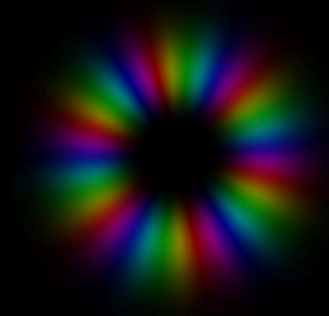




UNIVERSITÀ
DI TRENTO
Dipartimento di
Fisica



⑤ Fisica e chimica a braccetto

[la fabbrica delle meraviglie]

^
quantistica

ELEMENTI di FISICA MODERNA

[e intelligenza artificiale] 2025

Il punto di partenza:

bussole, calamite, atomi e

QUANTIZZAZIONE

SPAZIALE

Bohr quantizza il
MOMENTO ANGOLARE



La «trottola atomica» è una
bussola magnetica:

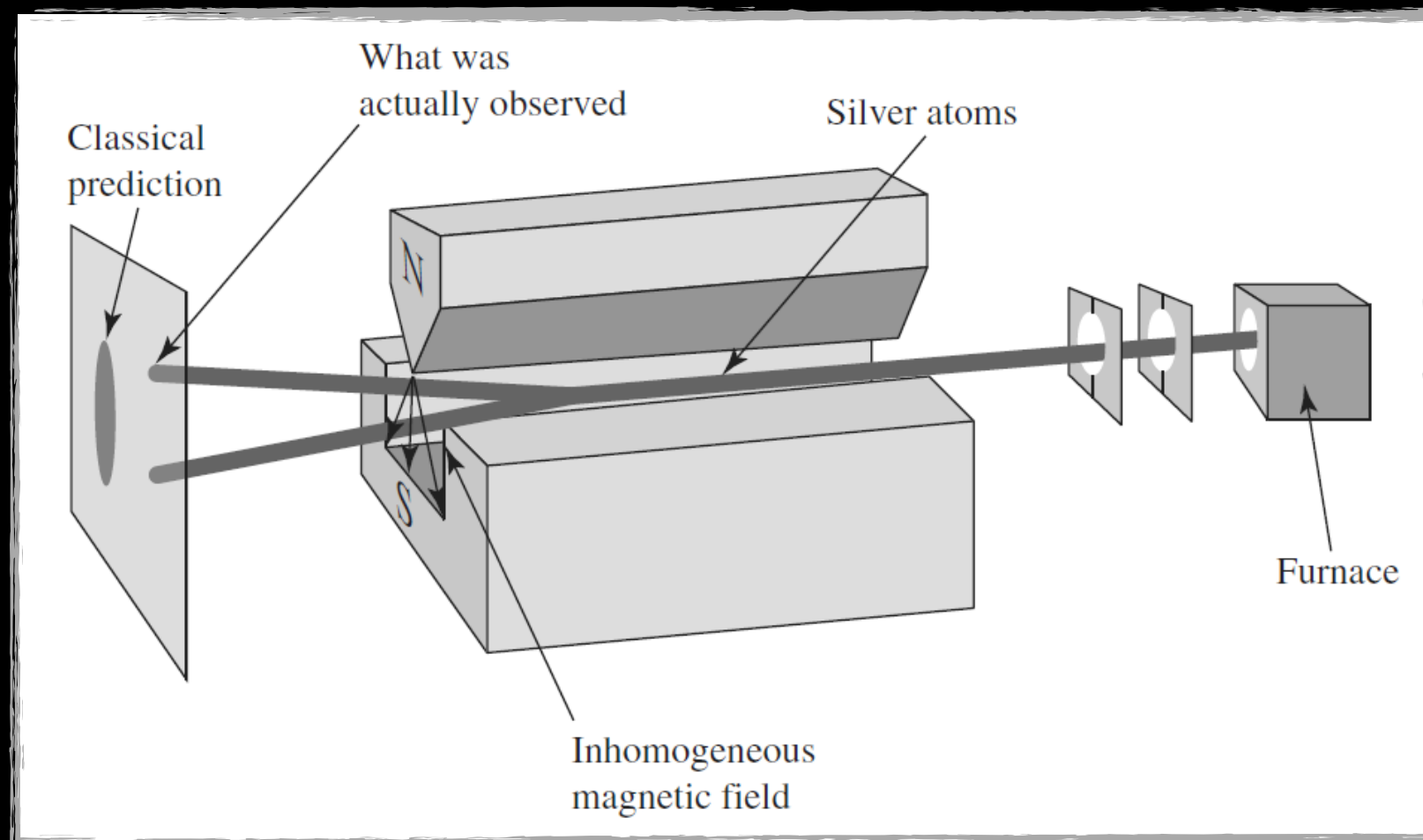
deve allinearsi a un
campo magnetico esterno



Esperimento di Stern-Gerlach

1922
N 1925

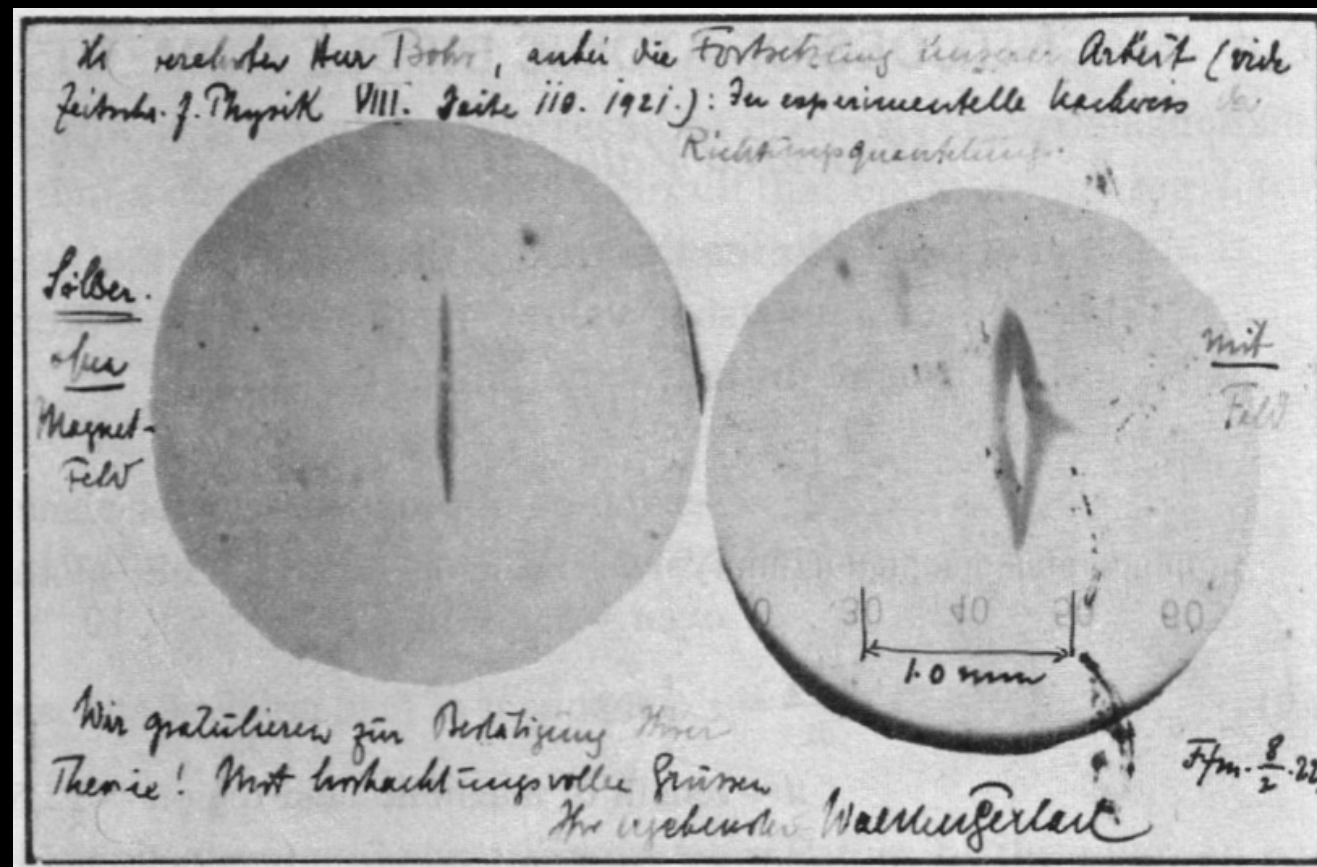
[a caccia del momento angolare
e del dipolo - bussola atomica]



Esperimento di Stern-Gerlach

1922
N 1925

[a caccia del momento angolare
e del dipolo - bussola atomica]



L'elettone « vive » in
due stati magnetici

HA « SPIN » $1/2$

è una « calamita a scatti »

L'elettrone « vive » in
due stati magnetici

HA « SPIN » $1/2$

è una « calamita a scatti »

MA NON HA DIFFERENTI
VERSI di ROTAZIONE
PERCHÉ NON C'È NULLA
CHE RUOTA !

Il mondo è fatto da

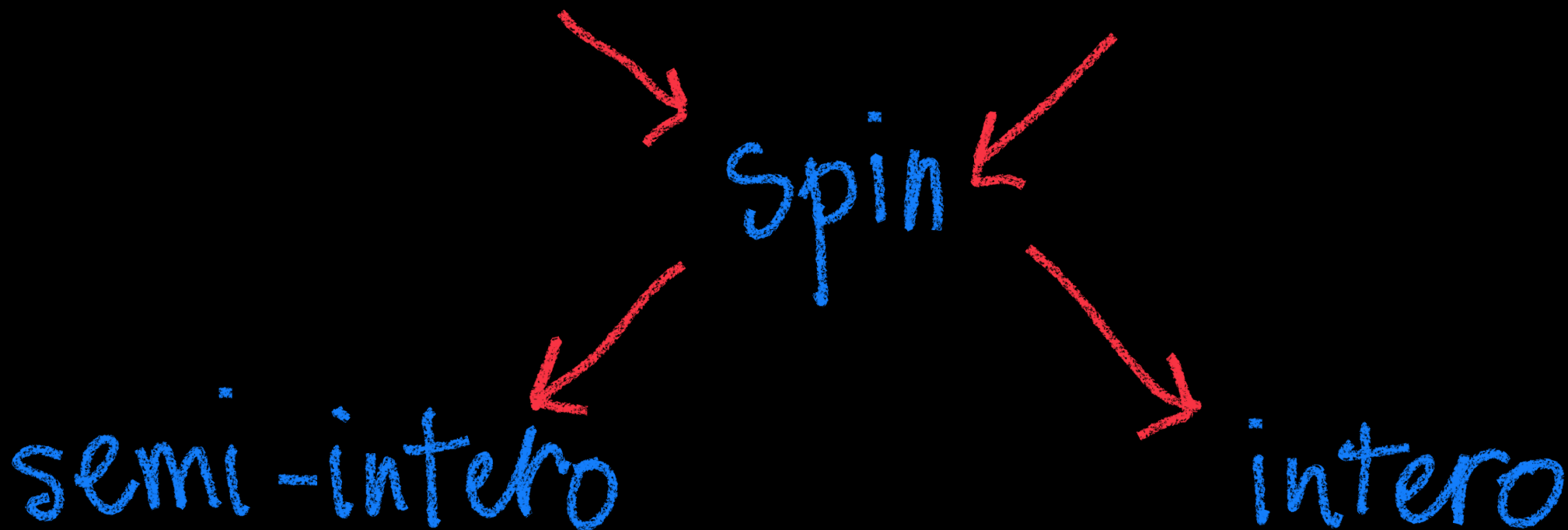
FERMIONI

BOSONI

spin

semi-intero

intero



PRINCIPIO di ESCLUSIONE

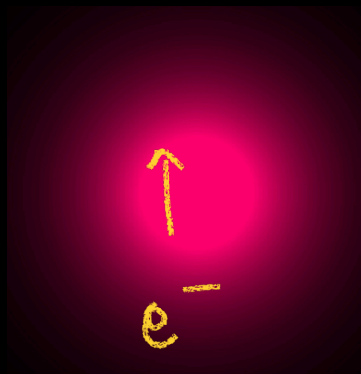
[W. Pauli - 1925 - N.1945]

due fermioni identici non possono
occupare lo stesso « stato »

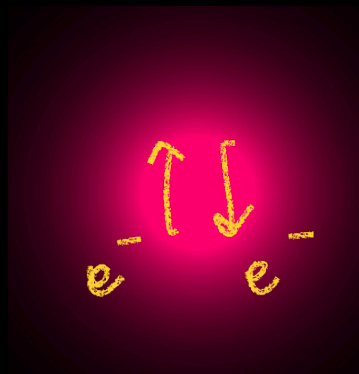
PRINCIPIO di ESCLUSIONE

[W. Pauli - 1925 - N.1945]

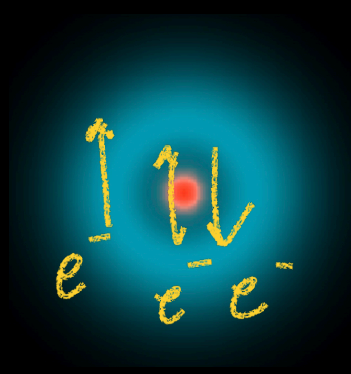
due fermioni identici non possono occupare lo stesso « stato »



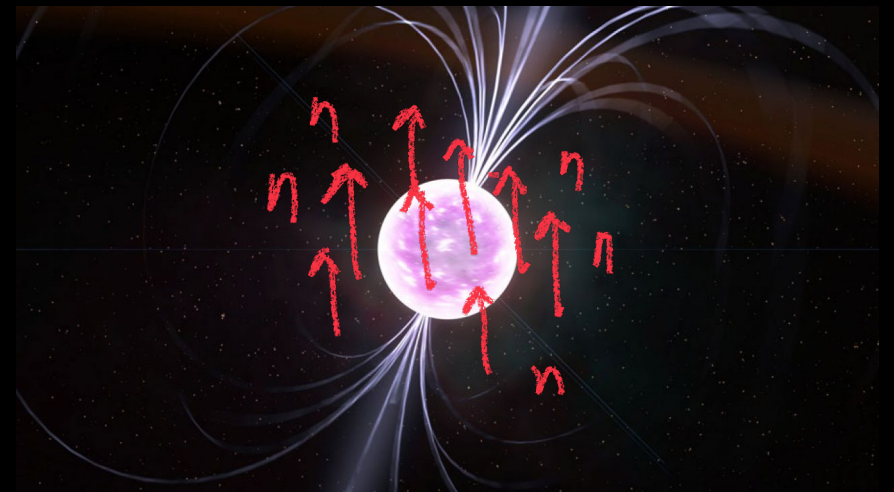
H



He

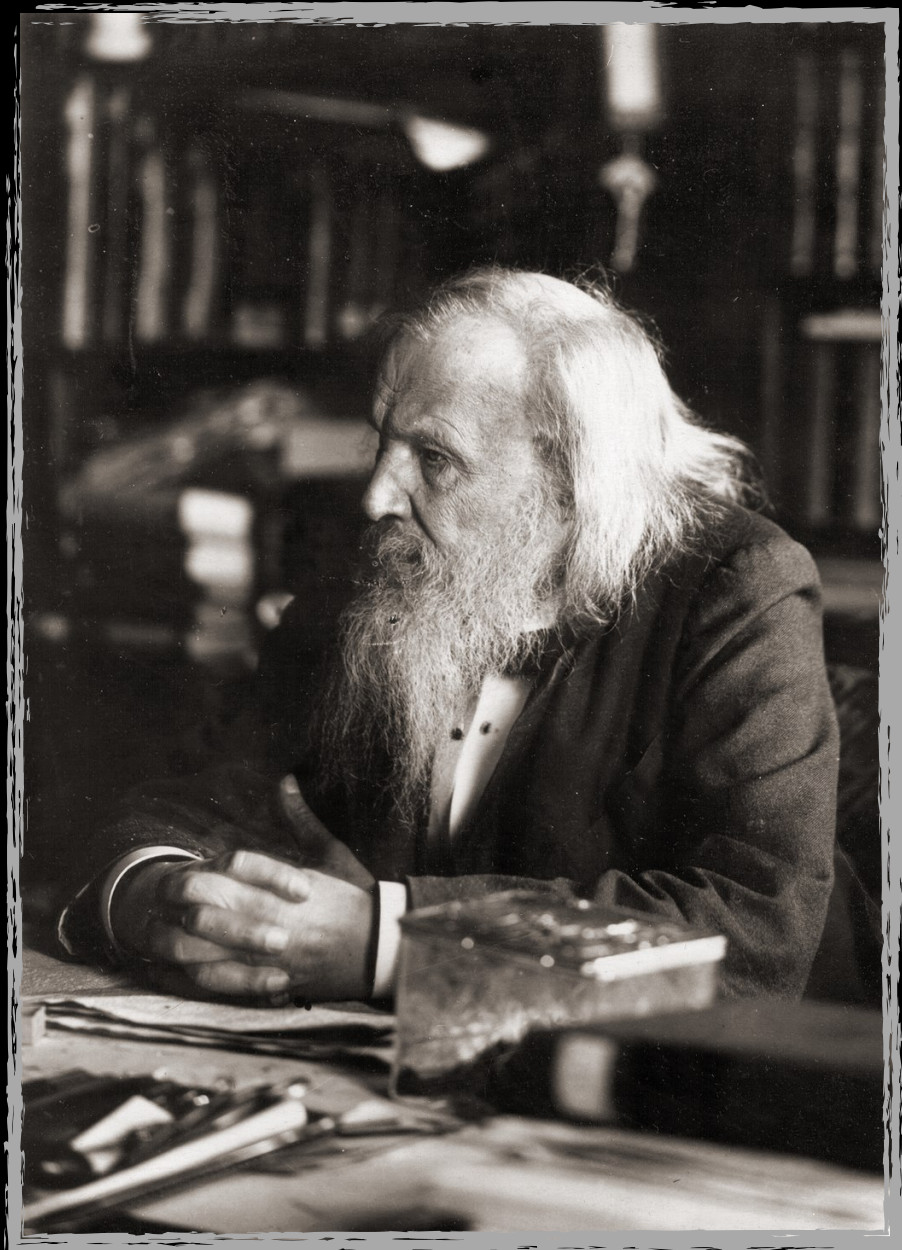


Li



stella di
neutroni

Tabella periodica degli elementi



~ 1860

Reihen	Gruppe I. R ² O	Gruppe II. R ² O	Gruppe III. R ² O ³	Gruppe IV. RH ⁴ RO ²	Gruppe V. RH ³ R ² O ⁵	Gruppe VI. RH ² RO ³	Gruppe VII. RH R ² O ⁷	Gruppe VIII. RO ⁴
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Ca=133	Ba=137	?Di=138	?Ce=140	—	—	—	—
9	(—)	—	—	—	—	—	—	—
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	—
12	—	—	—	Th=231	—	U=240	—	—

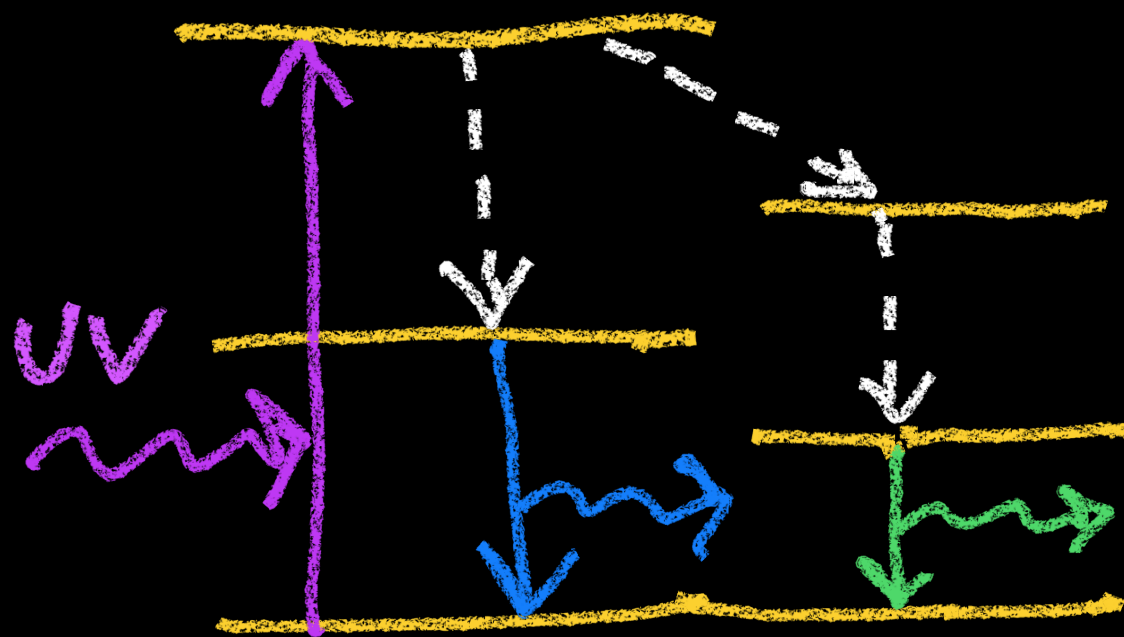
Tabella periodica degli elementi

Atomic number: 1 Electronegativity(eV): 2.2 Ionization en. (kJ/mole): 1,312 Radius (pm): 52.9 Ionic radius (pm): - Melting (C): -259.1 Boiling (°C): -252.9 Hydrogen Average atomic mass (amu): 1.0079 Alkali metals Alkaline earth metals Transition metals Other metals Metalloids Other Nonmetals Halogens Noble gases Cu Solid Br Liquid Ar Gas Am Not found in nature																	
1	2															18	2
1 1A H 1.0079	2 2A He 4.0026															8A	
3 Li 6.941	4 Be 9.0122															10	
11 Na 22.990	12 Mg 24.305	13 3A B 10.81	14 4A C 12.011	15 5A N 14.007	16 6A O 15.999	17 7A F 18.998	18 8A Ne 20.179										
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.941	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.71	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30
55 Cs 132.91	56 Ba 137.33	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04		
87 Fr (223)	88 Ra (226)	89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)		

~ 2023

Fluorescenza & Fosforescenza:

livelli e transizioni atomiche nascoste



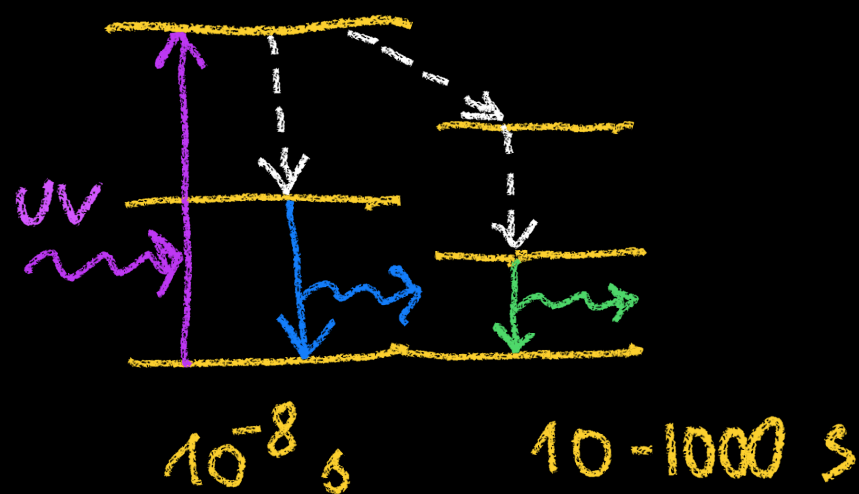
10^{-8} s

10 - 1000 s

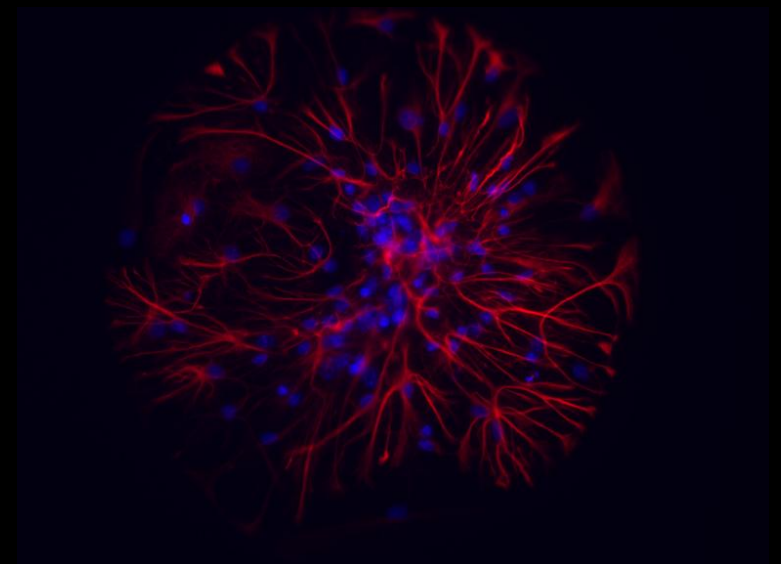
FOSFORO
&
FOSFÒRO

Fluorescenza & Fosforescenza:

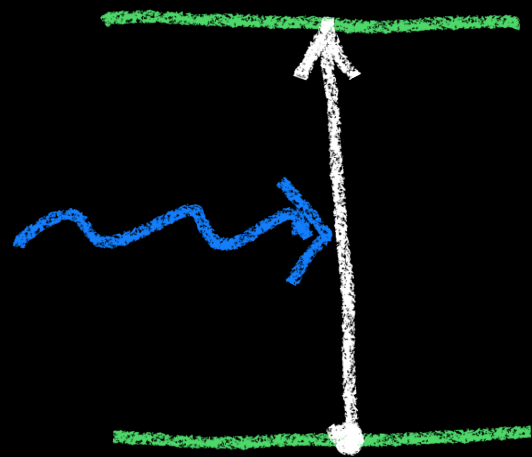
livelli e transizioni atomiche nascoste



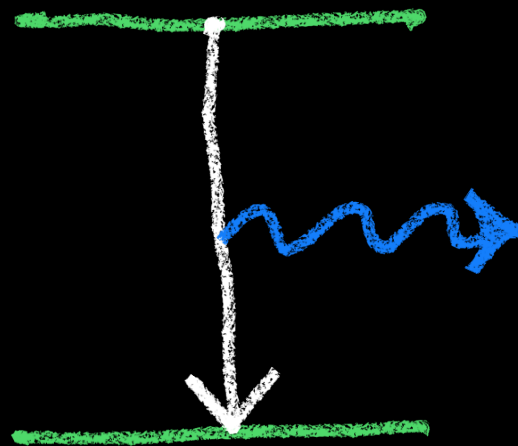
microscopi
a
fluorescenza



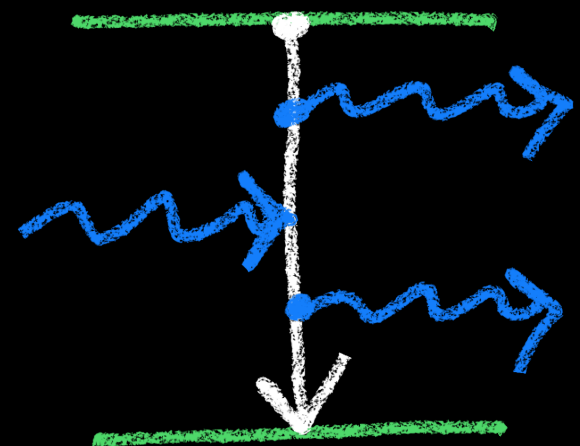
Amplificazione di luce per emissione stimolata di radiazione



assorbimento
spontaneo



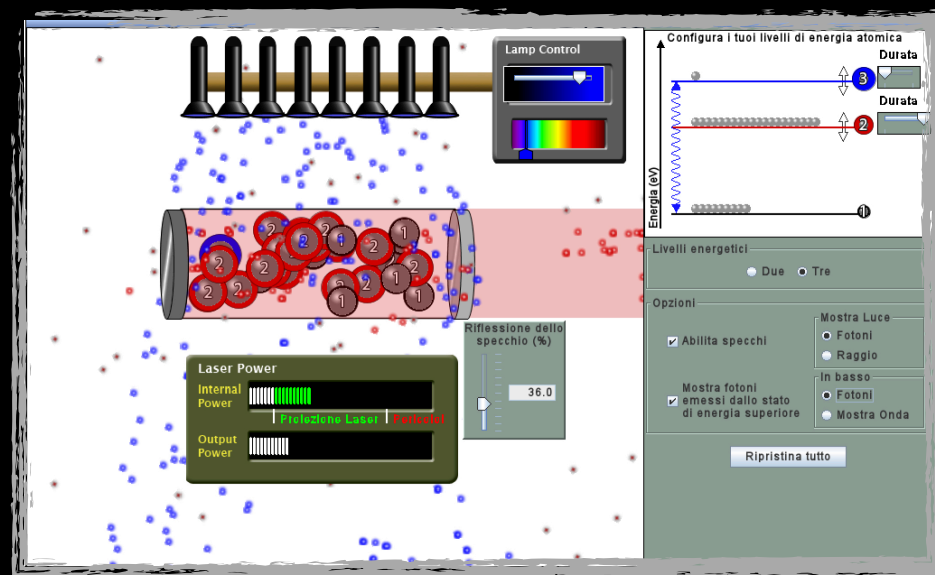
emissione
spontanea



emissione
stimolata

Amplificazione di luce per emissione stimolata di radiazione

Light Amplification by Stimulated Emission of Radiation



LUCE MONOCROMATICA COERENTE

Applicazioni del LASER ?

scientifiche

mediche

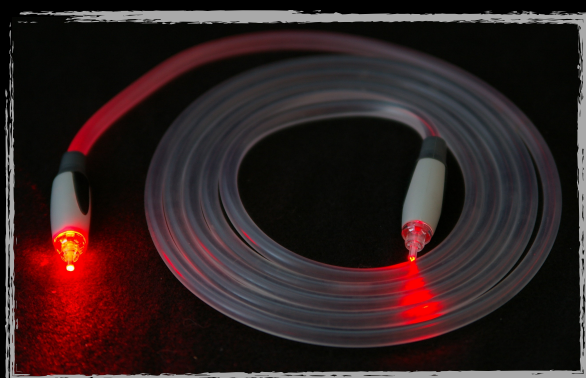
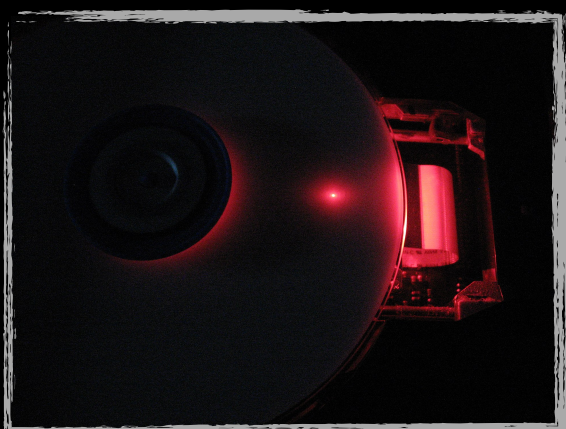
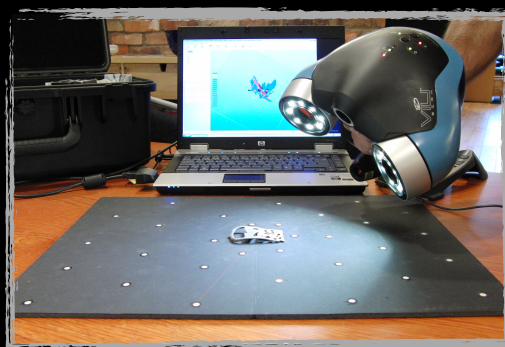
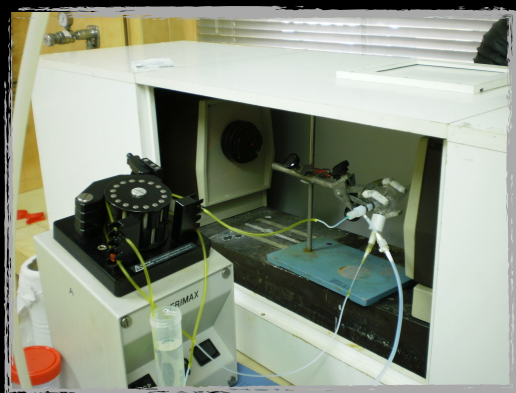
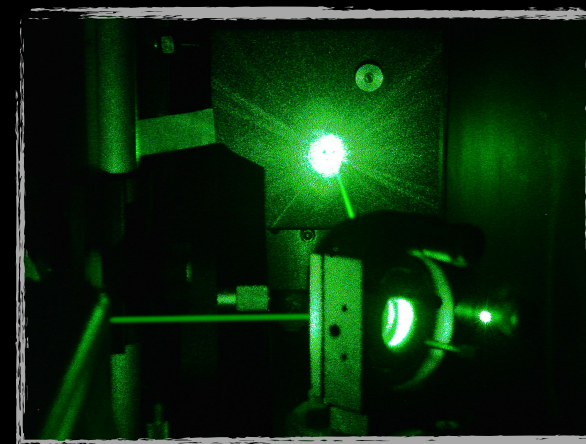
militari

industriali

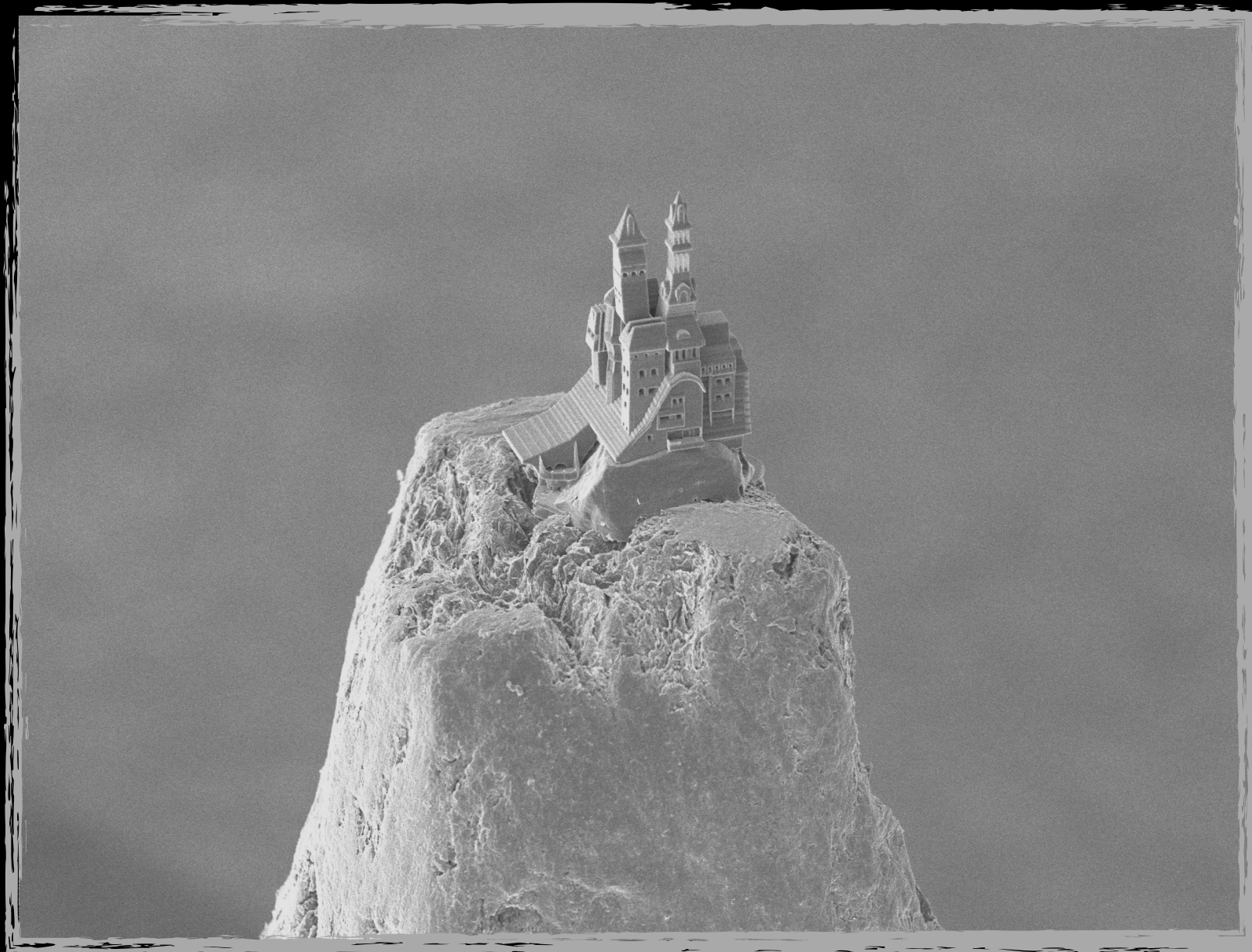
informatica

comunicazione

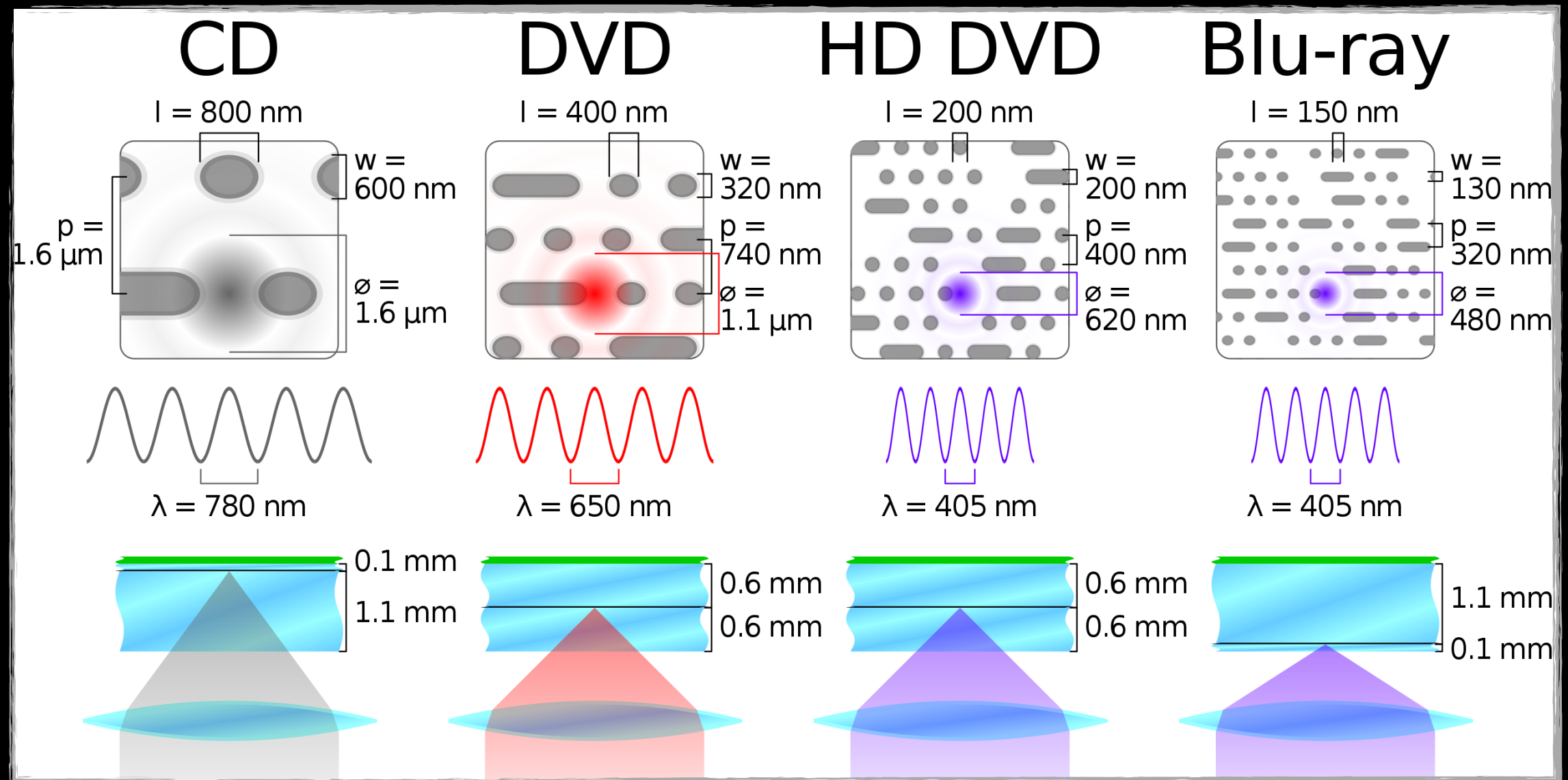
Applicazioni del LASER ?



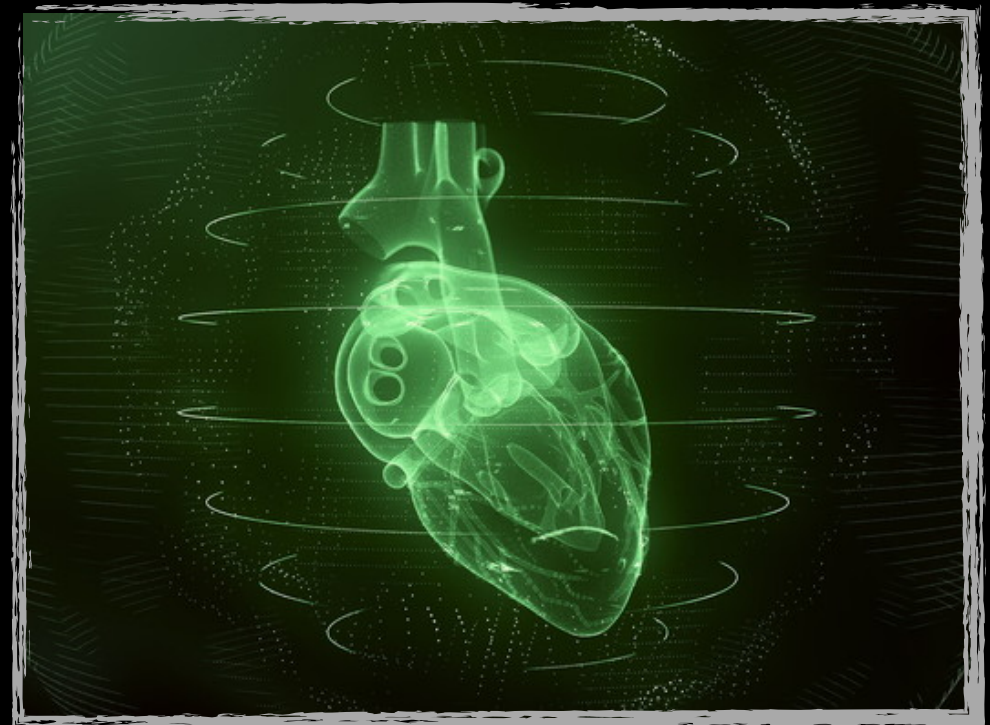
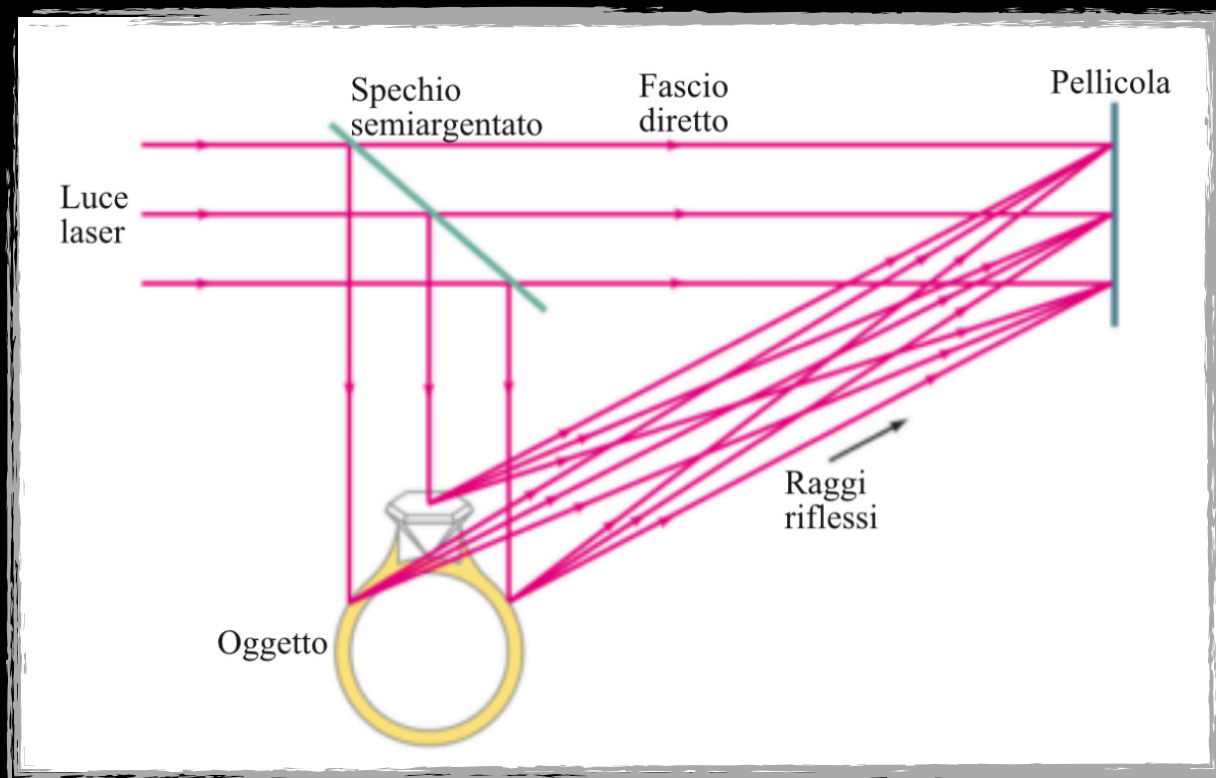
Applicazioni del LASER ?



Applicazioni del LASER ?



OLOGRAMMI, OLOGRAFIA

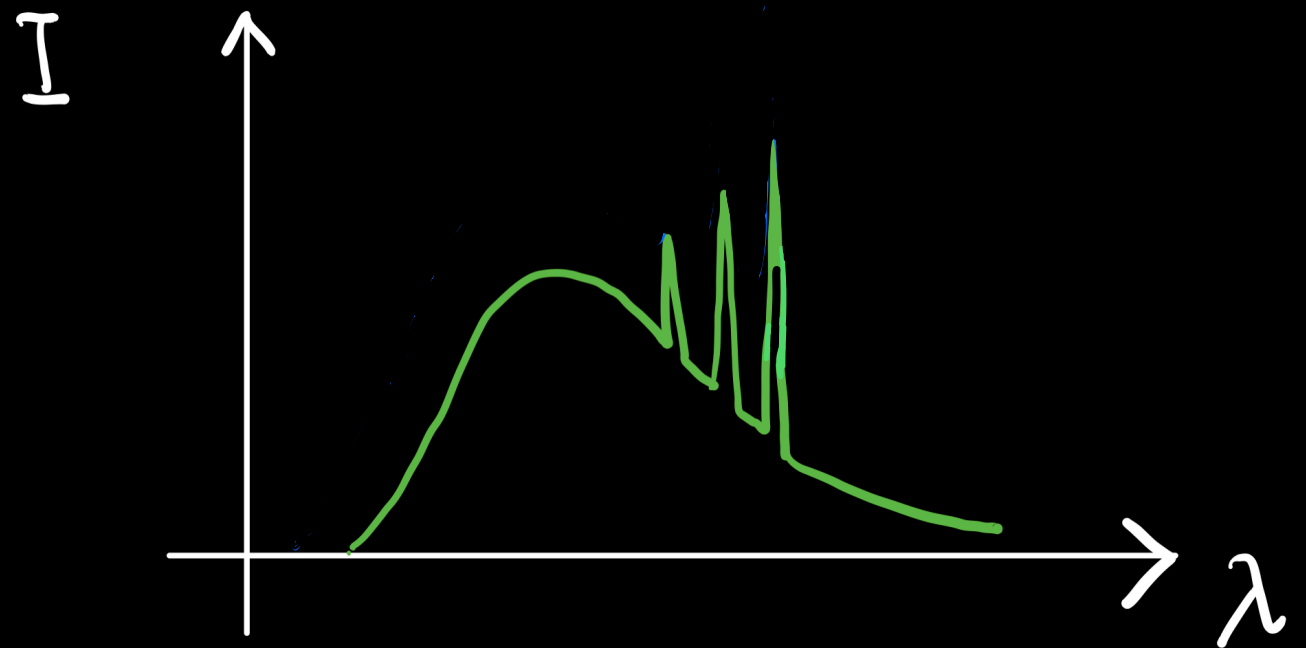
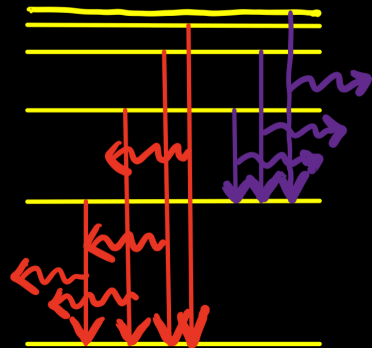
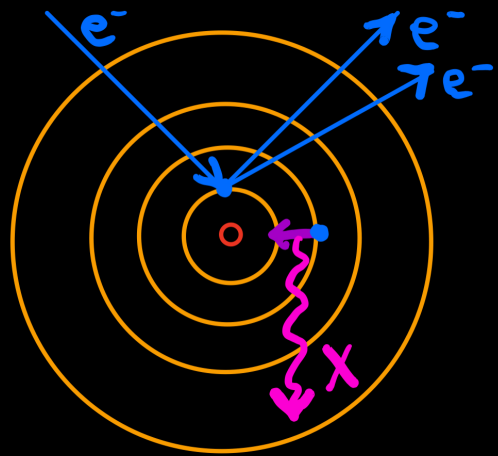


spettroscopia profonda : raggi X

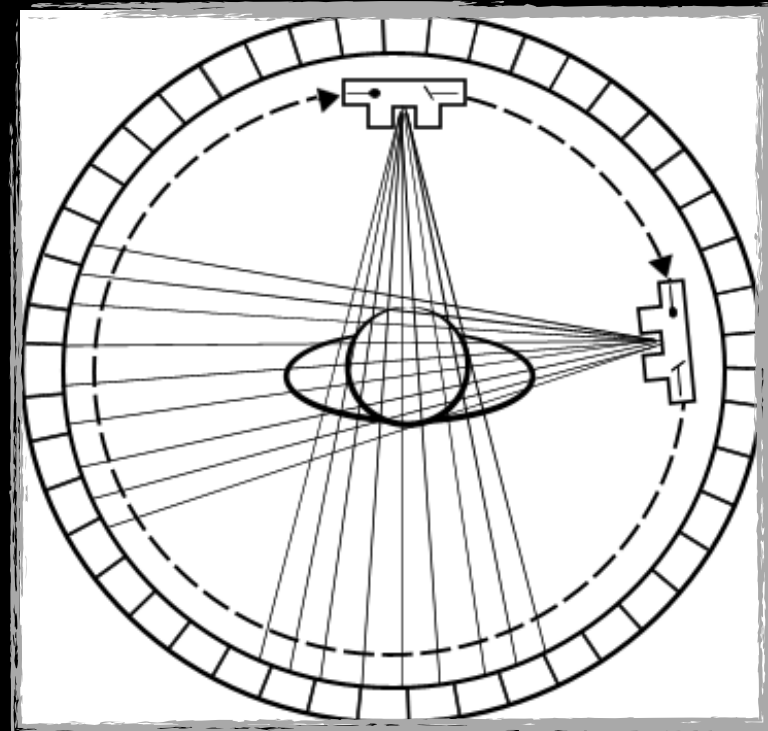
dalla nascita della radioattività
alla diagnostica moderna



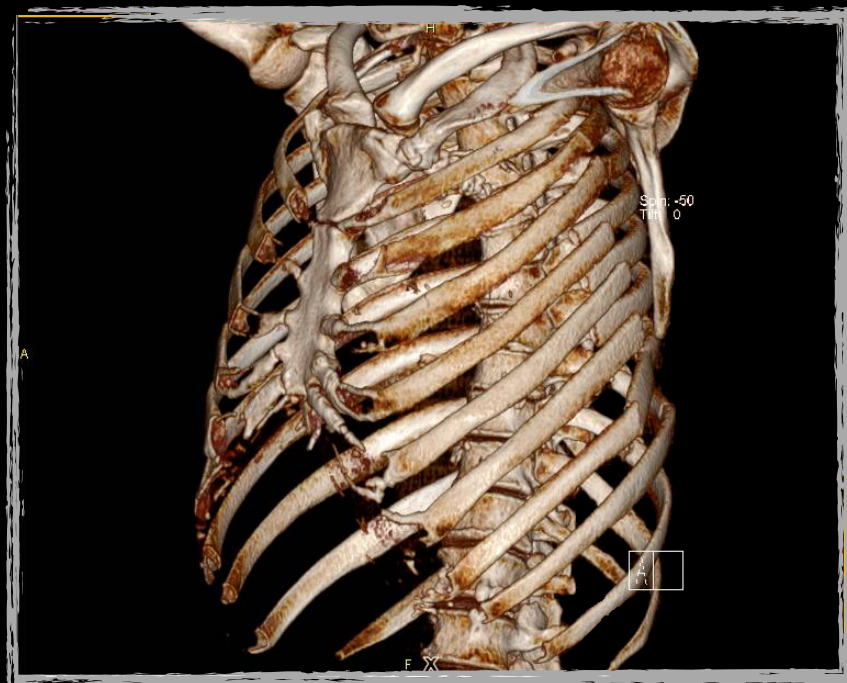
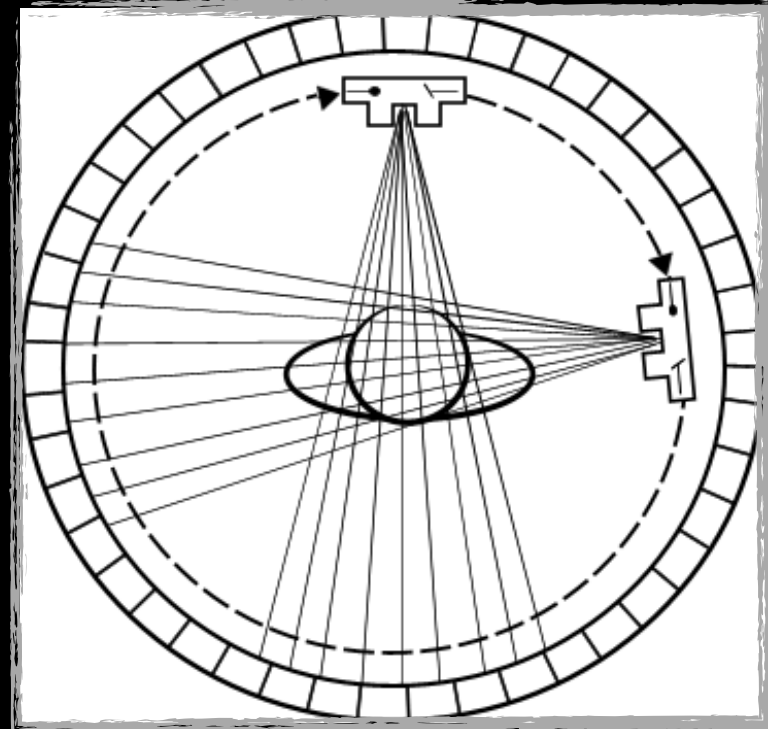
spettroscopia profonda : raggi X



spettroscopia profonda : raggi X



spettroscopia profonda : raggi X



e il gioco del Lego

continua

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