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CIE Mesopic photometry – implementation for outdoor lighting

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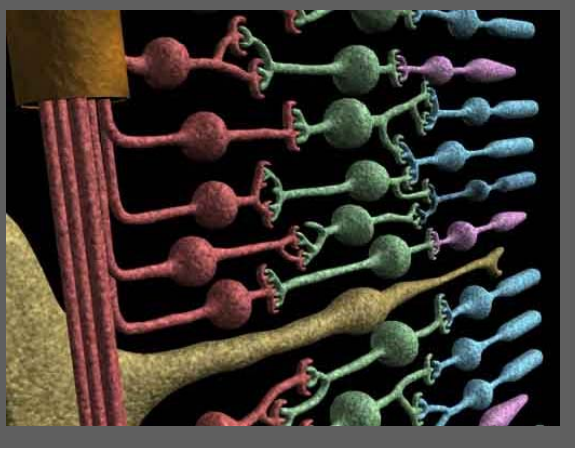
Introduction

Rods and Cones



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Introduction

Photopic and scotopic vision

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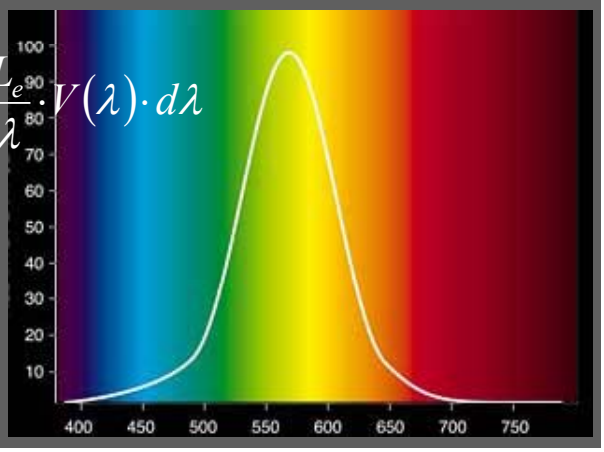
Photopic vision

Luminous efficiency function (CIE 1924)

$$L = K_m \cdot \int_0^\infty \frac{dL_e}{d\lambda} \cdot V(\lambda) \cdot d\lambda$$

K_m=683 lm/W



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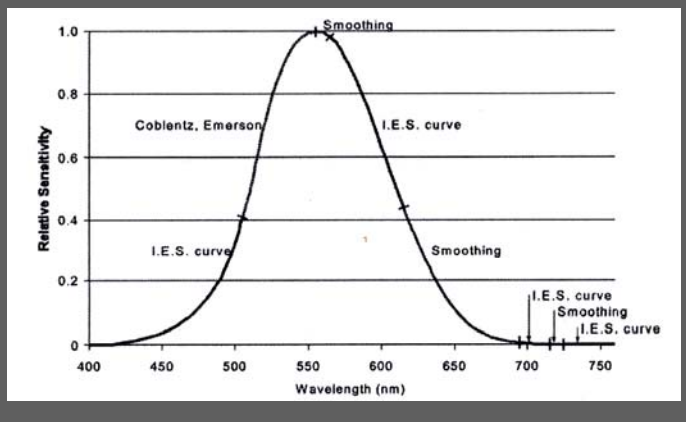
Photopic vision

Gibson & Tyndall (1923)



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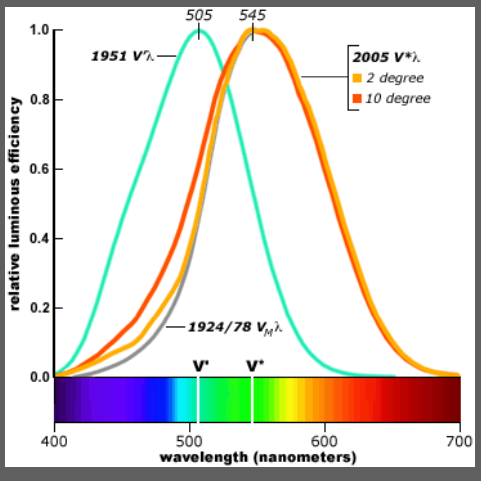
Photopic vision

Different modifications, especialy in blue region of spectrum (Judd 1951, Vos 1978).

$V_m(\lambda)$ – CIE 1988: as a supplement not replacement.



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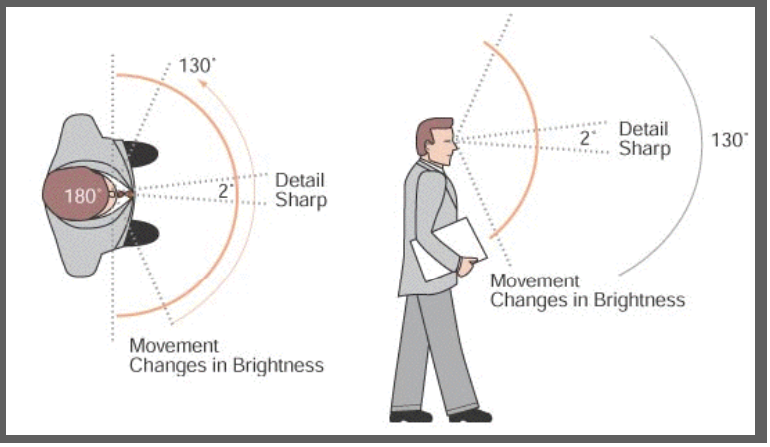
Field of vision

2° and 10° field of vision



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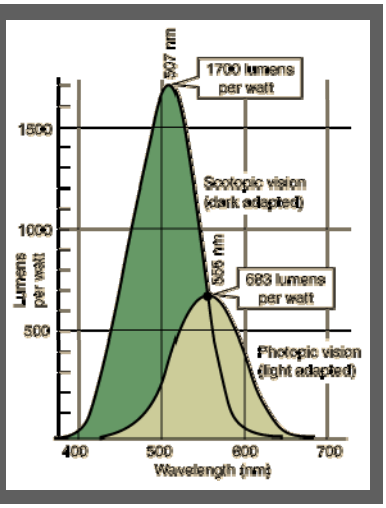
Photopic and Scotopic vision

Scotopic vision
V'(λ) – CIE 1951
K'_m=1700 lm/W

Same value of 683 lm/W
at 555 nm.



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Photopic and scotopic vision

At night we are more sensitive to blue light and K_m is larger:

white light

is better than

yelow light!

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Photopic and scotopic vision

Luminous efficacy of different light sources

Light source	Luminous efficacy lm/W	
	Photopic	Scotopic
100 W HPS	95	61
180 W LPS	180	41
100 W HP MH	85	142
36 W CFL 4000 K	93	141

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Photopic and scotopic vision

Luminances at outdoor (street) lighting are not in photopic or scotopic region but in mesopic!

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Mesopic vision

Photopic:
from 5 cd/m^2
to 10^{+4} cd/m^2

Mesopic:
from $5 \cdot 10^{-3}$ cd/m^2
to 5 cd/m^2

Scotopic:
from 10^{-6} cd/m^2
to $5 \cdot 10^{-3}$ cd/m^2

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Mesopic photometry

Between 2000 and 2005 two models of mesopic photometry were developed:

- X-mode (Rea at al., 2004)
- MOVE – model (Eloholma,) 2005

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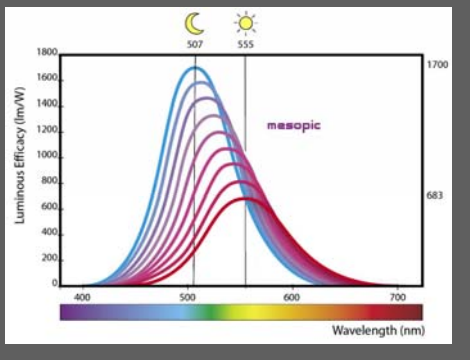
Mesopic photometry

Both models share the same idea:

$$M(x)V_{mes}(\lambda) = xV(\lambda) + (1-x)V'(\lambda)$$



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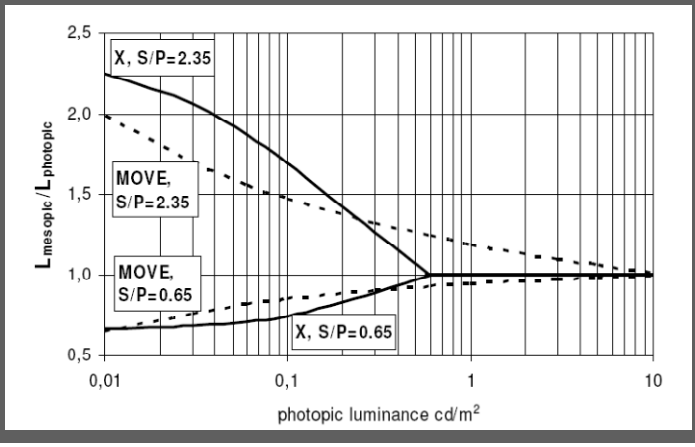
Mesopic Photometry

But gives different results:



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Mesopic photometry

CIE 191:2010 – Recomended System for Mesopic Photometry Based on Visual Performance

$$M(m)V_{mes}(\lambda) = mV(\lambda) + (1-m)V'(\lambda)$$

$$0 \le m \le 1$$

$$L_{mes} = \frac{683}{V_{mes}(\lambda_0)} \int V_{mes}(\lambda) L_e(\lambda)\, d\lambda$$

m … coefficient, depends on the visual adaptation conditions
$M(m)$ … normalizing function such that maximum value of $V_{mes}(\lambda)$ is 1
$V_{mes}(\lambda)$ … the value of $V_{mes}(\lambda)$ at 555 nm

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Mesopic photometry

To calculate the mesopic values one needs:

- background photopic luminance (i.e. adaptation luminance) and
- S/P – ratio.

	m	a Photopic luminance cd·m^{-2}						
	S/P	0,01	0,03	0,1	0,3	1	3	4,5
LPS ~	0,25		0,1542	0,3830	0,5644	0,7538	0,9225	0,9841
	0,35		0,1804	0,3920	0,5688	0,7558	0,9230	0,9842
	0,45	0,0000	0,1992	0,4000	0,5730	0,7576	0,9235	0,9843
HPS ~	0,55	0,0190	0,2140	0,4073	0,5770	0,7594	0,9240	0,9844
	0,65	0,0459	0,2265	0,4139	0,5808	0,7612	0,9245	0,9845
	0,75	0,0655	0,2373	0,4201	0,5844	0,7629	0,9249	0,9846
	0,85	0,0812	0,2468	0,4258	0,5878	0,7646	0,9254	0,9846
	0,95	0,0943	0,2553	0,4311	0,5911	0,7662	0,9258	0,9847
	1,05	0,1057	0,2631	0,4361	0,5942	0,7678	0,9263	0,9848

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Photopic and scotopic vision

At least one problem left to be solved:
in order to determine the background photopic luminance (adaptation luminance), we first need to define visual adaptation field:

- size of visual adaptation fiels;
- eye movement;
- ????

CIE JTC 001 – Implementation of CIE 191 Msopic Photometry in Outdoor lighting.

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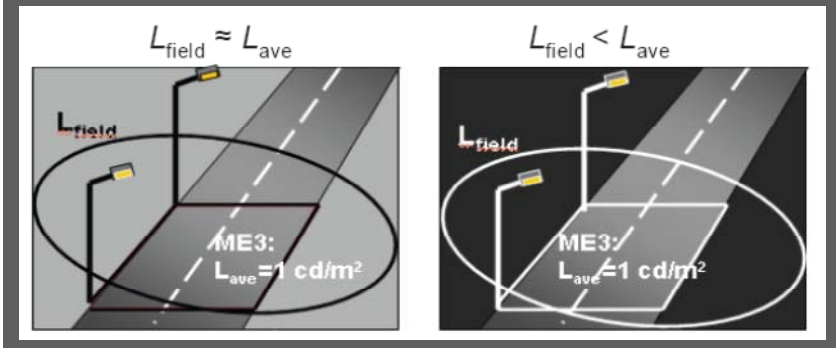
Photopic and scotopic vision

If the visual adaptation field is broader than the road, the road surrounding also influeces mesopic photometry!



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Conclusions

Thank you very much for your attention!