Lumina

De la licaririle stelelor... la
Infrastructura pentru Lumina Extrema (ELI)

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Aceasta prezentare a fost realizata cu gandul la fiul meu Sebastian, clasa a saptea.

Fiat Lux!

Si a zis Dumnezeu: sa fie lumina!



… si a fost lumina!
Şi a văzut Dumnezeu lumina că e frumoasă;

Ca adjectiv, kalós înseamnă „frumos" ; ca adverb, înseamnă „bine". „Lumina frumoasă" e opţiunea exegetică a Sfântului Vasile cel Mare. „Frumos" şi „bine", laolaltă, induc ideea de „armonie".

Sfanta Scriptura, trad. PSBartolomeu Anania, Facerea, capitolul 1, versetele 3-4

Continut



Pe cine intereseaza lumina?

Autopsia luminii: Lungimi de unda, dimensiuni, spectre

- Lumina in astrofizica
  - Cea mai mare parte din informatia despre univers
  - Semnaturile elementelor

Laserul: lumina intensa, durata scurta...

Proiectul ELI

Pe cine intereseaza lumina

All-time top ten in fizica

1. Albert Einstein

2. Isaac Newton

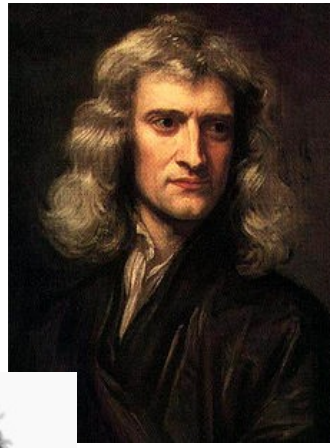
3. James Clerk Maxwell

4. Niels Bohr
5. Werner Heisenberg
6. Galileo Galilei
7. Richard Feynman
8. Paul Dirac
9. Erwin Schrödinger
10. Ernest Rutherford

http://news.bbc.co.uk/2/hi/science/nature/541840.stm

Pe cine intereseaza...

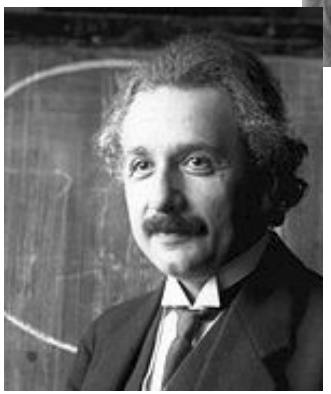
Secolul 17-18: Isaac Newton
a construit primul telescop cu reflexie;
a dezvoltat o teorie a culorilor bazata pe descompunerea luminii albe in multe culori



Secolul 19: James Clerck Maxwell
a scris ecuatiile luminii (ecuatiile campului electromagnetic) in forma completa



Secolul 20: Albert Einstein
Postuleaza ca viteza luminii e aceeasi in toate sistemele de referinta
Prezice efectul laser



Secolul 21: Numele tau si poza ta aici

Ce reprezinta imaginea?



Coperta albumului
The Dark side of the Moon
al formatiei Pink Floyd (1973)

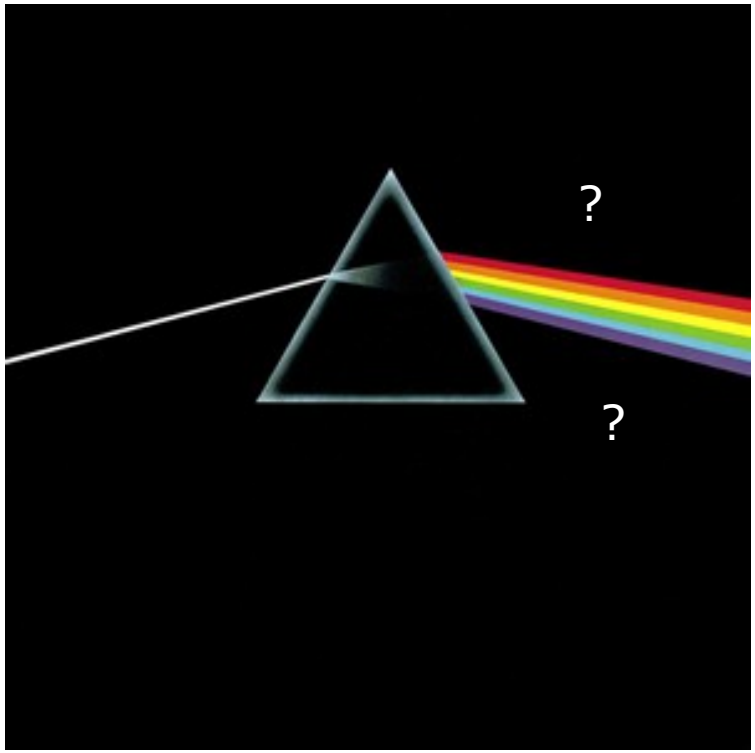
In topul Billboard 741 de saptamani, cel mai longeviv album din istorie

Cei mai mari oameni de stiinta au studiat lumina

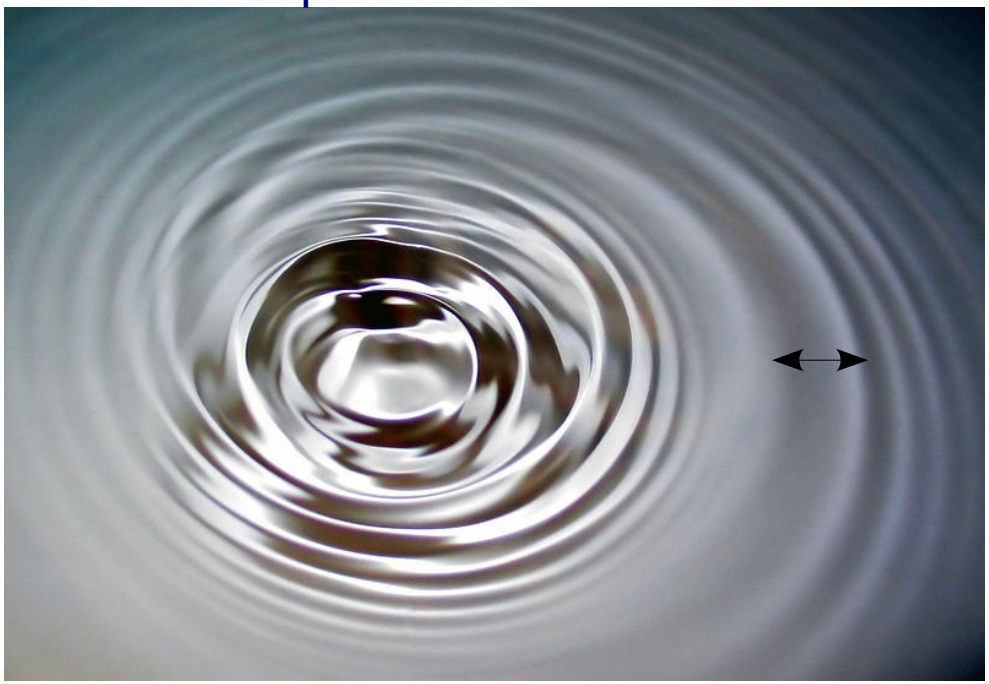
Lumina e aproape peste tot, din frigider si pana la albumele muzicale celebre!

*Daca studiezi lumina poti fi **chiar tu** urmatorul mare savant, pentru Secolul 21*

Proprietatile luminii:
Culorile si lungimea de unda



Lumina poate fi inteleasa ca o unda

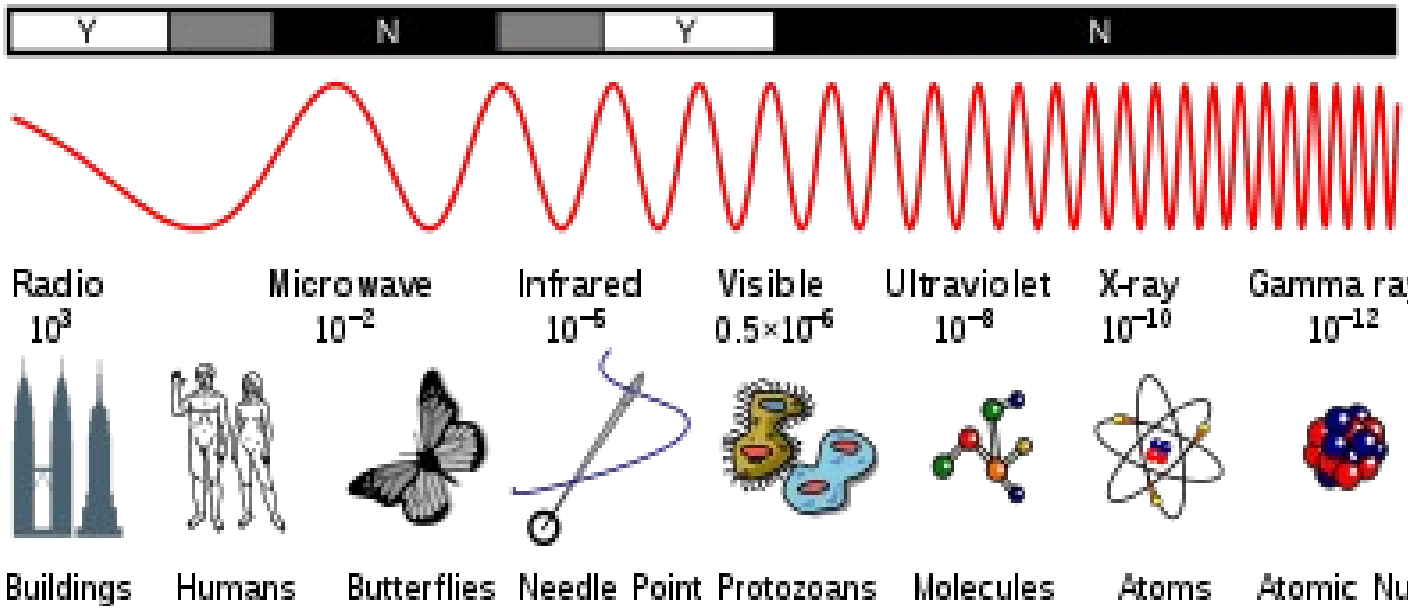


Distanta dintre valuri=lungimea de unda

Fiecare culoare corespunde unei lungimi de unda

Proprietatile luminii

Penetreaza atmosfera pamantului?



Lungimea de unda a radiatiei (m)

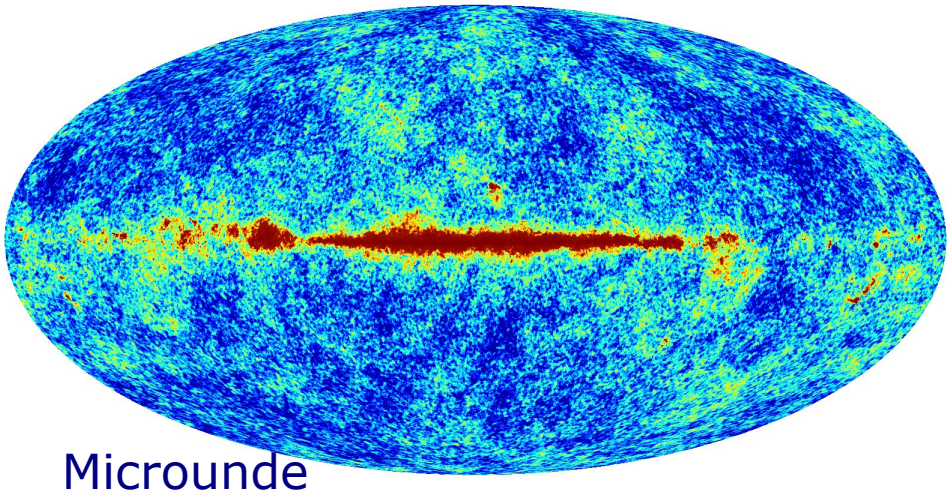
Obiecte cu dimensiuni similare

Hartile universului

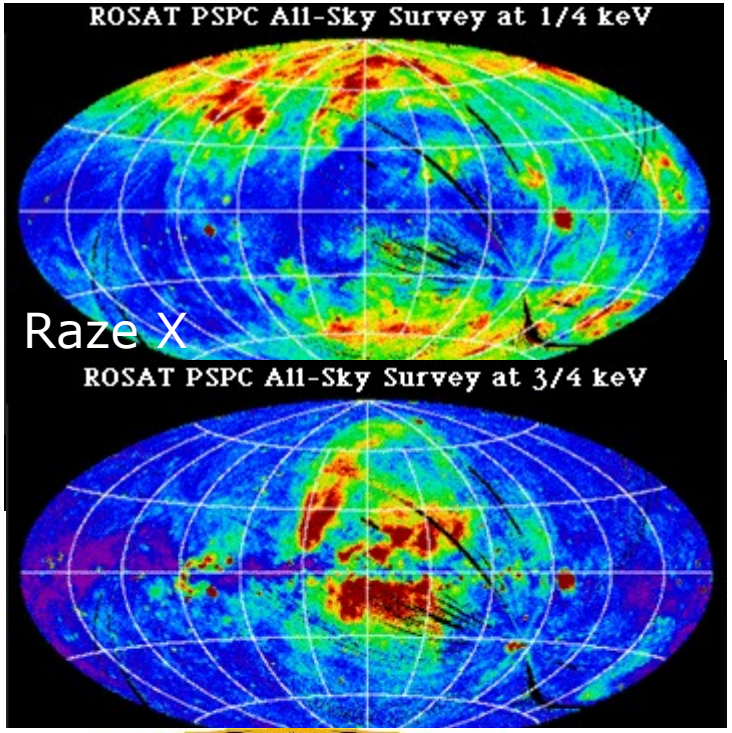


Harta unei sfere incape intr-un oval plat;
aici mai sus e harta pamantului

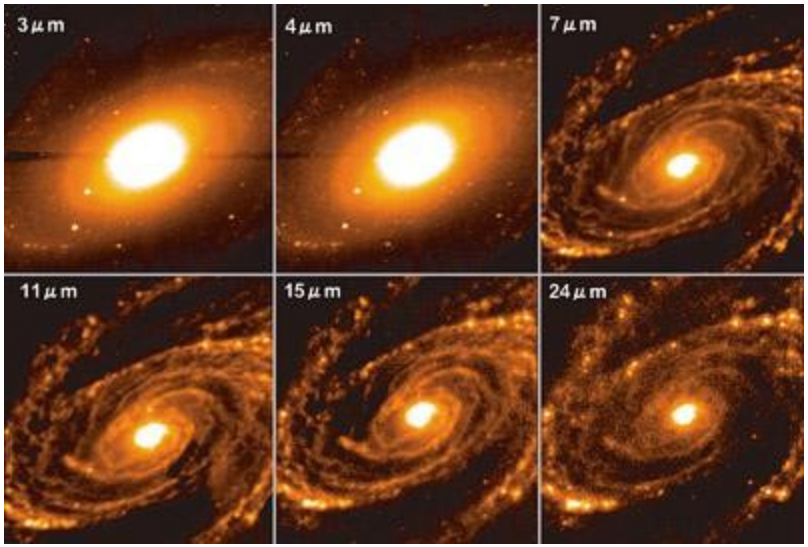
Hartile universului

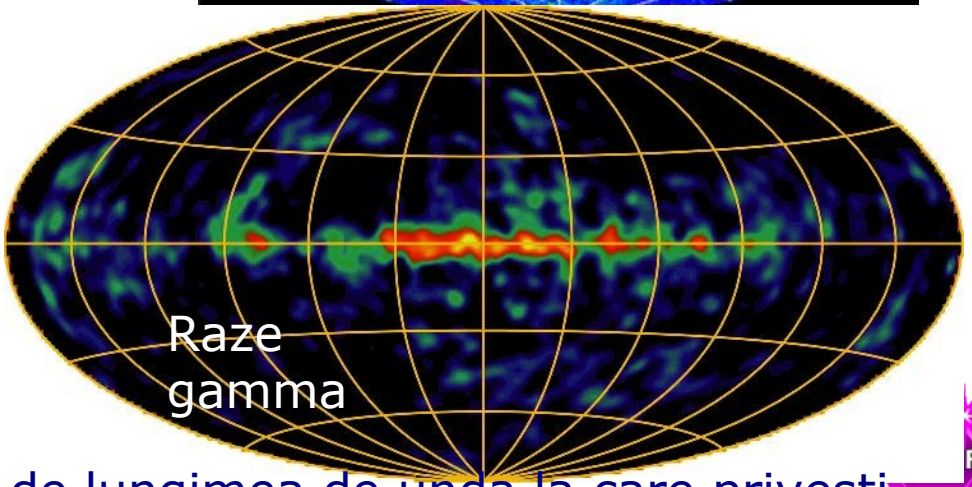


Microunde



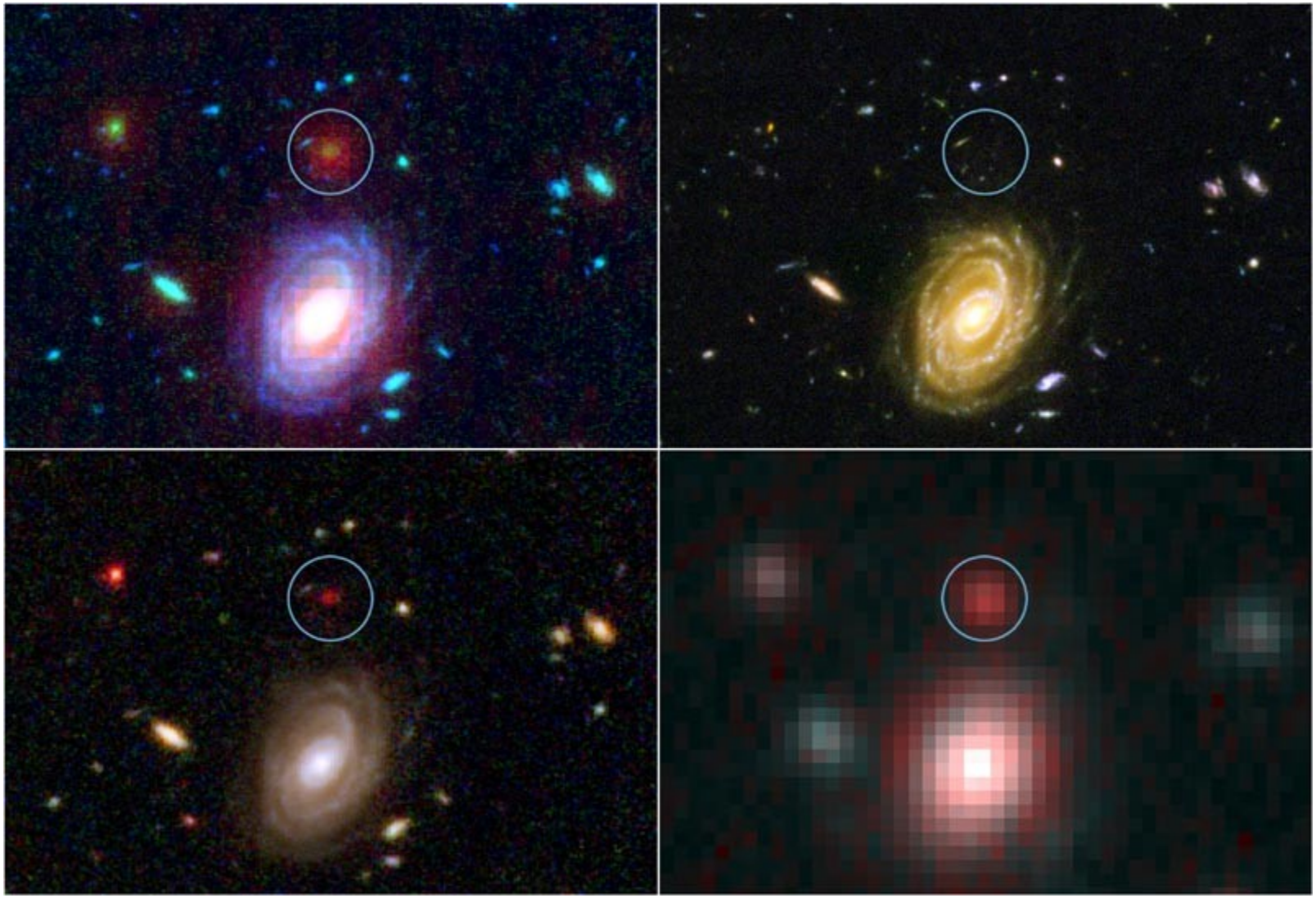
Infrarosu





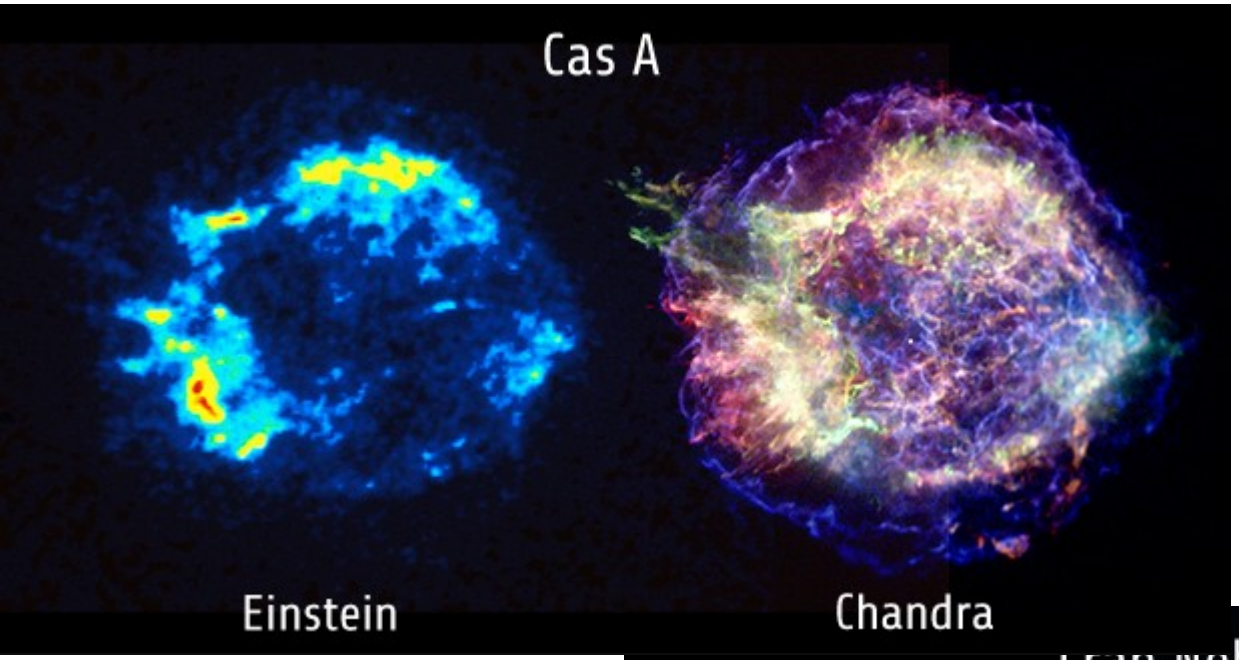
Hartile universului difera in functie de lungimea de unda la care privesti

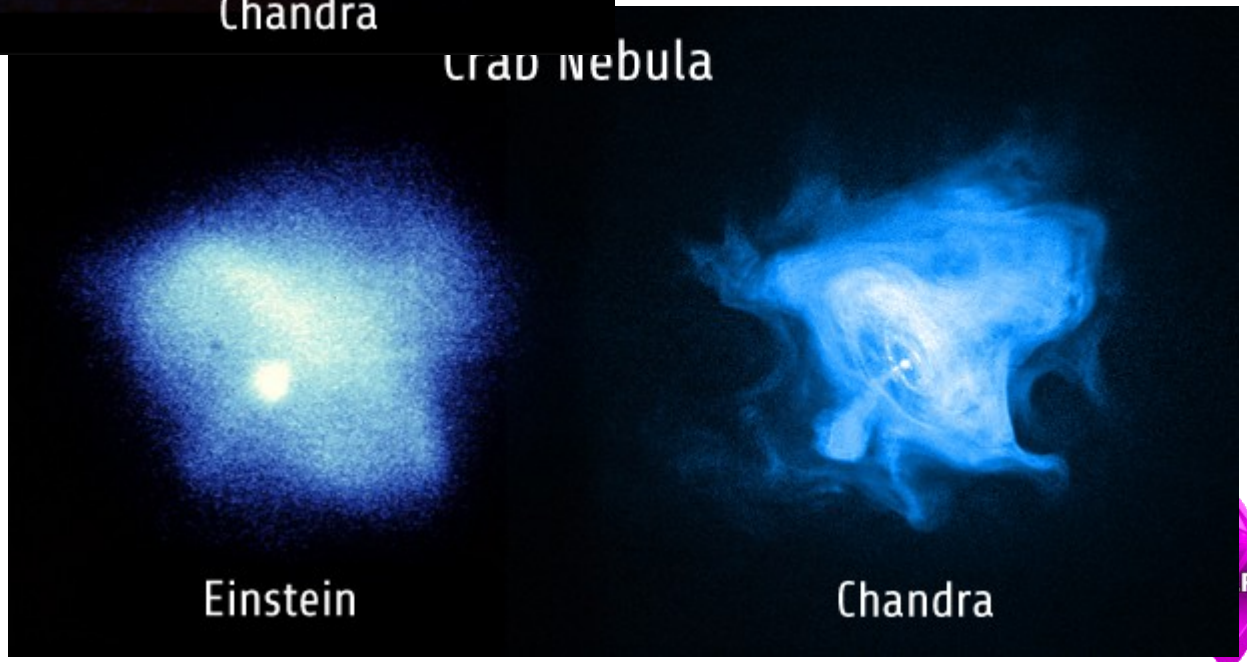
Hartile universului: rezolutie



Combinand imagini la lungimi de unda diferite facem harti mai complete

Hartile universului: rezolutie





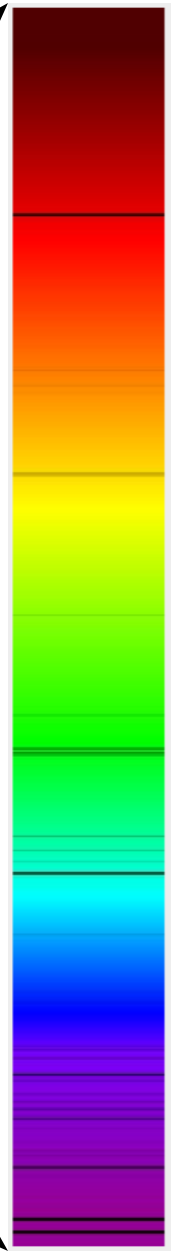
Aparatura moderna e din ce in ce mai performanta

Materia din univers

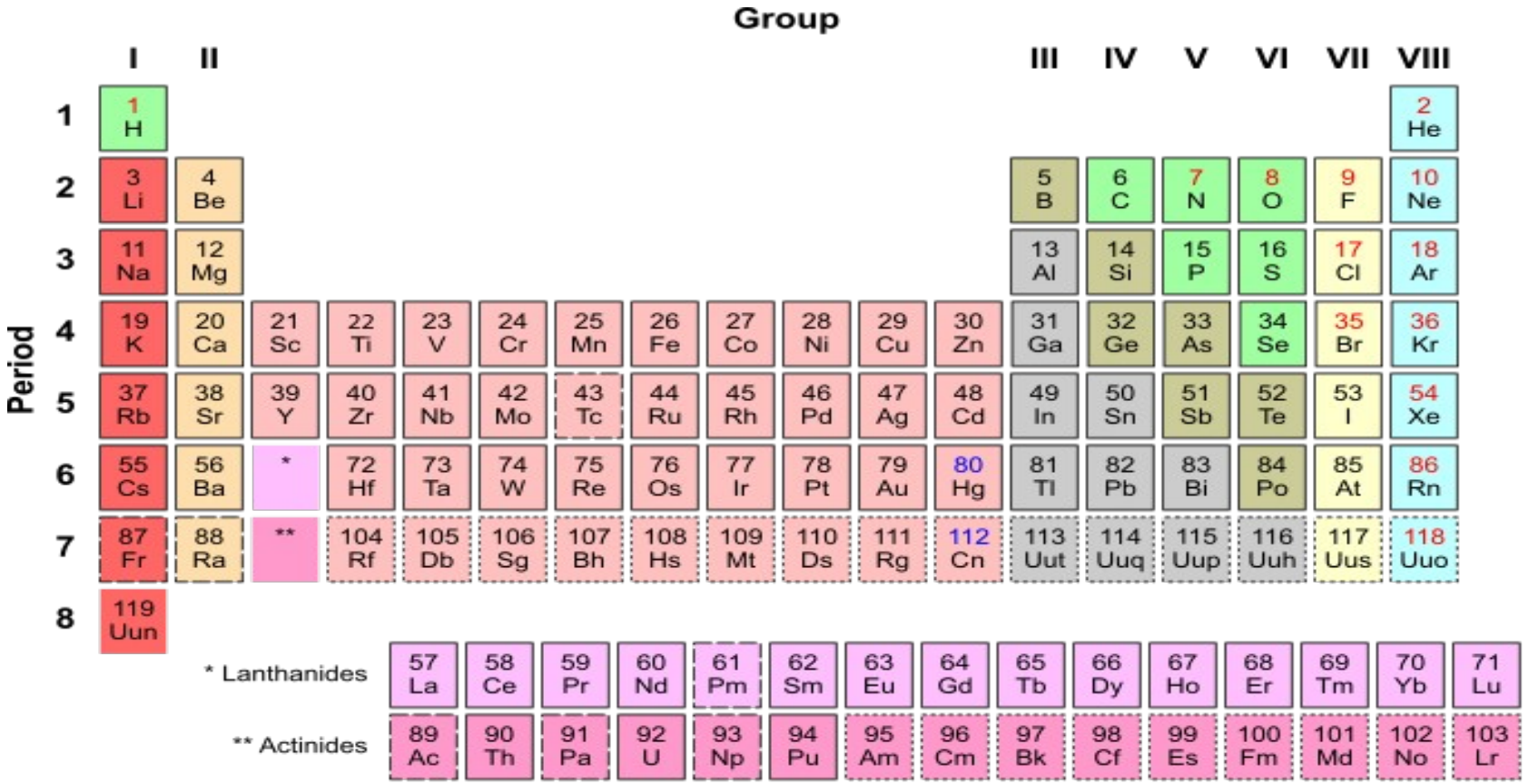
Semnatura elementelor = cod de bare



Pentru raze de la soare
Obtinem un cod de bare

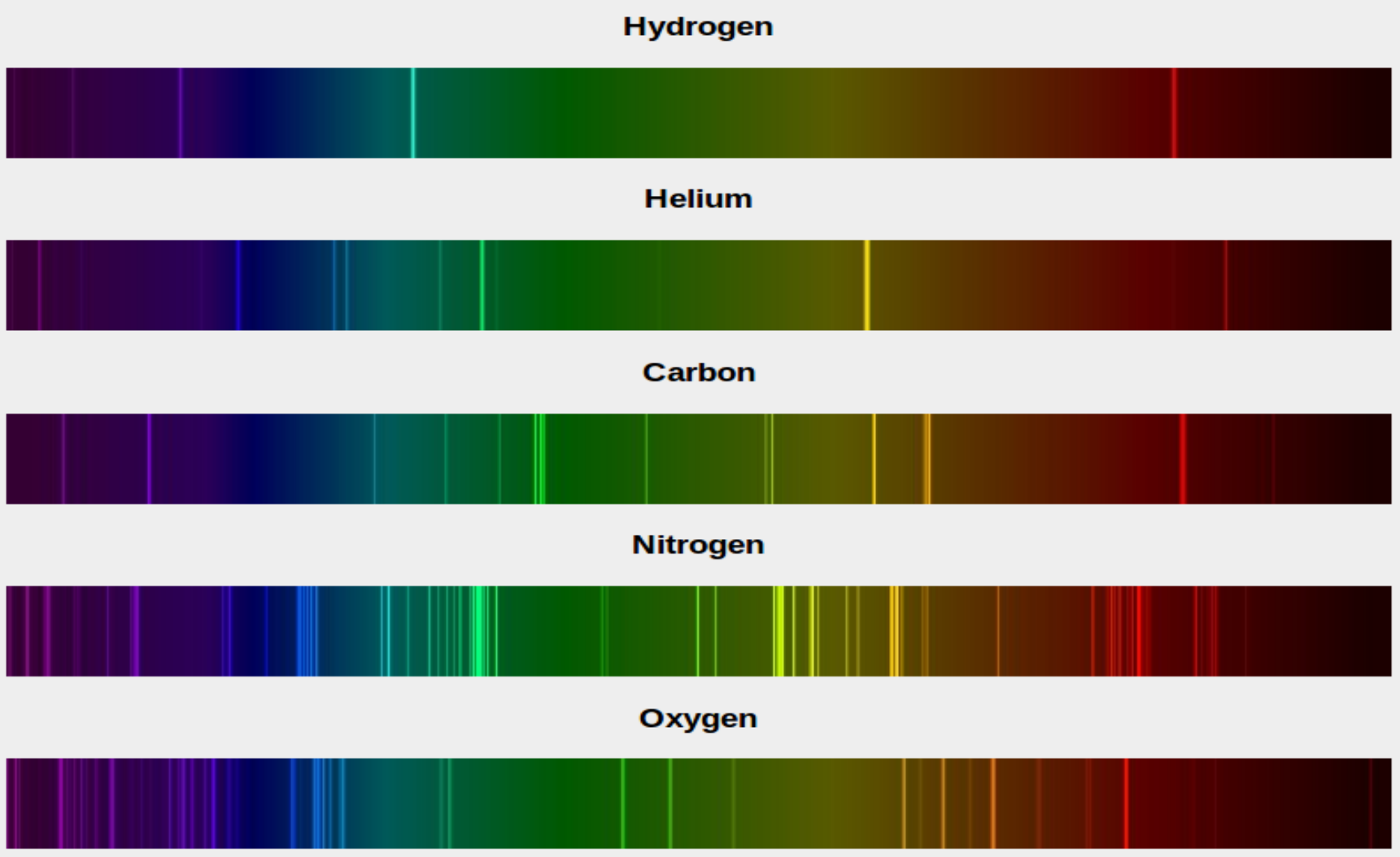


Atomii ...



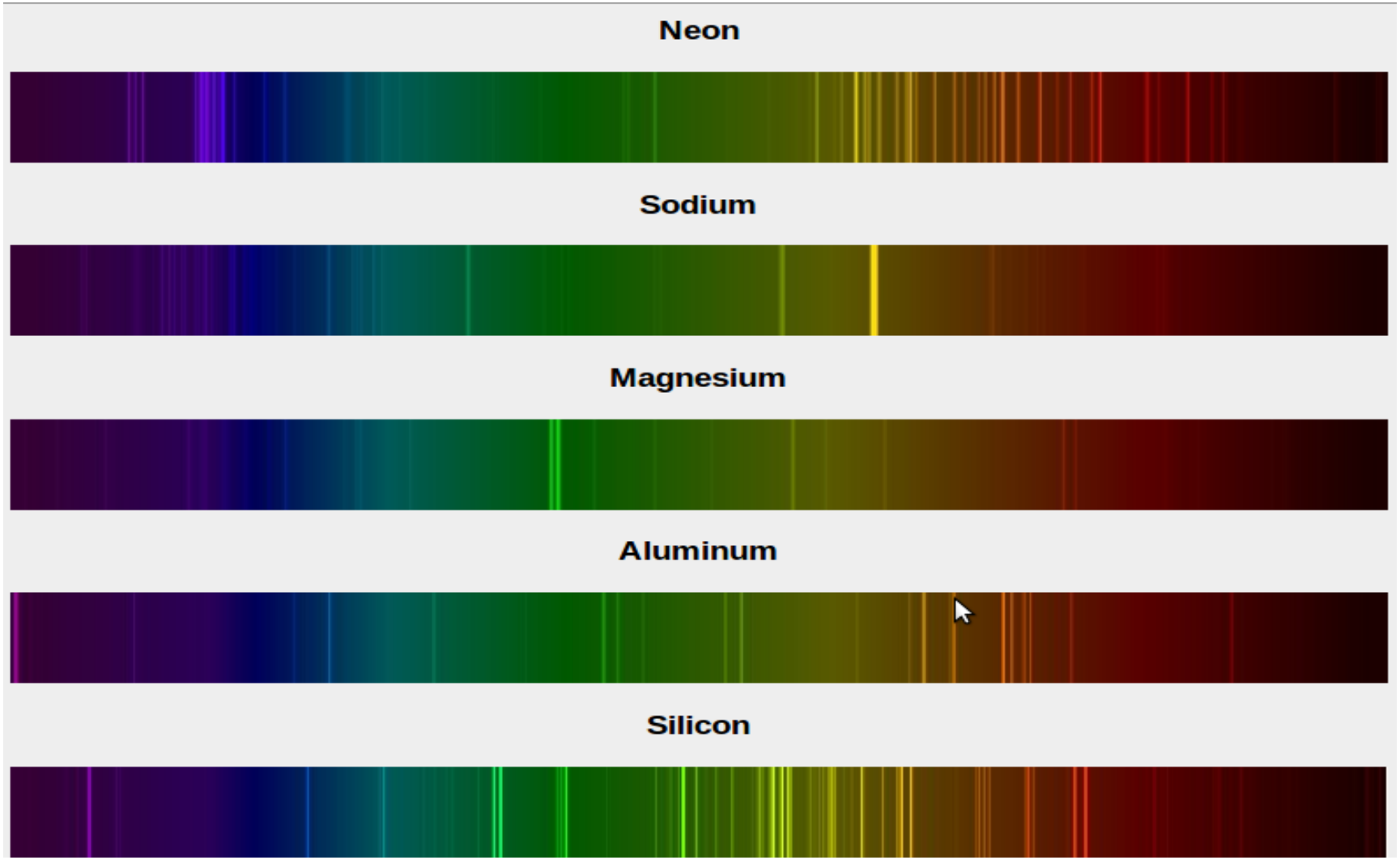
Tabelul lui Mendeleev contine lista cu toti atomii din univers... (?)

...si semnaturile lor spectrale



Fiecare atom are un spectru specific, ca un cod de bare

...si semnaturile lor spectrale

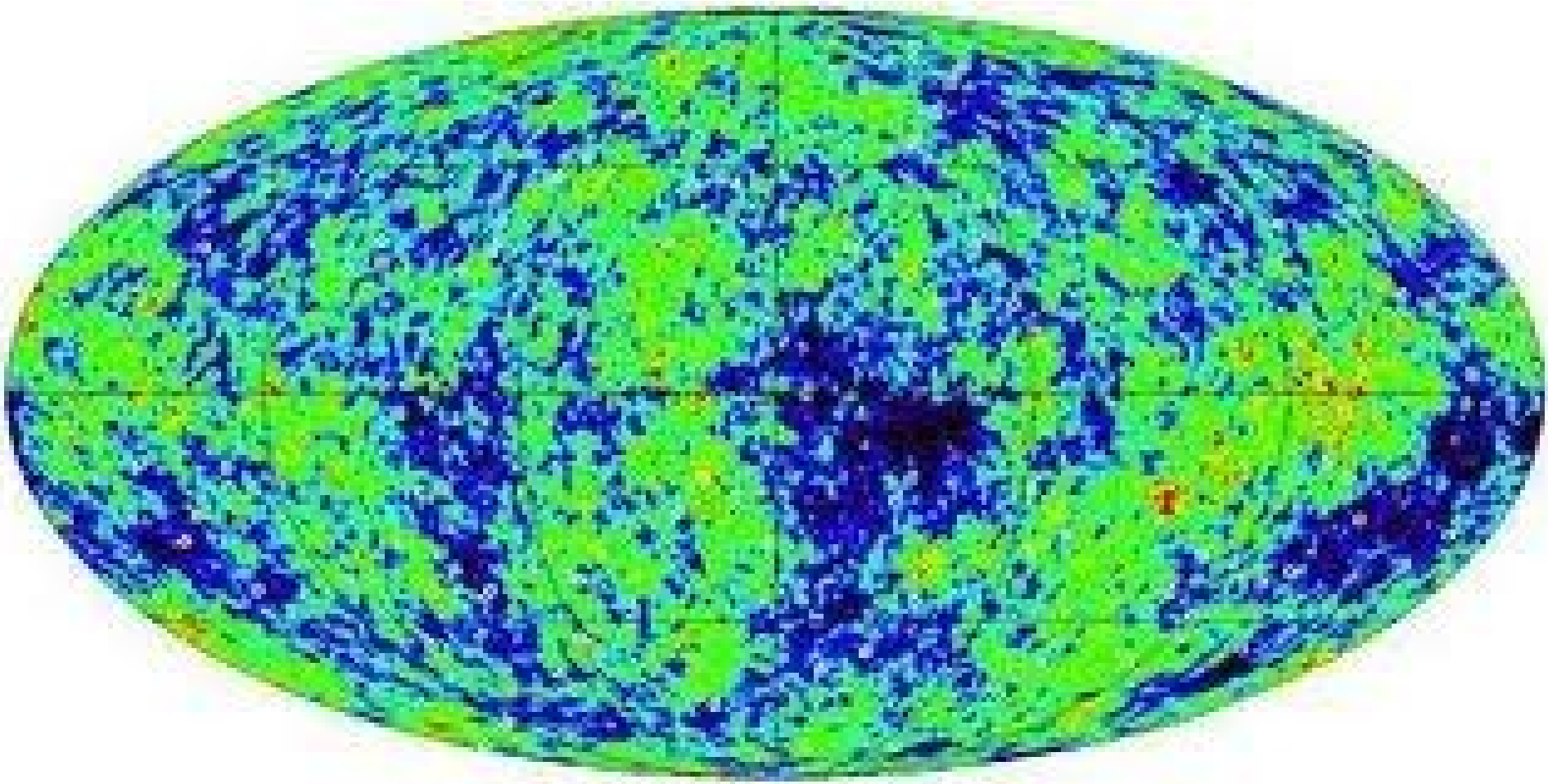


Fiecare atom are un spectru specific, ca un cod de bare

Spectroscopie = Citit coduri de bare



Hartile universului: densitatea universului



Cunoscand spectrele de lumina de la un corp ceresc, putem ghici compozitia lui
Materie lipsa = dark matter

Lumina e ca o unda

Distanta dintre doua valuri consecutive se numeste lungimea de unda

Lungimea de unda da culoarea luminii;
Exista si lumina invizibila pentru ochi

Lumina la diferite lungimi de unda ne da informatii felurite despre univers si materie

Proprietatile luminii:
Propagarea si intensitatea campurilor electrice si magnetice

Lumina poate fi inteleasa ca o unda



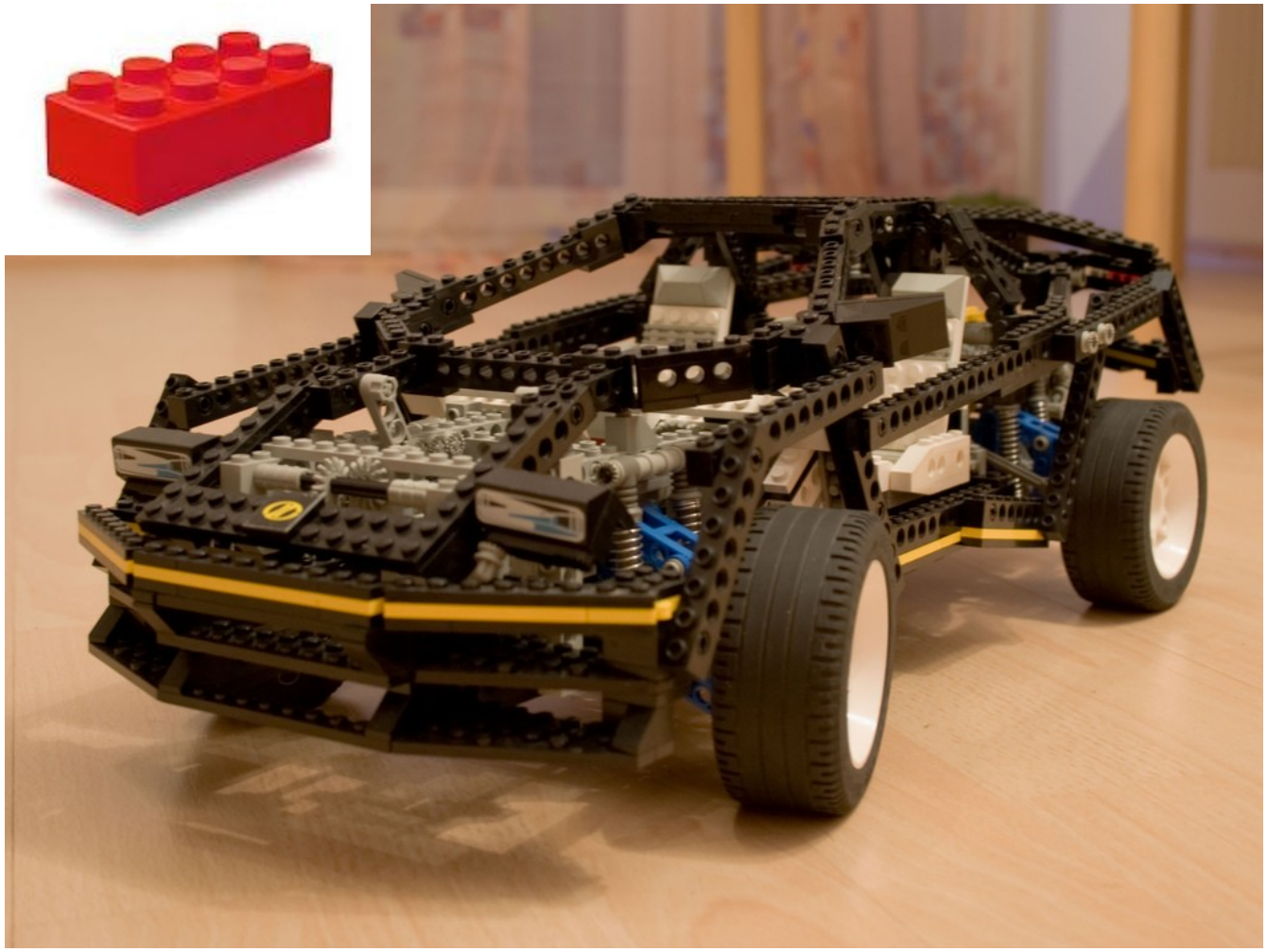


Valurile mai inalte corespund unei stralucirea mai mari pentru o culoare
= campuri mai intense

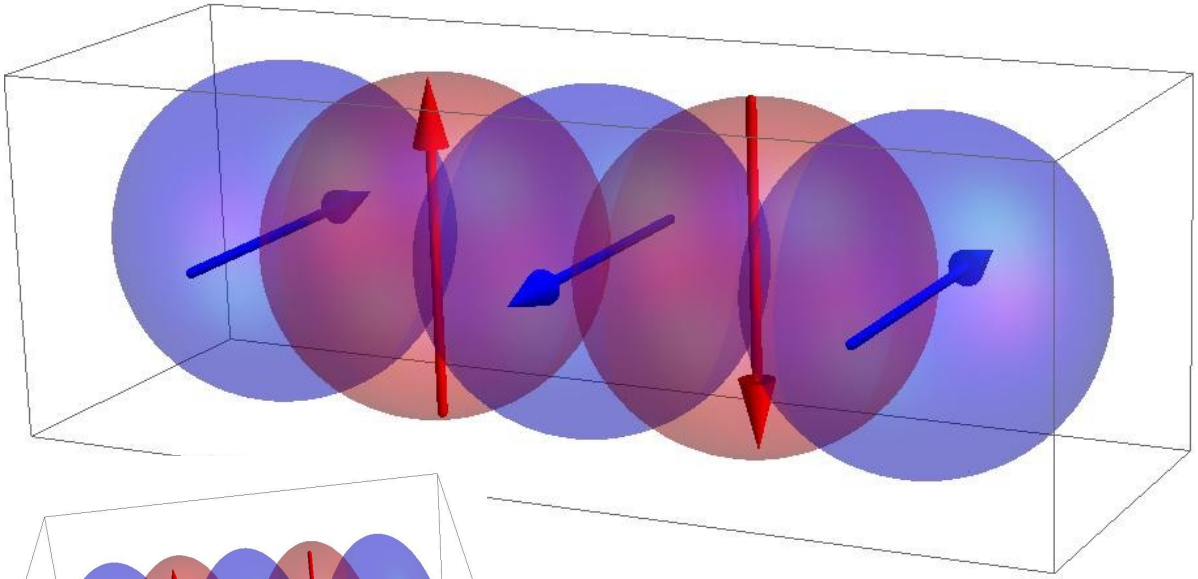
Lumina e o combinatie de forte (campuri) electrice si magnetice

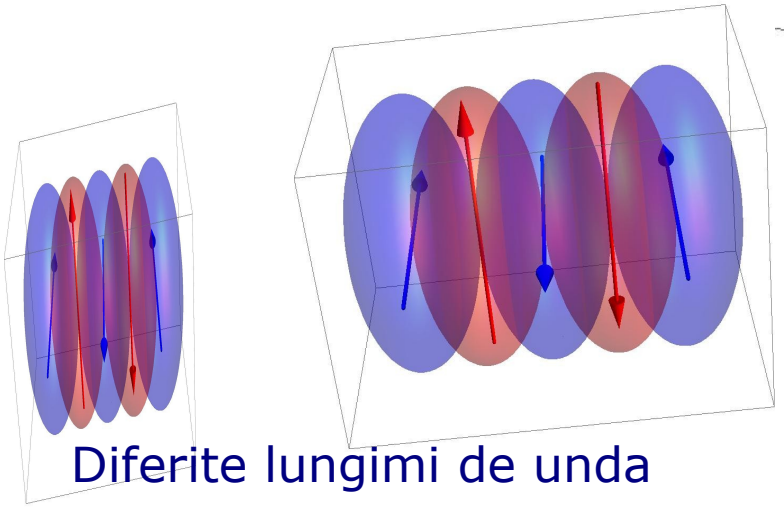
Principiul superpozitiei

Orice obiect complicat poate fi descompus in obiecte simple; apoi e mai usor de inteles



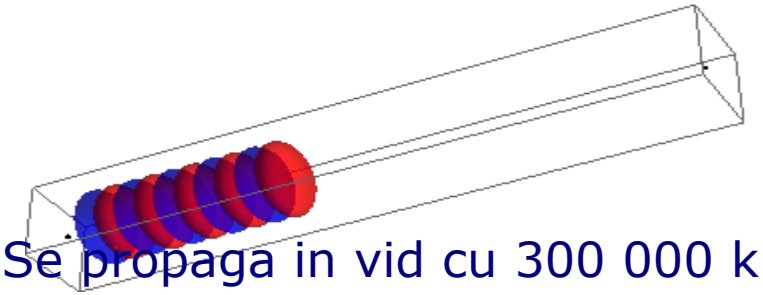
Undele electromagnetice





Diferite lungimi de unda

Campurile electrice: cu albastru
Campurile magnetice: cu rosu



Se propaga in vid cu 300 000 km/s

Lumina este o suprapunere de unde “simple” electromagnetice
Laserul este un aparat care produce astfel de unde “simple”

Ecuatiile lui Maxwell

Lumea era descrisa in termeni de forte (electrice si magnetice):

$$\mathbf{F}_E = q\mathbf{E}$$

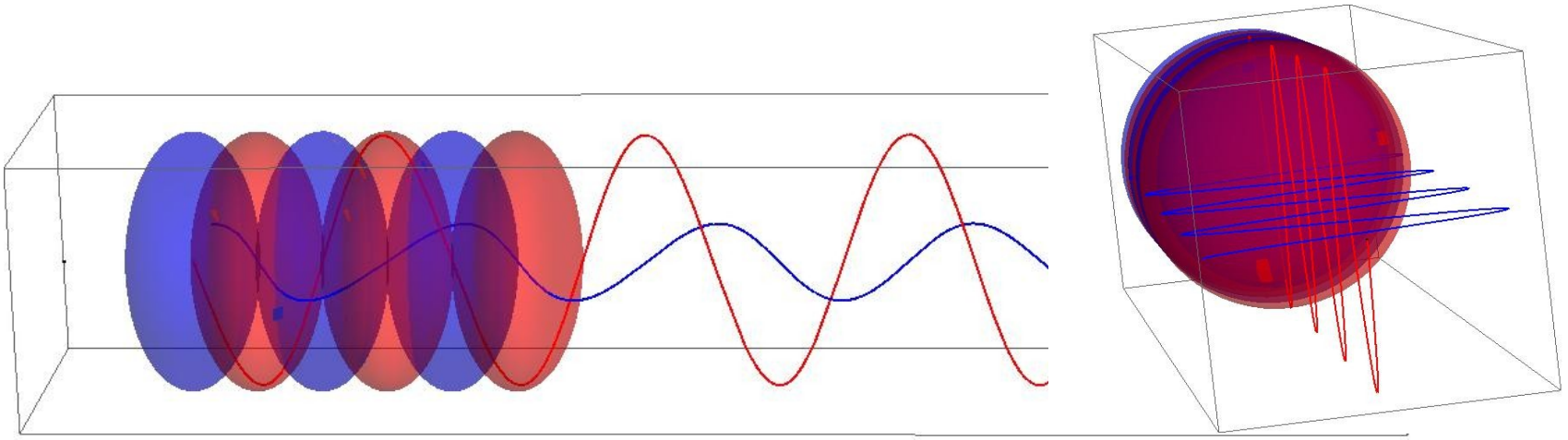
$$\mathbf{F}_B = q\mathbf{v} \times \mathbf{B}$$

Formulation in terms of *total* charge and current[note 3]

Name	Differential form	Integral form
Gauss's law	$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$	$\oiint_{\partial V} \mathbf{E} \cdot \mathrm{d}\mathbf{A} = \frac{Q(V)}{\varepsilon_0}$
Gauss's law for magnetism	$\nabla \cdot \mathbf{B} = 0$	$\oiint_{\partial V} \mathbf{B} \cdot \mathrm{d}\mathbf{A} = 0$
Maxwell–Faraday equation (Faraday's law of induction)	$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$	$\oint_{\partial S} \mathbf{E} \cdot \mathrm{d}\mathbf{l} = -\frac{\partial \Phi_{B,S}}{\partial t}$
Ampère's circuital law (with Maxwell's correction)	$\nabla \times \mathbf{B} = \mu_0\mathbf{J} + \mu_0\varepsilon_0\frac{\partial \mathbf{E}}{\partial t}$	$\oint_{\partial S} \mathbf{B} \cdot \mathrm{d}\mathbf{l} = \mu_0 I_S + \mu_0\varepsilon_0\frac{\partial \Phi_{E,S}}{\partial t}$

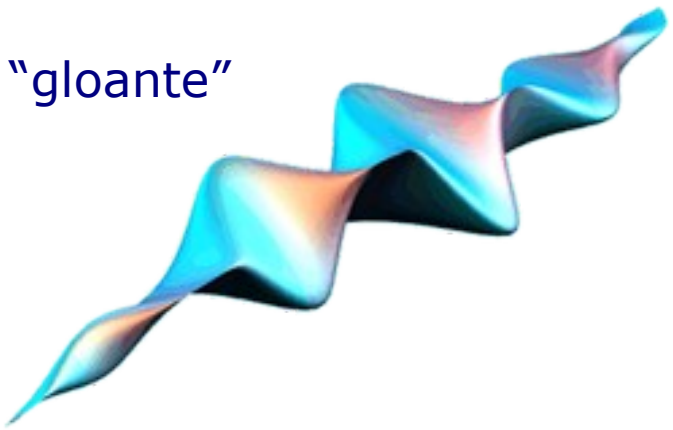
Fara matematica nu putem intelege bine fizica

Undele electromagnetice si fotonii



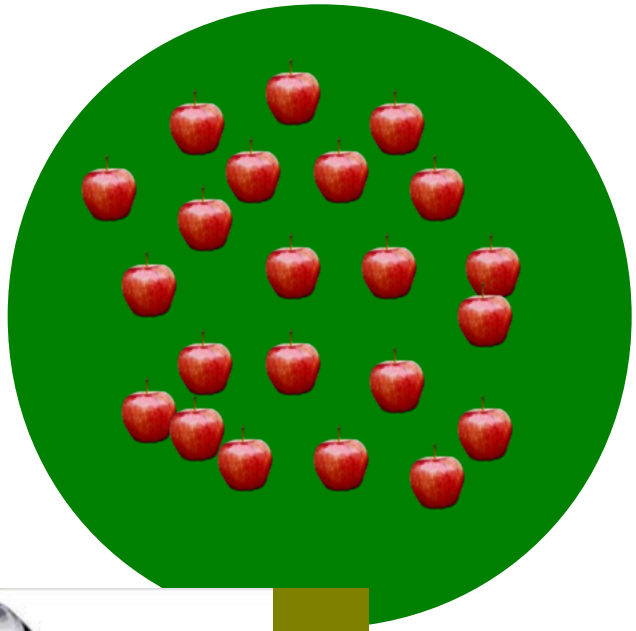
Campurile electrice: cu albastru
Campurile magnetice: cu rosu

Uneori insa se foloseste un model cu “gloante”
= particule/cuante de lumina=fotoni



Laserul 1



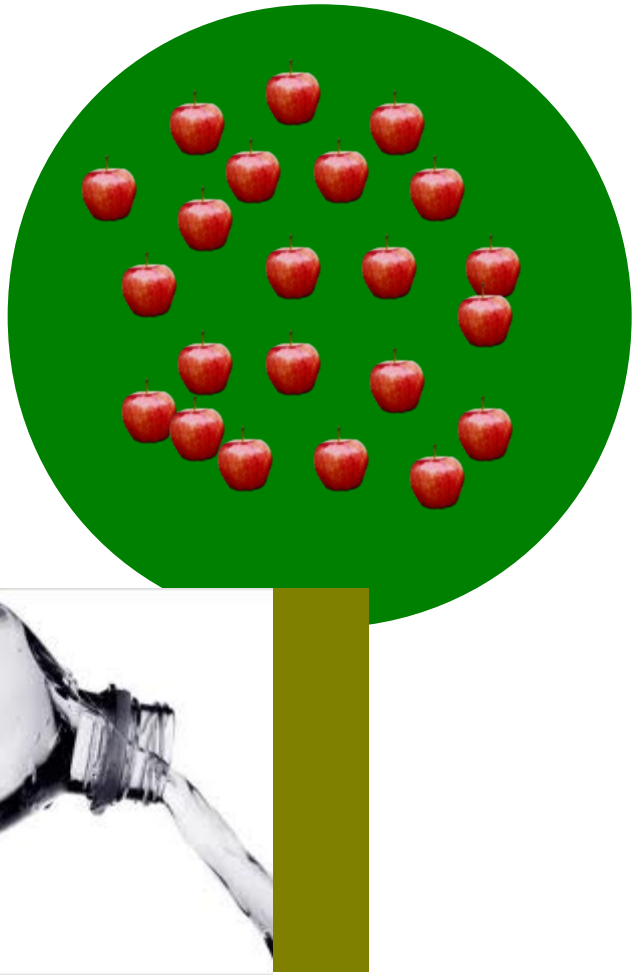






Laserul 2

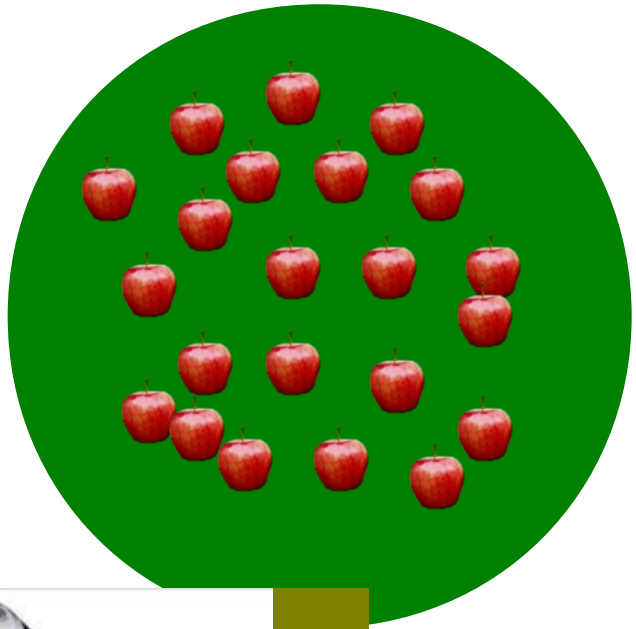






Laserul 3



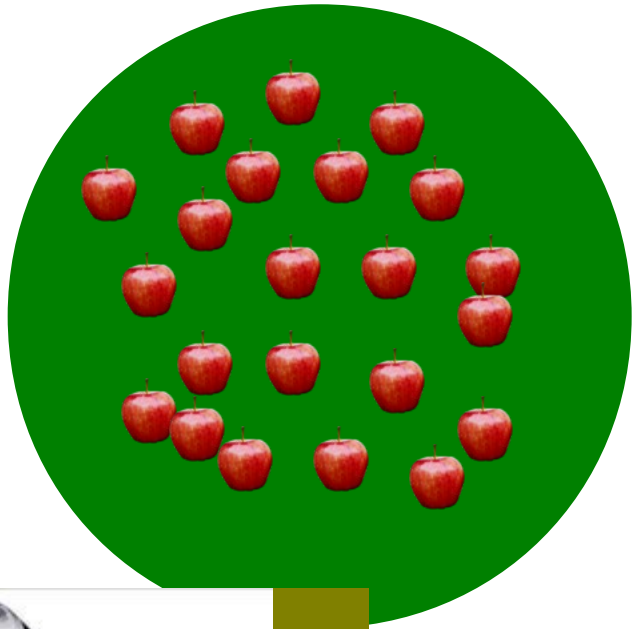






Laserul 4

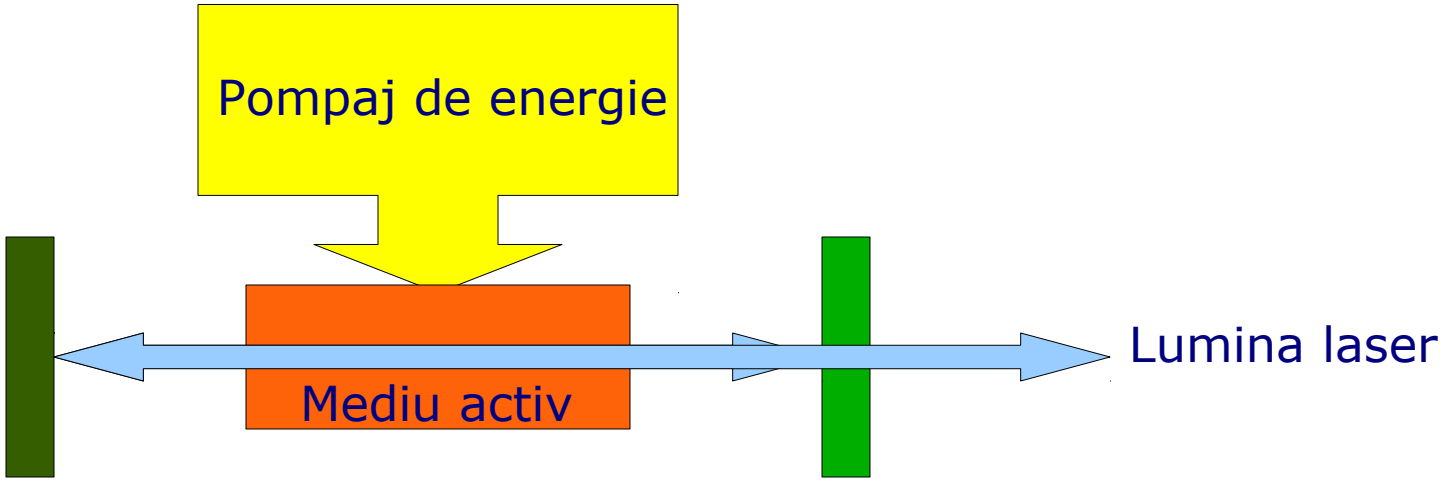








Laserul 5



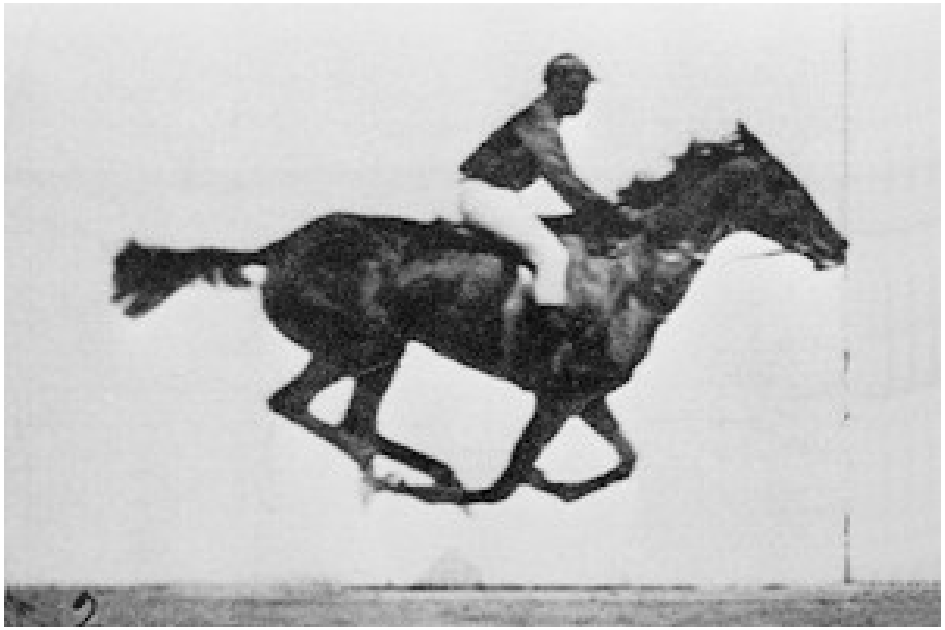
Oglinda perfecta

Oglinda cu transmisie partiala

Laserul nu e asa de complicat: doua oglinzi, un mediu activ si pompaj de energie

Proprietatile radiatiei laser: directionalitate, o singura culoare, coerenta

Rapiditate



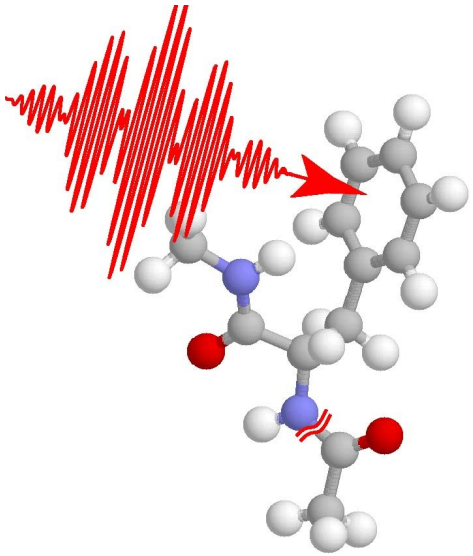


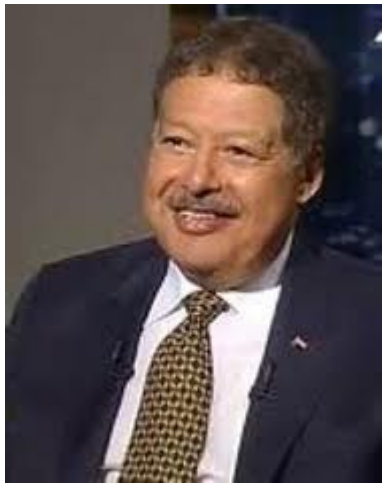


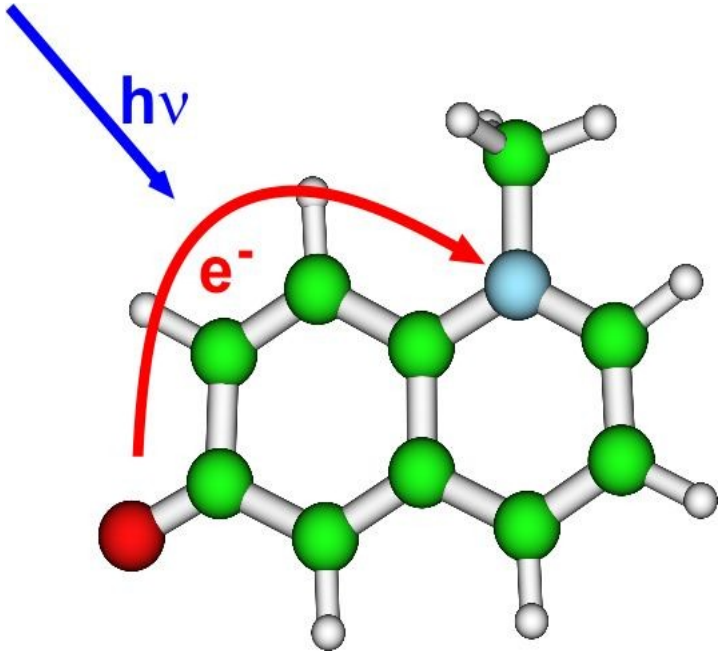
1872 dovada ca toate copitele calului sunt in aer in timpul cursei

Cu cat lumina de la blitz e mai scurta si mai intensa cu atat putem face poze “fara miscare” mai clare

Femtosecunda: O milionime de miliardime de secunda







1999 Premiul Nobel in chimie: Ahmed Zewail "is being rewarded for his pioneering investigation of fundamental chemical reactions, using ultra-short laser flashes on the time scale on which the reactions actually occur"...

Laserul poate da pulsuri de cateva femtosecunde:
putem fotografia reactii chimice

Laserii cu pulsuri scurte ne permit sa facem poze in timpi scurti;
In acest fel putem vedea procese de milioane de ori mai rapide decat un glont: reactii chimice

Lumina laser poate fi stransa in pete mici, cu diametre egale cu lungimea de unda;

astfel se obtin intensitati de lumina uriase dar pe zone foarte mici, cat un fir de par sau chiar mai subtiri

Laserii pot genera campuri electrice de 1000 de ori mai intense decat cele din acceleratorii de particule



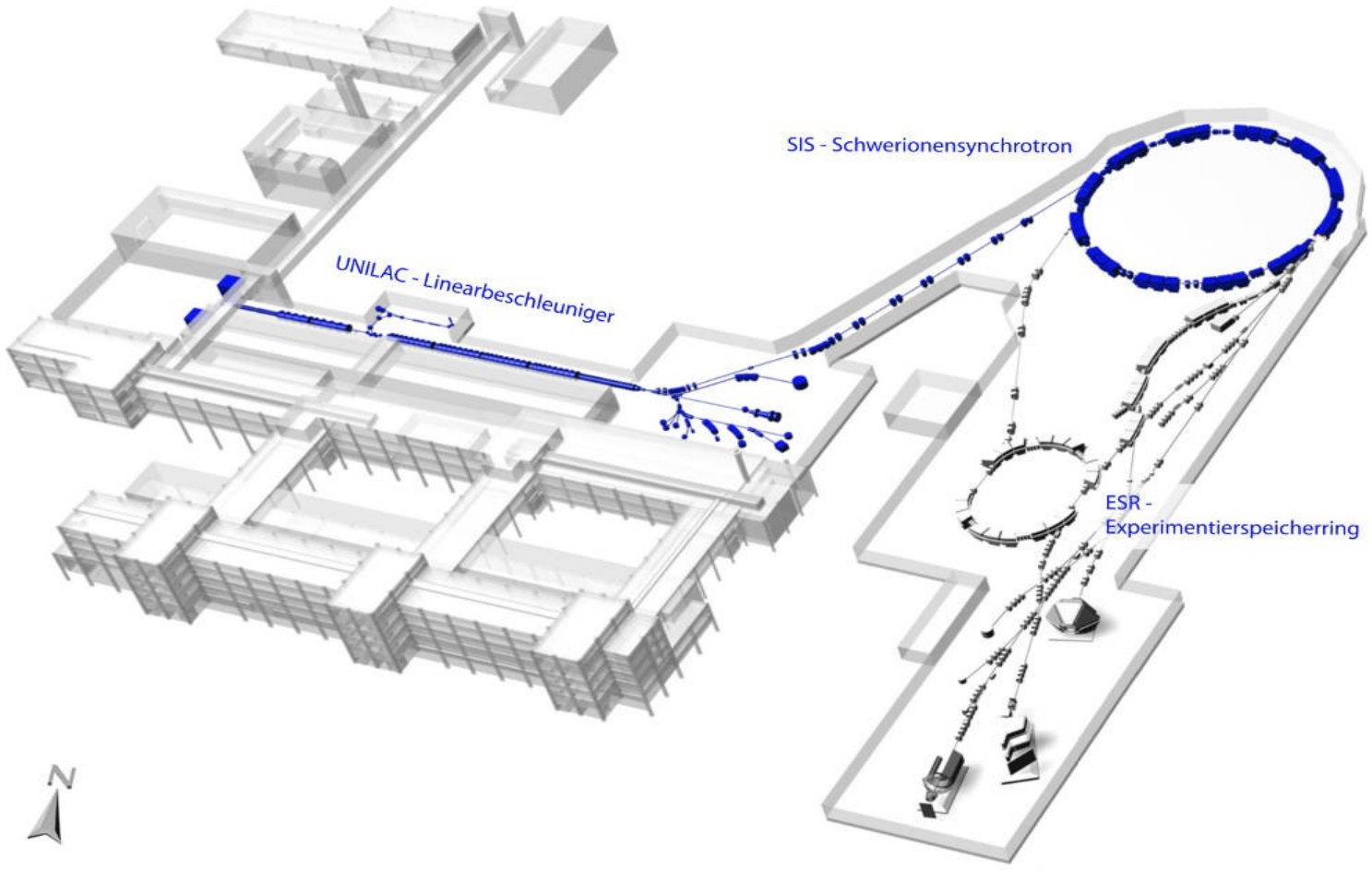
Soleil – Franta: electroni si fotoni

Campuri intense



Paul Scherrer Institute – Elvetia: protoni, neutroni, muoni

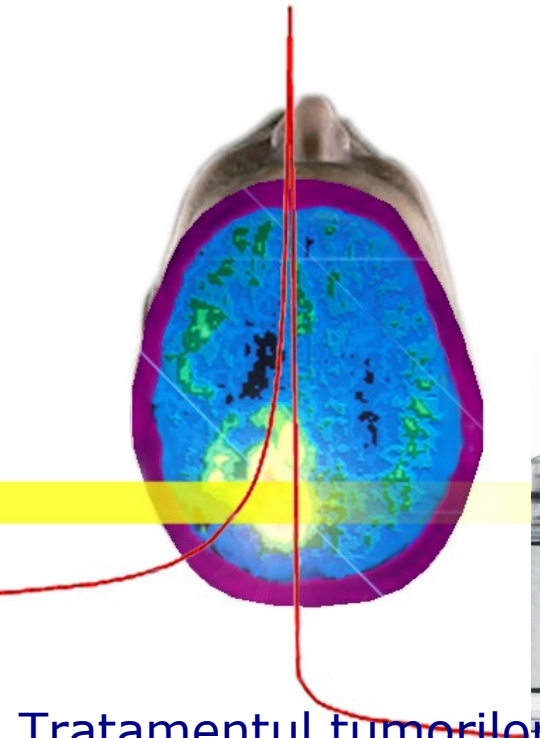
Campuri intense



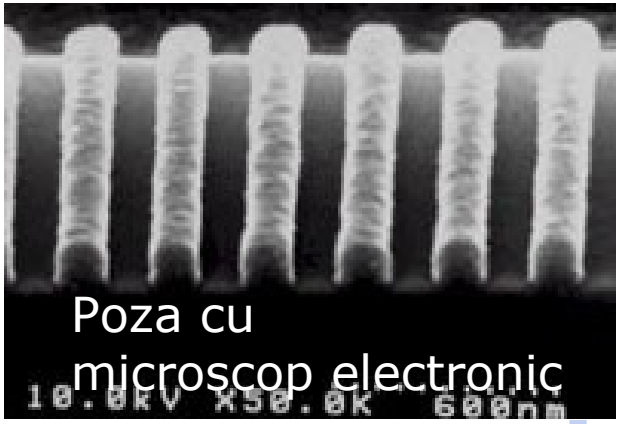
Gesellschaft fuer Schwerionenforschung - Germania: ioni grei

Sute de facilitati de cercetare mari exista raspandite in toata lumea.

Acestea ofera conditii de studiu unice in cele mai variate domenii, de la supercalculatoare la detectori si surse de radiatie.



Tratamentul tumorilor cu ioni





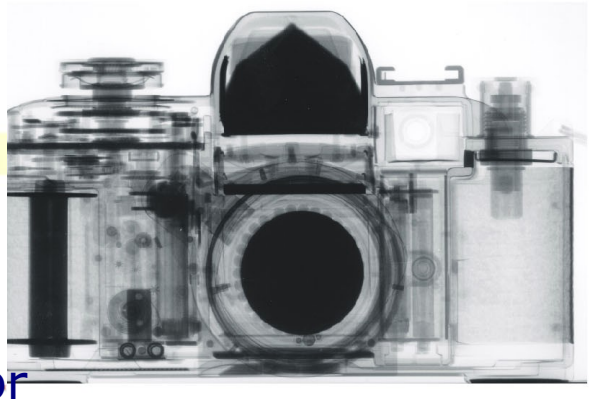


Fig. a: Neutron radiography of a camera

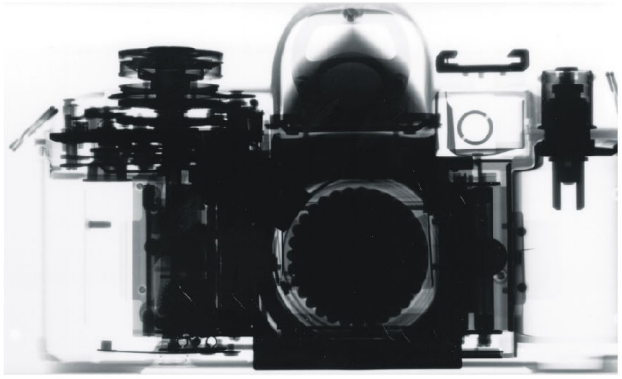


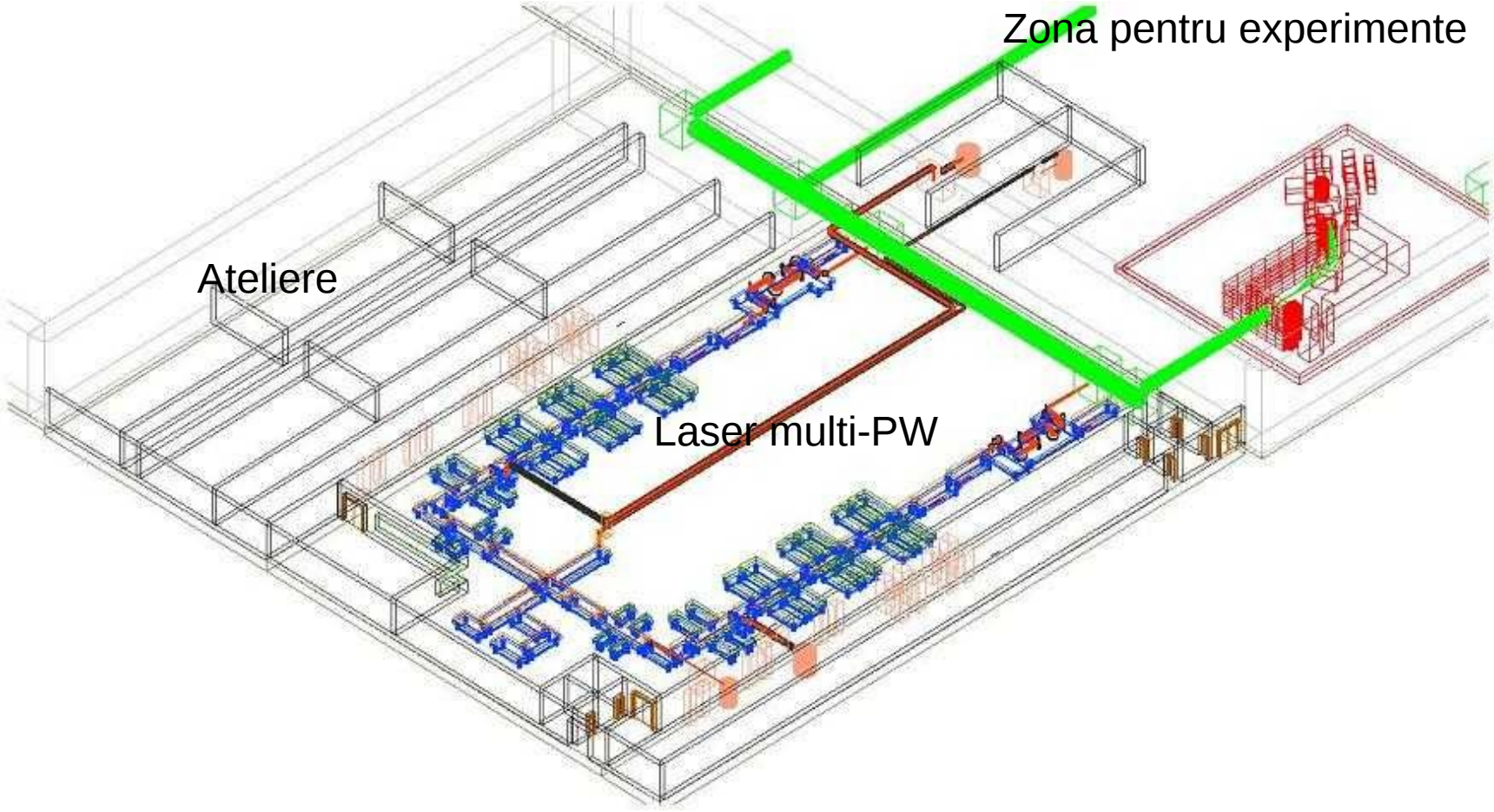
Fig. b: Radiographic image of a camera made X-rays

Facilitatea ELI-NP



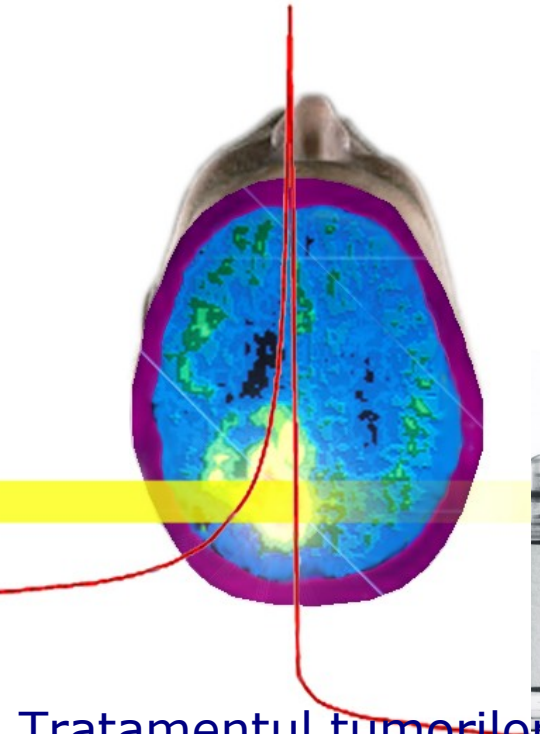
In Romania se intentioneaza constructia acestei facilitati de cercetare:ELI-NP

Facilitatea laser ELI-NP

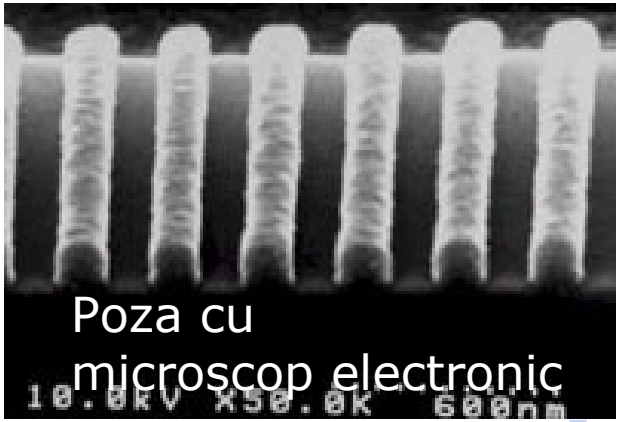


De 10 ori mai puternic decat orice sistem laser existent

Laserul poate induce toate tipurile de radiatie utilizate la facilitatile existente.



Tratamentul tumorilor cu ioni





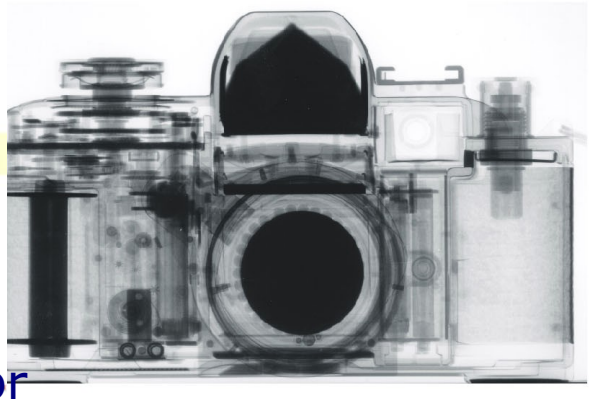


Fig. a: Neutron radiography of a camera

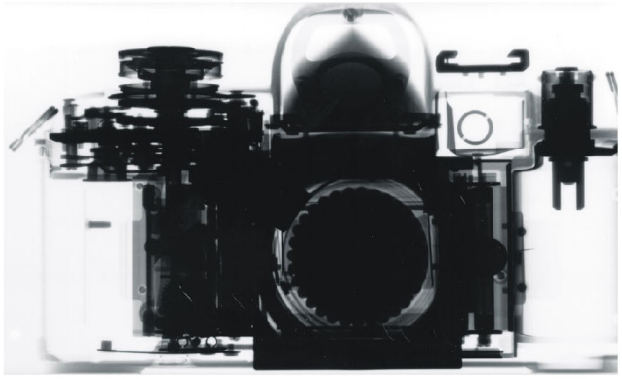
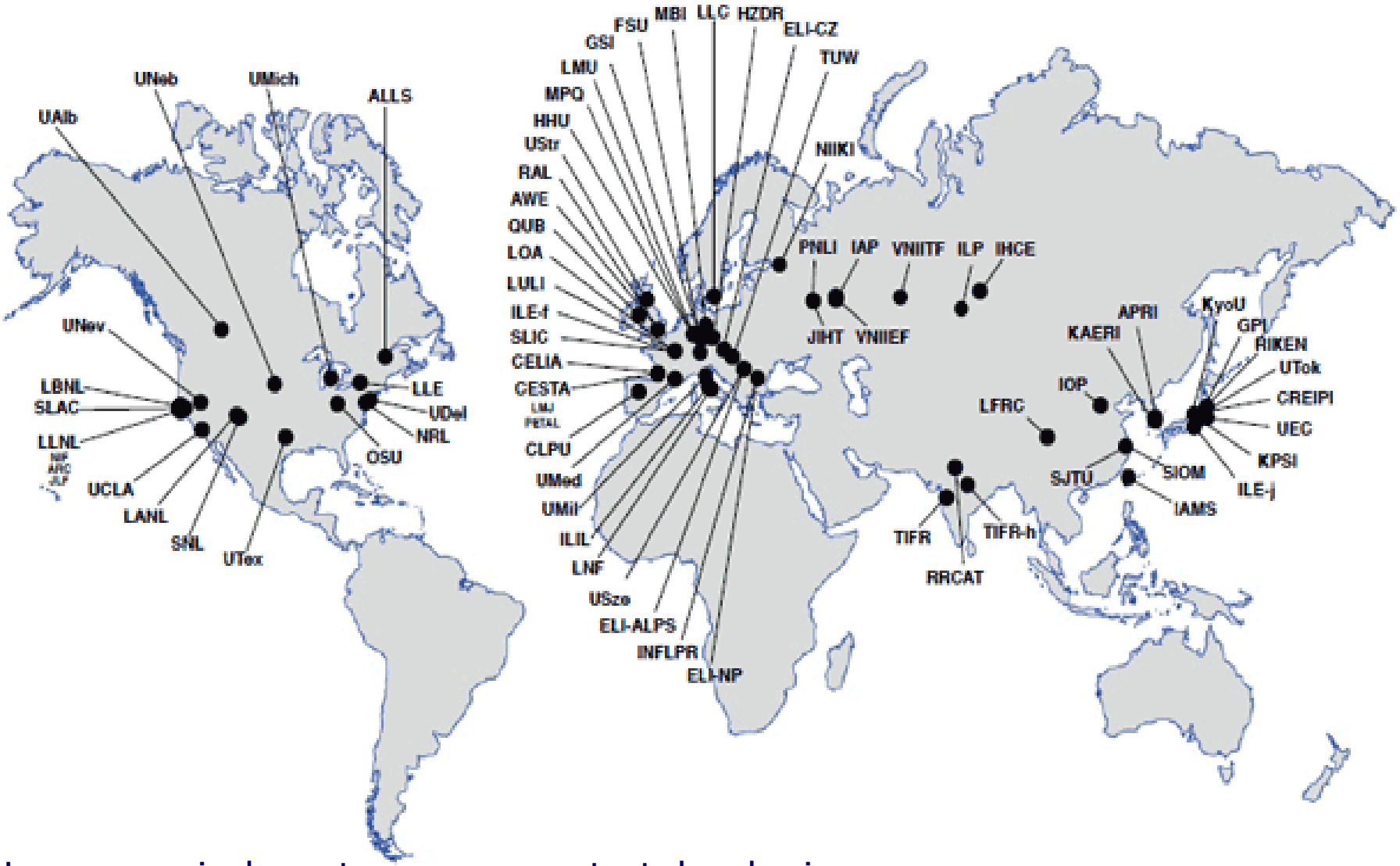


Fig. b: Radiographic image of a camera made X-rays

Harta lumii cu sisteme laser ultraintense



Lumea se indreapta spre aceasta tehnologie

Facilitatea laser ELI-NP

Sursa universala de radiatii – lampa lui Aladin

Pulsuri ultrascurte pentru filmat in maruntaiele materiei

Campuri ultraintense pentru experimente de creare de noi elemente, pentru generare de materie in vid

Lumina in secolul 21

Fibra optica devine atotputernica in telecomunicatii (premiul Nobel)

S-a incetinit lumina pana la viteza unui biciclist

S-au realizat experimente in care lumina se propaga pe o curba

S-au studiat metode de a convinge lumina sa ocoleasca obiectele, facandu-le invizibile (metamaterialele)

Se realizeaza criptarea informatiei transmise la distante lungi, fara posibilitatea interceptarii ei

Racirea materiei cu ajutorul fasciculelor laser a ajutat la realizarea unui “laser cu materie” (doua premii Nobel)

Laserii au devenit referintele pentru masurarea ultraprecisa a spatiului si timpului (premiul Nobel)

Femtochimia (premiul Nobel)

TEWALAS facility@INFLPR



Best result: E_{pulse} = 460 mJ, Pulse-width = 23 fs, P_{peak} ≈ 20 TW

Typical value: E_{pulse} = 400 mJ, Pulse-width = 25 fs, P_{peak} > 15 TW





La treaba!