



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

Userguide to the Equivalent Daylight (D65) Illuminance Toolbox

This Userguide relates to EDI Toolbox beta version E1.05 for Eindhoven Workshop

Tutorial on CIE S 026 - Use and application of the new metrology for
ipRGC-influenced responses to light - 15 March 2019, Eindhoven

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Toolbox main features

- **CIE S 026 calculations and conversions**

Weighted and unweighted quantities, α -opic equivalent daylight (D65) illuminance = EDI, etc.

- **Irradiance or radiance geometry**

Illuminance or luminance, α -opic equivalent daylight (D65) illuminance or luminance, etc.

- **Built-in illuminants**

A, D65, E, F11, LED-B3

- **User-defined Test spectrum**

Choice of resolution (1, 2, 4 or 5 nm) and SI prefixes (E,PT,G,M,k, ,m, μ ,n,p,f,a) / (,c,m)²



Toolbox optional features

- **Glossary and spectral weighting charts**

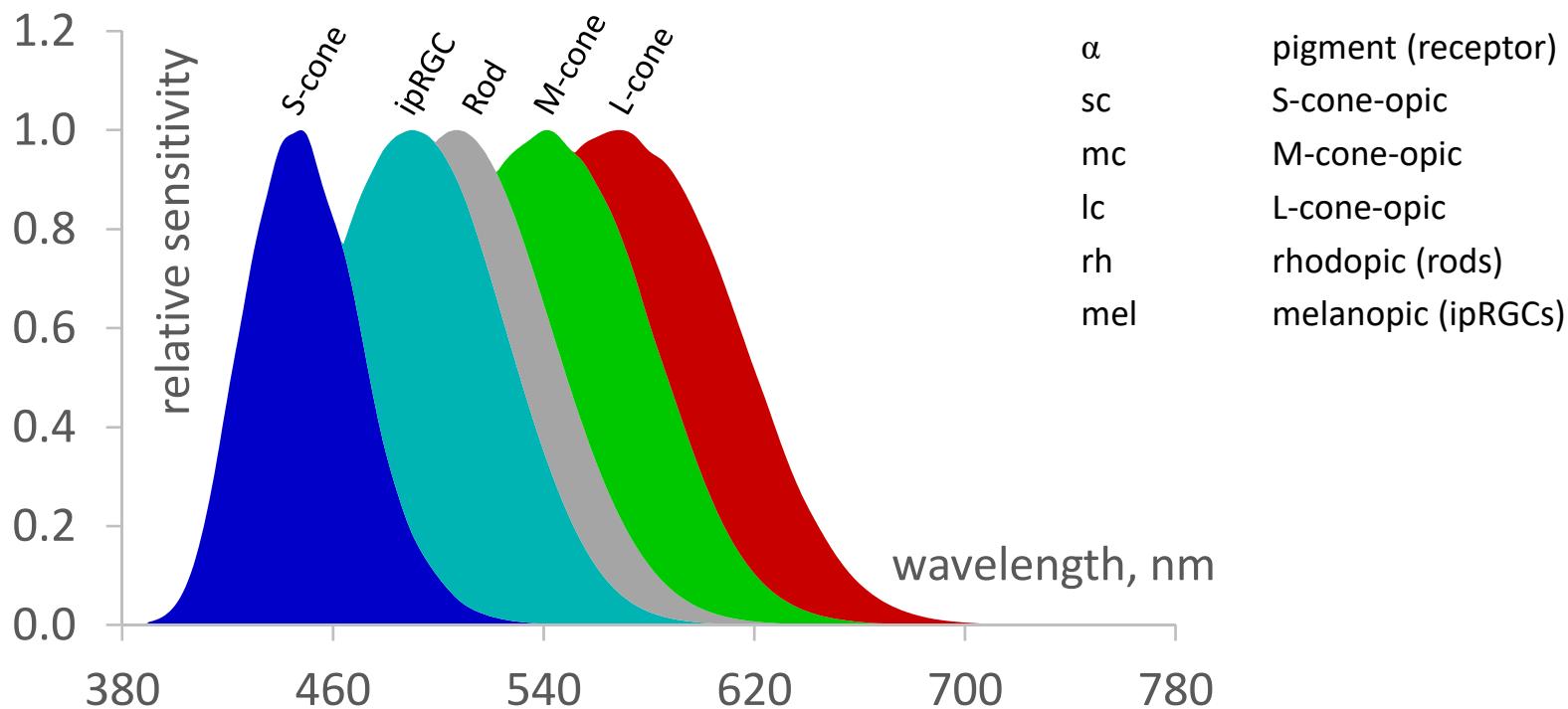
Version will be operational until 30 June 2019, when a final version is expected to be available.

The Equivalent Daylight (D65) Illuminance Toolbox and Userguide were designed by the International Commission on Illumination ("CIE") to enable calculations and conversions of measured quantities related to the non-visual effects of light, following the international standard *CIE S 026/E:2018. System for Metrology of Optical Radiation for ipRGC-Influenced Responses to Light. CIE, Vienna*.

This beta version (v1.05X) has been designed for early release and feedback from the participants of the *Tutorial on CIE S 026. Use and application of the new metrology for ipRGC-influenced responses to light. 14-15 March 2019, Eindhoven*. It is an important disclaimer that the user of the Toolbox should always check the results against manual calculations according to the standard.

After the 30 June 2019, a final version of the Toolbox is expected to be freely available. As a result, this beta version is programmed to stop working after this date. Considered feedback or enquiries about the Toolbox should be sent to Luke.Price@phe.gov.uk and I.j.m.schlangen@tue.nl who will endeavour to answer any questions as quickly as possible. The purpose of the toolbox is to support the usage of CIE S 026 but is not part of the official International Standard.

Five photoreceptors: Five α -opic action spectra





Examples of α -opic quantities

α -opic can be: S-cone-opic; M-cone-opic; L-cone-opic; Rhodopic; Melanopic

Quantity	Formula	Meaning	Unit
α -opic radiant flux	$\Phi_\alpha = \int \Phi_{e,\lambda}(\lambda) s_\alpha(\lambda) d\lambda$	weighted spectral power distribution (SPD) integrated over wavelength	W
α -opic irradiance	$E_\alpha = \int E_{e,\lambda}(\lambda) s_\alpha(\lambda) d\lambda$	weighted SPD integrated over wavelength per area	W/m ²
α -opic radiance	$L_\alpha = \int L_{e,\lambda}(\lambda) s_\alpha(\lambda) d\lambda$	weighted spectral radiance integrated over wavelength	W/(m ² ·sr)
α -opic efficacy of luminous radiation	$K_{\alpha,V} = \Phi_\alpha / \Phi_V$	quotient of α -opic radiant flux, Φ_α , and luminous flux, Φ_V	W/lm
α -opic equivalent daylight (D65) illuminance	$E_{V,\alpha}^{D65} = \frac{E_\alpha}{K_{\alpha,V}^{D65}}$	Illuminance level of daylight D65, producing an equal α -opic irradiance as the test source	lx



Physical Measurement of Radiation & Light

- By definition, light can only be measured using the photometric system

Photon system	Radiometric system	Photometric system
Unbounded	Unbounded	Bounded between 360 nm and 830 nm
Physical weighting Conserved property = number	Physical weighting Conserved property = energy	Psychophysical weighting $V(\lambda)$ Conserved property = brightness

Conversion factors

$$\rightarrow (hc/\lambda) \cdot n_a(\lambda) \quad \rightarrow K_{cd} \cdot V(\lambda)$$

where $K_{cd} = 683 \text{ lm.W}^{-1}$

CIE S 017/E:2011 is also freely available in a searchable electronic format at eilv.cie.co.at.



Toolbox Orientation

Inputs

CIE S 026 Toolbox

- Inputs

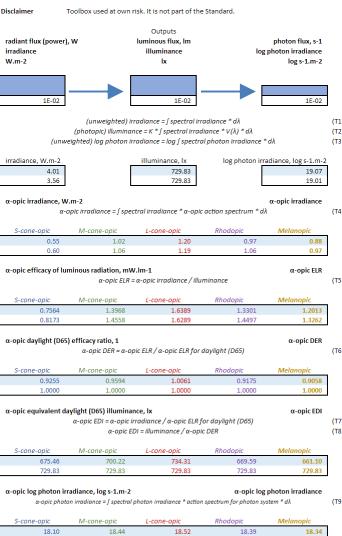
 1. Enter source of spectral data
 Select spectrum TEST
 2. Enter measurement details
 Spectral quantity Irradiance μ
 Input prefix c
 Area prefix
 3. Skip this step
 Clear this input 0.10
 4. Enter spectral resolution Resolution, nm 1
 5. Enter spectral irradiance data

Instructions + warnings

Outputs

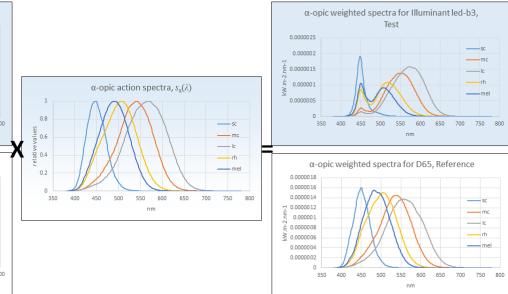
CIE S 026 Toolbox

- Output
 Inputs Basis of system: radiant flux (power), W
 Quantity: luminance μ
 Units: $\text{pW} \cdot \text{cm}^{-2}$
 Disclaimer Toolbox used own risk. It is not part of the Standard.
 Output prefix Area prefix μ
 Scaling factors 10^{-02}
 INPUTS At least one input error. Standard CIE S 026 calculations:
 Note to (T2) $k = k_{\mu} = 488 \text{ lm W}^{-1}$
 Note to (T3) etc. $\log = \log \text{base } 10$
 Values for Quick calculation Daylight (D65)
 $\alpha\text{-opic irradiance for Daylight}$



Charts

CIE S 026 Toolbox



Dark blue = data entry

* = Error indicators

Glossary

CIE S 026 Toolbox

Glossary
 List of symbols and abbreviations that can be used in scientific publications (units and formulae not shown)
 Previous page
 δ_{μ} = photon irradiance δ_{μ} , (i.e. unweighted) & δ_{μ} = (weighted) luminescence
 δ_{μ} = photon irradiance (i.e. unweighted) δ_{μ} + δ_{μ} = radiance (i.e. unweighted)
 δ_{μ} = photon irradiance (i.e. unweighted) & δ_{μ} = photon radiance (i.e. unweighted)
 From CIE S 026/2018
 λ = wavelength, nm
 λ_{c} = wavelength of the spectral weighting function (action spectrum)
 E_{μ} = $\alpha\text{-opic efficiency of luminous radiation}$, $\alpha\text{-opic ELR}$
 χ_{μ} = $\alpha\text{-opic ELR}$ for daylight (D65)
 χ_{μ} = $\alpha\text{-opic daylight (D65) efficiency ratio}$, $\alpha\text{-opic DER}$
 E_{μ} = $\alpha\text{-opic irradiance}$ (i.e. weighted by χ_{μ})
 χ_{μ} = $\alpha\text{-opic equivalent irradiance}$ (i.e. weighted by χ_{μ})
 χ_{μ} = $\alpha\text{-opic equivalent daylight (D65) efficiency ratio}$, $\alpha\text{-opic DER}$
 I_{μ} = $\alpha\text{-opic irradiance}$ (i.e. weighted by χ_{μ})
 I_{μ} = $\alpha\text{-opic equivalent daylight (D65) irradiance}$, $\alpha\text{-opic EDI}$
 From CIE S 026/2018 and the effect of SI Bureau (published draft)
 χ_{μ} = $\alpha\text{-opic equivalent daylight (D65) action spectrum in the photon system}$ (renormalised to maximum of 1)
 δ_{μ} = $\alpha\text{-opic photon irradiance}$ (i.e. weighted by χ_{μ})
 δ_{μ} = $\alpha\text{-opic photon radiance}$ (i.e. weighted by χ_{μ})
 From other quantities and their symbols can be derived, e.g. $\alpha\text{-opic equivalent daylight (D65) luminous flux}$, $\Phi^{\alpha\text{-ELR}}$. However, any other abbreviations, e.g., $\alpha\text{-opic EDI}$? may be ambiguous, and should be avoided.
 Due to prior publications, the subscript order for ELR and DER differs from $\alpha\text{-opic equivalent daylight (D65)}$ quantities.



Inputs: Quick calculations

For built-in spectra

1. Select from list
(5 CIE illuminants) < LED-B3 >

2. Select quantity
(6 options) < illuminance >
& units
(SI prefixes) < k > < blank >

3. Enter value
(The end) < 0.1 klx = 100 lx >

CIE S 026 Toolbox

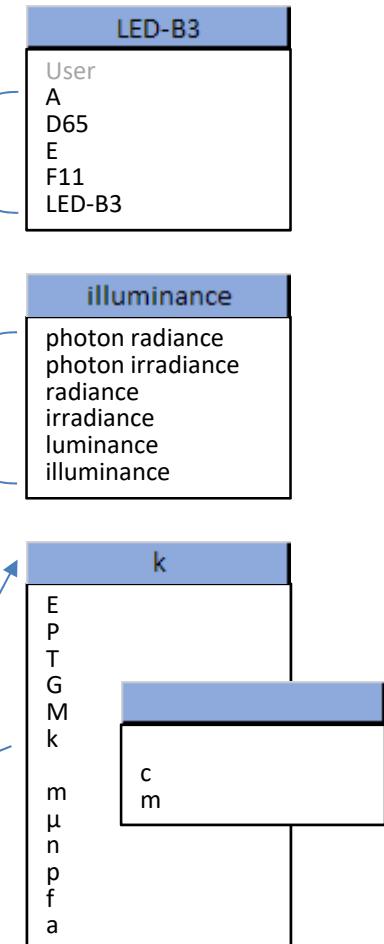
Inputs

Quick calculation

1. Enter source of spectral data
Select spectrum LED-B3

2. Enter measurement details
Quantity illuminance
Input prefix k
Clear this input

3. Enter illuminance value
Range 380 to 780 nm 0.10





Outputs: Results

Three basic quantities
irradiance, illuminance and log photon irradiance

α -opic irradiance
(in $\text{W} \cdot \text{m}^{-2}$)

α -opic ELR
efficacy of luminous radiation, (in $\text{mW} \cdot \text{lm}^{-1}$)

α -opic DER
daylight (D65) efficacy ratio, (dimensionless)

α -opic EDI
equivalent daylight (D65) illuminance, (in lux)
(in $\log_{10} \text{s}^{-1} \cdot \text{m}^{-2}$)

INPUTS: Standard CIE S 026 calculations. Note to (T2) $K = K_{\text{ref}} \approx 683 \text{ lm} \cdot \text{W}^{-1}$ Note to (T3) & (T9) $\log = \log \text{base } 10$					
Values for					
My calculation	315.52	100.00	13.952	(T1)	
Daylight (D65)	488.23	100.00	14.143	(T2)	
				(T3)	
α -opic irradiance for					
My calculation	128.70	101.26	83.87	α -opic irradiance	
Daylight (D65)	162.53	162.89	132.62	(T4)	
irradiance, $\text{mW} \cdot \text{m}^{-2}$		illuminance, lx		log photon irradiance, $\log \text{s} \cdot \text{cm}^{-2}$	
315.52	100.00	13.952			
488.23	100.00	14.143			
α -opic irradiance, $\text{mW} \cdot \text{m}^{-2}$					
α -opic irradiance = $\int \text{spectral irradiance} * V(\lambda) * d\lambda$					
α -cone- opic	$S\text{-cone-}\text{opic}$	$M\text{-cone-}\text{opic}$	$L\text{-cone-}\text{opic}$	$R\text{hodopic}$	$M\text{elanopic}$
50.57	128.70	162.53	101.26	83.87	
81.73	162.53	145.58	144.97	132.62	
α -opic efficacy of luminous radiation, $\text{mW} \cdot \text{lm}^{-1}$					
α -opic ELR = α -opic irradiance / illuminance				α -opic ELR	
				(T5)	
$S\text{-cone-}\text{opic}$	$M\text{-cone-}\text{opic}$	$L\text{-cone-}\text{opic}$	$R\text{hodopic}$	$M\text{elanopic}$	
0.5057	1.2870	1.6253	1.0126	0.8387	
0.8173	1.4558	1.6289	1.4497	1.3262	
α -opic daylight (D65) efficacy ratio, 1					
α -opic DER = α -opic ELR / α -opic ELR for daylight (D65)				α -opic DER	
				(T6)	
$S\text{-cone-}\text{opic}$	$M\text{-cone-}\text{opic}$	$L\text{-cone-}\text{opic}$	$R\text{hodopic}$	$M\text{elanopic}$	
0.6188	0.8840	0.9978	0.6985	0.6324	
1.0000	1.0000	1.0000	1.0000	1.0000	
α -opic equivalent daylight (D65) illuminance, lx					
α -opic EDI = α -opic irradiance / α -opic ELR for daylight (D65)				α -opic EDI	
				(T7)	
$S\text{-cone-}\text{opic}$	$M\text{-cone-}\text{opic}$	$L\text{-cone-}\text{opic}$	$R\text{hodopic}$	$M\text{elanopic}$	(T8)
61.88	88.40	99.78	69.85	63.24	
100.00	100.00	100.00	100.00	100.00	
α -opic log photon irradiance, $\log \text{s} \cdot \text{cm}^{-2}$					
α -opic photon irradiance = $\int \text{spectral photon irradiance} * \text{action spectrum for photon system} * d\lambda$				α -opic log photon irradiance	
				(T9)	
$S\text{-cone-}\text{opic}$	$M\text{-cone-}\text{opic}$	$L\text{-cone-}\text{opic}$	$R\text{hodopic}$	$M\text{elanopic}$	
13.056	13.544	13.666	13.411	13.315	
13.265	13.598	13.667	13.567	13.514	



Outputs: SI prefixes

CIE S 026 Toolbox

Outputs

Please note the toolbox is not part of the official International Standard. See Disclaimer sheet.

	Inputs		Outputs
Basis of system:	luminous flux, lm	Basis of system:	radiant flux (power), W
Quantity:	illuminance	Quantity:	irradiance
Units:	k lx	Units:	mW.m ⁻²
Output prefix	k		photon flux, s ⁻¹
Area prefix		m	log photon irradiance
Scaling factors	1E+03	1E+06	log s ⁻¹ .cm ⁻²



luminance, e.g. cd.mm⁻²
but not illuminance, lx



Outputs: Basic quantities

Irradiance
(in W.m⁻²)

Illuminance
(in lux)

Log photon irradiance
(in log₁₀ s⁻¹.m⁻²)

INPUTS: Standard CIE S 026 calculations.

Note to (T2) $K = K_{cd} \approx 683 \text{ lm.W}^{-1}$

Note to (T3) & (T9) log = log base 10

Values for

My calculation
Daylight (D65)

irradiance, W.m⁻²

0.32
0.49

(unweighted) irradiance = $\int \text{spectral irradiance} * d\lambda$
 (photopic) illuminance = $K * \int \text{spectral irradiance} * V(\lambda) * d\lambda$
 (unweighted) log photon irradiance = $\log \int \text{spectral photon irradiance} * d\lambda$

INPUTS: Standard CIE S 026 calculations.
 Note to (T2) $K = K_{cd} \approx 683 \text{ lm.W}^{-1}$
 Note to (T3) & (T9) log = log base 10

Values for

My calculation
Daylight (D65)

(unweighted) irradiance = $\int \text{spectral irradiance} * d\lambda$
 (photopic) illuminance = $K * \int \text{spectral irradiance} * V(\lambda) * d\lambda$
 (unweighted) log photon irradiance = $\log \int \text{spectral photon irradiance} * d\lambda$

(T1)
 (T2)
 (T3)

irradiance, W.m⁻² illuminance, lx log photon irradiance, log s⁻¹.m⁻²

0.32 100.00 17.952
 0.49 100.00 18.143

α -opic irradiance, W.m⁻²
 α -opic irradiance = $\int \text{spectral irradiance} * \alpha\text{-opic action spectrum} * d\lambda$

S-cone- α -opic	M-cone- α -opic	L-cone- α -opic	Rhodopic	Melanopic
0.05	0.13	0.16	0.10	0.08
0.08	0.15	0.16	0.14	0.13

α -opic efficacy of luminous radiation, mW.lm⁻¹
 α -opic ELR = α -opic irradiance / illuminance

S-cone- α -opic	M-cone- α -opic	L-cone- α -opic	Rhodopic	Melanopic
0.5057	1.2870	1.6253	1.0126	0.8387
0.8173	1.4558	1.6289	1.4497	1.3262

α -opic daylight (D65) efficacy ratio, 1
 α -opic DER = α -opic ELR / α -opic ELR for daylight (D65)

S-cone- α -opic	M-cone- α -opic	L-cone- α -opic	Rhodopic	Melanopic
0.6188	0.8840	0.9978	0.6985	0.6324
1.0000	1.0000	1.0000	1.0000	1.0000

(T1)
 (T2)

(T3)

log photon irradiance, log s⁻¹.m⁻²

17.952
 18.143



Outputs: Rescaling using SI prefixes

CIE S 026 Toolbox

Outputs

Please note the toolbox is not part of the official International Standard. See Disclaimer sheet.

Inputs

Basis of system: luminous flux, lm
 Quantity: illuminance
 Units: klx

Basis of system: radiant flux (power), W
 Quantity: irradiance
 Units: mW.m⁻²

Outputs

luminous flux, lm
 illuminance
 lx

photon flux, s⁻¹
 log photon irradiance
 log s^{-1.cm⁻²}

Output prefix	k
Area prefix	1E+03

m
1E+06

1E+03

c
1E-01

INPUTS: Standard CIE S 026 calculations.
 Note to (T2) $K = K_{cd} \approx 683 \text{ lm.W}^{-1}$
 Note to (T3) & (T9) log = log base 10

$$(\text{unweighted}) \text{ irradiance} = \int \text{spectral irradiance} * d\lambda \quad (\text{T1})$$

$$(\text{photopic}) \text{ illuminance} = K * \int \text{spectral irradiance} * V(\lambda) * d\lambda \quad (\text{T2})$$

$$(\text{unweighted}) \text{ log photon irradiance} = \log \int \text{spectral photon irradiance} * d\lambda \quad (\text{T3})$$

Values for
My calculation
Daylight (D65)

irradiance, mW.m ⁻²
315.52
488.23

illuminance, lx
100.00

log photon irradiance, log s ^{-1.cm⁻²}
13.952



Outputs: α -opic irradiance

E_α [in W.m^{-2}]

"effective photobiological irradiance with the spectral irradiance, $E_{e,\lambda}(\lambda)$, spectrally weighted with the α -opic action spectrum $s_\alpha(\lambda)$ "

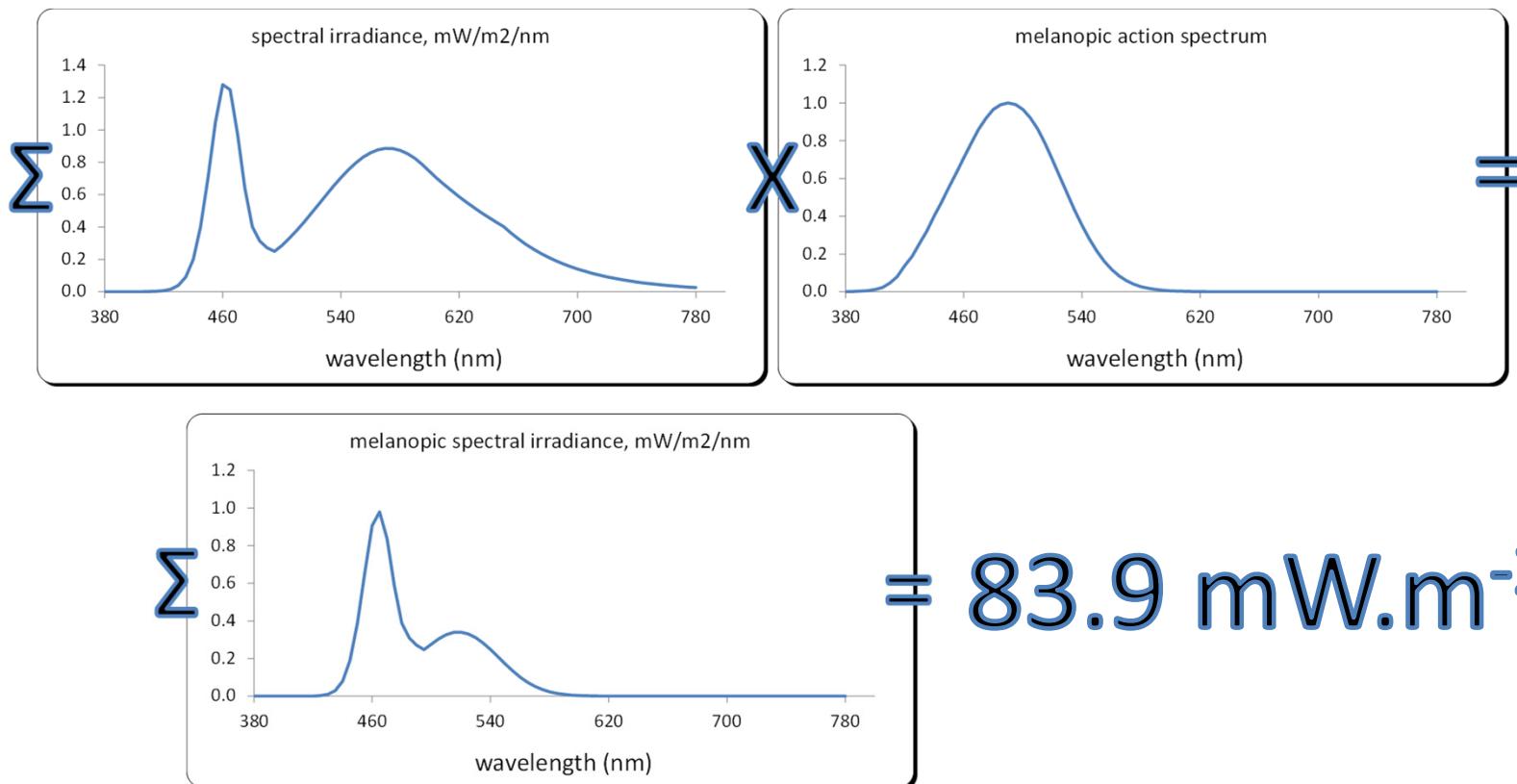
Basis of system:	radiant flux (power), W
Quantity:	irradiance
Units:	mW.m^{-2}
Output prefix	m
Area prefix	
Scaling factors	1E+06

α -opic irradiance for
My calculation
Daylight (D65)

INPUTS: Standard CIE S 026 calculations. Note to (T2) $K = K_{\text{ref}} \approx 683 \text{ lm.W}^{-1}$ Note to (T3) & (T9) $\log = \log \text{base 10}$	(unweighted) irradiance = $\int \text{spectral irradiance} * d\lambda$ (photopic) illuminance = $K * \int \text{spectral irradiance} * V(\lambda) * d\lambda$ (unweighted) log photon irradiance = $\log(\int \text{spectral photon irradiance} * d\lambda)$
Values for My calculation Daylight (D65)	irradiance, mW.m^{-2} 315.52 486.23
α -opic irradiance for My calculation Daylight (D65)	illuminance, lx 100.00 100.00
α -opic irradiance for My calculation Daylight (D65)	log photon irradiance, log s-1.cm^{-2} 13.952 14.143
	(T1) (T2) (T3)
	(T4)
	α -opic irradiance, mW.m^{-2} α -opic irradiance = $\int \text{spectral irradiance} * \alpha\text{-opic action spectrum} * d\lambda$
S-cone- α pic M-cone- α pic L-cone- α pic Rhodopic Melanopic	50.57 128.70 162.53 101.26 83.87 81.73 145.58 162.89 144.97 132.62
	(T4)
	α -opic efficacy of luminous radiation, mW.lm^{-1} α -opic ELR = α -opic irradiance / illuminance
S-cone- α pic M-cone- α pic L-cone- α pic Rhodopic Melanopic	0.5057 1.2870 1.6253 1.0126 0.8387 0.8173 1.4558 1.6289 1.4497 1.3262
	(T5)
	α -opic ELR
	(T5)
	α -opic DER α -opic DER = α -opic ELR / α -opic ELR for daylight (D65)
S-cone- α pic M-cone- α pic L-cone- α pic Rhodopic Melanopic	0.6188 0.8840 0.9978 0.6985 0.6324 1.0000 1.0000 1.0000 1.0000 1.0000
	(T6)
	α -opic DER
	(T6)
	α -opic equivalent daylight (D65) illuminance, lx α -opic EDI = α -opic irradiance / α -opic ELR for daylight (D65) α -opic EDI = illuminance / α -opic DER
	(T7) (T8)
	α -opic irradiance
	(T4)
	α -opic irradiance = $\int \text{spectral irradiance} * \alpha\text{-opic action spectrum} * d\lambda$
S-cone- α pic M-cone- α pic L-cone- α pic Rhodopic Melanopic	50.57 128.70 162.53 101.26 83.87 81.73 145.58 162.89 144.97 132.62
	(T4)



Calculating melanopic irradiance





Outputs: α -opic EDI

EDI = Equivalent Daylight (D65) Illuminance

"illuminance produced by radiation conforming to standard daylight (D65) that provides an equal α -opic irradiance, as the test source"

α -opic EDI for

My calculation
Daylight (D65)

S-cone-opic

M-cone-opic

L-cone-opic

Rhodopic

Melanopic

61.88
100.00

88.40
100.00

99.78
100.00

69.85
100.00

63.24
100.00

α -opic equivalent daylight (D65) illuminance, lx

α -opic EDI

α -opic EDI = α -opic irradiance / α -opic ELR for daylight (D65)

α -opic EDI = illuminance / α -opic DER

α -opic irradiance, mW.m ⁻² α -opic irradiance = \int spectral irradiance * α -opic action spectrum * dλ					α -opic irradiance (T4)
S-cone-opic	M-cone-opic	L-cone-opic	Rhodopic	Melanopic	
50.57 81.73	128.70 145.58	162.53 162.89	101.26 144.97	83.87 132.62	
α -opic efficacy of luminous radiation, mW.lm ⁻¹ α -opic ELR = α -opic irradiance / illuminance					α -opic ELR (T5)
S-cone-opic	M-cone-opic	L-cone-opic	Rhodopic	Melanopic	
0.5057 0.8173	1.2870 1.4558	1.6253 1.6289	1.0126 1.4497	0.8387 1.3262	
α -opic daylight (D65) efficacy ratio, 1 α -opic DER = α -opic ELR / α -opic ELR for daylight (D65)					α -opic DER (T6)
S-cone-opic	M-cone-opic	L-cone-opic	Rhodopic	Melanopic	
0.6188 1.0000	0.8840 1.0000	0.9978 1.0000	0.6985 1.0000	0.6324 1.0000	
α -opic equivalent daylight (D65) Illuminance, lx α -opic EDI = α -opic irradiance / α -opic ELR for daylight (D65) α -opic EDI = illuminance / α -opic DER					α -opic EDI (T7) (T8)
S-cone-opic	M-cone-opic	L-cone-opic	Rhodopic	Melanopic	
61.88 100.00	88.40 100.00	99.78 100.00	69.85 100.00	63.24 100.00	
α -opic log photon irradiance, log s·1.cm ⁻² α -opic photon irradiance = \int spectral photon irradiance * action spectrum for photon system * dλ					α -opic log photon irradiance (T9)
S-cone-opic	M-cone-opic	L-cone-opic	Rhodopic	Melanopic	
13.056 13.265	13.544 13.598	13.666 13.667	13.411 13.567	13.315 13.514	

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Outputs: Calculation of α -opic EDI

EDI = Equivalent
Daylight (D65)
Illuminance

"illuminance produced by radiation
conforming to standard daylight (D65)
that provides an equal α -opic irradiance,
as the test source"

$$E_{v,\alpha}^{D65} = E_\alpha \cdot E_v^{D65} / E_\alpha^{D65}$$

$$K_{\alpha,v}^{D65} = E_\alpha^{D65} / E_v^{D65}$$

$$E_{v,\alpha}^{D65} = E_\alpha / K_{\alpha,v}^{D65}$$

α -opic equivalent daylight (D65) illuminance, lx

α -opic EDI

α -opic EDI = α -opic irradiance / α -opic ELR for daylight (D65)

(T7)

α -opic EDI = illuminance / α -opic DER

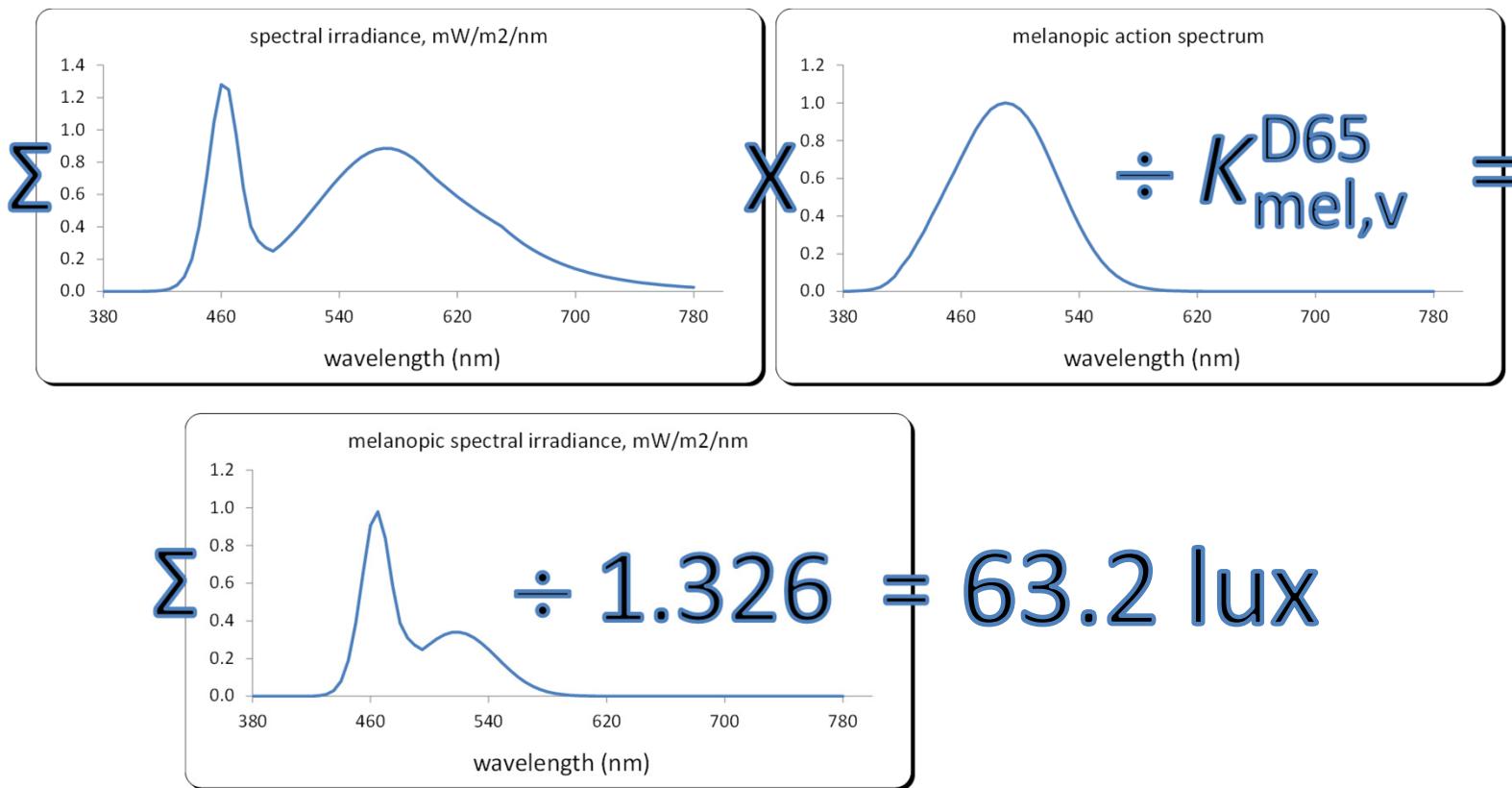
(T8)

α -opic EDI for

My calculation
Daylight (D65)

	S-cone-opic	M-cone-opic	L-cone-opic	Rhodopic	Melanopic
	61.88	88.40	99.78	69.85	63.24
	100.00	100.00	100.00	100.00	100.00

Calculating melanopic equivalent daylight (D65) illuminance





Calculation summary

melanopic
irradiance

÷

melanopic
ELR

=

melanopic
EDI

83.9 mW.m⁻²

÷

1.326 mW.lm⁻¹

=

63.2 lux

1 mW.m⁻²

÷

1 mW.lm⁻¹

=

1 lm.m⁻²

=

1 lux



$E_{p,\alpha}$ [in $\text{s}^{-1} \cdot \text{m}^{-2}$]

"effective photobiological photon irradiance with the spectral photon irradiance, $E_{p,\lambda}(\lambda)$ (or number of photons per second per square metre), spectrally weighted with the α -opic action spectrum $s_{p,\alpha}(\lambda)$ "

Output prefix
Area prefix
Scaling factors

C
1E-01

Outputs: α -opic photon irradiance

Measurement value (input sheet)

The value should match the quantity name and units selected, and shown above. Leave blank if using a spectral input.

Displayed to 2 d.p., but enter to required accuracy. Take extra care with accuracy for log quantities.

α -opic Irradiance				
$\text{Irradiance} = \int \text{spectral irradiance} * \alpha\text{-opic action spectrum} * d\lambda$				
α -opic	L-cone-opic	Rhodopic	Melanopic	
128.70	162.53	101.26	83.87	(T4)
145.58	162.89	144.97	132.62	

α -opic ELR				
$\text{ELR} = \alpha\text{-opic Irradiance} / \text{illuminance}$				
α -opic	L-cone-opic	Rhodopic	Melanopic	
1.2870	1.6253	1.0126	0.8387	(T5)
1.4558	1.6289	1.4497	1.3262	

α -opic DER				
$\text{DER} = \alpha\text{-opic ELR} / \alpha\text{-opic ELR for daylight (D65)}$				
α -opic	L-cone-opic	Rhodopic	Melanopic	
0.8840	0.9978	0.6985	0.6324	(T6)
1.0000	1.0000	1.0000	1.0000	

α -opic EDI					
$\text{EDI} = \alpha\text{-opic Irradiance} / \alpha\text{-opic ELR for daylight (D65)}$					
$\alpha\text{-opic EDI} = \text{illuminance} / \alpha\text{-opic DER}$					
α -opic	S-cone-opic	M-cone-opic	L-cone-opic	Rhodopic	
65) Illuminance, I_x	61.88	88.40	99.78	69.85	(T7)
	100.00	100.00	100.00	100.00	63.24

α -opic log photon irradiance					
$\alpha\text{-opic photon irradiance} = \int \text{spectral photon irradiance} * \text{action spectrum for photon system} * d\lambda$					
α -opic	S-cone-opic	M-cone-opic	L-cone-opic	Rhodopic	
65) Illuminance, I_x	13.056	13.544	13.666	13.411	(T8)
	13.265	13.598	13.667	13.567	13.315

α -opic log photon irradiance for

My calculation
Daylight (D65)

S-cone-opic
M-cone-opic
L-cone-opic

	S-cone-opic	M-cone-opic	L-cone-opic	Rhodopic	Melanopic
13.056	13.544	13.666	13.411	13.315	
13.265	13.598	13.667	13.567	13.514	



Inputs: User-defined spectrum

For user spectra

1. Select TEST

< User >

2. Select quantity

(4 options) < irradiance >

& units

(SI prefixes) < μ > < c >

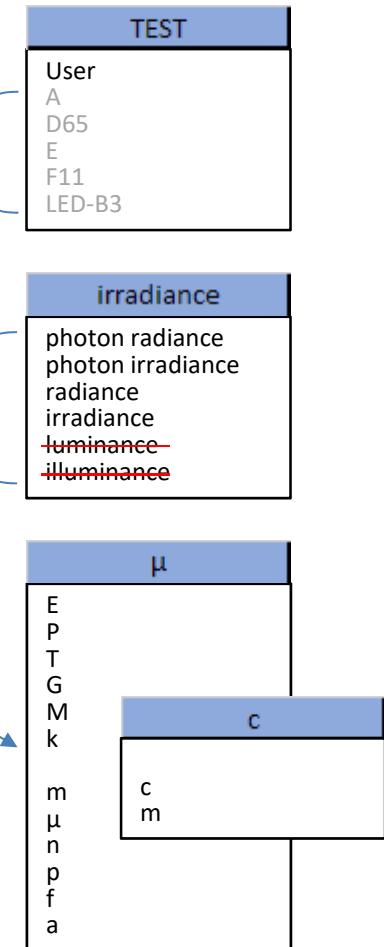
CIE S 026 Toolbox

Inputs

USER DEFINED SPECTRUM 001

1. Enter source of spectral data
Select spectrum User

2. Enter measurement details
Spectral quantity irradiance
Input prefix μ
Area prefix c





Inputs: User-defined spectrum (2)

2. Select quantity
(4 options) < irradiance >
& units
(SI prefixes) < μ > < c >

3. Clear step 3
4. Enter resolution
(1,2,4 or 5 nm) < 2 >
5. and spectrum
(380 nm to 780 nm)

2. Enter measurement details

Spectral quantity → **irradiance**

Input prefix → **μ**

Area prefix → **c**

3. Skip this step

Clear this input

4. Enter spectral resolution

Resolution, nm → **2**

5. Enter spectral irradiance data

nm	$\mu\text{W.cm}^{-2}\text{.nm}^{-1}$
380	1.000
382	1.000
384	1.000
386	1.000
388	1.000
390	1.000



Outputs: what else (1)

$\alpha\text{-opic ELR}$ [in $\text{mW} \cdot \text{lm}^{-1}$]

(efficacy of luminous radiation)

$$K_{\alpha,V}^{\text{D65}} = E_{\alpha}^{\text{D65}} / E_{V}^{\text{D65}}$$

Why? Because...

$$E_{V,\alpha}^{\text{D65}} = E_{\alpha} / K_{\alpha,V}^{\text{D65}}$$

$\alpha\text{-opic ELR}$ for

My calculation
Daylight (D65)

$\alpha\text{-opic irradiance, mW.m}^{-2}$					$\alpha\text{-opic irradiance}$
					$(T4)$
$S\text{-cone-opic}$ $M\text{-cone-opic}$ $L\text{-cone-opic}$ $Rhodopic$ $Melanopic$					
50.57 128.70 162.53 101.26 83.87					
81.73 145.58 162.89 144.97 132.62					
$\alpha\text{-opic efficacy of luminous radiation, mW.lm}^{-1}$					$\alpha\text{-opic ELR}$
					$\alpha\text{-opic ELR} = \alpha\text{-opic irradiance} / \text{illuminance}$
					$(T5)$
$S\text{-cone-opic}$ $M\text{-cone-opic}$ $L\text{-cone-opic}$ $Rhodopic$ $Melanopic$					
0.5057 1.2870 1.6253 1.0126 0.8387					
0.8173 1.4558 1.6289 1.4497 1.3262					
$\alpha\text{-opic daylight (D65) efficacy ratio, 1}$					$\alpha\text{-opic DER}$
					$\alpha\text{-opic DER} = \alpha\text{-opic ELR} / \alpha\text{-opic ELR for daylight (D65)}$
					$(T6)$
$S\text{-cone-opic}$ $M\text{-cone-opic}$ $L\text{-cone-opic}$ $Rhodopic$ $Melanopic$					
0.6188 0.8840 0.9978 0.6985 0.6324					
1.0000 1.0000 1.0000 1.0000 1.0000					
$\alpha\text{-opic equivalent daylight (D65) illuminance, lx}$					$\alpha\text{-opic EDI}$
					$\alpha\text{-opic EDI} = \alpha\text{-opic irradiance} / \alpha\text{-opic ELR for daylight (D65)}$
					$\alpha\text{-opic EDI} = \text{illuminance} / \alpha\text{-opic DER}$
					$(T7)$
					$(T8)$
$S\text{-cone-opic}$ $M\text{-cone-opic}$ $L\text{-cone-opic}$ $Rhodopic$ $Melanopic$					
61.88 88.40 99.78 69.85 63.24					
100.00 100.00 100.00 100.00 100.00					
$\alpha\text{-opic log photon irradiance, log s}^{-1}\text{cm}^{-2}$					$\alpha\text{-opic log photon irradiance}$
					$\alpha\text{-opic photon irradiance} = \int \text{spectral photon irradiance} * \text{action spectrum for photon system} * d\lambda$
					$(T9)$
$S\text{-cone-opic}$ $M\text{-cone-opic}$ $L\text{-cone-opic}$ $Rhodopic$ $Melanopic$					
13.056 13.544 13.666 13.411 13.335					
13.265 13.598 13.667 13.567 13.514					
$\alpha\text{-opic efficacy of luminous radiation, mW.lm}^{-1}$					$\alpha\text{-opic ELR}$
					$\alpha\text{-opic ELR} = \alpha\text{-opic irradiance} / \text{illuminance}$
					$(T5)$

$\alpha\text{-opic ELR}$ for

My calculation
Daylight (D65)

$S\text{-cone-opic}$

$M\text{-cone-opic}$

$L\text{-cone-opic}$

$Rhodopic$

$Melanopic$

0.5057

1.2870

1.6253

1.0126

0.8387

0.8173

1.4558

1.6289

1.4497

1.3262



Outputs: what else (2)

$\alpha\text{-opic DER}$ [no units]

(daylight (D65) efficacy ratio)

$$\gamma_{\alpha,v}^{D65} = K_{\alpha,v} / K_{\alpha,v}^{D65}$$

Why? Because...

$$E_{v,\alpha}^{D65} = E_v \cdot \gamma_{\alpha,v}^{D65}$$

$\alpha\text{-opic DER}$ for

USER DEFINED SPECTRUM 001
Daylight (D65)

S-cone-opic

M-cone-opic

L-cone-opic

Rhodopic

Melanopic

0.6188

0.8840

0.9978

0.6985

0.6324

1.0000

1.0000

1.0000

1.0000

1.0000

$\alpha\text{-opic daylight (D65) efficacy ratio, 1}$

$\alpha\text{-opic DER} = \alpha\text{-opic ELR} / \alpha\text{-opic ELR for daylight (D65)}$

$\alpha\text{-opic DER}$

(T6)

$\alpha\text{-opic irradiance, mW.m}^{-2}$					$\alpha\text{-opic irradiance}$
$\alpha\text{-opic irradiance} = \int \text{spectral irradiance} * \alpha\text{-opic action spectrum} * d\lambda$					(T4)
<i>S-cone-opic</i>	<i>M-cone-opic</i>	<i>L-cone-opic</i>	<i>Rhodopic</i>	<i>Melanopic</i>	
50.57	128.70	162.53	101.26	83.87	
81.73	145.58	162.89	144.97	132.62	

$\alpha\text{-opic efficacy of luminous radiation, mW.lm}^{-1}$					$\alpha\text{-opic ELR}$
$\alpha\text{-opic ELR} = \alpha\text{-opic irradiance} / \text{illuminance}$					(T5)
<i>S-cone-opic</i>	<i>M-cone-opic</i>	<i>L-cone-opic</i>	<i>Rhodopic</i>	<i>Melanopic</i>	
0.5057	1.2870	1.6253	1.0126	0.8387	
0.8173	1.4558	1.6289	1.4497	1.3262	

$\alpha\text{-opic daylight (D65) efficacy ratio, 1}$					$\alpha\text{-opic DER}$
$\alpha\text{-opic DER} = \alpha\text{-opic ELR} / \alpha\text{-opic ELR for daylight (D65)}$					(T6)
<i>S-cone-opic</i>	<i>M-cone-opic</i>	<i>L-cone-opic</i>	<i>Rhodopic</i>	<i>Melanopic</i>	
0.6188	0.8840	0.9978	0.6985	0.6324	
1.0000	1.0000	1.0000	1.0000	1.0000	

$\alpha\text{-opic equivalent daylight (D65) illuminance, lx}$					$\alpha\text{-opic EDI}$
$\alpha\text{-opic EDI} = \alpha\text{-opic irradiance} / \alpha\text{-opic ELR for daylight (D65)}$					(T7)
$\alpha\text{-opic EDI} = \text{illuminance} / \alpha\text{-opic DER}$					(T8)
<i>S-cone-opic</i>	<i>M-cone-opic</i>	<i>L-cone-opic</i>	<i>Rhodopic</i>	<i>Melanopic</i>	
61.88	88.40	99.78	69.85	63.24	
100.00	100.00	100.00	100.00	100.00	

$\alpha\text{-opic log photon irradiance, log s}^{-1}\text{cm}^{-2}$					$\alpha\text{-opic log photon irradiance}$
$\alpha\text{-opic photon irradiance} = \int \text{spectral photon irradiance} * \text{action spectrum for photon system} * d\lambda$					(T9)
<i>S-cone-opic</i>	<i>M-cone-opic</i>	<i>L-cone-opic</i>	<i>Rhodopic</i>	<i>Melanopic</i>	
13.056	13.544	13.666	13.411	13.335	
13.265	13.598	13.667	13.567	13.514	

cie Glossary

List of symbols and abbreviations that can be used in scientific publications (units and formulae not shown)

Previously published

E_v = (photopic) illuminance & L_v = (photopic) luminance

$E = E_e$ = irradiance (*i.e.* unweighted) & $L = L_e$ = radiance (*i.e.* unweighted)

E_p = photon irradiance (*i.e.* unweighted) & L_p = photon radiance (*i.e.* unweighted)

From CIE S 026:2018

$s_\alpha(\lambda) = s_{e,\alpha}(\lambda)$ = α -opic spectral weighting function (action spectrum)

$K_{\alpha,v}$ = α -opic efficacy of luminous radiation, α -opic ELR

$K^{D65}_{\alpha,v}$ = α -opic ELR for daylight (D65)

$\gamma_{\alpha,v}$ = α -opic daylight (D65) efficacy ratio, α -opic DER

$E_\alpha = E_{e,\alpha}$ = α -opic irradiance (*i.e.* weighted by $s_\alpha(\lambda)$)

$E^{D65}_{v,\alpha}$ = α -opic equivalent daylight (D65) illuminance, α -opic EDI

$L_\alpha = L_{e,\alpha}$ = α -opic radiance (*i.e.* weighted by $s_\alpha(\lambda)$)

$L^{D65}_{v,\alpha}$ = α -opic equivalent daylight (D65) luminance, α -opic EDL

From CIE S 026:2018 and 9th edition of SI Brochure (published draft)

$s_{p,\alpha}(\lambda)$ = α -opic spectral weighting function (action spectrum) in the photon system (renormalised to maximum of 1)

$E_{p,\alpha}$ = α -opic photon irradiance (*i.e.* weighted by $s_{p,\alpha}(\lambda)$)

$L_{p,\alpha}$ = α -opic photon radiance (*i.e.* weighted by $s_{p,\alpha}(\lambda)$)

Further α -opic quantities and their symbols can be derived, *e.g.* α -opic equivalent daylight (D65) luminous flux, $\Phi^{D65}_{v,\alpha}$.

However, any other abbreviations, *e.g.* " α -opic EDLF" may be ambiguous, and should be avoided.

Due to prior publications, the subscript order for ELR and DER differs from α -opic equivalent daylight (D65) quantities.

cie Charts

