Measurement of the Spectral Distribution of Gas Discharge, Fluorescent and Incandescent Sources

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Contents

1 Overview **3**

2 Spectral Distribution of Sources **3**
2.1 Gas Discharge Sources 3
2.1.1 Sodium Lamps 3
2.1.2 Mercury Lamps 5
2.2 Fluorescent Sources 6
2.3 Incandescent Light Sources 9
2.3.1 Tungsten-Halogen Lamps 9

List of Figures

1 a) Sodium streetlight and b) sodium building light. 3
2 Distribution of sodium sources a) across spectrum and b) in the VIS. 4
3 Comparing sodium to published data a) across spectru and b) in the VIS. 4
4 a) Mercury streetlight and b) mercury building light. 5
5 Mercury parking lot light. 5
6 Distribution of mercury sources a) across spectrum and b) in the VIS. 6
7 Typical high-pressure mercury lamp type a) MB and type b) MBF. 6
8 Fluorescent source with and with out diffuser a) across spectrum and in b) VIS region. 7
9 Fluorescent source with diffuser absorbing emission line. . . 7
10 Fluorescent source with and with out diffuser in VIS using PR650. 8
11 a) Bare and b) diffused fluorescent with ASD and PR650. . 8
12 Comparison of published data to measured data. 9
13 Tungsten-halogen light source a) across spectrum and b) in the VIS region. 10

Figure 1: a) Sodium streetlight and b) sodium building light.

1 Overview

This report investigates the spectral distributions of various sources, some of which are found in typical low-light-level scenes.

2 Spectral Distribution of Sources

2.1 Gas Discharge Sources

The spectra of a series of gas discharge sources were measured with a spectral radiometer from 350 to 2500 nm in 1 nm increments. The radiometer used was an ASD (Analytical Spectral Devices). This instrument was also cross-calibrated, in some cases, with a spectraphotometer (Photo Research PR650).

2.1.1 Sodium Lamps

Two high-pressure sodium lamps were measured. The first was a typical streetlight illuminating a busy roadway. The second was found on the side of a building illuminating a large parking area. A daylight picture of these sources can be seen in Figure 1. The corresponding spectral distributions can be seen in Figure 2 along with a blow up of the visible region.

The sources were then compared to published data (source: Hunt, R., Measuring Color). The results of this can be seen in Figure 3. Since the published data range from 380-780 nm, only a visible comparison was made. It is evident that the emission peaks correlated very well with literature.

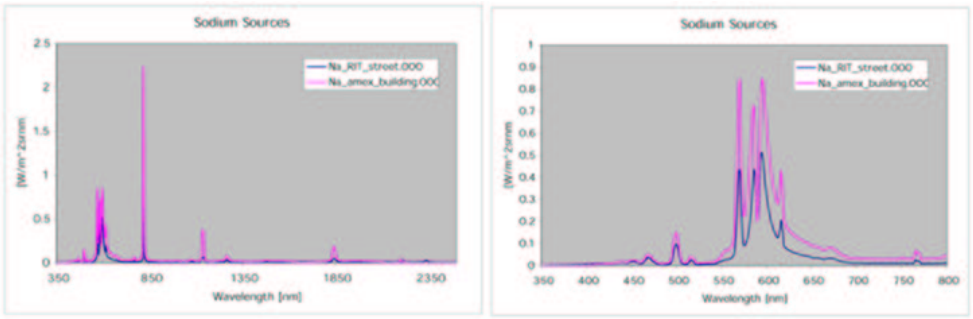

Figure 2: Distribution of sodium sources a) across spectrum and b) in the VIS.

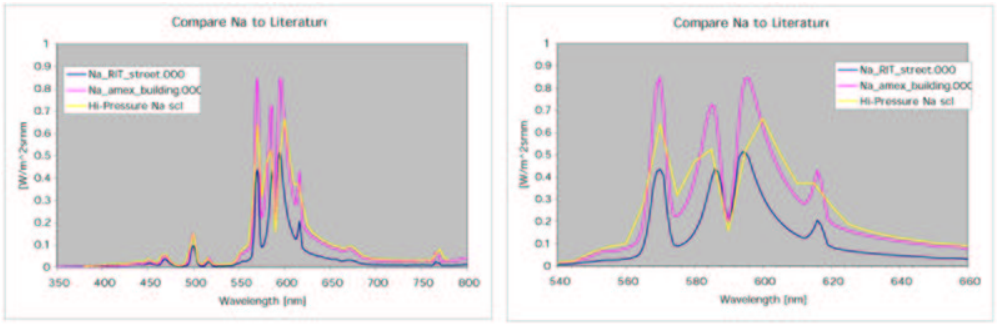

Figure 3: Comparing sodium to published data a) across spectru and b) in the VIS.

Figure 4: a) Mercury streetlight and b) mercury building light.

Figure 5: Mercury parking lot light.

2.1.2 Mercury Lamps

Various types of mercury gas discharge lamps were also measured. These included a standard streetlight and two lamps from the side of a building, illuminating large parking areas. Daylight images of these sources can be seen in Figure 4 and Figure 5. The corresponding spectral distributions can be seen in Figure 6. The spectrum consists mainly of a series of lines, the more prominent of which are at wavelengths of 253.7, 365.4, 404.7, 435.8, 546.1, and 578.0 nm.

When comparing these sources to published data, it was found that one of the parking lot sources was a high-pressure mercury lamp type MB (see Figure 7). The other parking lot source was of type MBF and had the same spectral distribution as the streetlight. Both of these can be seen in Figure 7 along with published data. The MBF type has a red-emitting phosphor

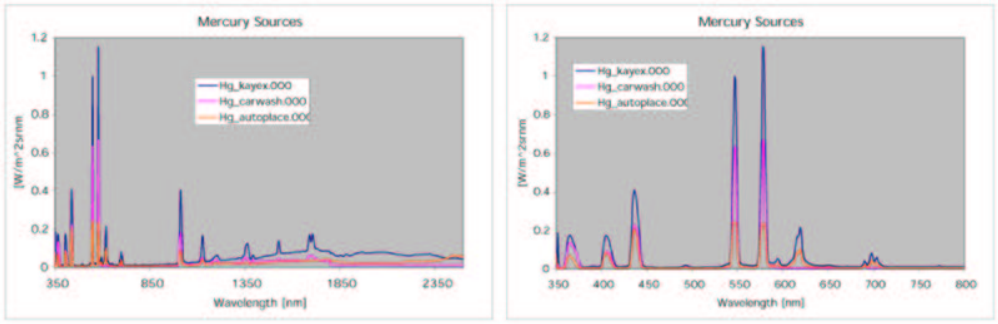

Figure 6: Distribution of mercury sources a) across spectrum and b) in the VIS.

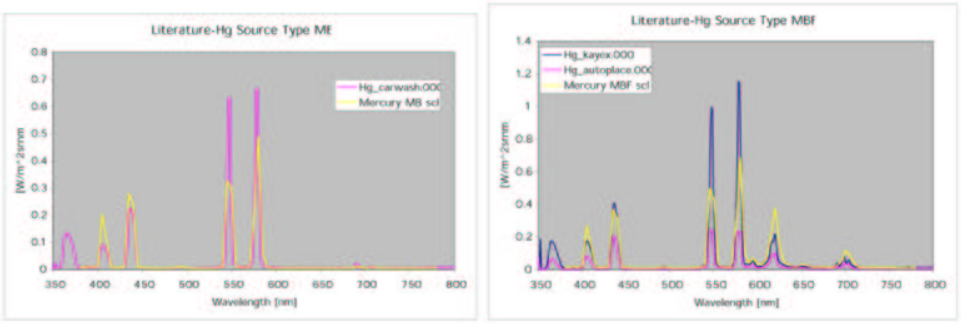

Figure 7: Typical high-pressure mercury lamp type a) MB and type b) MBF.

coated on the inside of the envelope. This improves the color rendering of the lamp appreciably.

2.2 Fluorescent Sources

A typical ceiling fluorescent source was also measured. This measurement was performed with and with out the diffuser over the light. Similarly, another device (PR650) was used to cross-reference the ASD measurements. The first set of ASD measurements for the light source can be seen in Figure 8.

For the most part the distributions are identical. That is, the diffuser has no effect on the output other than to diffuse the light. There is one region, however, located around 365 nm where the diffuser seems to absorb the

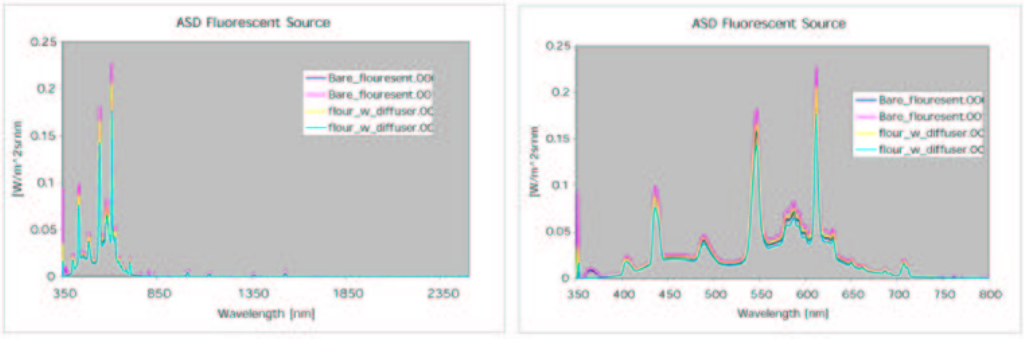

Figure 8: Fluorescent source with and with out diffuser a) across spectrum and in b) VIS region.

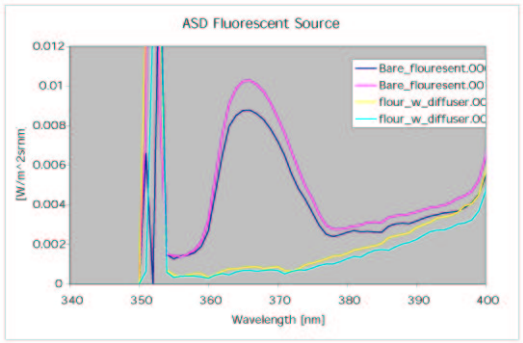

Figure 9: Fluorescent source with diffuser absorbing emission line.

fluorescent emission line (see Figure 9). This is a very small peak, relative to the entire spectrum, and could be neglected.

The PR650 was also used to measure the spectral output of the source. The results of this can be seen in Figure 10. Here we see that the diffuser simply attenuated the signal. We don't see the 365 nm absorption feature because the range on the instrument is from 380-780 nm.

We then compared the ASD reading to that of the PR650. The results of this can be seen in Figure 11. Both instruments recorded similar spectra. The fine structure in the ASD readings is evidence of the higher resolution in the instrument (1nm) while the resolution of the PR650 data was 4nm.

Finally, the measured fluorescent data for both the ASD and the PR650 was compared to published data. This comparison can be seen in Figure 12.

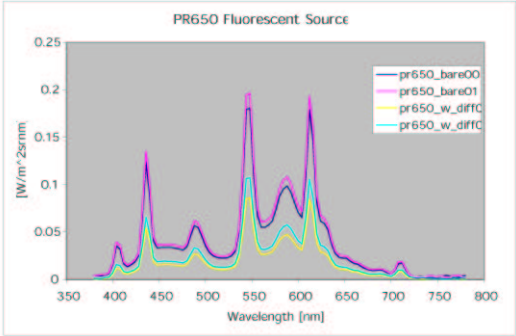

Figure 10: Fluorescent source with and with out diffuser in VIS using PR650.

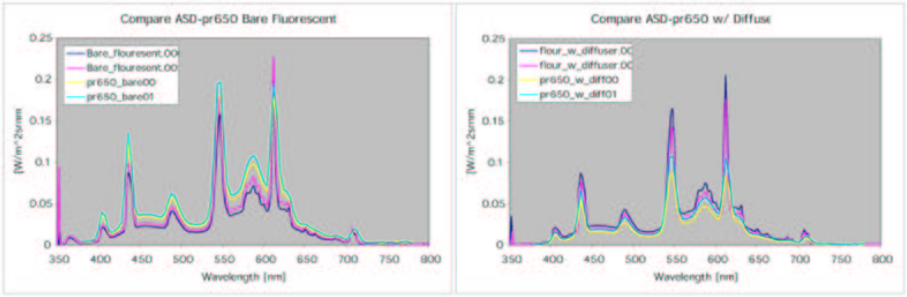

Figure 11: a) Bare and b) diffused fluorescent with ASD and PR650.

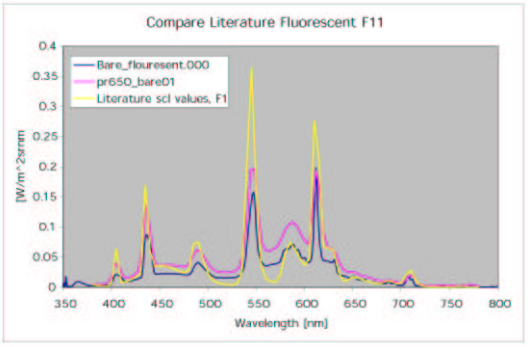

Figure 12: Comparison of published data to measured data.

The spectra looks fairly spikey like the mercury gas-discharge lamps. This is because the lamps consist of a glass tube containing low-pressure mercury gas, in which a gas-discharge is produced. The inside of the tube is coated with phosphors that are excited by the UV lines of the mercury spectrum, particularly that at 253.7 nm, to produce additional light. Therefore the light from these lamps comes partyly from the gas-discharge, but mainly from the phosphors.

There are 3 classes of fluorescent lamps designated *normal*, *broad-band*, and *three-band*. The ceiling lights recorded here are of the three-band type, specifically type F11. This is evident by the high correlation between the published and measured emission lines, as seen in Figure 12. As the name implies, the emission of three-band sources tend to be concentrated in three bands of the spectrum. These bands are also quite narrow and are designed to occur around 435, 545, and 610 nm.

2.3 Incandescent Light Sources

2.3.1 Tungsten-Halogen Lamps

A tungsten-halogen source was measured using both the ASD and the PR650. The results of these measurements can be seen in Figure 13. Incandescent sources are not spiky like some of the earlier gas-discharge or fluorescent sources. This is because in solids and liquids, the atoms are much more closely packed than in gases.

The PR650 almost recorded an exact match to that of the ASD. Additionally, the PR650 recorded a color temperature of 3200 K. For reference, an analytic planckian function was plotted for comparison with a color tem-

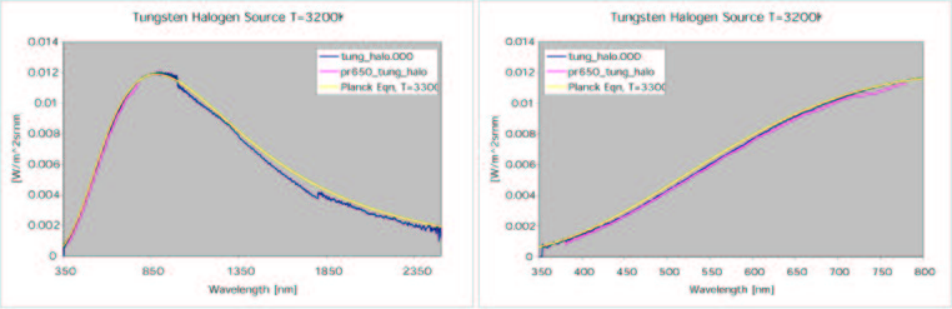

Figure 13: Tungsten-halogen light source a) across spectrum and b) in the VIS region.

perature of 3300 K.