SIM METROLOGY SCHOOL

Photometry and Radiometry

SPEAKER

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Centro Nacional de Metrología (CENAM)

Bogotá, Colombia | August 2024

Historical evolution of the measurements in Photometry and Radiometry

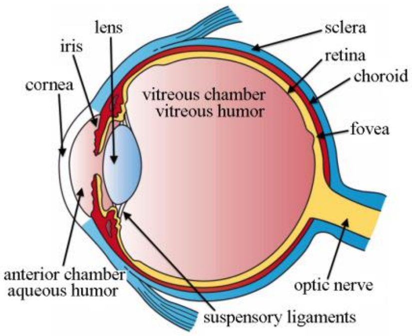
Artificial illumination

Light

Visible Light

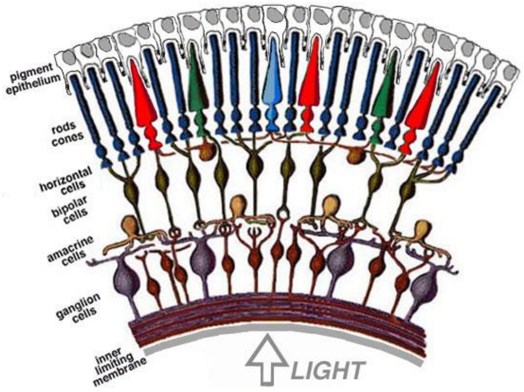
Optical radiation capable of causing a visual sensation directly

The visual sensation results from the process produced by the human visual system of the luminous stimulus (eye, optic nerve, brain visual center).

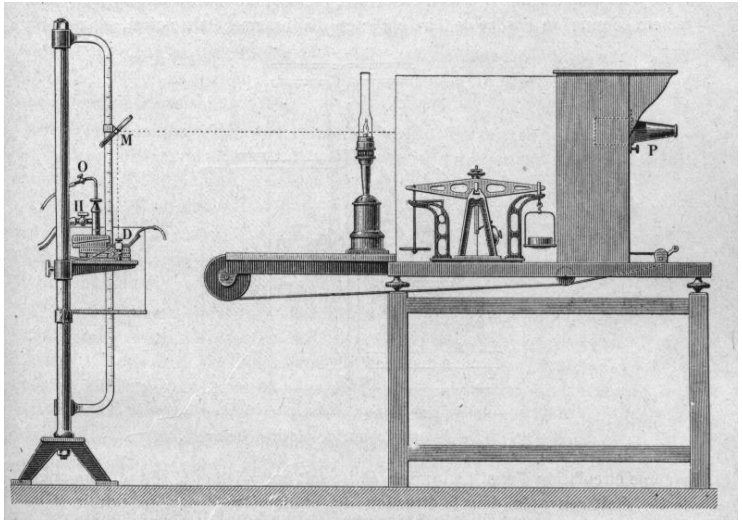


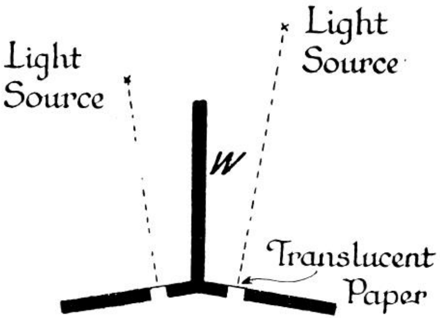
Photometry

Science that deals with optical radiation in the visible spectrum according to the effect produced in the human observer.



Historical evolution of measurements in photometry



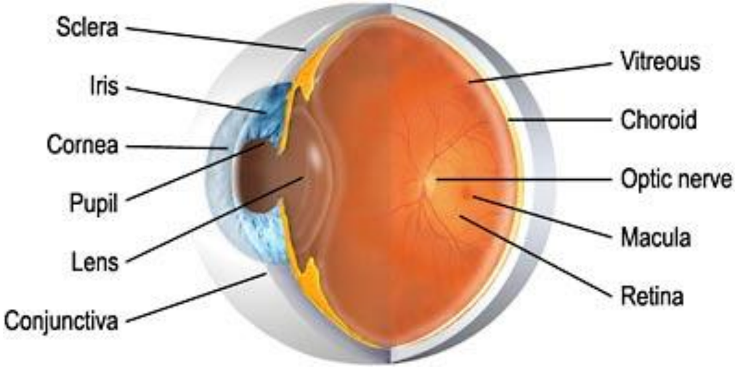


Fundament of photometry

The first optical detector

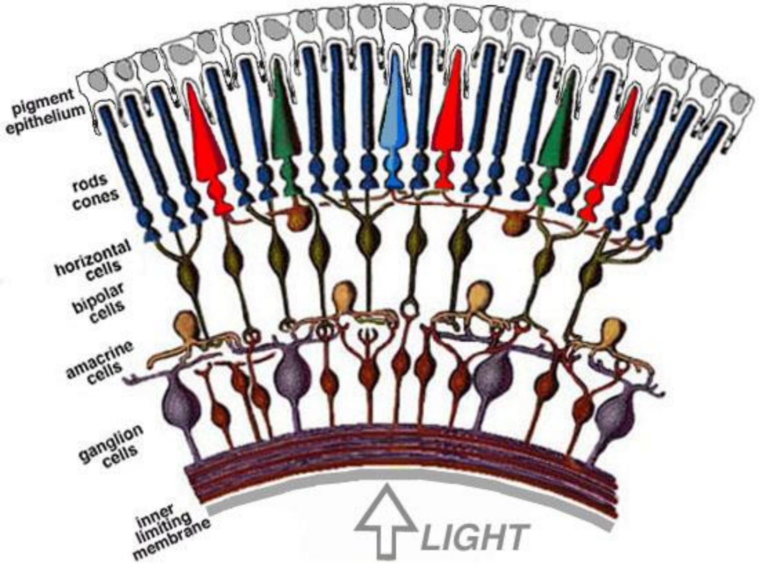
Characteristics

Cones: Low sensitivity (day light vision), High resolution, High temporal resolution, Acute, Chromatic vision (3 cones)
Rods: High sensitivity (night vision), Low resolution, achromatic vision (1 rod)
Ganglion cells
Pigment epithelium



Some data

- 38 % of the afferent nerve fibers are related to the visual system
- **Perception** is an active and creative process where **experience** plays a vital role

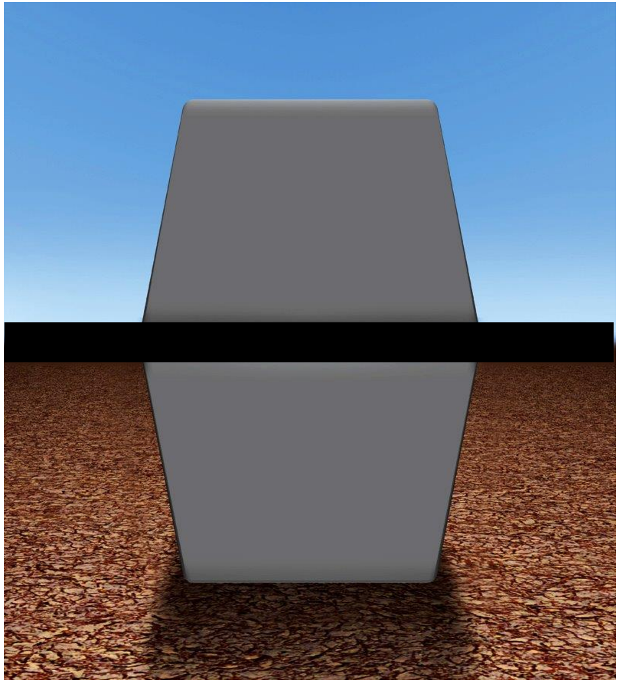


Visual agnosia

Shape: Can't recognize objects, real or drawn

Color: Recognition of proper color

Depp or movement: No stereoscopic vision, difficulties for identifying movement



Standard observer

ISO/CIE 23539 Photometry – The CIE system of physical photometry

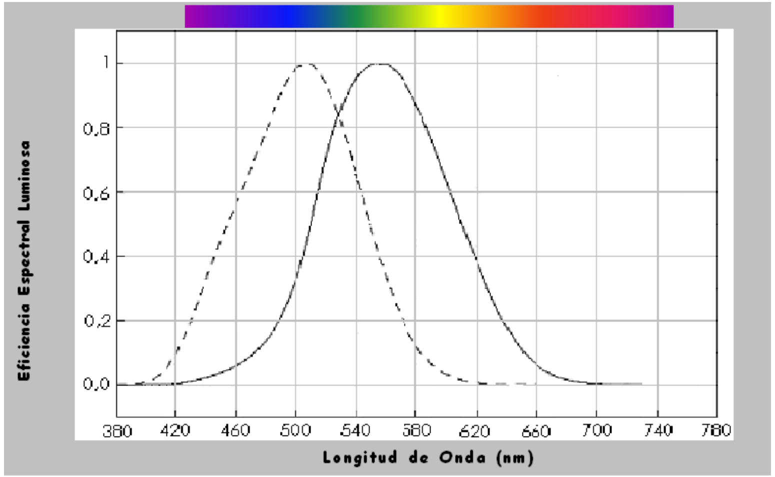
This international Standard specifies the characteristics of the system of physical photometry established by the CIE and accepted as the basis for the measurement of light. It defines the photometric quantities, units and standards that make up the CIE system of physical photometry and that have been officially accepted by the Comité International des Poids et Mesures (CIPM). They comprise:

- the definition of photometric quantities and units,
- the definition of **CIE standard spectral luminous efficiency** functions for photopic and scotopic vision,
- the definition of a **CIE standard photometric observer** that conforms to these functions,
- the definition of **maximum luminous efficacies** for photopic and scotopic vision.

CIE standard photometric observer

17-21-036

Ideal observer having a relative spectral responsivity curve that conforms to the spectral luminous efficiency function for photopic vision, *V*(*λ*), or to the function for scotopic vision, *V′*(*λ*), and that complies with the summation law implied in the definition of luminous flux

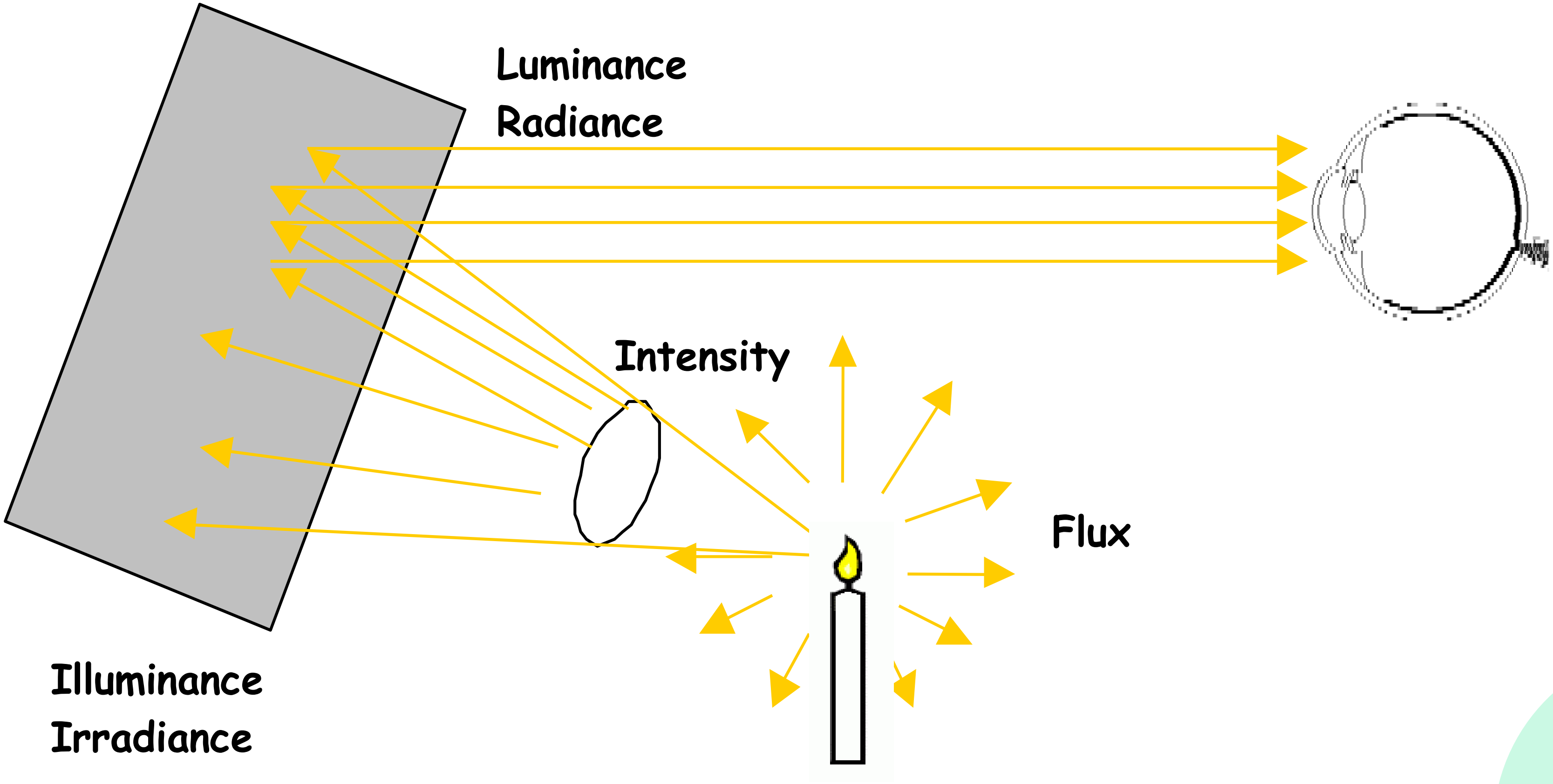


Note 1 to entry: See also ISO 23539:2005 (E)/CIE S 010/E: 2004 Photometry – The CIE System of Physical Photometry.

Note 2 to entry: This was numbered 845-01-23 in IEC 60050-845: 1987

Measurands and Quantities in Photometry and Radiometry

Measurands in photometry and radiometry



Quantities

Photometry and Radiometry

Radiometry			Photometry		
Radiant power	$\Phi_e = P_e$	W	Luminous flux	Φ_V	Lm
Radiant intensity	I_e	W/sr	Luminous intensity	I_V	cd
Radiance	L_e	$W/(sr \cdot m^2)$	Luminance	L_V	cd/m^2
Irradiance	E_e	W/m^2	Illuminance	E_V	lx

$$X_v = K_m \cdot \int_0^{\infty} V(\lambda) \cdot X(\lambda) d\lambda$$

Definition of quantities and units

ISO 80000-7 Quantities and units. Light and radiation

IEC 60050-845 International Electrotechnical Vocabulary - Lighting

CIE S 017 ILV International Lighting Vocabulary

https://www.electropedia.org

https://cie.co.at/e-ilv

Luminous intensity

The candela

The candela, symbol cd, is the SI unit of luminous intensity in a given direction. It is defined by taking the fixed numerical value of the luminous efficacy of monochromatic radiation of frequency 540 x 10^{12} Hz, K_{cd}, to be 683 when expressed in the unit lm W^{-1}, which is equal to cd sr W^{-1}, of cd sr kg^{-1} m^{-2} s^{3}, where the kilogram, metre and second are defined in terms of *h*, *c* and $\Delta\nu_{Cs}$.

This definition implies the exact relation of K_{cd} = 683 cd sr kg^{-1} m^{-2} s^{3} for monochromatic radiation of frequency ν = 540 x 10^{12} Hz. Inverting this relation gives an exact expression for the candela in terms of the defining constants K_{cd}, *h* and $\Delta\nu_{Cs}$:

$$1\,\mathrm{cd} = \left(\frac{K_{\mathrm{cd}}}{683}\right) \mathrm{kg\,m^2\,s^{-3}\,sr^{-1}} \frac{1}{((6.62607015x10^{34})(9192631770)^2\,683} (\Delta\nu_{\mathrm{Cs}})^2 h\, K_{\mathrm{cd}} \approx 2.614830x10^{10}\,(\Delta\nu_{\mathrm{Cs}})^2 h\, K_{\mathrm{cd}}$$

The effect of this definition is that one candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 10^{12} Hz and has a radiant intensity in that direction of (1/683) W/sr.

Quantities on Photometry

Luminous flux – lm

Φ_v; Φ

$$\mathbf{\Phi_V} = \frac{\mathrm{d}\boldsymbol{Q}_\mathrm{V}}{\mathrm{d}\boldsymbol{t}}$$

Radian flux / Radiant power - W

Φ_e; P_e ; Φ, P

$$\mathbf{\Phi_e} = \frac{\mathrm{d}\boldsymbol{Q}_\mathrm{e}}{\mathrm{d}\boldsymbol{t}}$$

Change in luminous energy with time radiant

Where $\boldsymbol{Q}_\mathrm{V}$ is the luminous energy emitted, transferred or received, and $\boldsymbol{t}$ is time

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

$$\mathbf{\Phi}_V = \boldsymbol{K}_\mathrm{m} \int_0^\infty \mathbf{\Phi}_{\mathrm{e},\lambda}(\lambda) V(\lambda)\, \mathrm{d}\lambda$$

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

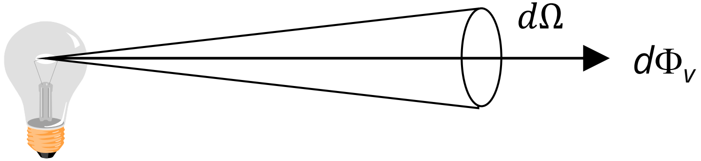
Quantities on Photometry

Luminous Intensity – cd

I_v; I

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

$$I_V = \frac{d\Phi_V}{d\Omega}$$



Where Φ_V is the luminous flux emitted in a specified 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.

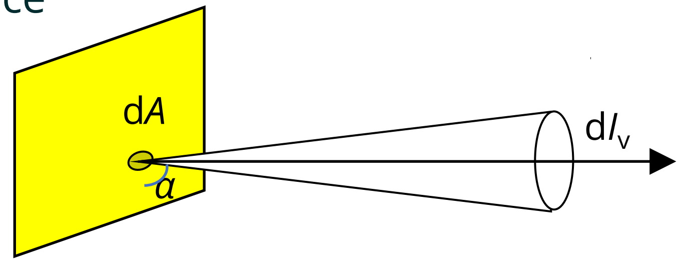
Quantities on Photometry

Luminance – cd/m²

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

$$L_V = \frac{dI_V}{dA}\frac{1}{\cos\alpha}$$



Where I_V is the luminous intensity, A is the area and α is the angle between the normal to the surface at the specified point and the specified direction

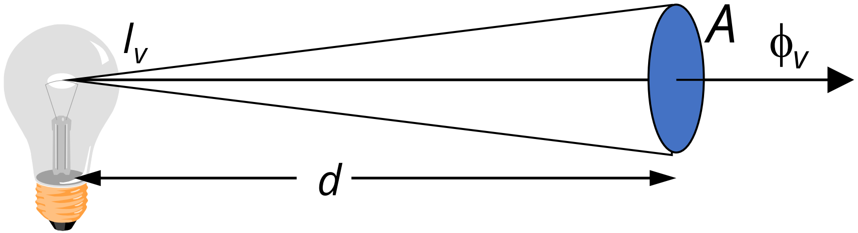
Quantities on Photometry

Illuminance – lx

E_v; E

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

$$E_V = \frac{d\Phi_V}{dA} = \frac{I_V}{d^2}$$



Where Φ_V is the luminous flux and A is the area in which the luminous flux is incident

Radiometry

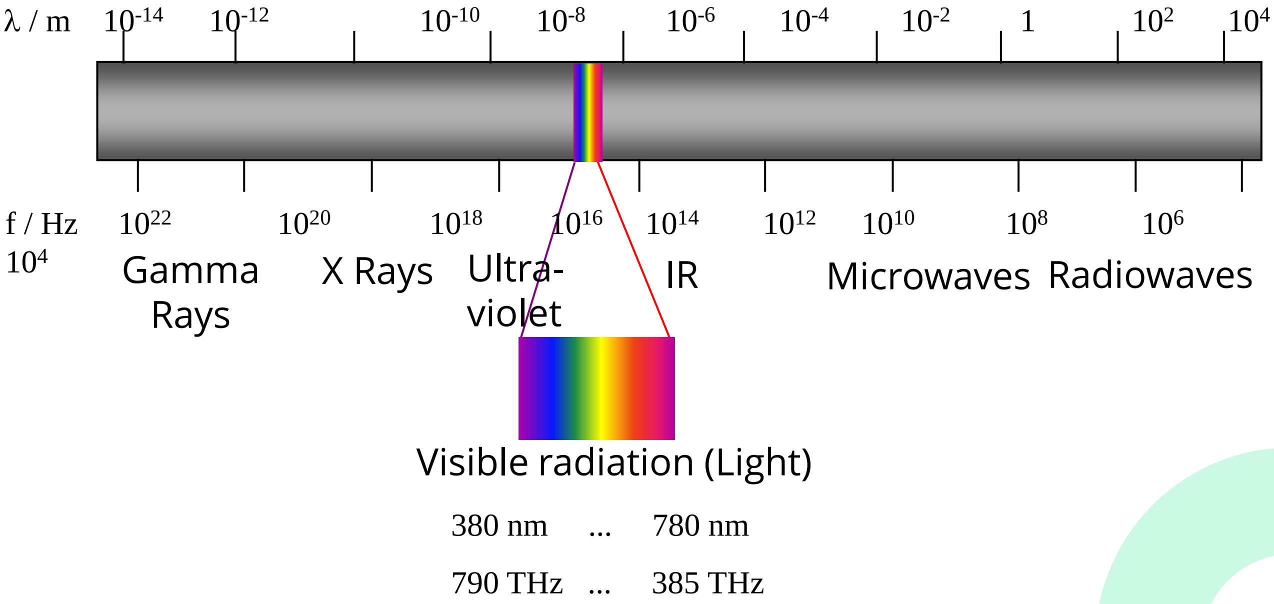
17-25-005

Measurement of the quantities associated with optical radiation

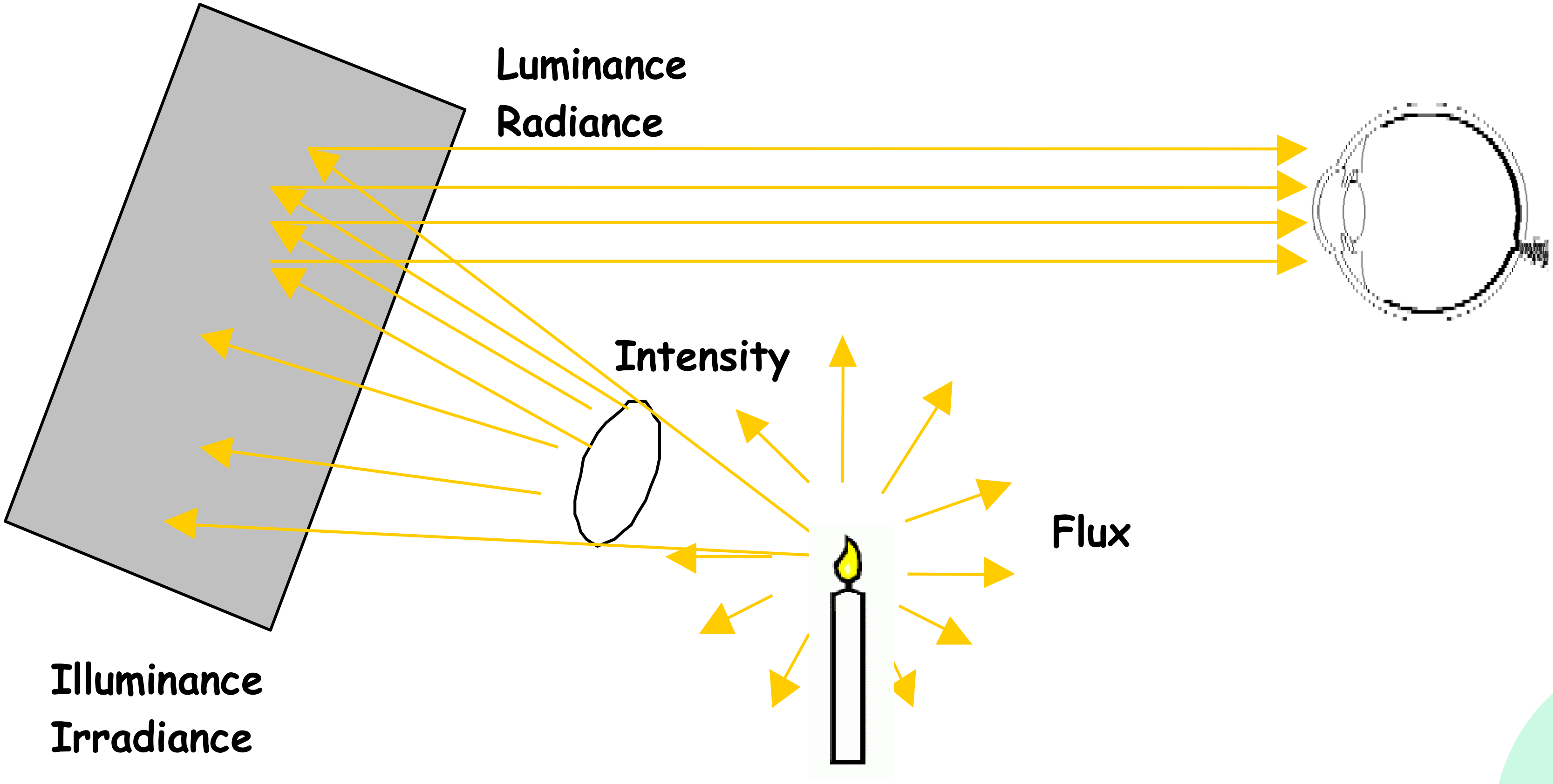
Optical Radiation

17-21-002

Electromagnetic radiation at wavelengths between the region of transition to X-rays (λ= 1 nm) and the region of transition to radio waves (λ = 1 mm)



Measurands in photometry and radiometry



Practical realization of the photometric and radiometric units

Mise en pratique for the definition of the candela and associated derived units for photometric and radiometric quantities in the SI

Consultative Committee for Photometry and Radiometry

1. Introduction

The purpose of this *mise en pratique*, prepared by the Consultative Committee for Photometry and Radiometry (CCPR) of the International Committee for Weights and Measures (CIPM) and formally adopted by the CIPM, is to indicate how the definition of the SI base unit, the candela, symbol cd, and the derived SI units lumen (lm), lux (lx) and candela per square metre (cd m^{-2}) may be realized in practice.

In general, the term “to realize a unit” is interpreted to mean the establishment of the value and associated

Mise en practique

For the definition of the candela and associated derived units for photometric and radiometric quantities in the SI

The scope of the mise en pratique **recognizes the fact that the two fields of photometry and radiometry and their units are closely related through the current definition of the SI base unit for the photometric quantity, luminous intensity: the candela. It covers the realization of the candela and other related units used for photometric and radiometric quantities.**

3.1 Photometry, radiometry and the candela

The definition of the candela is expressed in strictly physical terms and is given for only one frequency of the electromagnetic radiation. **The objective of photometry is to measure light in such a way that the result of the measurement correlates with the visual sensation of brightness experienced by a human observer** for the same radiation. Most light sources emit a broad spectrum of frequencies. For this purpose, the International Commission on Illumination (CIE) has defined a set of spectral weighting functions or action spectra, referred to as **spectral luminous efficiency functions** that describe the relative spectral sensitivity of the average human eye for specified visual conditions.

Mise en practique

For the definition of the candela and associated derived units for photometric and radiometric quantities in the SI

In 2007, the CIPM concluded an agreement with the CIE, in which the two organizations recognize that:

- **the CIPM is responsible for the definition of the photometric units in the SI** and
- **the CIE is responsible for the standardization of the spectral luminous efficiency functions of the human eye**

The general form of the equation relating a given spectral radiometric quantity $X_{e,\lambda}(\lambda)$ to its corresponding photometric quantity $X_{v,x}$ is given below:

$$X_{V,X} = \frac{K_{cd}}{V_X(\lambda_a)} \int_\lambda X_{e,\lambda}(\lambda)\, V_X(\lambda)\, d\lambda$$

where λ_a = 555.017 nm is the wavelength in standard air [3] at the frequency of 540 x 10^{12} Hz given in the definition of K_{cd} and $V_x(\lambda)$ is any of the CIE spectral luminous efficiency functions; the subscript "x" indicating the respective function.

Mise en practique

For the definition of the candela and associated derived units for photometric and radiometric quantities in the SI

The definition of the candela does not imply any particular experiment for its practical realization. While it is generally true that any method consistent with the laws of physics and the SI base unit definition may be used to realize any SI unit, base or derived, special considerations are required in the case of photometry to ensure that the realized unit is relevant for measurement of practical light sources, i.e. sources that emit not only at the wavelength corresponding to a frequency of 540×10^{12} Hz.

As the definition of the candela is based on K_{cd}, and therefore on radiometric units, the practical realization of the candela and the derived photometric units is almost always based on a practical realization of radiometric units. Thus, this mise en pratique logically begins with a description of methods for practical realization of radiometric units in order to provide the necessary foundation to describe the mise en pratique for the candela.

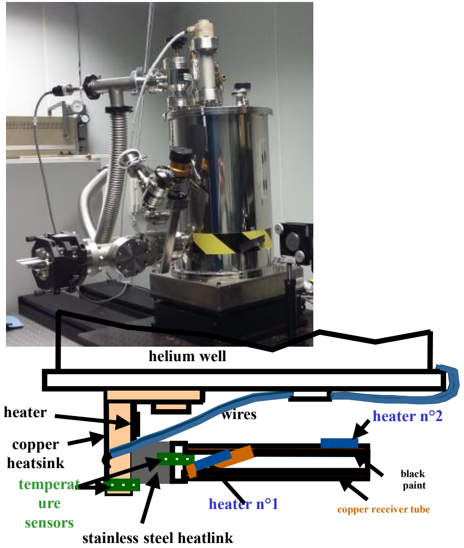
Mise en practique

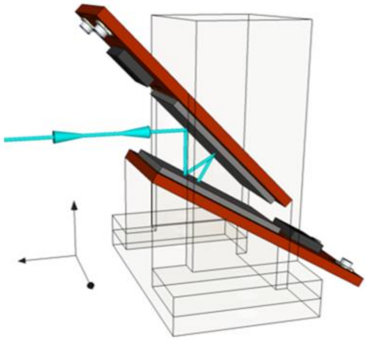
For the definition of the candela and associated derived units for photometric and radiometric quantities in the SI

5. Practical realization of radiometric units

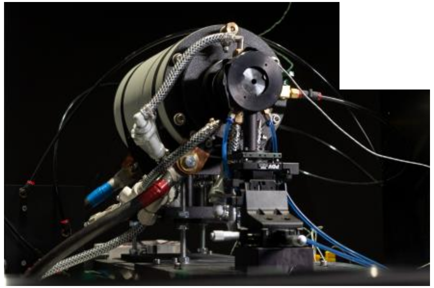
There are two types of primary methods in general use for realizing radiometric units. These are referred to as “detector-based” or “source-based” depending on whether they rely on a primary standard detector or primary standard source, respectively.

5.1 Detector-based radiometric traceability





Source-based radiometric traceability

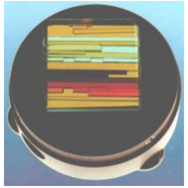


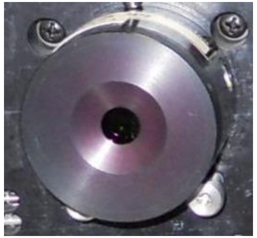
Mise en practique

For the definition of the candela and associated derived units for photometric and radiometric quantities in the SI

7.1.1 Detector-based photometric traceability

The most common method for realization of photometric units is to measure the photometric output of a standards-quality light source (described in more detail below in Section 7.2) in the desired geometric configuration using a reference photometric detector with a spectral responsivity that matches the desired luminous efficiency function and that has been spectrally calibrated for absolute irradiance responsivity traceable to an absolute radiometer (see 5.1) and which is equipped with a precise aperture, which has a calibrated area traceable to the SI unit of length.



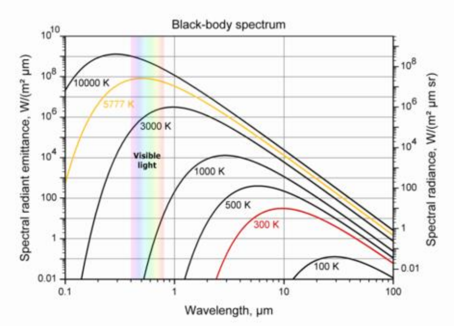


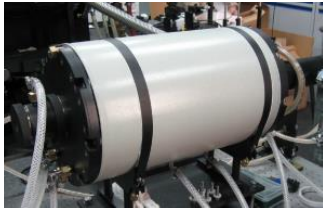
Mise en practique

For the definition of the candela and associated derived units for photometric and radiometric quantities in the SI

7.1.2 Source-based photometric traceability

The most common absolute (calculable) source is a **high temperature blackbody** (a cavity with high emissivity) whose **output radiant flux can be predicted from the thermodynamic temperature of the cavity using Planck's radiation law**. In this case, traceability is to the SI unit of temperature, the kelvin. However, at the high temperatures usually required for photometric applications, the thermodynamic temperature is generally determined by the inversion of Planck's law via a quasi-monochromatic measurement of the absolute radiant flux output of the radiator made using one or several narrow-band detector(s) that have been calibrated by reference to an absolute radiometer, as outlined in Section 5.1 above. In this case, the traceability is more appropriately considered to be "detector-based" to SI electrical units.





Mise en practique

For the definition of the candela and associated derived units for photometric and radiometric quantities in the SI

7.2 Practical realization of the candela (cd), SI base unit of luminous intensity, I_V.

The candela (cd) is most often realized using a standard lamp whose physical design is optimized for use in a defined direction to provide a light source (filament) that is small in relation to the distance between the source and the limiting aperture of the detector active area, such that it can be regarded as a point source in that specified direction. In the case of a **tungsten standard lamp** (the most commonly used form of standard lamp), the electrical operating parameters for the source are usually chosen such that the spectral output of the source approximates the defined **CIE Standard Illuminant A** [11], which has the same relative spectral output as a Planckian radiator operating at a temperature of approximately 2856 K.

International standards and publications related with measurements on photometry and radiometry

ISO/CIE

ISO/CIE 11664-1:2019 Colorimetry

- Part 1: CIE standard colorimetric observers
- Part 2: CIE Standard Illuminants
- Part 3: CIE tristimulus values
- Part 4: CIE 1976 L*a*b* colour space
- Part 5: CIE 1976 L*u*v* Colour Space and u', v' Uniform Chromaticity Scale Diagram
- Part 6: CIEDE2000 Colour-Difference Formula

ISO/CIE 19476:2014 Characterization of the Performance of Illuminance Meters and Luminance Meters

CIE

CIE S 025/E:2015 Test Method for LED Lamps, LED Luminaires and LED Modules

CIE 015:2018 Colorimetry, 4th Edition

CIE 044-1979 Absolute methods for reflection measurements

CIE 053-1982 Methods of characterizing the performance of radiometers and photometers

CIE 054.2:2001 Retroreflection: Definition & Measurement

CIE 084-1989 Measurement of luminous flux

CIE 105-1993 Spectroradiometry of pulsed optical radiation sources

CIE 121-1996 The Photometry & Goniophotometry of Luminaires

CIE 127:2007 Measurement of LEDs

International standards and publications related with measurements on photometry and radiometry

CIE

CIE 130-1998 Practical Methods for the Measurement of Reflectance and Transmittance

CIE 149:2002 The use of tungsten filament lamps as secondary standard sources

CIE 165:2005 CIE 10 degree photopic photometric observer

CIE 179:2007 Methods for characterizing tristimulus colorimeters for measuring the colour of light

CIE 182:2007 Calibration methods and photoluminescent standards for total radiance factor measurements

CIE 198:2011 Determination of Measurement Uncertainties in Photometry

CIE

CIE 202:2011 Spectral Responsivity Measurement of Detectors, Radiometers and Photometers

CIE 210:2014 Photometry Using V(λ)-Corrected Detectors as Reference and Transfer Standards

CIE 220:2016 Characterization and Calibration Methods of UV Radiometers

CIE 233:2019 Calibration, Characterization and Use of Array Spectroradiometers

CIE 239:2020 Goniospectroradiometry of Optical Radiation Sources

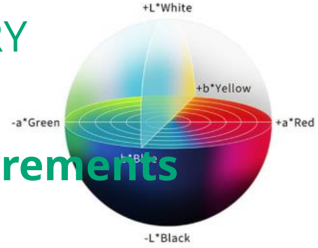
CIE 250:2022 Spectroradiometric measurement of optical radiation sources

CIE 251:2023 LED Reference Spectrum for Photometer Calibration

Other derived quantities

Other derived quantities

SEE: CLASSIFICATION OF SERVICES IN PHOTOMETRY AND RADIOMETRY



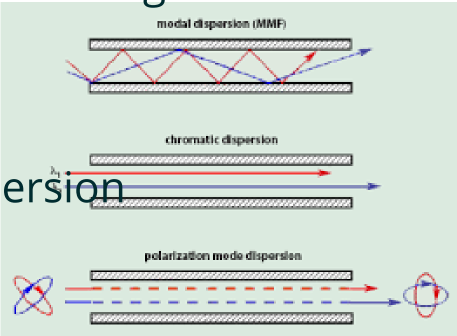
Properties of materials

Transmittance / Absorbance
Reflectance
Emissivity BRDF
Radiance factor
Wavelength
Refractive index
Angle of rotation of plane of polarization
Colour x,y,Y, L,a,b
Retroreflectance
Gloss Haze
Luminance factor
Whiteness

Spectrally integrated measurements and Fibre Optics

Distribution temperature
Correlated colour temperature
Colour emitted x, y, u, v, u’, v’, L*a*b*
Radiance flux, total
Colour rendering

Responsivity Wavelength
Modal properties
Attenuation
Chromatic dispersion
Polarization Mode Dispersion
Length (fiber, OTDR)



Consultative Committee for Photometry and Radiometry

Mission of CCPR

Between 1930 and 1933 the CCE dealt with matters concerning photometry. The Consultative Committee for Photometry (CCP) was set up in 1933, and its name was changed to Consultative Committee for Photometry and Radiometry in 1971.

Present activities concern measurement standards for photometric and radiometric quantities, development of absolute radiometry, and advice to the CIPM on matters concerned with radiometry and photometry.

President
Dr. M. L. Rastello
Former Scientifica Director
Istituto Nazionale di Ricerca Metrologica

Executive Secretary
Dr. J. Viallon - BIPM

Ex officio member
Dr. M.J.T. Milton
Director of the BIPM

August 2024

CCPR Members

August 2024

CENAM – Mexico
CMI – Check Republic
METAS – Switzerland
INMETRO – Brazil
IO-CSIC – Spain
KRISS – Korea
LNE – France
MSL – New Zealand
INRIM – Italy
NIM – China
NIST – United States of America
NMIA – Australia
NMS, A*STAR – Singapore

NMIJ/AIST – Japan
NMISA – South Africa
UME – Türkiye
NPL – United Kindom
NRC – Canada
NSC IM – Ukraine
JV – Norway
PMOD/WRC – Swiss
PTB – Germany
SMU – Slovakia
VSL – Netherlands
MIKES – Finland
VNIIOFI – Russia

SIM
SISTEMA INTERAMERICANO DE METROLOGIA

15 %

Official Observers
CMS/ITRI – Taiwan
SCL – Hong Kong

Liaisons
International Commission on Illumination – CIE
World Meteorological Organization - WMO

CCPR – Working Groups

CCPR-WG-CMC

CCPR Working group on CMCs

Chair: Dr. Marek Smid - Check Republic

Task Groups

CCPR-WG-CMC-TG1 USE OF COMPARISON RESULTS IN ASSESSMENT OF CMC CLAIMS	**CCPR-WG-CMC-TG2** UPDATE EXCEL PR CMC SUPPORTING EVIDENCE FILE
CCPR-WG-CMC-TG3 CLARIFY AND HARMONIZE THE CMC REVIEW PROCESS	**CCPR-WG-CMC-TG4** RECOMMENDING A CMC STRUCTURE FOR FIBRE OPTICS

CLASSIFICATION OF SERVICES IN PHOTOMETRY AND RADIOMETRY

Version No 17, 10 July 2023

METROLOGY AREA: PHOTOMETRY AND RADIOMETRY

https://www.bipm.org/en/committees/cc/ccpr

August 2024

CCPR – Working Groups

CCPR-WG-KC

CCPR Working group on key comparison

Chair: Dr Haiyong Gan – China

Task Groups

- CCPR-WG-KC-TG1
  PILOT COMPARISON FOR SPECTRAL REGULAR TRANSMITTANCE IN THE UV
- CCPR-WG-KC-TG2
  RMO LINKAGE
- CCPR-WG-KC-TG3
  COMPARISON ANALYSIS
- CCPR-WG-KC-TG4
  PILOT STUDY FOR THE USE OF ALTERNATIVE STANDARDS FOR PHOTOMETRIC COMPARISONS

https://www.bipm.org/en/committees/cc/ccpr

August 2024

CCPR – Working Groups

CCPR-WG-SP

CCPR Working group on strategic planning

Chair: Dr. Maria Nadal – USA

Task Groups

CCPR-WG-SP-TG6 DISCUSSION FORUM ON FIBRE OPTICS	**CCPR-WG-SP-TG7** DISCUSSION FORUM ON FEW-PHOTON METROLOGY
CCPR-WG-SP-TG8 TASK GROUP ON THZ METROLOGY	**CCPR-WG-SP-TG9** OTDR LENGTH COMPARISON
CCPR-WG-SP-TG10 CCPR STRATEGY DOCUMENT	**CCPR-WG-SP-TG11** SINGLE-PHOTON RADIOMETRY
CCPR-WG-SP-TG12 DISCUSSION FORUM ON THE USE OF WHITE LED SOURCES FOR PHOTOMETRY	**CCPR-WG-SP-TG13** OPTICAL FIBER POWER RESPONSIVITY
CCPR-WG-SP-TG14 RADIOMETRY TO SUPPORT GRAVITATIONAL WAVE DETECTION	**CCPR-WG-SP-TG15** THE IMPACT OF DIGITALIZATION ON MATTERS RELATED TO THE CCPR
CCPR-WG-SP-TG16 CONE FUNDAMENTAL	**CCPR-WG-SP-TG17** DISCUSSION FORUM ON METROLOGY FOR SATELLITE OBSERVATIONS

https://www.bipm.org/en/committees/cc/ccpr

August 2024

SIM – MWG 2 Photometry and Radiometry

SIM – MWG 2

Chair: Juan Pablo Babaro – INTI – Argentina August 2024

The Metrology Working Group for Photometry and Radiometry in SIM, MWG 2, supports SIM and its member NMIs in meeting the obligations under the CIPM MRA in the field of photometric and radiometric measurements

MWG 2 Activities:

- MWG 2 organizes regional key and supplementary comparisons in the field of radiometry and photometry, and links these SIM activities to the Consultative Committee for Photometry and Radiometry (CCPR) of the CIPM and to its counterparts in other Regional Metrology Organizations (RMOs).
- MWG 2 manages regional and Inter RMOs review of calibration and measurement capabilities (CMCs).
- MWG 2 facilitates cooperation in preparing, publishing and maintaining CMCs of member economies and of American NMIs.
- MWG 2 facilitates technical cooperation among its members through meetings, workshops and training opportunities at various NMIs.
- MWG 2 seeks harmonization among its members through sustainable networking.
- MWG 2 welcomes cooperation with other communities to promote and to share advanced technology.

SIM – MWG 2 Active NMIs

With recognized CMCs in BIPM-DB

- INTI – Argentina
- INMETRO – Brazil
- NRC – Canada
- LAMETRO – ICE – Costa Rica
- CENAM – Mexico
- NIST – USA

Without recognized CMCs in BIPM-DB

- IBMETRO – Bolivia
- INACAL – Peru
- INM – Colombia
- LATU - Uruguay

SIM – MWG 2 Project on going

UV Metrology: Evaluation of UVC Technologies for UV Radiation Disinfection

Description: Traceable UV metrology including sources/detectors and training to support SIM NMIs and DIs on the evaluation and calibration of UVC technologies for disinfection, including for SARS-CoV-2, the virus that causes COVID-19.

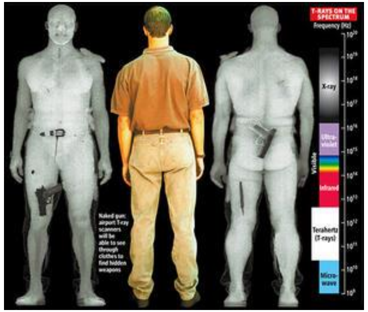
With NIST support.

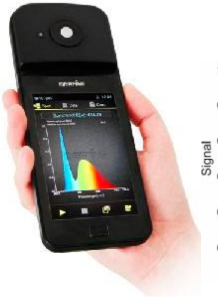
Current Technical Challenges and Future Trends

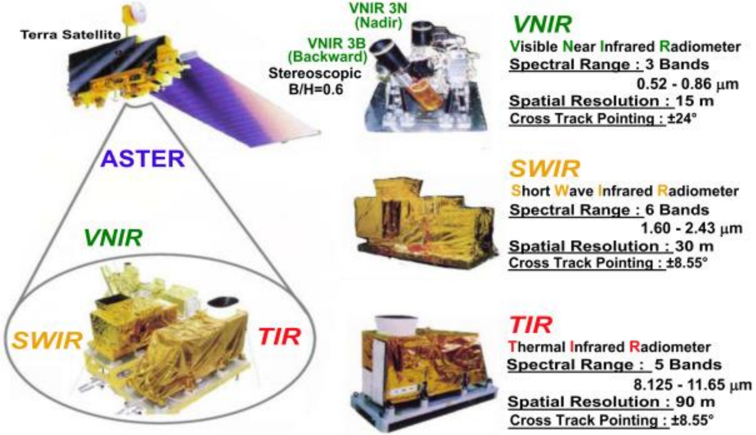
on Phomotery and Radiometry

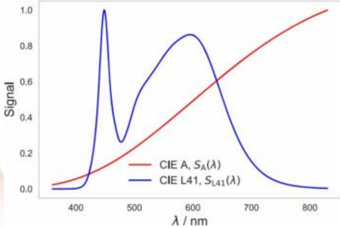
- Semiconductor manufacturing
- Health and safety, photo-biology, photo-chemistry
- Food, agriculture, biotechnology
- Quality of life, energy
- Military and security
- Telecommunications
- Meteorology, climate change, environment, space science – satellite obsevation
- Quantum cryptography
- Product quality (visual appearance)

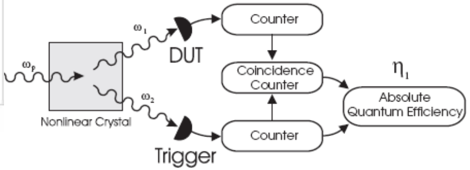
- Few Photons Metrology
- THz Metrology
- Future of the candela
- LED based standard lamps
- Digitalization
- UV metrology



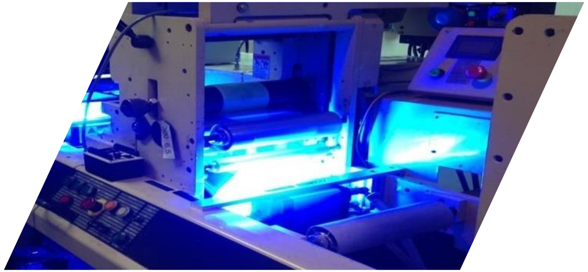



Terra Satellite
ASTER
VNIR
SWIR
TIR
VNIR 3N (Nadir)
VNIR 3B (Backward)
Stereoscopic B/H=0.6
VNIR
Visible Near Infrared Radiometer
Spectral Range : 3 Bands
0.52 - 0.86 μm
Spatial Resolution : 15 m
Cross Track Pointing : ±24°
SWIR
Short Wave Infrared Radiometer
Spectral Range : 6 Bands
1.60 - 2.43 μm
Spatial Resolution : 30 m
Cross Track Pointing : ±8.55°
TIR
Thermal Infrared Radiometer
Spectral Range : 5 Bands
8.125 - 11.65 μm
Spatial Resolution : 90 m
Cross Track Pointing : ±8.55°

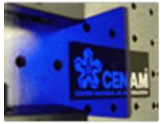

Signal
λ / nm
CIE A, $S_A(\lambda)$
CIE L41, $S_{L41}(\lambda)$


Counter
DUT
Coincidence Counter
η_1
Absolute Quantum Efficiency
Nonlinear Crystal
Counter
Trigger

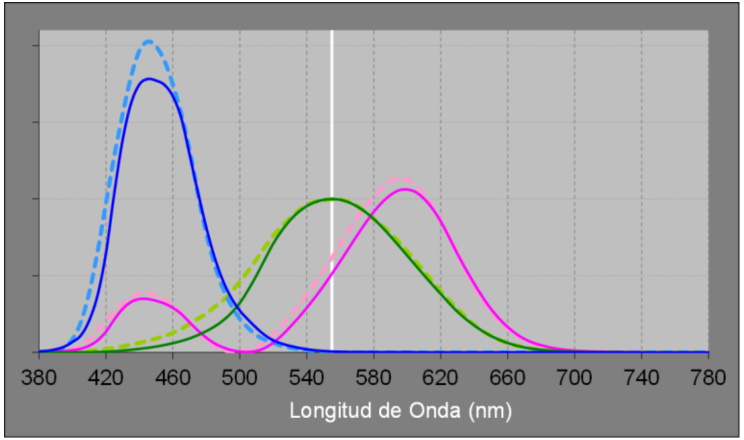

Optical Fiber
Communication

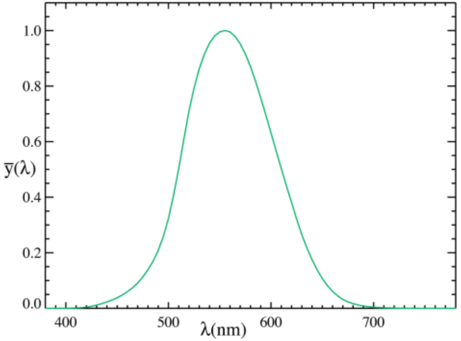


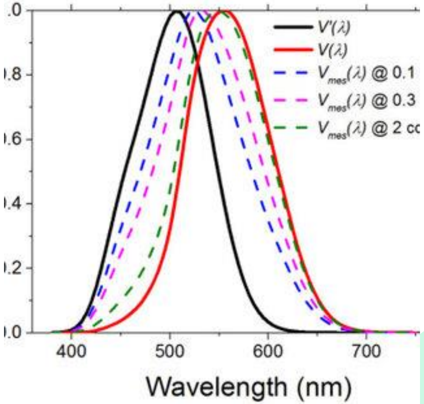












cie
International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

Celebrating 100 Years of V (λ)
with the art of light

Thanks!

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SIM METROLOGY SCHOOL

SIM SISTEMA INTERAMERICANO DE METROLOGÍA

CENAM CENTRO NACIONAL DE METROLOGÍA

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