Optoelectronică

Curs 1

2017/2018

- La facultate, profesorul intreaba:

  - Intrebare de "nota 10": cum ma numesc?
  Toti tac.

  - Intrebare de "nota 8": la ce obiect aveti examen?
  Toti tac.

  - Intrebare de "nota 5": ce culoare are manualul (site-ul laboratorului)?

  Din ultimele randuri se aude o voce:
  - Vrea sa ne pice magaru'!

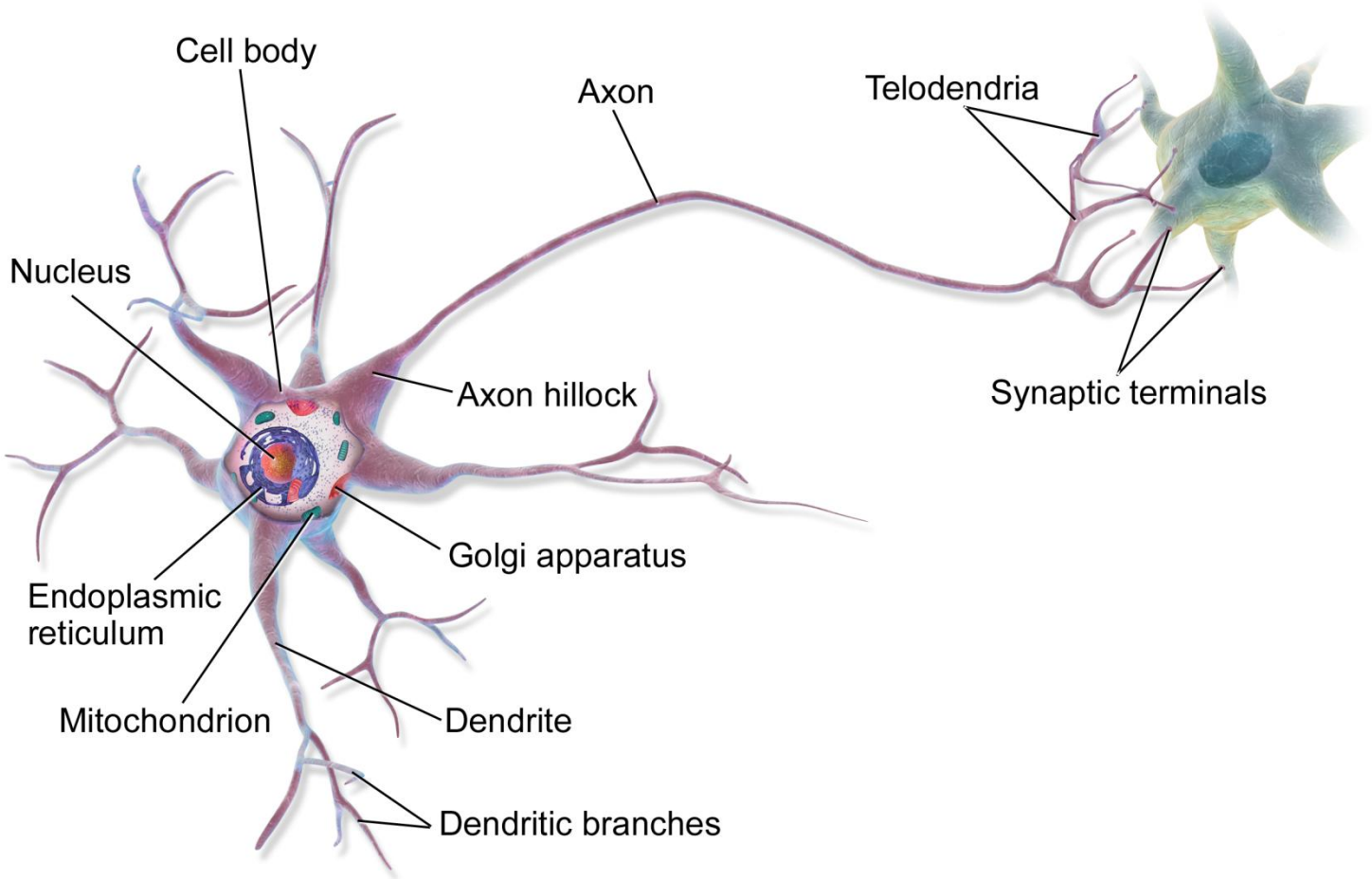
Disciplina 2017/2018

- 2C/1L Optoelectronică **OPTO**
- **Minim 7 prezente curs + laborator**
- Curs – **sl. Radu Damian**
  - an IV μE
  - Vineri 8-11, P5
  - E – 70% din nota
    - **20% test la curs**, saptamana 4-5?
  - probleme + (? 1 subiect teorie) + (2p prez. curs)
  - **toate materialele permise**
- Laborator – **sl. Daniel Matasaru**
  - an IV μE, an IV Tc
    - Joi 14-16 par/impar
  - L – 15% din nota
  - C – 15% din nota

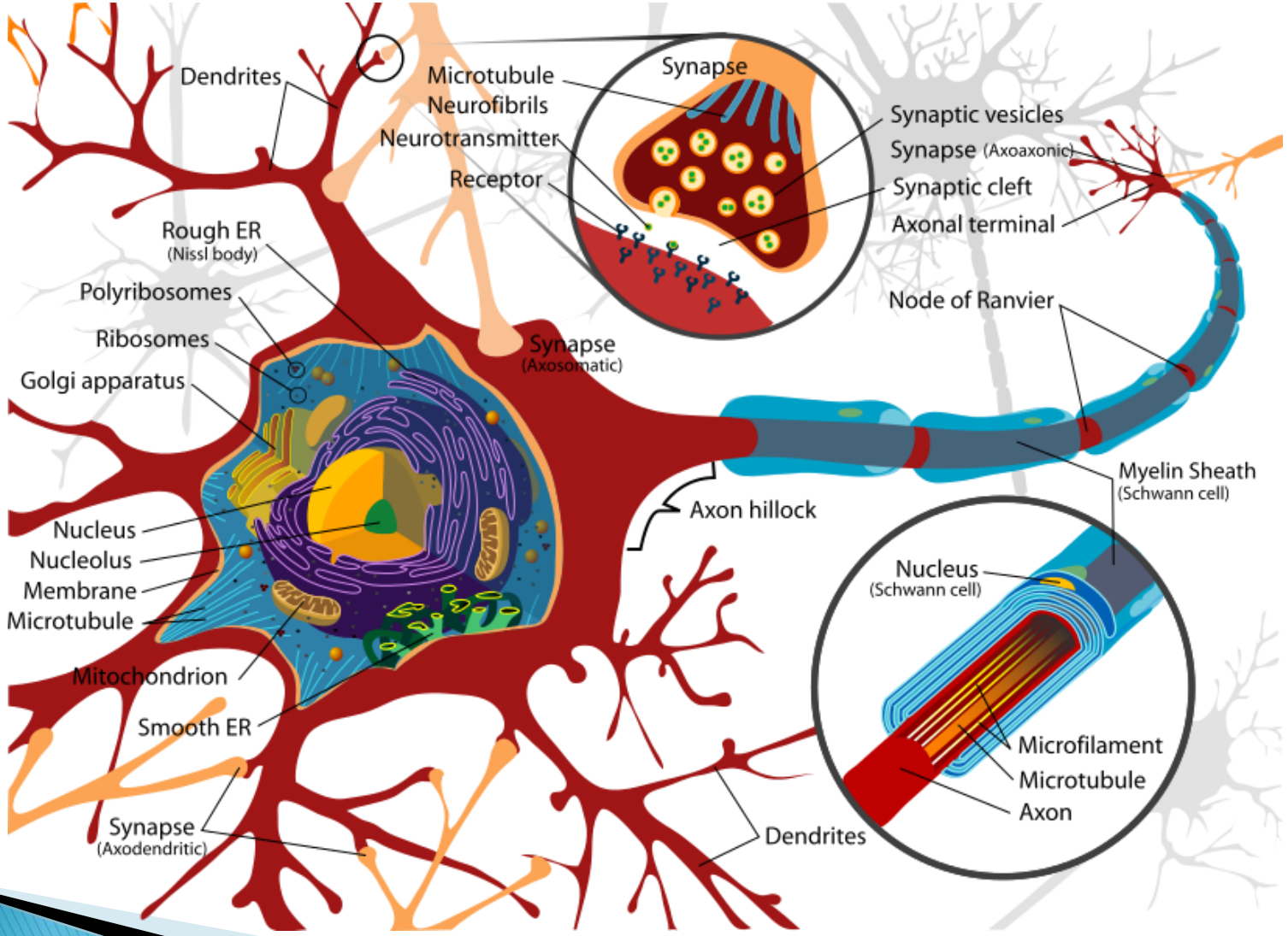
Orar 2017/2018

- Curs
  - Vineri 8-11, P5
  - 2C ⇨ 3C
    - 14*2/3≈9.33
    - 9÷10 C

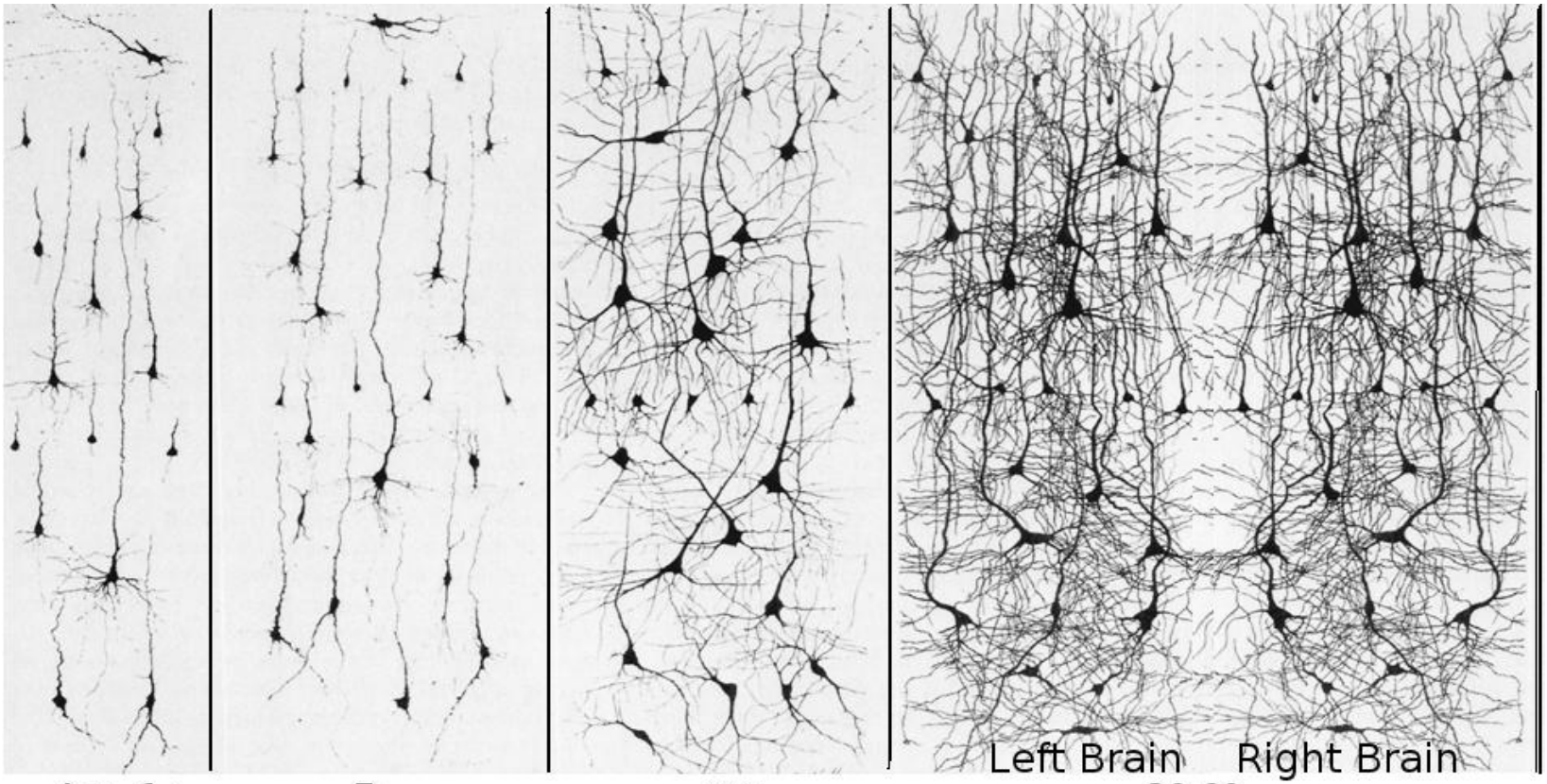
Scop 1


Cell body
Axon
Telodendria
Nucleus
Axon hillock
Synaptic terminals
Golgi apparatus
Endoplasmic reticulum
Mitochondrion
Dendrite
Dendritic branches

Scop 2


Dendrites
Microtubule
Neurofibrils
Neurotransmitter
Receptor
Synapse
Synaptic vesicles
Synapse (Axoaxonic)
Synaptic cleft
Axonal terminal
Rough ER
(Nissl body)
Polyribosomes
Ribosomes
Golgi apparatus
Synapse
(Axosomatic)
Node of Ranvier
Myelin Sheath
(Schwann cell)
Axon hillock
Nucleus
Nucleolus
Membrane
Microtubule
Mitochondrion
Smooth ER
Synapse
(Axodendritic)
Dendrites
Nucleus
(Schwann cell)
Microfilament
Microtubule
Axon

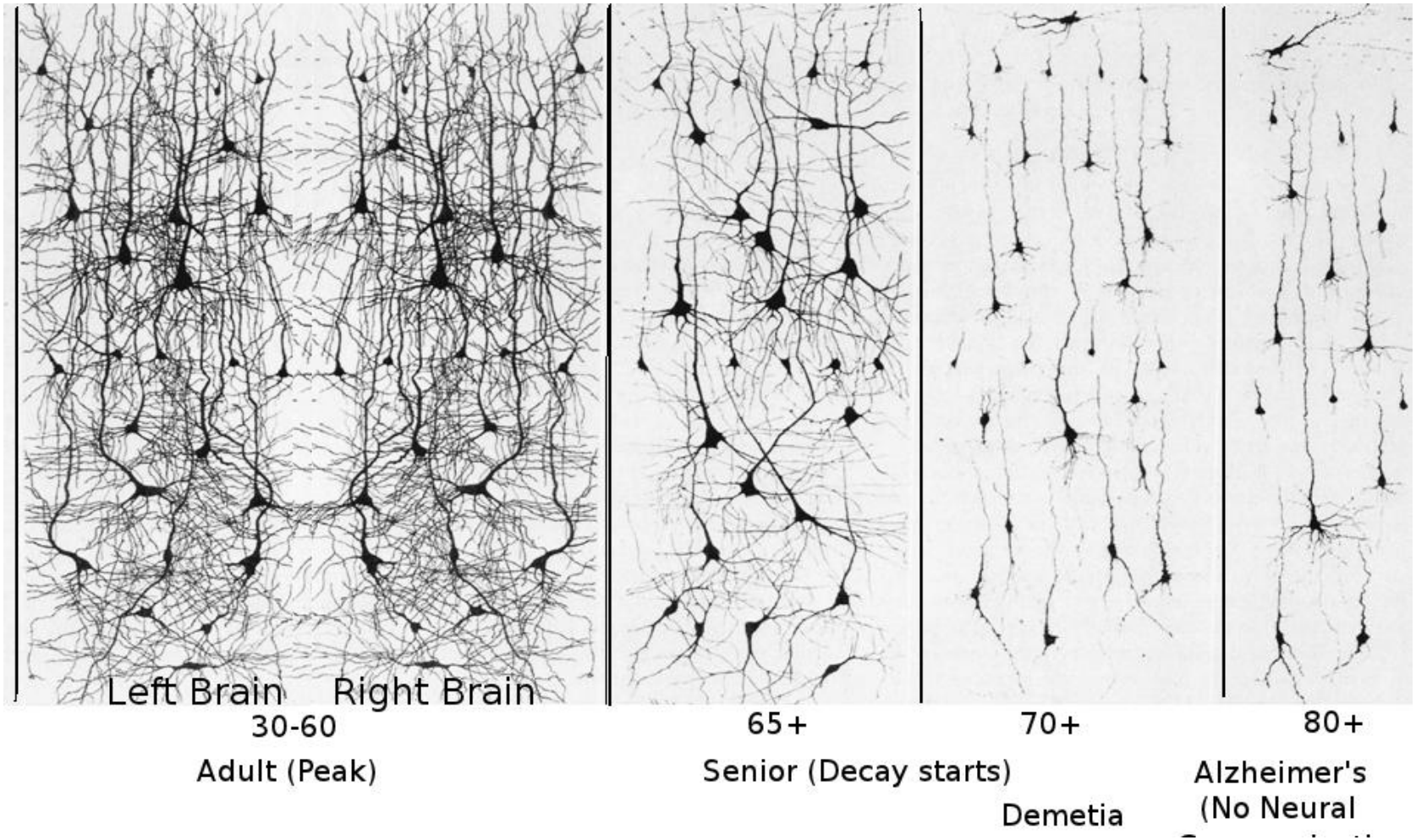
Scop 3


Left Brain
Right Brain
Age 1+
Infant-
-birth
7+
Child-
13+
-Teen
30-60
Adult (Peak)
(Stimulation and Growth)

Scop 4

Sinapse “inginerești”

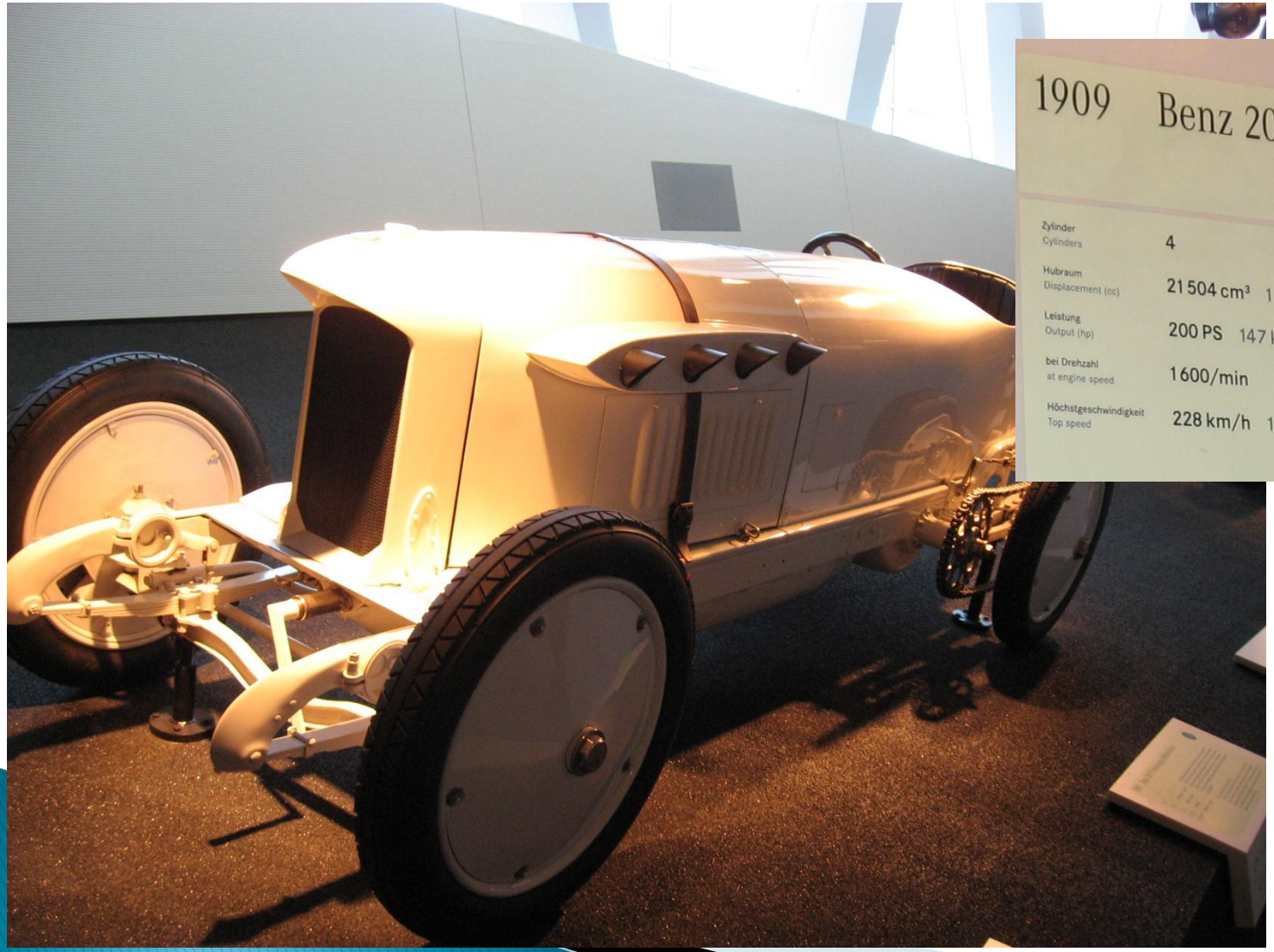
Termen


Left Brain
Right Brain
30-60
Adult (Peak)
65+
Senior (Decay starts)
70+
Demetia
80+
Alzheimer's
(No Neural

~1930

~1930

1909



1909 Benz 200 PS Rennwagen »Blitzen

Zylinder Cylinders	4	
Hubraum Displacement (cc)	21 504 cm³	1 312 cu in
Leistung Output (hp)	200 PS	147 kW
bei Drehzahl at engine speed	1 600/min	
Höchstgeschwindigkeit Top speed	228 km/h	142 mph

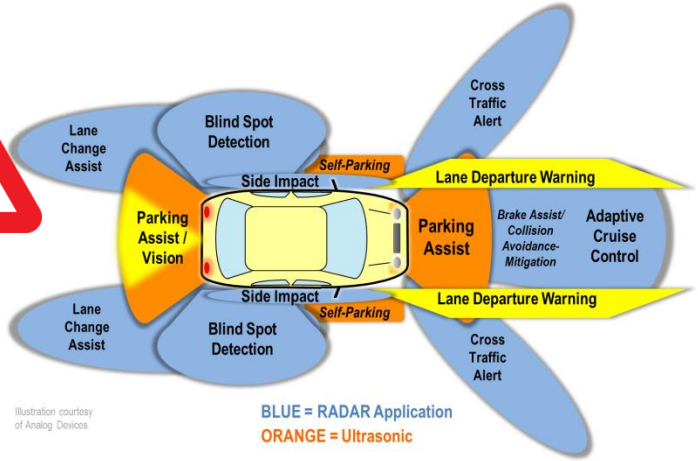
Der »Blitzen-Benz« ist 1909 der erst
200 km/h fährt. Seine größten Erfo
zylindermotor ausgestattete Rekor
Burman mit 228 km/h über die Sa
ist damit das schnellste Fahrzeug
jede Eisenbahn.

Benz »Lightning Benz« 200 hp rac
In 1909 the Lightning Benz

1930–1950

Tehnologie

> 2010



< 1950

Tehnologie

1x1 = 1 1x2 = 2 1x3 = 3 1x4 = 4 1x5 = 5 1x6 = 6 1x7 = 7 1x8 = 8 1x9 = 9 1x10 = 10	2x1 = 2 2x2 = 4 2x3 = 6 2x4 = 8 2x5 = 10 2x6 = 12 2x7 = 14 2x8 = 16 2x9 = 18 2x10 = 20	3x1 = 3 3x2 = 6 3x3 = 9 3x4 = 12 3x5 = 15 3x6 = 18 3x7 = 21 3x8 = 24 3x9 = 27 3x10 = 30	4x1 = 4 4x2 = 8 4x3 = 12 4x4 = 16 4x5 = 20 4x6 = 24 4x7 = 28 4x8 = 32 4x9 = 36 4x10 = 40	5x1 = 5 5x2 = 10 5x3 = 15 5x4 = 20 5x5 = 25 5x6 = 30 5x7 = 35 5x8 = 40 5x9 = 45 5x10 = 50
6x1 = 6 6x2 = 12 6x3 = 18 6x4 = 24 6x5 = 30 6x6 = 36 6x7 = 42 6x8 = 48 6x9 = 54 6x10 = 60	7x1 = 7 7x2 = 14 7x3 = 21 7x4 = 28 7x5 = 35 7x6 = 42 7x7 = 49 7x8 = 56 7x9 = 63 7x10 = 70	8x1 = 8 8x2 = 16 8x3 = 24 8x4 = 32 8x5 = 45 8x6 = 48 8x7 = 56 8x8 = 64 8x9 = 72 8x10 = 80	9x1 = 9 9x2 = 18 9x3 = 27 9x4 = 36 9x5 = 45 9x6 = 54 9x7 = 63 9x8 = 72 9x9 = 81 9x10 = 90	10x1 = 10 10x2 = 20 10x3 = 30 10x4 = 40 10x5 = 50 10x6 = 60 10x7 = 70 10x8 = 80 10x9 = 90 10x10 = 100

2x1 = 2
2x2 = 4
2x3 = 6
2x4 = 8
2x5 = 10
2x6 = 12
2x7 = 14
2x8 = 16
2x9 = 18
2x10 = 20

Cuprins

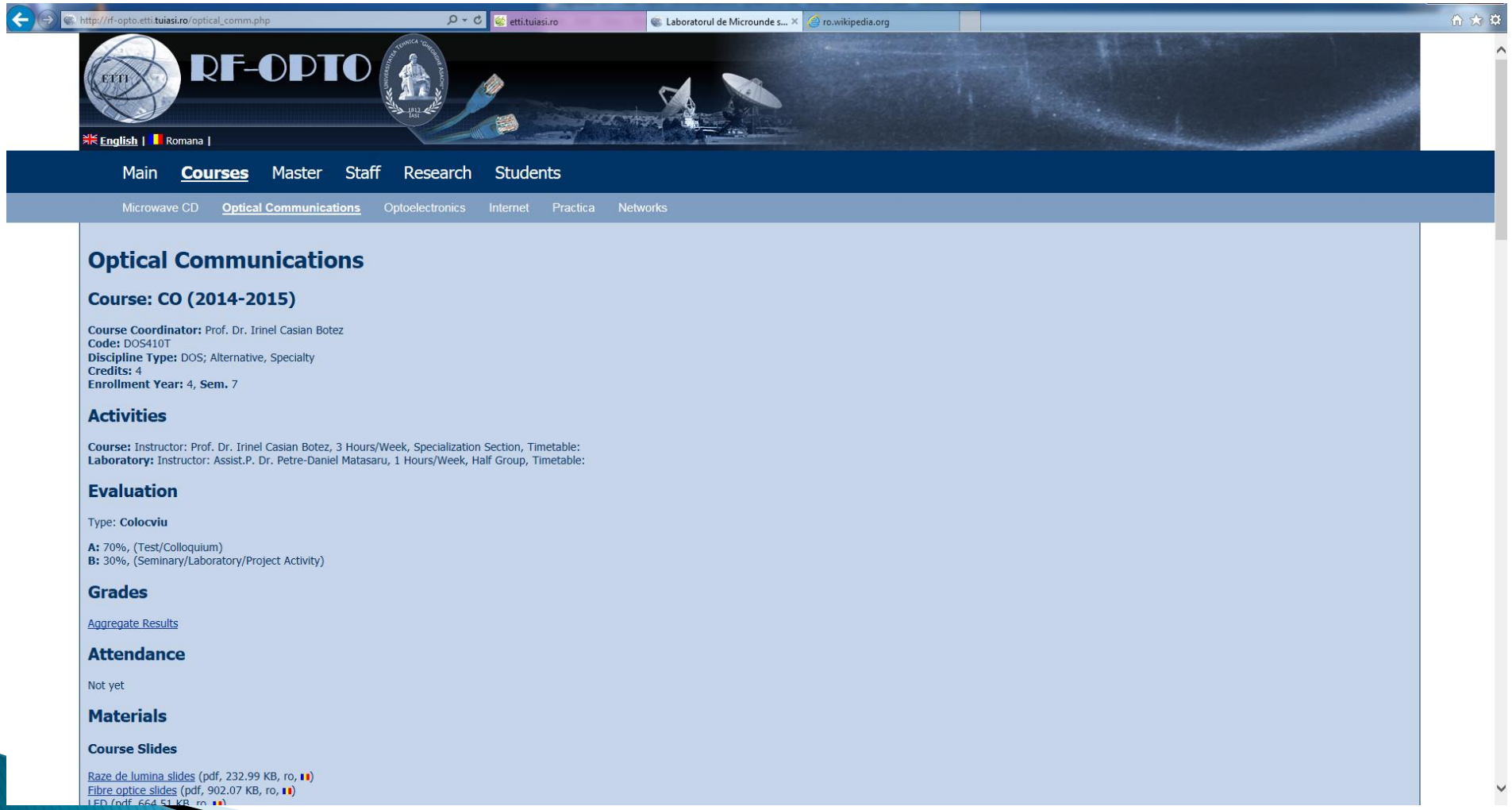
- **Lumina ca undă electromagnetică** (ecuaţiile lui Maxwell, ecuaţia undelor, parametrii de propagare)
- **Elemente de fotometrie şi radiometrie** (mărimi energetice/luminoase)
- **Fibra optică** (realizare, principiu de funcţionare, atenuare, dispersie, banda de frecvenţă)
- **Cabluri optice** (tehnologie, conectori, lipire – splice)
- **Proiectare sistemică a legăturii pe fibra optică** (bandă de frecvenţă, balanţa puterilor)
- **Emiţătoare optice** (LED şi dioda laser – realizare fizică şi functionare)
- **Receptoare optice** (dioda PIN, dioda cu avalanşă – realizare fizică şi functionare)
- **Amplificatoare transimpedanţă** (parametri, scheme tipice, TIA în buclă deschisă, cu reacţie, diferenţiale, control automat al câştigului)
- **Realizarea circuitelor pentru controlul emiţătoarelor optice (**parametri, scheme tipice, controlul puterii, multiplexoare**)**
- **Dispozitive de captare a energiei solare** (principiu de functionare, utilizare, proiectare)

Bibliografie

- http://rf-opto.etti.tuiasi.ro
- Irinel Casian-Botez, "Structuri Optoelectronice", Ed. "CANOVA", Iasi 2001, ISBN 973-96099-2-9
- Behzad Razavi – Design of Integrated Circuits for Optical Communications, Mc Graw Hill http://rf-opto.etti.tuiasi.ro/docs/opto/
- IBM – Understanding Optical Communications: on-line http://www.redbooks.ibm.com
- Radu Damian, I Casian, D Matăsaru – „Comunicatii Optice” , Indrumar de laborator, 2005

Documentatie

Documentatie



Documentatie

- RF-OPTO
  - http://rf-opto.etti.tuiasi.ro
- Fotografie
  - de trimis prin email: rdamian@etti.tuiasi.ro
  - necesara la laborator/curs

Fotografii

Studentii care au trimis fotografiile

Grupa: 5402

Nr.	Nume
1	APETRII MARIA

Grupa: 5403

Nr.	Nume
1	ALEXANDRESCU SEBASTIAN

Grupa: 5404

Nr.	Nume
1	APERGHIS MIHAI-ALIN

Grupa: 5405

Nr.	Nume
1	ANGHELUS MARIL

Studentii care inca nu au trimis fotografiile

Grupa: 5304

Nr.	Nume

Grupa: 5402

Nr.	Nume

Grupa: 5403

Nr.	Nume

Grupa: 5404

Nr.	Nume

Fotografii

Date:

Grupa	5304 (2015/2016)
Specializarea	Tehnologii si sisteme de telecomunicatii
Marca	5184

Trimite email acestui student | Adauga acest student la lista (0)

Detalii curente

Finantare	Buget
Bursa	Fara Bursa

Observatii

Date:

Grupa	5304 (2015/2016)
Specializarea	Tehnologii si sisteme de telecomunicatii
Marca	5244

Trimite email acestui student | Adauga acest student la lista (0)

Detalii curente

Finantare	Buget
Bursa	Bursa de Studii

Observatii

Date:

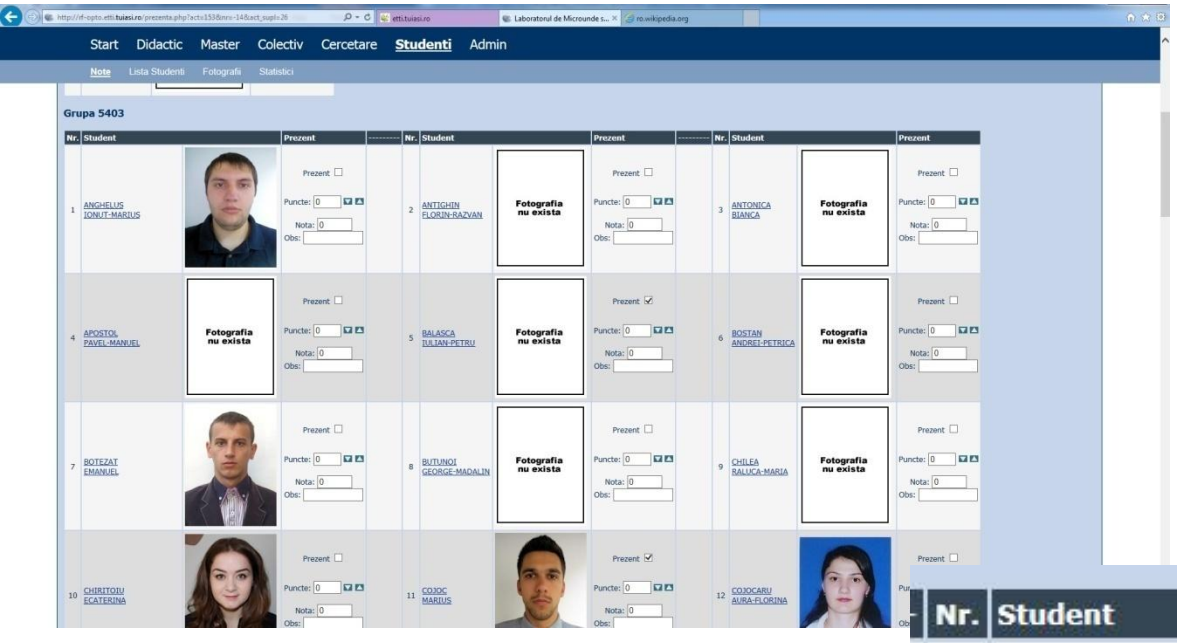
Grupa	5304 (2015/2016)
Specializarea	Tehnologii si sisteme de telecomunicatii
Marca	5184

Acceseaza ca acest student

Note obtinute

Disciplina	Tip	Data	Descriere	Nota	Puncte	Obs.
TW	**Tehnologii Web**					
	N	17/01/2014	Nota finala	10	-	
	A	17/01/2014	Colocviu Tehnologii Web 2013/2014	10	7.55	
	B	17/01/2014	Laborator Tehnologii Web 2013/2014	9	-	
	D	17/01/2014	Tema Tehnologii Web 2013/2014	9	-	

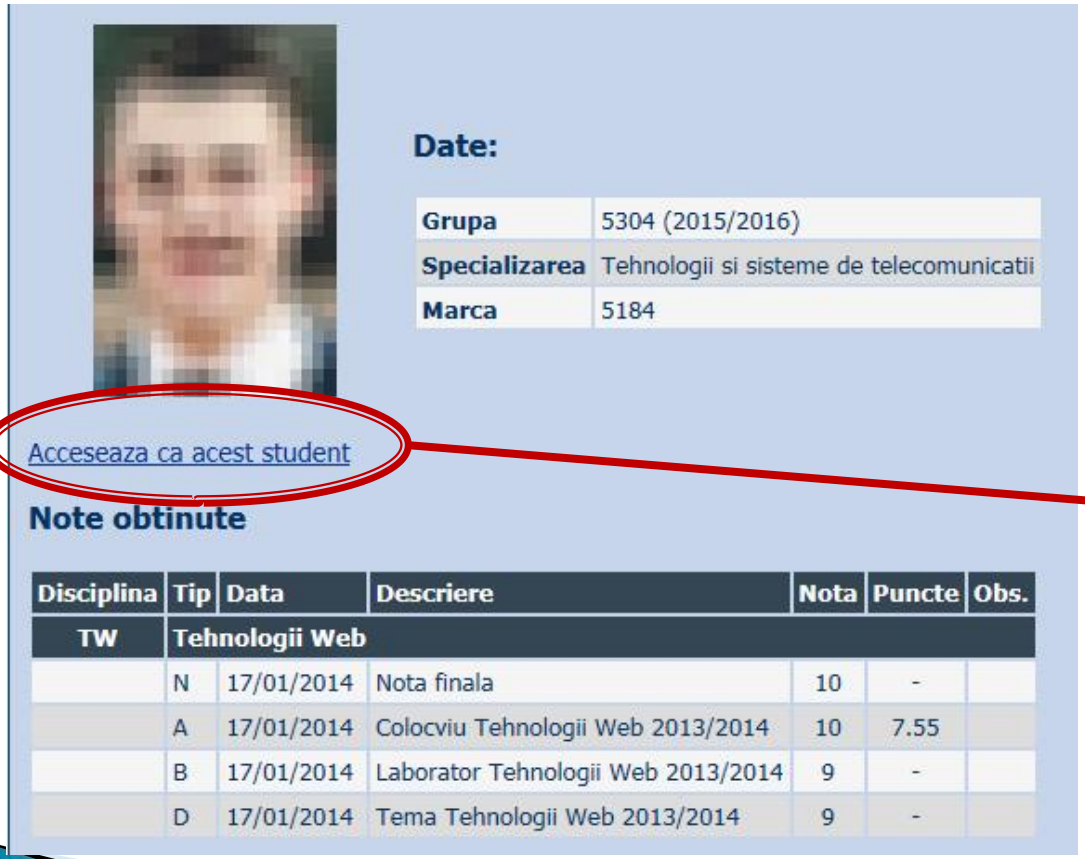
Fotografii


Start Didactic Master Colectiv Cercetare Studenti Admin
Note Lista Studenti Fotografii Statistici
Grupa 5403
Nr. Student Prezent
1 ANGHELUS IONUT-MARIUS
2 ANTIGHIN FLORIN-RAZVAN
3 ANTONICA BIANCA
4 APOSTOL PAVEL-MANUEL
5 BALASCA IULIAN-PETRU
6 BOSTAN ANDREI-PETRICA
7 BOTEZAT EMANUEL
8 BUTUNOI GEORGE-MADALIN
9 CHILEA RALUCA-MARIA
10 CHIRITOIU ECATERINA
11 COJOC MARIUS
12 COJOCARU AURA-FLORINA
Fotografia nu exista
Prezent
Puncte: 0
Nota: 0
Obs:


Nr.
Student
Prezent
2
ANTIGHIN FLORIN-RAZVAN
Fotografia nu exista
Prezent
Puncte: 0
Nota: 0
Obs:

Acces

- ~~Personalizat~~



Date:

Grupa	5304 (2015/2016)
Specializarea	Tehnologii si sisteme de telecomunicatii
Marca	5184

Acceseaza ca acest student

Note obtinute

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	B	17/01/2014	Laborator Tehnologii Web 2013/2014	9	-	
	D	17/01/2014	Tema Tehnologii Web 2013/2014	9	-	

Bonus

Disciplina: Optoelectronica, structuri, tehnologii, circuite
An: 2015/2016

Bonus-uri care se aplica la nota de la teza obtinute prin:
- prezenta la curs (0.5p / 3pr)
- 3 miniteste aplicate la curs (max. 3 X 1.5p)
- contributie la site rf-opto (foto <C5=1p, >C5=0.5p)

Nr.	Student	Grupa	Prezente curs	Bonus prezenta	Bonus foto	Bonus T1	Bonus T2	Bonus T3	Total Bonus	Obs.
1	CIOLPAN OCTAVIAN	5306	3	0.5					0.5	-
2	NITA COSTEL-CATALIN	5307	4	0.5	1				1.5	-
3	BARON BOGDAN-IONUT	5405	12	2	1	0.5		0.75	4.25	-

Prezenta

Curs
Laborator

Liste

Studenti care nu pot intra in examen
Bonus-uri acumulate

- **Minim** 7 prezente
- 0.5p/2(3)prez
- 3 teste
- foto

Examen

- subiecte individuale
- Note
  - 2007: 9.67±0.66/8.81±1.22
  - 2008: 6.24±1.36/ 4.82±2.10
  - 2009: 5.10±1.46
  - 2010: 3.89±1.32
- La prima aplicare (neanuntata)
  - 50% din studenti au parasit examenul in primele 10 minute
  - 50% din cei ramasi nu au promovat
  - promovabilitate totala **25%**, rata contestatiilor: **0%**
- Urmatoarele examinari (anuntate)
  - rata contestatiilor: 0%

Examen

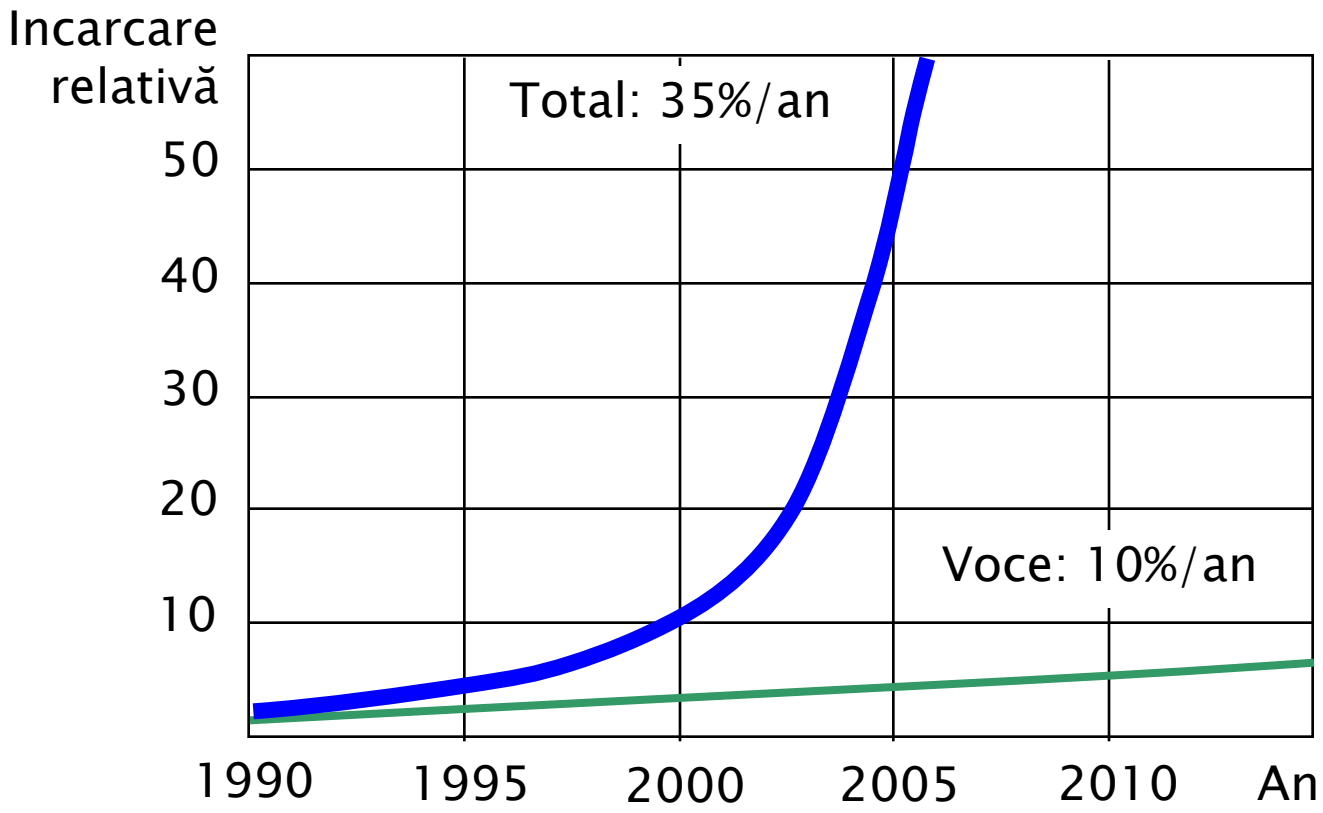
Introducere

Capitolul 1

Aplicatii majore

- Comunicatii
  - Infrarosu (InGaAsP)
- Vizibil
  - Spectru vizibil (GaAlAs)
- Iluminare
  - Putere ridicata, lumina alba (GaInN)

Evoluţia lăţimii de bandă utilizată în reţelele de telecomunicaţii

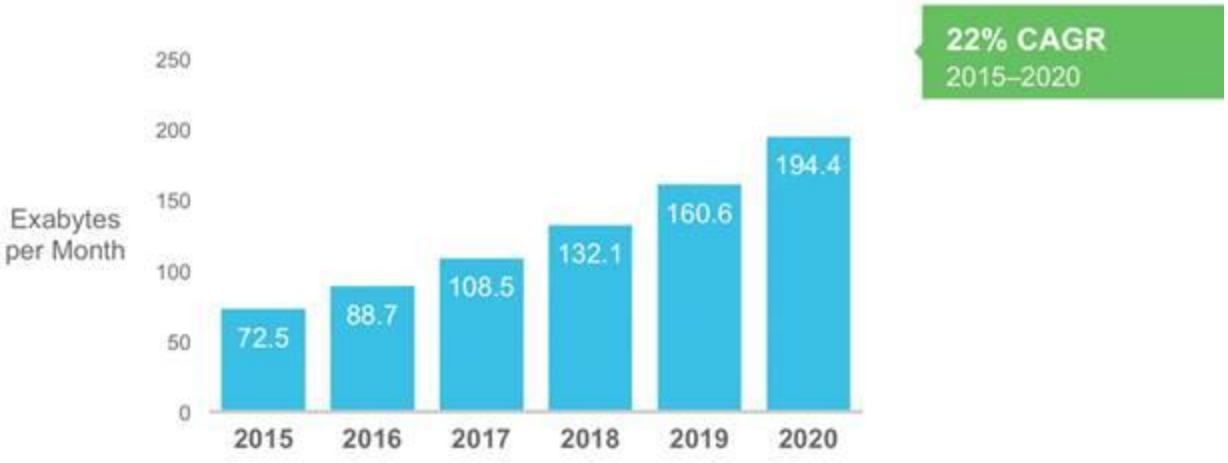


Sursa:

ElectroniCast Corporation

Table 1. The Cisco VNI Forecast—Historical Internet Context

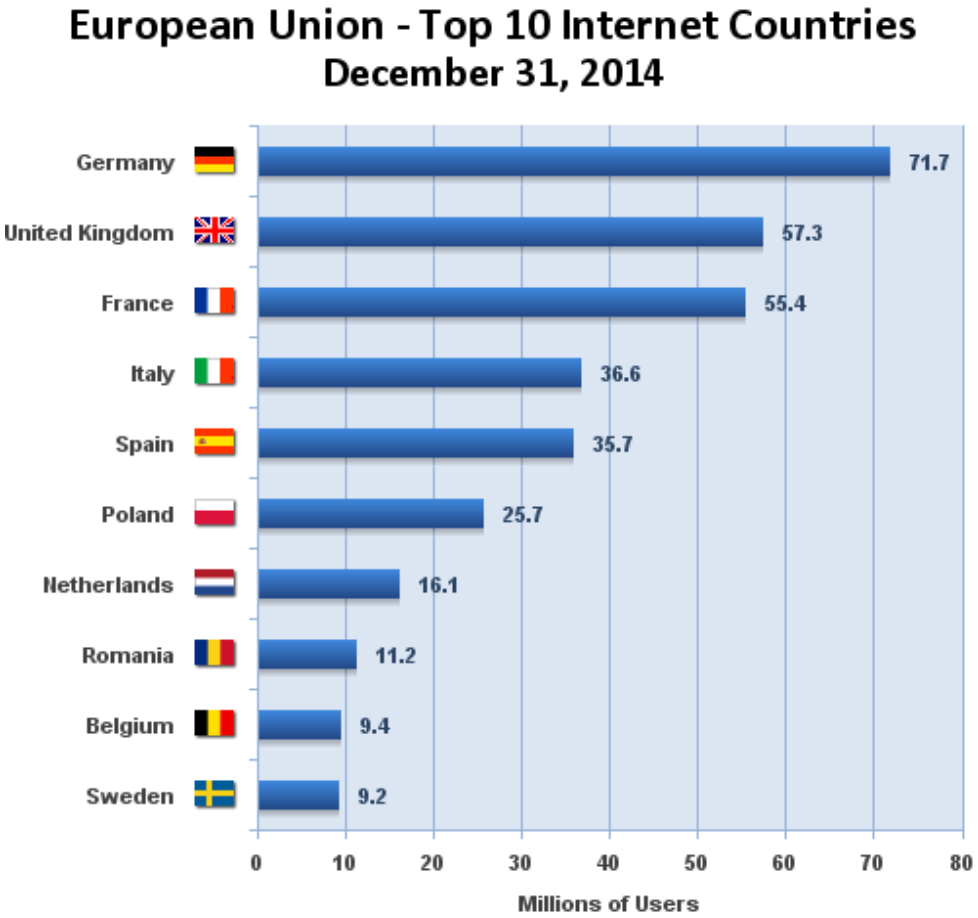
Evoluţia lăţimii de bandă



Source: Cisco VNI, 2016

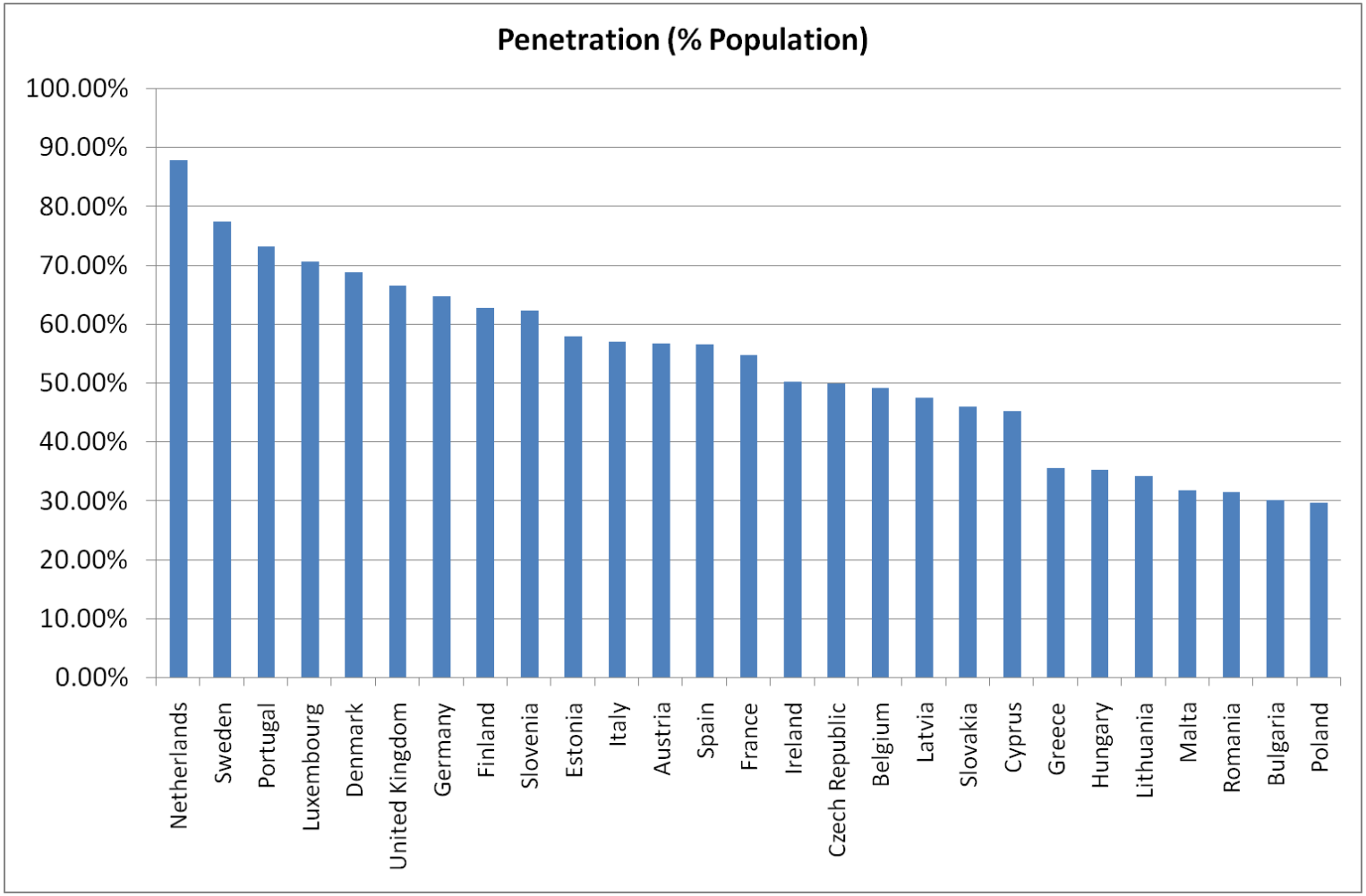
Year	Global Internet Traffic
1992	100 GB per day
1997	100 GB per hour
2002	100 GBps
2007	2,000 GBps
2015	20,235 GBps
2020	61,386 GBps

Utilizatori Internet in EU

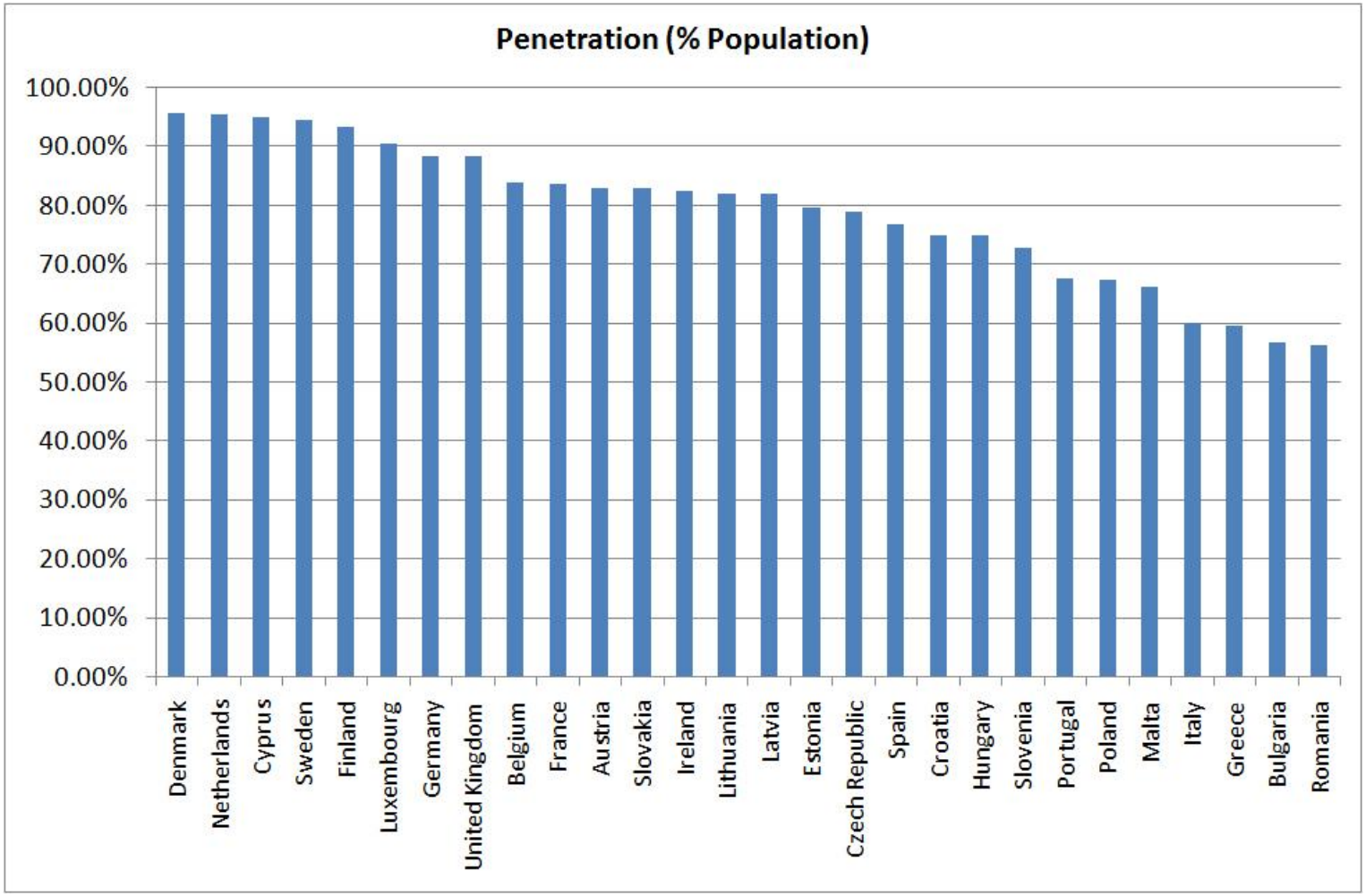


Source: Internet World Stats - www.internetworldstats.com/stats9.htm
398,972,533 estimated EU Internet users for 2014Q4

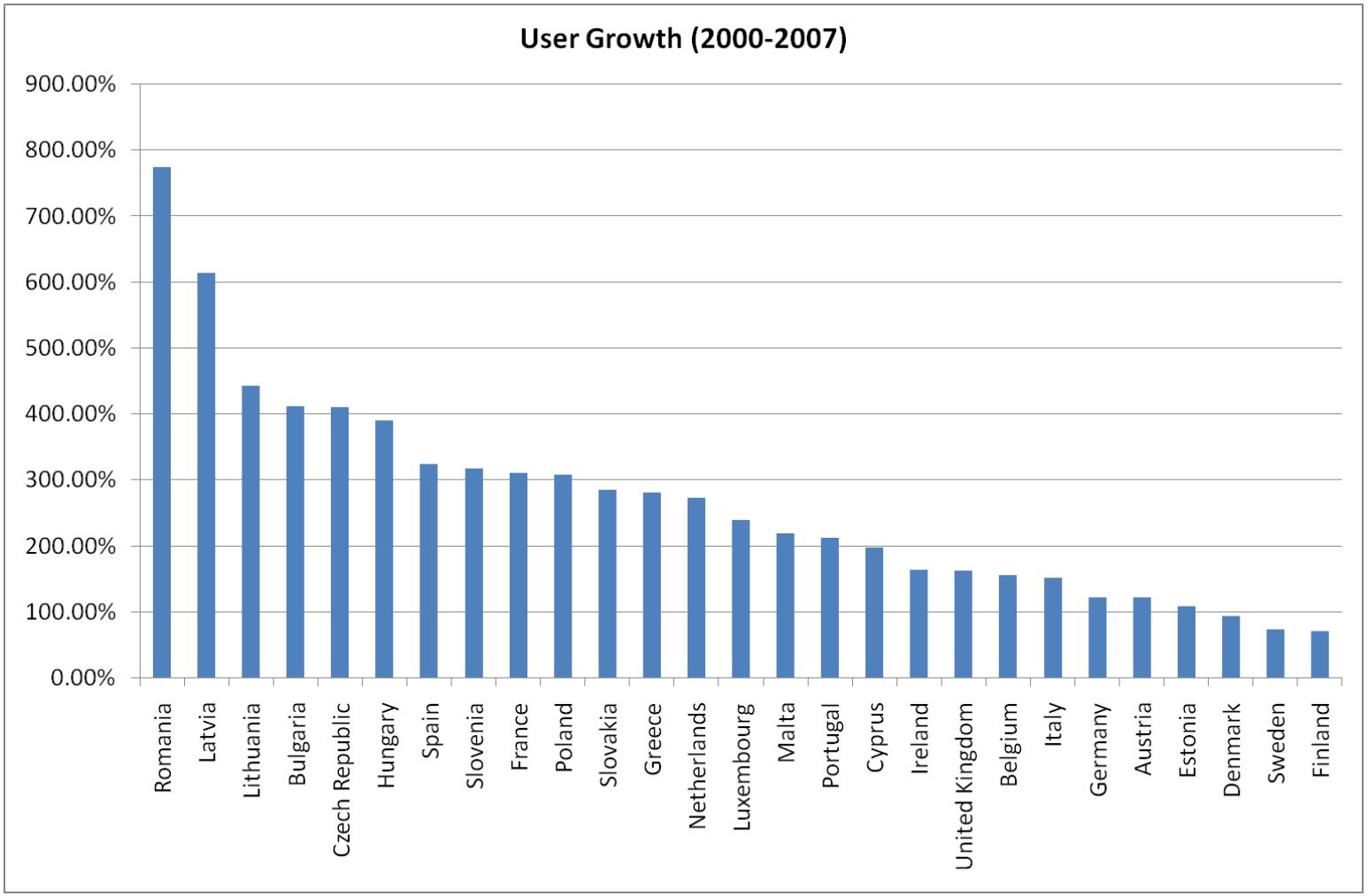
Rata de penetrare in EU 2007



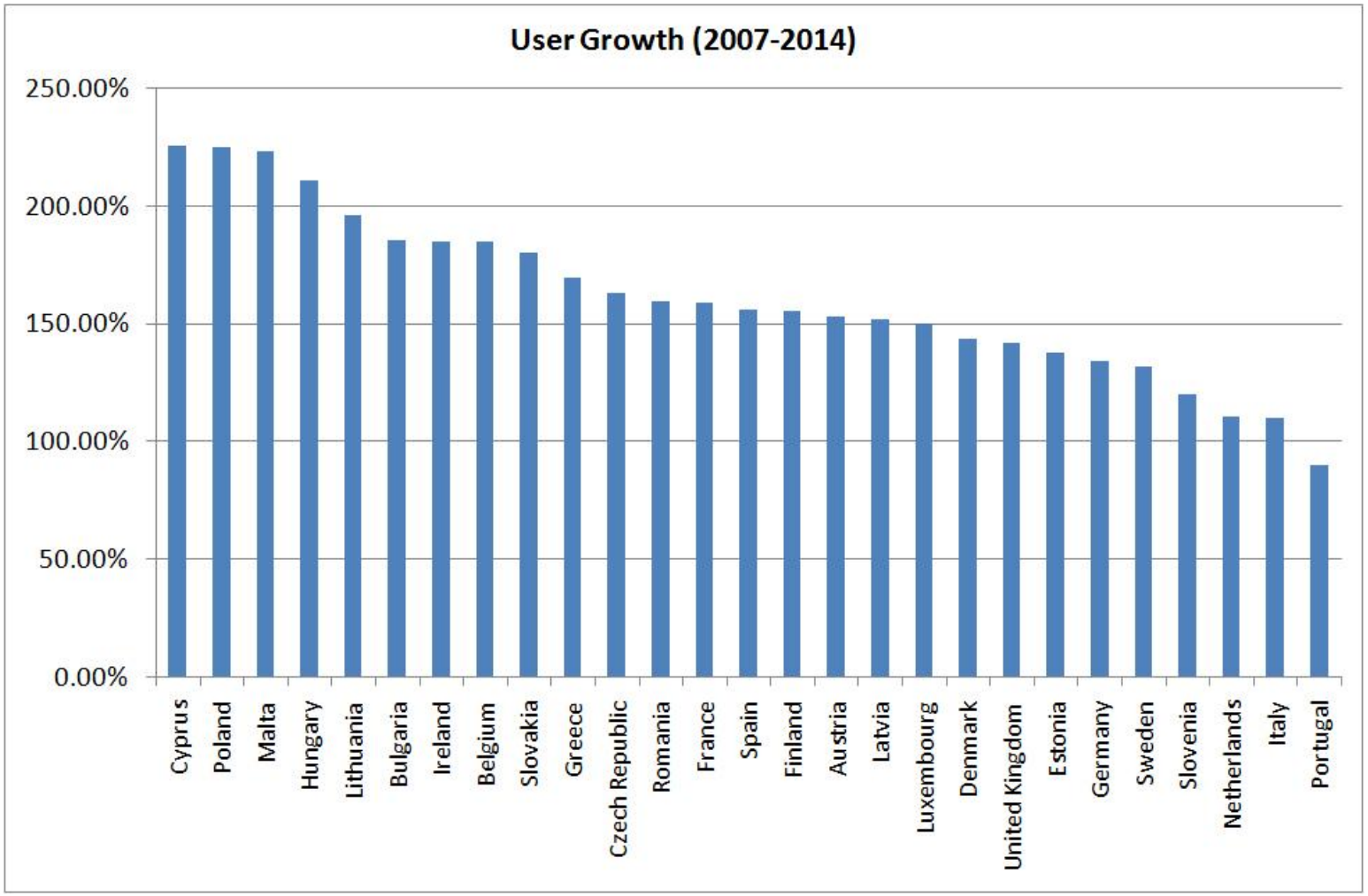
Rata de penetrare in EU 2014



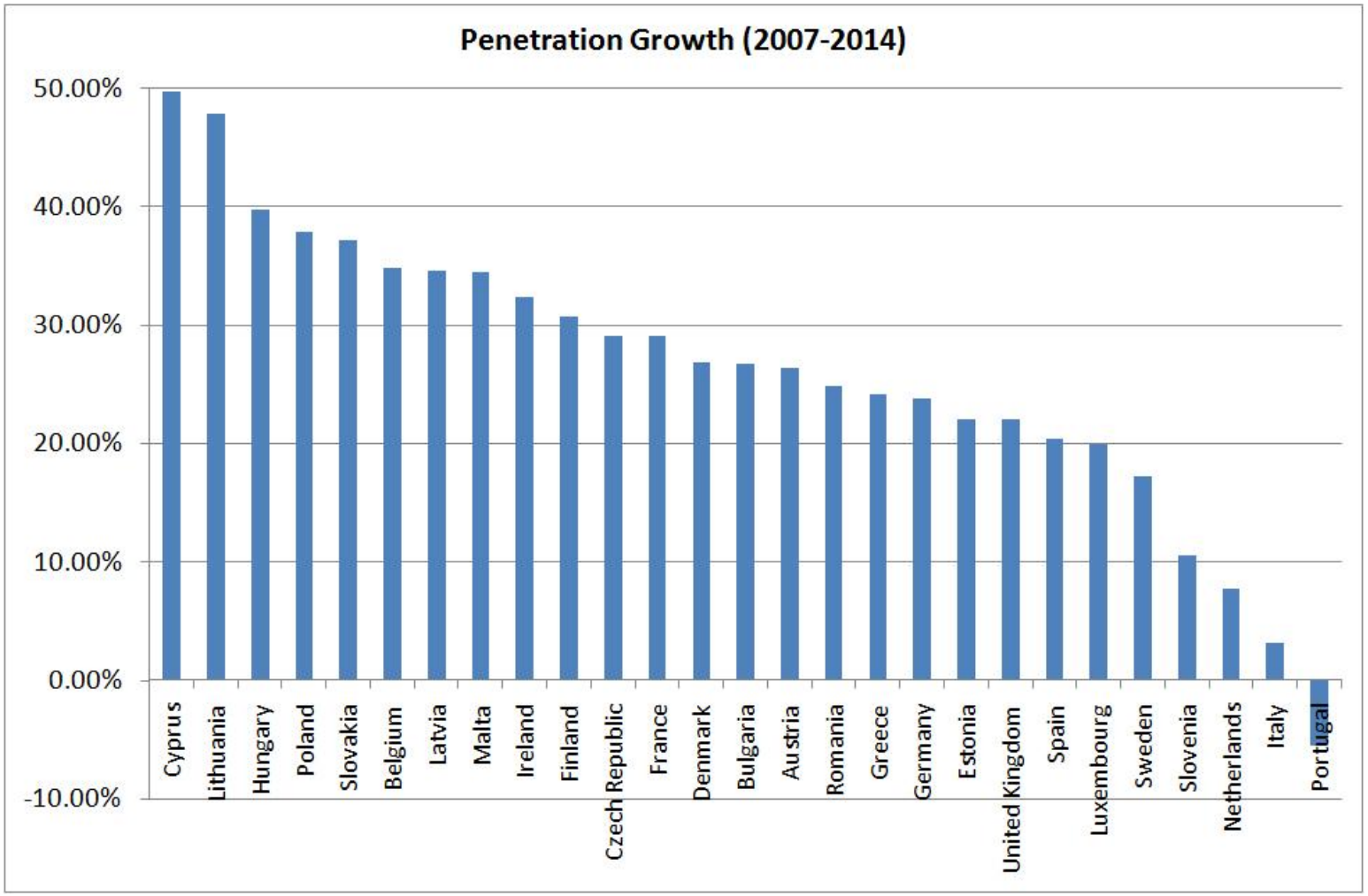
Crestere 2000-2007



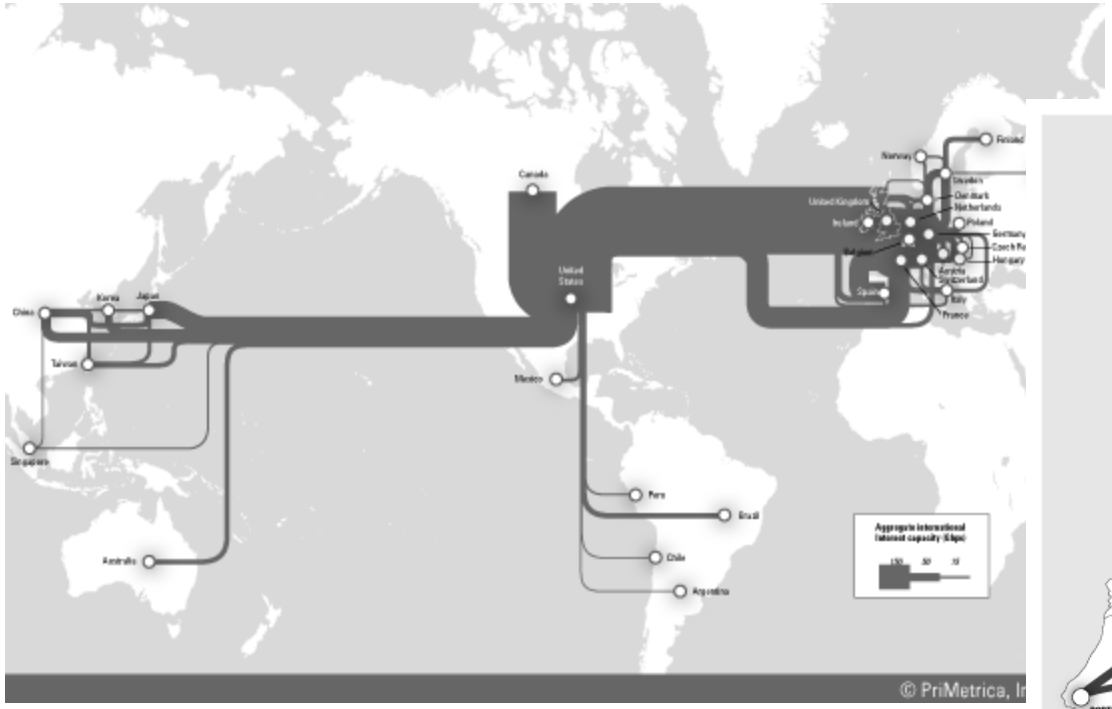
Crestere 2007-2014

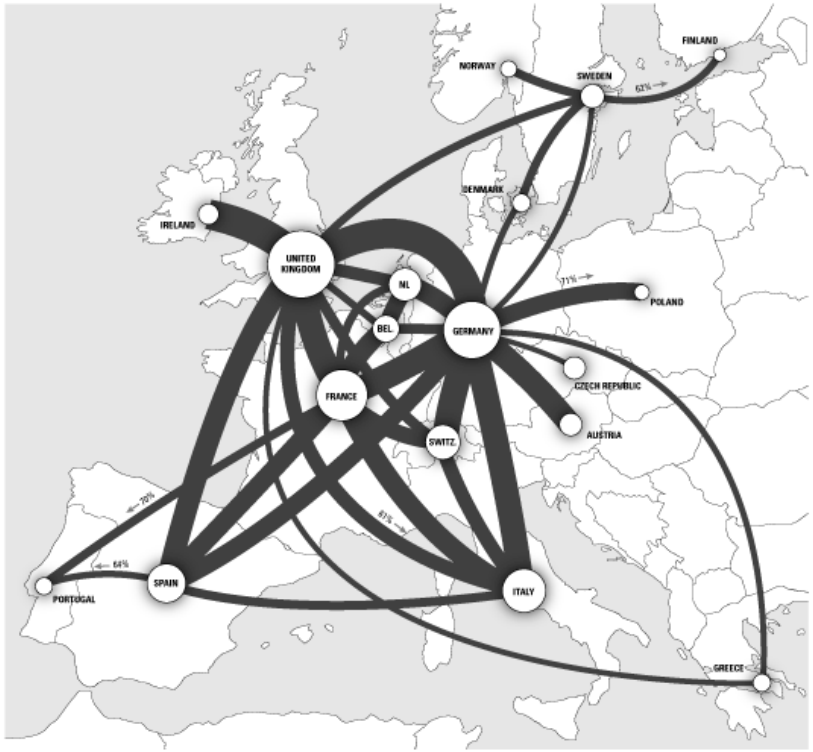


Crestere 2007-2014



Internet Backbone





Internet Backbone

Avantajele comunicaţiilor prin fibra optică – 1

- Greutate şi volum
- Costul materialelor primare
  - SiO_2/Cu
- Capacitate de transmisie a informaţiei **f~200THz**
  - 15.5 Tbit/s @ 7000 km, 69.1Tb/s @ 240km
  - Banda (Viteza) x Distanţă [MHz·km] [? MHz/km]
- Lipsa conexiunilor electrice
  - Bucle de masă (1-2V/km)
  - Siguranţă în exploatare
  - Imunitate la fulgere/lipsa scânteilor

Avantajele comunicaţiilor prin fibra optică – 2

- Imunitate la interferenţă electromagnetică
- Distanta între repetoare
  - 100km/2-5km
- Posibilitate de creştere a capacităţii de transmisie a informaţiei
  - Teoretic extrem de mare (aproape infinită) **f~200THz**
  - Reutilizarea cablurilor existente
- Securitate
  - Interceptare dificilă şi detectabilă
  - Inserare de semnal practic imposibilă

Dezavantajele comunicaţiilor prin fibra optică

- Conexiuni complexe şi esenţiale
  - Costul circuitelor integrate cresut considerabil de cuplarea luminii in fibra
- Curbarea cablurilor optice
- Dezvoltarea greoaie a standardelor
- Optica folosită strict pentru transmisie (aproape)
  - EDFA – Erbidium Dopped Fiber Amplifier
- Sensibilitate la radiaţii gama şi câmpuri electrice intense
- Rozătoare şi termite

Esantionare

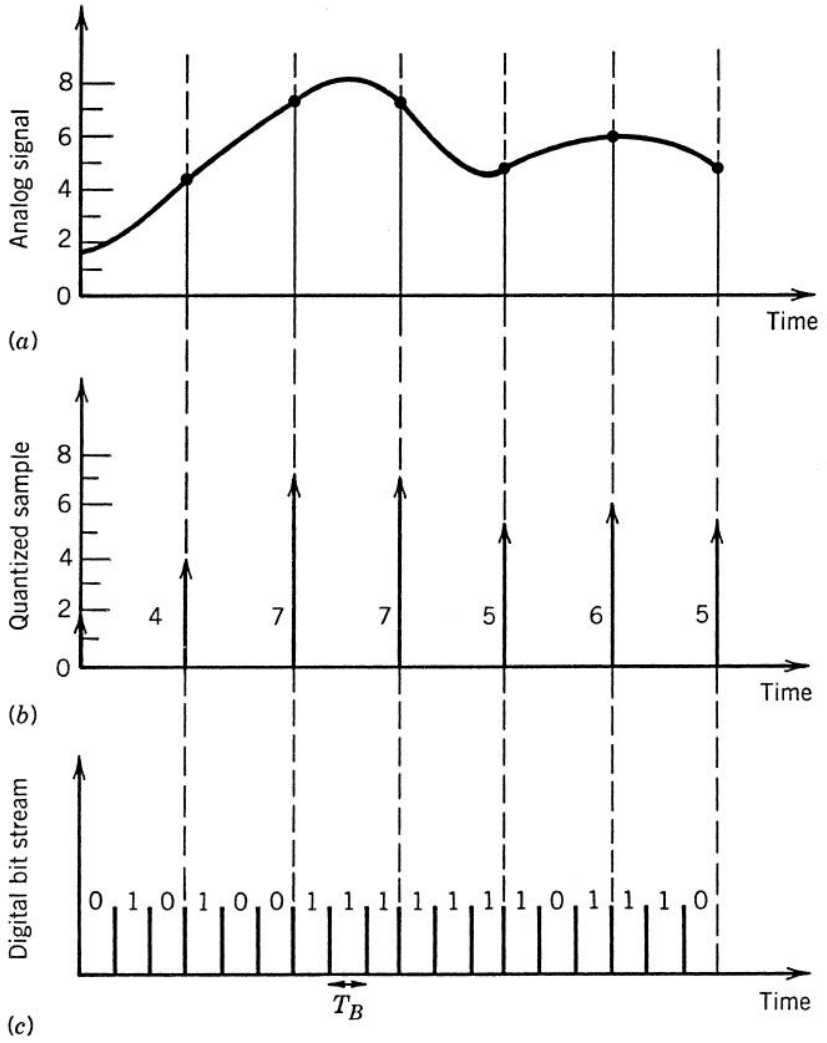
- pulse-position modulation
- pulse-duration modulation
- pulse-code modulation (PCM)

- esantionare (Nyquist)

$$f_s \geq 2 \cdot \Delta f$$

- cuantizare **M** intervale discrete
- zgomot de cuantizare
- minimizat

$$M \geq \frac{A_{\max}}{A_N}$$



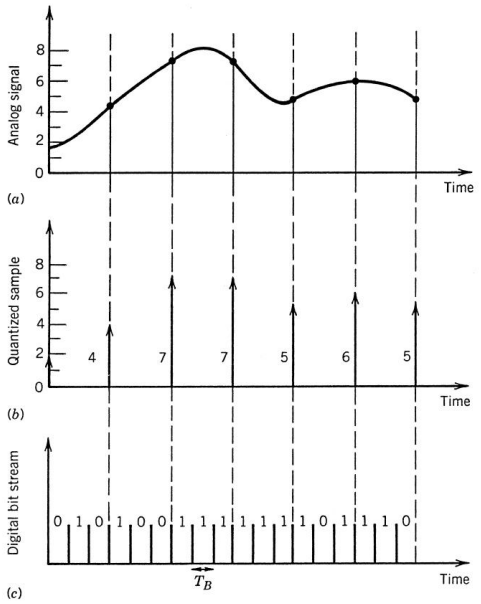
Esantionare

- pulse-code modulation (PCM)
- cuantizare **M** intervale discrete, codificate cu **m** biți

$$M = 2^m$$

- viteza necesara (bit rate) [b/s]

$$B = m \cdot f_s \geq (2\Delta f) \cdot \log_2 M$$



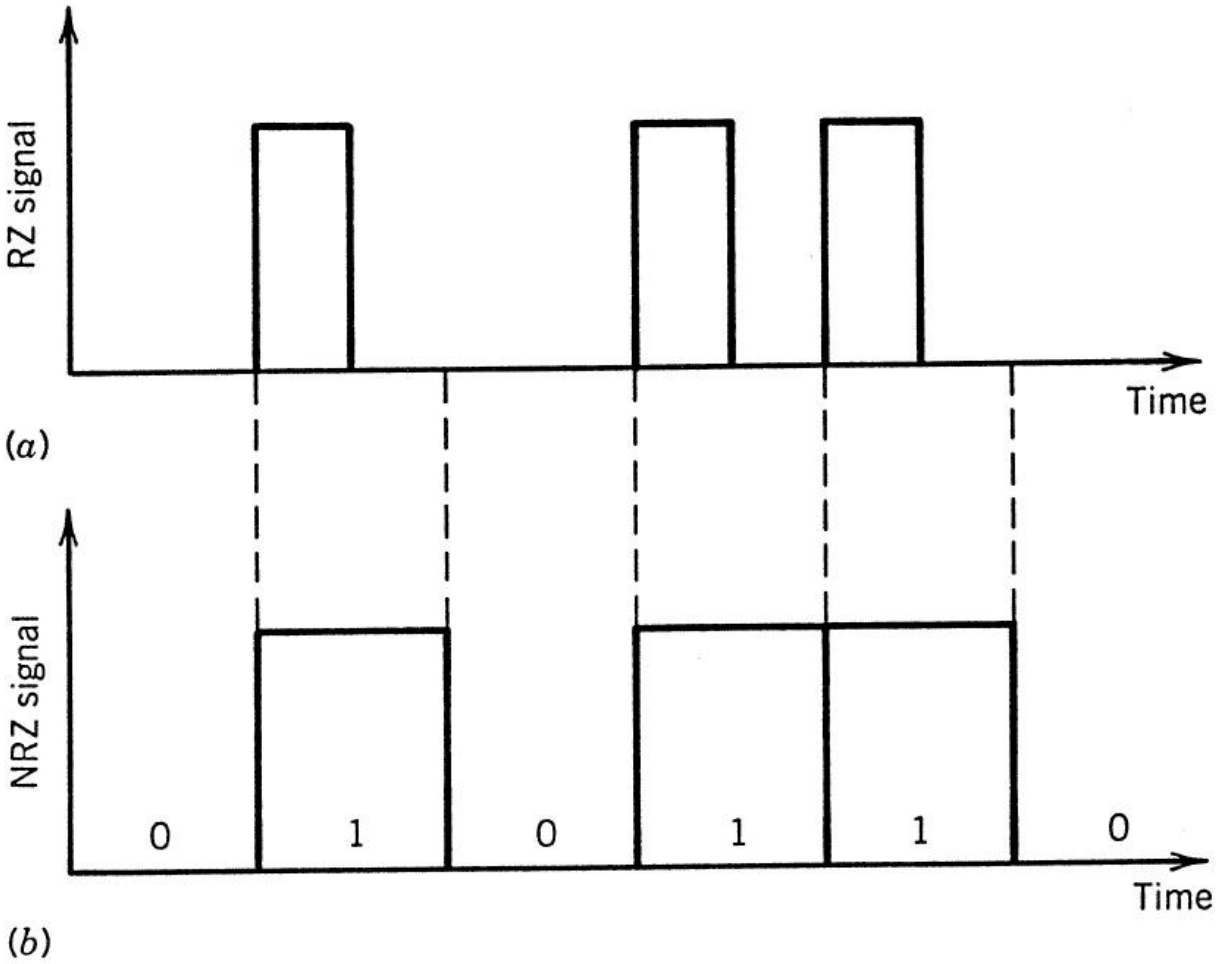
$$M \geq \frac{A_{max}}{A_N} \qquad SNR\,[\text{dB}] = 10 \cdot \log_{10}\left(\frac{P_{max}}{P_N}\right) = 20 \cdot \log_{10}\left(\frac{A_{max}}{A_N}\right) \qquad \log_2 10 \approx 3.33$$

$$B > (\Delta f / 3) \cdot SNR$$

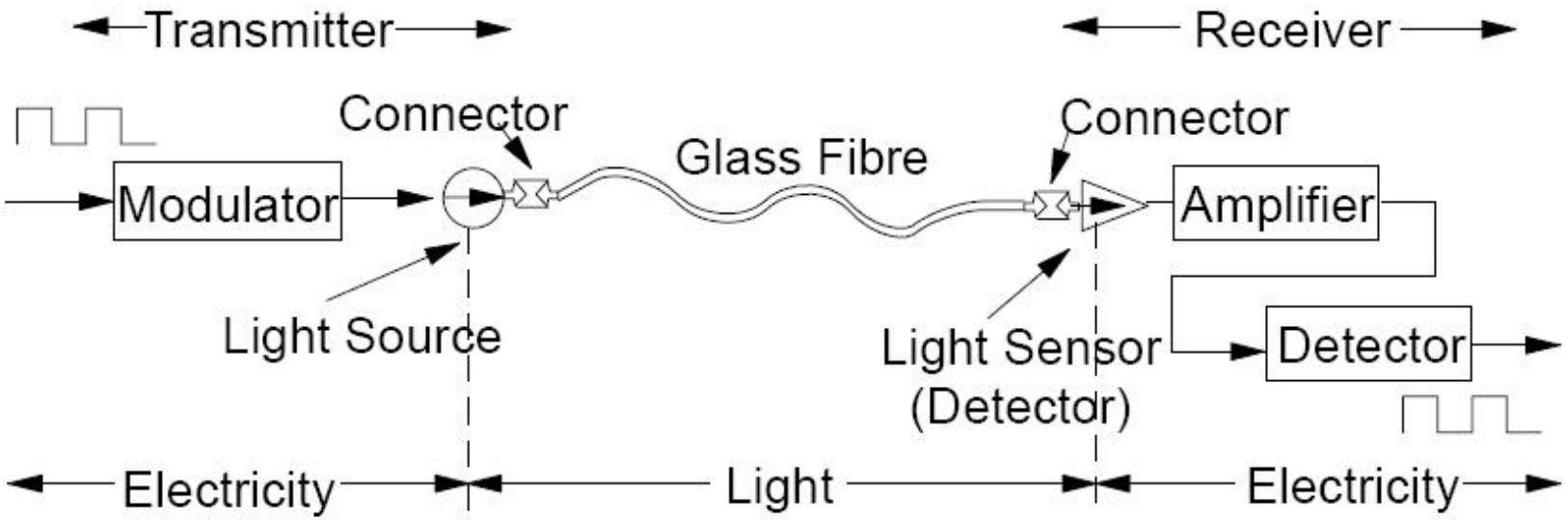
- telefonie: 3.1kHz @ SNR=30dB
  - B=31kb/s (64kb/s)
- televiziune: 4MHz @ SNR=50dB
  - B=66Mb/s (100Mb/s)

Modulare

- return-to-zero (RZ)
- nonreturn-to-zero (NRZ)

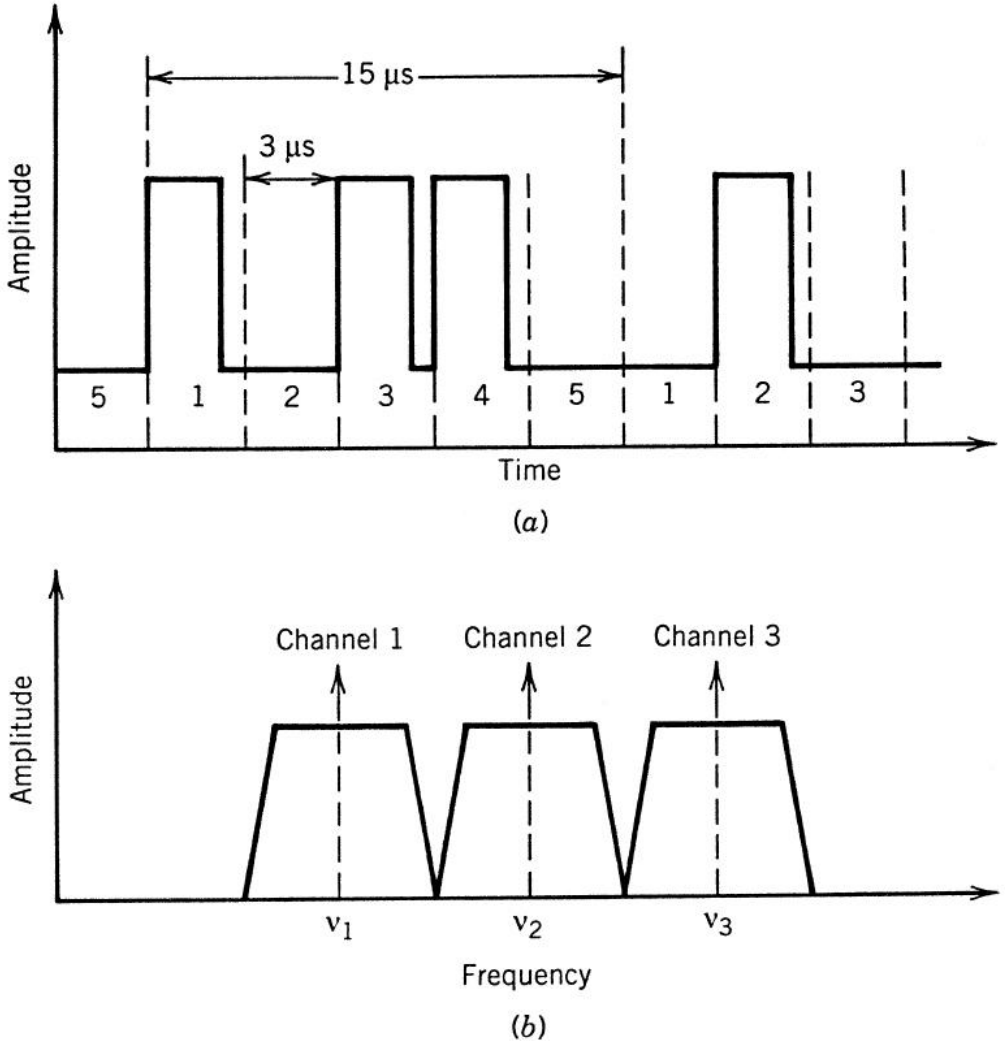


Transmisia optica



Multiplexare

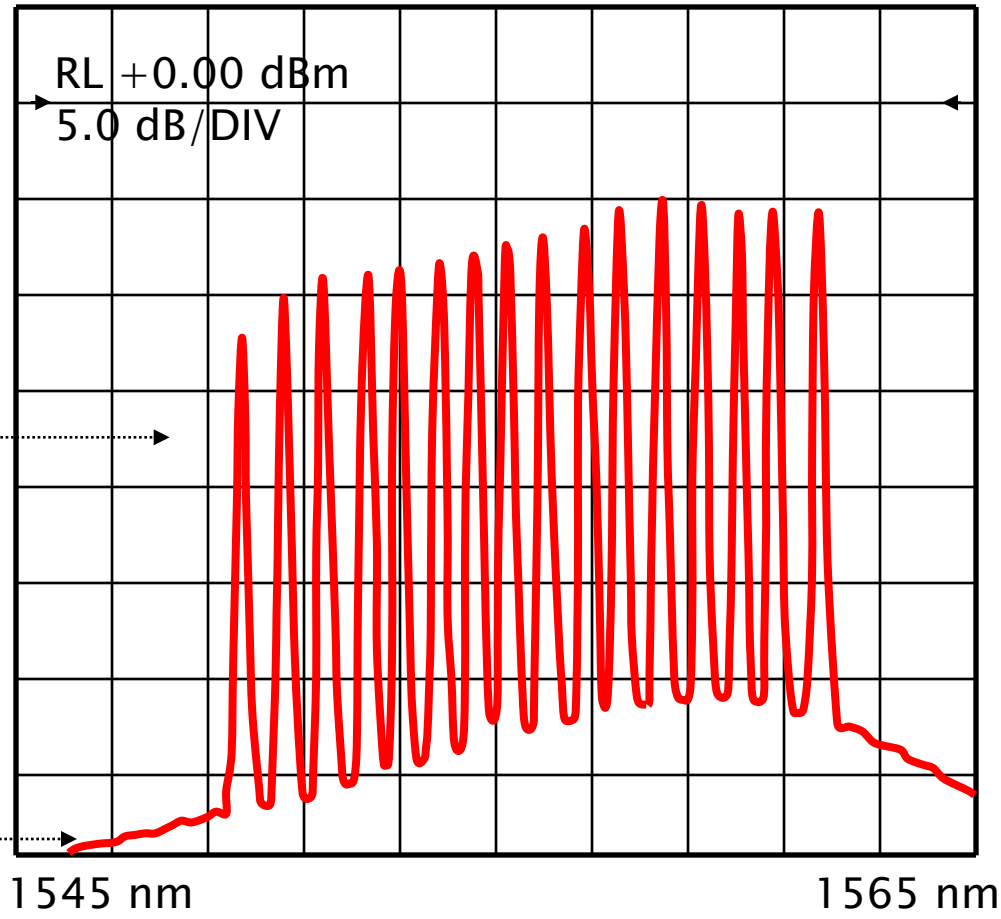
- TDM
  - time-division multiplexing
- FDM
  - frequency-division multiplexing
- Realizabila in domeniul **electric/optic**
- WDM
  - wavelength division multiplexing



Spectrul WDM – Wavelength Division Multiplexing

Canale: 16
Spaţiere: 0.8 nm

Emisie spontană
Amplificată (ASE)



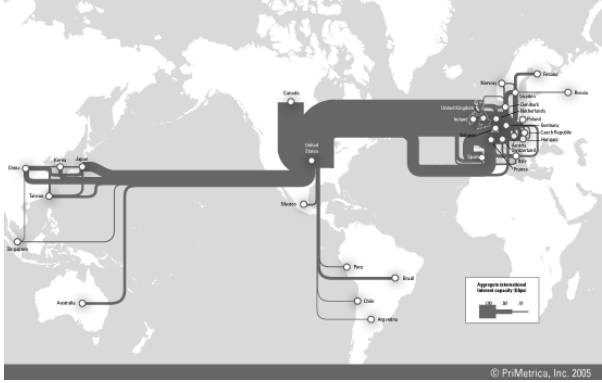
Standarde

- SUA, Japonia

SONET	SDH	*B* (Mb/s)	Channels
OC-1		51.84	672
OC-3	STM-1	155.52	2,016
OC-12	STM-4	622.08	8,064
OC-48	STM-16	2,488.32	32,256
OC-192	STM-64	9,953.28	129,024
OC-768	STM-256	39,813.12	516,096

- SONET – synchronous optical network
  - inlocuit de
- SDH – synchronous digital hierarchy

Standarde



- SUA

STS-1 and OC-1	51.840 Mb/s	
STS-3 and OC-3	155.52 Mb/s	same as STM-1
STS-9 and OC-9	466.56 Mb/s	
STS-12 and OC-12	622.08 Mb/s	same as STM-4
STS-18 and OC-18	933.12 Mb/s	
STS-24 and OC-24	1244.16 Mb/s	same as STM-8
STS-36 and OC-36	1866.24 Mb/s	
STS-48 and OC-48	2488.32 Mb/s	same as STM-16
STS-192 and OC-192	9953.28 Mb/s	same as STM-64
STS-256 and OC-256	13271.04 Mb/s	same as STM-86
STS-768 and OC-768	39813.12 Mb/s	same as STM-256
STS-3072 and OC-3072	159252.48 Mb/s	same as STM-1024
STS-12288 and OC-12288	639009.92 Mb/s	same as STM-4096

- Europa

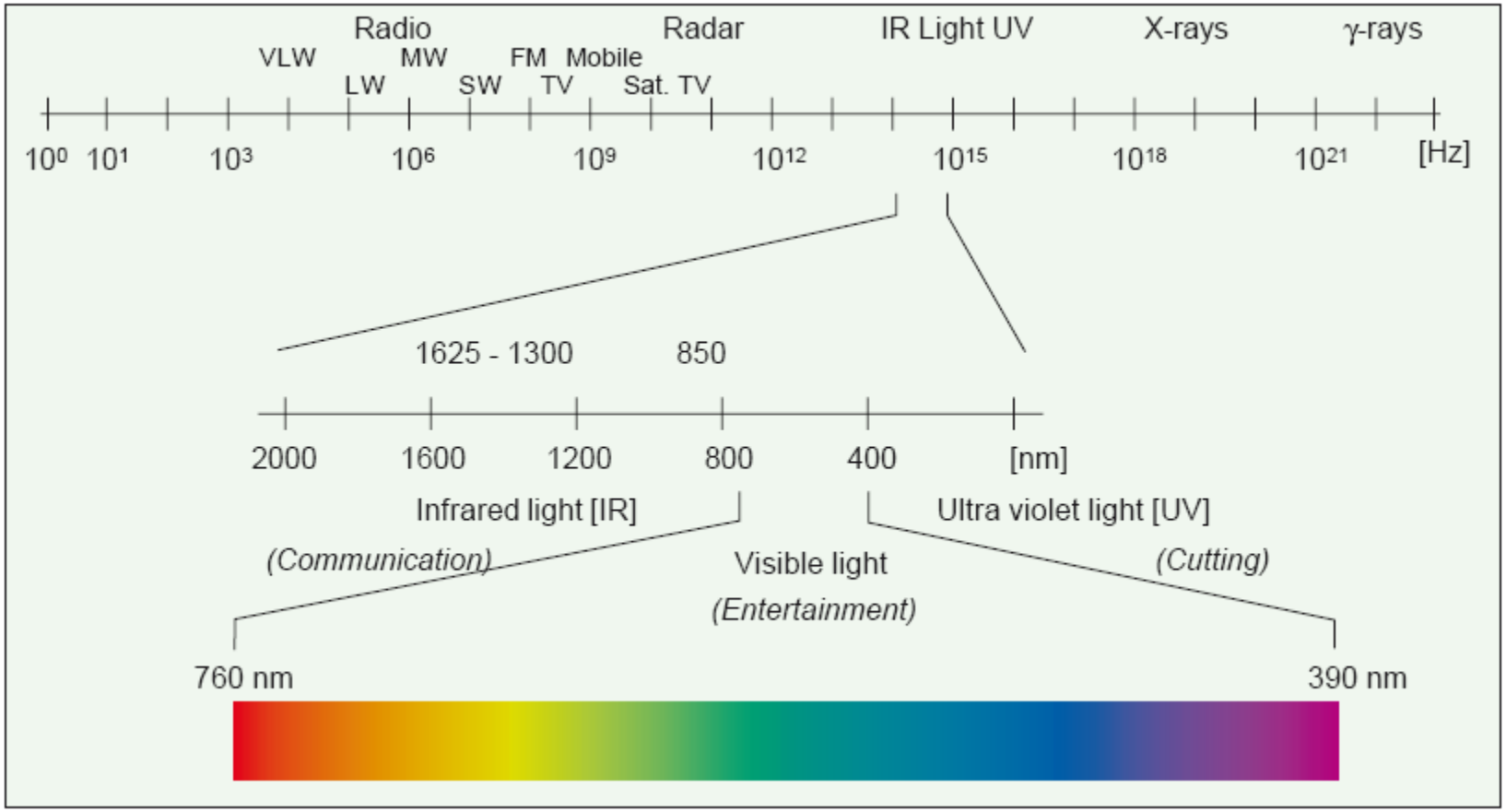
E0	64 Kb/s	
E1	2.048 Mb/s	
E2	8.448 Mb/s	4 E1s
E3	34.364 Mb/s	16 E1s
E4	139.264 Mb/s	64 E1s

1 mile=1760 yards

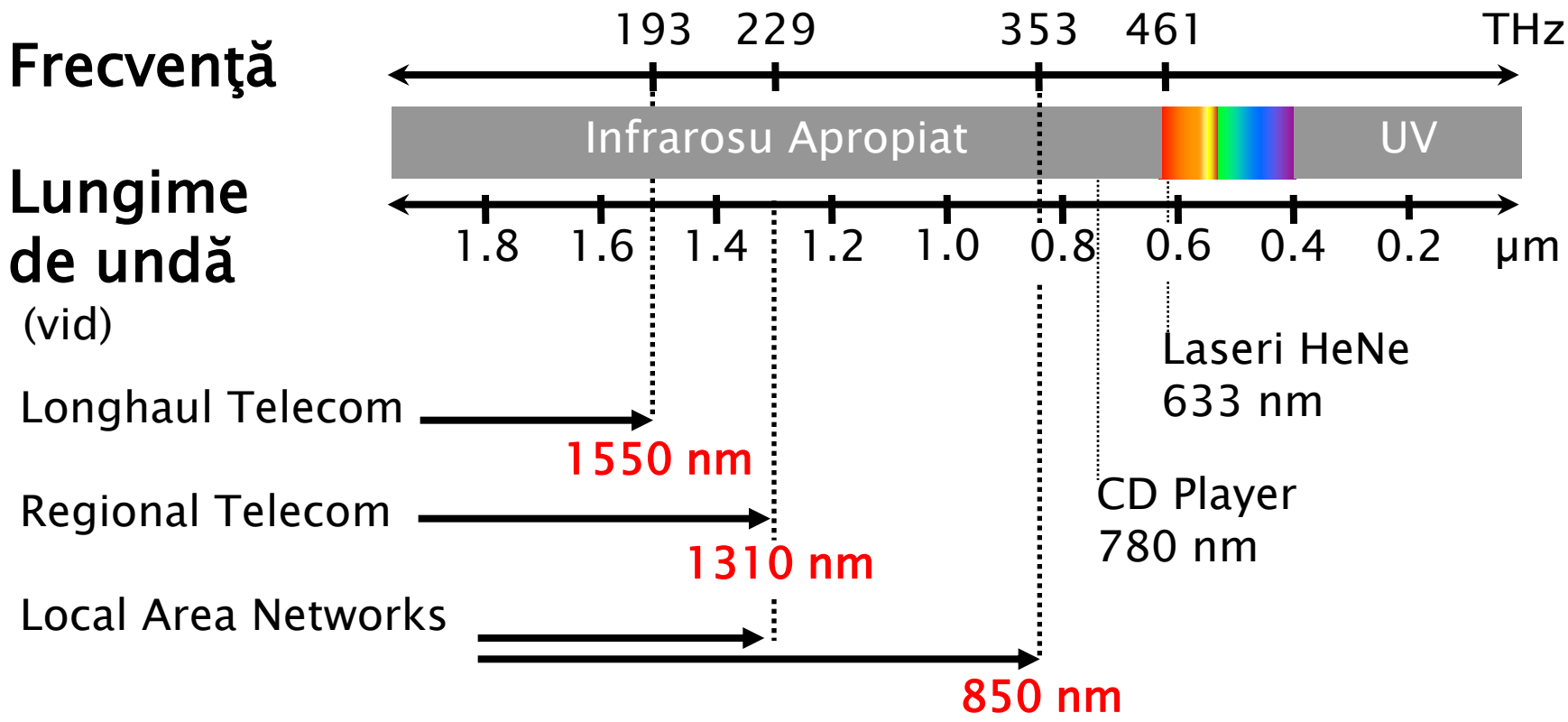
1 yards=3 feet

1 mile≈1609.34 m

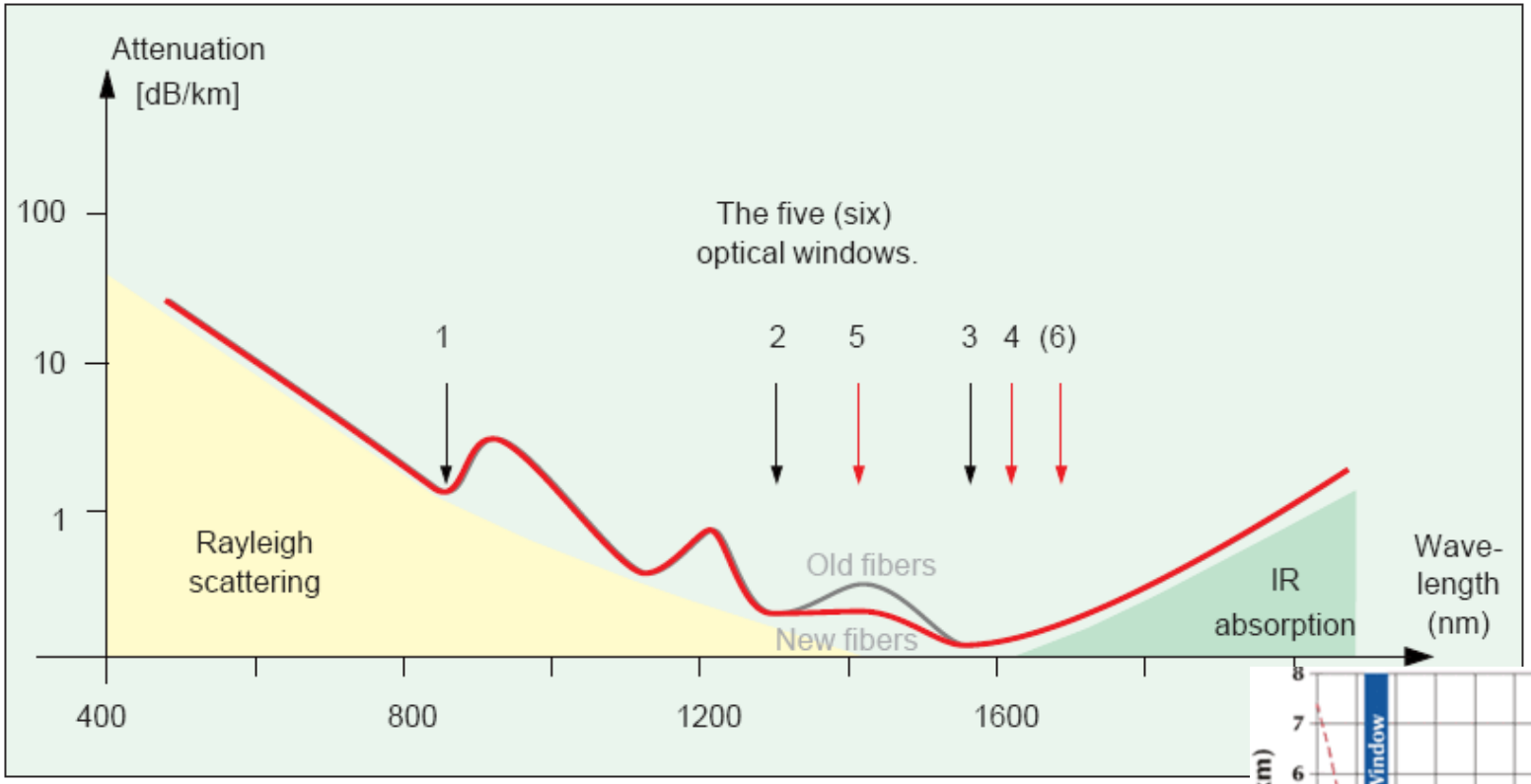
Spectrul electromagnetic



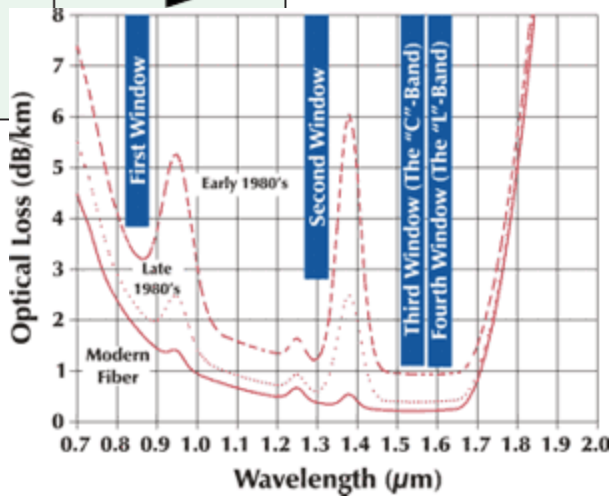
Benzi de lucru in comunicaţiile optice



Atenuarea în fibra optică (SiO_2)



850nm, 1310nm, 1550nm



Aplicatii majore

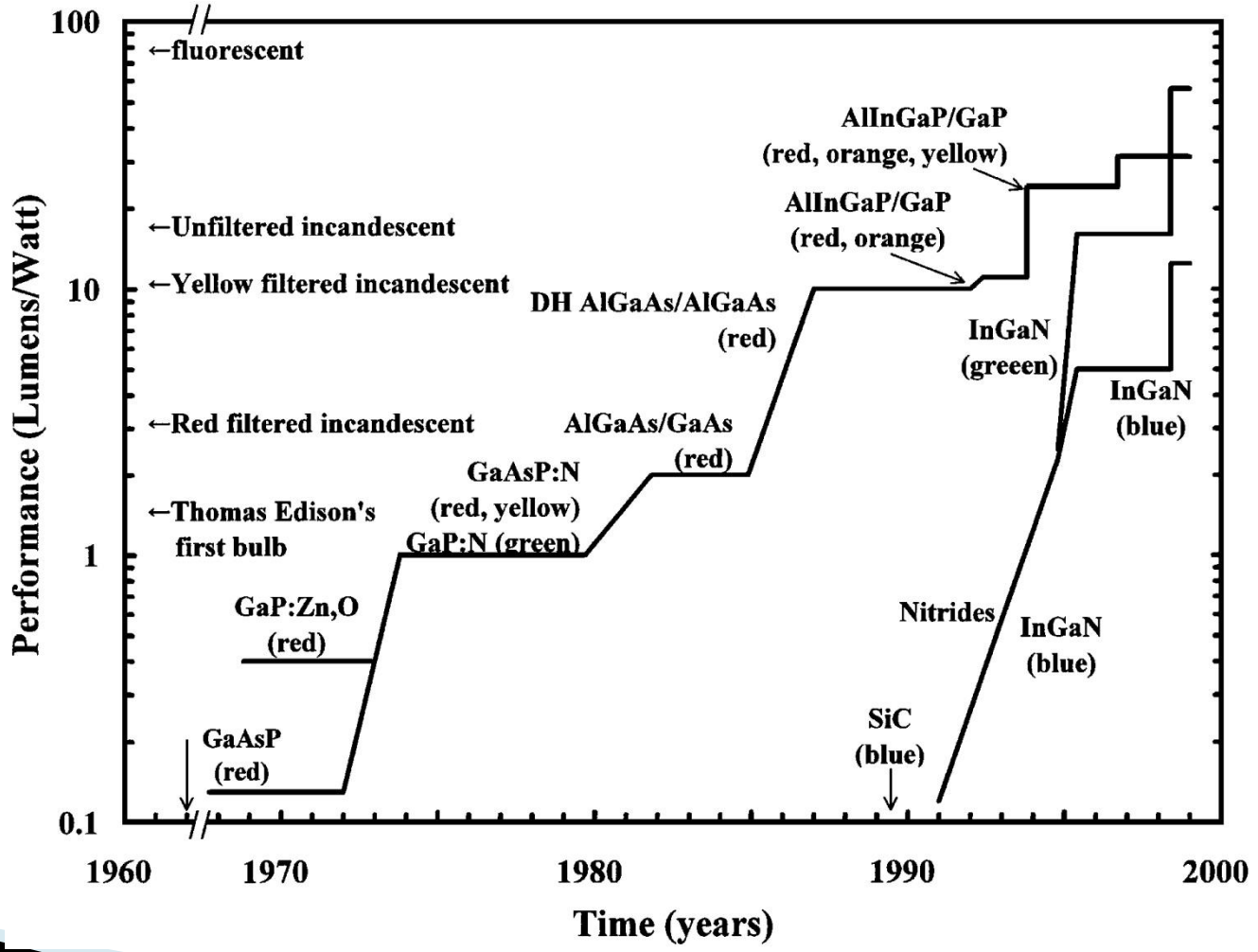
- Comunicatii
  - Infrarosu (InGaAsP)
- Vizibil
  - Spectru vizibil (GaAlAs)
- Iluminare
  - Putere ridicata, lumina alba (GaInN)

Eficienta

- Bec cu incadescenta
  - 16 lm/W
- Tub fluorescent
  - 100 lm/W
- LED
  - curent: 250 lm/W
  - curand: 300 lm/W

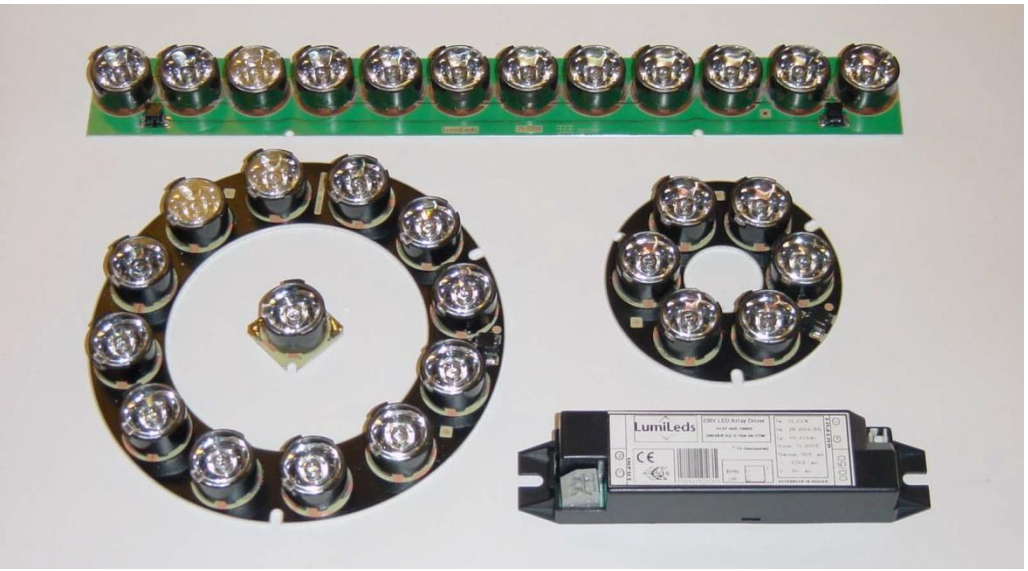
Premiul Nobel, Fizica, 2014

Eficienta in timp

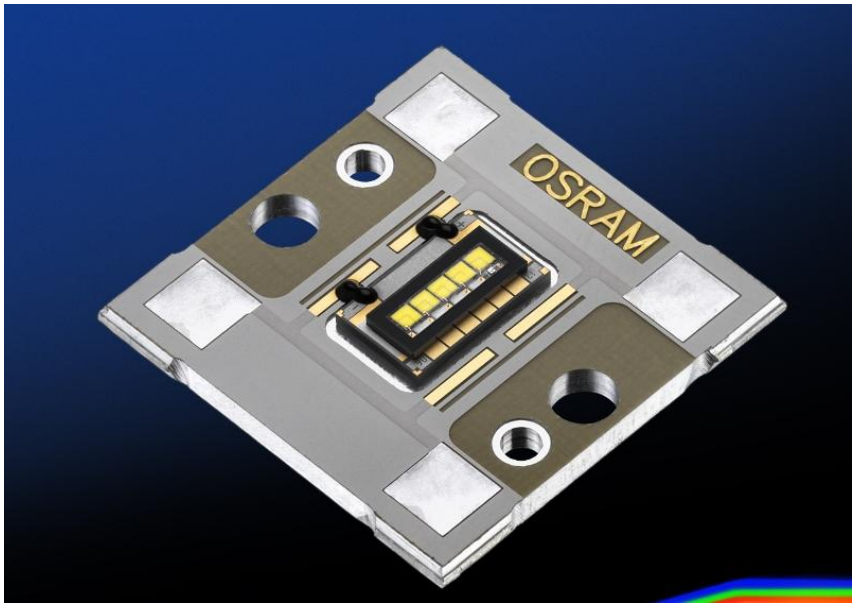


Aplicatii

- auto



Aplicatii



Aplicatii majore

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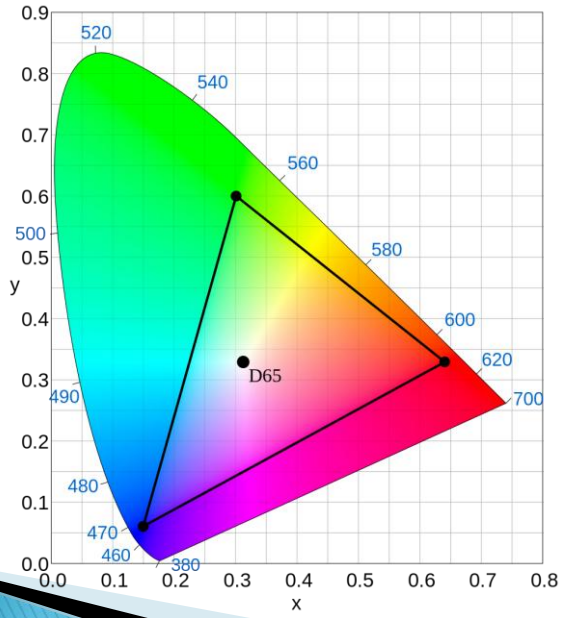
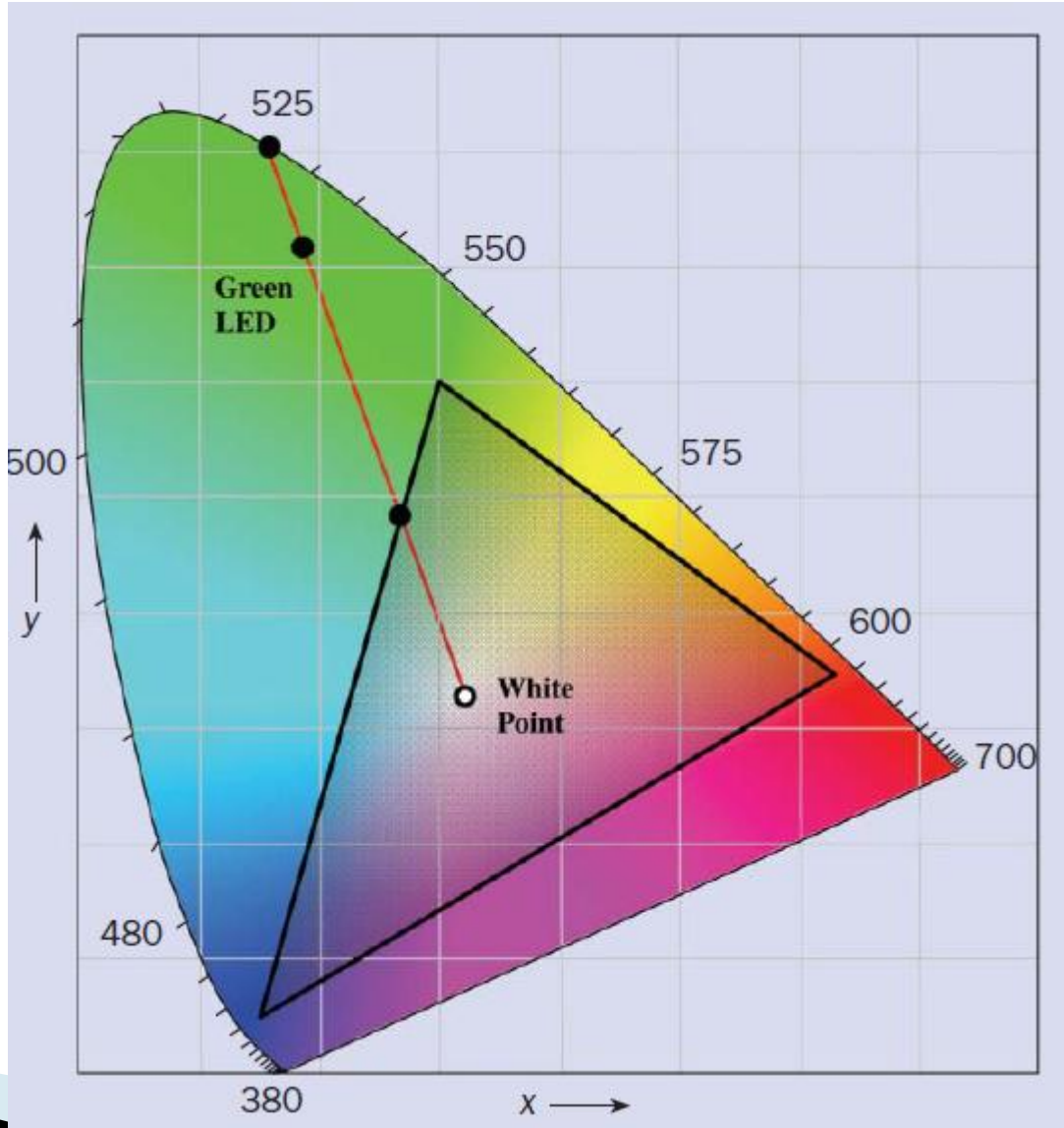
- Iluminare
  - Putere ridicata, lumina alba (GaInN)

ITU–R BT.709

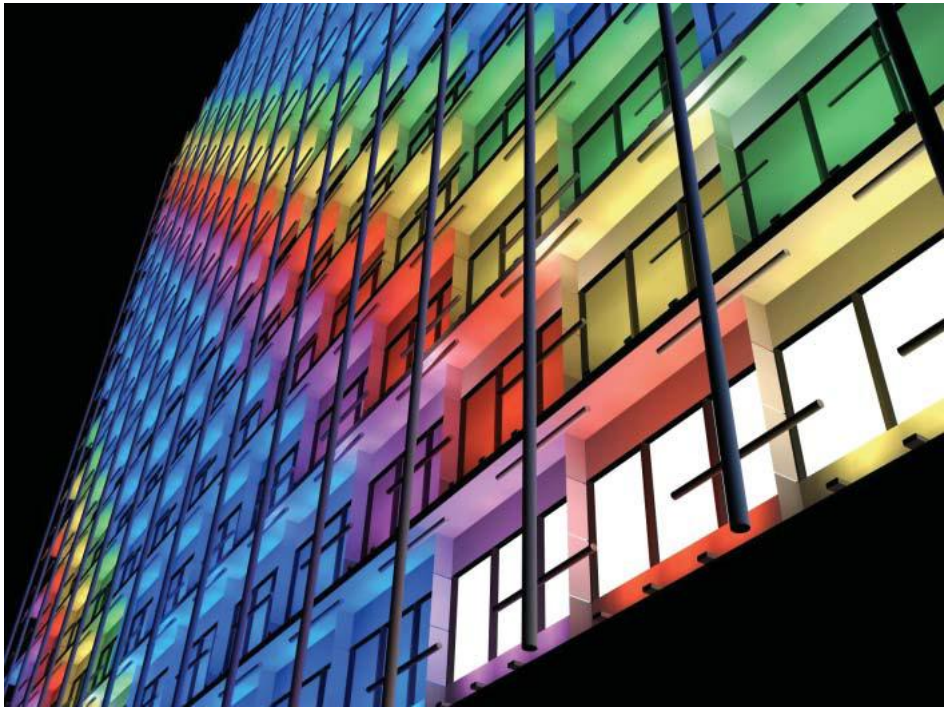
ITU-R BT.709 phosphor properties		
Phosphor	**x**	**y**
Red	0.640	0.330
Green	0.300	0.600
Blue	0.150	0.060

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





ITU-R BT.709



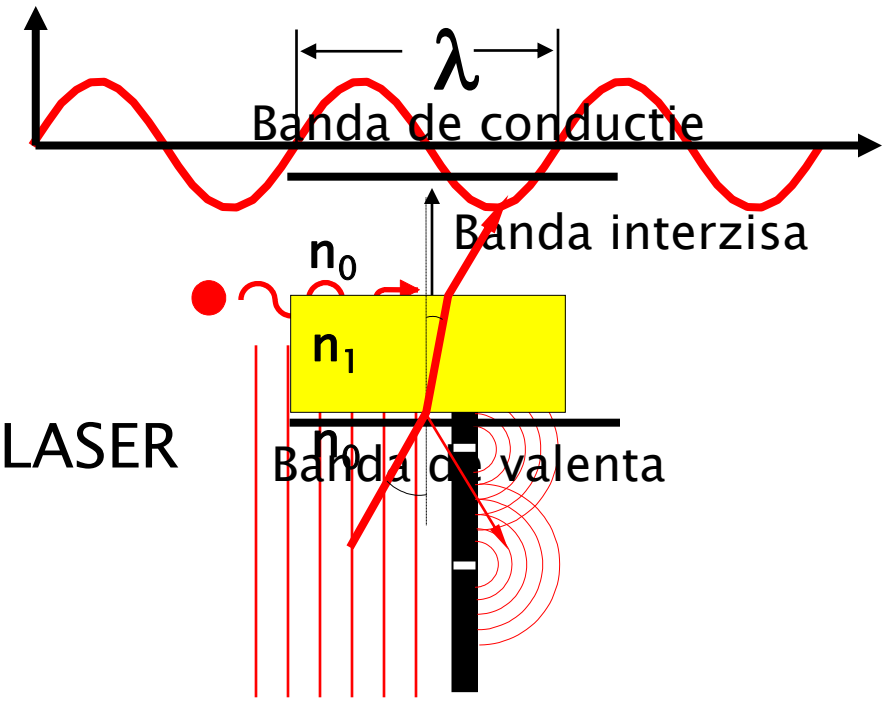
RGB values for Luxeon LEDs		
LED color	**Dominant wavelength λ_D (nm)**	**RGB values**
Royal blue	455	0.05, 0.00, 0.95
Blue	470	0.00, 0.11, 0.89
Cyan	505	0.00, 0.63, 0.37
Green	530	0.00, 0.77, 0.23
Amber	590	0.70, 0.30, 0.00
Red-orange	615	0.97, 0.00, 0.03
Red	625	0.92, 0.00, 0.08

Modelarea luminii

(tot) Capitolul 1

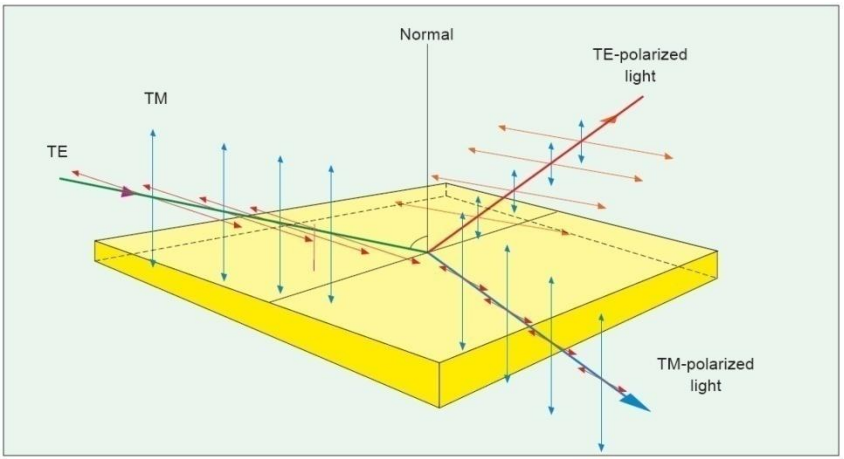
Modelarea luminii

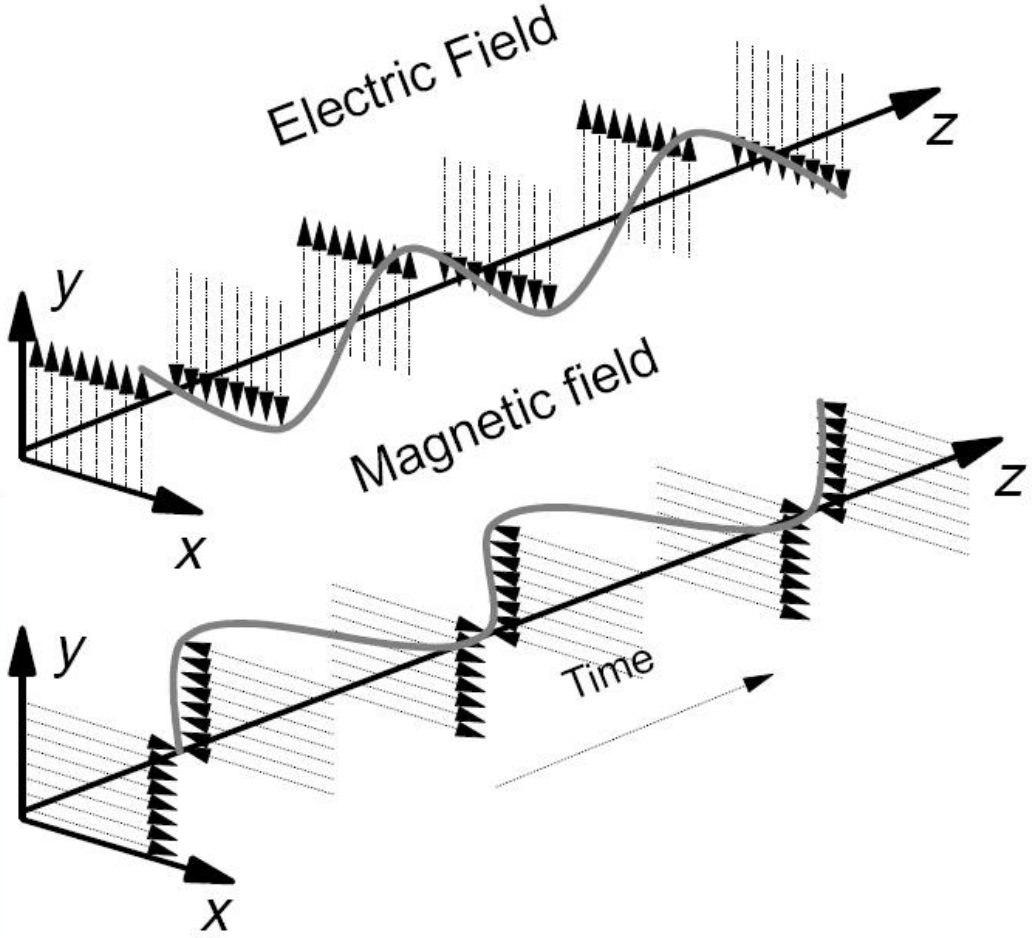
- Undă electromagnetică
  - Ecuaţiile lui Maxwell
  - λ, ε, ω, f
- Teoria cuantică
  - Benzi energetice $E = h \nu$
  - fotoni, emisie stimulată, LASER
- Optică geometrică
  - n, θ
  - raze de lumină
  - intuitivă



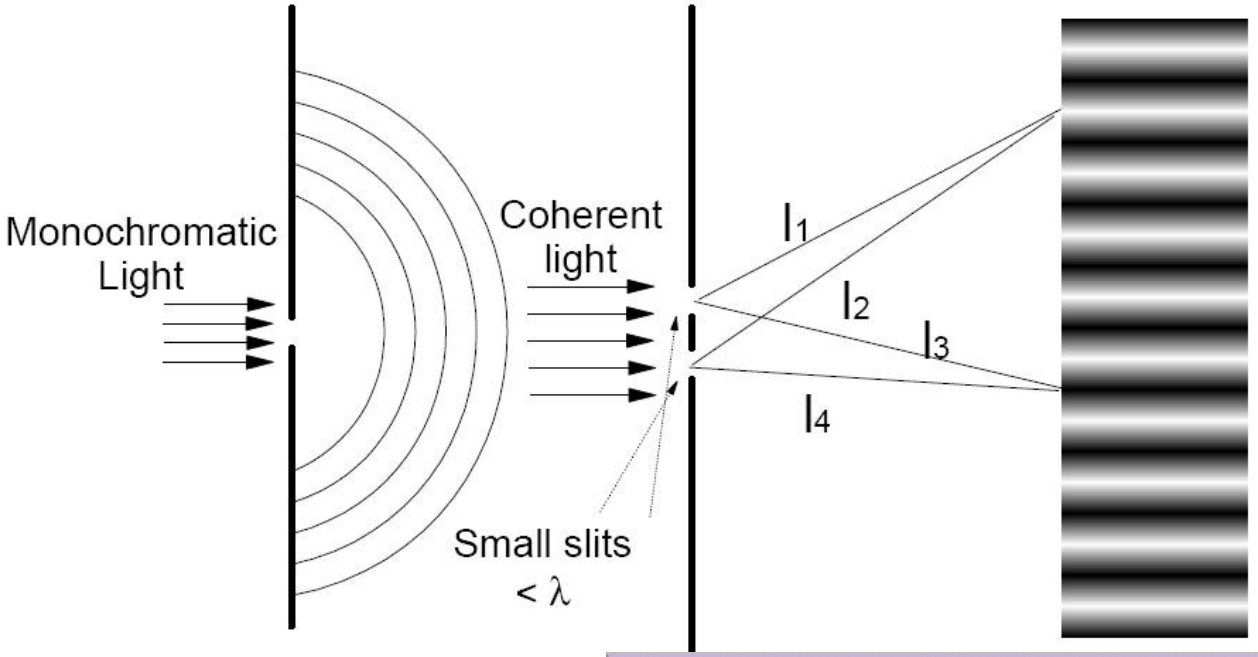
Unda electromagnetica

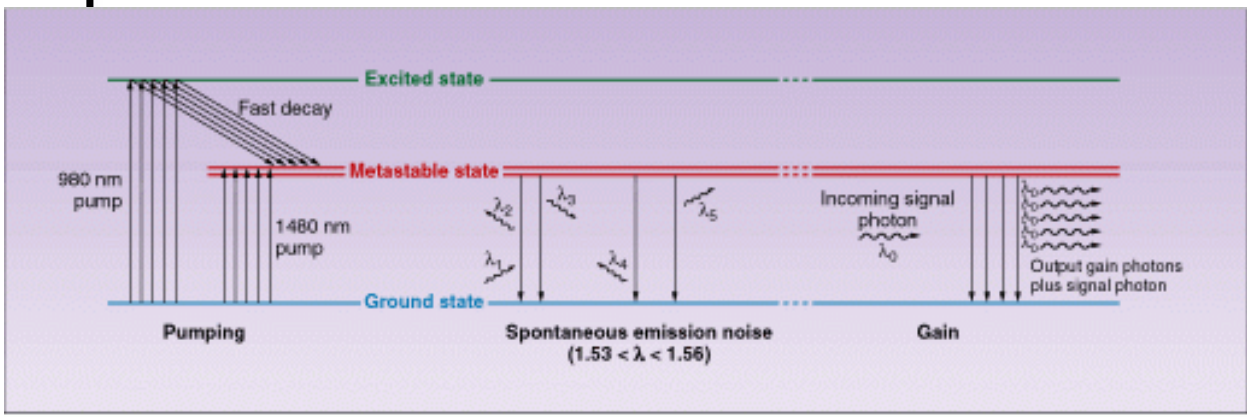
- Dispersie
- Fibre monomod
- Interferenta
- Polarizare





Fotoni/Unda

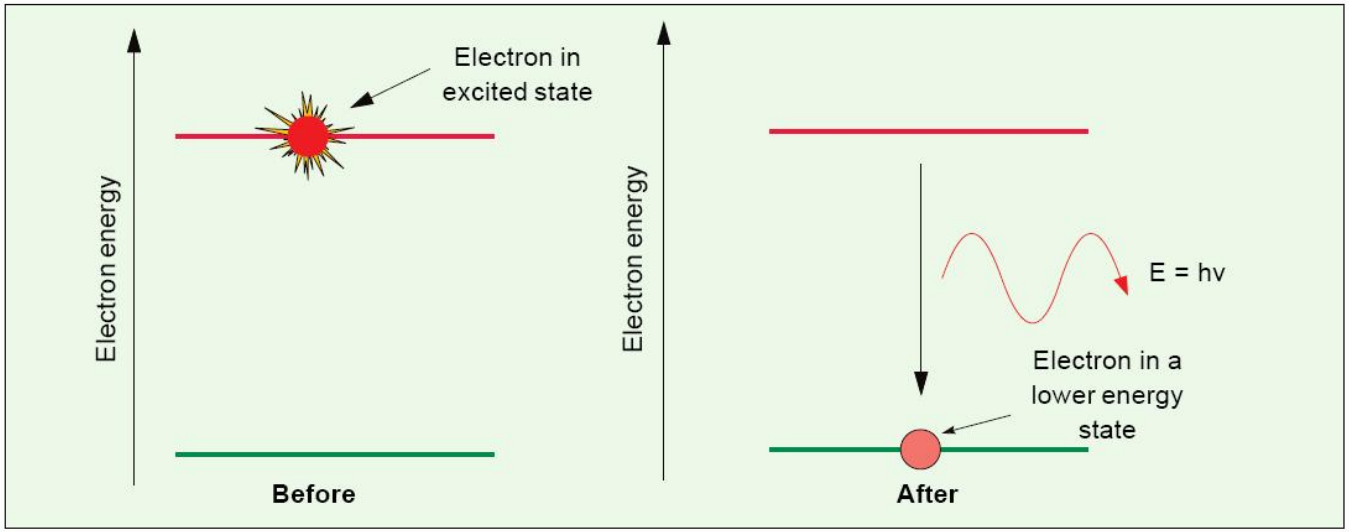




8-FEA-4 97 Fig. 2

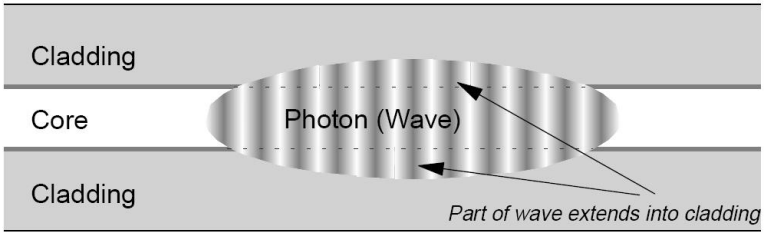
Through the Wormhole
S02E07 How Does the Universe Work

Model cuantic – foton



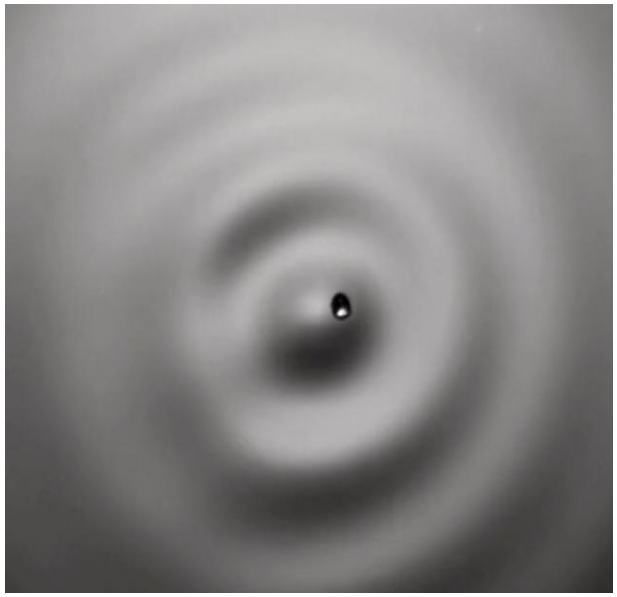
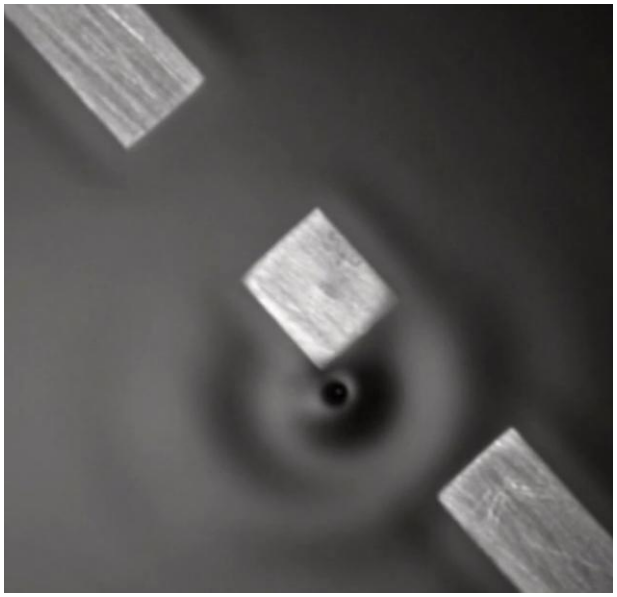
$$E_g = h\nu; \quad \lambda = \frac{hc}{E_g}; \quad \lambda[\mu m] = \frac{1.240}{E_g[eV]}$$

- h constanta lui Plank $6.62 \cdot 10^{-32}$ Ws^2
- c viteza luminii **in vid** $2.998 \cdot 10^8 m/s$

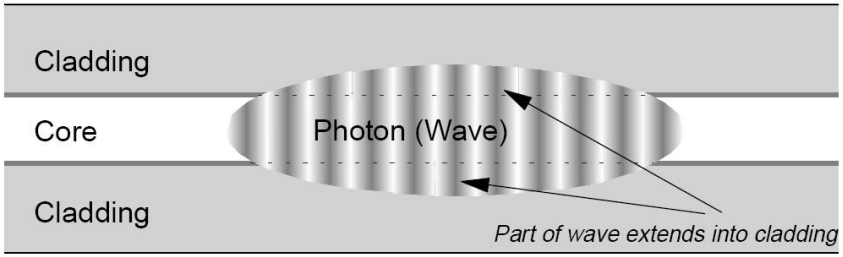


Through the Wormhole
S02E07 How Does the Universe Work

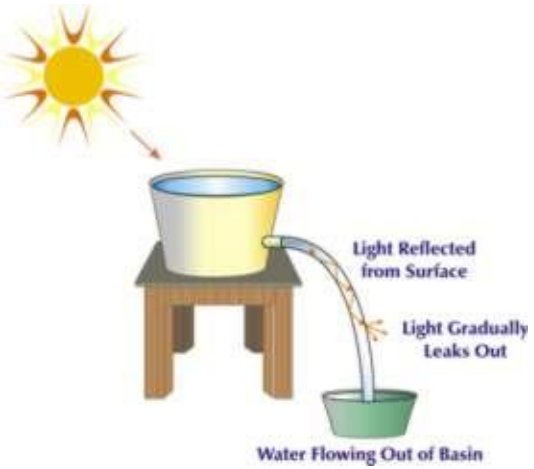
Modelare

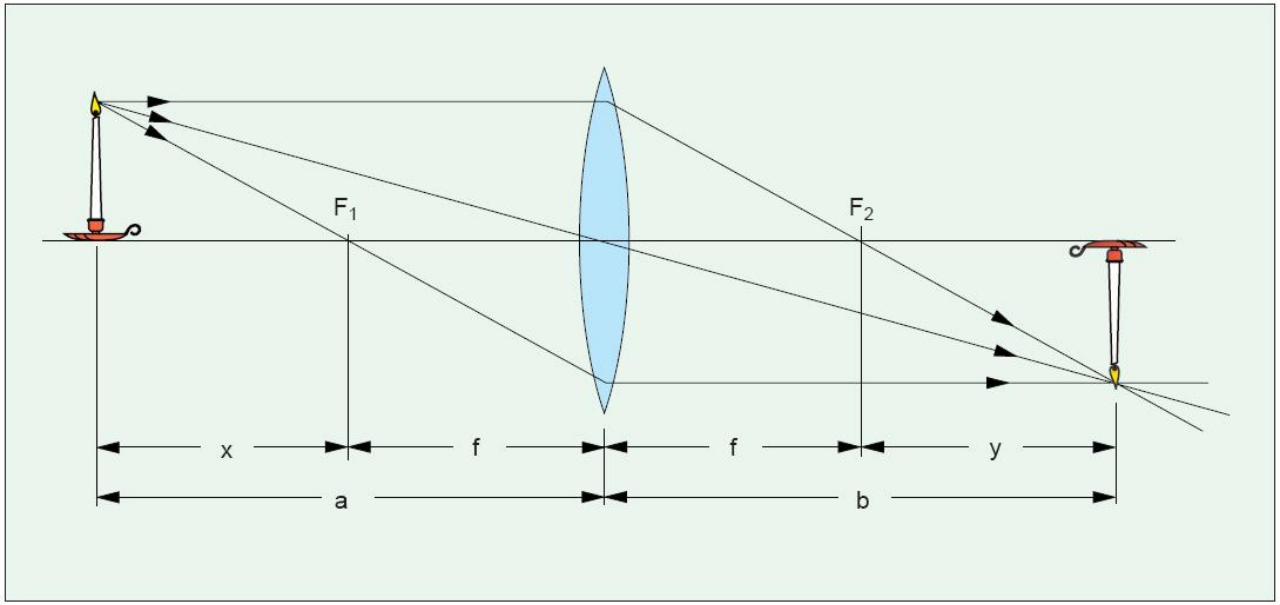



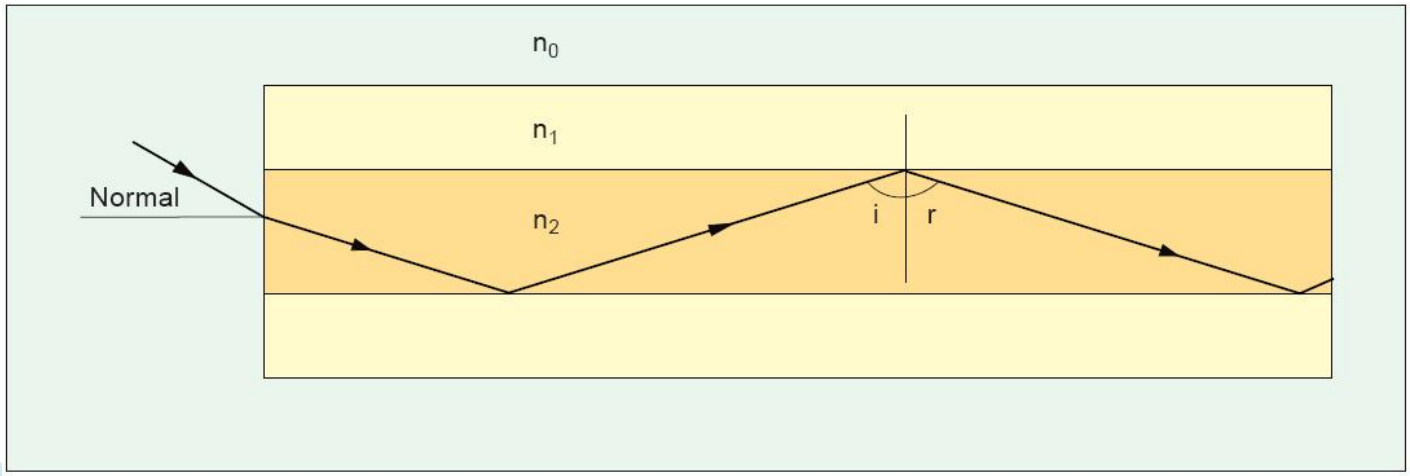

Through the Wormhole
S02E07 How Does the Universe Work



Optica geometrica







Reprezentare logaritmică

$dB = 10 \cdot \log_{10}(P_2 / P_1)$

$dBm = 10 \cdot \log_{10}(P / 1\ mW)$

0 dB	= 1
+ 0.1 dB	= 1.023 (+2.3%)
+ 3 dB	= 2
+ 5 dB	= 3
+ 10 dB	= 10
−3 dB	= 0.5
−10 dB	= 0.1
−20 dB	= 0.01
−30 dB	= 0.001

0 dBm	= 1 mW
3 dBm	= 2 mW
5 dBm	= 3 mW
10 dBm	= 10 mW
20 dBm	= 100 mW
−3 dBm	= 0.5 mW
−10 dBm	= 100 μW
−30 dBm	= 1 μW
−60 dBm	= 1 nW

[dBm] + [dB] = [dBm]

[dBm/Hz] + [dB] = [dBm/Hz]

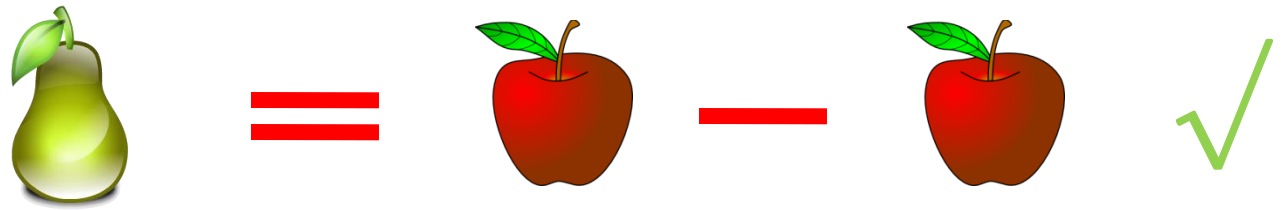
[x] + [dB] = [x]

Calculul atenuarii

$$\text{Pierderi} = \frac{P_{out}}{P_{in}}$$

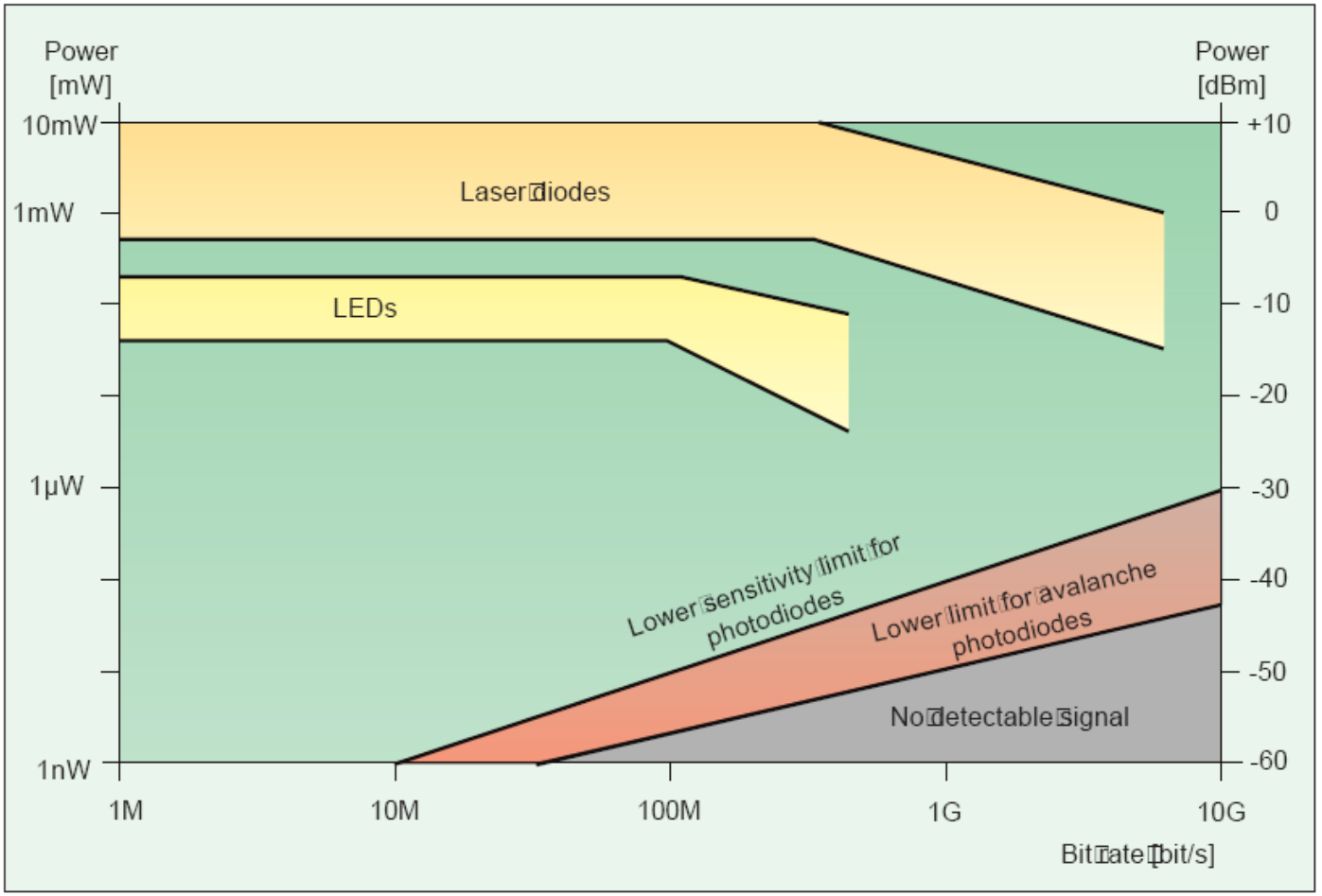
$$\text{Pierderi}[\text{dB}] = [-]10 \cdot \log_{10}\left(\frac{P_{out}}{P_{in}}\right)$$

$$\text{Pierderi}[\text{dB}] = [-](P_{out}[\text{dBm}] - P_{in}[\text{dBm}])$$



$$\text{Atenuare}[\text{dB/km}] = \frac{\text{Pierderi}[\text{dB}]}{\text{lungime}[\text{km}]}$$

Limite putere/bandă a dispozitivelor optoelectronice



Contact

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- rdamian@etti.tuiasi.ro