Spectral measurements of light sources with a goniophotometer with and without mirror arrangement

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Abstract: This paper presents a comparative study of the relative spectral radiance measurements of incandescent and LED light sources performed in two different setups with a rotating–mirror- goniophotometer. In one configuration the light is reflected by the goniophotometer´s mirror, while in the other the mirror is bypassed. This study permits to determine a spectral correction factor at each measured wavelength in order to obtain a more precise value for the Correlated Color Temperature (CCT) for any light sources with different spectral power distributions.

Keywords: Light source; spectral radiance; CCT; mirror; goniophotometer.

1. INTRODUCTION

The Inmetro´s spectrocolorimetric system performs calibration and tests services of color tiles (radiance factor and chromaticity coordinates) and light sources (correlated color temperature (CCT) and color reproduction index (CRI)).

This system is assembled onto an optical table where a lamp shines a standard white tile and the reflected light is collected and analyzed at the spectroradiometer. Larger and powerful lamps or the need of a variable angle for the input collected light made it necessary to assemble the system together with the large goniophotometer of the Radiometry and Photometry Laboratory (Laraf).

There are two possible different setups for this kind of measurements after the lamp is mounted in the goniophotometer arm: in the first the goniophotometer´s mirror reflected light shines the standard white tile and is collected by the spectroradiometer; in the second the mirror is bypassed and the lamp shines the tile directly. Comparing the results of both methods it was noticed a discrepancy in the obtained CCT measurement values.

In order to characterize for LEDs colorimetric measurements this assembled system a series of varied incandescent and LED lamps were measured to obtain a correction factor to be applied in the measurements with the mirror.

The main goal of this study is to quantify the discrepancies in the CCT measurements of the different light sources considering both setups and to show the comparison of the lamps spectral radiance measurements obtained with and without the goniophotometer mirror reflection.

2. METHODOLOGY

The characterization of both setups was based on the comparison of the spectral distribution of a calibrated standard lamp together with a reflectance standard white tile in order to assess the radiance scale systematic error.

2.1 Setup without mirror reflection

Figure 1 shows this setup where the PR650 spectroradiometer is fixed on a tripod at a 0º:45º geometry where the lamp illuminates the standard white tile at 0° incidence and the reflected light enters the spectroradiometer at 45º. A standard FEL lamp (F-603, calibration certificate NIST 844/274563-07) was positioned at 50 cm from the tile and the spectroradiometer focusing the tile at 71 cm and 45° to the tile surface normal.

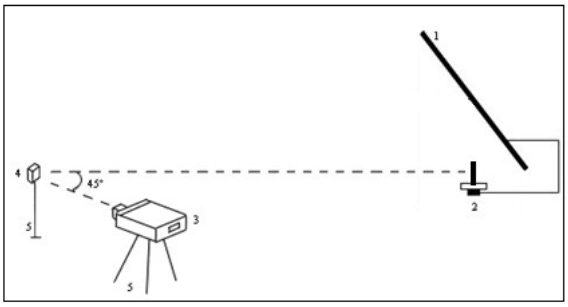

Figure 1. Setup without mirror reflection: 1: mirror; 2: lamp mounted on the goniophotometer arm; 3: spectroradiometer; 4: standard white tile; 5: tile mount and tripod.

2.2 Setup with the lamp radiation reflected from the mirror

In this setup depicted in figure 2 the same standard lamp is mounted on the goniophotometer arm distant 1,95 m from the mirror. The lamp reflected radiation incides perpendicularly to the tile positioned at 3,6 m from the mirror. The spectroradiometer is positioned at the same 0º:45º geometry as before. In this setup there is a black variable closure between the mirror and the rest in order to avoid spurious scattered light. In both setups the whole laboratory is maintained under dark conditions.

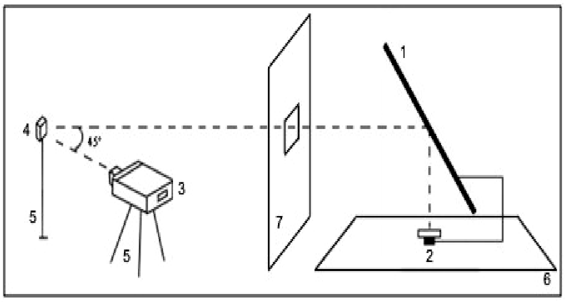

Figure 2. Setup using the mirror – 1: elliptical mirror (axis 2,83 m x 2 m); 2: lamp socket in the goniophotometer arm; 3: spectroradiometer; 4: standard white tile; 5: tile mount and tripod.

3. RESULTS AND DISCUSSION

Six light sources (source 01 incandescent lamp and the others LED sources) were measured using both setups described before in order to compare their CCT measured values shown in Table 1.

Table 1 – Calculated CCT values for the six measured lamps in both setups.

Lamp	**Without mirror**		**With mirror**		**Difference**
	CCT (K)	U(K) (k=2)	CCT (K)	U(K) (k=2)	CCT (K)
Source 01	2857	26	2963	26	-106
Source 02	2960	28	3022	28	-62
Source 03	4478	99	4494	93	-16
Source 04	3065	30	3105	30	-40
Source 05	3634	48	3732	50	-98
Source 06	3327	38	3335	35	-8

One can see a large difference on the CCT values calculated from the measurements results from both experimental setups (except source 06). This discrepancy is due to the light absorption by the mirror used in the setup described in 2.2 and is clearly seen in Figures 3, 4 and 5 that show the measured spectral distribution from sources 01, 02 and 06 respectively where the red squares are from the setup without mirror and the blue diamonds are from the setup with mirror.

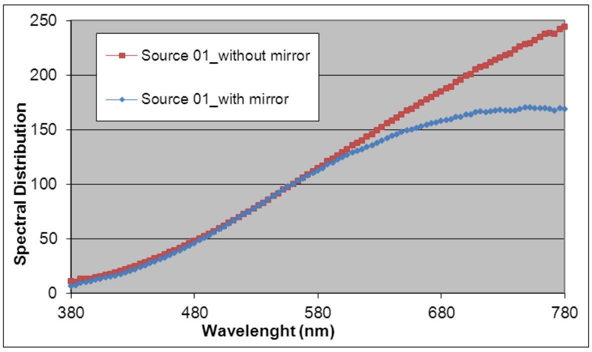

Figure 3 – Measured spectral distribution from source 01 with and without mirror.

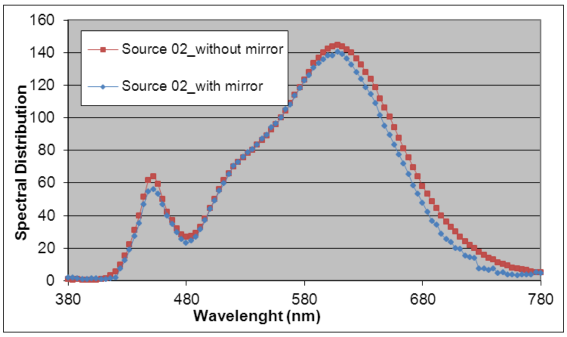

Figure 4 - Measured spectral distribution from source 02 with and without mirror.

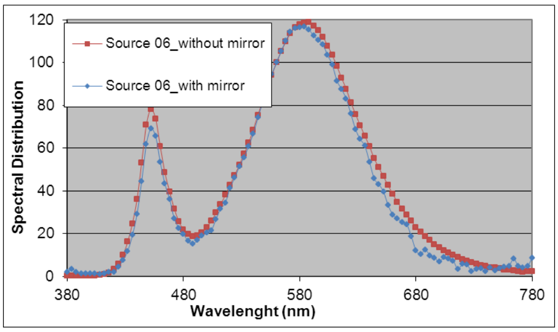

Figure 5 - Measured spectral distribution from source 06 with and without mirror.

Using the measurements from the standard lamp described in 2 a correction factor for the mirror absorption was established for application in all measurements using the setup in 2.2. Table 2 shows the calculated CCT values after applying the correction factor to the measured spectral distributions.

Table 2 – CCT values for the six sources calculated after applying the correction factor to the measurements with mirror.

Lamp	**Without mirror**		**With mirror**		**Difference**
	CCT (K)	U(K) (k=2)	CCT (K)	U(K) (k=2)	CCT (K)
Source 01	2857	26	2856	26	1
Source 02	2960	28	2937	28	23
Source 03	4478	99	4475	98	3
Source 04	3065	30	3032	29	33
Source 05	3634	48	3678	51	-44
Source 06	3327	38	3271	35	56

After applying the correction factor the differences in CCT from measurements with and without mirror became significantly smaller being lesser than the declared measurement uncertainty. The exception is source 06 where the correction enlarged the difference. This lamp had a very low intensity generating noisy spectra that may have caused in the spectra integration.

4. CONCLUSIONS

This article shows a comparative study of spectral radiance measurements of light sources using two experimental setups with and without reflection from the goniophotometer mirror. Incandescent as well as LED lamps were measured in both setups.

The conclusion is that the mirror absorbs a large amount of the incident radiation at the ends of the spectra and thus modifying the spectral radiance measured spectra and consequently the calculated CCT value. An experimental correction factor was defined and applied generating good results for the incandescent and the majority of the LED lamps. This spectral correction function diminishes the systematic error introduced by the wavelength dependence reflectance of the mirror.

Further studies are necessary for obtaining of a mirror correction factor using a source that presents a more uniform spectral distribution from the ultraviolet to the near infrared.

7. REFERÊNCIAS

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8. AGRADECIMENTOS

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