECTRORADIOMETERS

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1. Introduction

The precise knowledge of the spectral power distribution of radiation emitted by LEDs is of crucial importance for the determination of the associated photometric and colorimetric quantities. For this purpose, compact array spectroradiometers are increasingly used. The most important impediments to their reliable application, however, typically are high stray-light levels, a limited resolution, bandpass irregularities, the mechanical and thermal stability, etc.

Within the framework of this work, a set of selected LEDs has been spectrally characterised using calibrated array spectroradiometers with implemented numerical stray light correction. The results are compared with those obtained using double-monochromator spectroradiometers. This analysis shows the systematic effects which the most important instrumental parameters of the devices have on the derived photometric and colorimetric quantities and the associated uncertainty levels than can be achieved.

2. Spectroradiometric Measurements

For these studies, an RGB cluster of four high-power LEDs with peak wavelengths at 462 nm, 524 nm, 526 nm and 622 nm, and also one single LED with a peak wavelength at 408 nm were selected (Figure 1). All LEDs were built in specially designed holders and operated in the current- and temperature-stabilised mode [1].

The measurements of the spectral power distribution of the LED radiation were carried out with the help of two different types of spectroradiometers: a CCD array spectro-radiometer and a scanning-type double-monochromator spectroradiometer. The measurement geometry complied with the requirements of the CIE standard condition B [2].

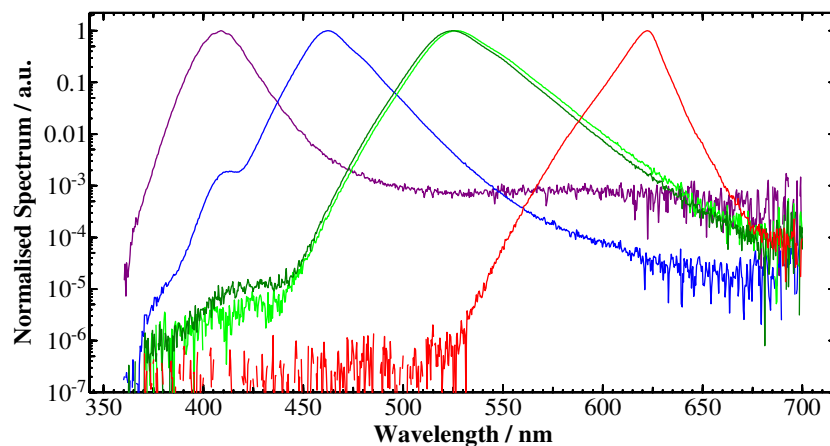


Figure 1. Spectral power distribution of the radiation emitted by the selected LEDs.

A 1024x1024-pixel CCD array spectro-radiometer had an integrating sphere as input optics which was attached via an optical fibre-bundle. The device has a working spectral range

from 360 nm to 860 nm and a spectral bandpass of 1.8 nm. The dynamic resolution is defined by a 15-bit A/D converter. The stray light characteristics of the spectroradiometer were determined using the tunable pulsed laser for an advanced characterization of spectroradiometers (PLACOS) of the PTB [3]. Figure 2 shows the line spread function of the CCD spectroradiometer at several representative wavelengths. Based on the characterisation results, a stray light correction matrix has been developed using the method of [4].

The fast-scanning spectroradiometer contains a double-monochromator in a subtractive diffraction configuration. It had a diffuser head with a fibre-bundle as input optics. The usable spectral range spanned wavelengths from 210 nm up to 700 nm. During the measurements, the bandpass was set to 1.0 nm

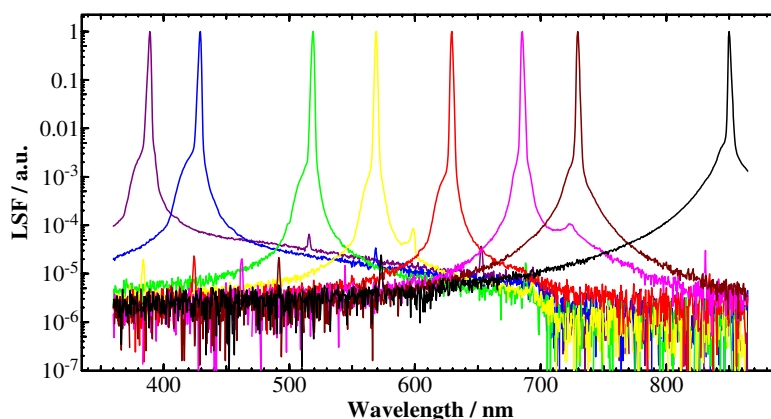


Figure 2. Line spread function of the array spectroradiometer at several representative wavelengths.

Prior to the LED measurements, the wavelength scales and the spectral response of the spectroradiometers were calibrated with the help of the respective standards. Then the spectral power distribution of each LED was consecutively measured by both spectroradiometers. Figure 3 provides the representative spectra for one of the LEDs obtained from the high-end CCD spectroradiometer with and without the stray light correction as well as from the double-monochromator spectroradiometer.

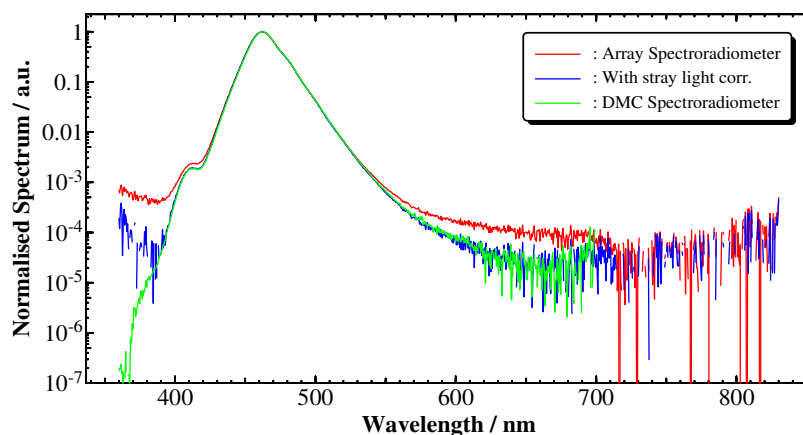


Figure 3. Spectral power distribution of the blue LED, measured using the CCD array spectroradiometer, effect of the stray light correction, and the measurement results obtained by the double-monochromator spectroradiometer.

3. Discussion

The measurement results obtained from the different array spectroradiometers were compared. First of all, the comparison showed the spectral stray light effect (see Figure 3). It appeared that - in the case where it was large - the quantity most sensitive to the spectral stray light was a spectral mismatch correction. This is typically the case for photometric measurements of LEDs with peak wavelengths below approx. 450 nm. Nevertheless, this effect could be successfully eliminated by applying the stray-light correction matrix. If not corrected, the stray light of array spectroradiometers will also limit the achievable uncertainties in the determined colorimetric quantities of the LEDs. However, it had little effect on the calculated dominant wavelength, also for the short-wavelength LEDs. For this quantity, effects of the bandpass irregularities prevailed, especially if the low-end array spectroradiometers are used. Even in the case of a relatively high spectral resolution of the high-end array spectro-radiometers (< 2 nm), the bandpass function is typically non-symmetric and varying throughout the spectral range of operations. This leads to noticeable errors in the measured bandwidth (FWHM) as well as in the dominant wavelength and in the colour of the LEDs. Thus bandpass correction techniques may be required. More details on the studied effects will be given during the presentation.

References

1. LINDEMANN M., MAASS R., TADDEO M., MEHROTRA R., SPERLING A., Reliable photometric and radiometric measurements of bare LEDs and high power LEDs using special LED Holder, Proceedings of NEWRAD 2008: 10th International Conference on New Developments and Applications in Optical Radiometry, Daejeon, 2008.
2. CIE Technical report 127 - 2007, Measurements of LEDs, 2nd Edition, International Commission on Illumination, Vienna, 2007.
3. NEVAS S, SPERLING A., Stray light characterization of array spectroradiometers with PLACOS for applications in the UV spectral range., Proceedings of NEWRAD 2008: 10th International Conference on New Developments and Applications in Optical Radiometry, Daejeon, 2008.
4. ZONG Y., BROWN S. W., JOHNSON B. C., LYKKE K. R., OHNO Y., Simple spectral stray light correction method for array spectroradiometers, Appl. Opt. 45, 1111-1119, 2006.