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1 Brontes Integrating Sphere

The Brontes Integrating Sphere (Brontes-is) accepts light energy through a 9.6 mm input port and measures the spectral properties of LEDs and other light sources.

With the Brontes Integrating Sphere you're able to measure high speed in line:

- Luminous Flux (lm)
- Luminous Intensity (cd)
- colour coordinates (x,y)
- dominant wavelength

The Brontes-IS consists of a Ø38.2mm Spectralon sphere encased in an aluminium housing. The interior of the Brontes-IS is made from Spectralon, a white diffusing material that provides a highly lambertian reflecting surface.

Picture 1: Brontes-is

The Brontes-is colorimeter has a fixed tristimulus sensor. The characteristics of the sensor closely match the CIE1931 colour matching curves as used by many spectrometers to calculate colour. Within a spectrometer the measured spectrum can be multiplied by these curves and integrated. The resulting three values are X,Y and Z. The Brontes gives X,Y and Z straight away, so spectral correction can not be performed.

The Brontes relative spectral sensitivity can be seen in the below graph.

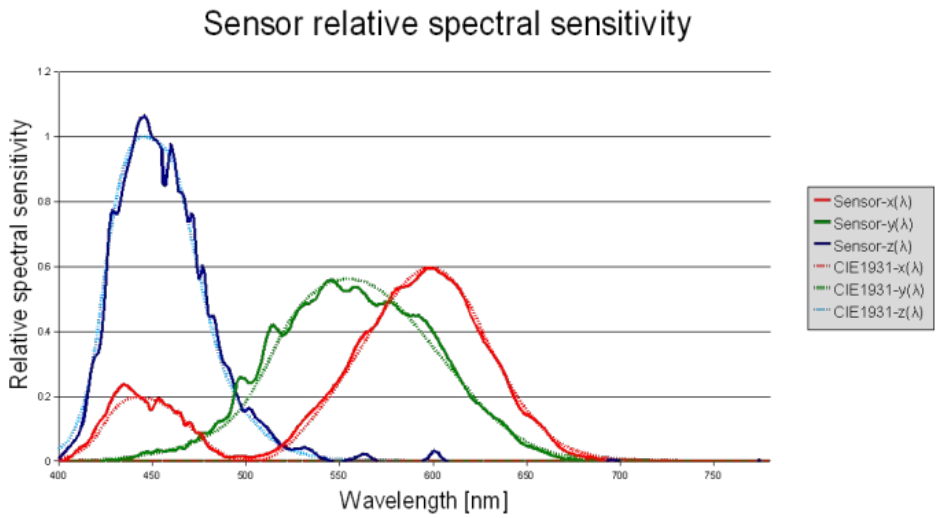


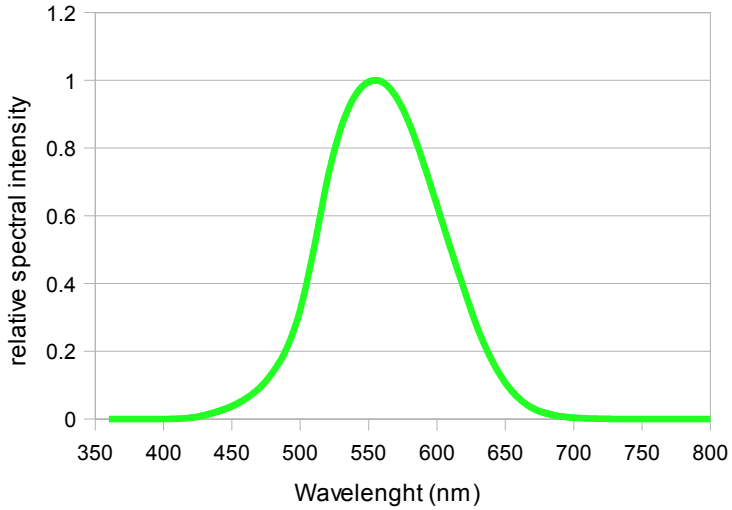
Illustration 1: brontes-is spectral sensitivity

It can be seen that at some wavelengths in the spectrum the Brontes sensitivity differs a little from the CIE1931 colour matching curves.

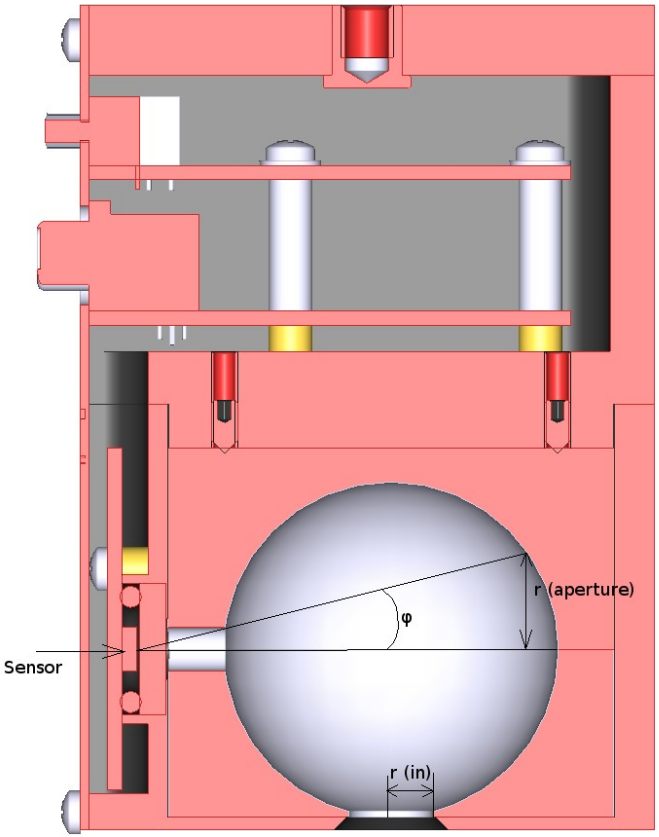
The Brontes colorimeter provides the user not with the spectral data, but the X,Y and Z value, meaning that only the visible spectrum is taken into account.

2 Brontes-is formulas

Picture 2 shows a cross sections of the Brontes-is with a few symbols to explain the parameters that are used in the formulas in this chapter. The Luminous flux of the Brontes-is is measured and adjusted for the sensitivity of the human eye (see picture 3), where the spectral sensitivity of the CIE 1931 Y curve is normalised at 555nm.



Picture 3: sensitivity of the human eye (CIE 1931 Y curve)



Picture 2: Brontes-is cross section

2.1 Luminous flux (Φ)

The sphere wall ($r_{aperture}$) determines the total flux incident on the tristimulus sensor mounted near the port of the integrating sphere.
The definition for calculating the luminous Flux (Φ) [lm] is:

$$\Phi = L * A_{aperture} * \Omega_{sphere}$$

where the L (cd/m2) is the normalised measured intensity of the Brontes-IS, the $A_{aperture}$ [mm^2] is the surface of the aperture ($A = \pi * r^2$) that the sensor will be measuring and Ω [sr] is the projected solid angle of the detectors field of view.

$$\Omega_{sphere} = \pi * \sin^2(\varphi_{radians})$$

2.2 luminous intensity (I)

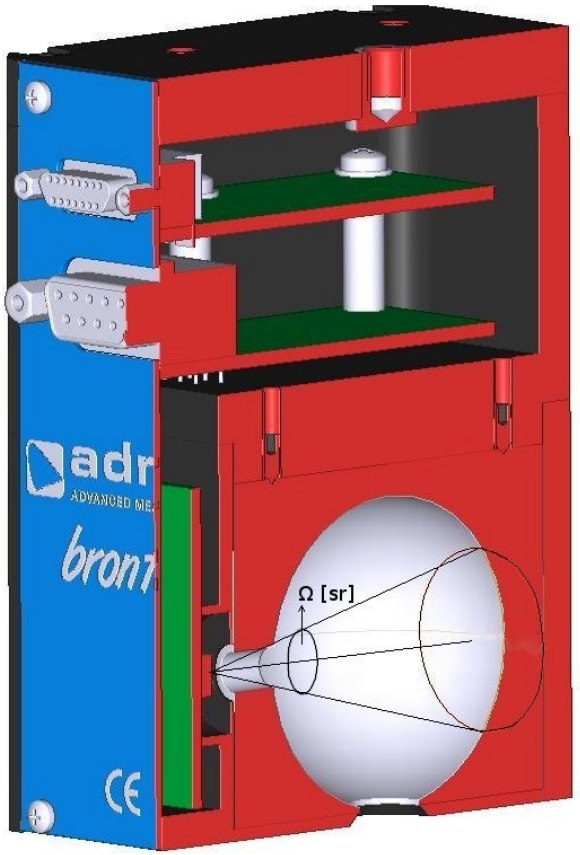
1. Luminous intensity (I) [cd=lm/m^2] is the amount of flux per unit solid angle from a point light source.

For calculating the luminous intensity (I) [cd=lm/sr] the following formula is used:

$$I = \frac{\Phi}{\Omega_{source}}$$

where Φ is the luminous flux of the source and Ω [sr] is the solid angle regarding to the beam width (ω) of the source.

$$\Omega_{source} = 2 * \pi * (1 - \cos(\frac{\omega_{radians}}{2}))$$



Picture 4: Brontes-is

2.3 Colour space formulas

The Brontes-is uses an XYZ sensor, meaning that other colour spaces are being converted from XYZ. The following sections show the mathematical conversions that are used by the Brontes colorimeter to perform conversion from XYZ to other colour spaces.

2.3.1 XYZ to xy conversion

$$x = \frac{X}{(X+Y+Z)}$$

$$y = \frac{Y}{(X+Y+Z)}$$

$$z = \frac{Z}{(X+Y+Z)} = 1 - x - y$$

2.3.2 XYZ to CIE 1976 UCS Yu'v' conversion

Note : u'v' is noted without the hyphen in the Brontes commands. All Yuv commands perform CIE Yu'v' calculations.

$$u' = \frac{4X}{(X+15Y+3Z)}$$

$$v' = \frac{9Y}{(X+15Y+3Z)}$$

2.3.3 Dominant wavelength

The Brontes-is can measure dominant wavelength according to CIE15:2004, Technical report on Colorimetry.

3 Considerations

The relationship between luminous flux, luminous intensity, and beam angle means is that focussing a given LED into a tighter beam, meaning decreasing the beam angle, will increase its luminous intensity, without increasing the luminous flux.
Keep in mind when LED's are used for illuminating purposes, for example a amount of cd for a 30° LED puts out as much light as an 4 times the amount of cd for a LED with a 15° viewing angle.