Optoelectronică

Curs 2

2020/2021

Disciplina 2020/2021

- 2C/1L Optoelectronică OPTO
- **Minim** 7 prezente curs + laborator
- Curs – conf. Radu Damian
  - an IV μE
  - Miercuri 11-14, online, Microsoft Teams
  - E – 70% din nota (50+20), online, rf-opto
    - **20% test la curs**, saptamana 4-5?
  - probleme + (**?** 1 subiect teorie) + (2p prez. curs)
  - toate materialele permise
- Laborator – sl. Daniel Matasaru
  - an IV μE
    - Marti 10-14 impar/par
  - L – 30% din nota (+Caiet de laborator)

Orar 2020/2021

- Curs
  - Miercuri 11-14, online
  - 2C ⇨ 3C
    - 14*2/3 ≈ 9.33
    - 9÷10 C ≈ 9C + E

Online

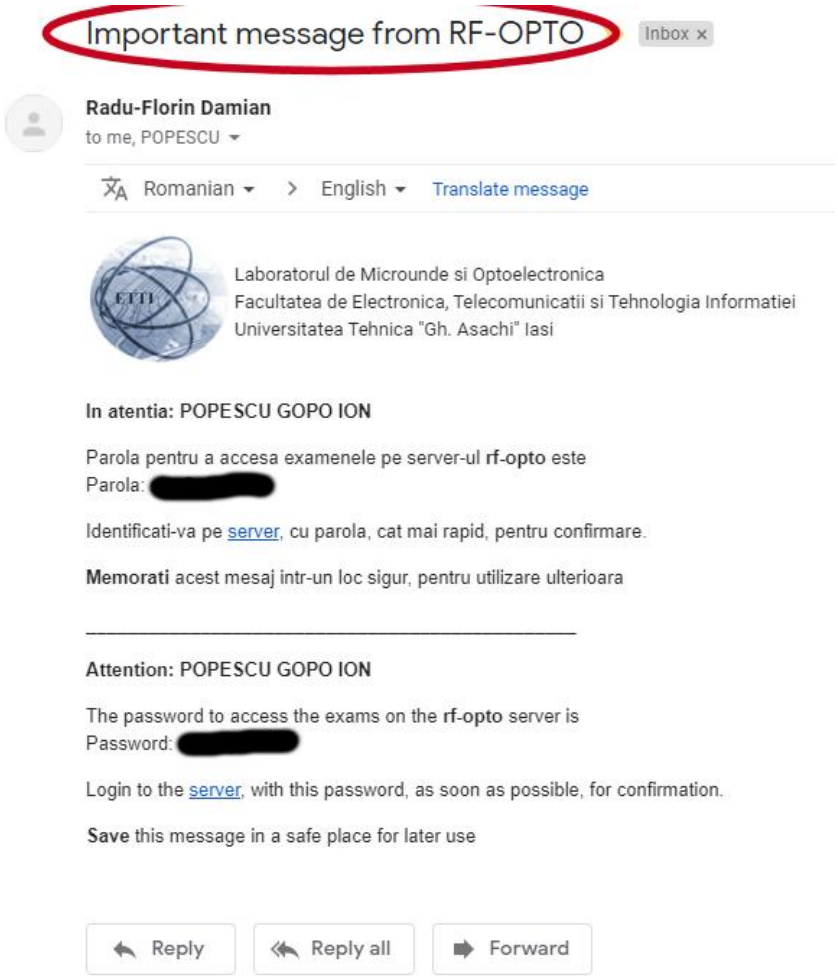
- acces la examene necesita parola primita prin email

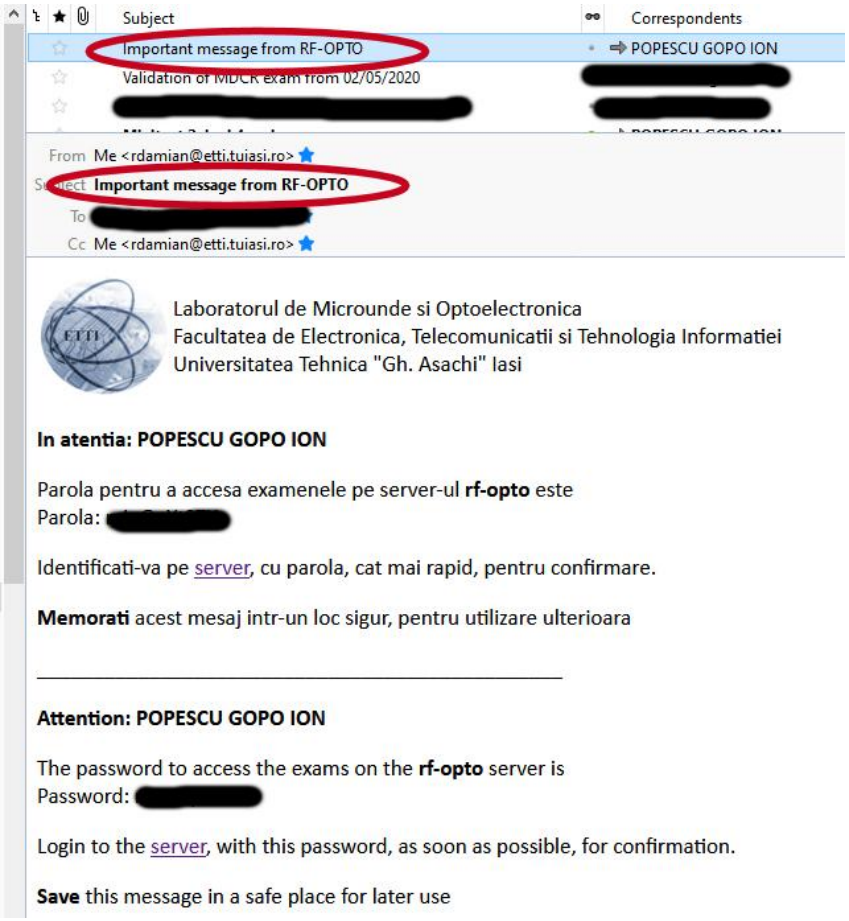
Online

- acces email/parola

Parola

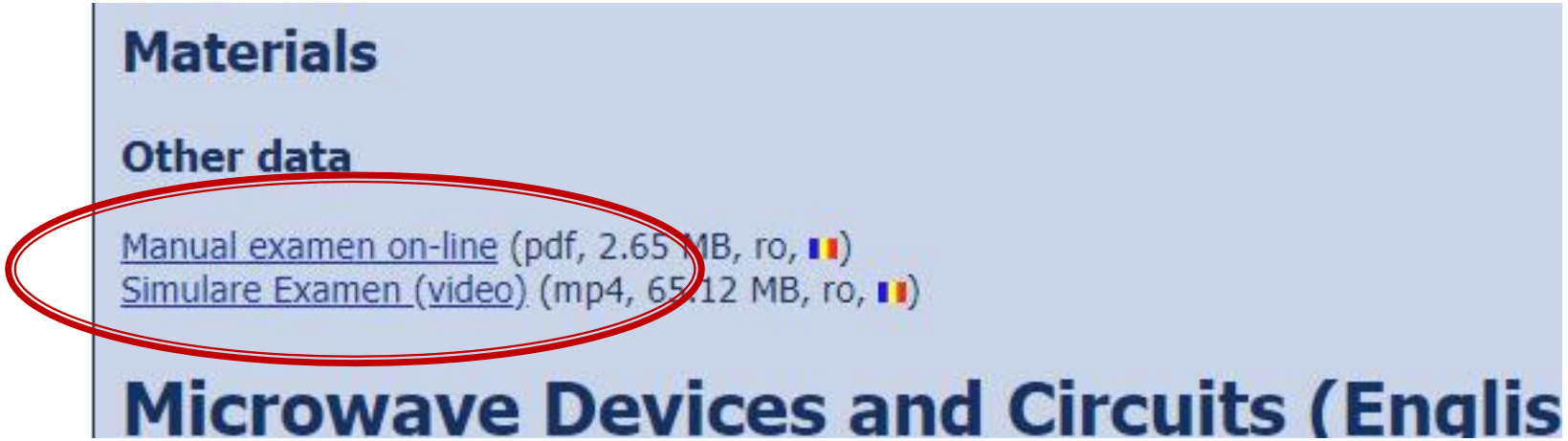
- primita prin email





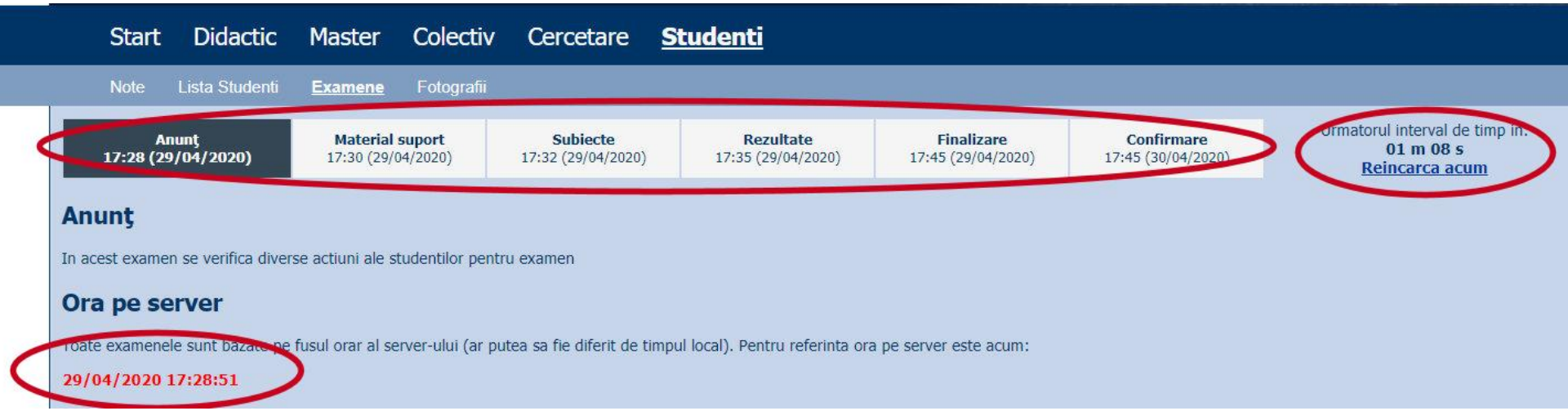
Manual examen online

- Aplicatia de examen online utilizata intens la:
  - curs (prezenta)
  - miniteste
  - examen



Examen online

- intotdeauna **contratimp**
  - perioada lunga (prezenta curs/rezultate laborator)
  - perioada scurta (teste: 15min, examen: 2h)



Introducere

Capitolul 1

Aplicatii majore

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

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
  - 159 Tb/s @ 1045 km
  - 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

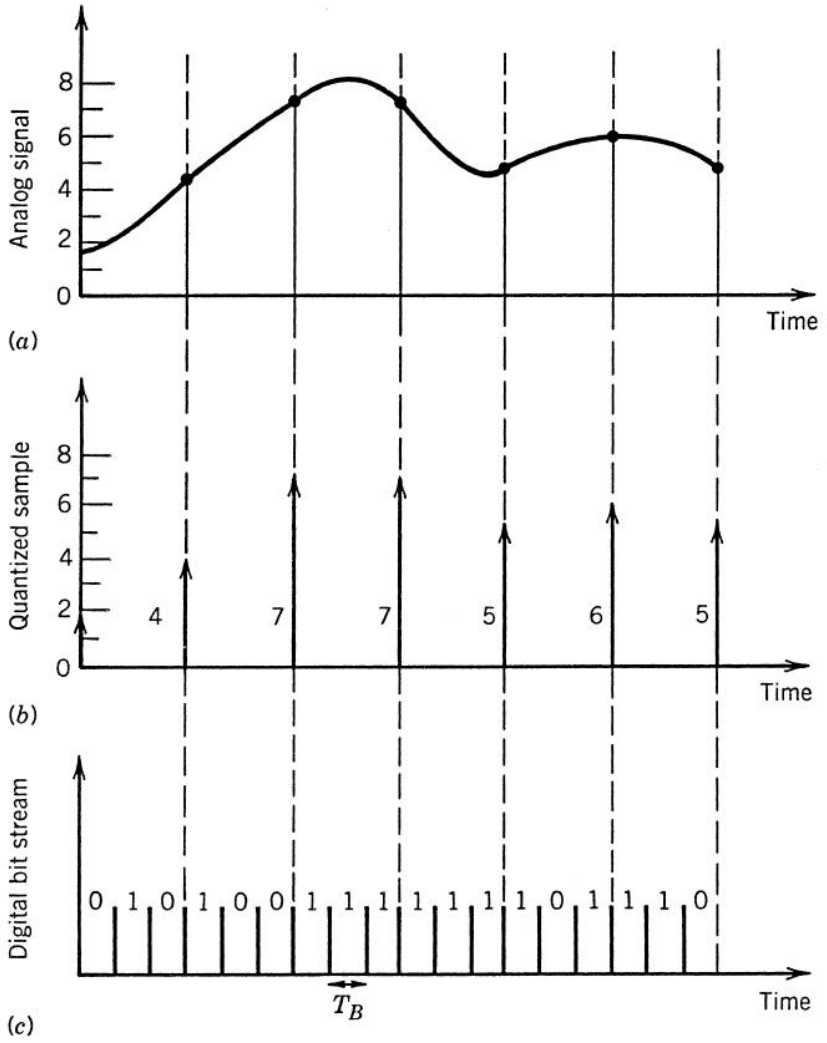
- pulse-position modulation
- pulse-duration modulation
- pulse-code modulation (PCM)

- esantionare (Nyquist)

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

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

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



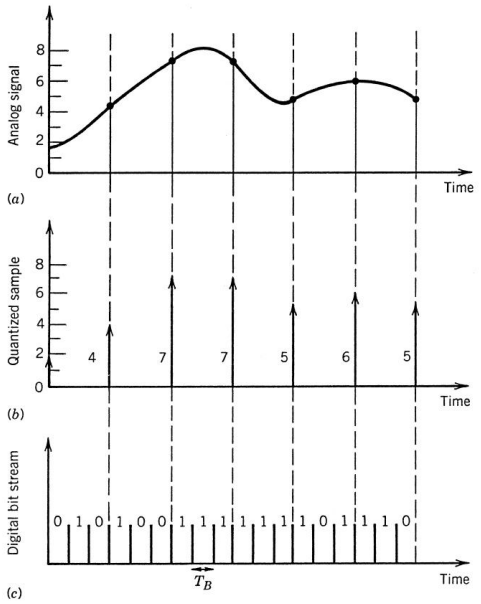
Esantionare

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

$$M = 2^m$$

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

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



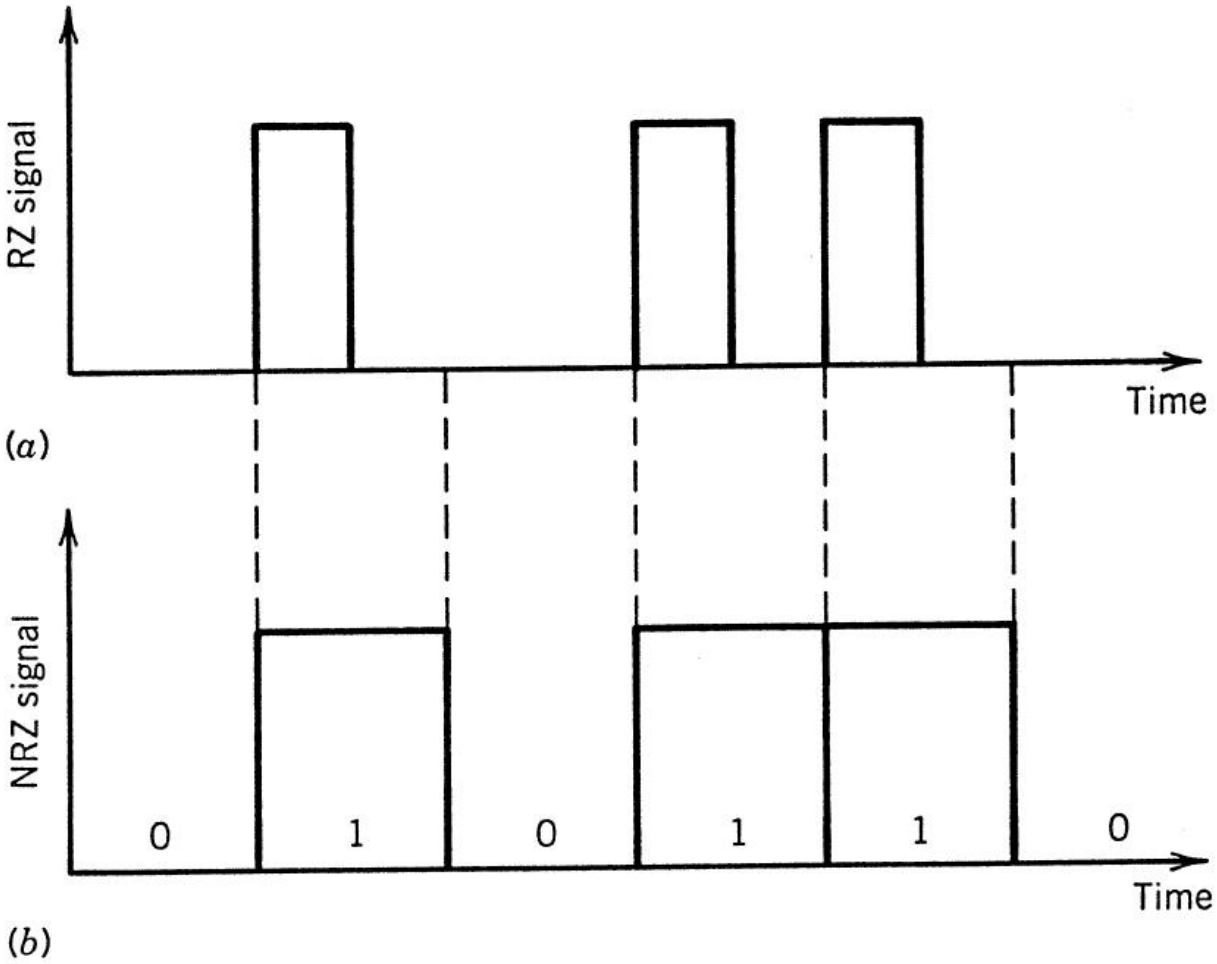
$$M \geq \frac{A_{\max}}{A_N} \qquad SNR\,[\text{dB}] = 10 \cdot \log_{10}\left(\frac{P_{\max}}{P_N}\right) = 20 \cdot \log_{10}\left(\frac{A_{\max}}{A_N}\right) \qquad \log_2 10 \approx 3.33$$

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

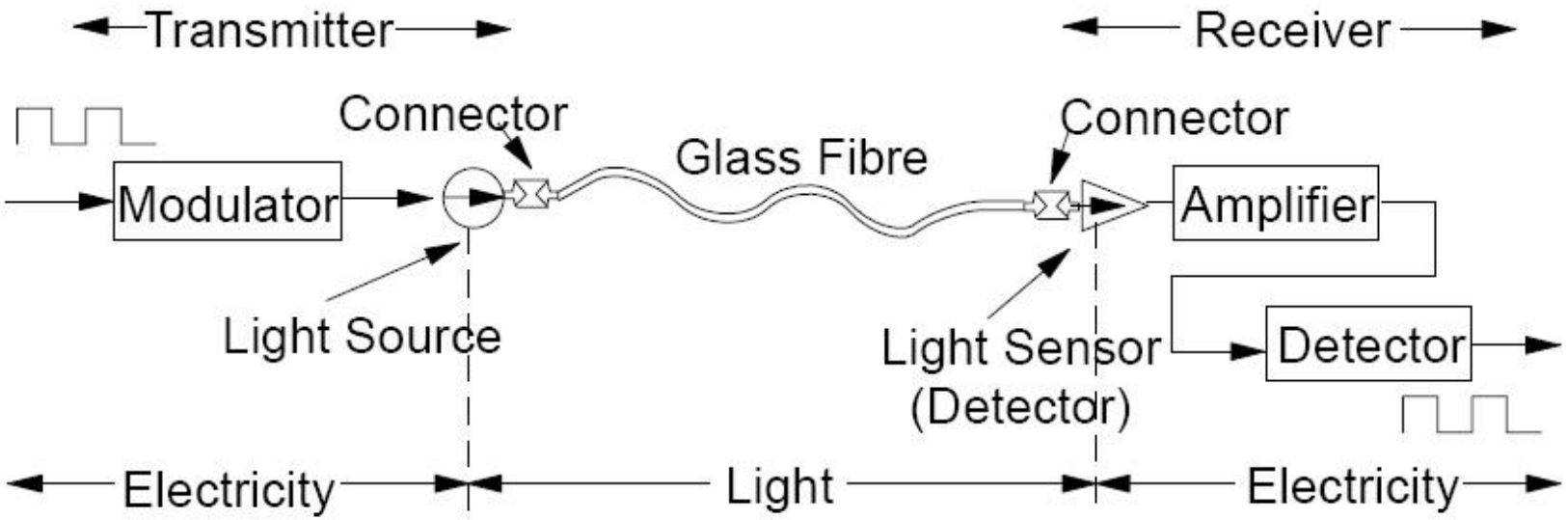
- telefonie: 3.1kHz @ SNR=30dB
  - B=31kb/s (64kb/s)
- televiziune: 4MHz @ SNR=50dB
  - B=66Mb/s (100Mb/s)

Modulare

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

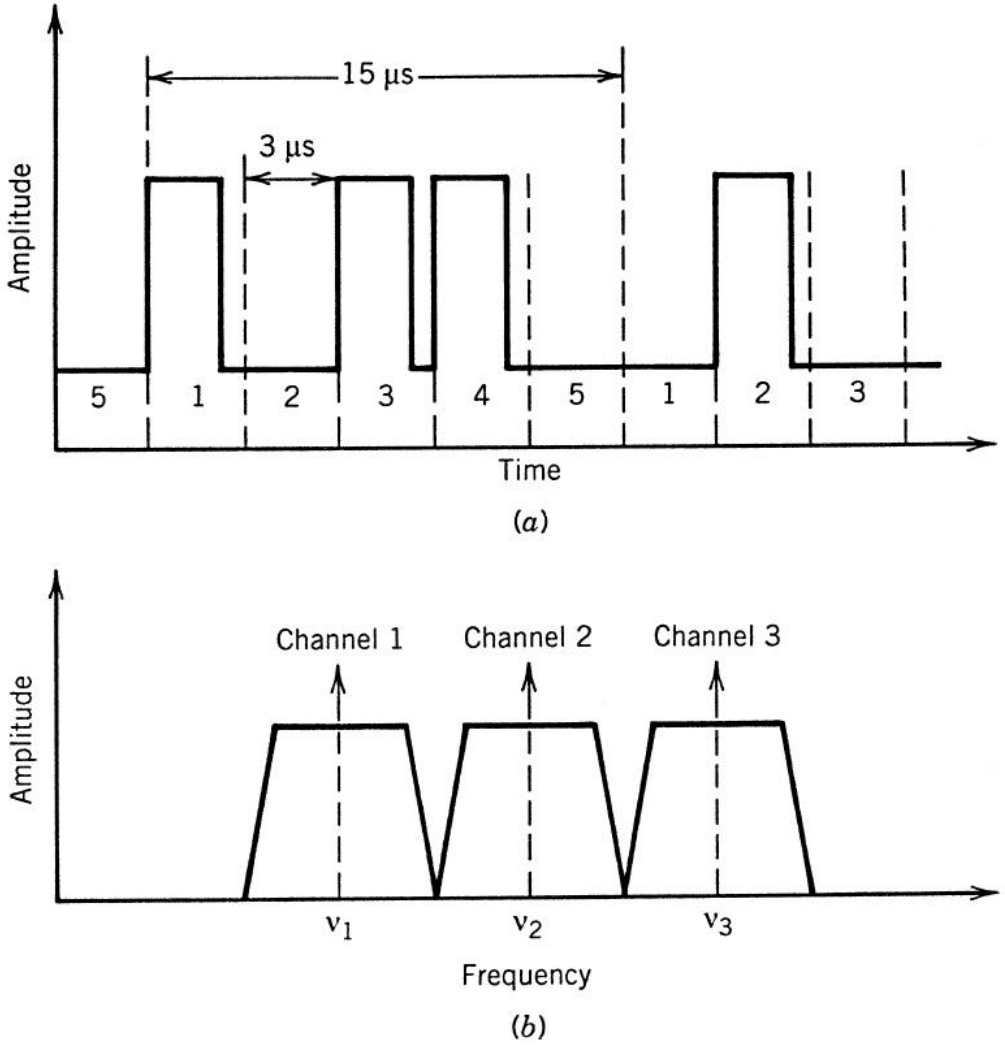


Transmisia optica



Multiplexare

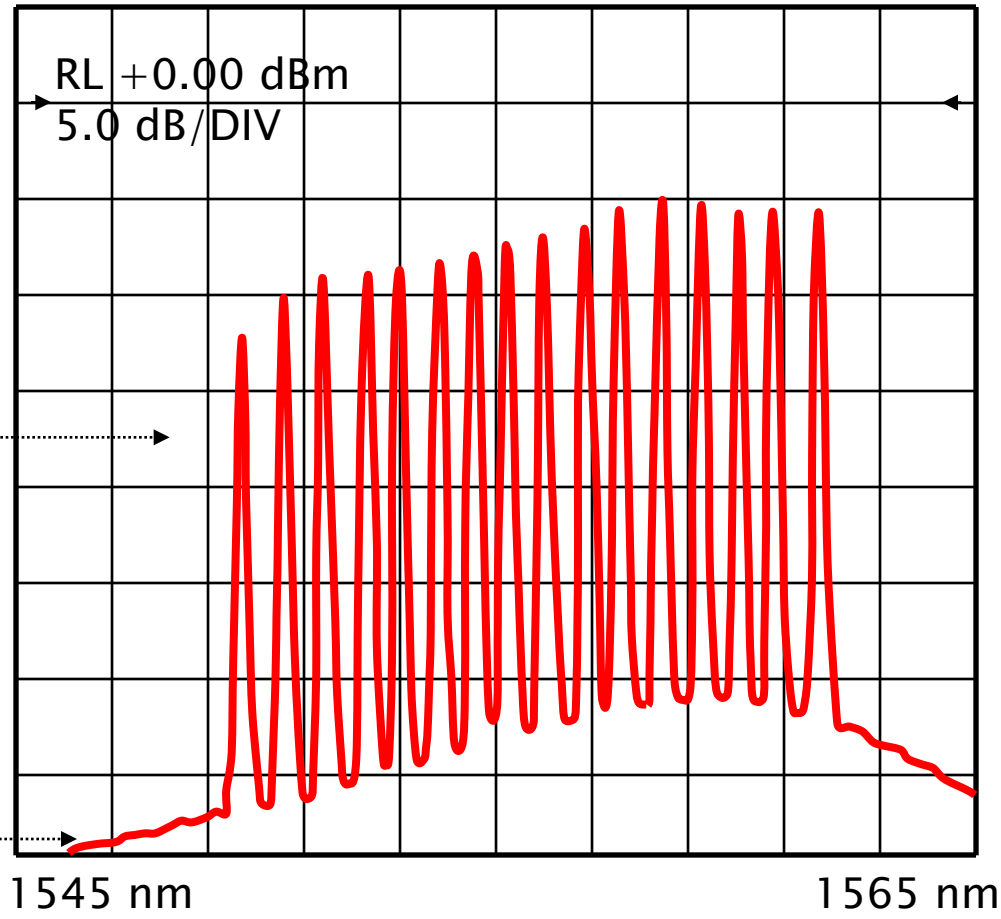
- TDM
  - time-division multiplexing
- FDM
  - frequency-division multiplexing
- Realizabila in domeniul **electric/optic**
- WDM
  - wavelength division multiplexing



Spectrul WDM – Wavelength Division Multiplexing

Canale: 16
Spaţiere: 0.8 nm

Emisie spontană
Amplificată (ASE)



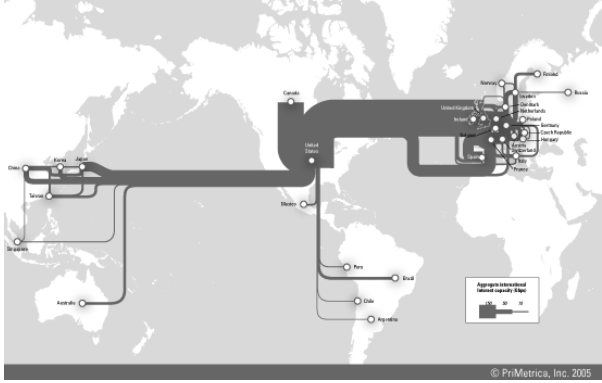
Standarde

- 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

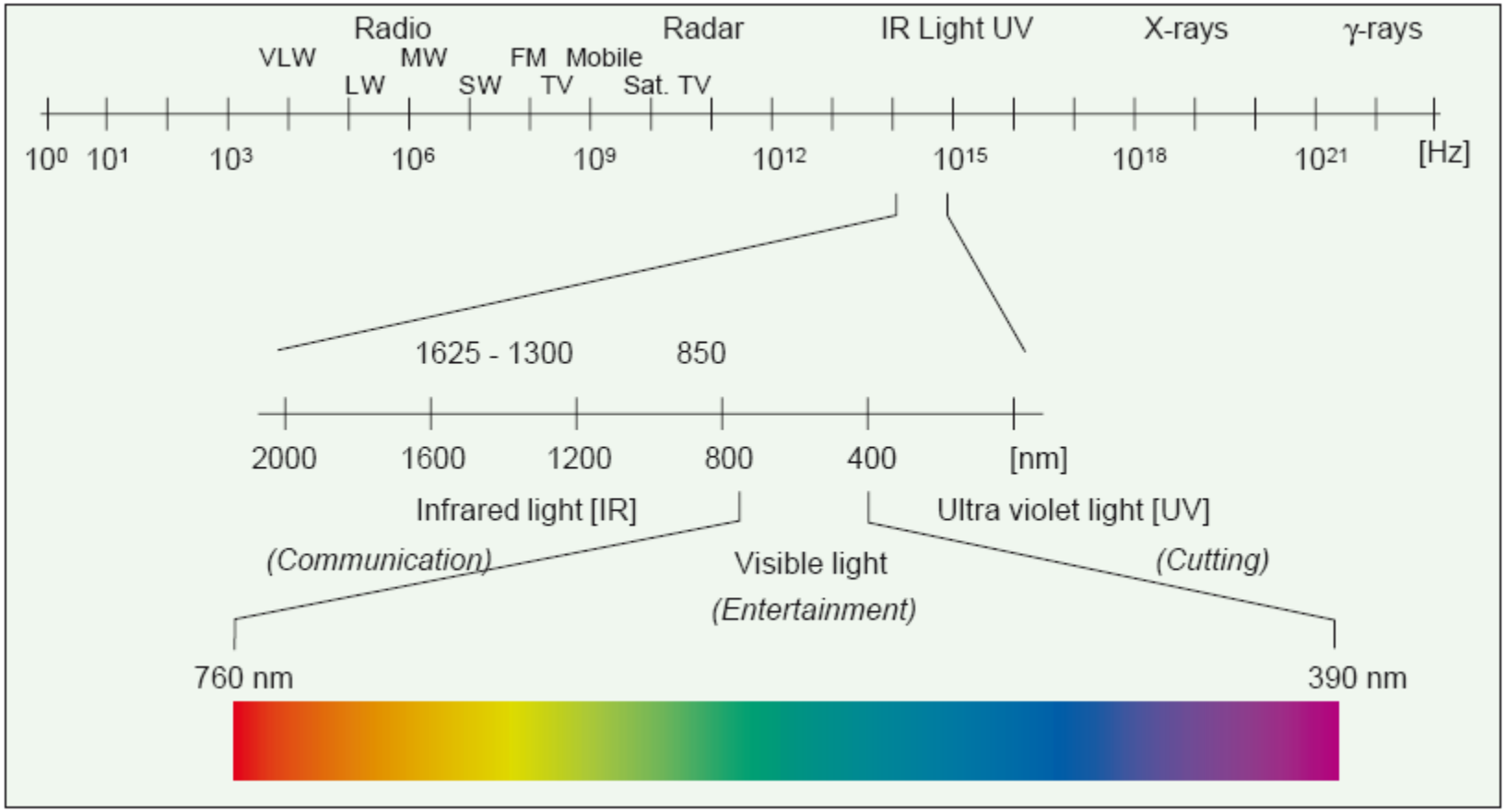
E0	64 Kb/s	
E1	2.048 Mb/s	
E2	8.448 Mb/s	4 E1s
E3	34.364 Mb/s	16 E1s
E4	139.264 Mb/s	64 E1s

1 mile=1760 yards

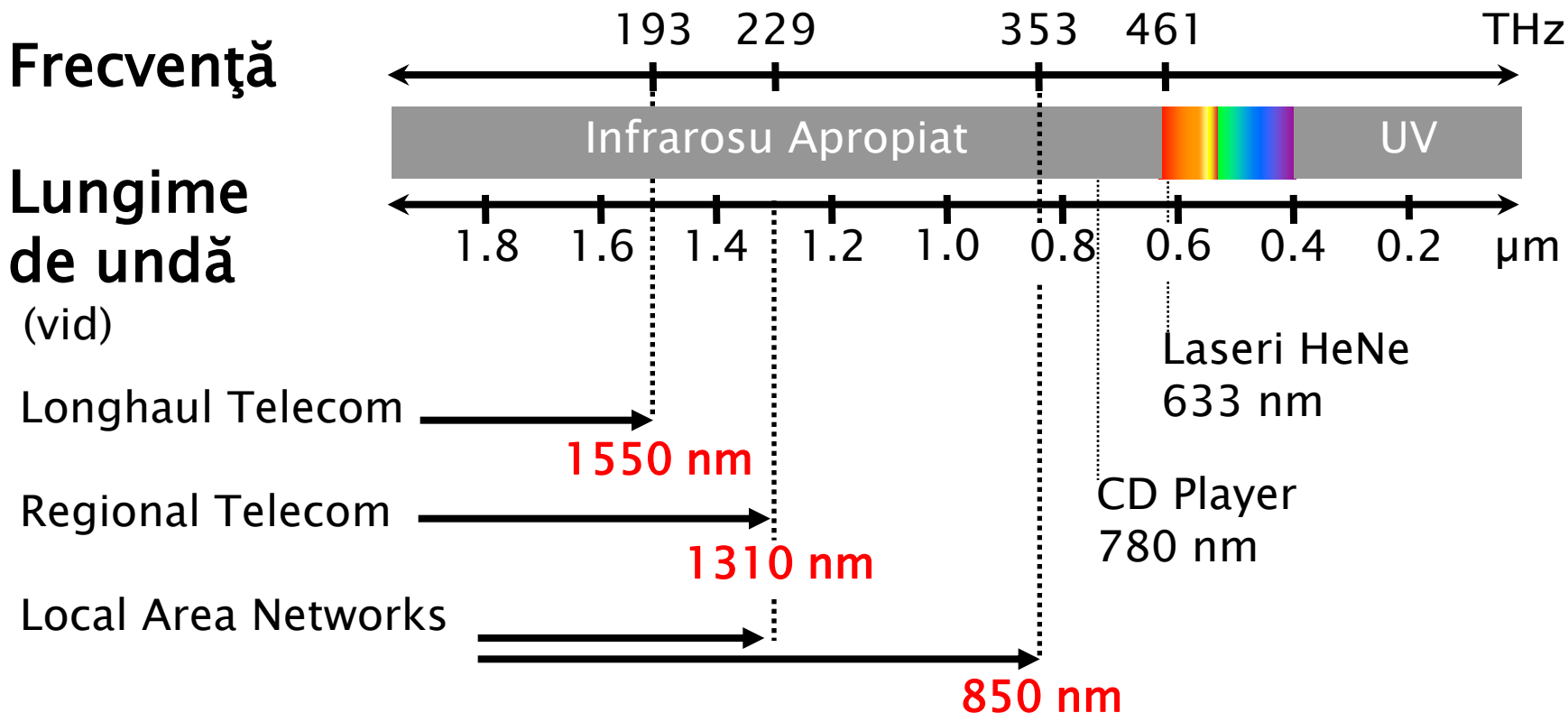
1 yards=3 feet

1 mile≈1609.34 m

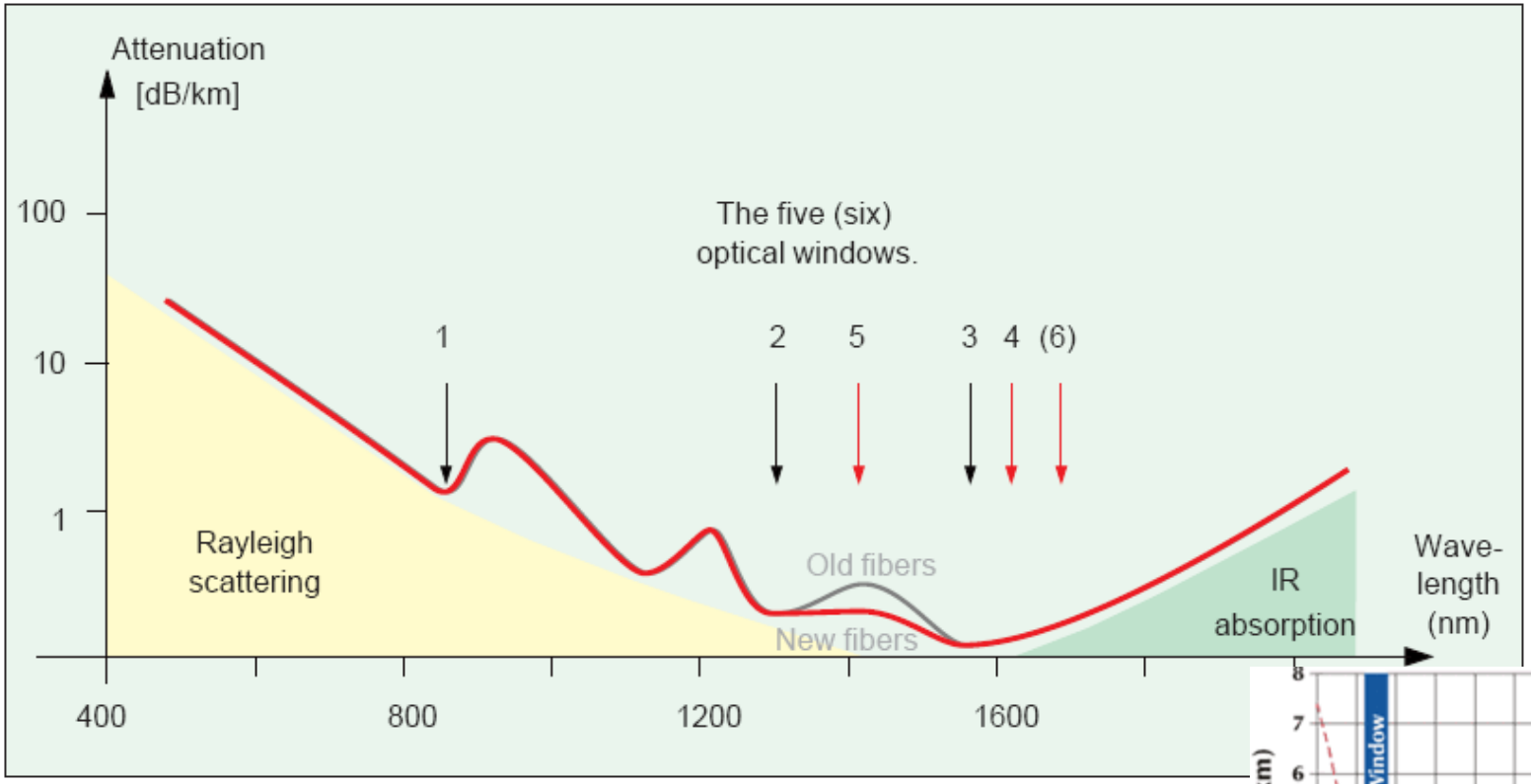
Spectrul electromagnetic



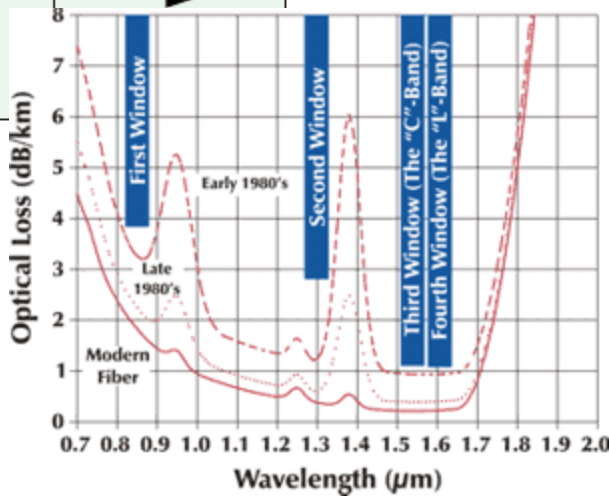
Benzi de lucru in comunicaţiile optice



Atenuarea în fibra optică (SiO_2)



850nm, 1310nm, 1550nm



Aplicatii majore

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  - 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

The Nobel Prize in Physics 2014

Isamu Akasaki
Hiroshi Amano
Shuji Nakamura

Share this

The Nobel Prize in Physics 2014

Isamu Akasaki

Prize share: 1/3

Hiroshi Amano

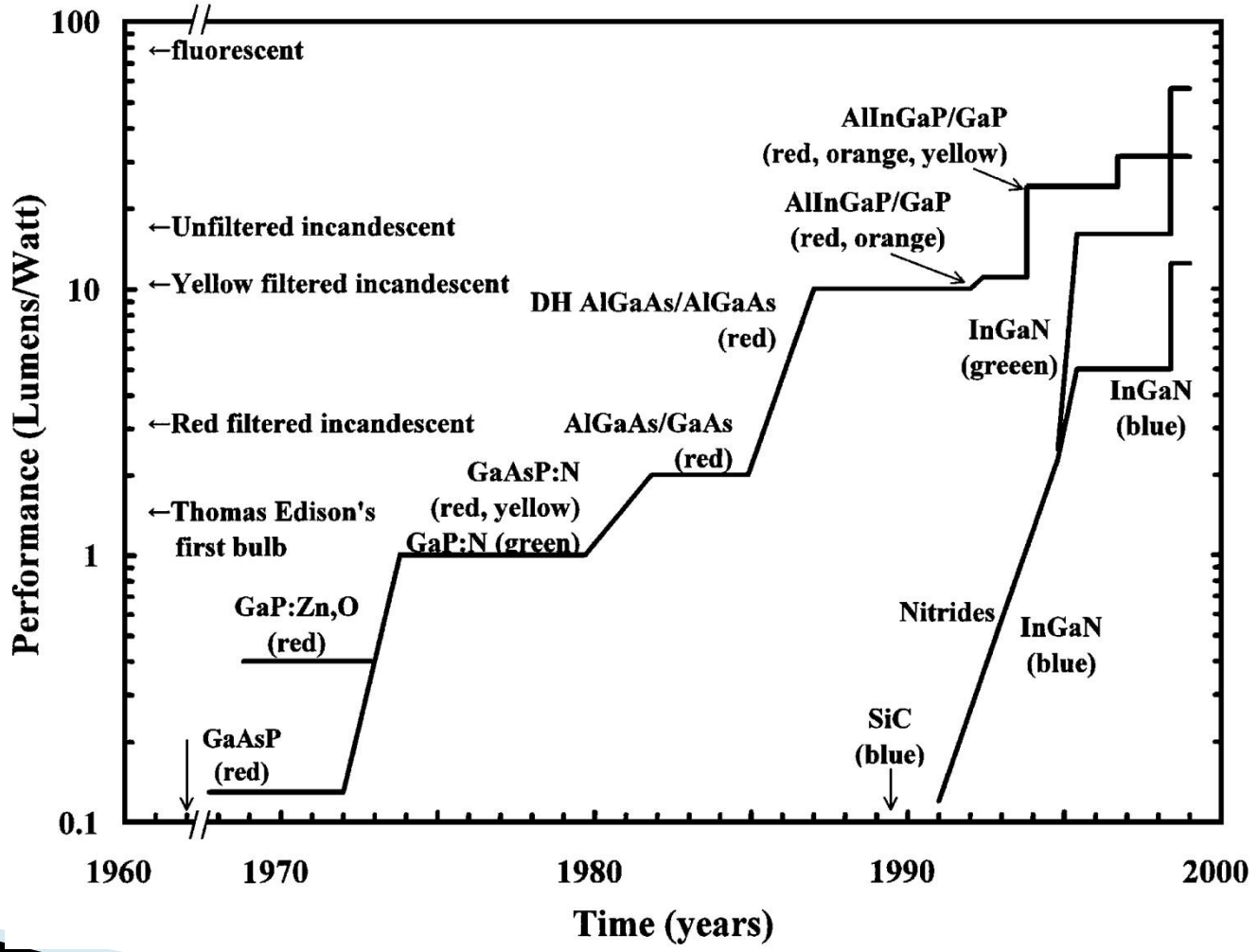
Prize share: 1/3

Shuji Nakamura

Prize share: 1/3

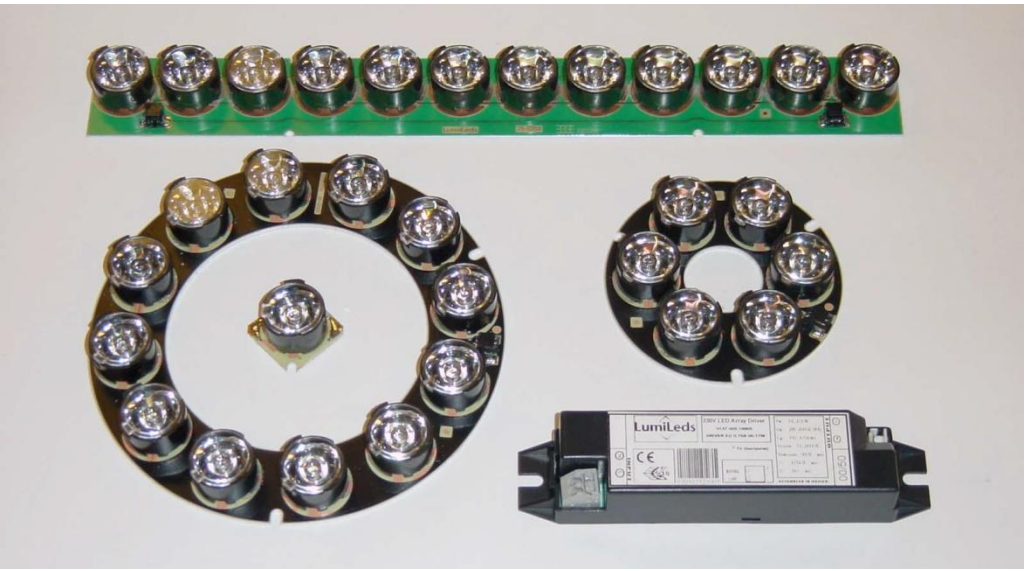
The Nobel Prize in Physics 2014 was awarded jointly to Isamu Akasaki, Hiroshi Amano and Shuji Nakamura "for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources."

Eficienta in timp



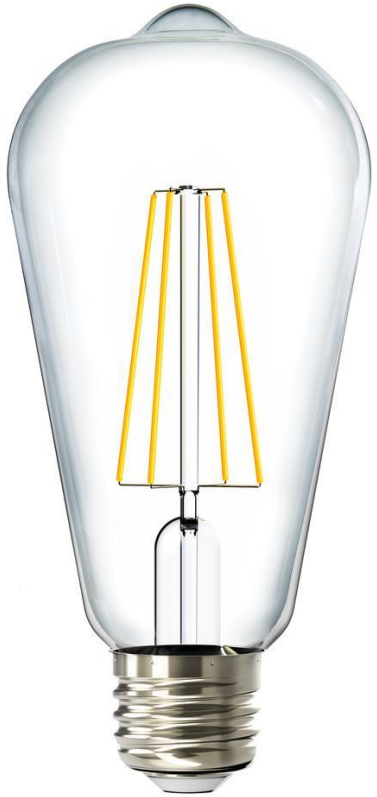
Aplicatii

- auto

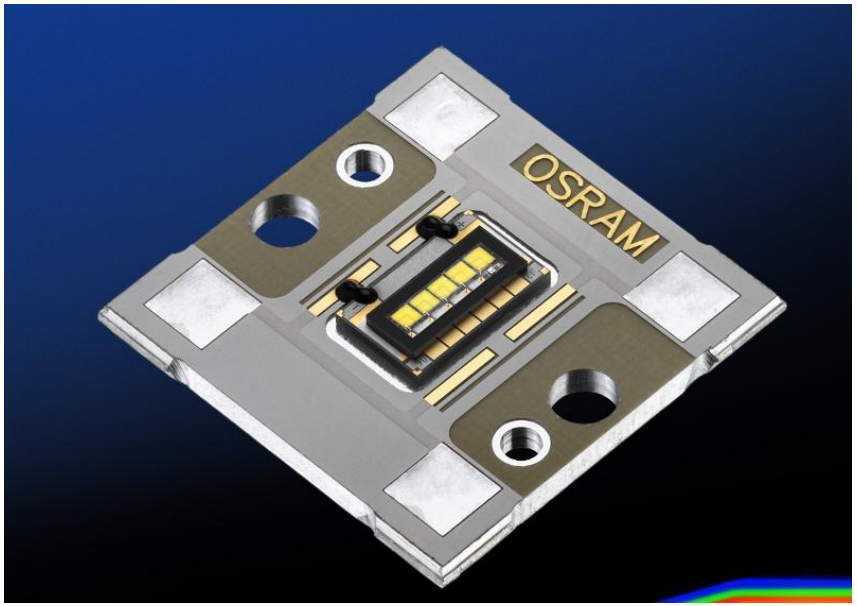


Aplicatii

- casnic



Aplicatii



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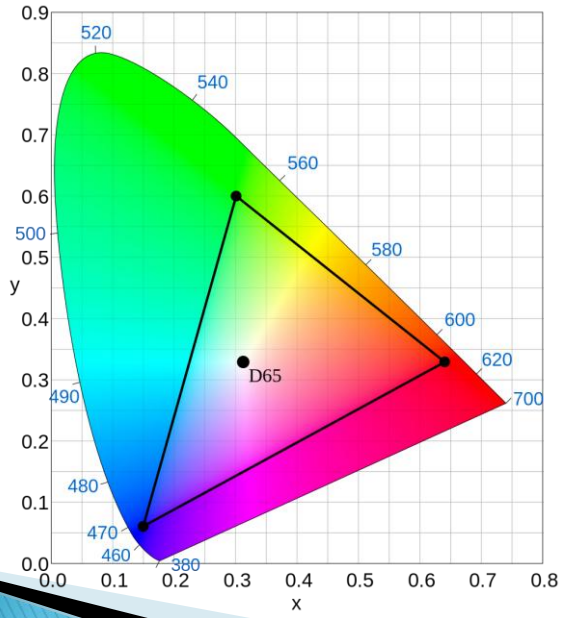
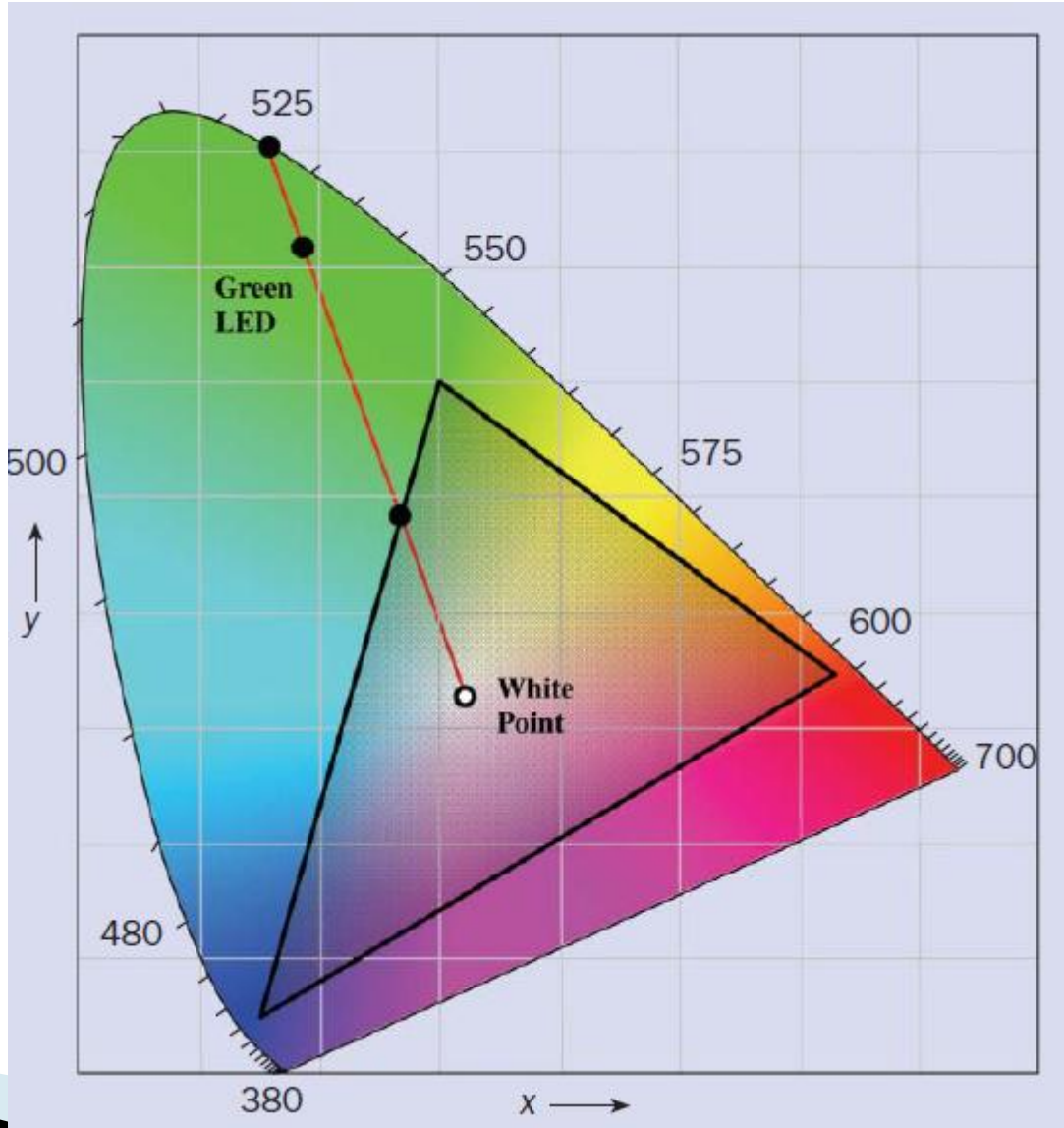
ITU–R BT.709

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

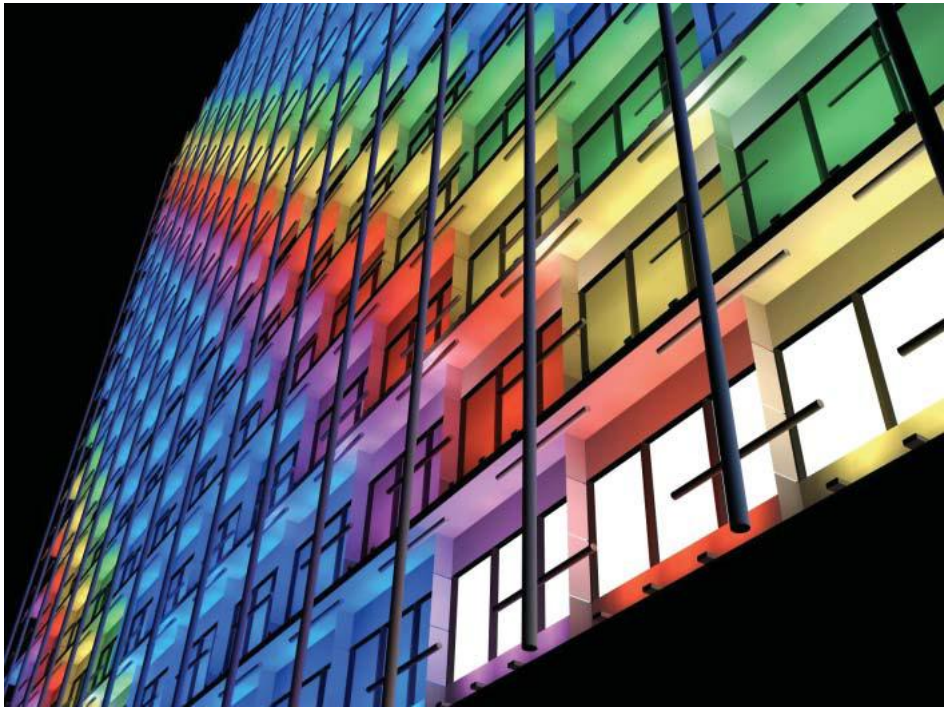
Data refers to xy chromaticity co-ordinates of ITU-R BT.709 phosphors which are used in most CRT displays [1].





Spectru vizibil

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

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

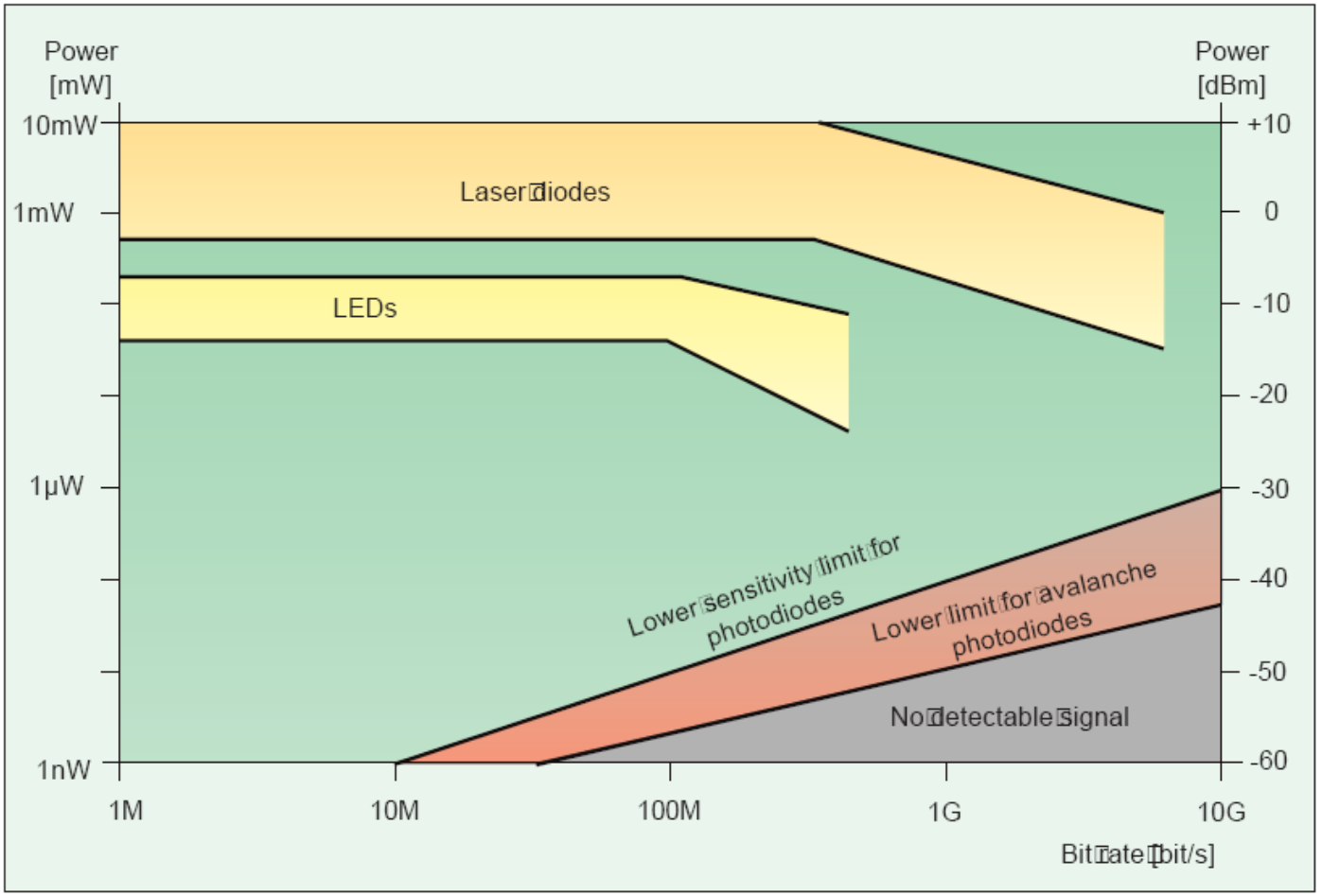
0 dBm	= 1 mW
3 dBm	= 2 mW
5 dBm	= 3 mW
10 dBm	= 10 mW
20 dBm	= 100 mW
−3 dBm	= 0.5 mW
−10 dBm	= 100 μW
−30 dBm	= 1 μW
−60 dBm	= 1 nW

[dBm] + [dB] = [dBm]

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

[x] + [dB] = [x]

Limite putere/bandă a dispozitivelor optoelectronice

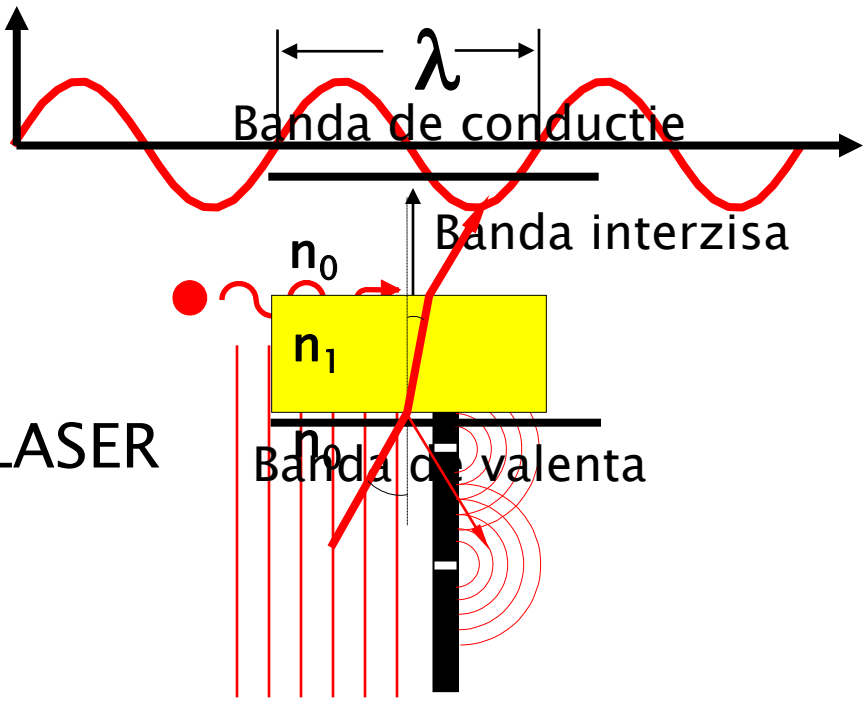


Modelarea luminii

(tot) Capitolul 1

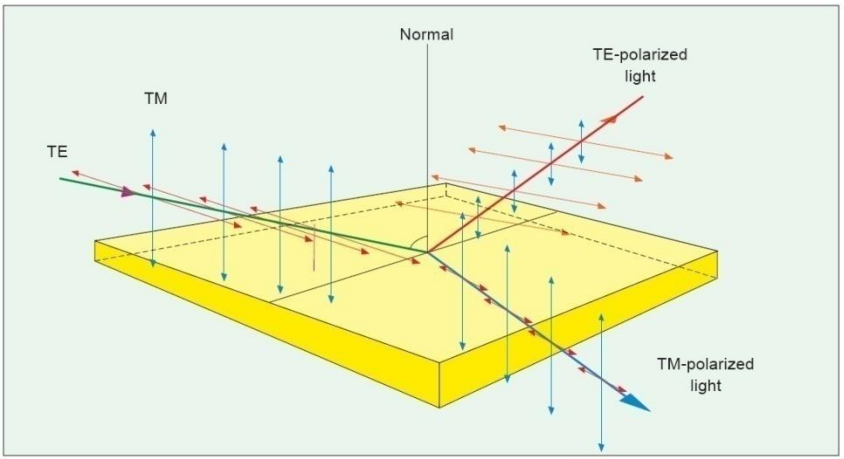
Modelarea luminii

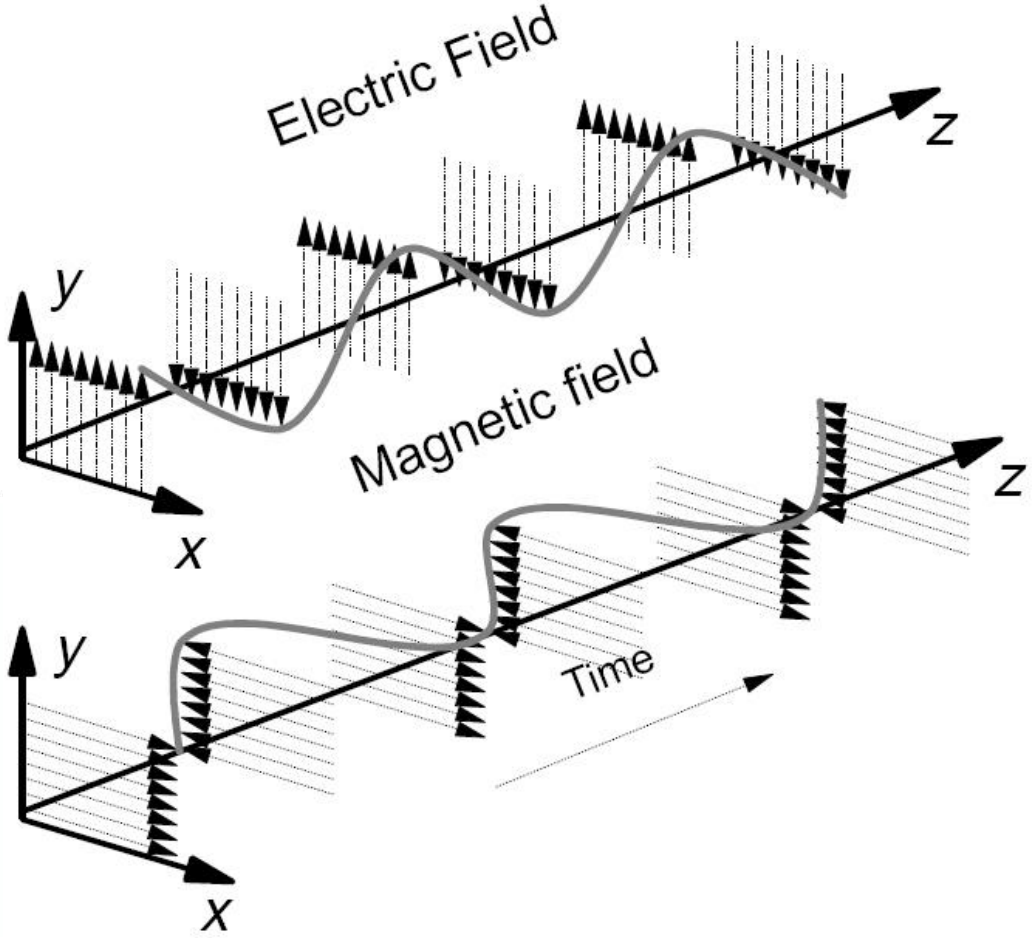
- Undă electromagnetică
  - Ecuaţiile lui Maxwell
  - λ, ε, ω, f
- Teoria cuantică
  - Benzi energetice $E = h \nu$
  - fotoni, emisie stimulată, LASER
- Optică geometrică
  - n, θ
  - raze de lumină
  - intuitivă



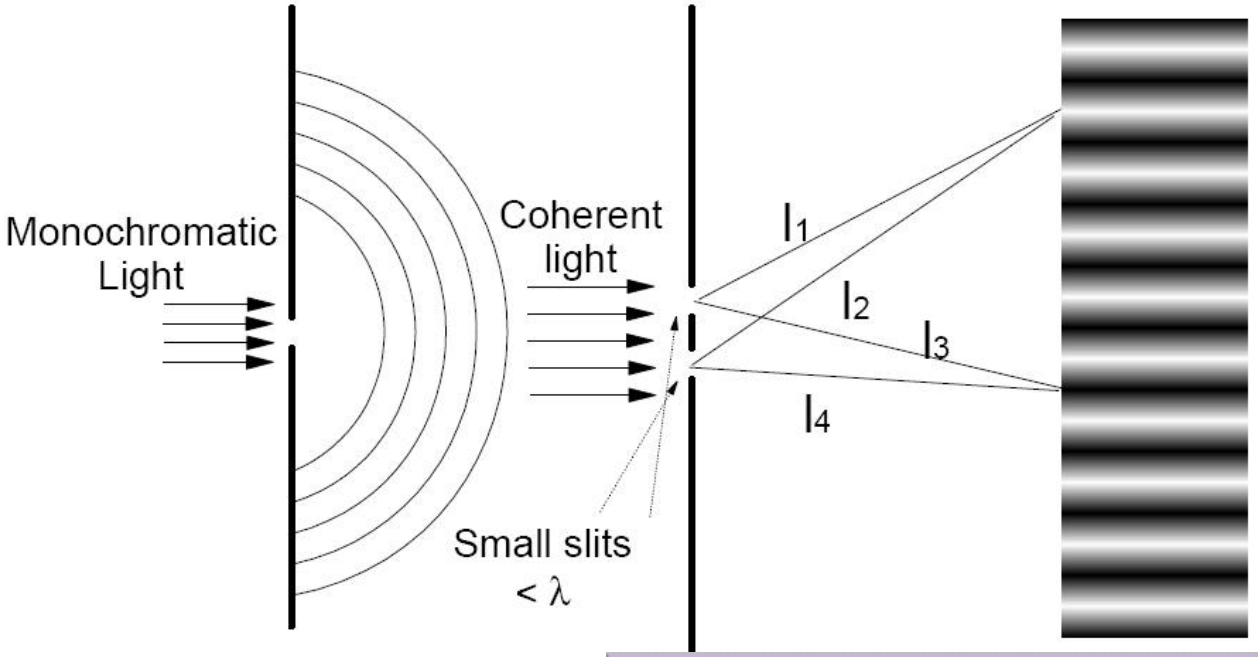
Unda electromagnetica

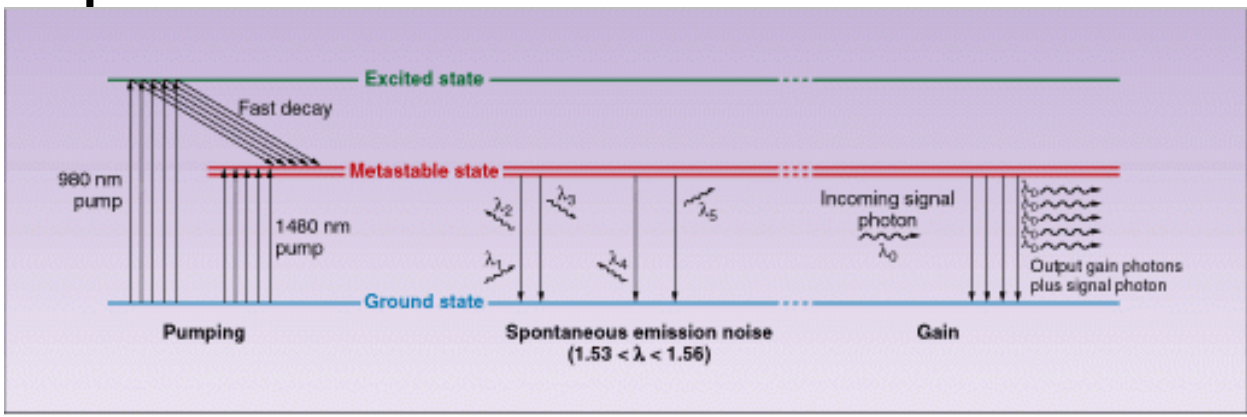
- Dispersie
- Fibre monomod
- Interferenta
- Polarizare





Fotoni/Unda

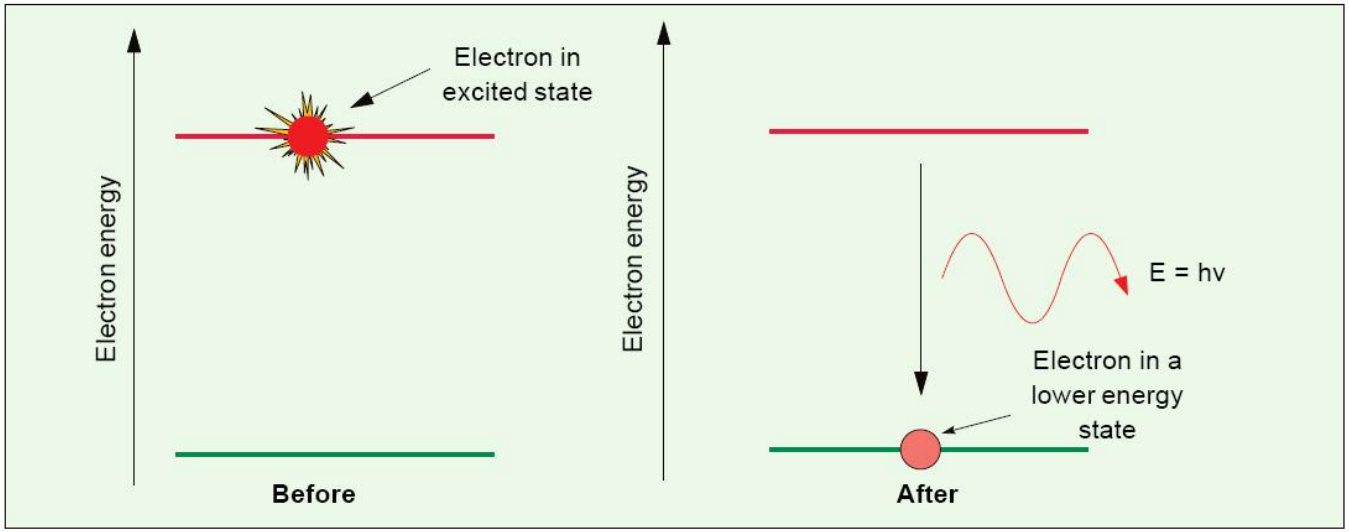




8-FEA-4 97 Fig. 2

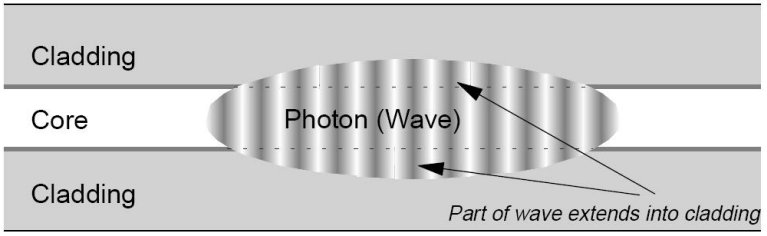
Through the Wormhole
S02E07 How Does the Universe Work

Model cuantic – foton



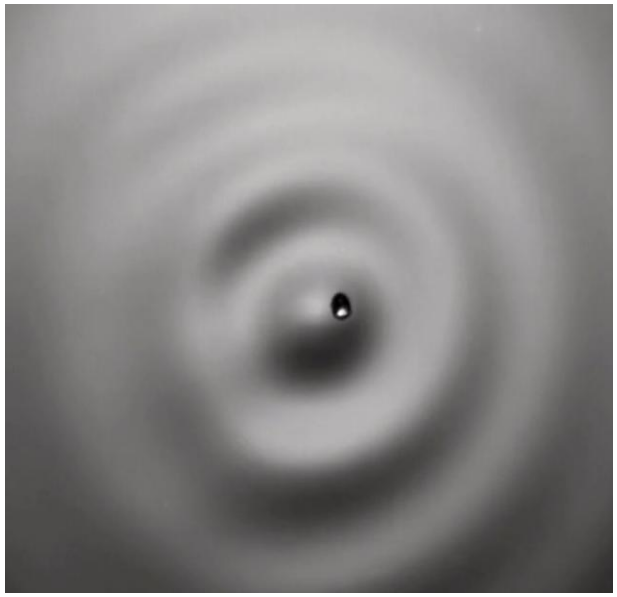
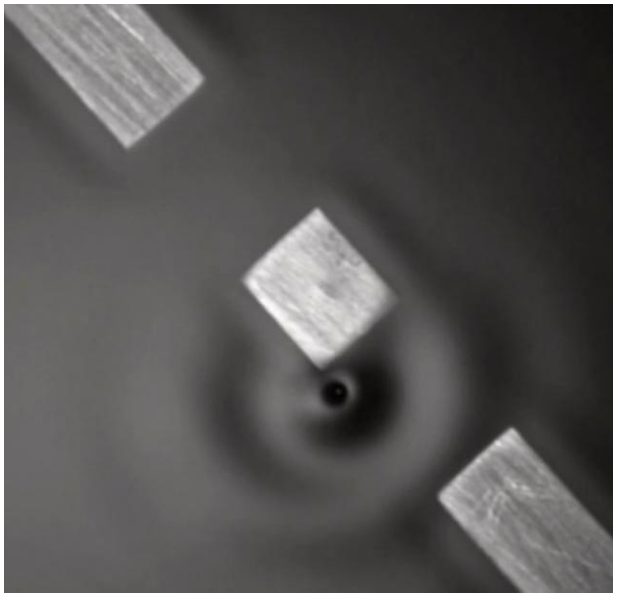
$$E_g = h\nu; \quad \lambda = \frac{hc}{E_g}; \quad \lambda[\mu m] = \frac{1.240}{E_g[eV]}$$

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

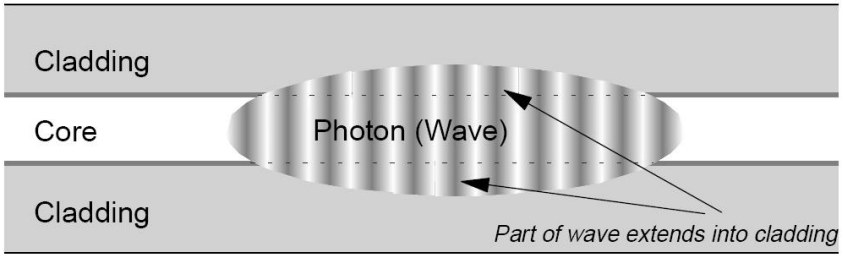


Through the Wormhole
S02E07 How Does the Universe Work

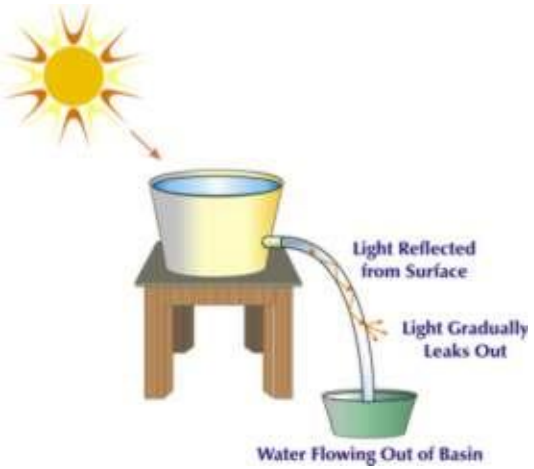
Modelare

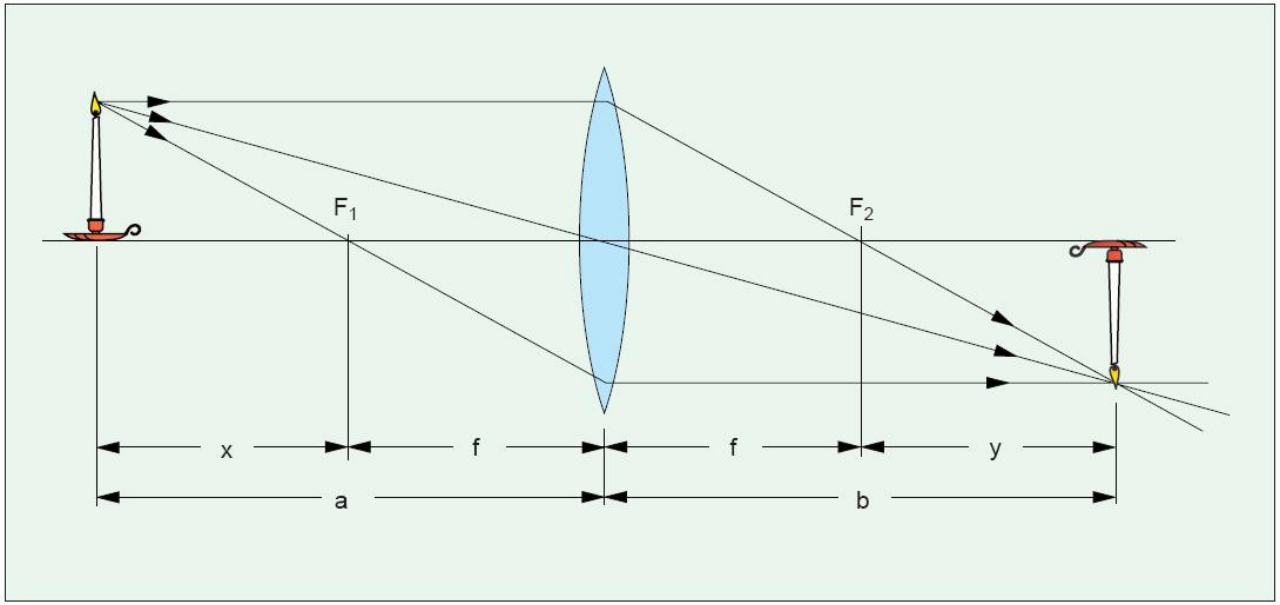



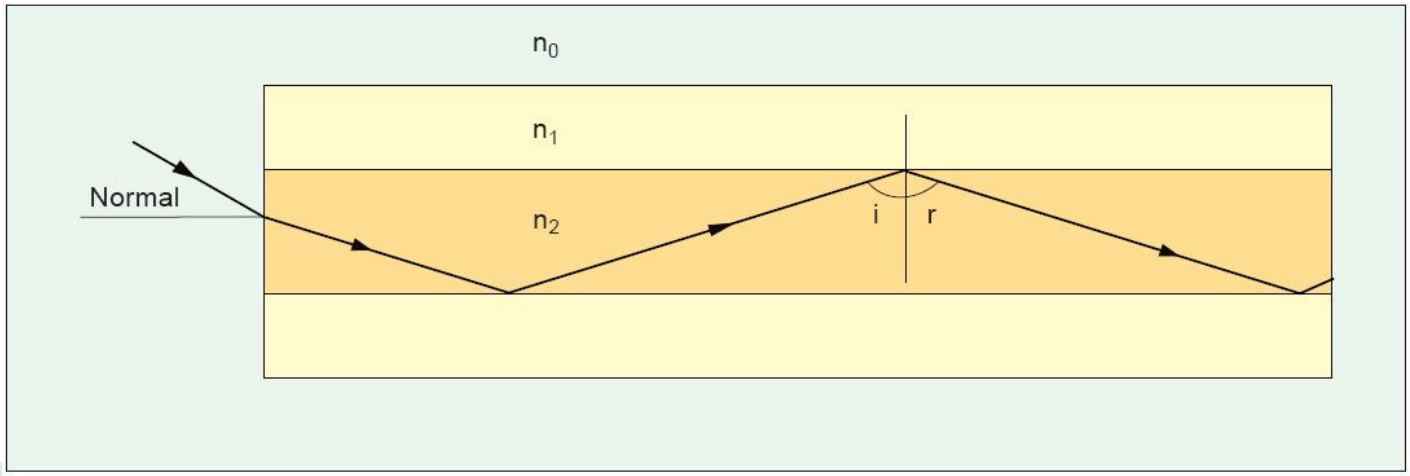

Through the Wormhole
S02E07 How Does the Universe Work



Optica geometrica







Contact

- Laboratorul de microunde si optoelectronica
- http://rf-opto.etti.tuiasi.ro
- rdamian@etti.tuiasi.ro