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PRINCIPLES GOVERNING PHOTOMETRY

2nd Edition

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Principles Governing Photometry
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Foreword

The purpose of this document is to bring together the definitions and the tables of numerical values for photometry already adopted (or recommended) and published, by the Conférence Générale des Poids et Mesures (CGPM), by the Comité International des Poids et Mesures (CIPM), or by the Commission Internationale de l'Eclairage (CIE). This document provides the link between the definition of the candela in the International System of Units (SI) and the internationally-agreed spectral luminous efficiency functions for human vision.

The original document, BIPM Monographie: Principles Governing Photometry (1983) was approved at the 10th meeting (28-30 September 1982) of the Comité Consultatif de Photométrie et Radiométrie (CCPR), the body established to advise the CIPM on these questions.

The purpose of this 2nd edition is to update the document by adding the spectral luminous efficiency functions recently published by the CIE, i.e., the spectral luminous efficiency functions for mesopic vision and the spectral luminous efficiency function for photopic vision for a 10° field of view. The definitions of photometric units and quantities have also been updated with the reformulated definition of the candela in the International System of Units (SI) 2019 and the latest definitions of the photometric quantities by the CIE.

The 2nd edition was prepared by the joint technical committee JTC 2 (CIE-CCPR) consisting of the following members:

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The 2nd edition was approved by the CCPR on April 14, 2019. A harmonized document, CIE 18:2019, The Basis of Physical Photometry, 3rd Edition, containing identical technical contents, has also been published by the CIE.

1 Introduction

Photometric procedures are used to measure light, i.e. measuring the universal and essential attribute of all perceptions and sensations which are peculiar to the human visual system and which are produced through the agency of that system. Thus, photometric quantities must take into account both the purely physical characteristics of the radiant power stimulating the visual system and the spectral responsivity of the latter. The psychophysical nature of the second of these two factors sets photometric quantities apart from purely physical quantities.

The purpose of this document is to describe and explain the usage of the photometric quantities as well as their units, and to explain briefly the conventions relating them with the purely physical quantity, radiant power, and its unit, the watt. These definitions and conventions aim at enabling photometric measurements to be made by purely physical methods, but to yield results that correlate adequately with visual experience. The relationships between these photometric quantities and photobiological, photochemical, and colorimetric quantities are also given. The practical realization of the units for these photometric quantities is outside the scope of this document and is available in the *mise en pratique* for the definition of the candela and associated derived units for photometric and radiometric quantities (Zwinkels et al., 2016).

If electromagnetic radiation is of sufficient power and of wavelengths within the range 360 nm to 830 nm (approximately), it stimulates the visual organ, i.e. the eye. The retinal receptor elements involved may be principally the cones (photopic vision, eye adapted to higher levels of luminance), the rods (scotopic vision, eye adapted to lower levels of luminance), or a combination of the cones and rods (mesopic vision, intermediate between photopic and scotopic vision).

This 2nd edition has been updated to include, in the definitions of photometric quantities and units, the spectral luminous efficiency functions for mesopic vision based on CIE 191:2010 (CIE, 2010), as well as the 10° spectral luminous efficiency functions based on CIE 165:2005 (CIE, 2005), and to introduce the defining constant for photometry, denoted K_{cd}, adopted in the International System of Units (SI) 2019 (BIPM, 2019).

2 Photometric quantities

The photometric quantities generally used are:

- luminous flux,
- luminous intensity,
- luminance,
- illuminance.

These quantities are defined by the International Commission on Illumination (CIE, 2016a) and their definitions adopted by the Consultative Committee for Photometry and Radiometry of the International Committee for Weights and Measures (CIPM), are shown in this section.

To avoid confusion, photometric and radiometric quantities are distinguished symbolically from each other by the subscript “v” or “e”, respectively. The same subscripts are applicable to photometric quantities other than those listed above (e.g. luminous exposure). For photometric quantities using spectral luminous efficiency functions other than that for 2° photopic vision, $V(\lambda)$, the notations described in Clause 5 are used.

Luminous flux is the most fundamental quantity in photometry because it has the simplest relationship with radiant power. The other three quantities are defined as follows in terms of luminous flux and appropriate geometric factors. The defining relationships for scotopic and mesopic photometric quantities are formed from the formulae in definitions 2.1 to 2.4 below by replacing the quantity symbols by those defined in Clause 5.

2.1 luminous flux

Φ_v; Φ

change of luminous energy with time

$$\Phi_\mathrm{v} = \frac{\mathrm{d}Q_\mathrm{v}}{\mathrm{d}t}$$

where Q_v is the luminous energy emitted, transferred or received and *t* is time

Note 1 to entry: Luminous flux is a quantity derived from the radiant flux Φ_e, by evaluating the radiation according to its action upon the CIE standard photometric observer. Luminous flux can be derived from the spectral radiant flux distribution by

$$\Phi_\mathrm{v} = K_\mathrm{m} \int_0^\infty \Phi_{\mathrm{e},\lambda}(\lambda) V(\lambda)\, \mathrm{d}\lambda$$

where K_m is maximum luminous efficacy, $\Phi_{\mathrm{e},\lambda}(\lambda)$ is spectral radiant flux, $V(\lambda)$ is spectral luminous efficiency and λ is wavelength.

Note 2 to entry: The distribution of the luminous intensities as a function of the direction of emission, e.g. given by the polar angles (ϑ, φ), is used to determine the luminous flux, Φ_v, within a certain solid angle, Ω, of a source:

$$\Phi_\mathrm{v} = \iint_\Omega I_\mathrm{v}(\vartheta, \varphi) \sin\vartheta \, \mathrm{d}\varphi \, \mathrm{d}\vartheta .$$

Note 3 to entry: The corresponding radiometric quantity is “radiant flux”. The corresponding quantity for photons is “photon flux”.

Note 4 to entry: The luminous flux is expressed in lumen (lm).

[SOURCE: CIE DIS 017:2016: Term 17-21-039, modified – ", expressed by" removed.]

2.2 luminous intensity

I_v; I

density of luminous flux with respect to solid angle in a specified direction

$$I_\mathrm{v} = \frac{\mathrm{d}\Phi_\mathrm{v}}{\mathrm{d}\Omega}$$

where Φ_v is the luminous flux emitted in the given direction, and Ω is the solid angle containing that direction.

Note 1 to entry: For practical realization of the quantity the source is approximated by a point source.

Note 2 to entry: The distribution of the luminous intensities as a function of the direction of emission, e.g. given by the polar angles (ϑ, φ), is used to determine the luminous flux, Φ_v, within a certain solid angle, Ω, of a source:

$$\Phi_\mathrm{v} = \iint_\Omega I_\mathrm{v}(\vartheta, \varphi) \sin\vartheta \, \mathrm{d}\varphi \, \mathrm{d}\vartheta .$$

Note 3 to entry: Luminous intensity can be derived from the spectral radiant intensity distribution by

$$I_\mathrm{v} = K_\mathrm{m} \int_0^\infty I_{\mathrm{e},\lambda}(\lambda)\, V(\lambda)\, \mathrm{d}\lambda$$

where K_m is maximum luminous efficacy, $I_{\mathrm{e},\lambda}(\lambda)$ is the spectral radiant intensity at wavelength λ, and $V(\lambda)$ is spectral luminous efficiency.

Note 4 to entry: The corresponding radiometric quantity is “radiant intensity”. The corresponding quantity for photons is “photon intensity”.

Note 5 to entry: The luminous intensity is expressed in candela ($\mathrm{cd} = \mathrm{lm}\cdot\mathrm{sr}^{-1}$).

[SOURCE: CIE DIS 017:2016, Term 17-21-045, modified – ", expressed by" removed, Note 1 to entry changed, formula in Note 3 to entry adjusted]

2.3 luminance

L_v; L

density of luminous intensity with respect to projected area in a specified direction at a specified point on a real or imaginary surface

$$L_\mathrm{v} = \frac{\mathrm{d}I_\mathrm{v}}{\mathrm{d}A} \frac{1}{\cos\alpha}$$

where I_v is luminous intensity, A is area and α is the angle between the normal to the surface at the specified point and the given direction

Note 1 to entry: In a practical sense, the definition of luminance can be thought of as dividing a real or imaginary surface into an infinite number of infinitesimally small surfaces, which can be considered as point sources, each of which has a specific luminous intensity, I_v, in the specified direction. The luminance of the surface is then the integral of these luminance elements over the whole surface.

The equation in the definition can mathematically be interpreted as a derivative (i.e. a rate of change of luminous intensity with projected area) and could alternatively be rewritten in terms of the average luminous intensity $\overline{I}_\mathrm{v}$ as

$$L_\mathrm{v} = \lim_{A \to 0} \frac{\overline{I}_\mathrm{v}}{A} \frac{1}{\cos\alpha}$$

Hence, luminance is often considered as a quotient of averaged quantities; the area, A, should be small enough that uncertainties due to variations in luminous intensity within that area are negligible, otherwise, the quotient $\overline{L}_\mathrm{v} = \frac{\overline{I}_\mathrm{v}}{A} \frac{1}{\cos\alpha}$ gives the average luminance and the specific measurement conditions must be reported with the result.

Note 2 to entry: For a surface being irradiated, an equivalent formula in terms of illuminance, E_v, and solid angle, Ω, is $L_\mathrm{v} = \frac{\mathrm{d}E_\mathrm{v}}{\mathrm{d}\Omega} \frac{1}{\cos\theta}$ where θ is the angle between the normal to the surface being irradiated and the direction of irradiation. This form is useful when the source has no surface (e.g. the sky, the plasma of a discharge).

Note 3 to entry: An equivalent formula is $L_\mathrm{v} = \frac{\mathrm{d}\Phi_\mathrm{v}}{\mathrm{d}G}$, where Φ_v is luminous flux and G is geometric extent.

Note 4 to entry: Luminous flux may be obtained by integrating luminance over projected area, $A\cdot\cos\alpha$, and solid angle, Ω: $\Phi_\mathrm{v} = \iint L_\mathrm{v} \cos\alpha\, \mathrm{d}A\, \mathrm{d}\Omega$.

Note 5 to entry: Since the optical extent, expressed by $G\cdot n^2$, where G is geometric extent and n is refractive index, is invariant, the quantity expressed by $L_\mathrm{v}\cdot n^{-2}$ is also invariant along the path of the beam if the losses by absorption, reflection and diffusion are taken as 0. That quantity is called “basic luminance”.

Note 6 to entry: The equation in the definition can also be described as a function of luminous flux, Φ_v. In this case, it is mathematically interpreted as a second partial derivative of the luminous flux at a specified point (x, y) in space in a specified direction (ϑ, φ) with respect to projected area, $A\cdot\cos\alpha$, and solid angle, Ω,

$$L_\text{v}(x,y,\vartheta,\varphi)=\frac{\partial^2\Phi_\text{v}(x,y,\vartheta,\varphi)}{\partial A(x,y)\cdot\cos\alpha\cdot\partial\Omega(\vartheta,\varphi)}$$

where α is the angle between the normal to that area at the specified point and the specified direction.

Note 7 to entry: The corresponding radiometric quantity is “radiance”. The corresponding quantity for photons is “photon radiance”.

Note 8 to entry: The luminance is expressed in candela per square metre ($\text{cd}\cdot\text{m}^{-2} = \text{lm}\cdot\text{m}^{-2}\cdot\text{sr}^{-1}$).

[SOURCE: CIE DIS 017:2016, Term 17-21-050, modified – ", expressed by" removed, in Note 1 to entry "radiance" replaced by "luminance" at two places, and "radiant intensity" replaced by "luminous intensity"]

2.4 illuminance

E_v; E

density of incident luminous flux with respect to area at a point on a real or imaginary surface

$$E_\text{v}=\frac{\text{d}\Phi_\text{v}}{\text{d}A}$$

where Φ_v is luminous flux and A is the area on which the luminous flux is incident

Note 1 to entry: Illuminance can be derived from the spectral irradiance distribution by

$$E_\text{v}=K_\text{m}\int_0^\infty E_{\text{e},\lambda}(\lambda)V(\lambda)\,\text{d}\lambda$$

where K_m is maximum luminous efficacy, $E_{\text{e},\lambda}(\lambda)$ is the spectral irradiance at wavelength λ, and $V(\lambda)$ is spectral luminous efficiency.

Note 2 to entry: The corresponding radiometric quantity is “irradiance”. The corresponding quantity for photons is “photon irradiance”.

Note 3 to entry: The illuminance is expressed in lux ($\text{lx} = \text{lm}\cdot\text{m}^{-2}$)

[SOURCE: CIE DIS 017:2016, Term 17-21-060, modified – ", expressed by" removed, formula in Note 1 to entry adjusted]

3 Photometric units

Historically the SI units have been presented in terms of a set of seven base units. All other units (“derived units”) are then constructed as products of powers of the base units. In the field of photometry, the definition of the unit of luminous intensity (based on a blackbody at the freezing point temperature of platinum), was adopted at the 9th meeting of the General Conference on Weights and Measures (CGPM) in 1948 (CGPM, 1948). The name “candela” was assigned to this unit by the CIPM in 1949. The candela was endorsed as one of the international base units at the 10th meeting of the CGPM in 1954 (CGPM, 1955). The “Système International d’unités”, abbreviation “SI”, was established at the 11th meeting of the CGPM in 1960. In 1979, the candela was linked to radiometric quantities for monochromatic radiation of frequency 540×10^{12} Hz (CGPM, 1979). In 2018 the CGPM adopted a new approach for the SI based on seven defining constants (CGPM, 2018). In the International System of Units (SI) 2019 (BIPM, 2019) the definition of the candela is reformulated by introducing the constant K_{cd} = 683 lm·W^{-1}, which is the luminous efficacy of monochromatic radiation of frequency 540×10^{12} Hz.

The frequency in the candela definition of 540×10^{12} Hz, denoted as ν_{cd}, corresponds to a wavelength in standard air[1] (Ciddor, 1996) that is usually rounded to 555,017 nm, and denoted λ_{cd}. All wavelength values given in this document are in standard air. For photometric measurements in air under real environmental conditions, the influence of the variation of the refractive index of air on λ_{cd} with respect to standard air is typically in the range of a few picometres and can be neglected.

The above definition of the candela applies to photopic, scotopic and mesopic vision.

The definition of K_{cd} relates the unit of luminous flux (*lumen,* lm) to the unit of radiant flux (*watt*, W) at wavelength λ_{cd}. For wavelengths other than λ_{cd}, the luminous efficacy is proportional to one of the spectral luminous efficiency functions described in Clause 4.

The SI units of the three other photometric quantities, luminous intensity, luminance, and illuminance, defined in Clause 2 of this document, are derived directly from the unit of luminous flux, the *lumen*, and the units of the geometric quantities, area and solid angle.

The SI unit of luminous intensity is *lumen per steradian* (lm·sr^{-1}), which is termed *candela* (cd).

The SI unit of luminance is *lumen per square metre per steradian* (lm·sr^{-1}·m^{-2}) or *candela per square metre* (cd·m^{-2}).

The SI unit of illuminance is *lumen per square metre* (lm·m^{-2}), which is termed *lux* (lx).

While the units above are defined independently of any luminous efficiency function, the corresponding quantities include the descriptor (photopic, mesopic, scotopic); where no descriptor is given, it is assumed that the quantity is for photopic vision (see Clause 5).

4 Spectral luminous efficiency functions

Photometric quantities are related to radiometric quantities through internationally agreed spectral weighting functions defined by the CIE as *spectral luminous efficiency functions*. These provide agreed representations of the relative spectral sensitivity of the human visual system under defined conditions and are normalized to unity at the wavelength of peak sensitivity. The relevant spectral luminous efficiency function is applied as a spectral weighting for the spectral distribution of the corresponding radiometric quantity (see Clause 6 for further details).

The most common spectral luminous efficiency functions are described in 4.1 to 4.4.

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[1] The value of λ_{cd} is for standard air (dry air at 15 °C and 101 325 Pa, containing 0.045 % of carbon dioxide by volume), see Ciddor (1996). This value changes slightly if laboratory air conditions are different but such changes are negligible in practice.

4.1 Photopic vision

The spectral luminous efficiency function for photopic vision is denoted by $V(\lambda)$; its values are given in Table 1, adopted from (ISO/CIE, 2005).

4.2 Scotopic vision

The spectral luminous efficiency function for scotopic vision is denoted by $V'(\lambda)$; its values are given in Table 2, adopted from (ISO/CIE, 2005).

4.3 Mesopic vision

The spectral luminous efficiency function for mesopic vision is denoted by $V_{\text{mes};m}(\lambda)$, and is defined as

$$V_{\text{mes};m}(\lambda) = \frac{1}{M(m)}\left\{mV(\lambda) + (1-m)V'(\lambda)\right\} \quad \text{for} \quad 0 \le m \le 1 \qquad (1)$$

where

m is the adaptation coefficient, the value of which depends on the visual adaptation conditions (see 6.4);

$M(m)$ is a normalizing function such that $V_{\text{mes};m}(\lambda)$ attains a maximum value of 1.

Figure 1 shows the curves of the mesopic spectral luminous efficiency function $V_{\text{mes};m}(\lambda)$ at m = 0.2, 0.4, 0.6, 0.8 as examples, plotted with $V(\lambda)$ and $V'(\lambda)$. Table 3 shows the values of $V_{\text{mes};m}(\lambda)$ at m = 0.8 as an example, which corresponds to the visual adaptation condition for a typical road lighting luminance level (≈ 1 cd m^{-2}).

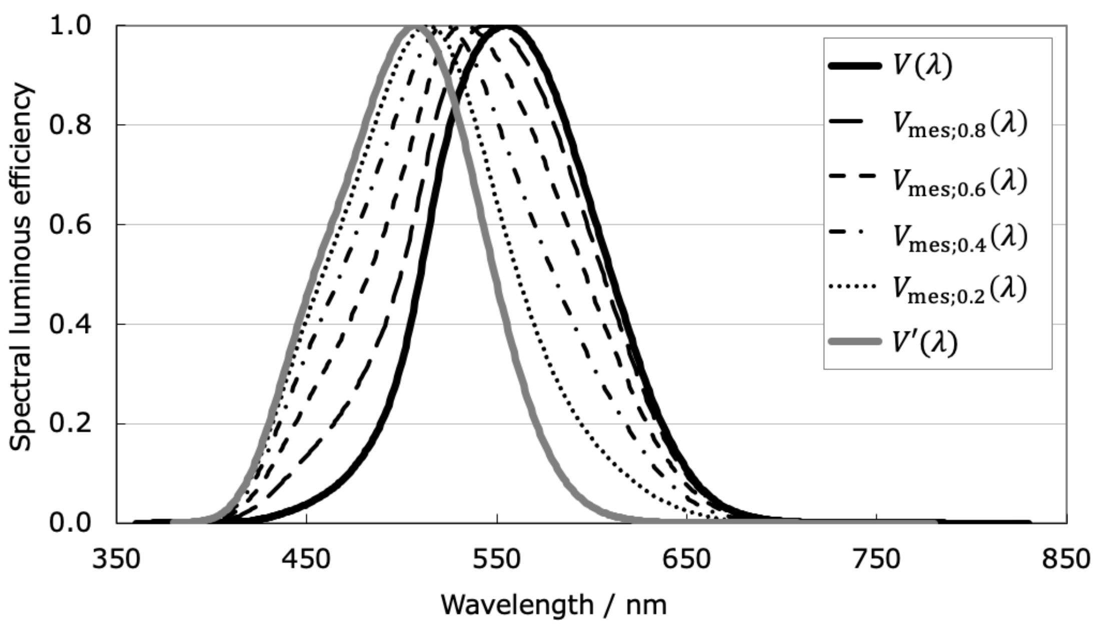

Figure 1 – The spectral luminous efficiency functions for mesopic vision, $V_{\text{mes};m}(\lambda)$, at m = 0.2; 0.4; 0.6; 0.8 as examples, plotted with $V(\lambda)$ and $V'(\lambda)$

4.4 10° photopic vision

The spectral luminous efficiency function for 10° photopic vision is denoted by $V_{10}(\lambda)$; its values are given in Table 5, adopted from (ISO/CIE, 2005).

4.5 Use of these spectral luminous efficiency functions

It is important to note that the $V(\lambda)$ function applies at all luminance levels for foveal view, i.e. for all on-axis visual tasks (where objects seen by the eye are in a narrow field of view in central vision). For visual tasks that are not on-axis (larger field of view and/or peripheral vision), the following specifications apply (CIE, 2010):

- Scotopic photometric quantities are applicable to the condition where the eye is adapted to an average luminance of < 0.005 $\text{cd}\cdot\text{m}^{-2}$.
- Mesopic photometric quantities are applicable to the condition where the eye is adapted to average luminance levels between 0.005 $\text{cd}\cdot\text{m}^{-2}$ and 5 $\text{cd}\cdot\text{m}^{-2}$.
- Above 5 $\text{cd}\cdot\text{m}^{-2}$, photopic photometric quantities should be used. The $V(\lambda)$ function was determined on the basis of experimental studies for photopic vision with a narrow field of view (about 4° or less). For situations where the visual target has an angular subtense larger than 4° or is seen off-axis, the $V_{10}(\lambda)$ function, based on experimental studies for photopic vision with a 10° field of view (CIE, 2005), can be used.

For the purpose of practical photometry, and to avoid confusion, the relevant spectral luminous efficiency function used for the photometric quantities must be specified, either through use of an appropriate descriptor linked with the quantity (e.g. photopic, scotopic, mesopic) or by use of the appropriate symbol (see Clause 5). If the luminous efficiency function used is not specified, it is assumed to be the $V(\lambda)$ function.

5 Photometric quantity names and symbols

The names and symbols of photometric quantities listed in Clause 2, with the spectral luminous efficiency functions listed in Clause 4, are defined in the following subsections. Similar names and symbols are used for photometric quantities other than those given below.

5.1 Photometric quantities for photopic vision

The following quantity names and symbols apply for photopic vision (using the $V(\lambda)$ function):

- (photopic) luminous flux, Φ_v
- (photopic) luminous intensity, I_v
- (photopic) illuminance, E_v
- (photopic) luminance, L_v

NOTE The descriptor ”photopic” is used only when quantities other than photopic are reported or discussed in the same document and there is a possibility of confusion.

5.2 Photometric quantities for scotopic vision

The following quantity names and symbols apply for scotopic vision (using the $V'(\lambda)$ function):

- scotopic luminous flux, Φ'_v
- scotopic luminous intensity, I'_v
- scotopic illuminance, E'_v
- scotopic luminance, L'_v

5.3 Photometric quantities for mesopic vision

The following quantity names and symbols apply for mesopic vision (CIE, 2016b) (using the $V_{\mathrm{mes};m}(\lambda)$ function):

- mesopic luminous flux, $\Phi_{\mathrm{mes};m}$
- mesopic luminous intensity, $I_{\mathrm{mes};m}$
- mesopic illuminance, $E_{\mathrm{mes};m}$
- mesopic luminance, $L_{\mathrm{mes};m}$

where m is a coefficient $(0 \le m \le 1)$ determined by the visual adaptation level. The value of m should be specified in the quantity name as well as in the symbol, e.g. mesopic luminous flux (m = 0.5), $\Phi_{\mathrm{mes};0,5}$. Further guidance is available in (CIE, 2016b).

Note that mesopic photometric quantities follow the law of additivity only within a scene at a certain adaptation luminance level. For $m = 1$ and $m = 0$, the mesopic photometric quantities are identical to the photopic and scotopic quantities, respectively (see 6.4).

5.4 Photometric quantities for 10° photopic vision

The following quantity names and symbols apply for photopic vision using the $V_{10}(\lambda)$ function.

- 10° luminous flux, Φ_{10}
- 10° luminous intensity, I_{10}
- 10° illuminance, E_{10}
- 10° luminance, L_{10}

5.5 Photometric quantities for other observers

For research purposes, photometric quantities for observers other than those introduced in the above subclauses may be used, e.g. the CIE 2015 physiologically-based spectral luminous efficiency function (CIE, 2015), and the CIE 1988 modified 2° observer (CIE,1990). When one of these alternative CIE-defined observers is used, an appropriate quantity name (e.g. CIE 2015 luminous flux, or CIE 1988 luminous flux), and an appropriate symbol for the quantities (e.g. Φ_{F} or Φ_{M}) should be used to avoid any confusion with other CIE-defined photometric quantities. In any case, the same SI units – cd, lm, lx, $\mathrm{cd{\cdot}m^{-2}}$ – are used and these must not be modified. Also, when a photometric quantity is expressed with photometric units, additivity must hold (at least within the stated visual adaptation conditions). Photometric units are not used for non-visual effects (CIE, 2018a). For non-visual effects radiometric units are used.

6 Basic equations relating photometric quantities to radiometric quantities

6.1 General equation

For a chosen spectral luminous efficiency function $V_{\mathrm{X}}(\lambda)$, the relationship between a photometric quantity, such as luminous flux, $\Phi_{\mathrm{v,X}}$, and the corresponding radiometric quantity spectral radiant flux, $\Phi_{\mathrm{e},\lambda}(\lambda)$, is given by:

$$\Phi_{\mathrm{v,X}} = \frac{K_{\mathrm{cd}}}{V_{\mathrm{X}}(\lambda_{\mathrm{cd}})} \int_{\lambda} \Phi_{\mathrm{e},\lambda}(\lambda)\, V_{\mathrm{X}}(\lambda)\, \mathrm{d}\lambda \tag{2}$$

where

K_{cd}	is the luminous efficacy of monochromatic radiation of frequency 540 × 10^{12} Hz (683 lm·W^{-1});
$V_{\mathrm{X}}(\lambda)$	represents one of the spectral luminous efficiency functions;
$\Phi_{\mathrm{v,X}}$	is the luminous flux evaluated using a defined spectral luminous efficiency function $V_{\mathrm{X}}(\lambda)$;
$\Phi_{\mathrm{e},\lambda}(\lambda) = \frac{\mathrm{d}\Phi_{\mathrm{e}}}{\mathrm{d}\lambda}$	is spectral radiant flux, i.e. the spectral distribution of radiant flux Φ_{e};
λ_{cd}	is the wavelength at 540 × 10^{12} Hz according to the definition of the unit candela (555.017 nm in standard air).

Equation (2) requires that the spectral luminous efficiency function must have a non-zero value at wavelength λ_{cd}. The wavelengths for the spectral luminous efficiency functions are typically wavelengths in air.

6.2 (Photopic) luminous flux

For photopic vision, evaluated using the spectral luminous efficiency function for photopic vision, $V(\lambda)$, (see 4.1), the relationship between luminous flux and spectral radiant flux given in Equation (2) can be simplified to:

$$\Phi_{\mathrm{v}} = K_{\mathrm{m}} \int_{\lambda} \Phi_{\mathrm{e},\lambda}(\lambda)\, V(\lambda)\, \mathrm{d}\lambda \tag{3}$$

where

Φ_{v}	is the luminous flux;
$\Phi_{\mathrm{e},\lambda}(\lambda) = \frac{\mathrm{d}\Phi_{\mathrm{e}}}{\mathrm{d}\lambda}$	is spectral radiant flux, i.e. the spectral distribution of radiant flux Φ_{e};
K_{m}	is the maximum luminous efficacy for photopic vision, i.e. the luminous efficacy at the peak of the $V(\lambda)$ function, which is at a wavelength of λ_{m} = 555 nm (exactly), and is given by: $K_{\mathrm{m}} = K_{\mathrm{cd}} \cdot \left[V(\lambda_{\mathrm{m}}) / V(\lambda_{\mathrm{cd}})\right]$ (4) (= 683.002 lm·W^{-1} ≈ 683 lm·W^{-1} in standard air).

Other photopic photometric quantities (e.g. luminance, illuminance, luminous intensity) are calculated similarly.

6.3 Scotopic luminous flux

The scotopic luminous flux, Φ', is related to spectral radiant flux by:

$$\Phi' = K'_{\mathrm{m}} \int_{\lambda} \Phi_{\mathrm{e},\lambda}(\lambda)\; V'(\lambda)\; \mathrm{d}\lambda \tag{5}$$

where

$V'(\lambda)$	is the spectral luminous efficiency function for scotopic vision (see 4.2);

$\Phi_{e,\lambda}(\lambda) = \dfrac{d\Phi_e}{d\lambda}$ is spectral radiant flux, i.e. the spectral distribution of radiant flux, Φ_e ;

K'_m is the maximum luminous efficacy for scotopic vision, i.e. the luminous efficacy at the peak of the $V'(\lambda)$ function, which is at a wavelength of λ'_m = 507 nm (exactly):

$$K'_m = K_{cd} \cdot \left[V'(\lambda'_m) / V'(\lambda_{cd}) \right] \tag{6}$$

(= 1 700.13 lm·W^{-1} ≈ 1 700 lm·W^{-1} in standard air).

Other scotopic photometric quantities (e.g. scotopic luminance, scotopic illuminance, scotopic luminous intensity) are calculated similarly.

6.4 Mesopic luminous flux

The mesopic luminous flux, $\Phi_{mes;m}$, is related to spectral radiant flux by:

$$\Phi_{mes;m} = \frac{K_{cd}}{V_{mes;m}(\lambda_{cd})} \int_\lambda \Phi_{e,\lambda}(\lambda)\, V_{mes;m}(\lambda)\ d\lambda \tag{7}$$

where

K_{cd} is the luminous efficacy of monochromatic radiation of frequency 540 × 10^{12} Hz (683 lm·W^{-1});

$V_{mes;m}(\lambda)$ is the spectral luminous efficiency function for mesopic vision (see 4.3)

$\Phi_{e,\lambda}(\lambda) = \dfrac{d\Phi_e}{d\lambda}$ is spectral radiant flux, i.e. the spectral distribution of radiant flux, Φ_e ;

λ_{cd} is the wavelength at 540 × 10^{12} Hz according to the definition of the unit candela (555.017 nm in standard air).

The maximum luminous efficacy for mesopic vision, $K_{m,mes;m}$, varies as a function of m, and is given by

$$K_{m,mes;m} = \frac{K_{cd}}{V_{mes;m}(\lambda_{cd})} \tag{8}$$

The value of $K_{m,mes;m}$ varies from 683 lm·W^{-1} at m = 1 (photopic) to 1 700 lm·W^{-1} at m = 0 (scotopic)[2].

Hence Equation (7) can be rewritten in similar form as Equations (3) and (5):

$$\Phi_{mes;m} = K_{m,mes;m} \int_\lambda \Phi_{e,\lambda}(\lambda)\, V_{mes;m}(\lambda)\ d\lambda \tag{9}$$

The values of $K_{m,mes;m}$ are given in Table 4 for representative values of m.

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2 The subscript m, in Roman font, in $K_{m,mes;m}$ refers to "maximum", whereas the subscript m, in Italic font, represents a variable, referring to the adaptation coefficient.

The value of m is determined from the photopic luminance, $L_{\text{v,adapt}}$, and scotopic luminance, $L'_{\text{v,adapt}}$, of the visual adaptation field[3], and it is obtained as the solution for the simultaneous equations (CIE, 2010):

$$L_{\text{mes},n} = \frac{m_{(n-1)} L_{\text{v,adapt}} + (1 - m_{(n-1)})\, L'_{\text{v,adapt}}\, V'(\lambda_{\text{m}})}{m_{(n-1)} + (1 - m_{(n-1)})\, V'(\lambda_{\text{m}})} \tag{10}$$

and

$$m_n = a + b \log_{10}(L_{\text{mes},n}) \quad \text{for } 0 \le m_n \le 1, \tag{11}$$

where a and b are parameters which have the values a = 0.7670 and b = 0.3334, and $V'(\lambda_{\text{m}})$ is the value of the spectral luminous efficiency function for scotopic vision at λ_{m} = 555 nm. These equations can be solved by iterative calculations, n being the iteration step.

Other mesopic photometric quantities (e.g. mesopic luminance, mesopic illuminance, mesopic luminous intensity) are calculated similarly.

Mesopic photometric quantities should always be given with the value of m, e.g. $L_{\text{mes;0,4}}$ = 0.12 cd m^{-2}.

6.5 Luminous flux for 10° photopic vision

The 10° luminous flux, Φ_{10}, is related to spectral radiant flux by:

$$\Phi_{10} = K_{\text{m},10} \int_{\lambda} \Phi_{\text{e},\lambda}(\lambda)\, V_{10}(\lambda)\, \text{d}\lambda \tag{12}$$

where

$K_{\text{m},10}$ is the maximum luminous efficacy for 10° photopic vision, i.e. the luminous efficacy at the peak of the $V_{10}(\lambda)$ function, which is at a wavelength of $\lambda_{\text{m},10}$ = 557 nm (exactly):

$$K_{\text{m},10} = K_{\text{cd}} \cdot \left[V_{10}(\lambda_{\text{m},10}) / V_{10}(\lambda_{\text{cd}}) \right] \tag{13}$$

(= 683.601 lm·W^{-1} ≈ 684 lm·W^{-1} in standard air).

$V_{10}(\lambda)$ is the spectral luminous efficiency function for 10° photopic vision (see 4.4)

$\Phi_{\text{e},\lambda}(\lambda) = \frac{\text{d}\Phi_{\text{e}}}{\text{d}\lambda}$ is spectral radiant flux, i.e. the spectral distribution of radiant flux, Φ_{e};

λ_{cd} is the wavelength at 540 × 10^{12} Hz according to the definition of the unit candela (555.017 nm in standard air).

Other photometric quantities for 10° photopic vision (e.g. 10° luminance, 10° illuminance, 10° luminous intensity) are calculated similarly.

[3] Determination of adaptation luminance in various application conditions is still in research. An interim recommendation is available in (CIE, 2017).

7 Relating photochemical and photobiological quantities to photometric quantities

According to the present SI, a photochemical or photobiological quantity is defined in purely physical terms as the quantity derived from the corresponding radiometric quantity by evaluating the radiation according to its action upon a selective receptor. Similar to a photometric quantity, the photochemical or photobiological quantity is given by the integral over wavelength of the spectral distribution of the radiometric quantity weighted by the appropriate actinic spectrum (Appendix 3 of BIPM, 2019).

Like the action spectra for vision (the spectral luminous efficiency functions), the action spectrum for other actinic effects is a relative quantity that is typically normalized to a value of one at the wavelength of “maximum action”; it is dimensionless with the SI unit one. However, while specific photometric units are defined for photometric quantities, the unit of a photochemical or photobiological quantity is always the radiometric unit of the radiometric quantity being weighted and integrated. When giving a quantitative value in these latter cases, it is essential to specify whether a radiometric or actinic quantity is intended, because the unit is the same for both. Further information is available in (CIE, 2014).

8 Colorimetric quantities

The CIE has published basic colorimetric recommendations (CIE, 2018b) that describe the methods to be used for calculating various colorimetric quantities for a given spectral power distribution. These quantities are derived from a triplet of numbers that are calculated from a measured colour stimulus according to a specified CIE standard colorimetric system. The most commonly used system for photometric and radiometric applications is the CIE XYZ trichromatic system, called the CIE 1931 standard colorimetric system, using the CIE 1931 colour-matching functions. These colorimetric quantities and their ranges of applicability are described below.

8.1 CIE 1931 colour-matching functions

The CIE 1931 colour-matching functions define the colour-matching properties of an average observer (the CIE 1931 standard colorimetric observer) with normal colour vision viewing fields of angular subtense between 1° and 4° (0,017 rad and 0,07 rad). The colour-matching functions are the tristimulus values of monochromatic stimuli of equal radiant power and of wavelengths within the visible spectrum (360 nm to 830 nm). They are denoted by $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, $\bar{z}(\lambda)$ and their values are given in Table 6 (adopted from ISO/CIE, 2007). For a larger field of view, the colour-matching functions for the CIE 10° observer (the CIE 1964 standard colorimetric observer), $\bar{x}_{10}(\lambda)$, $\bar{y}_{10}(\lambda)$, $\bar{z}_{10}(\lambda)$, are available (ISO/CIE, 2007).

NOTE The $\bar{y}(\lambda)$ function is identical to the $V(\lambda)$ function given in Table 1, and $\bar{y}_{10}(\lambda)$ is identical to the $V_{10}(\lambda)$ function given in Table 5 (CIE, 2005).

8.2 Tristimulus values and chromaticity coordinates

Tristimulus values X, Y and Z are given by:

$$
\begin{aligned}
X &= k\int_{\lambda} \Phi_{\mathrm{e},\lambda}(\lambda)\,\bar{x}(\lambda)\,\mathrm{d}\lambda \\
Y &= k\int_{\lambda} \Phi_{\mathrm{e},\lambda}(\lambda)\,\bar{y}(\lambda)\,\mathrm{d}\lambda \qquad (14) \\
Z &= k\int_{\lambda} \Phi_{\mathrm{e},\lambda}(\lambda)\,\bar{z}(\lambda)\,\mathrm{d}\lambda
\end{aligned}
$$

where

$\Phi_{\mathrm{e},\lambda}(\lambda) = \dfrac{\mathrm{d}\Phi_{\mathrm{e}}}{\mathrm{d}\lambda}$ is spectral radiant flux, i.e. the spectral distribution of radiant flux, Φ_{e};

$\bar{x}(\lambda)$, $\bar{y}(\lambda)$, $\bar{z}(\lambda)$ are the CIE 1931 colour-matching functions;

k is a normalizing factor rendering the X, Y, Z tristimulus values dimensionless.

For light sources, k = 683 lm·W^{-1} is often used, so that Y is the value of a photometric quantity.

The tristimulus values X_{10}, Y_{10}, Z_{10} for a 10° field of view are calculated similarly using $\bar{x}_{10}(\lambda)$, $\bar{y}_{10}(\lambda)$, $\bar{z}_{10}(\lambda)$.

The above equations for calculation of CIE tristimulus values have been shown using spectral radiant flux of a self-luminous object, but they are generally applicable for any spectral radiometric quantity (e.g. spectral radiance, spectral irradiance). The equations for object-colour stimuli, reflecting or transmitting objects, are outside the scope of this document; for details consult CIE Publication 15:2018 (CIE, 2018b).

The chromaticity coordinates define the chromaticity of a visual stimulus given by its relative spectral distribution. The chromaticity can be represented as a point in the CIE 1931 (x, y) chromaticity diagram.

$$x = \frac{X}{X+Y+Z}$$
$$y = \frac{Y}{X+Y+Z} \qquad (15)$$

Where X, Y, Z are the tristimulus values.

NOTE In the special case of $X = \bar{x}(\lambda)$, $Y = \bar{y}(\lambda)$, $Z = \bar{z}(\lambda)$ the chromaticity coordinates are denoted by $x(\lambda)$, $y(\lambda)$. They define the chromaticity of monochromatic visual stimuli of wavelength λ (see Table 6).

The chromaticity coordinates x_{10}, y_{10} for a 10° field of view are calculated similarly as X_{10}, Y_{10}, Z_{10}.

9 General notes

The equations using an integral, shown in Clauses 2, 6 and 8, to derive photometric or colorimetric quantities are, in practice, replaced by summations ($\sum_{\lambda}$) over the visible spectrum. The wavelength boundaries and wavelength intervals may be those given in Tables 1 to 3, 5 and 6 or those matched to measured data. When it is necessary to obtain values of spectral luminous efficiency functions or colour matching functions at wavelengths intermediate to those given in the tables, linear interpolation should be used.

Luminance is intended to correlate with the perception of brightness. However, in photopic vision, it does so only for lights having the same colour. It has been established experimentally that lights having identical photopic luminances or photopic luminous intensities but different colours, i.e. different values for the chromaticity coordinates, are in general not perceived as equally bright. The brightness differences depend on the colours involved.

At present there is no agreed photometric quantity that is more satisfactory than luminance or luminous intensity for quantifying the absolute brightness of luminous sources. However, the CIE has developed a supplementary system of photometry that provides a more perceptually-relevant approach for comparative brightness evaluation of lights at any level, including mesopic levels (CIE, 2011). This system introduces the concept of equivalent luminance and develops a photometric model to calculate brightness-related equivalent luminance using existing photometric and colorimetric quantities, by introducing a chromatic contribution to brightness that depends upon the adaptation level. The CIE supplementary system for comparative brightness evaluation is used for research purposes, to provide a measure of luminance that corresponds more closely to the visual effect when comparing two lights of different colour. The equivalent luminance values calculated using this system are expressed in units of $\mathrm{cd \cdot m^{-2}}$ and must always be accompanied by full details of the parameters used in the calculation (i.e. the photopic and scotopic luminances and the x and y chromaticity coordinates).

It is also known that the spectral luminous efficiency function for photopic vision, $V(\lambda)$, underestimates the visual response in the blue region, and an improved function, known as the CIE 1988 modified 2° spectral luminous efficiency function for photopic vision, $V_{\mathrm{M}}(\lambda)$, was recommended by the CIE as a supplement to, and not a replacement of, $V(\lambda)$ (CIE, 1990). The physiologically-based function, known as the cone-fundamental-based spectral luminous efficiency function, $V_{\mathrm{F}}(\lambda)$, is based on the latest research (CIE, 2015) and is considered to provide further improvements. The $V_{\mathrm{F}}(\lambda)$ or $V_{\mathrm{M}}(\lambda)$ functions are not recognized by the CIPM and are used only for research purposes to measure perceived brightness more accurately. Benefits and impacts of the new luminous efficiency functions will be evaluated in the near future.

10 Tables

Table 1 – Values of spectral luminous efficiency for photopic vision, $V(\lambda)$ (λ in standard air)

λ/nm	$V(\lambda)$	λ/nm	$V(\lambda)$	λ/nm	$V(\lambda)$
360	0.000 003 917 000 0	401	0.000 433 714 700 0	442	0.025 610 240 000 0
361	0.000 004 393 581 0	402	0.000 473 024 000 0	443	0.026 958 570 000 0
362	0.000 004 929 604 0	403	0.000 517 876 000 0	444	0.028 351 250 000 0
363	0.000 005 532 136 0	404	0.000 572 218 700 0	445	0.029 800 000 000 0
364	0.000 006 208 245 0	405	0.000 640 000 000 0	446	0.031 310 830 000 0
365	0.000 006 965 000 0	406	0.000 724 560 000 0	447	0.032 883 680 000 0
366	0.000 007 813 219 0	407	0.000 825 500 000 0	448	0.034 521 120 000 0
367	0.000 008 767 336 0	408	0.000 941 160 000 0	449	0.036 225 710 000 0
368	0.000 009 839 844 0	409	0.001 069 880 000 0	450	0.038 000 000 000 0
369	0.000 011 043 230 0	410	0.001 210 000 000 0	451	0.039 846 670 000 0
370	0.000 012 390 000 0	411	0.001 362 091 000 0	452	0.041 768 000 000 0
371	0.000 013 886 410 0	412	0.001 530 752 000 0	453	0.043 766 000 000 0
372	0.000 015 557 280 0	413	0.001 720 368 000 0	454	0.045 842 670 000 0
373	0.000 017 442 960 0	414	0.001 935 323 000 0	455	0.048 000 000 000 0
374	0.000 019 583 750 0	415	0.002 180 000 000 0	456	0.050 243 680 000 0
375	0.000 022 020 000 0	416	0.002 454 800 000 0	457	0.052 573 040 000 0
376	0.000 024 839 650 0	417	0.002 764 000 000 0	458	0.054 980 560 000 0
377	0.000 028 041 260 0	418	0.003 117 800 000 0	459	0.057 458 720 000 0
378	0.000 031 531 040 0	419	0.003 526 400 000 0	460	0.060 000 000 000 0
379	0.000 035 215 210 0	420	0.004 000 000 000 0	461	0.062 601 970 000 0
380	0.000 039 000 000 0	421	0.004 546 240 000 0	462	0.065 277 520 000 0
381	0.000 042 826 400 0	422	0.005 159 320 000 0	463	0.068 042 080 000 0
382	0.000 046 914 600 0	423	0.005 829 280 000 0	464	0.070 911 090 000 0
383	0.000 051 589 600 0	424	0.006 546 160 000 0	465	0.073 900 000 000 0
384	0.000 057 176 400 0	425	0.007 300 000 000 0	466	0.077 016 000 000 0
385	0.000 064 000 000 0	426	0.008 086 507 000 0	467	0.080 266 400 000 0
386	0.000 072 344 210 0	427	0.008 908 720 000 0	468	0.083 666 800 000 0
387	0.000 082 212 240 0	428	0.009 767 680 000 0	469	0.087 232 800 000 0
388	0.000 093 508 160 0	429	0.010 664 430 000 0	470	0.090 980 000 000 0
389	0.000 106 136 100 0	430	0.011 600 000 000 0	471	0.094 917 550 000 0
390	0.000 120 000 000 0	431	0.012 573 170 000 0	472	0.099 045 840 000 0
391	0.000 134 984 000 0	432	0.013 582 720 000 0	473	0.103 367 400 000 0
392	0.000 151 492 000 0	433	0.014 629 680 000 0	474	0.107 884 600 000 0
393	0.000 170 208 000 0	434	0.015 715 090 000 0	475	0.112 600 000 000 0
394	0.000 191 816 000 0	435	0.016 840 000 000 0	476	0.117 532 000 000 0
395	0.000 217 000 000 0	436	0.018 007 360 000 0	477	0.122 674 400 000 0
396	0.000 246 906 700 0	437	0.019 214 480 000 0	478	0.127 992 800 000 0
397	0.000 281 240 000 0	438	0.020 453 920 000 0	479	0.133 452 800 000 0
398	0.000 318 520 000 0	439	0.021 718 240 000 0	480	0.139 020 000 000 0
399	0.000 357 266 700 0	440	0.023 000 000 000 0	481	0.144 676 400 000 0
400	0.000 396 000 000 0	441	0.024 294 610 000 0	482	0.150 469 300 000 0

λ/nm	$V(\lambda)$	λ/nm	$V(\lambda)$	λ/nm	$V(\lambda)$
483	0.156 461 900 000 0	528	0.836 306 800 000 0	573	0.931 162 800 000 0
484	0.162 717 700 000 0	529	0.849 491 600 000 0	574	0.923 457 600 000 0
485	0.169 300 000 000 0	530	0.862 000 000 000 0	575	0.915 400 000 000 0
486	0.176 243 100 000 0	531	0.873 810 800 000 0	576	0.907 006 400 000 0
487	0.183 558 100 000 0	532	0.884 962 400 000 0	577	0.898 277 200 000 0
488	0.191 273 500 000 0	533	0.895 493 600 000 0	578	0.889 204 800 000 0
489	0.199 418 000 000 0	534	0.905 443 200 000 0	579	0.879 781 600 000 0
490	0.208 020 000 000 0	535	0.914 850 100 000 0	580	0.870 000 000 000 0
491	0.217 119 900 000 0	536	0.923 734 800 000 0	581	0.859 861 300 000 0
492	0.226 734 500 000 0	537	0.932 092 400 000 0	582	0.849 392 000 000 0
493	0.236 857 100 000 0	538	0.939 922 600 000 0	583	0.838 622 000 000 0
494	0.247 481 200 000 0	539	0.947 225 200 000 0	584	0.827 581 300 000 0
495	0.258 600 000 000 0	540	0.954 000 000 000 0	585	0.816 300 000 000 0
496	0.270 184 900 000 0	541	0.960 256 100 000 0	586	0.804 794 700 000 0
497	0.282 293 900 000 0	542	0.966 007 400 000 0	587	0.793 082 000 000 0
498	0.295 050 500 000 0	543	0.971 260 600 000 0	588	0.781 192 000 000 0
499	0.308 578 000 000 0	544	0.976 022 500 000 0	589	0.769 154 700 000 0
500	0.323 000 000 000 0	545	0.980 300 000 000 0	590	0.757 000 000 000 0
501	0.338 402 100 000 0	546	0.984 092 400 000 0	591	0.744 754 100 000 0
502	0.354 685 800 000 0	547	0.987 418 200 000 0	592	0.732 422 400 000 0
503	0.371 698 600 000 0	548	0.990 312 800 000 0	593	0.720 003 600 000 0
504	0.389 287 500 000 0	549	0.992 811 600 000 0	594	0.707 496 500 000 0
505	0.407 300 000 000 0	550	0.994 950 100 000 0	595	0.694 900 000 000 0
506	0.425 629 900 000 0	551	0.996 710 800 000 0	596	0.682 219 200 000 0
507	0.444 309 600 000 0	552	0.998 098 300 000 0	597	0.669 471 600 000 0
508	0.463 394 400 000 0	553	0.999 112 000 000 0	598	0.656 674 400 000 0
509	0.482 939 500 000 0	554	0.999 748 200 000 0	599	0.643 844 800 000 0
510	0.503 000 000 000 0	555	1.000 000 000 000 0	600	0.631 000 000 000 0
511	0.523 569 300 000 0	556	0.999 856 700 000 0	601	0.618 155 500 000 0
512	0.544 512 000 000 0	557	0.999 304 600 000 0	602	0.605 314 400 000 0
513	0.565 690 000 000 0	558	0.998 325 500 000 0	603	0.592 475 600 000 0
514	0.586 965 300 000 0	559	0.996 898 700 000 0	604	0.579 637 900 000 0
515	0.608 200 000 000 0	560	0.995 000 000 000 0	605	0.566 800 000 000 0
516	0.629 345 600 000 0	561	0.992 600 500 000 0	606	0.553 961 100 000 0
517	0.650 306 800 000 0	562	0.989 742 600 000 0	607	0.541 137 200 000 0
518	0.670 875 200 000 0	563	0.986 444 400 000 0	608	0.528 352 800 000 0
519	0.690 842 400 000 0	564	0.982 724 100 000 0	609	0.515 632 300 000 0
520	0.710 000 000 000 0	565	0.978 600 000 000 0	610	0.503 000 000 000 0
521	0.728 185 200 000 0	566	0.974 083 700 000 0	611	0.490 468 800 000 0
522	0.745 463 600 000 0	567	0.969 171 200 000 0	612	0.478 030 400 000 0
523	0.761 969 400 000 0	568	0.963 856 800 000 0	613	0.465 677 600 000 0
524	0.777 836 800 000 0	569	0.958 134 900 000 0	614	0.453 403 200 000 0
525	0.793 200 000 000 0	570	0.952 000 000 000 0	615	0.441 200 000 000 0
526	0.808 110 400 000 0	571	0.945 450 400 000 0	616	0.429 080 000 000 0
527	0.822 496 200 000 0	572	0.938 499 200 000 0	617	0.417 036 000 000 0

λ/nm	$V(\lambda)$
618	0.405 032 000 000 0
619	0.393 032 000 000 0
620	0.381 000 000 000 0
621	0.368 918 400 000 0
622	0.356 827 200 000 0
623	0.344 776 800 000 0
624	0.332 817 600 000 0
625	0.321 000 000 000 0
626	0.309 338 100 000 0
627	0.297 850 400 000 0
628	0.286 593 600 000 0
629	0.275 624 500 000 0
630	0.265 000 000 000 0
631	0.254 763 200 000 0
632	0.244 889 600 000 0
633	0.235 334 400 000 0
634	0.226 052 800 000 0
635	0.217 000 000 000 0
636	0.208 161 600 000 0
637	0.199 548 800 000 0
638	0.191 155 200 000 0
639	0.182 974 400 000 0
640	0.175 000 000 000 0
641	0.167 223 500 000 0
642	0.159 646 400 000 0
643	0.152 277 600 000 0
644	0.145 125 900 000 0
645	0.138 200 000 000 0
646	0.131 500 300 000 0
647	0.125 024 800 000 0
648	0.118 779 200 000 0
649	0.112 769 100 000 0
650	0.107 000 000 000 0
651	0.101 476 200 000 0
652	0.096 188 640 000 0
653	0.091 122 960 000 0
654	0.086 264 850 000 0
655	0.081 600 000 000 0
656	0.077 120 640 000 0
657	0.072 825 520 000 0
658	0.068 710 080 000 0
659	0.064 769 760 000 0
660	0.061 000 000 000 0
661	0.057 396 210 000 0
662	0.053 955 040 000 0

λ/nm	$V(\lambda)$
663	0.050 673 760 000 0
664	0.047 549 650 000 0
665	0.044 580 000 000 0
666	0.041 758 720 000 0
667	0.039 084 960 000 0
668	0.036 563 840 000 0
669	0.034 200 480 000 0
670	0.032 000 000 000 0
671	0.029 962 610 000 0
672	0.028 076 640 000 0
673	0.026 329 360 000 0
674	0.024 708 050 000 0
675	0.023 200 000 000 0
676	0.021 800 770 000 0
677	0.020 501 120 000 0
678	0.019 281 080 000 0
679	0.018 120 690 000 0
680	0.017 000 000 000 0
681	0.015 903 790 000 0
682	0.014 837 180 000 0
683	0.013 810 680 000 0
684	0.012 834 780 000 0
685	0.011 920 000 000 0
686	0.011 068 310 000 0
687	0.010 273 390 000 0
688	0.009 533 311 000 0
689	0.008 846 157 000 0
690	0.008 210 000 000 0
691	0.007 623 781 000 0
692	0.007 085 424 000 0
693	0.006 591 476 000 0
694	0.006 138 485 000 0
695	0.005 723 000 000 0
696	0.005 343 059 000 0
697	0.004 995 796 000 0
698	0.004 676 404 000 0
699	0.004 380 075 000 0
700	0.004 102 000 000 0
701	0.003 838 453 000 0
702	0.003 589 099 000 0
703	0.003 354 219 000 0
704	0.003 134 093 000 0
705	0.002 929 000 000 0
706	0.002 738 139 000 0
707	0.002 559 876 000 0

λ/nm	$V(\lambda)$
708	0.002 393 244 000 0
709	0.002 237 275 000 0
710	0.002 091 000 000 0
711	0.001 953 587 000 0
712	0.001 824 580 000 0
713	0.001 703 580 000 0
714	0.001 590 187 000 0
715	0.001 484 000 000 0
716	0.001 384 496 000 0
717	0.001 291 268 000 0
718	0.001 204 092 000 0
719	0.001 122 744 000 0
720	0.001 047 000 000 0
721	0.000 976 589 600 0
722	0.000 911 108 800 0
723	0.000 850 133 200 0
724	0.000 793 238 400 0
725	0.000 740 000 000 0
726	0.000 690 082 700 0
727	0.000 643 310 000 0
728	0.000 599 496 000 0
729	0.000 558 454 700 0
730	0.000 520 000 000 0
731	0.000 483 913 600 0
732	0.000 450 052 800 0
733	0.000 418 345 200 0
734	0.000 388 718 400 0
735	0.000 361 100 000 0
736	0.000 335 383 500 0
737	0.000 311 440 400 0
738	0.000 289 165 600 0
739	0.000 268 453 900 0
740	0.000 249 200 000 0
741	0.000 231 301 900 0
742	0.000 214 685 600 0
743	0.000 199 288 400 0
744	0.000 185 047 500 0
745	0.000 171 900 000 0
746	0.000 159 778 100 0
747	0.000 148 604 400 0
748	0.000 138 301 600 0
749	0.000 128 792 500 0
750	0.000 120 000 000 0
751	0.000 111 859 500 0
752	0.000 104 322 400 0

λ/nm	$V(\lambda)$
753	0.000 097 335 600 0
754	0.000 090 845 870 0
755	0.000 084 800 000 0
756	0.000 079 146 670 0
757	0.000 073 858 000 0
758	0.000 068 916 000 0
759	0.000 064 302 670 0
760	0.000 060 000 000 0
761	0.000 055 981 870 0
762	0.000 052 225 600 0
763	0.000 048 718 400 0
764	0.000 045 447 470 0
765	0.000 042 400 000 0
766	0.000 039 561 040 0
767	0.000 036 915 120 0
768	0.000 034 448 680 0
769	0.000 032 148 160 0
770	0.000 030 000 000 0
771	0.000 027 991 250 0
772	0.000 026 113 560 0
773	0.000 024 360 240 0
774	0.000 022 724 610 0
775	0.000 021 200 000 0
776	0.000 019 778 550 0
777	0.000 018 452 850 0
778	0.000 017 216 870 0
779	0.000 016 064 590 0
780	0.000 014 990 000 0
781	0.000 013 987 280 0
782	0.000 013 051 550 0
783	0.000 012 178 180 0
784	0.000 011 362 540 0
785	0.000 010 600 000 0
786	0.000 009 885 877 0
787	0.000 009 217 304 0
788	0.000 008 592 362 0
789	0.000 008 009 133 0
790	0.000 007 465 700 0
791	0.000 006 959 567 0
792	0.000 006 487 995 0
793	0.000 006 048 699 0
794	0.000 005 639 396 0
795	0.000 005 257 800 0
796	0.000 004 901 771 0
797	0.000 004 569 720 0

λ/nm	$V(\lambda)$
798	0.000 004 260 194 0
799	0.000 003 971 739 0
800	0.000 003 702 900 0
801	0.000 003 452 163 0
802	0.000 003 218 302 0
803	0.000 003 000 300 0
804	0.000 002 797 139 0
805	0.000 002 607 800 0
806	0.000 002 431 220 0
807	0.000 002 266 531 0
808	0.000 002 113 013 0
809	0.000 001 969 943 0
810	0.000 001 836 600 0
811	0.000 001 712 230 0
812	0.000 001 596 228 0
813	0.000 001 488 090 0
814	0.000 001 387 314 0
815	0.000 001 293 400 0
816	0.000 001 205 820 0
817	0.000 001 124 143 0
818	0.000 001 048 009 0
819	0.000 000 977 057 8
820	0.000 000 910 930 0
821	0.000 000 849 251 3
822	0.000 000 791 721 2
823	0.000 000 738 090 4
824	0.000 000 688 109 8
825	0.000 000 641 530 0
826	0.000 000 598 089 5
827	0.000 000 557 574 6
828	0.000 000 519 808 0
829	0.000 000 484 612 3
830	0.000 000 451 810 0

Table 2 – Values of spectral luminous efficiency for scotopic vision, $V'(\lambda)$ (λ in standard air)

λ/nm	$V'(\lambda)$
380	0.000 589 000 0
381	0.000 665 000 0
382	0.000 752 000 0
383	0.000 854 000 0
384	0.000 972 000 0
385	0.001 108 000 0
386	0.001 268 000 0
387	0.001 453 000 0
388	0.001 668 000 0
389	0.001 918 000 0
390	0.002 209 000 0
391	0.002 547 000 0
392	0.002 939 000 0
393	0.003 394 000 0
394	0.003 921 000 0
395	0.004 530 000 0
396	0.005 240 000 0
397	0.006 050 000 0
398	0.006 980 000 0
399	0.008 060 000 0
400	0.009 290 000 0
401	0.010 700 000 0
402	0.012 310 000 0
403	0.014 130 000 0
404	0.016 190 000 0
405	0.018 520 000 0
406	0.021 130 000 0
407	0.024 050 000 0
408	0.027 300 000 0
409	0.030 890 000 0
410	0.034 840 000 0
411	0.039 160 000 0
412	0.043 900 000 0
413	0.049 000 000 0
414	0.054 500 000 0
415	0.060 400 000 0
416	0.066 800 000 0
417	0.073 600 000 0
418	0.080 800 000 0
419	0.088 500 000 0
420	0.096 600 000 0
421	0.105 200 000 0
422	0.114 100 000 0
423	0.123 500 000 0
424	0.133 400 000 0
425	0.143 600 000 0
426	0.154 100 000 0
427	0.165 100 000 0
428	0.176 400 000 0
429	0.187 900 000 0
430	0.199 800 000 0
431	0.211 900 000 0
432	0.224 300 000 0
433	0.236 900 000 0
434	0.249 600 000 0
435	0.262 500 000 0
436	0.275 500 000 0
437	0.288 600 000 0
438	0.301 700 000 0
439	0.314 900 000 0
440	0.328 100 000 0
441	0.341 200 000 0
442	0.354 300 000 0
443	0.367 300 000 0
444	0.380 300 000 0
445	0.393 100 000 0
446	0.406 000 000 0
447	0.418 000 000 0
448	0.431 000 000 0
449	0.443 000 000 0
450	0.455 000 000 0
451	0.467 000 000 0
452	0.479 000 000 0
453	0.490 000 000 0
454	0.502 000 000 0
455	0.513 000 000 0
456	0.524 000 000 0
457	0.535 000 000 0
458	0.546 000 000 0
459	0.557 000 000 0
460	0.567 000 000 0
461	0.578 000 000 0
462	0.588 000 000 0
463	0.599 000 000 0
464	0.610 000 000 0
465	0.620 000 000 0
466	0.631 000 000 0
467	0.642 000 000 0
468	0.653 000 000 0
469	0.664 000 000 0
470	0.676 000 000 0
471	0.687 000 000 0
472	0.699 000 000 0
473	0.710 000 000 0
474	0.722 000 000 0
475	0.734 000 000 0
476	0.745 000 000 0
477	0.757 000 000 0
478	0.769 000 000 0
479	0.781 000 000 0
480	0.793 000 000 0
481	0.805 000 000 0
482	0.817 000 000 0
483	0.828 000 000 0
484	0.840 000 000 0
485	0.851 000 000 0
486	0.862 000 000 0
487	0.873 000 000 0
488	0.884 000 000 0
489	0.894 000 000 0
490	0.904 000 000 0
491	0.914 000 000 0
492	0.923 000 000 0
493	0.932 000 000 0
494	0.941 000 000 0
495	0.949 000 000 0
496	0.957 000 000 0
497	0.964 000 000 0
498	0.970 000 000 0
499	0.976 000 000 0
500	0.982 000 000 0
501	0.986 000 000 0
502	0.990 000 000 0
503	0.994 000 000 0
504	0.997 000 000 0
505	0.998 000 000 0
506	1.000 000 000 0
507	1.000 000 000 0
508	1.000 000 000 0

λ/nm	$V'(\lambda)$
509	0.998 000 000 0
510	0.997 000 000 0
511	0.994 000 000 0
512	0.990 000 000 0
513	0.986 000 000 0
514	0.981 000 000 0
515	0.975 000 000 0
516	0.968 000 000 0
517	0.961 000 000 0
518	0.953 000 000 0
519	0.944 000 000 0
520	0.935 000 000 0
521	0.925 000 000 0
522	0.915 000 000 0
523	0.904 000 000 0
524	0.892 000 000 0
525	0.880 000 000 0
526	0.867 000 000 0
527	0.854 000 000 0
528	0.840 000 000 0
529	0.826 000 000 0
530	0.811 000 000 0
531	0.796 000 000 0
532	0.781 000 000 0
533	0.765 000 000 0
534	0.749 000 000 0
535	0.733 000 000 0
536	0.717 000 000 0
537	0.700 000 000 0
538	0.683 000 000 0
539	0.667 000 000 0
540	0.650 000 000 0
541	0.633 000 000 0
542	0.616 000 000 0
543	0.599 000 000 0
544	0.581 000 000 0
545	0.564 000 000 0
546	0.548 000 000 0
547	0.531 000 000 0
548	0.514 000 000 0
549	0.497 000 000 0
550	0.481 000 000 0
551	0.465 000 000 0
552	0.448 000 000 0
553	0.433 000 000 0
554	0.417 000 000 0

λ/nm	$V'(\lambda)$
555	0.402 000 000 0
556	0.386 400 000 0
557	0.371 500 000 0
558	0.356 900 000 0
559	0.342 700 000 0
560	0.328 800 000 0
561	0.315 100 000 0
562	0.301 800 000 0
563	0.288 800 000 0
564	0.276 200 000 0
565	0.263 900 000 0
566	0.251 900 000 0
567	0.240 300 000 0
568	0.229 100 000 0
569	0.218 200 000 0
570	0.207 600 000 0
571	0.197 400 000 0
572	0.187 600 000 0
573	0.178 200 000 0
574	0.169 000 000 0
575	0.160 200 000 0
576	0.151 700 000 0
577	0.143 600 000 0
578	0.135 800 000 0
579	0.128 400 000 0
580	0.121 200 000 0
581	0.114 300 000 0
582	0.107 800 000 0
583	0.101 500 000 0
584	0.095 600 000 0
585	0.089 900 000 0
586	0.084 500 000 0
587	0.079 300 000 0
588	0.074 500 000 0
589	0.069 900 000 0
590	0.065 500 000 0
591	0.061 300 000 0
592	0.057 400 000 0
593	0.053 700 000 0
594	0.050 200 000 0
595	0.046 900 000 0
596	0.043 800 000 0
597	0.040 900 000 0
598	0.038 160 000 0
599	0.035 580 000 0
600	0.033 150 000 0

λ/nm	$V'(\lambda)$
601	0.030 870 000 0
602	0.028 740 000 0
603	0.026 740 000 0
604	0.024 870 000 0
605	0.023 120 000 0
606	0.021 470 000 0
607	0.019 940 000 0
608	0.018 510 000 0
609	0.017 180 000 0
610	0.015 930 000 0
611	0.014 770 000 0
612	0.013 690 000 0
613	0.012 690 000 0
614	0.011 750 000 0
615	0.010 880 000 0
616	0.010 070 000 0
617	0.009 320 000 0
618	0.008 620 000 0
619	0.007 970 000 0
620	0.007 370 000 0
621	0.006 820 000 0
622	0.006 300 000 0
623	0.005 820 000 0
624	0.005 380 000 0
625	0.004 970 000 0
626	0.004 590 000 0
627	0.004 240 000 0
628	0.003 913 000 0
629	0.003 613 000 0
630	0.003 335 000 0
631	0.003 079 000 0
632	0.002 842 000 0
633	0.002 623 000 0
634	0.002 421 000 0
635	0.002 235 000 0
636	0.002 062 000 0
637	0.001 903 000 0
638	0.001 757 000 0
639	0.001 621 000 0
640	0.001 497 000 0
641	0.001 382 000 0
642	0.001 276 000 0
643	0.001 178 000 0
644	0.001 088 000 0
645	0.001 005 000 0
646	0.000 928 000 0

λ/nm	$V'(\lambda)$
647	0.000 857 000 0
648	0.000 792 000 0
649	0.000 732 000 0
650	0.000 677 000 0
651	0.000 626 000 0
652	0.000 579 000 0
653	0.000 536 000 0
654	0.000 496 000 0
655	0.000 459 000 0
656	0.000 425 000 0
657	0.000 393 500 0
658	0.000 364 500 0
659	0.000 337 700 0
660	0.000 312 900 0
661	0.000 290 100 0
662	0.000 268 900 0
663	0.000 249 300 0
664	0.000 231 300 0
665	0.000 214 600 0
666	0.000 199 100 0
667	0.000 184 800 0
668	0.000 171 600 0
669	0.000 159 300 0
670	0.000 148 000 0
671	0.000 137 500 0
672	0.000 127 700 0
673	0.000 118 700 0
674	0.000 110 400 0
675	0.000 102 600 0
676	0.000 095 400 0
677	0.000 088 800 0
678	0.000 082 600 0
679	0.000 076 900 0
680	0.000 071 500 0
681	0.000 066 600 0
682	0.000 062 000 0
683	0.000 057 800 0
684	0.000 053 800 0
685	0.000 050 100 0
686	0.000 046 700 0
687	0.000 043 600 0
688	0.000 040 600 0
689	0.000 037 890 0
690	0.000 035 330 0
691	0.000 032 950 0
692	0.000 030 750 0

λ/nm	$V'(\lambda)$
693	0.000 028 700 0
694	0.000 026 790 0
695	0.000 025 010 0
696	0.000 023 360 0
697	0.000 021 820 0
698	0.000 020 380 0
699	0.000 019 050 0
700	0.000 017 800 0
701	0.000 016 640 0
702	0.000 015 560 0
703	0.000 014 540 0
704	0.000 013 600 0
705	0.000 012 730 0
706	0.000 011 910 0
707	0.000 011 140 0
708	0.000 010 430 0
709	0.000 009 760 0
710	0.000 009 140 0
711	0.000 008 560 0
712	0.000 008 020 0
713	0.000 007 510 0
714	0.000 007 040 0
715	0.000 006 600 0
716	0.000 006 180 0
717	0.000 005 800 0
718	0.000 005 440 0
719	0.000 005 100 0
720	0.000 004 780 0
721	0.000 004 490 0
722	0.000 004 210 0
723	0.000 003 951 0
724	0.000 003 709 0
725	0.000 003 482 0
726	0.000 003 270 0
727	0.000 003 070 0
728	0.000 002 884 0
729	0.000 002 710 0
730	0.000 002 546 0
731	0.000 002 393 0
732	0.000 002 250 0
733	0.000 002 115 0
734	0.000 001 989 0
735	0.000 001 870 0
736	0.000 001 759 0
737	0.000 001 655 0
738	0.000 001 557 0

λ/nm	$V'(\lambda)$
739	0.000 001 466 0
740	0.000 001 379 0
741	0.000 001 299 0
742	0.000 001 223 0
743	0.000 001 151 0
744	0.000 001 084 0
745	0.000 001 022 0
746	0.000 000 962 0
747	0.000 000 907 0
748	0.000 000 855 0
749	0.000 000 806 0
750	0.000 000 760 0
751	0.000 000 716 0
752	0.000 000 675 0
753	0.000 000 637 0
754	0.000 000 601 0
755	0.000 000 567 0
756	0.000 000 535 0
757	0.000 000 505 0
758	0.000 000 477 0
759	0.000 000 450 0
760	0.000 000 425 0
761	0.000 000 401 0
762	0.000 000 379 0
763	0.000 000 358 0
764	0.000 000 338 2
765	0.000 000 319 6
766	0.000 000 302 1
767	0.000 000 285 5
768	0.000 000 269 9
769	0.000 000 255 2
770	0.000 000 241 3
771	0.000 000 228 2
772	0.000 000 215 9
773	0.000 000 204 2
774	0.000 000 193 2
775	0.000 000 182 9
776	0.000 000 173 1
777	0.000 000 163 8
778	0.000 000 155 1
779	0.000 000 146 8
780	0.000 000 139 0

Table 3 – Values of spectral luminous efficiency for mesopic vision, $V_{\mathrm{mes};m}(\lambda)$, at m = 0.8 (i.e. $V_{\mathrm{mes};0,8}(\lambda)$) as an example (for other m values, use Eq. (1))

λ/nm	$V_{\mathrm{mes};m}(\lambda)$
360	0.000 003 493 3
361	0.000 003 918 3
362	0.000 004 396 3
363	0.000 004 933 6
364	0.000 005 536 6
365	0.000 006 211 5
366	0.000 006 968 0
367	0.000 007 818 9
368	0.000 008 775 4
369	0.000 009 848 4
370	0.000 011 049 7
371	0.000 012 383 8
372	0.000 013 874 1
373	0.000 015 556 1
374	0.000 017 465 4
375	0.000 019 637 9
376	0.000 022 152 9
377	0.000 025 007 6
378	0.000 028 120 0
379	0.000 031 405 5
380	0.000 166 101 8
381	0.000 186 458 6
382	0.000 209 502 4
383	0.000 236 413 1
384	0.000 267 703 6
385	0.000 304 111 3
386	0.000 347 225 5
387	0.000 397 272 8
388	0.000 455 282 3
389	0.000 522 286 6
390	0.000 599 527 3
391	0.000 688 245 8
392	0.000 790 368 3
393	0.000 908 508 0
394	0.001 045 277 8
395	0.001 203 513 8
396	0.001 388 486 6
397	0.001 599 696 8
398	0.001 840 292 5
399	0.002 115 642 6
400	0.002 424 418 1
401	0.002 772 415 9
402	0.003 166 431 8
403	0.003 612 218 0
404	0.004 119 967 9
405	0.004 699 901 9
406	0.005 357 228 2
407	0.006 098 278 8
408	0.006 926 032 3
409	0.007 841 237 8
410	0.008 846 874 2
411	0.009 945 679 1
412	0.011 152 902 9
413	0.012 459 083 2
414	0.013 877 035 6
415	0.015 410 684 0
416	0.017 082 671 9
417	0.018 874 520 6
418	0.020 795 326 9
419	0.022 876 482 7
420	0.025 104 789 1
421	0.027 509 355 2
422	0.030 040 417 4
423	0.032 733 684 1
424	0.035 580 272 9
425	0.038 526 710 1
426	0.041 569 169 7
427	0.044 754 945 2
428	0.048 040 381 7
429	0.051 404 111 3
430	0.054 891 643 6
431	0.058 457 299 6
432	0.062 122 286 6
433	0.065 865 227 9
434	0.069 664 755 2
435	0.073 544 100 6
436	0.077 483 599 4
437	0.081 480 852 6
438	0.085 506 929 5
439	0.089 577 490 4
440	0.093 663 604 7
441	0.097 738 883 4
442	0.101 832 908 2
443	0.105 933 800 1
444	0.110 074 244 2
445	0.114 220 101 7
446	0.118 443 619 0
447	0.122 521 787 2
448	0.126 880 513 7
449	0.131 076 170 5
450	0.135 333 987 3
451	0.139 656 354 2
452	0.144 045 304 6
453	0.148 279 675 4
454	0.152 807 161 3
455	0.157 183 626 1
456	0.161 637 099 8
457	0.166 166 984 7
458	0.170 766 574 5
459	0.175 429 162 6
460	0.179 925 087 0
461	0.184 698 091 5
462	0.189 313 760 8
463	0.194 231 766 7
464	0.199 242 923 4
465	0.204 138 054 0
466	0.209 369 481 9
467	0.214 720 770 5
468	0.220 205 832 5
469	0.225 838 580 2
470	0.231 855 881 6
471	0.237 819 985 7
472	0.244 177 151 5
473	0.250 483 724 2
474	0.257 187 728 5
475	0.264 068 491 9
476	0.270 919 468 5

λ/nm	$V_{\text{mes};m}(\lambda)$
477	0.278 181 039 9
478	0.285 599 571 9
479	0.293 144 386 0
480	0.300 784 803 4
481	0.308 504 771 2
482	0.316 346 472 8
483	0.324 143 315 8
484	0.332 397 841 8
485	0.340 720 592 2
486	0.349 365 111 9
487	0.358 341 300 3
488	0.367 674 574 2
489	0.377 167 573 4
490	0.387 068 581 1
491	0.397 413 627 0
492	0.407 994 738 3
493	0.419 028 895 0
494	0.430 510 300 5
495	0.442 209 934 9
496	0.454 325 247 5
497	0.466 685 008 5
498	0.479 399 357 9
499	0.492 801 212 9
500	0.507 000 802 6
501	0.521 628 556 1
502	0.537 042 539 9
503	0.553 106 751 1
504	0.569 461 785 4
505	0.585 748 684 6
506	0.602 541 603 5
507	0.619 200 570 8
508	0.636 220 815 1
509	0.653 205 654 2
510	0.670 873 093 7
511	0.688 548 381 3
512	0.706 333 719 8
513	0.724 328 904 0
514	0.742 187 906 9
515	0.759 787 746 4
516	0.777 085 169 0
517	0.794 218 139 7
518	0.810 777 847 1

λ/nm	$V_{\text{mes};m}(\lambda)$
519	0.826 578 435 7
520	0.841 657 005 3
521	0.855 645 411 6
522	0.868 825 113 7
523	0.881 092 838 7
524	0.892 568 269 0
525	0.903 594 042 6
526	0.913 993 043 8
527	0.923 924 195 1
528	0.933 119 415 0
529	0.941 756 532 6
530	0.949 567 466 3
531	0.956 756 265 0
532	0.963 357 174 7
533	0.969 181 842 5
534	0.974 487 826 6
535	0.979 309 819 0
536	0.983 666 1018
537	0.987 329 349 9
538	0.990 522 251 0
539	0.993 467 582 3
540	0.995 719 254 4
541	0.997 508 338 5
542	0.998 847 230 9
543	0.999 741 906 7
544	0.999 975 474 9
545	1.000 000 000 0
546	0.999 814 857 8
547	0.998 990 635 9
548	0.997 781 860 3
549	0.996 220 101 7
550	0.994 559 975 0
551	0.992 562 918 0
552	0.990 010 077 6
553	0.987 569 785 1
554	0.984 569 874 3
555	0.981 450 102 6
556	0.977 844 198 7
557	0.974 029 786 9
558	0.969 901 453 7
559	0.965 463 034 0
560	0.960 670 650 1

λ/nm	$V_{\text{mes};m}(\lambda)$
561	0.955 476 232 9
562	0.949 962 186 7
563	0.944 122 358 0
564	0.937 995 273 3
565	0.931 574 957 6
566	0.924 871 756 0
567	0.917 904 396 7
568	0.910 667 796 3
569	0.903 134 665 1
570	0.895 300 098 1
571	0.887 184 874 7
572	0.878 800 677 8
573	0.870 162 133 2
574	0.861 239 275 8
575	0.852 091 322 6
576	0.842 710 603 8
577	0.833 119 771 7
578	0.823 289 753 0
579	0.813 236 065 3
580	0.802 907 339 7
581	0.792 327 031 1
582	0.781 541 068 4
583	0.770 531 525 9
584	0.759 369 749 4
585	0.748 037 991 6
586	0.736 573 352 4
587	0.724 968 340 3
588	0.713 294 390 4
589	0.701 533 666 3
590	0.689 712 833 3
591	0.677 855 257 3
592	0.665 988 049 6
593	0.654 087 755 3
594	0.642 153 304 2
595	0.630 183 715 3
596	0.618 183 537 0
597	0.606 168 376 0
598	0.594 144 653 5
599	0.582 127 708 9
600	0.570 130 651 9
601	0.558 167 305 8
602	0.546 240 435 2

λ/nm	$V_{\mathrm{mes};m}(\lambda)$
603	0.534 344 600 0
604	0.522 478 730 0
605	0.510 639 436 4
606	0.498 821 546 4
607	0.487 043 788 5
608	0.475 323 553 0
609	0.463 682 600 6
610	0.452 138 143 2
611	0.440 703 915 1
612	0.429 370 284 5
613	0.418 130 830 3
614	0.406 974 672 3
615	0.395 897 618 8
616	0.384 908 142 3
617	0.373 999 821 6
618	0.363 138 321 6
619	0.352 291 536 6
620	0.341 427 361 1
621	0.330 530 099 0
622	0.319 630 964 1
623	0.308 777 133 7
624	0.298 013 555 7
625	0.287 382 948 4
626	0.276 897 886 4
627	0.266 574 868 5
628	0.256 462 900 2
629	0.246 613 528 9
630	0.237 076 384 6
631	0.227 889 904 6
632	0.219 031 570 5
633	0.210 461 205 7
634	0.202 138 633 7
635	0.194 023 677 9
636	0.186 102 827 1
637	0.178 386 292 7
638	0.170 868 144 1
639	0.163 542 004 8
640	0.156 402 613 0
641	0.149 441 719 4
642	0.142 660 661 7
643	0.136 067 154 2
644	0.129 669 044 9

λ/nm	$V_{\mathrm{mes};m}(\lambda)$
645	0.123 473 869 6
646	0.117 481 762 2
647	0.111 690 939 1
648	0.106 106 483 5
649	0.100 733 166 9
650	0.095 575 894 1
651	0.090 638 277 0
652	0.085 912 235 8
653	0.081 384 963 9
654	0.077 043 476 3
655	0.072 875 011 1
656	0.068 872 638 9
657	0.065 035 133 3
658	0.061 358 427 7
659	0.057 838 388 5
660	0.054 470 904 3
661	0.051 251 881 7
662	0.048 178 244 0
663	0.045 247 556 4
664	0.042 457 393 2
665	0.039 805 270 7
666	0.037 285 735 3
667	0.034 898 029 1
668	0.032 646 695 8
669	0.030 536 257 0
670	0.028 571 301 2
671	0.026 751 970 9
672	0.025 067 836 4
673	0.023 507 567 1
674	0.022 059 796 7
675	0.020 713 145 5
676	0.019 463 676 1
677	0.018 303 148 1
678	0.017 213 707 3
679	0.016 177 575 1
680	0.015 176 915 2
681	0.014 198 198 5
682	0.013 245 946 7
683	0.012 329 555 0
684	0.011 458 334 1
685	0.010 641 688 2
686	0.009 881 374 3

λ/nm	$V_{\mathrm{mes};m}(\lambda)$
687	0.009 171 756 0
688	0.008 511 067 5
689	0.007 897 647 8
690	0.007 329 735 6
691	0.006 806 401 1
692	0.006 325 789 3
693	0.005 884 825 6
694	0.005 480 413 4
695	0.005 109 473 4
696	0.004 770 266 7
697	0.004 460 229 2
698	0.004 175 060 2
699	0.003 910 499 0
700	0.003 662 222 4
701	0.003 426 924 1
702	0.003 204 307 5
703	0.002 994 608 9
704	0.002 798 082 6
705	0.002 614 984 8
706	0.002 444 588 9
707	0.002 285 441 0
708	0.002 136 669 5
709	0.001 997 431 6
710	0.001 866 837 6
711	0.001 744 163 0
712	0.001 628 988 7
713	0.001 520 964 5
714	0.001 419 736 0
715	0.001 324 935 3
716	0.001 236 105 4
717	0.001 152 876 1
718	0.001 075 046 8
719	0.001 002 421 3
720	0.000 934 803 4
721	0.000 871 945 5
722	0.000 813 486 6
723	0.000 759 045 5
724	0.000 708 255 8
725	0.000 660 724 6
726	0.000 616 157 6
727	0.000 574 402 5
728	0.000 535 290 3

λ/nm	$V_{mes;m}(\lambda)$
729	0.000 498 642 2
730	0.000 464 315 1
731	0.000 432 095 1
732	0.000 401 866 1
733	0.000 373 565 3
734	0.000 347 112 5
735	0.000 322 453 8
736	0.000 299 491 4
737	0.000 278 118 0
738	0.000 258 235 3
739	0.000 239 736 5
740	0.000 222 549 5
741	0.000 206 568 0
742	0.000 191 737 9
743	0.000 177 987 8
744	0.000 165 273 3
745	0.000 153 532 1
746	0.000 142 709 8
747	0.000 132 727 0
748	0.000 123 529 6
749	0.000 115 037 5
750	0.000 107 188 1
751	0.000 099 918 8
752	0.000 093 185 4
753	0.000 086 948 4
754	0.000 081 152 5
755	0.000 075 752 9
756	0.000 070 704 3
757	0.000 065 980 8
758	0.000 061 567 2
759	0.000 057 447 2
760	0.000 053 604 1
761	0.000 050 015 4
762	0.000 046 660 8
763	0.000 043 527 6
764	0.000 040 606 0
765	0.000 037 884 5
766	0.000 035 348 7
767	0.000 032 985 3
768	0.000 030 782 6
769	0.000 028 727 2
770	0.000 026 808 5

λ/nm	$V_{mes;m}(\lambda)$
771	0.000 025 013 9
772	0.000 023 337 2
773	0.000 021 770 3
774	0.000 020 309 7
775	0.000 018 947 4
776	0.000 017 677 9
777	0.000 016 493 3
778	0.000 015 389 1
779	0.000 014 359 9
780	0.000 013 399 4
781	0.000 012 473 9
782	0.000 011 640 1
783	0.000 010 860 6
784	0.000 010 133 8
785	0.000 009 453 3
786	0.000 008 816 5
787	0.000 008 220 2
788	0.000 007 662 9
789	0.000 007 142 7
790	0.000 006 658 1
791	0.000 006 206 7
792	0.000 005 786 1
793	0.000 005 394 4
794	0.000 005 029 3
795	0.000 004 689 0
796	0.000 004 371 5
797	0.000 004 075 4
798	0.000 003 799 3
799	0.000 003 542 0
800	0.000 003 302 3
801	0.000 003 078 7
802	0.000 002 870 2
803	0.000 002 675 7
804	0.000 002 494 5
805	0.000 002 325 7
806	0.000 002 168 2
807	0.000 002 021 3
808	0.000 001 884 4
809	0.000 001 756 8
810	0.000 001 637 9
811	0.000 001 527 0
812	0.000 001 423 5

λ/nm	$V_{mes;m}(\lambda)$
813	0.000 001 327 1
814	0.000 001 237 2
815	0.000 001 153 5
816	0.000 001 075 4
817	0.000 001 002 5
818	0.000 000 934 6
819	0.000 000 871 4
820	0.000 000 812 4
821	0.000 000 757 4
822	0.000 000 706 1
823	0.000 000 658 2
824	0.000 000 613 7
825	0.000 000 572 1
826	0.000 000 533 4
827	0.000 000 497 3
828	0.000 000 463 6
829	0.000 000 432 2
830	0.000 000 402 9

Table 4 – Values of maximum luminous efficacy for mesopic vision, $K_{\mathrm{m,mes};m}$, at varied m values (for other m values use Eq. (8))

m	$K_{\mathrm{m,mes};m}$
0	1700.13
0.1	1402.22
0.2	1181.84
0.3	1020.44
0.4	902.64
0.5	816.88
0.6	757.24
0.7	718.49
0.8	695.95
0.9	685.46
1.0	683.00

Table 5 – Values of spectral luminous efficiency for 10° photopic vision, $V_{10}(\lambda)$ (λ in standard air)

λ/nm	$V_{10}(\lambda)$	λ/nm	$V_{10}(\lambda)$	λ/nm	$V_{10}(\lambda)$
360	0.000 000 013 398	402	0.002 822 000 000	444	0.072 218 000 000
361	0.000 000 020 294	403	0.003 319 000 000	445	0.074 704 000 000
362	0.000 000 030 560	404	0.003 880 000 000	446	0.077 272 000 000
363	0.000 000 045 740	405	0.004 509 000 000	447	0.079 979 000 000
364	0.000 000 068 050	406	0.005 209 000 000	448	0.082 874 000 000
365	0.000 000 100 650	407	0.005 985 000 000	449	0.086 000 000 000
366	0.000 000 147 980	408	0.006 833 000 000	450	0.089 456 000 000
367	0.000 000 216 270	409	0.007 757 000 000	451	0.092 947 000 000
368	0.000 000 314 200	410	0.008 756 000 000	452	0.096 275 000 000
369	0.000 000 453 700	411	0.009 816 000 000	453	0.099 535 000 000
370	0.000 000 651 100	412	0.010 918 000 000	454	0.102 829 000 000
371	0.000 000 928 800	413	0.012 058 000 000	455	0.106 256 000 000
372	0.000 001 317 500	414	0.013 237 000 000	456	0.109 901 000 000
373	0.000 001 857 200	415	0.014 456 000 000	457	0.113 835 000 000
374	0.000 002 602 000	416	0.015 717 000 000	458	0.118 167 000 000
375	0.000 003 625 000	417	0.017 025 000 000	459	0.122 932 000 000
376	0.000 005 019 000	418	0.018 399 000 000	460	0.128 201 000 000
377	0.000 006 907 000	419	0.019 848 000 000	461	0.133 457 000 000
378	0.000 009 449 000	420	0.021 391 000 000	462	0.138 323 000 000
379	0.000 012 848 000	421	0.022 992 000 000	463	0.143 042 000 000
380	0.000 017 364 000	422	0.024 598 000 000	464	0.147 787 000 000
381	0.000 023 327 000	423	0.026 213 000 000	465	0.152 761 000 000
382	0.000 031 150 000	424	0.027 841 000 000	466	0.158 102 000 000
383	0.000 041 350 000	425	0.029 497 000 000	467	0.163 941 000 000
384	0.000 054 560 000	426	0.031 195 000 000	468	0.170 362 000 000
385	0.000 071 560 000	427	0.032 927 000 000	469	0.177 425 000 000
386	0.000 093 300 000	428	0.034 738 000 000	470	0.185 190 000 000
387	0.000 120 870 000	429	0.036 654 000 000	471	0.193 025 000 000
388	0.000 155 640 000	430	0.038 676 000 000	472	0.200 313 000 000
389	0.000 199 200 000	431	0.040 792 000 000	473	0.207 156 000 000
390	0.000 253 400 000	432	0.042 946 000 000	474	0.213 644 000 000
391	0.000 320 200 000	433	0.045 114 000 000	475	0.219 940 000 000
392	0.000 402 400 000	434	0.047 333 000 000	476	0.226 170 000 000
393	0.000 502 300 000	435	0.049 602 000 000	477	0.232 467 000 000
394	0.000 623 200 000	436	0.051 934 000 000	478	0.239 025 000 000
395	0.000 768 500 000	437	0.054 337 000 000	479	0.245 997 000 000
396	0.000 941 700 000	438	0.056 822 000 000	480	0.253 589 000 000
397	0.001 147 800 000	439	0.059 399 000 000	481	0.261 876 000 000
398	0.001 390 300 000	440	0.062 077 000 000	482	0.270 643 000 000
399	0.001 674 000 000	441	0.064 737 000 000	483	0.279 645 000 000
400	0.002 004 400 000	442	0.067 285 000 000	484	0.288 694 000 000
401	0.002 386 000 000	443	0.069 764 000 000	485	0.297 665 000 000

λ/nm	$V_{10}(\lambda)$	λ/nm	$V_{10}(\lambda)$	λ/nm	$V_{10}(\lambda)$
486	0.306 469 000 000	531	0.885 370 000 000	576	0.905 954 000 000
487	0.315 035 000 000	532	0.895 370 000 000	577	0.896 608 000 000
488	0.323 335 000 000	533	0.905 150 000 000	578	0.887 249 000 000
489	0.331 366 000 000	534	0.914 650 000 000	579	0.877 986 000 000
490	0.339 133 000 000	535	0.923 810 000 000	580	0.868 934 000 000
491	0.347 860 000 000	536	0.932 550 000 000	581	0.860 164 000 000
492	0.358 326 000 000	537	0.940 810 000 000	582	0.851 519 000 000
493	0.370 001 000 000	538	0.948 520 000 000	583	0.842 963 000 000
494	0.382 464 000 000	539	0.955 600 000 000	584	0.834 393 000 000
495	0.395 379 000 000	540	0.961 988 000 000	585	0.825 623 000 000
496	0.408 482 000 000	541	0.967 540 000 000	586	0.816 764 000 000
497	0.421 588 000 000	542	0.972 230 000 000	587	0.807 544 000 000
498	0.434 619 000 000	543	0.976 170 000 000	588	0.797 947 000 000
499	0.447 601 000 000	544	0.979 460 000 000	589	0.787 893 000 000
500	0.460 777 000 000	545	0.982 200 000 000	590	0.777 405 000 000
501	0.474 340 000 000	546	0.984 520 000 000	591	0.766 490 000 000
502	0.488 200 000 000	547	0.986 520 000 000	592	0.755 309 000 000
503	0.502 340 000 000	548	0.988 320 000 000	593	0.743 845 000 000
504	0.516 740 000 000	549	0.990 020 000 000	594	0.732 190 000 000
505	0.531 360 000 000	550	0.991 761 000 000	595	0.720 353 000 000
506	0.546 190 000 000	551	0.993 530 000 000	596	0.708 281 000 000
507	0.561 180 000 000	552	0.995 230 000 000	597	0.696 055 000 000
508	0.576 290 000 000	553	0.996 770 000 000	598	0.683 621 000 000
509	0.591 500 000 000	554	0.998 090 000 000	599	0.671 048 000 000
510	0.606 741 000 000	555	0.999 110 000 000	600	0.658 341 000 000
511	0.622 150 000 000	556	0.999 770 000 000	601	0.645 545 000 000
512	0.637 830 000 000	557	1.000 000 000 000	602	0.632 718 000 000
513	0.653 710 000 000	558	0.999 710 000 000	603	0.619 815 000 000
514	0.669 680 000 000	559	0.998 850 000 000	604	0.606 887 000 000
515	0.685 660 000 000	560	0.997 340 000 000	605	0.593 878 000 000
516	0.701 550 000 000	561	0.995 260 000 000	606	0.580 781 000 000
517	0.717 230 000 000	562	0.992 740 000 000	607	0.567 653 000 000
518	0.732 570 000 000	563	0.989 750 000 000	608	0.554 490 000 000
519	0.747 460 000 000	564	0.986 300 000 000	609	0.541 228 000 000
520	0.761 757 000 000	565	0.982 380 000 000	610	0.527 963 000 000
521	0.775 340 000 000	566	0.977 980 000 000	611	0.514 634 000 000
522	0.788 220 000 000	567	0.973 110 000 000	612	0.501 363 000 000
523	0.800 460 000 000	568	0.967 740 000 000	613	0.488 124 000 000
524	0.812 140 000 000	569	0.961 890 000 000	614	0.474 935 000 000
525	0.823 330 000 000	570	0.955 552 000 000	615	0.461 834 000 000
526	0.834 120 000 000	571	0.948 601 000 000	616	0.448 823 000 000
527	0.844 600 000 000	572	0.940 981 000 000	617	0.435 917 000 000
528	0.854 870 000 000	573	0.932 798 000 000	618	0.423 153 000 000
529	0.865 040 000 000	574	0.924 158 000 000	619	0.410 526 000 000
530	0.875 211 000 000	575	0.915 175 000 000	620	0.398 057 000 000

λ/nm	$V_{10}(\lambda)$
621	0.385 835 000 000
622	0.373 951 000 000
623	0.362 311 000 000
624	0.350 863 000 000
625	0.339 554 000 000
626	0.328 309 000 000
627	0.317 118 000 000
628	0.305 936 000 000
629	0.294 737 000 000
630	0.283 493 000 000
631	0.272 222 000 000
632	0.260 990 000 000
633	0.249 877 000 000
634	0.238 946 000 000
635	0.228 254 000 000
636	0.217 853 000 000
637	0.207 780 000 000
638	0.198 072 000 000
639	0.188 748 000 000
640	0.179 828 000 000
641	0.171 285 000 000
642	0.163 059 000 000
643	0.155 151 000 000
644	0.147 535 000 000
645	0.140 211 000 000
646	0.133 170 000 000
647	0.126 400 000 000
648	0.119 892 000 000
649	0.113 640 000 000
650	0.107 633 000 000
651	0.101 870 000 000
652	0.096 347 000 000
653	0.091 063 000 000
654	0.086 010 000 000
655	0.081 187 000 000
656	0.076 583 000 000
657	0.072 198 000 000
658	0.068 024 000 000
659	0.064 052 000 000
660	0.060 281 000 000
661	0.056 697 000 000
662	0.053 292 000 000
663	0.050 059 000 000
664	0.046 998 000 000
665	0.044 096 000 000
666	0.041 345 000 000
667	0.038 750 700 000
668	0.036 297 800 000
669	0.033 983 200 000
670	0.031 800 400 000
671	0.029 739 500 000
672	0.027 791 800 000
673	0.025 955 100 000
674	0.024 226 300 000
675	0.022 601 700 000
676	0.021 077 900 000
677	0.019 650 500 000
678	0.018 315 300 000
679	0.017 068 600 000
680	0.015 905 100 000
681	0.014 818 300 000
682	0.013 800 800 000
683	0.012 849 500 000
684	0.011 960 700 000
685	0.011 130 300 000
686	0.010 355 500 000
687	0.009 633 200 000
688	0.008 959 900 000
689	0.008 332 400 000
690	0.007 748 800 000
691	0.007 204 600 000
692	0.006 697 500 000
693	0.006 225 100 000
694	0.005 785 000 000
695	0.005 375 100 000
696	0.004 994 100 000
697	0.004 639 200 000
698	0.004 309 300 000
699	0.004 002 800 000
700	0.003 717 740 000
701	0.003 452 620 000
702	0.003 205 830 000
703	0.002 976 230 000
704	0.002 762 810 000
705	0.002 564 560 000
706	0.002 380 480 000
707	0.002 209 710 000
708	0.002 051 320 000
709	0.001 904 490 000
710	0.001 768 470 000
711	0.001 642 360 000
712	0.001 525 350 000
713	0.001 416 720 000
714	0.001 315 950 000
715	0.001 222 390 000
716	0.001 135 550 000
717	0.001 054 940 000
718	0.000 980 140 000
719	0.000 910 660 000
720	0.000 846 190 000
721	0.000 786 290 000
722	0.000 730 680 000
723	0.000 678 990 000
724	0.000 631 010 000
725	0.000 586 440 000
726	0.000 545 110 000
727	0.000 506 720 000
728	0.000 471 110 000
729	0.000 438 050 000
730	0.000 407 410 000
731	0.000 378 962 000
732	0.000 352 543 000
733	0.000 328 001 000
734	0.000 305 208 000
735	0.000 284 041 000
736	0.000 264 375 000
737	0.000 246 109 000
738	0.000 229 143 000
739	0.000 213 376 000
740	0.000 198 730 000
741	0.000 185 115 000
742	0.000 172 454 000
743	0.000 160 678 000
744	0.000 149 730 000
745	0.000 139 550 000
746	0.000 130 086 000
747	0.000 121 290 000
748	0.000 113 106 000
749	0.000 105 501 000
750	0.000 098 428 000
751	0.000 091 853 000
752	0.000 085 738 000
753	0.000 080 048 000
754	0.000 074 751 000
755	0.000 069 819 000

λ/nm	$V_{10}(\lambda)$
756	0.000 065 222 000
757	0.000 060 939 000
758	0.000 056 942 000
759	0.000 053 217 000
760	0.000 049 737 000
761	0.000 046 491 000
762	0.000 043 464 000
763	0.000 040 635 000
764	0.000 038 000 000
765	0.000 035 540 500
766	0.000 033 244 800
767	0.000 031 100 600
768	0.000 029 099 000
769	0.000 027 230 700
770	0.000 025 486 000
771	0.000 023 856 100
772	0.000 022 333 200
773	0.000 020 910 400
774	0.000 019 580 800
775	0.000 018 338 400
776	0.000 017 177 700
777	0.000 016 093 400
778	0.000 015 080 000
779	0.000 014 133 600
780	0.000 013 249 000
781	0.000 012 422 600
782	0.000 011 649 900
783	0.000 010 927 700
784	0.000 010 251 900
785	0.000 009 619 600
786	0.000 009 028 100
787	0.000 008 474 000
788	0.000 007 954 800
789	0.000 007 468 600
790	0.000 007 012 800
791	0.000 006 585 800
792	0.000 006 185 700
793	0.000 005 810 700
794	0.000 005 459 000
795	0.000 005 129 800
796	0.000 004 820 600
797	0.000 004 531 200
798	0.000 004 259 100
799	0.000 004 004 200
800	0.000 003 764 730

λ/nm	$V_{10}(\lambda)$
801	0.000 003 539 950
802	0.000 003 329 140
803	0.000 003 131 150
804	0.000 002 945 290
805	0.000 002 770 810
806	0.000 002 607 050
807	0.000 002 453 290
808	0.000 002 308 940
809	0.000 002 173 380
810	0.000 002 046 130
811	0.000 001 926 620
812	0.000 001 814 400
813	0.000 001 708 950
814	0.000 001 609 880
815	0.000 001 516 770
816	0.000 001 429 210
817	0.000 001 346 860
818	0.000 001 269 450
819	0.000 001 196 620
820	0.000 001 128 090
821	0.000 001 063 680
822	0.000 001 003 130
823	0.000 000 946 220
824	0.000 000 892 630
825	0.000 000 842 160
826	0.000 000 794 640
827	0.000 000 749 780
828	0.000 000 707 440
829	0.000 000 667 480
830	0.000 000 629 700

Table 6 – CIE 1931 colour-matching functions and chromaticity coordinates

λ/nm	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$	$x(\lambda)$	$y(\lambda)$	$z(\lambda)$
360	0.000 129 900 000	0.000 003 917 000 0	0.000 606 100 000	0.175 56	0.005 29	0.819 15
361	0.000 145 847 000	0.000 004 393 581 0	0.000 680 879 200	0.175 48	0.005 29	0.819 23
362	0.000 163 802 100	0.000 004 929 604 0	0.000 765 145 600	0.175 40	0.005 28	0.819 32
363	0.000 184 003 700	0.000 005 532 136 0	0.000 860 012 400	0.175 32	0.005 27	0.819 41
364	0.000 206 690 200	0.000 006 208 245 0	0.000 966 592 800	0.175 24	0.005 26	0.819 50
365	0.000 232 100 000	0.000 006 965 000 0	0.001 086 000 000	0.175 16	0.005 26	0.819 58
366	0.000 260 728 000	0.000 007 813 219 0	0.001 220 586 000	0.175 09	0.005 25	0.819 66
367	0.000 293 075 000	0.000 008 767 336 0	0.001 372 729 000	0.175 01	0.005 24	0.819 75
368	0.000 329 388 000	0.000 009 839 844 0	0.001 543 579 000	0.174 94	0.005 23	0.819 83
369	0.000 369 914 000	0.000 011 043 230 0	0.001 734 286 000	0.174 88	0.005 22	0.819 90
370	0.000 414 900 000	0.000 012 390 000 0	0.001 946 000 000	0.174 82	0.005 22	0.819 96
371	0.000 464 158 700	0.000 013 886 410 0	0.002 177 777 000	0.174 77	0.005 23	0.820 00
372	0.000 518 986 000	0.000 015 557 280 0	0.002 435 809 000	0.174 72	0.005 24	0.820 04
373	0.000 581 854 000	0.000 017 442 960 0	0.002 731 953 000	0.174 66	0.005 24	0.820 10
374	0.000 655 234 700	0.000 019 583 750 0	0.003 078 064 000	0.174 59	0.005 22	0.820 19
375	0.000 741 600 000	0.000 022 020 000 0	0.003 486 000 000	0.174 51	0.005 18	0.820 31
376	0.000 845 029 600	0.000 024 839 650 0	0.003 975 227 000	0.174 41	0.005 13	0.820 46
377	0.000 964 526 800	0.000 028 041 260 0	0.004 540 880 000	0.174 31	0.005 07	0.820 62
378	0.001 094 949 000	0.000 031 531 040 0	0.005 158 320 000	0.174 22	0.005 02	0.820 76
379	0.001 231 154 000	0.000 035 215 210 0	0.005 802 907 000	0.174 16	0.004 98	0.820 86
380	0.001 368 000 000	0.000 039 000 000 0	0.006 450 001 000	0.174 11	0.004 96	0.820 93
381	0.001 502 050 000	0.000 042 826 400 0	0.007 083 216 000	0.174 09	0.004 96	0.820 95
382	0.001 642 328 000	0.000 046 914 600 0	0.007 745 488 000	0.174 07	0.004 97	0.820 96
383	0.001 802 382 000	0.000 051 589 600 0	0.008 501 152 000	0.174 06	0.004 98	0.820 96
384	0.001 995 757 000	0.000 057 176 400 0	0.009 414 544 000	0.174 04	0.004 98	0.820 98
385	0.002 236 000 000	0.000 064 000 000 0	0.010 549 990 000	0.174 01	0.004 98	0.821 01
386	0.002 535 385 000	0.000 072 344 210 0	0.011 965 800 000	0.173 97	0.004 97	0.821 06
387	0.002 892 603 000	0.000 082 212 240 0	0.013 655 870 000	0.173 93	0.004 94	0.821 13
388	0.003 300 829 000	0.000 093 508 160 0	0.015 588 050 000	0.173 89	0.004 93	0.821 18
389	0.003 753 236 000	0.000 106 136 100 0	0.017 730 150 000	0.173 84	0.004 92	0.821 24
390	0.004 243 000 000	0.000 120 000 000 0	0.020 050 010 000	0.173 80	0.004 92	0.821 28
391	0.004 762 389 000	0.000 134 984 000 0	0.022 511 360 000	0.173 76	0.004 92	0.821 32
392	0.005 330 048 000	0.000 151 492 000 0	0.025 202 880 000	0.173 70	0.004 94	0.821 36
393	0.005 978 712 000	0.000 170 208 000 0	0.028 279 720 000	0.173 66	0.004 94	0.821 40
394	0.006 741 117 000	0.000 191 816 000 0	0.031 897 040 000	0.173 61	0.004 94	0.821 45
395	0.007 650 000 000	0.000 217 000 000 0	0.036 210 000 000	0.173 56	0.004 92	0.821 52
396	0.008 751 373 000	0.000 246 906 700 0	0.041 437 710 000	0.173 51	0.004 90	0.821 59
397	0.010 028 880 000	0.000 281 240 000 0	0.047 503 720 000	0.173 47	0.004 86	0.821 67
398	0.011 421 700 000	0.000 318 520 000 0	0.054 119 880 000	0.173 42	0.004 84	0.821 74
399	0.012 869 010 000	0.000 357 266 700 0	0.060 998 030 000	0.173 38	0.004 81	0.821 81
400	0.014 310 000 000	0.000 396 000 000 0	0.067 850 010 000	0.173 34	0.004 80	0.821 86
401	0.015 704 430 000	0.000 433 714 700 0	0.074 486 320 000	0.173 29	0.004 79	0.821 92
402	0.017 147 440 000	0.000 473 024 000 0	0.081 361 560 000	0.173 24	0.004 78	0.821 98
403	0.018 781 220 000	0.000 517 876 000 0	0.089 153 640 000	0.173 17	0.004 78	0.822 05
404	0.020 748 010 000	0.000 572 218 700 0	0.098 540 480 000	0.173 10	0.004 77	0.822 13
405	0.023 190 000 000	0.000 640 000 000 0	0.110 200 000 000	0.173 02	0.004 78	0.822 20
406	0.026 207 360 000	0.000 724 560 000 0	0.124 613 300 000	0.172 93	0.004 78	0.822 29
407	0.029 782 480 000	0.000 825 500 000 0	0.141 701 700 000	0.172 84	0.004 79	0.822 37

λ/nm	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$	$x(\lambda)$	$y(\lambda)$	$z(\lambda)$
408	0.033 880 920 000	0.000 941 160 000 0	0.161 303 500 000	0.172 75	0.004 80	0.822 45
409	0.038 468 240 000	0.001 069 880 000 0	0.183 256 800 000	0.172 66	0.004 80	0.822 54
410	0.043 510 000 000	0.001 210 000 000 0	0.207 400 000 000	0.172 58	0.004 80	0.822 62
411	0.048 995 600 000	0.001 362 091 000 0	0.233 692 100 000	0.172 49	0.004 80	0.822 71
412	0.055 022 600 000	0.001 530 752 000 0	0.262 611 400 000	0.172 39	0.004 80	0.822 81
413	0.061 718 800 000	0.001 720 368 000 0	0.294 774 600 000	0.172 30	0.004 80	0.822 90
414	0.069 212 000 000	0.001 935 323 000 0	0.330 798 500 000	0.172 19	0.004 82	0.822 99
415	0.077 630 000 000	0.002 180 000 000 0	0.371 300 000 000	0.172 09	0.004 83	0.823 08
416	0.086 958 110 000	0.002 454 800 000 0	0.416 209 100 000	0.171 98	0.004 86	0.823 16
417	0.097 176 720 000	0.002 764 000 000 0	0.465 464 200 000	0.171 87	0.004 89	0.823 24
418	0.108 406 300 000	0.003 117 800 000 0	0.519 694 800 000	0.171 74	0.004 94	0.823 32
419	0.120 767 200 000	0.003 526 400 000 0	0.579 530 300 000	0.171 59	0.005 01	0.823 40
420	0.134 380 000 000	0.004 000 000 000 0	0.645 600 000 000	0.171 41	0.005 10	0.823 49
421	0.149 358 200 000	0.004 546 240 000 0	0.718 483 800 000	0.171 21	0.005 21	0.823 58
422	0.165 395 700 000	0.005 159 320 000 0	0.796 713 300 000	0.170 99	0.005 33	0.823 68
423	0.181 983 100 000	0.005 829 280 000 0	0.877 845 900 000	0.170 77	0.005 47	0.823 76
424	0.198 611 000 000	0.006 546 160 000 0	0.959 439 000 000	0.170 54	0.005 62	0.823 84
425	0.214 770 000 000	0.007 300 000 000 0	1.039 050 100 000	0.170 30	0.005 79	0.823 91
426	0.230 186 800 000	0.008 086 507 000 0	1.115 367 300 000	0.170 05	0.005 97	0.823 98
427	0.244 879 700 000	0.008 908 720 000 0	1.188 497 100 000	0.169 78	0.006 18	0.824 04
428	0.258 777 300 000	0.009 767 680 000 0	1.258 123 300 000	0.169 50	0.006 40	0.824 10
429	0.271 807 900 000	0.010 664 430 000 0	1.323 929 600 000	0.169 20	0.006 64	0.824 16
430	0.283 900 000 000	0.011 600 000 000 0	1.385 600 000 000	0.168 88	0.006 90	0.824 22
431	0.294 943 800 000	0.012 573 170 000 0	1.442 635 200 000	0.168 53	0.007 18	0.824 29
432	0.304 896 500 000	0.013 582 720 000 0	1.494 803 500 000	0.168 15	0.007 49	0.824 36
433	0.313 787 300 000	0.014 629 680 000 0	1.542 190 300 000	0.167 75	0.007 82	0.824 43
434	0.321 645 400 000	0.015 715 090 000 0	1.584 880 700 000	0.167 33	0.008 17	0.824 50
435	0.328 500 000 000	0.016 840 000 000 0	1.622 960 000 000	0.166 90	0.008 55	0.824 55
436	0.334 351 300 000	0.018 007 360 000 0	1.656 404 800 000	0.166 45	0.008 96	0.824 59
437	0.339 210 100 000	0.019 214 480 000 0	1.685 295 900 000	0.165 98	0.009 40	0.824 62
438	0.343 121 300 000	0.020 453 920 000 0	1.709 874 500 000	0.165 48	0.009 87	0.824 65
439	0.346 129 600 000	0.021 718 240 000 0	1.730 382 100 000	0.164 96	0.010 35	0.824 69
440	0.348 280 000 000	0.023 000 000 000 0	1.747 060 000 000	0.164 41	0.010 86	0.824 73
441	0.349 599 900 000	0.024 294 610 000 0	1.760 044 600 000	0.163 83	0.011 38	0.824 79
442	0.350 147 400 000	0.025 610 240 000 0	1.769 623 300 000	0.163 21	0.011 94	0.824 85
443	0.350 013 000 000	0.026 958 570 000 0	1.776 263 700 000	0.162 55	0.012 52	0.824 93
444	0.349 287 000 000	0.028 351 250 000 0	1.780 433 400 000	0.161 85	0.013 14	0.825 01
445	0.348 060 000 000	0.029 800 000 000 0	1.782 600 000 000	0.161 11	0.013 79	0.825 10
446	0.346 373 300 000	0.031 310 830 000 0	1.782 968 200 000	0.160 31	0.014 49	0.825 20
447	0.344 262 400 000	0.032 883 680 000 0	1.781 699 800 000	0.159 47	0.015 23	0.825 30
448	0.341 808 800 000	0.034 521 120 000 0	1.779 198 200 000	0.158 57	0.016 02	0.825 41
449	0.339 094 100 000	0.036 225 710 000 0	1.775 867 100 000	0.157 63	0.016 84	0.825 53
450	0.336 200 000 000	0.038 000 000 000 0	1.772 110 000 000	0.156 64	0.017 71	0.825 65
451	0.333 197 700 000	0.039 846 670 000 0	1.768 258 900 000	0.155 60	0.018 61	0.825 79
452	0.330 041 100 000	0.041 768 000 000 0	1.764 039 000 000	0.154 52	0.019 56	0.825 92
453	0.326 635 700 000	0.043 766 000 000 0	1.758 943 800 000	0.153 40	0.020 55	0.826 05
454	0.322 886 800 000	0.045 842 670 000 0	1.752 466 300 000	0.152 22	0.021 61	0.826 17
455	0.318 700 000 000	0.048 000 000 000 0	1.744 100 000 000	0.150 99	0.022 74	0.826 27
456	0.314 025 100 000	0.050 243 680 000 0	1.733 559 500 000	0.149 69	0.023 95	0.826 36
457	0.308 884 000 000	0.052 573 040 000 0	1.720 858 100 000	0.148 34	0.025 25	0.826 41

λ/nm	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$	$x(\lambda)$	$y(\lambda)$	$z(\lambda)$
458	0.303 290 400 000	0.054 980 560 000 0	1.705 936 900 000	0.146 93	0.026 63	0.826 44
459	0.297 257 900 000	0.057 458 720 000 0	1.688 737 200 000	0.145 47	0.028 12	0.826 41
460	0.290 800 000 000	0.060 000 000 000 0	1.669 200 000 000	0.143 96	0.029 70	0.826 34
461	0.283 970 100 000	0.062 601 970 000 0	1.647 528 700 000	0.142 41	0.031 39	0.826 20
462	0.276 721 400 000	0.065 277 520 000 0	1.623 412 700 000	0.140 80	0.033 21	0.825 99
463	0.268 917 800 000	0.068 042 080 000 0	1.596 022 300 000	0.139 12	0.035 20	0.825 68
464	0.260 422 700 000	0.070 911 090 000 0	1.564 528 000 000	0.137 37	0.037 40	0.825 23
465	0.251 100 000 000	0.073 900 000 000 0	1.528 100 000 000	0.135 50	0.039 88	0.824 62
466	0.240 847 500 000	0.077 016 000 000 0	1.486 111 400 000	0.133 51	0.042 69	0.823 80
467	0.229 851 200 000	0.080 266 400 000 0	1.439 521 500 000	0.131 37	0.045 88	0.822 75
468	0.218 407 200 000	0.083 666 800 000 0	1.389 879 900 000	0.129 09	0.049 45	0.821 46
469	0.206 811 500 000	0.087 232 800 000 0	1.338 736 200 000	0.126 66	0.053 43	0.819 91
470	0.195 360 000 000	0.090 980 000 000 0	1.287 640 000 000	0.124 12	0.057 80	0.818 08
471	0.184 213 600 000	0.094 917 550 000 0	1.237 422 300 000	0.121 47	0.062 59	0.815 94
472	0.173 327 300 000	0.099 045 840 000 0	1.187 824 300 000	0.118 70	0.067 83	0.813 47
473	0.162 688 100 000	0.103 367 400 000 0	1.138 761 100 000	0.115 81	0.073 58	0.810 61
474	0.152 283 300 000	0.107 884 600 000 0	1.090 148 000 000	0.112 78	0.079 89	0.807 33
475	0.142 100 000 000	0.112 600 000 000 0	1.041 900 000 000	0.109 60	0.086 84	0.803 56
476	0.132 178 600 000	0.117 532 000 000 0	0.994 197 600 000	0.106 26	0.094 49	0.799 25
477	0.122 569 600 000	0.122 674 400 000 0	0.947 347 300 000	0.102 78	0.102 86	0.794 36
478	0.113 275 200 000	0.127 992 800 000 0	0.901 453 100 000	0.099 13	0.112 01	0.788 86
479	0.104 297 900 000	0.133 452 800 000 0	0.856 619 300 000	0.095 31	0.121 94	0.782 75
480	0.095 640 000 000	0.139 020 000 000 0	0.812 950 100 000	0.091 29	0.132 70	0.776 01
481	0.087 299 550 000	0.144 676 400 000 0	0.770 517 300 000	0.087 08	0.144 32	0.768 60
482	0.079 308 040 000	0.150 469 300 000 0	0.729 444 800 000	0.082 68	0.156 87	0.760 45
483	0.071 717 760 000	0.156 461 900 000 0	0.689 913 600 000	0.078 12	0.170 42	0.751 46
484	0.064 580 990 000	0.162 717 700 000 0	0.652 104 900 000	0.073 44	0.185 03	0.741 53
485	0.057 950 010 000	0.169 300 000 000 0	0.616 200 000 000	0.068 71	0.200 72	0.730 57
486	0.051 862 110 000	0.176 243 100 000 0	0.582 328 600 000	0.063 99	0.217 47	0.718 54
487	0.046 281 520 000	0.183 558 100 000 0	0.550 416 200 000	0.059 32	0.235 25	0.705 43
488	0.041 150 880 000	0.191 273 500 000 0	0.520 337 600 000	0.054 67	0.254 09	0.691 24
489	0.036 412 830 000	0.199 418 000 000 0	0.491 967 300 000	0.050 03	0.274 00	0.675 97
490	0.032 010 000 000	0.208 020 000 000 0	0.465 180 000 000	0.045 39	0.294 98	0.659 63
491	0.027 917 200 000	0.217 119 900 000 0	0.439 924 600 000	0.040 76	0.316 98	0.642 26
492	0.024 144 400 000	0.226 734 500 000 0	0.416 183 600 000	0.036 20	0.339 90	0.623 90
493	0.020 687 000 000	0.236 857 100 000 0	0.393 882 200 000	0.031 76	0.363 60	0.604 64
494	0.017 540 400 000	0.247 481 200 000 0	0.372 945 900 000	0.027 49	0.387 92	0.584 59
495	0.014 700 000 000	0.258 600 000 000 0	0.353 300 000 000	0.023 46	0.412 70	0.563 84
496	0.012 161 790 000	0.270 184 900 000 0	0.334 857 800 000	0.019 70	0.437 76	0.542 54
497	0.009 919 960 000	0.282 293 900 000 0	0.317 552 100 000	0.016 27	0.462 95	0.520 78
498	0.007 967 240 000	0.295 050 500 000 0	0.301 337 500 000	0.013 18	0.488 21	0.498 61
499	0.006 296 346 000	0.308 578 000 000 0	0.286 168 600 000	0.010 48	0.513 40	0.476 12
500	0.004 900 000 000	0.323 000 000 000 0	0.272 000 000 000	0.008 17	0.538 42	0.453 41
501	0.003 777 173 000	0.338 402 100 000 0	0.258 817 100 000	0.006 28	0.563 07	0.430 65
502	0.002 945 320 000	0.354 685 800 000 0	0.246 483 800 000	0.004 87	0.587 12	0.408 01
503	0.002 424 880 000	0.371 698 600 000 0	0.234 771 800 000	0.003 98	0.610 45	0.385 57
504	0.002 236 293 000	0.389 287 500 000 0	0.223 453 300 000	0.003 64	0.633 01	0.363 35
505	0.002 400 000 000	0.407 300 000 000 0	0.212 300 000 000	0.003 86	0.654 82	0.341 32
506	0.002 925 520 000	0.425 629 900 000 0	0.201 169 200 000	0.004 64	0.675 90	0.319 46
507	0.003 836 560 000	0.444 309 600 000 0	0.190 119 600 000	0.006 01	0.696 12	0.297 87

λ/nm	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$	$x(\lambda)$	$y(\lambda)$	$z(\lambda)$
508	0.005 174 840 000	0.463 394 400 000 0	0.179 225 400 000	0.007 99	0.715 34	0.276 67
509	0.006 982 080 000	0.482 939 500 000 0	0.168 560 800 000	0.010 60	0.733 41	0.255 99
510	0.009 300 000 000	0.503 000 000 000 0	0.158 200 000 000	0.013 87	0.750 19	0.235 94
511	0.012 149 490 000	0.523 569 300 000 0	0.148 138 300 000	0.017 77	0.765 61	0.216 62
512	0.015 535 880 000	0.544 512 000 000 0	0.138 375 800 000	0.022 24	0.779 63	0.198 13
513	0.019 477 520 000	0.565 690 000 000 0	0.128 994 200 000	0.027 27	0.792 11	0.180 62
514	0.023 992 770 000	0.586 965 300 000 0	0.120 075 100 000	0.032 82	0.802 93	0.164 25
515	0.029 100 000 000	0.608 200 000 000 0	0.111 700 000 000	0.038 85	0.812 02	0.149 13
516	0.034 814 850 000	0.629 345 600 000 0	0.103 904 800 000	0.045 33	0.819 39	0.135 28
517	0.041 120 160 000	0.650 306 800 000 0	0.096 667 480 000	0.052 18	0.825 16	0.122 66
518	0.047 985 040 000	0.670 875 200 000 0	0.089 982 720 000	0.059 32	0.829 43	0.111 25
519	0.055 378 610 000	0.690 842 400 000 0	0.083 845 310 000	0.066 72	0.832 27	0.101 01
520	0.063 270 000 000	0.710 000 000 000 0	0.078 249 990 000	0.074 30	0.833 80	0.091 90
521	0.071 635 010 000	0.728 185 200 000 0	0.073 208 990 000	0.082 05	0.834 09	0.083 86
522	0.080 462 240 000	0.745 463 600 000 0	0.068 678 160 000	0.089 94	0.833 29	0.076 77
523	0.089 739 960 000	0.761 969 400 000 0	0.064 567 840 000	0.097 94	0.831 59	0.070 47
524	0.099 456 450 000	0.777 836 800 000 0	0.060 788 350 000	0.106 02	0.829 18	0.064 80
525	0.109 600 000 000	0.793 200 000 000 0	0.057 250 010 000	0.114 16	0.826 21	0.059 63
526	0.120 167 400 000	0.808 110 400 000 0	0.053 904 350 000	0.122 35	0.822 77	0.054 88
527	0.131 114 500 000	0.822 496 200 000 0	0.050 746 640 000	0.130 55	0.818 93	0.050 52
528	0.142 367 900 000	0.836 306 800 000 0	0.047 752 760 000	0.138 70	0.814 78	0.046 52
529	0.153 854 200 000	0.849 491 600 000 0	0.044 898 590 000	0.146 77	0.810 40	0.042 83
530	0.165 500 000 000	0.862 000 000 000 0	0.042 160 000 000	0.154 72	0.805 86	0.039 42
531	0.177 257 100 000	0.873 810 800 000 0	0.039 507 280 000	0.162 53	0.801 24	0.036 23
532	0.189 140 000 000	0.884 962 400 000 0	0.036 935 640 000	0.170 24	0.796 52	0.033 24
533	0.201 169 400 000	0.895 493 600 000 0	0.034 458 360 000	0.177 85	0.791 69	0.030 46
534	0.213 365 800 000	0.905 443 200 000 0	0.032 088 720 000	0.185 39	0.786 73	0.027 88
535	0.225 749 900 000	0.914 850 100 000 0	0.029 840 000 000	0.192 88	0.781 63	0.025 49
536	0.238 320 900 000	0.923 734 800 000 0	0.027 711 810 000	0.200 31	0.776 40	0.023 29
537	0.251 066 800 000	0.932 092 400 000 0	0.025 694 440 000	0.207 69	0.771 05	0.021 26
538	0.263 992 200 000	0.939 922 600 000 0	0.023 787 160 000	0.215 03	0.765 59	0.019 38
539	0.277 101 700 000	0.947 225 200 000 0	0.021 989 250 000	0.222 34	0.760 02	0.017 64
540	0.290 400 000 000	0.954 000 000 000 0	0.020 300 000 000	0.229 62	0.754 33	0.016 05
541	0.303 891 200 000	0.960 256 100 000 0	0.018 718 050 000	0.236 89	0.748 52	0.014 59
542	0.317 572 600 000	0.966 007 400 000 0	0.017 240 360 000	0.244 13	0.742 62	0.013 25
543	0.331 438 400 000	0.971 260 600 000 0	0.015 863 640 000	0.251 36	0.736 61	0.012 03
544	0.345 482 800 000	0.976 022 500 000 0	0.014 584 610 000	0.258 58	0.730 51	0.010 91
545	0.359 700 000 000	0.980 300 000 000 0	0.013 400 000 000	0.265 78	0.724 32	0.009 90
546	0.374 083 900 000	0.984 092 400 000 0	0.012 307 230 000	0.272 96	0.718 06	0.008 98
547	0.388 639 600 000	0.987 418 200 000 0	0.011 301 880 000	0.280 13	0.711 72	0.008 15
548	0.403 378 400 000	0.990 312 800 000 0	0.010 377 920 000	0.287 29	0.705 32	0.007 39
549	0.418 311 500 000	0.992 811 600 000 0	0.009 529 306 000	0.294 45	0.698 84	0.006 71
550	0.433 449 900 000	0.994 950 100 000 0	0.008 749 999 000	0.301 60	0.692 31	0.006 09
551	0.448 795 300 000	0.996 710 800 000 0	0.008 035 200 000	0.308 76	0.685 71	0.005 53
552	0.464 336 000 000	0.998 098 300 000 0	0.007 381 600 000	0.315 92	0.679 06	0.005 02
553	0.480 064 000 000	0.999 112 000 000 0	0.006 785 400 000	0.323 06	0.672 37	0.004 57
554	0.495 971 300 000	0.999 748 200 000 0	0.006 242 800 000	0.330 21	0.665 63	0.004 16
555	0.512 050 100 000	1.000 000 000 000 0	0.005 749 999 000	0.337 36	0.658 85	0.003 79
556	0.528 295 900 000	0.999 856 700 000 0	0.005 303 600 000	0.344 51	0.652 03	0.003 46
557	0.544 691 600 000	0.999 304 600 000 0	0.004 899 800 000	0.351 67	0.645 17	0.003 16

λ/nm	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$	$x(\lambda)$	$y(\lambda)$	$z(\lambda)$
558	0.561 209 400 000	0.998 325 500 000 0	0.004 534 200 000	0.358 81	0.638 29	0.002 90
559	0.577 821 500 000	0.996 898 700 000 0	0.004 202 400 000	0.365 96	0.631 38	0.002 66
560	0.594 500 000 000	0.995 000 000 000 0	0.003 900 000 000	0.373 10	0.624 45	0.002 45
561	0.611 220 900 000	0.992 600 500 000 0	0.003 623 200 000	0.380 24	0.617 50	0.002 26
562	0.627 975 800 000	0.989 742 600 000 0	0.003 370 600 000	0.387 38	0.610 54	0.002 08
563	0.644 760 200 000	0.986 444 400 000 0	0.003 141 400 000	0.394 51	0.603 57	0.001 92
564	0.661 569 700 000	0.982 724 100 000 0	0.002 934 800 000	0.401 63	0.596 59	0.001 78
565	0.678 400 000 000	0.978 600 000 000 0	0.002 749 999 000	0.408 73	0.589 61	0.001 66
566	0.695 239 200 000	0.974 083 700 000 0	0.002 585 200 000	0.415 83	0.582 62	0.001 55
567	0.712 058 600 000	0.969 171 200 000 0	0.002 438 600 000	0.422 92	0.575 63	0.001 45
568	0.728 828 400 000	0.963 856 800 000 0	0.002 309 400 000	0.429 99	0.568 65	0.001 36
569	0.745 518 800 000	0.958 134 900 000 0	0.002 196 800 000	0.437 04	0.561 67	0.001 29
570	0.762 100 000 000	0.952 000 000 000 0	0.002 100 000 000	0.444 06	0.554 72	0.001 22
571	0.778 543 200 000	0.945 450 400 000 0	0.002 017 733 000	0.451 06	0.547 77	0.001 17
572	0.794 825 600 000	0.938 499 200 000 0	0.001 948 200 000	0.458 04	0.540 84	0.001 12
573	0.810 926 400 000	0.931 162 800 000 0	0.001 889 800 000	0.464 99	0.533 93	0.001 08
574	0.826 824 800 000	0.923 457 600 000 0	0.001 840 933 000	0.471 90	0.527 05	0.001 05
575	0.842 500 000 000	0.915 400 000 000 0	0.001 800 000 000	0.478 78	0.520 20	0.001 02
576	0.857 932 500 000	0.907 006 400 000 0	0.001 766 267 000	0.485 61	0.513 39	0.001 00
577	0.873 081 600 000	0.898 277 200 000 0	0.001 737 800 000	0.492 41	0.506 61	0.000 98
578	0.887 894 400 000	0.889 204 800 000 0	0.001 711 200 000	0.499 15	0.499 89	0.000 96
579	0.902 318 100 000	0.879 781 600 000 0	0.001 683 067 000	0.505 85	0.493 21	0.000 94
580	0.916 300 000 000	0.870 000 000 000 0	0.001 650 001 000	0.512 49	0.486 59	0.000 92
581	0.929 799 500 000	0.859 861 300 000 0	0.001 610 133 000	0.519 07	0.480 03	0.000 90
582	0.942 798 400 000	0.849 392 000 000 0	0.001 564 400 000	0.525 60	0.473 53	0.000 87
583	0.955 277 600 000	0.838 622 000 000 0	0.001 513 600 000	0.532 07	0.467 09	0.000 84
584	0.967 217 900 000	0.827 581 300 000 0	0.001 458 533 000	0.538 46	0.460 73	0.000 81
585	0.978 600 000 000	0.816 300 000 000 0	0.001 400 000 000	0.544 79	0.454 43	0.000 78
586	0.989 385 600 000	0.804 794 700 000 0	0.001 336 667 000	0.551 03	0.448 23	0.000 74
587	0.999 548 800 000	0.793 082 000 000 0	0.001 270 000 000	0.557 19	0.442 10	0.000 71
588	1.009 089 200 000	0.781 192 000 000 0	0.001 205 000 000	0.563 27	0.436 06	0.000 67
589	1.018 006 400 000	0.769 154 700 000 0	0.001 146 667 000	0.569 26	0.430 10	0.000 64
590	1.026 300 000 000	0.757 000 000 000 0	0.001 100 000 000	0.575 15	0.424 23	0.000 62
591	1.033 982 700 000	0.744 754 100 000 0	0.001 068 800 000	0.580 94	0.418 46	0.000 60
592	1.040 986 000 000	0.732 422 400 000 0	0.001 049 400 000	0.586 65	0.412 76	0.000 59
593	1.047 188 000 000	0.720 003 600 000 0	0.001 035 600 000	0.592 22	0.407 19	0.000 59
594	1.052 466 700 000	0.707 496 500 000 0	0.001 021 200 000	0.597 66	0.401 76	0.000 58
595	1.056 700 000 000	0.694 900 000 000 0	0.001 000 000 000	0.602 93	0.396 50	0.000 57
596	1.059 794 400 000	0.682 219 200 000 0	0.000 968 640 000	0.608 03	0.391 41	0.000 56
597	1.061 799 200 000	0.669 471 600 000 0	0.000 929 920 000	0.612 98	0.386 48	0.000 54
598	1.062 806 800 000	0.656 674 400 000 0	0.000 886 880 000	0.617 78	0.381 71	0.000 51
599	1.062 909 600 000	0.643 844 800 000 0	0.000 842 560 000	0.622 46	0.377 05	0.000 49
600	1.062 200 000 000	0.631 000 000 000 0	0.000 800 000 000	0.627 04	0.372 49	0.000 47
601	1.060 735 200 000	0.618 155 500 000 0	0.000 760 960 000	0.631 52	0.368 03	0.000 45
602	1.058 443 600 000	0.605 314 400 000 0	0.000 723 680 000	0.635 90	0.363 67	0.000 43
603	1.055 224 400 000	0.592 475 600 000 0	0.000 685 920 000	0.640 16	0.359 43	0.000 41
604	1.050 976 800 000	0.579 637 900 000 0	0.000 645 440 000	0.644 27	0.355 33	0.000 40
605	1.045 600 000 000	0.566 800 000 000 0	0.000 600 000 000	0.648 2 3	0.351 40	0.000 37
606	1.039 036 900 000	0.553 961 100 000 0	0.000 547 866 700	0.652 03	0.347 63	0.000 34
607	1.031 360 800 000	0.541 137 200 000 0	0.000 491 600 000	0.655 6 7	0.344 02	0.000 31

λ/nm	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$	$x(\lambda)$	$y(\lambda)$	$z(\lambda)$
608	1.022 666 200 000	0.528 352 800 000 0	0.000 435 400 000	0.659 17	0.340 55	0.000 28
609	1.013 047 700 000	0.515 632 300 000 0	0.000 383 466 700	0.662 53	0.337 22	0.000 25
610	1.002 600 000 000	0.503 000 000 000 0	0.000 340 000 000	0.665 76	0.334 01	0.000 23
611	0.991 367 500 000	0.490 468 800 000 0	0.000 307 253 300	0.668 87	0.330 92	0.000 21
612	0.979 331 400 000	0.478 030 400 000 0	0.000 283 160 000	0.671 86	0.327 95	0.000 19
613	0.966 491 600 000	0.465 677 600 000 0	0.000 265 440 000	0.674 72	0.325 09	0.000 19
614	0.952 847 900 000	0.453 403 200 000 0	0.000 251 813 300	0.677 46	0.322 36	0.000 18
615	0.938 400 000 000	0.441 200 000 000 0	0.000 240 000 000	0.680 08	0.319 75	0.000 17
616	0.923 194 000 000	0.429 080 000 000 0	0.000 229 546 700	0.682 58	0.317 25	0.000 17
617	0.907 244 000 000	0.417 036 000 000 0	0.000 220 640 000	0.684 97	0.314 86	0.000 17
618	0.890 502 000 000	0.405 032 000 000 0	0.000 211 960 000	0.687 25	0.312 59	0.000 16
619	0.872 920 000 000	0.393 032 000 000 0	0.000 202 186 700	0.689 43	0.310 41	0.000 16
620	0.854 449 900 000	0.381 000 000 000 0	0.000 190 000 000	0.691 51	0.308 34	0.000 15
621	0.835 084 000 000	0.368 918 400 000 0	0.000 174 213 300	0.693 49	0.306 37	0.000 14
622	0.814 946 000 000	0.356 827 200 000 0	0.000 155 640 000	0.695 39	0.304 48	0.000 13
623	0.794 186 000 000	0.344 776 800 000 0	0.000 135 960 000	0.697 21	0.302 67	0.000 12
624	0.772 954 000 000	0.332 817 600 000 0	0.000 116 853 300	0.698 94	0.300 95	0.000 11
625	0.751 400 000 000	0.321 000 000 000 0	0.000 100 000 000	0.700 61	0.299 30	0.000 09
626	0.729 583 600 000	0.309 338 100 000 0	0.000 086 133 330	0.702 19	0.297 73	0.000 08
627	0.707 588 800 000	0.297 850 400 000 0	0.000 074 600 000	0.703 71	0.296 22	0.000 07
628	0.685 602 200 000	0.286 593 600 000 0	0.000 065 000 000	0.705 16	0.294 77	0.000 07
629	0.663 810 400 000	0.275 624 500 000 0	0.000 056 933 330	0.706 56	0.293 38	0.000 06
630	0.642 400 000 000	0.265 000 000 000 0	0.000 049 999 990	0.707 92	0.292 03	0.000 05
631	0.621 514 900 000	0.254 763 200 000 0	0.000 044 160 000	0.709 23	0.290 72	0.000 05
632	0.601 113 800 000	0.244 889 600 000 0	0.000 039 480 000	0.710 50	0.289 45	0.000 05
633	0.581 105 200 000	0.235 334 400 000 0	0.000 035 720 000	0.711 73	0.288 23	0.000 04
634	0.561 397 700 000	0.226 052 800 000 0	0.000 032 640 000	0.712 90	0.287 06	0.000 04
635	0.541 900 000 000	0.217 000 000 000 0	0.000 030 000 000	0.714 03	0.285 93	0.000 04
636	0.522 599 500 000	0.208 161 600 000 0	0.000 027 653 330	0.715 12	0.284 84	0.000 04
637	0.503 546 400 000	0.199 548 800 000 0	0.000 025 560 000	0.716 16	0.283 80	0.000 04
638	0.484 743 600 000	0.191 155 200 000 0	0.000 023 640 000	0.717 16	0.282 81	0.000 03
639	0.466 193 900 000	0.182 974 400 000 0	0.000 021 813 330	0.718 12	0.281 85	0.000 03
640	0.447 900 000 000	0.175 000 000 000 0	0.000 020 000 000	0.719 03	0.280 94	0.000 03
641	0.429 861 300 000	0.167 223 500 000 0	0.000 018 133 330	0.719 91	0.280 06	0.000 03
642	0.412 098 000 000	0.159 646 400 000 0	0.000 016 200 000	0.720 75	0.279 22	0.000 03
643	0.394 644 000 000	0.152 277 600 000 0	0.000 014 200 000	0.721 55	0.278 42	0.000 03
644	0.377 533 300 000	0.145 125 900 000 0	0.000 012 133 330	0.722 32	0.277 66	0.000 02
645	0.360 800 000 000	0.138 200 000 000 0	0.000 010 000 000	0.723 03	0.276 95	0.000 02
646	0.344 456 300 000	0.131 500 300 000 0	0.000 007 733 333	0.723 70	0.276 28	0.000 02
647	0.328 516 800 000	0.125 024 800 000 0	0.000 005 400 000	0.724 33	0.275 66	0.000 01
648	0.313 019 200 000	0.118 779 200 000 0	0.000 003 200 000	0.724 91	0.275 08	0.000 01
649	0.298 001 100 000	0.112 769 100 000 0	0.000 001 333 333	0.725 47	0.274 53	0.000 00
650	0.283 500 000 000	0.107 000 000 000 0	0.000 000 000 000	0.725 99	0.274 01	0.000 00
651	0.269 544 800 000	0.101 476 200 000 0	0.000 000 000 000	0.726 49	0.273 51	0.000 00
652	0.256 118 400 000	0.096 188 640 000 0	0.000 000 000 000	0.726 98	0.273 02	0.000 00
653	0.243 189 600 000	0.091 122 960 000 0	0.000 000 000 000	0.727 4 3	0.272 57	0.000 00
654	0.230 727 200 000	0.086 264 850 000 0	0.000 000 000 000	0.727 86	0.272 14	0.000 00
655	0.218 700 000 000	0.081 600 000 000 0	0.000 000 000 000	0.728 27	0.271 73	0.000 00
656	0.207 097 100 000	0.077 120 640 000 0	0.000 000 000 000	0.728 66	0.271 34	0.000 00
657	0.195 923 200 000	0.072 825 520 000 0	0.000 000 000 000	0.729 02	0.270 98	0.000 00

λ/nm	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$	$x(\lambda)$	$y(\lambda)$	$z(\lambda)$
658	0.185 170 800 000	0.068 710 080 000 0	0.000 000 000 000	0.729 36	0.270 64	0.000 00
659	0.174 832 300 000	0.064 769 760 000 0	0.000 000 000 000	0.729 68	0.270 32	0.000 00
660	0.164 900 000 000	0.061 000 000 000 0	0.000 000 000 000	0.729 97	0.270 03	0.000 00
661	0.155 366 700 000	0.057 396 210 000 0	0.000 000 000 000	0.730 23	0.269 77	0.000 00
662	0.146 230 000 000	0.053 955 040 000 0	0.000 000 000 000	0.730 47	0.269 53	0.000 00
663	0.137 490 000 000	0.050 673 760 000 0	0.000 000 000 000	0.730 69	0.269 31	0.000 00
664	0.129 146 700 000	0.047 549 650 000 0	0.000 000 000 000	0.730 90	0.269 10	0.000 00
665	0.121 200 000 000	0.044 580 000 000 0	0.000 000 000 000	0.731 09	0.268 91	0.000 00
666	0.113 639 700 000	0.041 758 720 000 0	0.000 000 000 000	0.731 28	0.268 72	0.000 00
667	0.106 465 000 000	0.039 084 960 000 0	0.000 000 000 000	0.731 47	0.268 53	0.000 00
668	0.099 690 440 000	0.036 563 840 000 0	0.000 000 000 000	0.731 65	0.268 35	0.000 00
669	0.093 330 610 000	0.034 200 480 000 0	0.000 000 000 000	0.731 83	0.268 17	0.000 00
670	0.087 400 000 000	0.032 000 000 000 0	0.000 000 000 000	0.731 99	0.268 01	0.000 00
671	0.081 900 960 000	0.029 962 610 000 0	0.000 000 000 000	0.732 15	0.267 85	0.000 00
672	0.076 804 280 000	0.028 076 640 000 0	0.000 000 000 000	0.732 30	0.267 70	0.000 00
673	0.072 077 120 000	0.026 329 360 000 0	0.000 000 000 000	0.732 44	0.267 56	0.000 00
674	0.067 686 640 000	0.024 708 050 000 0	0.000 000 000 000	0.732 58	0.267 42	0.000 00
675	0.063 600 000 000	0.023 200 000 000 0	0.000 000 000 000	0.732 72	0.267 28	0.000 00
676	0.059 806 850 000	0.021 800 770 000 0	0.000 000 000 000	0.732 86	0.267 14	0.000 00
677	0.056 282 160 000	0.020 501 120 000 0	0.000 000 000 000	0.733 00	0.267 00	0.000 00
678	0.052 971 040 000	0.019 281 080 000 0	0.000 000 000 000	0.733 14	0.266 86	0.000 00
679	0.049 818 610 000	0.018 120 690 000 0	0.000 000 000 000	0.733 28	0.266 72	0.000 00
680	0.046 770 000 000	0.017 000 000 000 0	0.000 000 000 000	0.733 42	0.266 58	0.000 00
681	0.043 784 050 000	0.015 903 790 000 0	0.000 000 000 000	0.733 55	0.266 45	0.000 00
682	0.040 875 360 000	0.014 837 180 000 0	0.000 000 000 000	0.733 68	0.266 32	0.000 00
683	0.038 072 640 000	0.013 810 680 000 0	0.000 000 000 000	0.733 81	0.266 19	0.000 00
684	0.035 404 610 000	0.012 834 780 000 0	0.000 000 000 000	0.733 94	0.266 06	0.000 00
685	0.032 900 000 000	0.011 920 000 000 0	0.000 000 000 000	0.734 05	0.265 95	0.000 00
686	0.030 564 190 000	0.011 068 310 000 0	0.000 000 000 000	0.734 14	0.265 86	0.000 00
687	0.028 380 560 000	0.010 273 390 000 0	0.000 000 000 000	0.734 22	0.265 78	0.000 00
688	0.026 344 840 000	0.009 533 311 000 0	0.000 000 000 000	0.734 29	0.265 71	0.000 00
689	0.024 452 750 000	0.008 846 157 000 0	0.000 000 000 000	0.734 34	0.265 66	0.000 00
690	0.022 700 000 000	0.008 210 000 000 0	0.000 000 000 000	0.734 39	0.265 61	0.000 00
691	0.021 084 290 000	0.007 623 781 000 0	0.000 000 000 000	0.734 44	0.265 56	0.000 00
692	0.019 599 880 000	0.007 085 424 000 0	0.000 000 000 000	0.734 48	0.265 52	0.000 00
693	0.018 237 320 000	0.006 591 476 000 0	0.000 000 000 000	0.734 52	0.265 48	0.000 00
694	0.016 987 170 000	0.006 138 485 000 0	0.000 000 000 000	0.734 56	0.265 44	0.000 00
695	0.015 840 000 000	0.005 723 000 000 0	0.000 000 000 000	0.734 59	0.265 41	0.000 00
696	0.014 790 640 000	0.005 343 059 000 0	0.000 000 000 000	0.734 62	0.265 38	0.000 00
697	0.013 831 320 000	0.004 995 796 000 0	0.000 000 000 000	0.734 65	0.265 35	0.000 00
698	0.012 948 680 000	0.004 676 404 000 0	0.000 000 000 000	0.734 67	0.265 33	0.000 00
699	0.012 129 200 000	0.004 380 075 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
700	0.011 359 160 000	0.004 102 000 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
701	0.010 629 350 000	0.003 838 453 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
702	0.009 938 846 000	0.003 589 099 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
703	0.009 288 422 000	0.003 354 219 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
704	0.008 678 854 000	0.003 134 093 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
705	0.008 110 916 000	0.002 929 000 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
706	0.007 582 388 000	0.002 738 139 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
707	0.007 088 746 000	0.002 559 876 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00

λ/nm	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$	$x(\lambda)$	$y(\lambda)$	$z(\lambda)$
708	0.006 627 313 000	0.002 393 244 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
709	0.006 195 408 000	0.002 237 275 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
710	0.005 790 346 000	0.002 091 000 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
711	0.005 409 826 000	0.001 953 587 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
712	0.005 052 583 000	0.001 824 580 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
713	0.004 717 512 000	0.001 703 580 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
714	0.004 403 507 000	0.001 590 187 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
715	0.004 109 457 000	0.001 484 000 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
716	0.003 833 913 000	0.001 384 496 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
717	0.003 575 748 000	0.001 291 268 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
718	0.003 334 342 000	0.001 204 092 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
719	0.003 109 075 000	0.001 122 744 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
720	0.002 899 327 000	0.001 047 000 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
721	0.002 704 348 000	0.000 976 589 600 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
722	0.002 523 020 000	0.000 911 108 800 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
723	0.002 354 168 000	0.000 850 133 200 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
724	0.002 196 616 000	0.000 793 238 400 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
725	0.002 049 190 000	0.000 740 000 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
726	0.001 910 960 000	0.000 690 082 700 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
727	0.001 781 438 000	0.000 643 310 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
728	0.001 660 110 000	0.000 599 496 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
729	0.001 546 459 000	0.000 558 454 700 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
730	0.001 439 971 000	0.000 520 000 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
731	0.001 340 042 000	0.000 483 913 600 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
732	0.001 246 275 000	0.000 450 052 800 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
733	0.001 158 471 000	0.000 418 345 200 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
734	0.001 076 430 000	0.000 388 718 400 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
735	0.000 999 949 300	0.000 361 100 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
736	0.000 928 735 800	0.000 335 383 500 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
737	0.000 862 433 200	0.000 311 440 400 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
738	0.000 800 750 300	0.000 289 165 600 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
739	0.000 743 396 000	0.000 268 453 900 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
740	0.000 690 078 600	0.000 249 200 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
741	0.000 640 515 600	0.000 231 301 900 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
742	0.000 594 502 100	0.000 214 685 600 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
743	0.000 551 864 600	0.000 199 288 400 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
744	0.000 512 429 000	0.000 185 047 500 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
745	0.000 476 021 300	0.000 171 900 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
746	0.000 442 453 600	0.000 159 778 100 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
747	0.000 411 511 700	0.000 148 604 400 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
748	0.000 382 981 400	0.000 138 301 600 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
749	0.000 356 649 100	0.000 128 792 500 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
750	0.000 332 301 100	0.000 120 000 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
751	0.000 309 758 600	0.000 111 859 500 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
752	0.000 288 887 100	0.000 104 322 400 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
753	0.000 269 539 400	0.000 097 335 600 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
754	0.000 251 568 200	0.000 090 845 870 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
755	0.000 234 826 100	0.000 084 800 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
756	0.000 219 171 000	0.000 079 146 670 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
757	0.000 204 525 800	0.000 073 858 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00

λ/nm	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$	$x(\lambda)$	$y(\lambda)$	$z(\lambda)$
758	0.000 190 840 500	0.000 068 916 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
759	0.000 178 065 400	0.000 064 302 670 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
760	0.000 166 150 500	0.000 060 000 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
761	0.000 155 023 600	0.000 055 981 870 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
762	0.000 144 621 900	0.000 052 225 600 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
763	0.000 134 909 800	0.000 048 718 400 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
764	0.000 125 852 000	0.000 045 447 470 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
765	0.000 117 413 000	0.000 042 400 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
766	0.000 109 551 500	0.000 039 561 040 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
767	0.000 102 224 500	0.000 036 915 120 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
768	0.000 095 394 450	0.000 034 448 680 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
769	0.000 089 023 900	0.000 032 148 160 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
770	0.000 083 075 270	0.000 030 000 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
771	0.000 077 512 690	0.000 027 991 250 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
772	0.000 072 313 040	0.000 026 113 560 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
773	0.000 067 457 780	0.000 024 360 240 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
774	0.000 062 928 440	0.000 022 724 610 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
775	0.000 058 706 520	0.000 021 200 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
776	0.000 054 770 280	0.000 019 778 550 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
777	0.000 051 099 180	0.000 018 452 850 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
778	0.000 047 676 540	0.000 017 216 870 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
779	0.000 044 485 670	0.000 016 064 590 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
780	0.000 041 509 940	0.000 014 990 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
781	0.000 038 733 240	0.000 013 987 280 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
782	0.000 036 142 030	0.000 013 051 550 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
783	0.000 033 723 520	0.000 012 178 180 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
784	0.000 031 464 870	0.000 011 362 540 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
785	0.000 029 353 260	0.000 010 600 000 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
786	0.000 027 375 730	0.000 009 885 877 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
787	0.000 025 524 330	0.000 009 217 304 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
788	0.000 023 793 760	0.000 008 592 362 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
789	0.000 022 178 700	0.000 008 009 133 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
790	0.000 020 673 830	0.000 007 465 700 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
791	0.000 019 272 260	0.000 006 959 567 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
792	0.000 017 966 400	0.000 006 487 995 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
793	0.000 016 749 910	0.000 006 048 699 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
794	0.000 015 616 480	0.000 005 639 396 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
795	0.000 014 559 770	0.000 005 257 800 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
796	0.000 013 573 870	0.000 004 901 771 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
797	0.000 012 654 360	0.000 004 569 720 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
798	0.000 011 797 230	0.000 004 260 194 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
799	0.000 010 998 440	0.000 003 971 739 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
800	0.000 010 253 980	0.000 003 702 900 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
801	0.000 009 559 646	0.000 003 452 163 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
802	0.000 008 912 044	0.000 003 218 302 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
803	0.000 008 308 358	0.000 003 000 300 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
804	0.000 007 745 769	0.000 002 797 139 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
805	0.000 007 221 456	0.000 002 607 800 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
806	0.000 006 732 475	0.000 002 431 220 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
807	0.000 006 276 423	0.000 002 266 531 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00

λ/nm	$\overline{x}(\lambda)$	$\overline{y}(\lambda)$	$\overline{z}(\lambda)$	$x(\lambda)$	$y(\lambda)$	$z(\lambda)$
808	0.000 005 851 304	0.000 002 113 013 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
809	0.000 005 455 118	0.000 001 969 943 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
810	0.000 005 085 868	0.000 001 836 600 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
811	0.000 004 741 466	0.000 001 712 230 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
812	0.000 004 420 236	0.000 001 596 228 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
813	0.000 004 120 783	0.000 001 488 090 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
814	0.000 003 841 716	0.000 001 387 314 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
815	0.000 003 581 652	0.000 001 293 400 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
816	0.000 003 339 127	0.000 001 205 820 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
817	0.000 003 112 949	0.000 001 124 143 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
818	0.000 002 902 121	0.000 001 048 009 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
819	0.000 002 705 645	0.000 000 977 057 8	0.000 000 000 000	0.734 69	0.265 31	0.000 00
820	0.000 002 522 525	0.000 000 910 930 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
821	0.000 002 351 726	0.000 000 849 251 3	0.000 000 000 000	0.734 69	0.265 31	0.000 00
822	0.000 002 192 415	0.000 000 791 721 2	0.000 000 000 000	0.734 69	0.265 31	0.000 00
823	0.000 002 043 902	0.000 000 738 090 4	0.000 000 000 000	0.734 69	0.265 31	0.000 00
824	0.000 001 905 497	0.000 000 688 109 8	0.000 000 000 000	0.734 69	0.265 31	0.000 00
825	0.000 001 776 509	0.000 000 641 530 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
826	0.000 001 656 215	0.000 000 598 089 5	0.000 000 000 000	0.734 69	0.265 31	0.000 00
827	0.000 001 544 022	0.000 000 557 574 6	0.000 000 000 000	0.734 69	0.265 31	0.000 00
828	0.000 001 439 440	0.000 000 519 808 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00
829	0.000 001 341 977	0.000 000 484 612 3	0.000 000 000 000	0.734 69	0.265 31	0.000 00
830	0.000 001 251 141	0.000 000 451 810 0	0.000 000 000 000	0.734 69	0.265 31	0.000 00

References

BIPM, 2019. *BIPM – The International System of Units (SI), 9th ed.* 2019.

CGPM, 1948. *Comptes Rendus des Séances de la Neuvième Conférence Générale des Poids et Mesures*, Réuni à Paris en 1948, page 53 et 54.

CGPM, 1955. *Comptes Rendus des Séances de la Dixième Conférence Générale des Poids et Mesures,* Réunie à Paris en 1954.

CGPM, 1979. *Comptes Rendus des Séances de la 16e Conférence Générale des Poids et Mesures*, Paris, 8–12 Octobre, 1979, p. 100, Bureau International des Poids et Mesures, F-92310 Sevres, France.

CGPM, 2018. *Comptes Rendus des Séances de la 26e Conférence Générale des Poids et Mesures*, Paris, 13–16 Novembre, 2018, Bureau International des Poids et Mesures, F-92310 Sevres, France [in press].

CIDDOR, P.E. 1996. Refractive index of air: new equations for the visible and near infrared. *Appl. Optics* **35**: 1566-1573.

CIE, 1990. CIE 86-1990 *CIE 1988 2° Spectral Luminous Efficiency Function for Photopic vision*. Vienna: CIE.

CIE, 2004. CIE 15:2004 *Colorimetry, 3rd Ed.* Vienna: CIE.

CIE, 2005. CIE 165:2005 *CIE 10 Degree Photopic Photometric Observer*. Vienna: CIE.

CIE, 2010. CIE 191:2010 *Recommended System for Mesopic Photometry based on Visual Performance*. Vienna: CIE.

CIE, 2011. CIE 200:2011 *CIE Supplementary System of Photometry*. Vienna: CIE.

CIE, 2014. CIE TN 002:2014 *Relating Photochemical and Photobiological Quantities to Photometric Quantities*. Vienna: CIE.

CIE, 2015. CIE 170-2:2015 *Fundamental Chromaticity Diagram with Physiological Axes – Part 2: Spectral Luminous Efficiency Functions and Chromaticity Diagrams*. Vienna: CIE.

CIE, 2016a. CIE DIS 017:2016 *ILV: International Lighting Vocabulary, 2nd Ed.* Vienna: CIE.

CIE, 2016b. CIE TN 004: 2016 *The Use of Terms and Units in Photometry – Implementation of the CIE System for Mesopic Photometry*. Vienna: CIE.

CIE, 2017. CIE TN 007:2017 *Interim Recommendation for Practical Application of the CIE System for Mesopic Photometry in Outdoor Lighting.* Vienna: CIE.

CIE, 2018a. S 026/E:2018 *System for Metrology of Optical Radiation for ipRGC-Influenced Responses to Light.* Vienna: CIE.

CIE, 2018b. CIE 015:2018 *Colorimetry, 4th Edition.* Vienna: CIE.

ISO/CIE, 2005. ISO 23539:2005/CIE S 010:2004 *Photometry – The CIE System of Physical Photometry*. Vienna: CIE.

ISO/CIE, 2007. ISO 11664-1:2007/CIE S 014-1:2006 *Colorimetry – Part 1: Standard Colorimetric Observers*. Vienna: CIE.

ZWINKELS, J., SPERLING, A., GOODMAN, T., CAMPOS, J., OHNO, Y., RASTELLO, M.L., STOCK, M, WOOLLIAMS, E. 2016. Mise en pratique for the definition of the candela and associated derived units for photometric and radiometric quantities in the International System of Units (SI). *Metrologia*: **53,** G1. (The 2019 revision is in press.)