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OSA Handbook of Optics, Volume III Visual Optics and Vision
Chapter for Photometry and Radiometry

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CONTENTS

1. Introduction

Radiometry is the measurement of optical radiation, which is electromagnetic radiation in the frequency range between 3 x 10^{11} Hz and 3 x 10^{16} Hz. This range corresponds to wavelengths between 10 nm and 1000 μm, and includes the regions commonly called the ultraviolet, the visible, and the infrared. Typical radiometric units include watt (radiant flux), watt per steradian (radiant intensity), watt per square meter (irradiance), and watt per square meter per steradian (radiance).

Photometry is the measurement of light, which is defined as electromagnetic radiation detectable by the human eye. It is thus restricted to the visible region (wavelength range from 360 nm to 830 nm), and all the quantities are weighted by the spectral response of the eye. Photometry uses either optical radiation detectors constructed to mimic the spectral response of the eye, or spectroradiometry coupled with appropriate calculations for weighting by the spectral response of the eye. Typical photometric units include lumen (luminous flux), candela (luminous intensity), lux (illuminance), and candela per square meter (luminance).

The difference between radiometry and photometry is that radiometry includes the entire optical radiation spectrum (and often involves spectrally resolved measurements), while photometry deals with the visible spectrum weighted by the response of the eye. This chapter provides some guidance in photometry and radiometry; Refs. [1-6] are available for further details. The terminology used in this chapter follows international standards and recommendations [7-9].

2. Basis of Physical Photometry

The primary aim of photometry is to measure visible optical radiation, light, in such a way that the results correlate with what the visual sensation is to a normal human observer exposed to that radiation. Until about 1940, visual comparison techniques of measurements were predominant in photometry.

In modern photometric practice, measurements are made with photodetectors. This is referred to as physical photometry. In order to achieve the aim of photometry, one must take into account the characteristics of human vision. The relative spectral responsivity of the human eye was first defined by the CIE (Commission Internationale de l'Éclairage) in 1924 [10], and redefined as part of colorimetric standard observers in 1931 [11]. It is called *the spectral luminous efficiency function for photopic vision*, or the $V(\lambda)$ function, defined in the domain from 360 nm to 830 nm, and is normalized to one at its peak, 555 nm (Fig. 1). This model has gained wide acceptance. The values were republished by CIE in 1983 [12], and published by CIPM (Comité International des Poids et Mesures) in 1982 [13] to supplement the 1979 definition of the candela. The tabulated values of the function at 1 nm increments are available in Refs. [12-15]. In most cases, the region from 380 nm to 780 nm suffices for calculation with negligible errors because the value of the $V(\lambda)$ function falls below 10^{-4} outside this region. Thus, a photodetector having a spectral responsivity matched to the $V(\lambda)$ function replaced the role of human eyes in photometry.

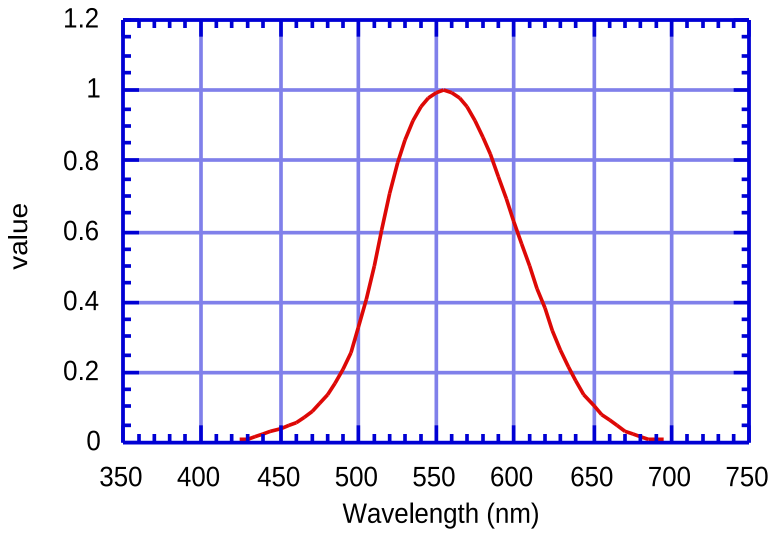

Figure 1 CIE $V(\lambda)$ Function.

Radiometry concerns physical measurement of optical radiation as a function of its wavelength. As specified in the definition of the candela by CGPM (Conférence Générale des Poids et Mesures) in 1979 [16] and CIPM in 1982 [13], a photometric quantity X_v is defined in relation to the corresponding radiometric quantity $X_{e,\lambda}$ by the equation:

$$X_v = K_m \int_{360\,\mathrm{nm}}^{830\,\mathrm{nm}} X_{e,\lambda}\, V(\lambda)\, d\lambda \tag{1}$$

The constant, K_m, relates the photometric quantities and radiometric quantities, and is called the *maximum spectral luminous efficacy (of radiation) for photopic vision*. The value of K_m is given by the 1979 definition of candela which defines the spectral luminous efficacy of light at the frequency 540 x 10^{12} Hz (at the wavelength 555.016 nm in standard air) to be 683 lm/W. The value of K_m is calculated as 683 x V(555.000 nm)/V(555.016 nm) = 683.002 lm/W [12]. K_m is normally rounded to 683 lm/W with negligible errors.

It should be noted that the $V(\lambda)$ function is defined for the *CIE standard photometric observer for photopic vision*, which assumes additivity of sensation and a 2° field of view at relatively high luminance levels (higher than approximately 1 cd/m^2). The human vision in this level is called photopic vision. The spectral responsivity of human vision deviates significantly at very low levels of luminance (less than approximately 10^{-3} cd/m^2). This type of vision is called scotopic vision. Its spectral responsivity, peaking at 507 nm, is designated by the $V'(\lambda)$ function, which was defined by CIE in 1951 [17], recognized by CIPM (Comité International des Poids et Mesures) in 1976 [18], and republished by CIPM in 1982 [13]. The human vision in the region between photopic vision and scotopic vision is called mesopic vision. While there have been active researches in this area [19], there is no internationally accepted spectral luminous efficiency function for the mesopic region yet. In current practice, almost all photometric quantities are given in terms of photopic vision, even at low light levels. Quantities in scotopic vision are seldom used except for special calculations for research purposes. Further details of the contents in this section are given in Ref. [12].

3. Photometric Base Unit, the Candela

The history of photometric standards dates back to the early nineteenth century, when the intensity of light sources was measured in comparison with a standard candle using visual bar photometers. At that time, the flame of a candle was used as a unit of luminous intensity that was called *the candle*. The old name for luminous intensity "candle power" came from this origin. Standard candles were gradually superseded by flame standards of oil lamps, and in the early twentieth century, investigations on platinum point blackbodies began at some national laboratories. An agreement was first established in 1909 among several national laboratories to use such a blackbody to define the unit of luminous intensity, and the unit was recognized as *the international candle*. This standard was adopted by the CIE in 1921. In 1948, it was adopted by the CGPM with a new Latin name "candela" with the definition:

> The candela is the luminous intensity, in the perpendicular direction, of a surface of 1/600000 square meter of a blackbody (full radiator) at the temperature of freezing platinum under a pressure of 101325 newton per square meter.

Although the 1948 definition served to establish the uniformity of photometric measurements in the world, difficulties in fabricating the blackbodies and in improving accuracy were addressed. Since the mid 1950s, suggestions were made to define the candela in relation to the optical power, watt, so that complicated source standards would not be necessary. Finally, in 1979, a new definition of the candela was adopted by the CGPM [16] as

> "The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 10^{12} hertz and that has a radiant intensity in that direction of (1/683) watt per steradian."

The value of K_m (683 lm/W) was determined in such a way that the consistency from the prior unit was maintained, and was determined based on the measurements by several national laboratories. Technical details on this redefinition of the candela are reported in Refs. [20-21]. This 1979 redefinition of the candela has enabled the derivation of the photometric units from the radiometric units using a variety of different techniques.

The early history of photometric standards is described in greater detail in Ref. [22].

4. Quantities and Units in Photometry and Radiometry

In 1960, the SI (Système International) was established, and the candela became one of the seven SI base units [23]. For further details on the SI, Refs. [23-26] can be consulted.

Several quantities and units, defined in different geometries, are used in photometry and radiometry. **Table 1** lists the photometric quantities and units, along with corresponding quantities and units for radiometry.

Table 1. Quantities and units used in photometry and radiometry.

Photometric quantity	Unit	relationship with lumen	Radiometric Quantity	Unit
Luminous flux	lm (lumen)		Radiant flux	W (watt)
Luminous intensity	cd (candela)	lm sr^{-1}	Radiant intensity	W sr^{-1}
Illuminance	lx (lux)	lm m^{-2}	Irradiance	W m^{-2}
Luminance	cd m^{-2}	lm sr^{-1} m^{-2}	Radiance	W sr^{-1} m^{-2}
Luminous exitance	lm m^{-2}		Radiant exitance	W m^{-2}
Luminous exposure	lx s		Radiant exposure	W m^{-2} s
Luminous energy	lm s		Radiant energy	J (joule)
Total luminous flux	lm (lumen)		Total radiant flux	W (watt)
Color temperature	K (kelvin)		Radiance temperature	K (kelvin)

While the candela is the SI base unit, the luminous flux (lumen) is perhaps the most fundamental photometric quantity, as the other photometric quantities are defined in terms of lumen with an appropriate geometric factor. The definitions of these photometric quantities are described below. The descriptions given here are simplified from the definitions given in official Refs. [7, 9]. Refer to these references for official, rigorous definitions.

4.1 Radiant Flux and Luminous Flux

Radiant flux (also called optical power or radiant power) is the energy Q (in Joules) radiated by a source per unit of time, expressed as

$$\Phi = \frac{\mathrm{d}Q}{\mathrm{d}t}. \tag{2}$$

The unit of radiant flux is the watt (W= J/s).

Luminous flux (Φ_v) is the time rate of flow of light as weighted by $V(\lambda)$. The unit of luminous flux is the lumen (lm). It is defined as

$$\Phi_v = K_m \int_\lambda \Phi_{e,\lambda}\, V(\lambda)\, \mathrm{d}\lambda \quad , \tag{3}$$

where $\Phi_{e,\lambda}$ is the spectral concentration of radiant flux as a function of wavelength λ. The term, luminous flux, is often used in the meaning of total luminous flux (see 4.8) in photometry.

4.2 Radiant Intensity and Luminous Intensity

Radiant intensity (I_e) or luminous intensity (I_v) is the radiant flux (luminous flux) from a point source emitted per unit solid angle in a given direction, as defined by

$$I = \frac{\mathrm{d}\Phi}{\mathrm{d}\Omega}, \tag{4}$$

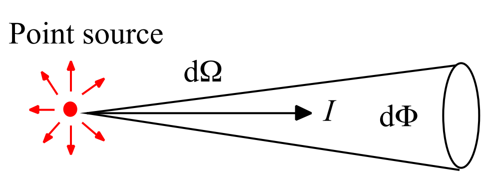

Figure 2. Radiant intensity and Luminous intensity

where $\mathrm{d}\Phi$ is the radiant flux (luminous flux) leaving the source and propagating in an element of solid angle $\mathrm{d}\Omega$ containing the given direction. The unit of radiant intensity is W/sr, and that of luminous intensity is the candela (cd = lm/sr).

Solid angle

The solid angle (Ω) of a cone is defined as the ratio of the area (A) cut out on a spherical surface (with its center at the apex of that cone) to the square of the radius (r) of the sphere, as given by

$$\Omega = \frac{A}{r^2}. \qquad (5)$$

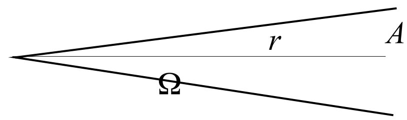

Figure 3. Solid angle

The unit of solid angle is steradian (sr), which is a dimensionless unit.

4.3 Irradiance and Illuminance

Irradiance (E_e) or illuminance (E_v) is the density of incident radiant flux or luminous flux at a point on a surface, and is defined as radiant flux (luminous flux) per unit area, as given by

$$E = \frac{d\Phi}{dA},$$

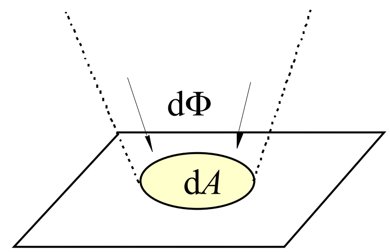

Figure 4. Irradiance and illuminance

where dΦ is the radiant flux (luminous flux) incident on an element dA of the surface containing the point. The unit of irradiance is W/m^2, and that of illuminance is lux (lx = lm/m^2).

4.4 Radiance and Luminance

Radiance (L_e) or luminance (L_v) is the radiant flux (luminous flux) per unit solid angle emitted from a surface element in a given direction, per unit projected area of the surface element perpendicular to the direction. The unit of radiance is W·sr^{-1}·m^{-2}, and that of luminance is cd/m^2. These quantities are defined by

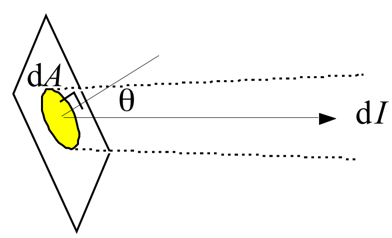

Figure 5. Radiance and luminance

$$L = \frac{d^2\Phi}{d\Omega \ \ dA \ \ \cos\theta}, \qquad (7)$$

where dΦ is the radiant flux (luminous flux) emitted (reflected or transmitted) from the surface element and propagating in the solid angle dΩ containing the given direction. dA is the area of the surface element, and θ is the angle between the normal to the surface element and the direction of the beam. The term dA cosθ gives the projected area of the surface element perpendicular to the direction of measurement.

4.5 Radiant Exitance and Luminous Exitance

Radiant exitance (M_e) or luminous exitance (M_v) is defined to be the density of radiant flux (luminous flux) leaving a surface at a point. The unit of radiant exitance is W/m^2 and that of luminous exitance is lm/m^2 (but it is not lux). These quantities are defined by

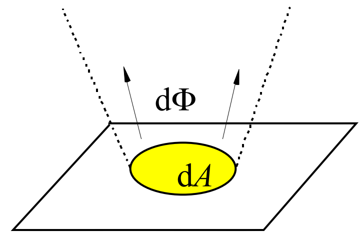

Figure 6. Radiant exitance and luminous exitance

$$E = \frac{\mathrm{d}\Phi}{\mathrm{d}A}, \tag{8}$$

where $\mathrm{d}\Phi$ is the radiant flux (luminous flux) leaving the surface element. Luminous exitance is rarely used in the general practice of photometry.

4.6 Radiant Exposure and Luminous Exposure

Radiant exposure (H_e) or luminous exposure (H_v) is the time integral of irradiance $E_e(t)$ or illuminance $E_v(t)$ over a given duration Δt, as defined by

$$H = \int_{\Delta t} E(t)\mathrm{d}t\,. \tag{9}$$

The unit of radiant exposure is J·m^{-2}, and that of luminous exposure is lux·second (lx·s).

4.7 Radiant Energy and Luminous Energy

Radiant energy (Q_e) or luminous energy (Q_v) is the time integral of the radiant flux or luminous flux (Φ) over a given duration Δt, as defined by

$$Q = \int_{\Delta t} \Phi(t)\mathrm{d}t\,. \tag{10}$$

The unit of radiant energy is Joule (J), and that of luminous energy is lumen·second (lm·s).

4.8 Total Radiant Flux and Total Luminous Flux

Total radiant flux or total luminous flux (Φ_v) is the geometrically total radiant (luminous) flux of a light source. It is defined as

$$\Phi = \int_{\Omega} I \;\mathrm{d}\Omega \tag{11}$$

or

$$\Phi = \int_{A} E \;\mathrm{d}A, \tag{12}$$

where I is the radiant (luminous) intensity distribution of the light source and E is the irradiance (illuminance) distribution over a given closed surface surrounding the light source. If the radiant (luminous) intensity distribution or the irradiance (illuminance) distribution is given in polar coordinates (θ,ϕ), the total radiant (luminous) flux of the source Φ is given by

$$\Phi = \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi} I(\theta,\phi) \sin\theta \, d\theta \, d\phi \tag{13}$$

or

$$\Phi = r^2 \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi} E(\theta,\phi) \sin\theta \, d\theta \, d\phi \, . \tag{14}$$

For example, the total luminous flux of an isotropic point source having luminous intensity of 1 cd would be 4π lumens.

4.9 Radiance Temperature and Color Temperature

Radiance temperature (unit: kelvin) is the temperature of the Planckian radiator for which the radiance at the specified wavelength has the same spectral concentration as for the thermal radiator considered.

Color temperature (unit: kelvin) is the temperature of a Planckian radiator with radiation of the same chromaticity as that of the light source in question. This term is commonly used to specify the colors of incandescent lamps even though the chromaticity coordinates of real incandescent lamps are not exactly on the blackbody locus. The next two terms are also important in photometry.

Distribution temperature (unit: kelvin) is the temperature of a blackbody with a spectral power distribution closest to that of the light source in question, and is used for quasi-Planckian sources such as incandescent lamps. Refer to Ref. [27] for details.

Correlated color temperature (unit: kelvin) is the temperature of the Planckian radiator whose perceived color most closely resembles that of the light source in question. Correlated color temperature is used for sources with a spectral power distribution significantly different from that of Planckian radiation (e.g., discharge lamps). Refer to Ref.[28] for details.

4.10 Relationship between SI units and English Units

The SI units as described above should be used in all radiometric and photometric measurements according to international standards and recommendations on SI units. However, some English units are still rather widely used in some countries, including the United States. The use of these non-SI units is discouraged. The definitions of these English units are given in Table 2 for conversion purposes only.

Table 2. English units and definition.

Unit	Quantity	Definition
foot-candle (fc)	illuminance	lumen per square foot (lm ft^{-2})
foot-Lambert (fL)	luminance	$1/\pi$ candela per square foot (π^{-1} cd ft^{-2})

The definition of foot-Lambert is such that the luminance of a perfect diffuser is 1 fL when illuminated at 1 fc. In the SI unit, the luminance of a perfect diffuser would be $1/\pi$ (cd/m^2) when illuminated at 1 lx. For convenience of changing from English units to SI units, the conversion factors are listed in Table 3. For example, 1000 lx is the same illuminance as 92.9 fc, and 1000 cd/m^2 is the same luminance as 291.9 fL. Conversion factors to and from some more units are given in Ref.[5].

Table 3. Conversion between English units and SI units.

To obtain the value in	multiply the value in	by
lx from fc	fc	10.764
fc from lx	lx	0.09290
cd/m^2 from fL	fL	3.4263
fL from cd/m^2	cd/m^2	0.29186
m (meter) from feet	feet	0.30480
mm (millimeter) from inch	inch	25.400

4.11 Troland

This unit is not an SI unit, not used in metrology, and is totally different from all other photometric units mentioned above. It is introduced here because this unit is commonly used by vision scientists. Troland is defined as the retinal illuminance when a surface of luminance one candela per square meter is viewed through a pupil at the eye (natural or artificial) of area one square millimeter. Thus, the troland value, T, for the luminance, L [cd/m^2], of an external field and the pupil size, p [mm^2], is given by

$$T = L \cdot p, \tag{15}$$

or, for pupil size p [m^2],

$$T = L \cdot 10^6 \times p. \tag{16}$$

The troland value is not the real illuminance in lux on the retina but is a quantity proportional to it. Since the natural pupil size changes with luminance level, luminance changes do not have a proportional visual effect. Thus, troland value rather than luminance is often useful in visual experiments. There is no simple or defined conversion between troland value (for natural pupil) and luminance [cd/m^2], without knowing the actual pupil size. Further details of this unit can be found in reference [29].

5. Principles in Photometry and Radiometry

Several important theories in practical photometry and radiometry are introduced in this section.

5.1 Inverse Square Law

Illuminance E [lx] at a distance d [m] from a point source having luminous intensity I[cd] is given by

$$E = \frac{I}{d^2}. \tag{17}$$

For example, if the luminous intensity of a lamp in a given direction is 1000 cd, the illuminance at 2 m from the lamp in this direction is 250 lx. Note that the inverse square law is valid only when the light source is regarded as a point source. Sufficient distances relative to the size of the source are needed to assume this relationship.

5.2 Lambert's Cosine Law

The luminous intensity of a Lambertian surface element is given by

$$I(\theta) = I_n \cos\theta . \tag{18}$$

Lambertian surface:
A surface whose luminance is the same in all directions of the hemisphere above the surface.

Perfect (reflecting/transmitting) diffuser:
A Lambertian diffuser with a reflectance (transmittance) equal to 1.

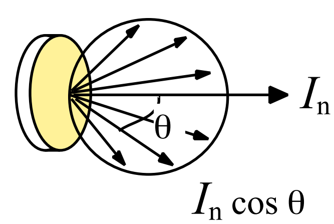

Figure 7. Lambert's cosine law

5.3 Relationship between Illuminance and Luminance

The luminance L [cd/m^2] of a Lambertian surface of reflectance ρ, illuminated by E [lx] is given by

$$L = \frac{\rho\ E}{\pi} \qquad (19)$$

Reflectance (ρ):
The ratio of the reflected flux to the incident flux in a given condition. The value of ρ can be between 0 and 1.

In the real world, there is no existing perfect diffuser nor perfectly Lambertian surfaces, and Eq. (19) does not apply. For real object surfaces, the following terms apply.

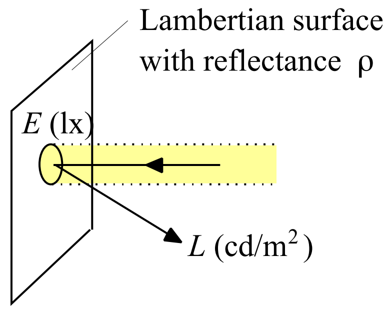

Figure 8. Relationship between illuminance and luminance

Luminance factor (β):
Ratio of the luminance of a surface element in a given direction to that of a perfect reflecting or transmitting diffuser, under specified conditions of illumination. The value of β can be larger than 1. For a Lambertian surface, reflectance is equal to the luminance factor. Eq.(19) for real object is restated using β as

$$L = \frac{\beta\ E}{\pi}. \qquad (20)$$

Luminance coefficient (q):
Quotient of the luminance of a surface element in a given direction by the illuminance on the surface element, under specified conditions of illumination.

$$q = \frac{L}{E}\ . \qquad (21)$$

Using q, the relationship between luminance and illuminance is thus given by

$$L = q \cdot E. \qquad (22)$$

Luminance factor corresponds to radiance factor, and luminance coefficient corresponds to radiance coefficient in radiometry. BRDF (bidirectional reflectance distribution function) is also used for the same concept as radiance coefficient.

5.4 Integrating Sphere

An integrating sphere is a device to make a spatial integration of luminous flux (or radiant flux) generated (or introduced) in the sphere and to detect it with a single photodetector. In the case of measurement of light sources, the spatial integration is made over the entire solid angle (4π).

In Fig. 1, assuming that the integrating sphere wall surfaces are perfectly Lambertian, the illuminance E on any part of the sphere wall created by luminance L of an element Δa is given by,

$$E = \frac{L\Delta a}{4R^2}. \tag{23}$$

where R is the radius of the sphere. This equation holds no matter where the two surface elements are. In other words, the same amount of flux incident anywhere on the sphere wall will create an equal illuminance on the detector port. In the case of actual integrating spheres, the surface is not perfectly Lambertian, but due to interreflections of light in the sphere, the distribution of reflected light will be uniform enough to assume the relationship of Eq. (23).

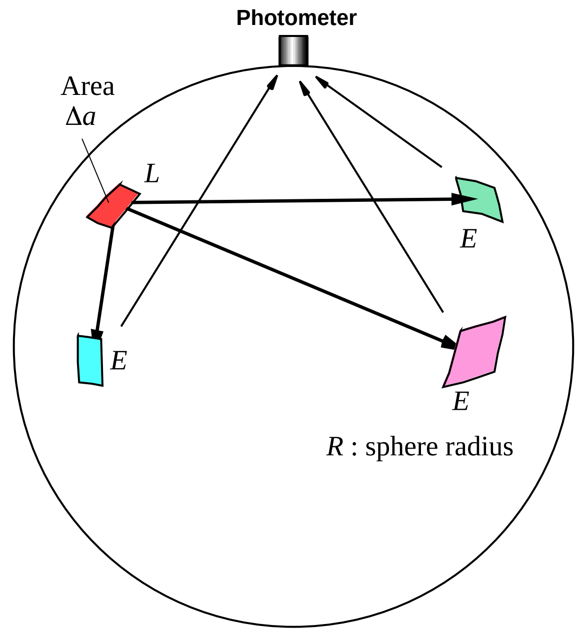

Figure 9. Flux transfer in a sphere.

The direct light from an actual light source is normally not uniform, thus is usually shielded from the detector. When a light source with luminous flux Φ is operated in a sphere having reflectance ρ, the flux created by interreflections is given by

$$\Phi(\rho + \rho^2 + \rho^3 + ...) = \Phi \frac{\rho}{1-\rho} \tag{24}$$

Then, the illuminance E_d created by all the interreflections is given by

$$E_d = \frac{\Phi \rho}{1-\rho} \frac{1}{4\pi R^2} \tag{25}$$

The sphere efficiency (E_d/Φ) is strongly dependent on reflectance ρ due to the term 1-ρ in the denominator. For example, the detector signal at ρ = 0.98 is 10 times larger than at ρ = 0.8.

5.5 Planck's Law

The spectral radiance of a blackbody at a temperature T [K] is given by,

$$L_e(\lambda,T) = c_1 n^{-2} \pi^{-1} \lambda^{-5} \left[\exp\left(\frac{c_2}{n\lambda T} \right) - 1 \right]^{-1} \tag{26}$$

where $c_1=2\pi hc^2=3.7417749 \times 10^{-16}$ W·m^2, $c_2=hc/k=1.438769 \times 10^{-2}$ m·K (1986 CODATA from Ref. [9]), h is Planck's constant, c is the speed of light in vacuum, k is the Boltzmann constant, n (=1.00028) is the refractive index of standard air [12, 30], and λ is the wavelength.

5.6 Wien's Displacement Law

Taking the partial derivative of the Planck's equation with respect to temperature T, and setting the result equal to zero, the solution yields the relationship between the peak wavelength λ_m for Planck's radiation and temperature T [K], as given by

$$\lambda_m T = 2897.8\ \mu\text{m}\cdot\text{K}. \tag{27}$$

This shows that the peak wavelength of blackbody radiation shifts to shorter wavelengths as the temperature of the blackbody increases.

5.7 Stefan-Boltzmann's Law

The (spectrally total) radiant exitance M_e from a blackbody in a vacuum is expressed in relation to the temperature T [K] of the blackbody, in the form

$$M_e(T) = \int_0^\infty M_e(\lambda,T)\,\mathrm{d}\lambda = \sigma T^4 \tag{28}$$

Where $M_e(\lambda,T)$ is the spectral radiant exitance of the blackbody, and σ is the Stefan-Boltzmann constant, equal to 5.67051×10^{-8} W·m^{-2}·K^{-4} (1986 CODATA from Ref. [9]). Using this value, the unit for M_e is W·m^{-2}.

6. Practice in Photometry and Radiometry

Photometry and radiometry are practiced in many different areas and applications, dealing with various light sources and detectors, and cannot be covered in this chapter. Various references are available on practical measurements in photometry and radiometry.

Further references in practical radiometry include books on absolute radiometry [31], optical detectors [32], spectroradiometry [33], photoluminescence [34], radiometric calibration [35], etc. There are a number of publications from CIE, which are regarded as international recommendations or standards. CIE publications in radiometry include reports on absolute radiometry [36], reflectance [37], spectroradiometry [38], detector spectral response [39], photobiology and photochemistry [40], etc. There are also a number of publications from National Institute of Standards and Technology (NIST) in radiometry, on spectral radiance [41], spectral irradiance [42], spectral reflectance [43], and spectral responsivity [44], etc. Ref. [45] provides greater depths of knowledge in radiometry.

For practical photometry, Ref. [4] provides the latest information on standards and practical measurements of photometry in many aspects. A recent publication from NIST [46] is also available. CIE Publications are also available on many subjects in photometry, including characterization of illuminance meters and luminance meters [47], luminous flux measurement [48], measurements of LEDs [49], characteristics of displays [50], and many others. A series of measurement guide documents are published from the Illuminating Engineering Society of North America (IESNA) for operation and measurement of particular types of lamps [51-53] and luminaires. The American Society for Testing and Materials (ASTM) provides many useful standards and recommendations on optical properties of materials and color measurements [54]. Colorimetry is a branch of radiometry and becoming increasingly important among color imaging industry and multimedia applications. The basis of colorimetry is provided by CIE publications [28, 55, 56], and many other authoritative references are available [29, 57].

For further treatment of issues in radiometry and measurement of optical properties of materials, two chapters in the previous volume of the Handbook of Optics [58, 59] can be referred to.

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Photometry is the science of the measurement of light, in terms of its perceived brightness to the human eye. It is distinct from radiometry, which is the science of measurement of radiant energy (including light) in terms of absolute power. In modern photometry, the radiant power at each wavelength is weighted by a luminosity function that models human brightness sensitivity. Typically, this weighting function is the photopic sensitivity function, although the scotopic function or other functions may Radiometry and Photometry for Vision Optics;Chapter 38. Spectroradiometry;Chapter 39. Nonimaging Optics: Concentration and Illumination;Chapter 40. Lighting and Applications;Index show more. About Michael Bass. The Optical Society of America is a professional society dedicated to serving optics professionals and academics, in the U.S. and around the world. Editor-in-Chief: Dr. Michael Bass is professor emeritus at the University of Central Florida's Center for Research and Education in Optics and Lasers (CREOL). Associate Editors: Dr. Casimer M. DeCusatis is a distinguished engineer and t