Optoelectronică, structuri şi tehnologii

Curs 3

2011/2012

Lumina ca undă electromagnetică

Capitolul 2

Parametri, dependenta de mediu

$$\eta_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = 377\Omega$$

$$c_0 = \frac{1}{\sqrt{\varepsilon_0 \cdot \mu_0}} = 2{,}99790 \cdot 10^8 \ m/s$$

$n = 1$

$$T = \frac{2\pi}{\omega} = \frac{1}{f}$$

$$\lambda_0 = \frac{2\pi}{\beta} = \frac{c_0}{f}$$

$$\eta = \frac{\eta_0}{n}$$

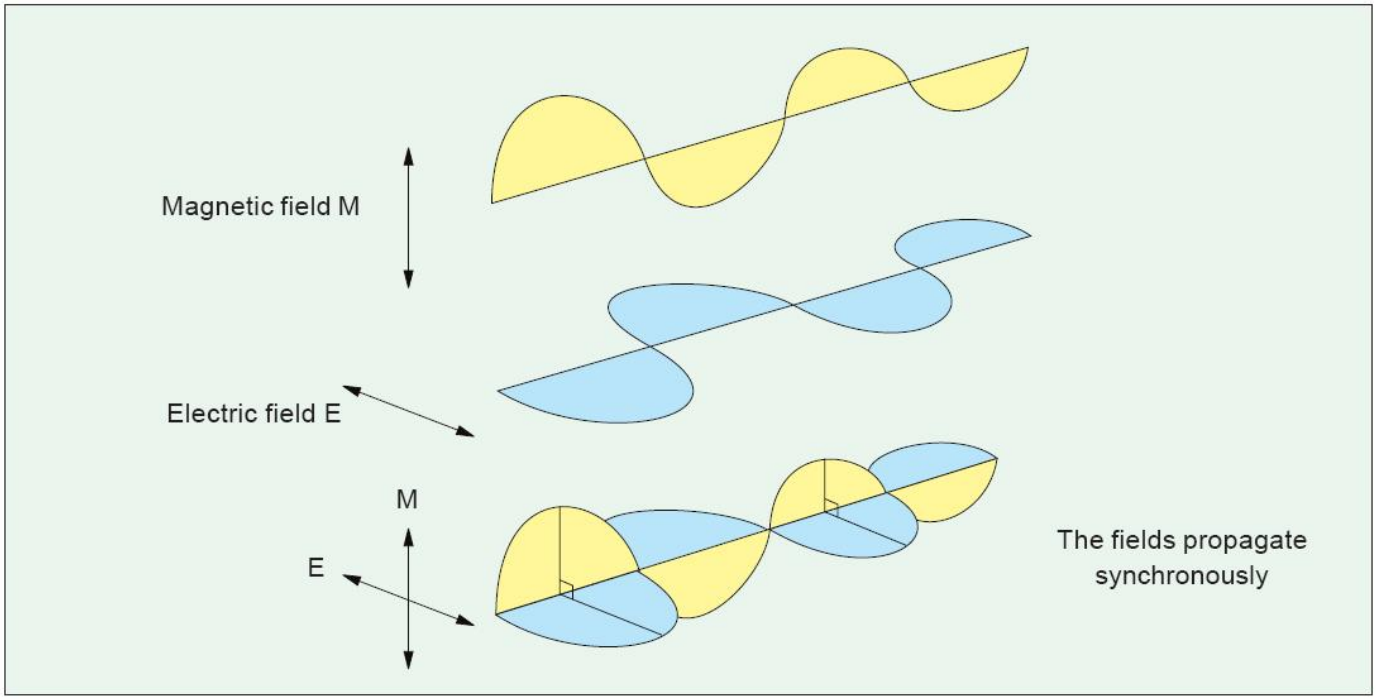
$$c = \frac{c_0}{n}$$

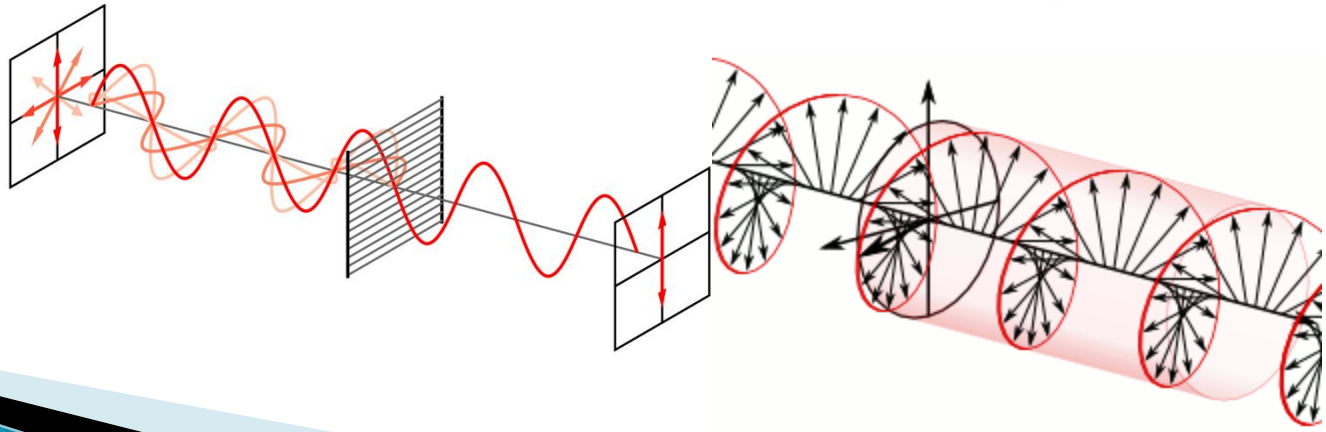
$$n = \sqrt{\varepsilon_r}$$

$$T = \frac{2\pi}{\omega} = \frac{1}{f}$$

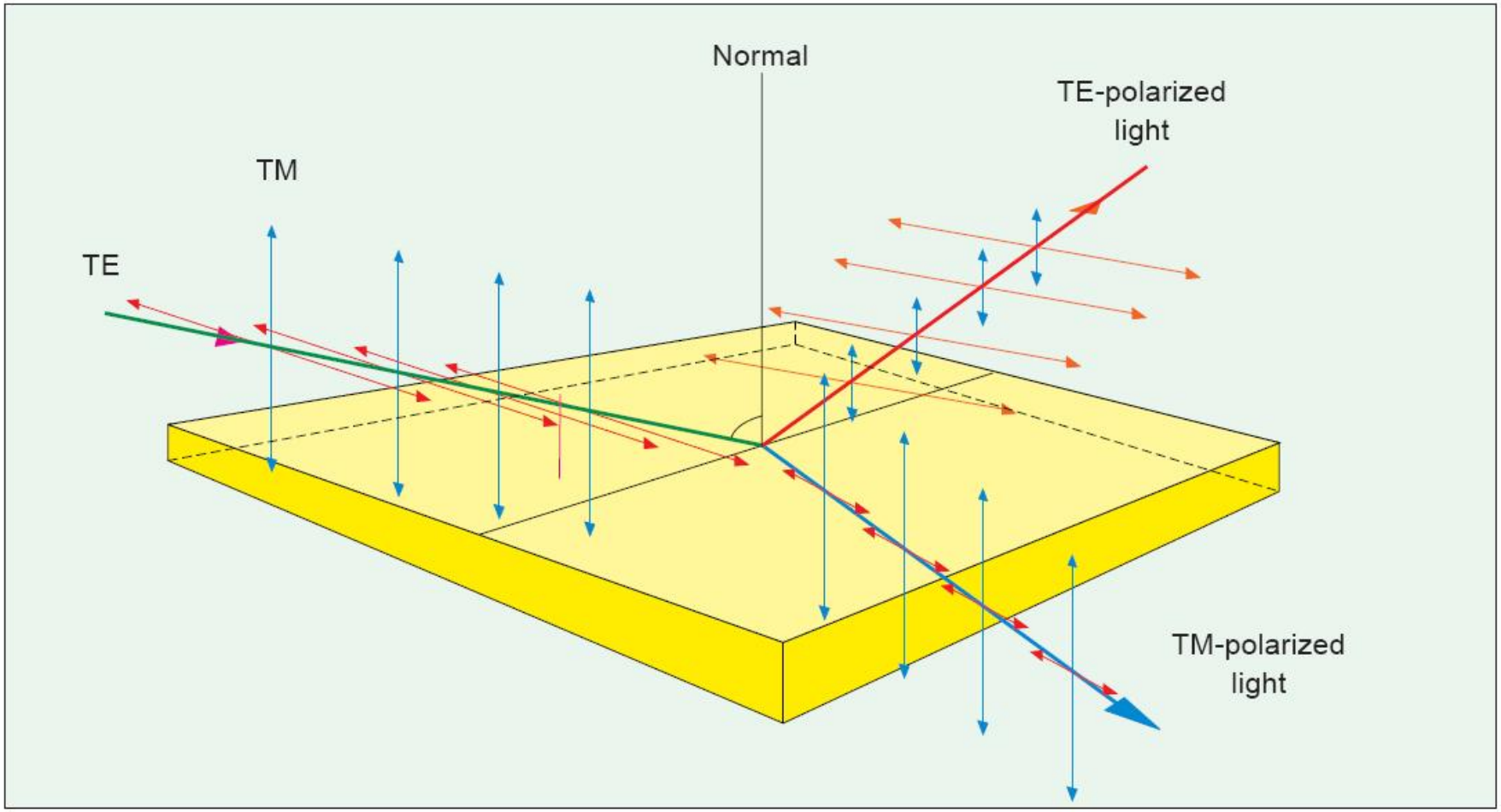
$$\lambda = \frac{c_0}{n \cdot f} = \frac{\lambda_0}{n}$$

Polarizarea luminii

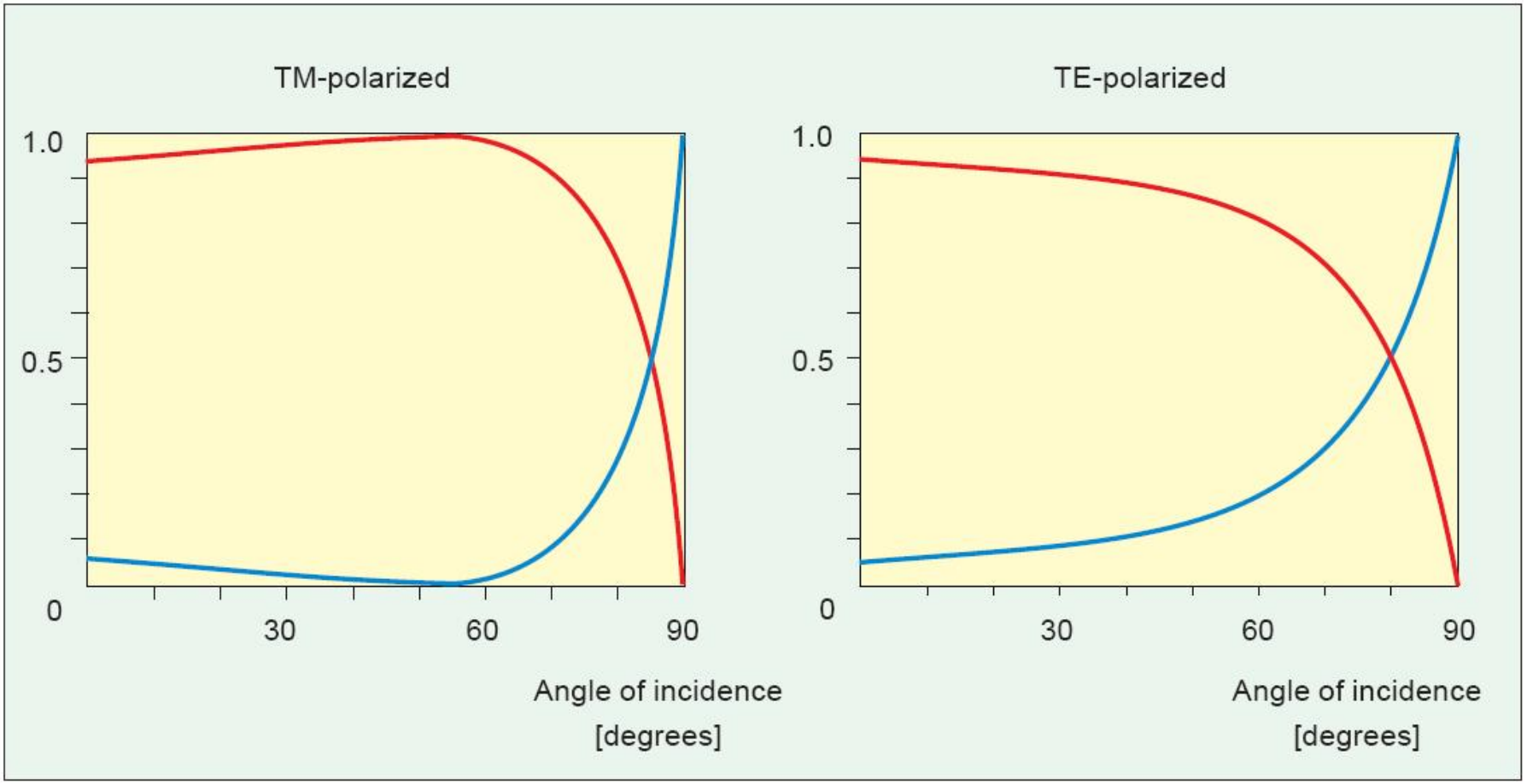




Polarizarea luminii



Polarizarea luminii



Transmisia puterii intre medii

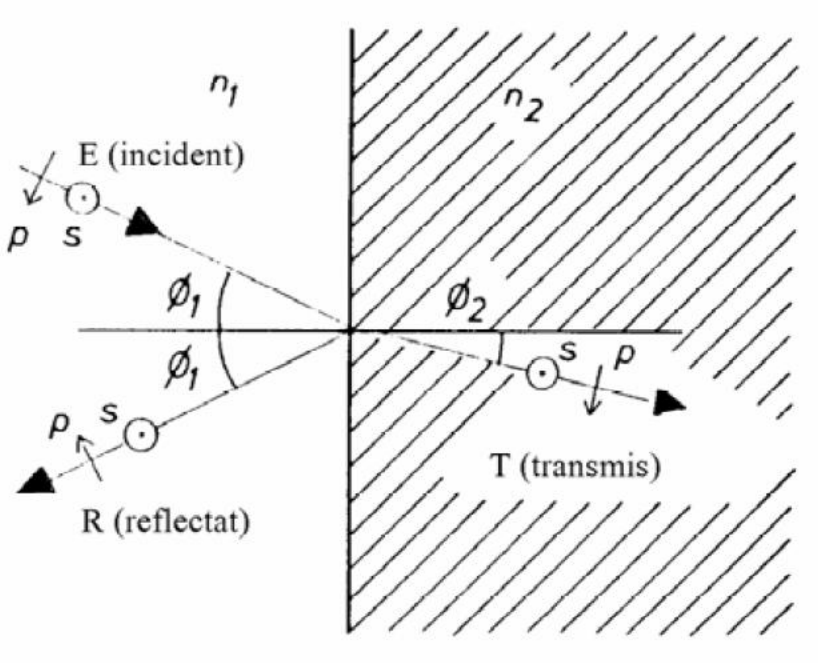
- incidenta oblica
- reflexiile in amplitudine a campului:

$$r_s = -\frac{\sin(\phi_1 - \phi_2)}{\sin(\phi_1 + \phi_2)}$$

$$r_p = \frac{\tan(\phi_1 - \phi_2)}{\tan(\phi_1 + \phi_2)}$$

$$t_s = \frac{2\sin\phi_2 \cos\phi_1}{\sin(\phi_1 + \phi_2)}$$

$$t_p = \frac{2\sin\phi_2 \cos\phi_1}{\sin(\phi_1 + \phi_2)\cos(\phi_1 - \phi_2)}$$



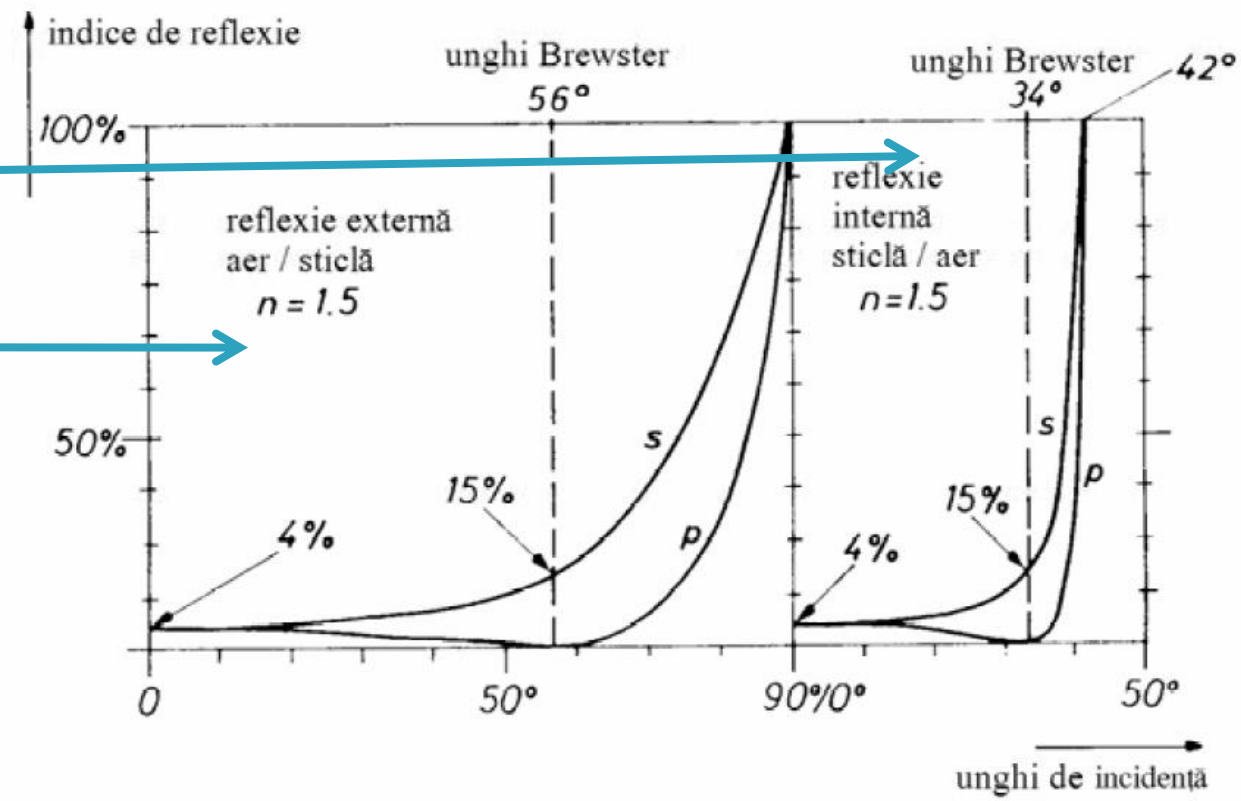
Unghi Brewster

- transmisia totala a polarizarii p
- lumina reflectata este total polarizata (s)

$$\phi_B = \arctan\left(\frac{n_2}{n_1}\right)$$

$\phi_B = 34°$

$\phi_B = 56°$

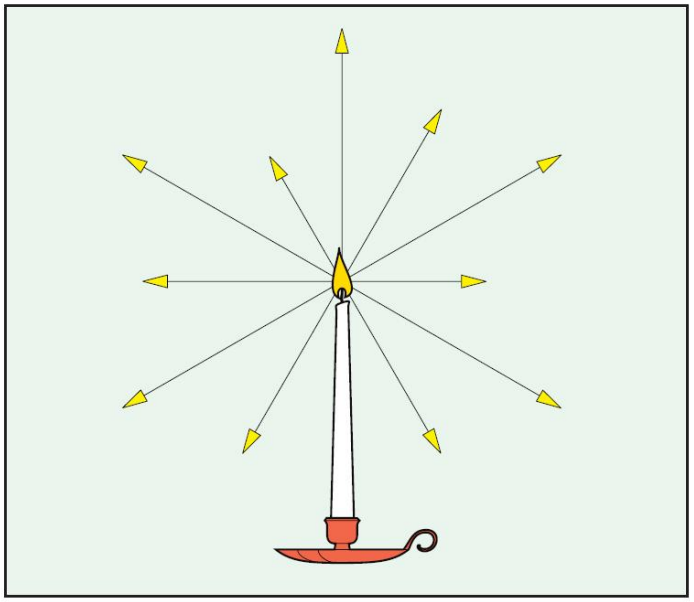


Optică geometrică

Capitolul 4

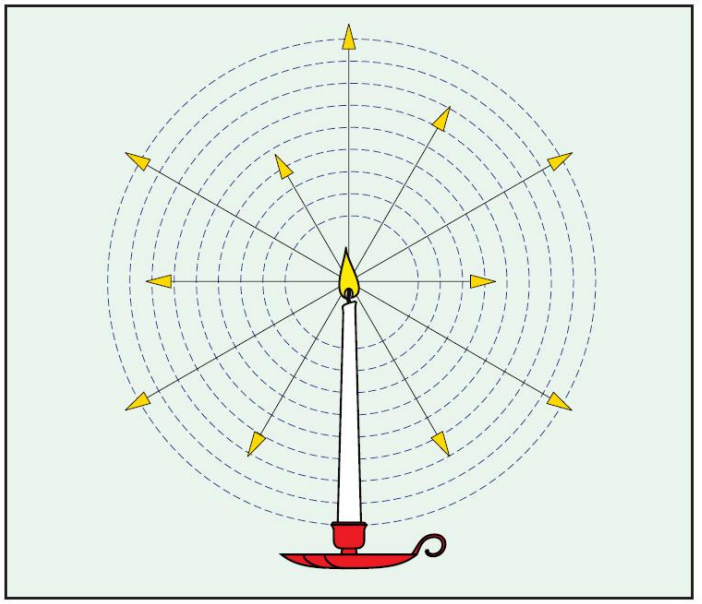
Raze de lumina

- Lumina este constituita din raze care se propaga in linie dreapta in medii omogene
- Sursa omnidirectionala: emite similar in toate directiile



- Energia luminoasa descreste invers proportional cu patratul distantei fata de sursa (energia se imparte uniform pe suprafata intregii sfere)

$$P = \frac{P_0}{r^2}$$

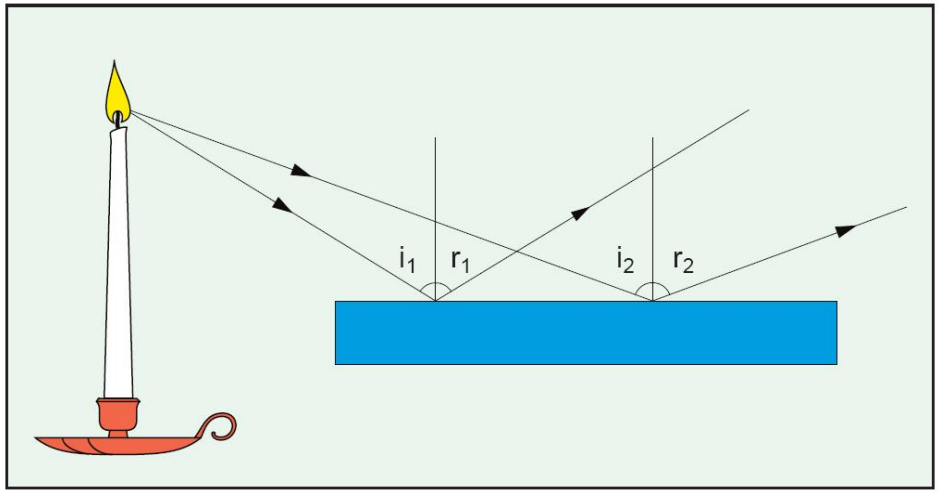


Reflexia luminii

- la suprafata de separatie dintre doua medii, (o parte din) lumina se intoarce in mediul de incidenta
- unghiul facut de raza incidenta cu normala (ϕ_i) este egal cu unghiul facut de raza reflectata cu normala (ϕ_r)

- Legea reflexiei

$$\phi_i = \phi_r$$

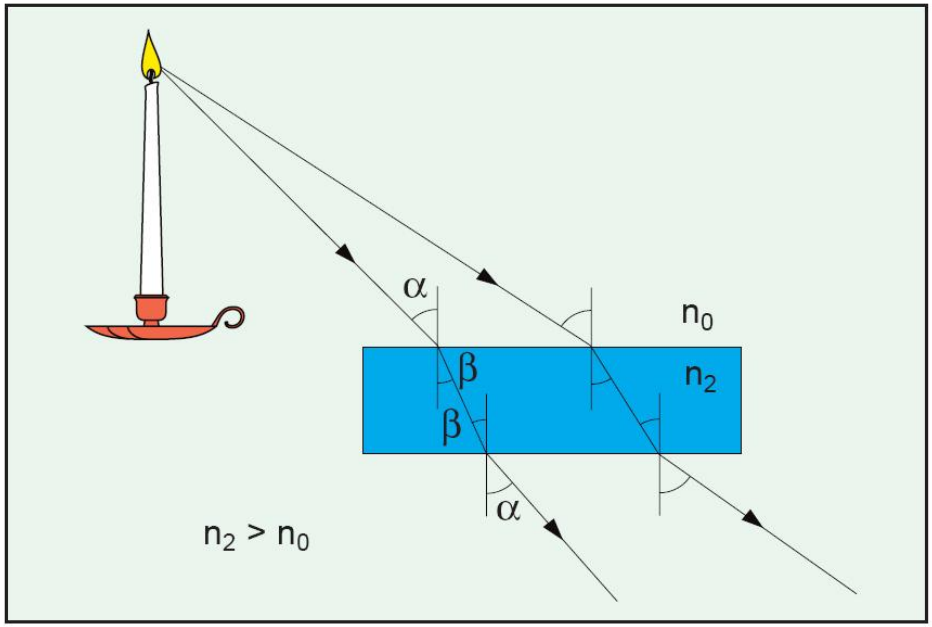


Refractia luminii

- la suprafata de separatie dintre doua medii, (o parte din) lumina se (poate) propaga in mediul de transmisie sub un unghi diferit de unghiul incident
- la trecerea in medii mai “dense” (optic) lumina se apropie de normala
- Legea lui Snell (a refractiei)

$$n_1 \cdot \sin \phi_i = n_2 \cdot \sin \phi_R$$

Φ_i – unghi incident
Φ_R – unghi de refractie



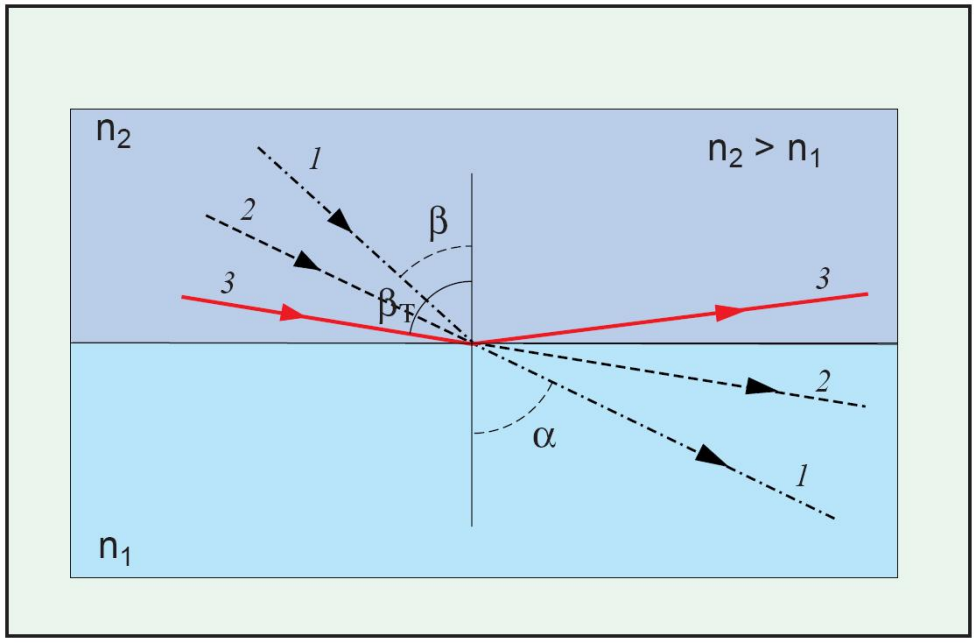
Reflexia totala

- Apare numai când lumina se propaga dintr-un mediu mai dens optic intr-un mediu mai putin dens
- La intersectia luminii cu suprafata de separatie a doua medii se intalnesc in general raze reflectate **si** raze refractate
- Pentru un unghi de incidenta numit **unghi critic**, raza refractata se obtine in lungul suprafetei de separatie

$$n_1 > n_2; \quad \phi_R = 90°$$

$$n_1 \cdot \sin\phi_C = n_2$$

$$\phi_C = \arcsin\left(\frac{n_2}{n_1}\right)$$

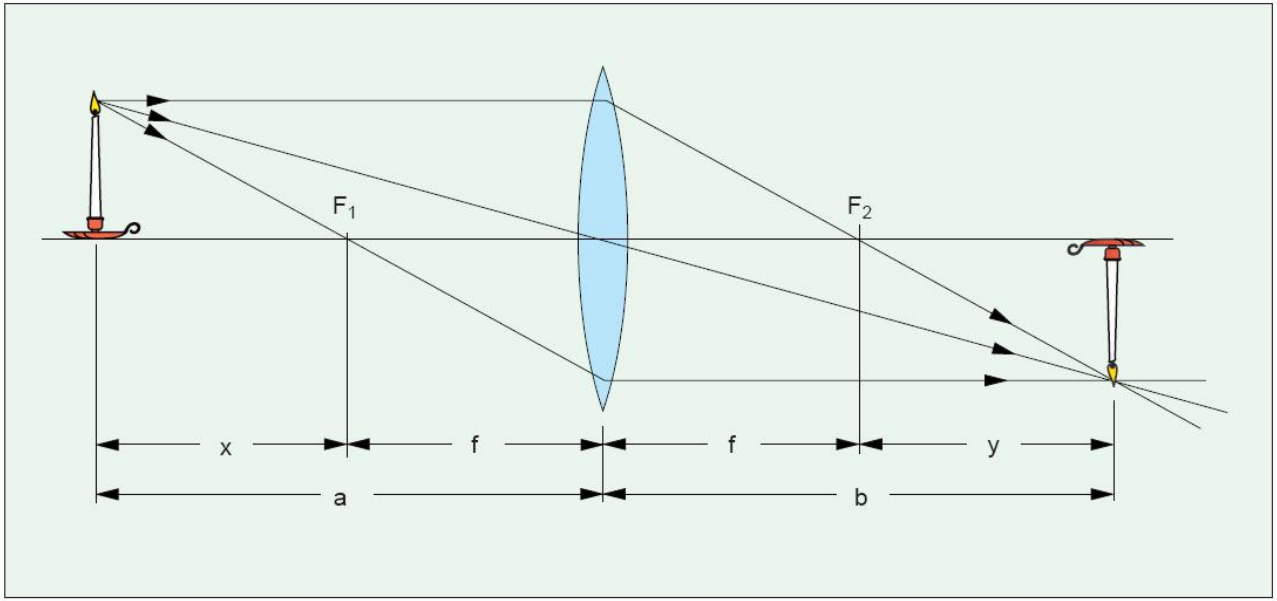


Lentile

- Razele de lumina paralele sunt concentrate intr-un punct numit focar, aflat la **distanta focala** de planul lentilei
- O sursa omnidirectionala pozitionata in focar va permite obtinerea unui fascicul paralel

$$\frac{1}{a}+\frac{1}{b}=\frac{1}{f}$$

$$x \cdot y = f^2$$



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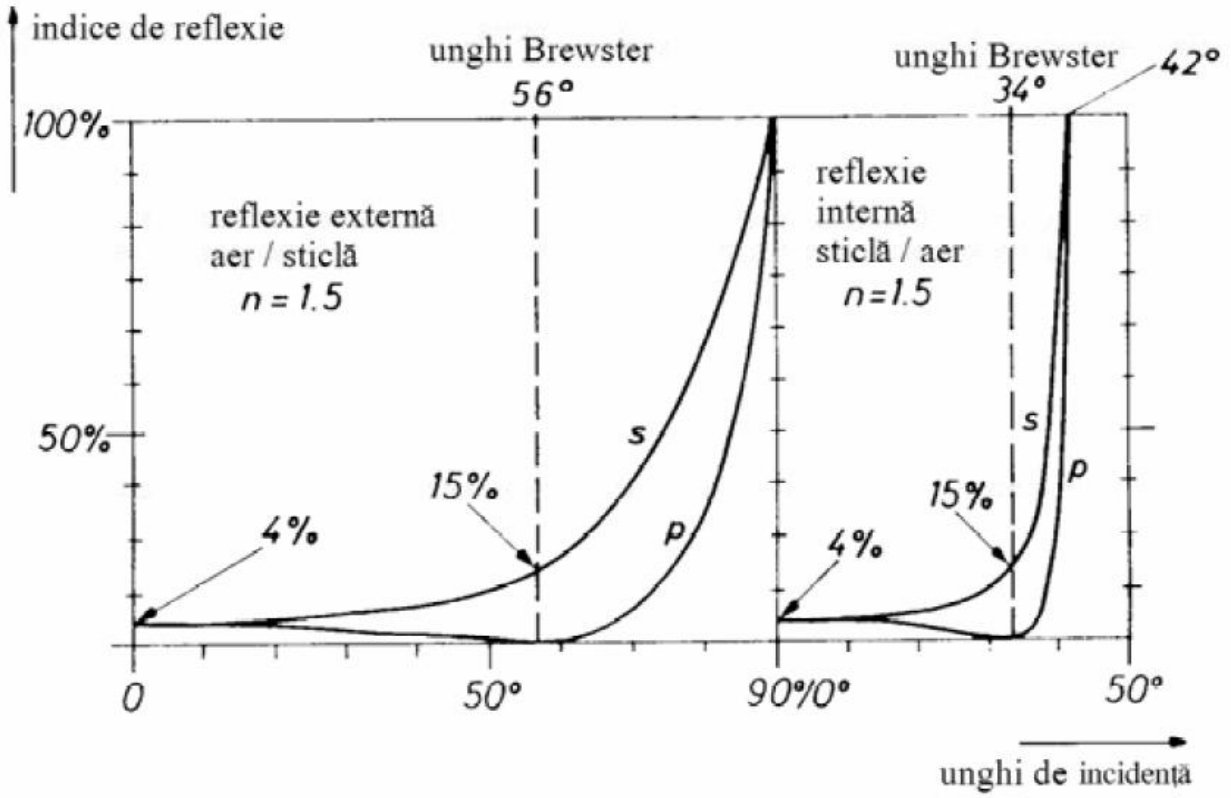


Fotometrie şi radiometrie

Capitolul 3

O alta dualitate

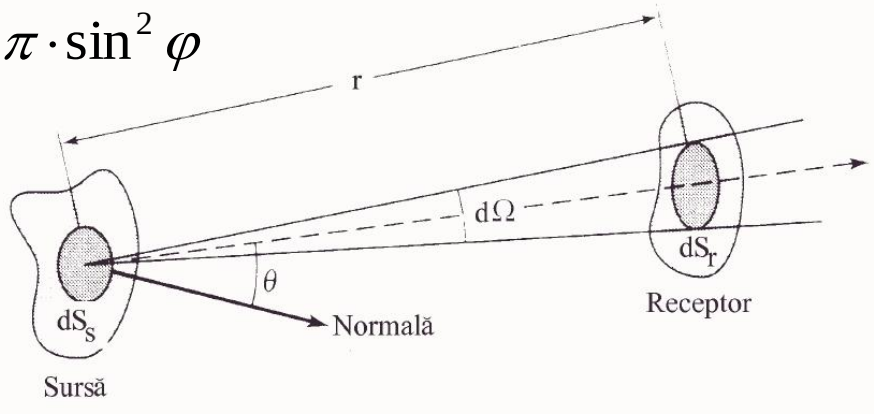
- In optoelectronica lumina poate fi privita din doua puncte de vedere
  - energetic (efect asupra dispozitivului)
  - uman (efect asupra ochiului)
- Dualitatea marimilor implicate
  - energetice
  - luminoase
- Candela (cd) este una din cele 7 marimi fundamentale ale SI
  - Cd = intensitatea luminoasa a unei surse ce emite o radiatie monocromatica cu frecventa $540 \cdot 10^{12}$ Hz (λ = 555nm in vid) si are o intensitate radianta de 1/683 W/sr

Flux energetic

- Flux energetic al luminii
  - viteza cu care energia trece printr-o suprafata
  - energie/unitatea de timp
  - unitatea SI – W

$$\Phi_e = \frac{dE}{dt} \quad [W]$$

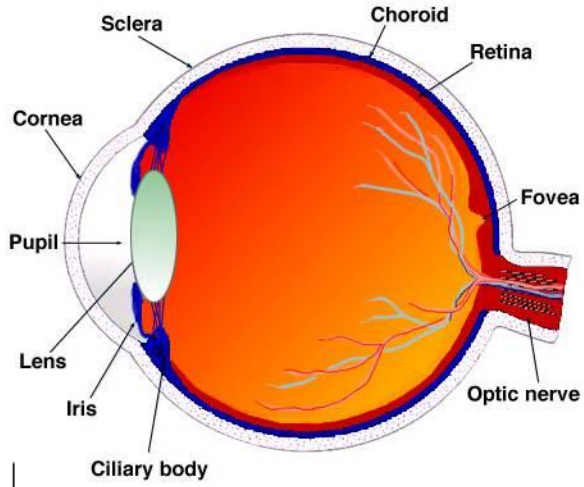
- Unghi solid
  - definitie $\Omega = \frac{A}{r^2} \quad [sr]$
  - valoarea maxima: $\Omega = 4\pi$ sr
  - pentru unghiuri mici $\Omega = \pi \cdot \sin^2 \varphi$

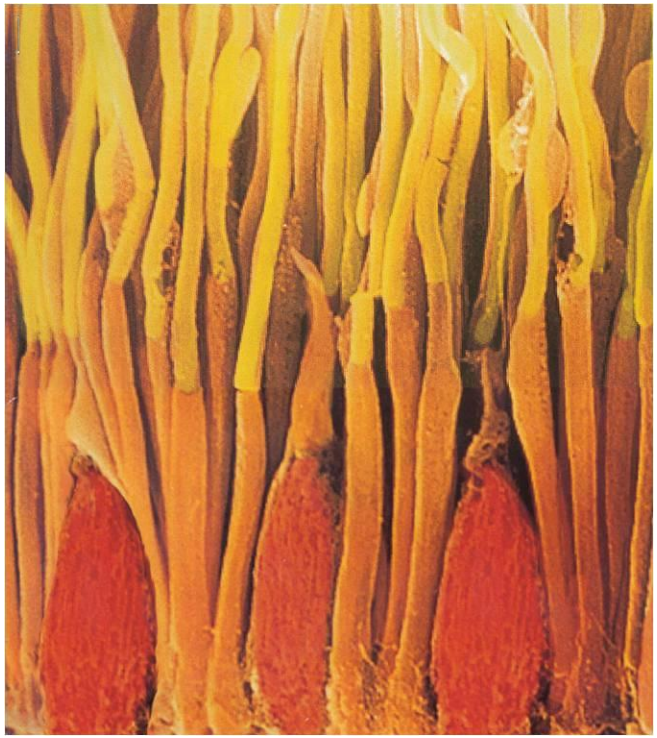


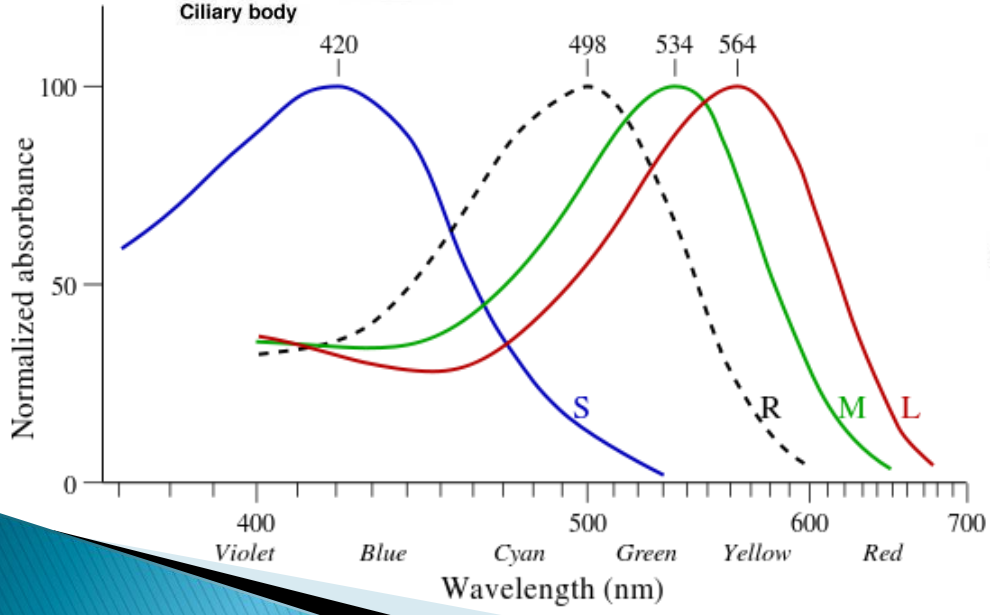
Flux luminos

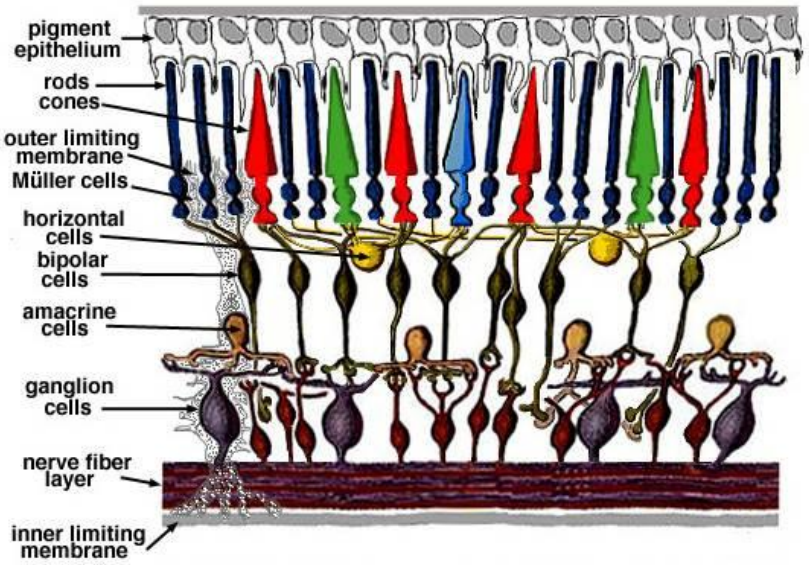
- Flux luminos, definitie
  - o masura a puterii luminoase percepute de om
- Unitate de masura – lm = lumen
  - In SI de unitati **lumenul** este definit ca fluxul luminos al unei surse luminoase punctiforme cu intensitatea luminoasa de o candela intr-un unghi solid egal cu 1 sr.
  - la $\lambda = 555\text{nm}$ $\Phi_e = 1W \Leftrightarrow \Phi_v = 683lm$
- Dualitate pentru toate marimile implicate
  - radiometrie – indice “e”
  - fotometri – indice “v”
- La alte lungimi de unda se tine cont de sensibilitatea relativa medie a ochiului uman

Ochiul uman


Sclera
Choroid
Retina
Cornea
Fovea
Pupil
Lens
Iris
Optic nerve
Ciliary body



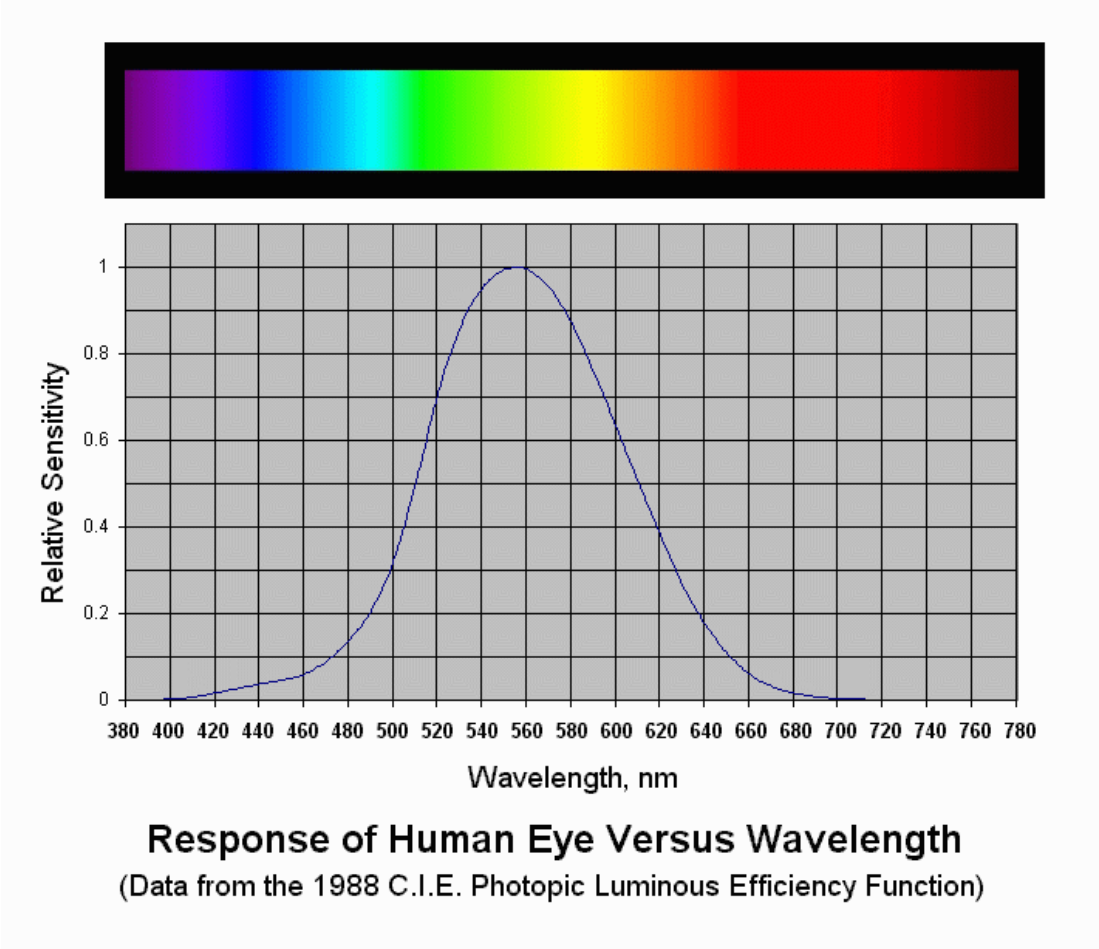

420
498
534
564
100
50
0
Normalized absorbance
S
R
M
L
400
500
600
700
Violet
Blue
Cyan
Green
Yellow
Red
Wavelength (nm)


pigment epithelium
rods
cones
outer limiting membrane
Müller cells
horizontal cells
bipolar cells
amacrine cells
ganglion cells
nerve fiber layer
inner limiting membrane

Standarde

- Se incearca definirea omului “standard”
- CIE – Commission Internationale de l'Éclairage
  - 1931 – luminozitatea relativa standard V(λ) – fotopic
  - 1951 – luminozitatea relativa standard V(λ) – scotopic
  - 1978 – Vos
  - 2005 – Sharpe, Stockman, Jagla, Jägle
- Sensibilitatea maxima a ochiului uman
  - vedere diurna (fotopic), λ=555 nm
  - vedere nocturna (scotopic), λ=507 nm

CIE V(λ)



Response of Human Eye Versus Wavelength

(Data from the 1988 C.I.E. Photopic Luminous Efficiency Function)

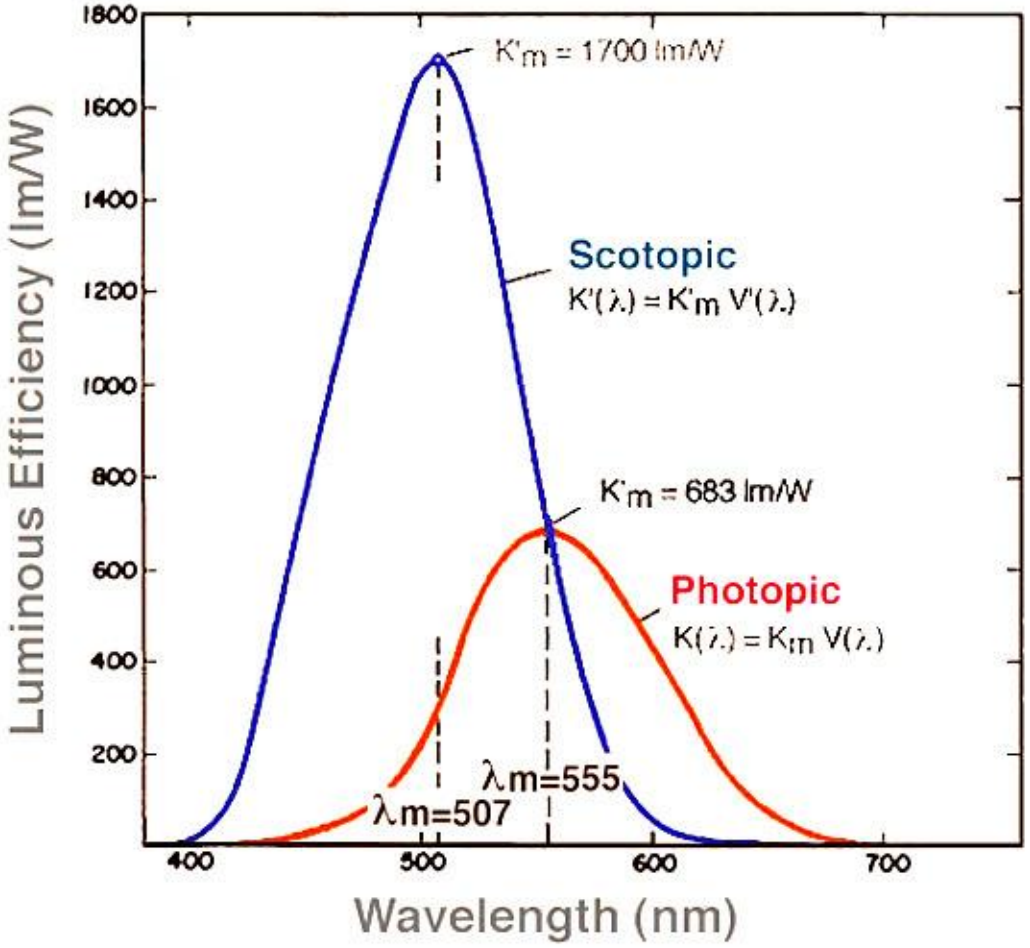


Figure 9. The scotopic and the photopic curves of spectral luminous efficacy (non-normalised values).

efect Purkinje

Curbe normalizate CIE

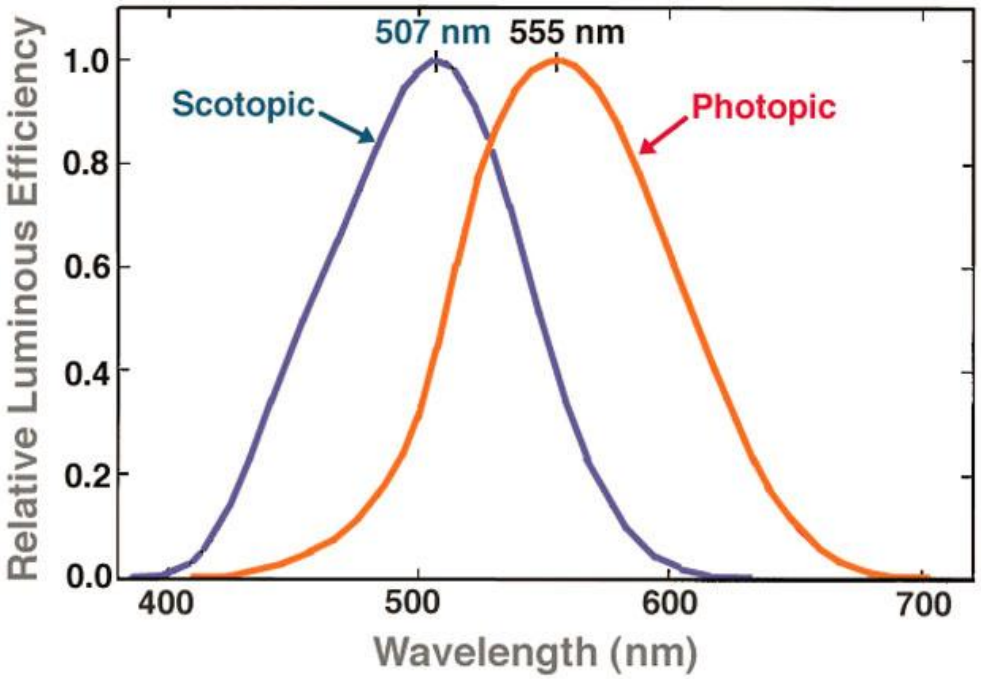
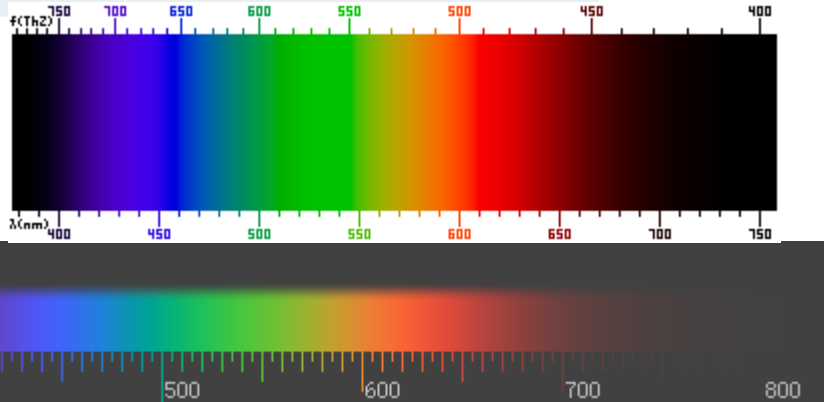


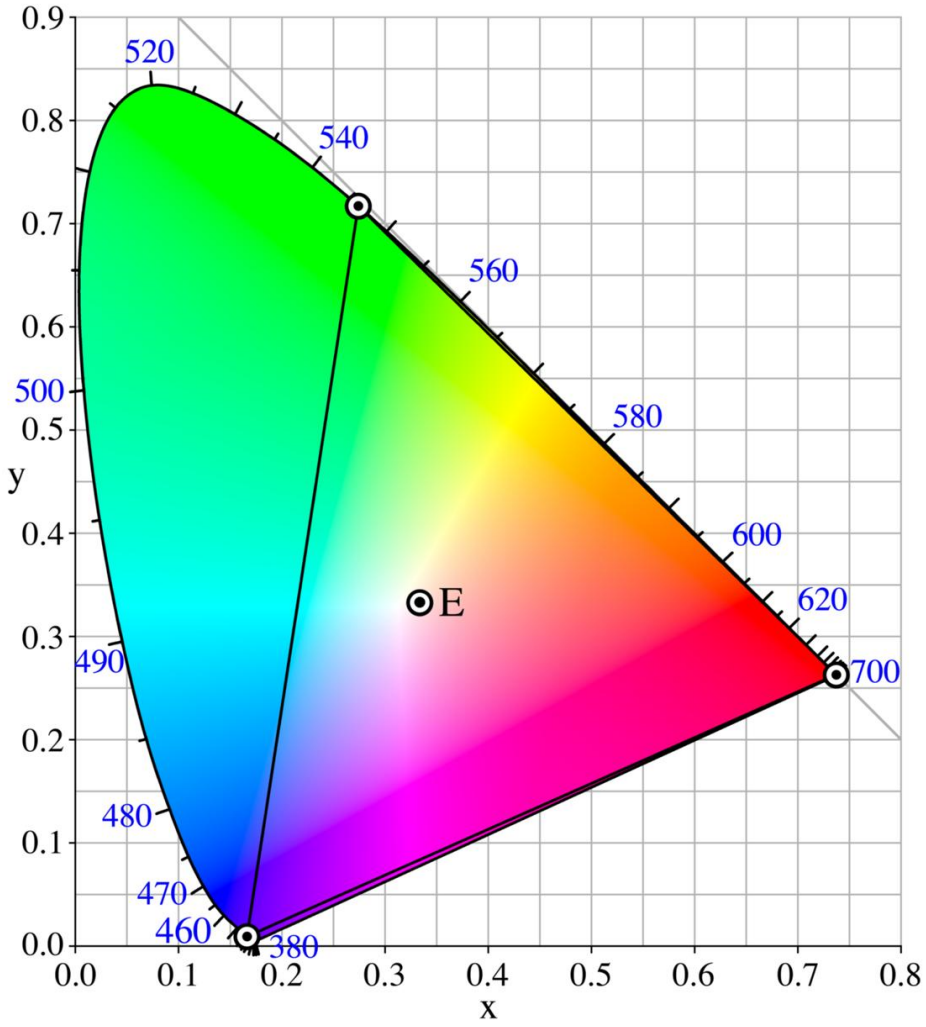
Figure 10. The scotopic and the photopic curves of relative spectral luminous efficiency as specified by the CIE (normalised values).

Culori – lungime de unda

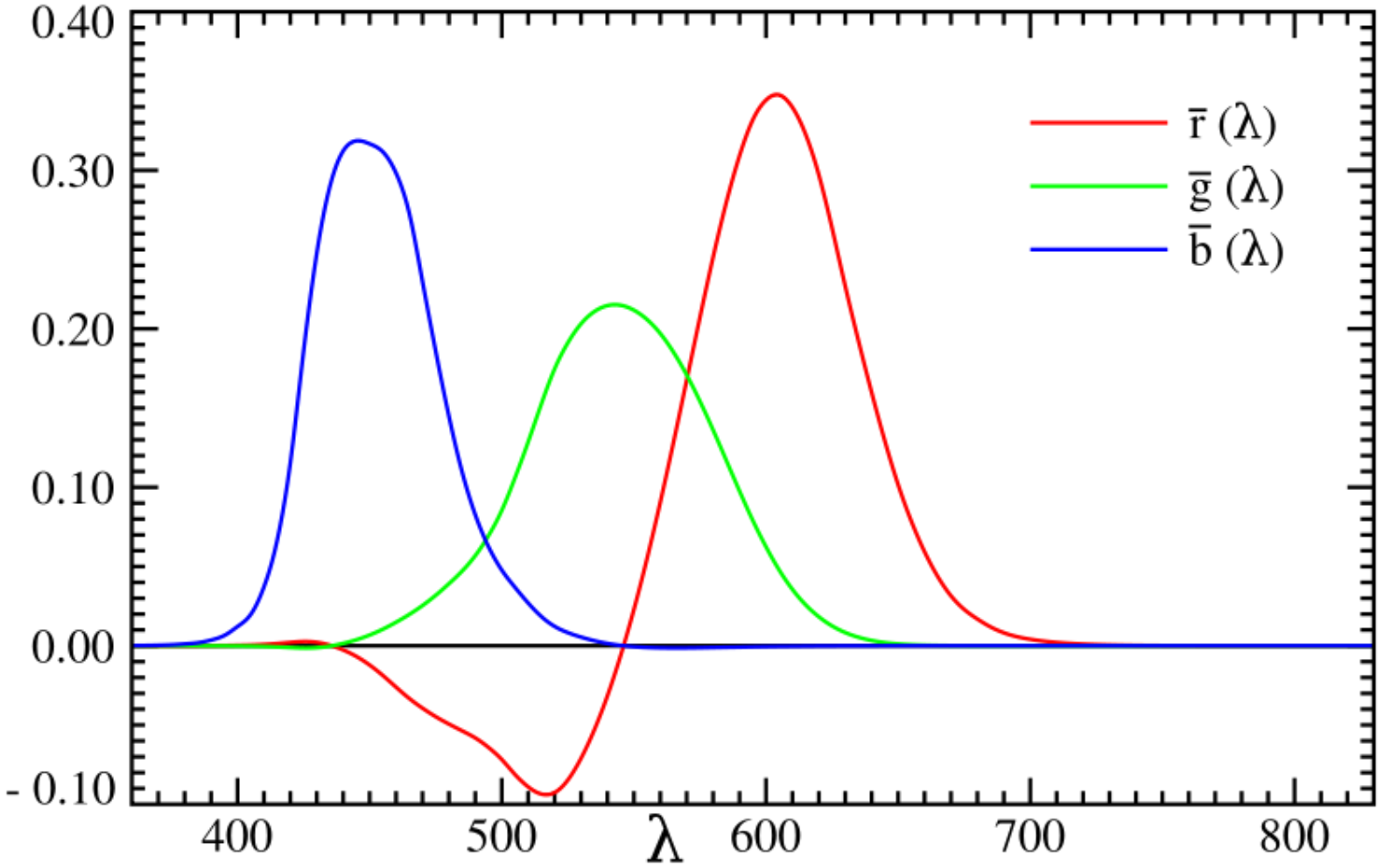
Culoare	Lungime de unda	Frecventa
Rosu	~ 700–630 nm	~ 430–480 THz
Portocaliu	~ 630–590 nm	~ 480–510 THz
Galben	~ 590–560 nm	~ 510–540 THz
Verde	~ 560–490 nm	~ 540–610 THz
Albastru	~ 490–450 nm	~ 610–670 THz
Violet	~ 450–400 nm	~ 670–750 THz



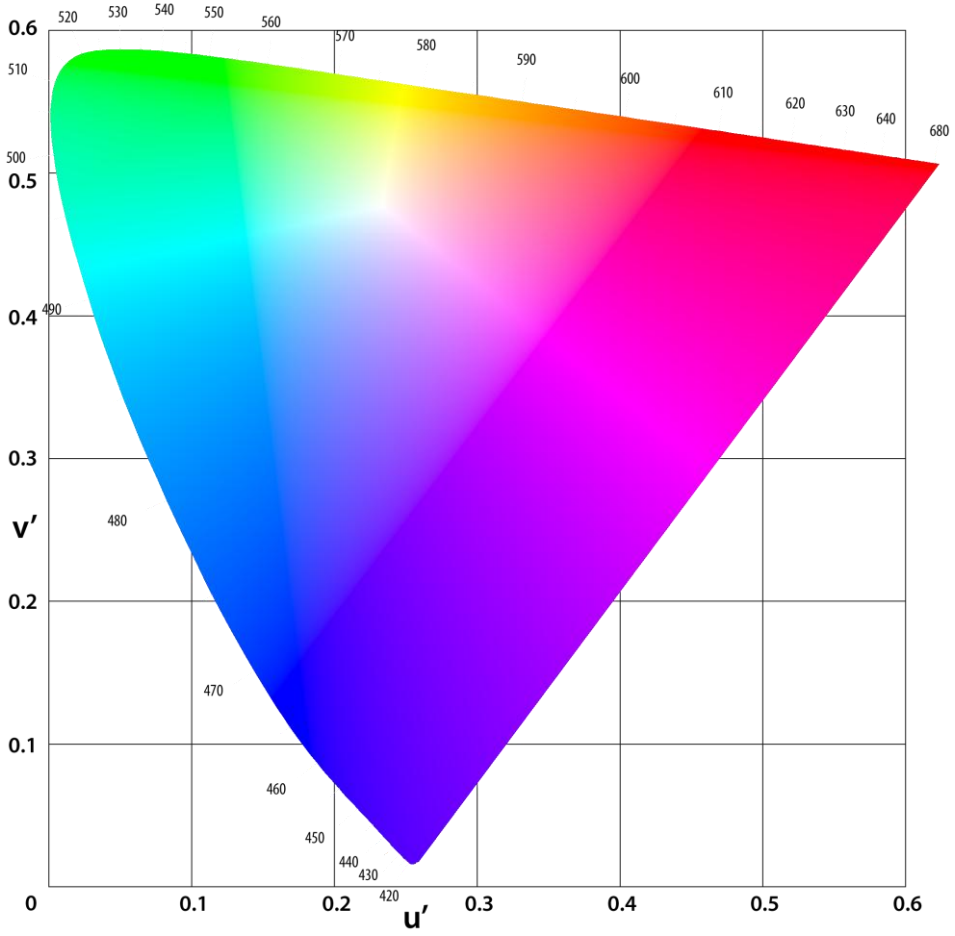
CIE xy 1931


0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
y
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
x
520
540
560
580
600
620
700
500
490
480
470
460
380
E

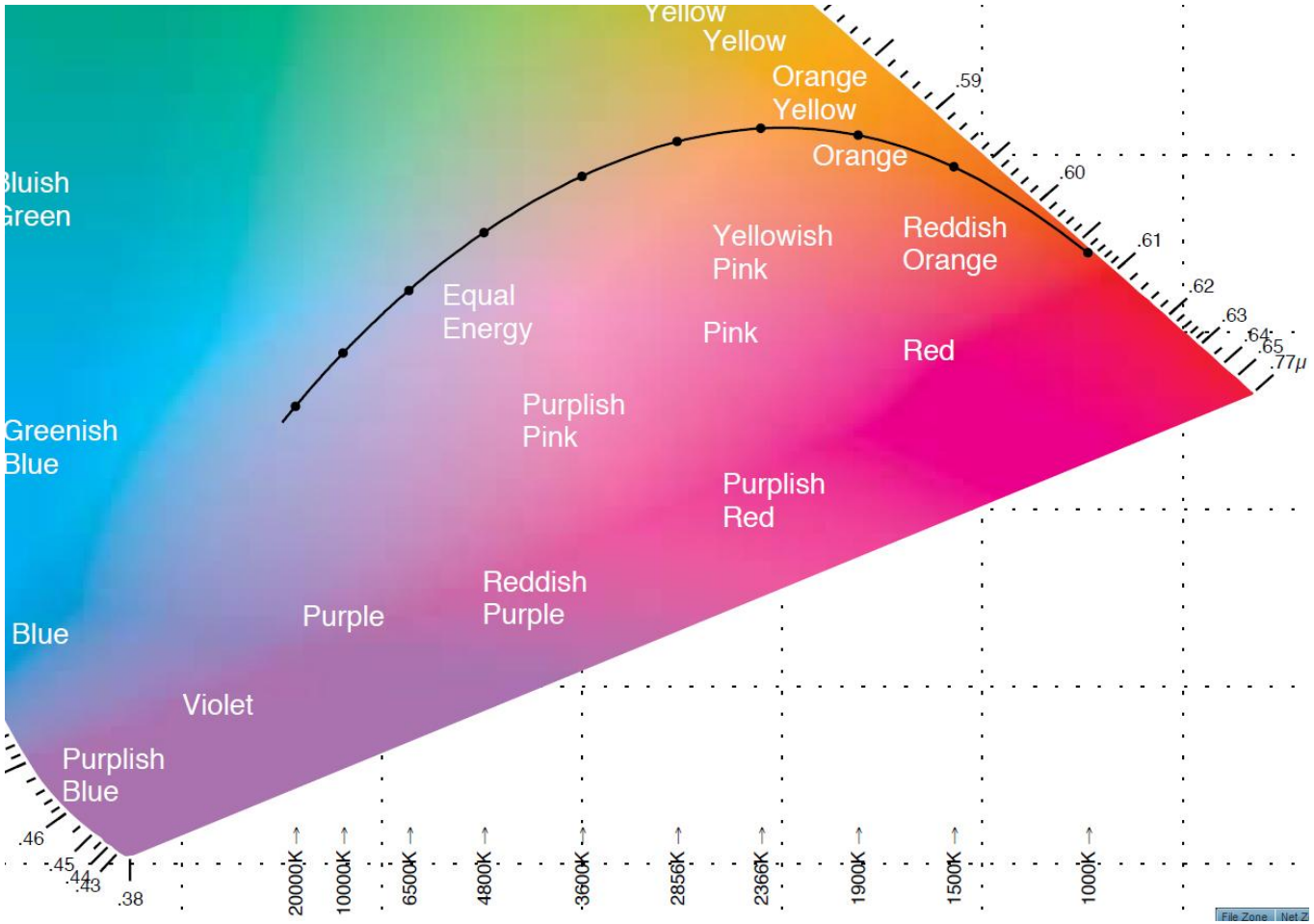
Cantitatea din culorile primare pentru aceeasi senzatie de culoare



CIELUV 1976


520
530
540
550
560
570
580
590
600
610
620
630
640
680
510
500
490
480
470
460
450
440
430
420
0.6
0.5
0.4
0.3
0.2
0.1
0
v′
0
0.1
0.2
0.3
0.4
0.5
0.6
u′

CIE xy 1931

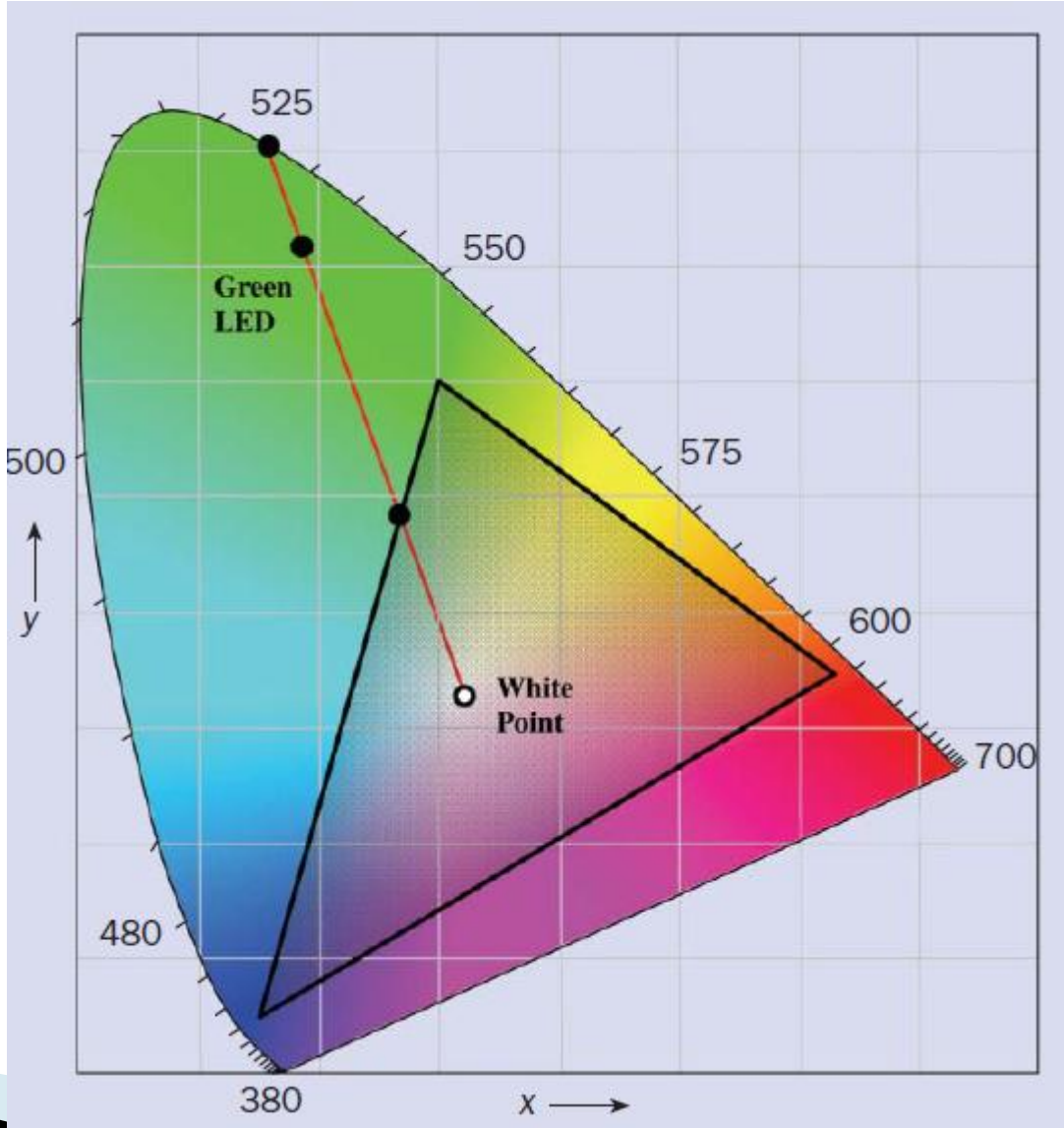

Yellow
Yellow
Orange
Yellow
Orange
Bluish
Green
Yellowish
Pink
Reddish
Orange
Equal
Energy
Pink
Red
Purplish
Pink
Greenish
Blue
Purplish
Red
Reddish
Purple
Purple
Blue
Violet
Purplish
Blue
.59
.60
.61
.62
.63
.64
.65
.77μ
.46
.45
.44
.43
.38
20000K
10000K
6500K
4800K
3600K
2856K
2366K
1900K
1500K
1000K

ITU–R BT.709

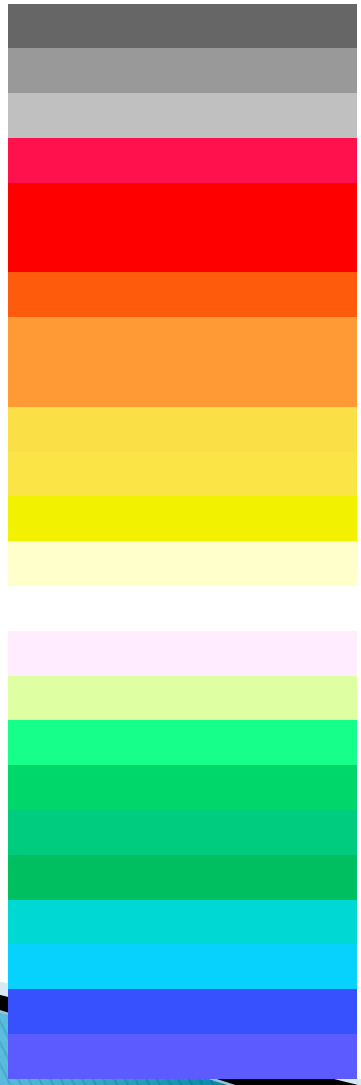
ITU-R BT.709 phosphor properties		
Phosphor	**x**	**y**
Red	0.640	0.330
Green	0.300	0.600
Blue	0.150	0.060

Data refers to xy chromaticity co-ordinates of ITU-R BT.709 phosphors which are used in most CRT displays [1].

RGB values for Luxeon LEDs		
LED color	**Dominant wavelength λ_D (nm)**	**RGB values**
Royal blue	455	0.05, 0.00, 0.95
Blue	470	0.00, 0.11, 0.89
Cyan	505	0.00, 0.63, 0.37
Green	530	0.00, 0.77, 0.23
Amber	590	0.70, 0.30, 0.00
Red-orange	615	0.97, 0.00, 0.03
Red	625	0.92, 0.00, 0.08



Lungimi de unda tipice – LED



Wavelength (nm)	Color Name
940	Infrared
880	Infrared
850	Infrared
660	Ultra Red
635	High Eff. Red
633	Super Red
620	Super Orange
612	Super Orange
605	Orange
595	Super Yellow
592	Super Pure Yellow
585	Yellow
4500K	"Incandescent" White
6500K	Pale White
8000K	Cool White
574	Super Lime Yellow
570	Super Lime Green
565	High Efficiency Green
560	Super Pure Green
555	Pure Green
525	Aqua Green
505	Blue Green
470	Super Blue
430	Ultra Blue

Contact

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