

Materia

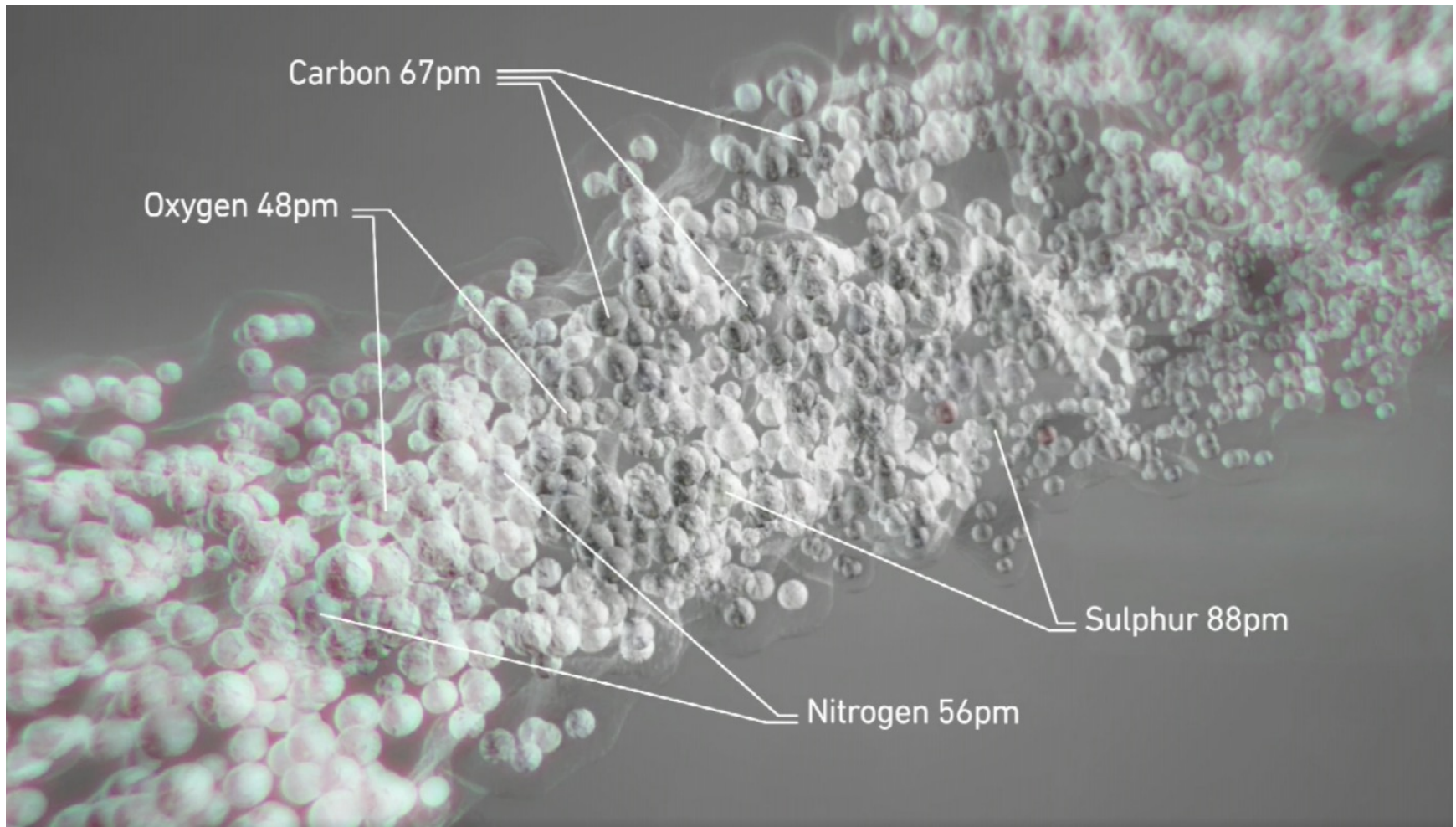
*«Noi siamo fatti con la stessa materia dei sogni»
(W. Shakespeare, Tempesta, atto IV)*



- Barbara Sciascia (INFN) -

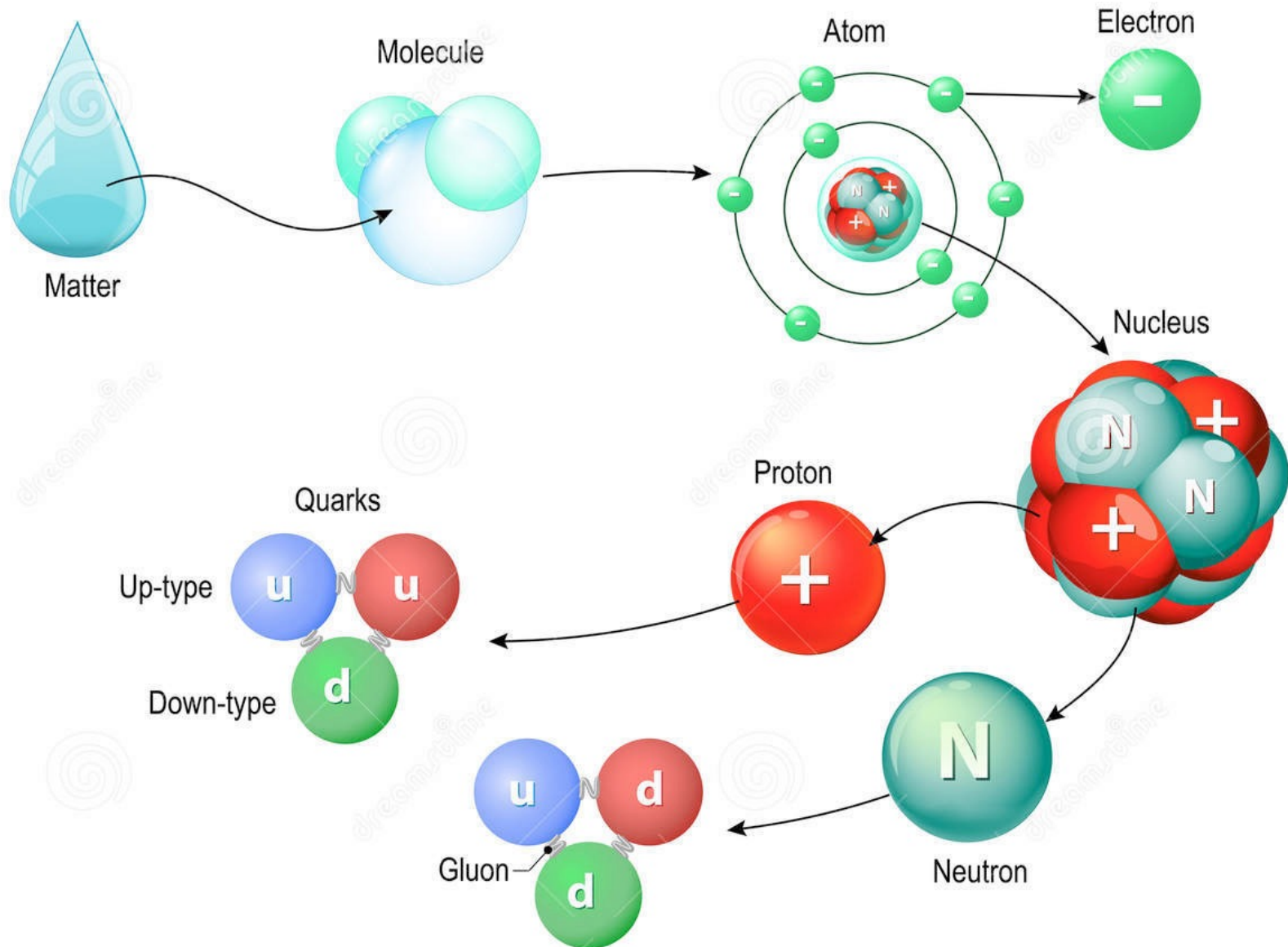


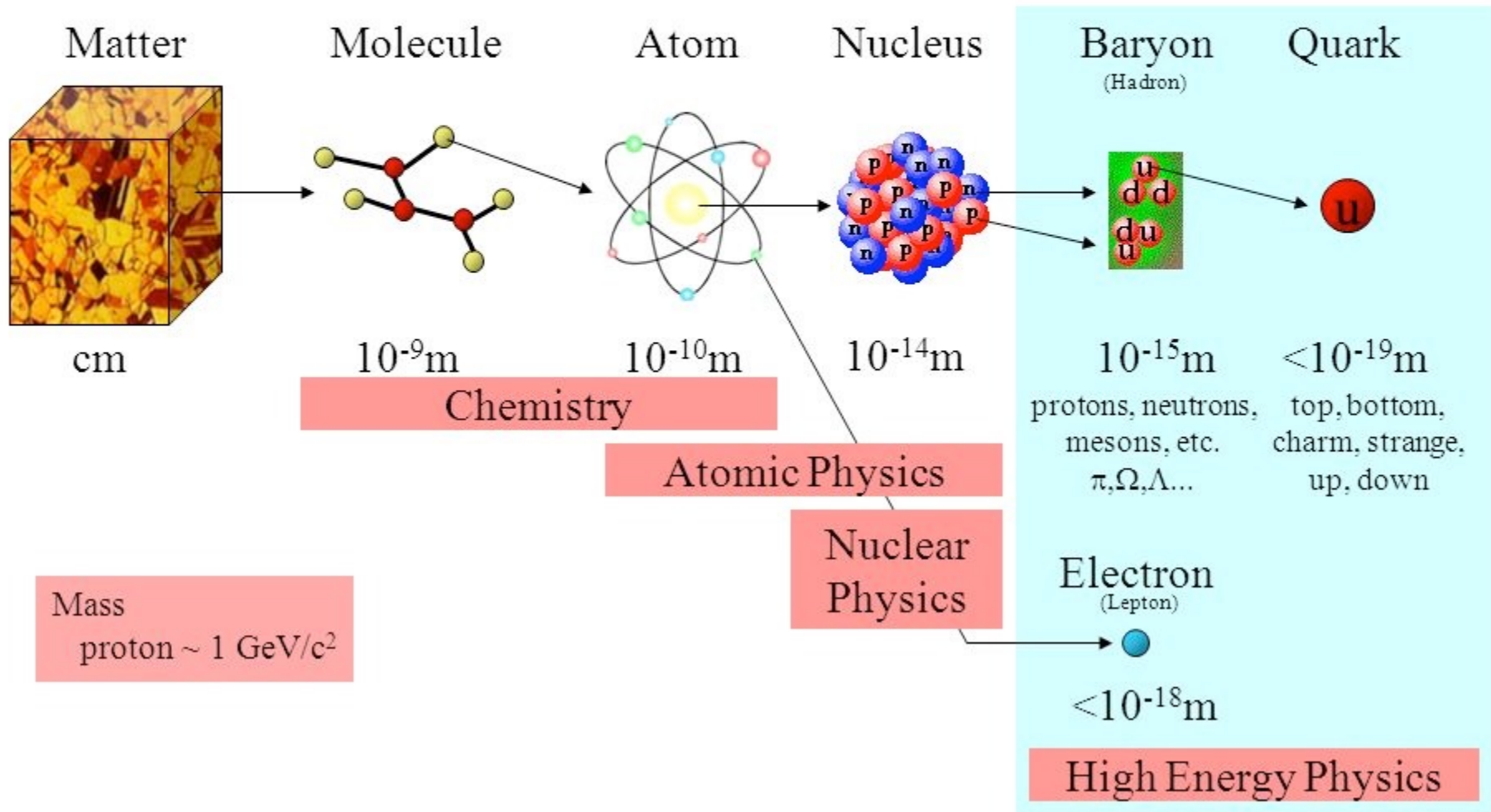
«viaggio» nel mondo degli atomi



(disponibile qui <https://videos.cern.ch/record/2307613>)

Componenti





Атомные веса элементов.

47,5
15,5
830

$Zr = 90$
 $La = 138$
 $Pr = 140$
 $Nd = 144$
 $Pm = 147$
 $Sm = 150$
 $Eu = 152$
 $Gd = 157$
 $Tb = 159$
 $Dy = 163$
 $Ho = 165$
 $Er = 167$
 $Tm = 169$
 $Yb = 173$
 $Lu = 175$
 $Hf = 178$
 $Ta = 182$
 $W = 186$
 $Re = 187$
 $Os = 190$
 $Ir = 192$
 $Pt = 195$
 $Au = 197$
 $Hg = 200$
 $Tl = 204$
 $Pb = 207$
 $Bi = 210$
 $Po = 210$
 $At = 210$
 $Rn = 210$
 $Ac = 227$
 $Th = 232$
 $Pa = 231$
 $U = 238$
 $Np = 237$
 $Pu = 244$
 $Am = 243$
 $Cm = 247$
 $Bk = 247$
 $Cf = 251$
 $Es = 252$
 $Fm = 257$
 $Mn = 55$
 $Fe = 56$
 $Co = 59$
 $Ni = 59$
 $Cu = 63,5$
 $Zn = 65,4$
 $Ga = 70$
 $Ge = 73$
 $As = 75$
 $Se = 79$
 $Br = 80$
 $Kr = 84$
 $Rb = 85,5$
 $Sr = 87,6$
 $Y = 89$
 $Zr = 90$
 $Nb = 93$
 $Mo = 96$
 $Tc = 98$
 $Ru = 101$
 $Rh = 104,4$
 $Pd = 106,3$
 $Ag = 108$
 $Cd = 112$
 $In = 115$
 $Sn = 118$
 $Sb = 122$
 $Te = 128$
 $I = 127$
 $Xe = 131$
 $Ba = 137$
 $La = 138$
 $Ce = 140$
 $Pr = 140$
 $Nd = 144$
 $Pm = 147$
 $Sm = 150$
 $Eu = 152$
 $Gd = 157$
 $Tb = 159$
 $Dy = 163$
 $Ho = 165$
 $Er = 167$
 $Tm = 169$
 $Yb = 173$
 $Lu = 175$
 $Hf = 178$
 $Ta = 182$
 $W = 186$
 $Re = 187$
 $Os = 190$
 $Ir = 192$
 $Pt = 195$
 $Au = 197$
 $Hg = 200$
 $Tl = 204$
 $Pb = 207$
 $Bi = 210$
 $Po = 210$
 $At = 210$
 $Rn = 210$
 $Ac = 227$
 $Th = 232$
 $Pa = 231$
 $U = 238$
 $Np = 237$
 $Pu = 244$
 $Am = 243$
 $Cm = 247$
 $Bk = 247$
 $Cf = 251$
 $Es = 252$
 $Fm = 257$

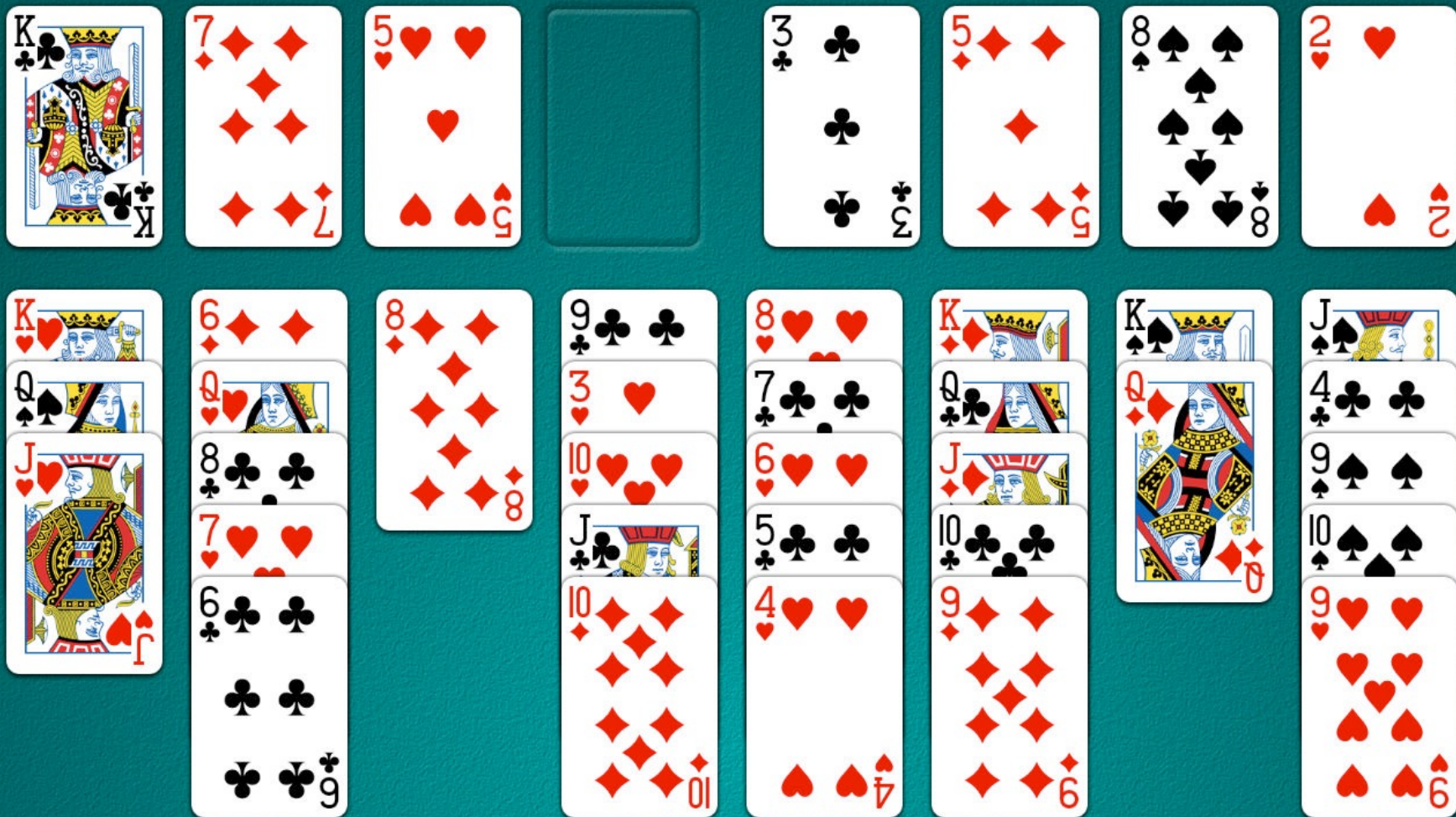
ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

H = 1	Ti = 50	Zr = 90	? = 180.
Be = 9,1	V = 51	Nb = 94	Ta = 182.
B = 11	Cr = 52	Mo = 96	W = 186.
C = 12	Mn = 55	Rh = 104,4	Pt = 197,1.
N = 14	Fe = 56	Rn = 104,4	Ir = 198.
O = 16	Ni = Co = 59	Pl = 106,8	O = 199.
F = 19	Cu = 63,4	Ag = 108	Hg = 200.
Li = 7	Be = 9,1	Mg = 24	Zn = 65,2
Na = 23	B = 11	Al = 27,1	? = 68
K = 39	C = 12	Si = 28	? = 70
Rb = 85,4	N = 14	P = 31	As = 75
Cs = 133	O = 16	S = 32	Se = 79,4
Tl = 204.	F = 19	Cl = 35,5	Br = 80
Pb = 207.	Li = 7	Na = 23	K = 39
Bi = 210?	Ca = 40	Sr = 87,6	Ba = 137
Bl = 210?	? = 45	Ce = 92	La = 94
	?Er = 56	La = 94	
	?Yt = 60	Di = 95	
	?In = 75,6	Th = 118?	

Д. Менделѣевъ

Classificare



Tutti gli elementi

Group →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period ↓	1 1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La *	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac *	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
			* 58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu		
			* 90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr		

Tutti gli elementi

Group Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	1 H																	2 He	
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y		40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	*	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
				*	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
				*	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

Primordiali

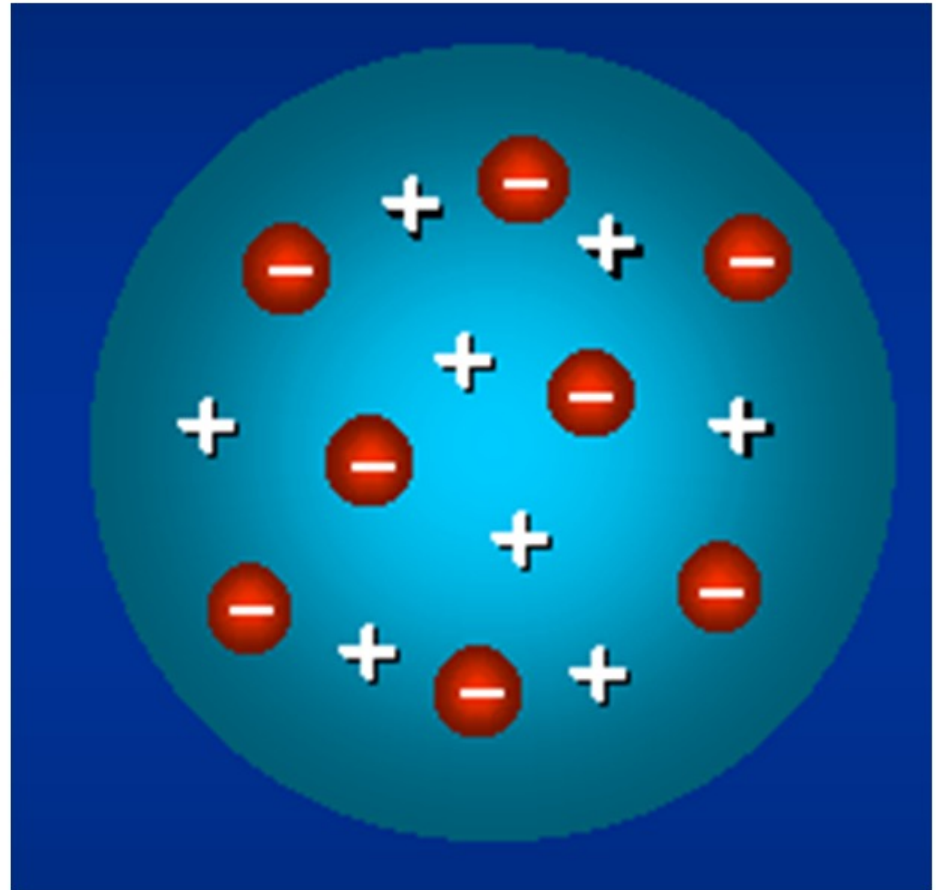
Nelle stelle

Fuori dalle stelle (Supernovae, scontri di stelle di neutroni, scontri di buchi neri, artificiali)

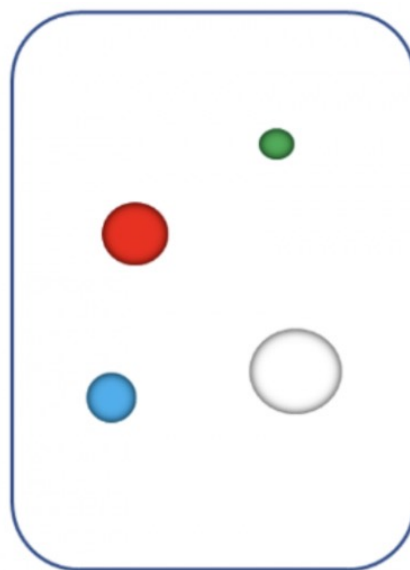
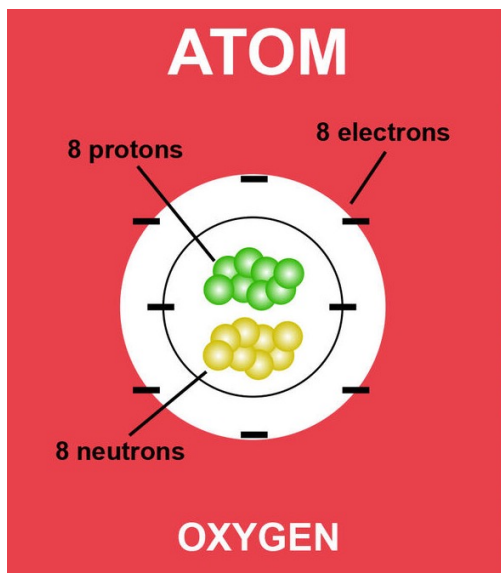
The Periodic Table of the Elements, in Pictures

Periods	Alkali Metals Group 1		Alkali Earth Metals 2		Transition Metals										Boron Group 13	Carbon Group 14	Nitrogen Group 15	Oxygen Group 16	Halogens 17	Noble Gases 18																
	H Hydrogen 1		He Helium 2												B Boron 5	C Carbon 6	N Nitrogen 7	O Oxygen 8	F Fluorine 9	Ne Neon 10																
	Li Lithium 3		Be Beryllium 4												Al Aluminum 13	Si Silicon 14	P Phosphorus 15	S Sulfur 16	Cl Chlorine 17	Ar Argon 18																
	Na Sodium 11		Mg Magnesium 12												K Potassium 19	Ca Calcium 20	Sc Scandium 21	Ti Titanium 22	V Vanadium 23	Cr Chromium 24	Mn Manganese 25	Fe Iron 26	Co Cobalt 27	Ni Nickel 28	Cu Copper 29	Zn Zinc 30	Ga Gallium 31	Ge Germanium 32	As Arsenic 33	Se Selenium 34	Br Bromine 35	Kr Krypton 36				
	K Potassium 19		Ca Calcium 20		Scandium 21		Titanium 22		Vanadium 23		Chromium 24		Manganese 25		Iron 26		Cobalt 27		Nickel 28		Copper 29		Zinc 30		Gallium 31		Germanium 32		Arsenic 33		Selenium 34		Bromine 35		Krypton 36	
	Rb Rubidium 37		Sr Strontium 38		Yttrium 39		Zirconium 40		Niobium 41		Molybdenum 42		Technetium 43		Ruthenium 44		Rhodium 45		Palladium 46		Silver 47		Cadmium 48		Indium 49		Tin 50		Antimony 51		Tellurium 52		Iodine 53		Xenon 54	
	Rb Rubidium 37		Sr Strontium 38		Yttrium 39		Zirconium 40		Niobium 41		Molybdenum 42		Technetium 43		Ruthenium 44		Rhodium 45		Palladium 46		Silver 47		Cadmium 48		Indium 49		Tin 50		Antimony 51		Tellurium 52		Iodine 53		Xenon 54	
	Cs Cesium 55		Ba Barium 56		71 - 72		Hf Hafnium 72		Ta Tantalum 73		W Tungsten 74		Re Rhenium 75		Os Osmium 76		Ir Iridium 77		Pt Platinum 78		Au Gold 79		Hg Mercury 80		Tl Thallium 81		Pb Lead 82		Bi Bismuth 83		Po Polonium 84		At Astatine 85		Rn Radon 86	
	Cs Cesium 55		Ba Barium 56		71 - 72		Hf Hafnium 72		Ta Tantalum 73		W Tungsten 74		Re Rhenium 75		Os Osmium 76		Ir Iridium 77		Pt Platinum 78		Au Gold 79		Hg Mercury 80		Tl Thallium 81		Pb Lead 82		Bi Bismuth 83		Po Polonium 84		At Astatine 85		Rn Radon 86	
	Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118	
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
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Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
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Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium 116		Uus Ununseptium 117		Uuo Ununoctium 118		
Fr Francium 87		Ra Radium 88		89 - 103		Rf Rutherfordium 104		Db Dubnium 105		Sg Seaborgium 106		Bh Bohrium 107		Hs Hassium 108		Mt Meitnerium 109		Ds Darmstadtium 110		Rg Roentgenium 111		Cn Copernicium 112		Uut Ununtrium 113		Fl Flerovium 114		Uup Ununpentium 115		Lv Livermorium						

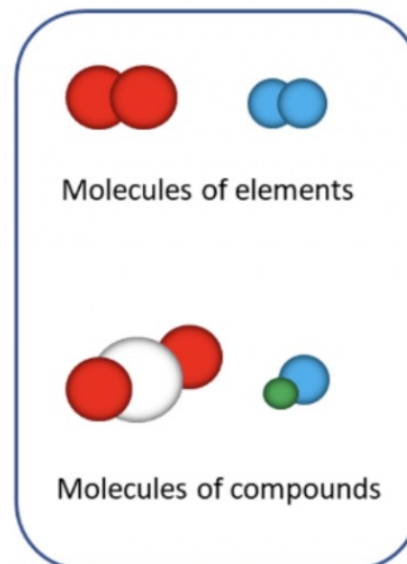
«a panettone»



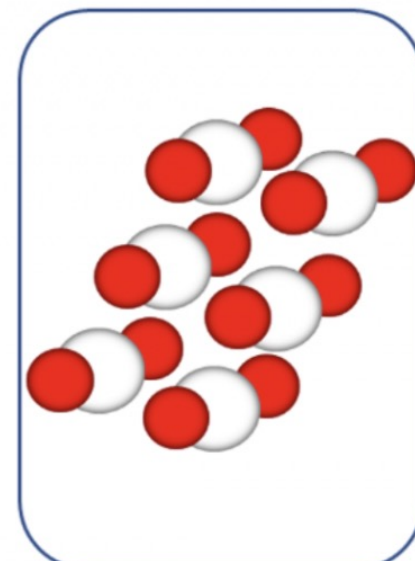
Bonus track: elettrizzazione



Atoms



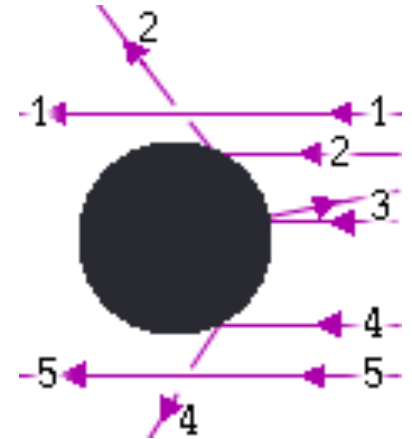
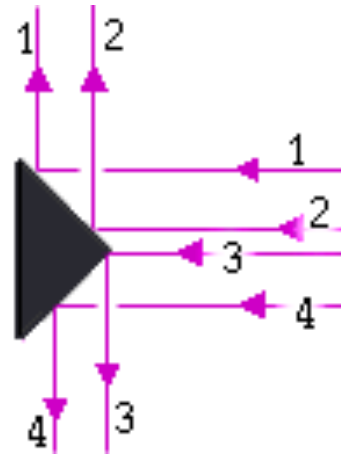
Molecules



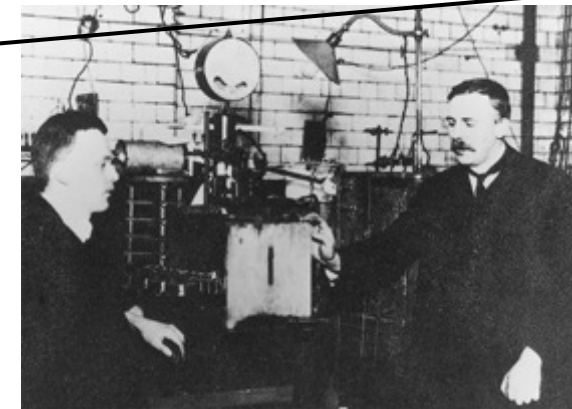
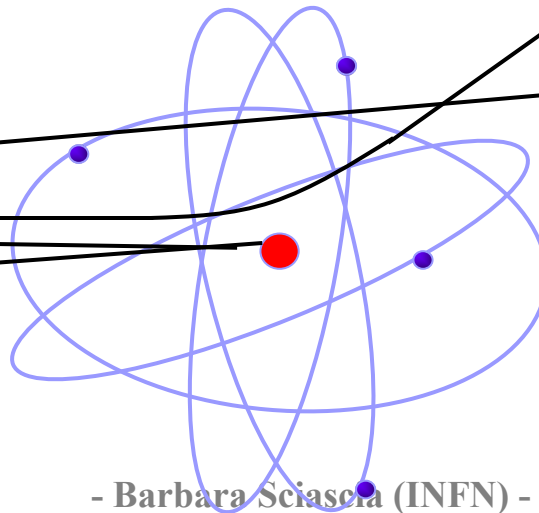
Compounds

Fenomeno fisico per cui un corpo elettricamente neutro, conduttore o no, acquista cariche elettriche positive o negative, oppure, conservando carica totale nulla, presenta sulla sua superficie, o nel suo volume, una distribuzione di cariche di segno contrario.

«Vedere» le cose

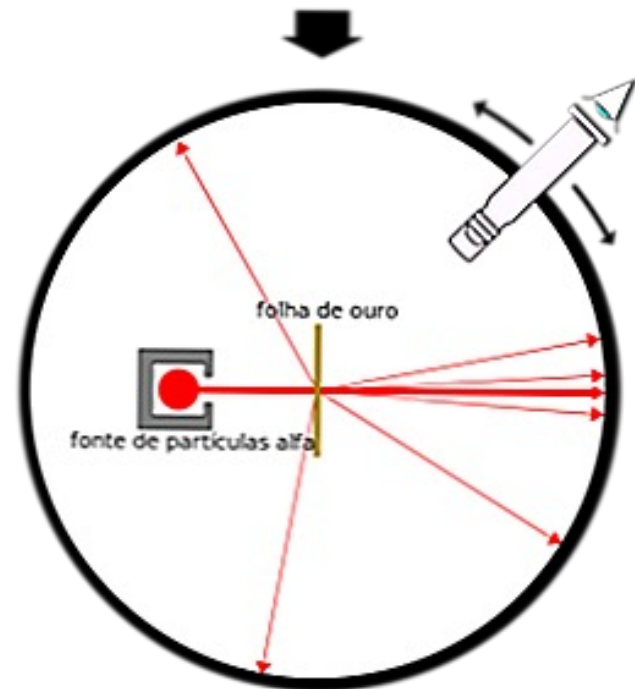
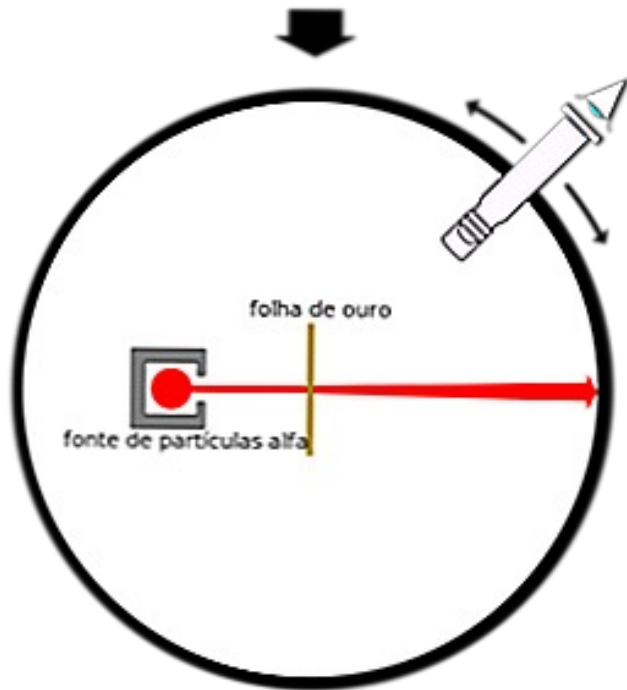
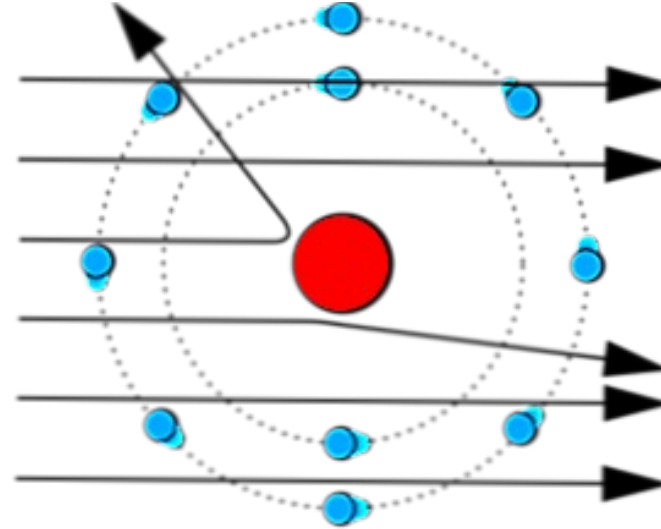
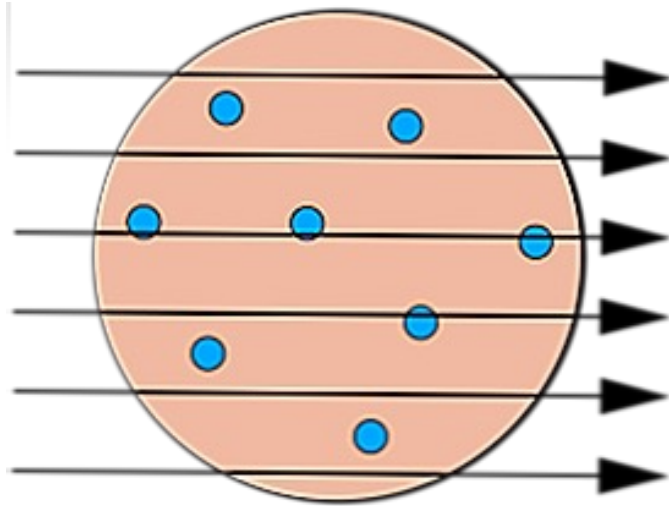


L'atomo di Rutherford



- Barbara Sciascia (INFN) -

Modelli a confronto



NEUTRON:
LARGE WITH
NO CHARGE



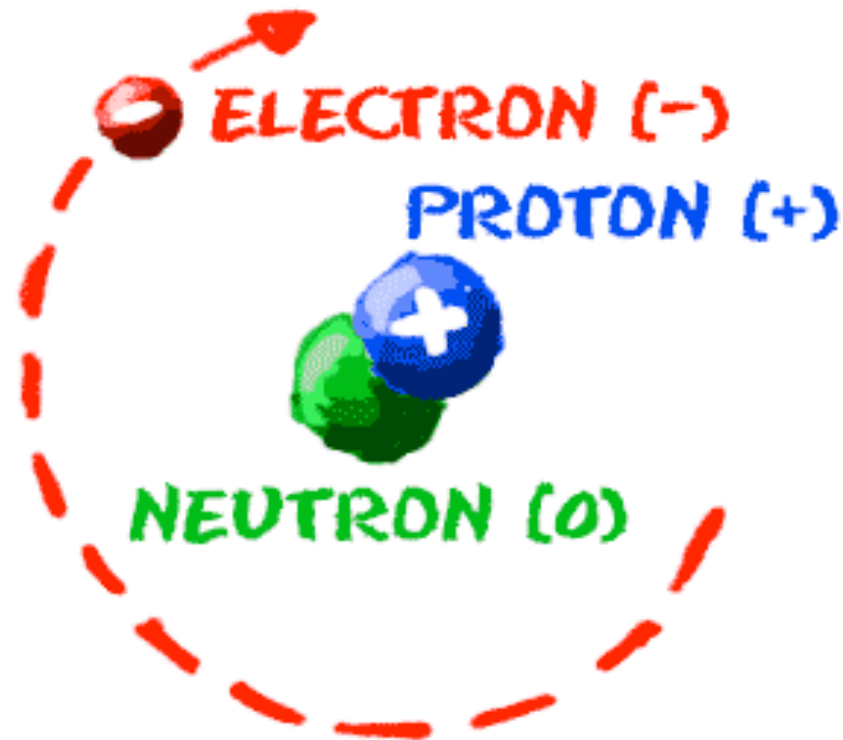
PROTON:
LARGE WITH
POSITIVE CHARGE



ELECTRON:
SMALL WITH
NEGATIVE CHARGE

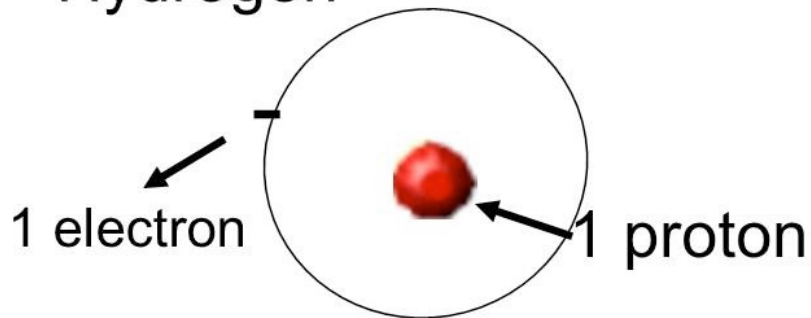


ATOMIC PARTICLES HAVE
DIFFERENT SIZES AND
DIFFERENT CHARGES

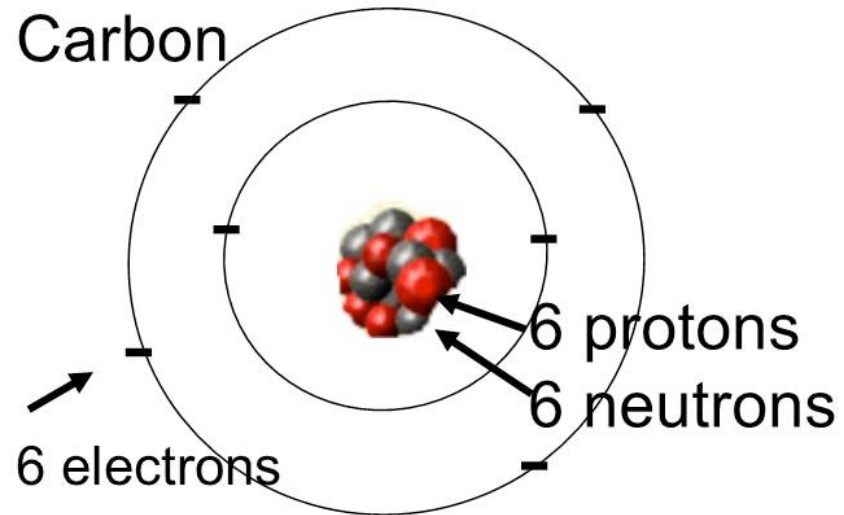


ELECTRONS ORBIT THE
ATOMIC NUCLEUS WHERE
YOU FIND PROTONS
AND NEUTRONS

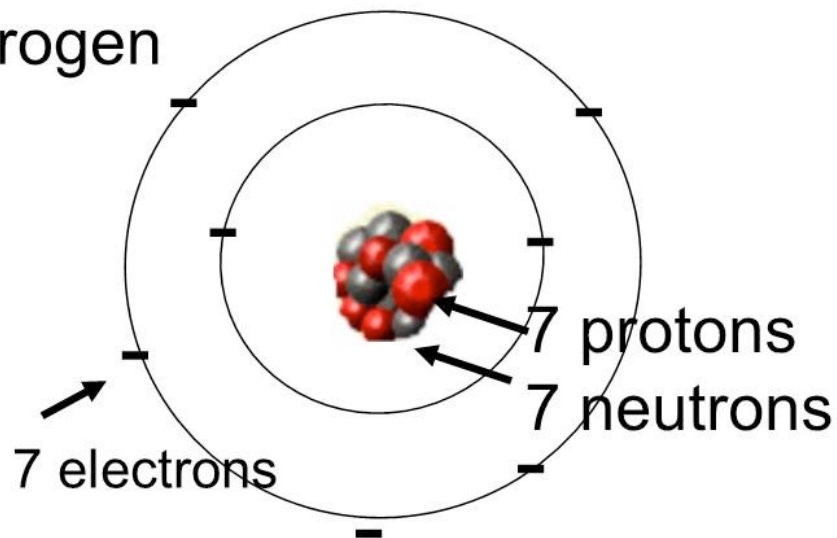
Hydrogen



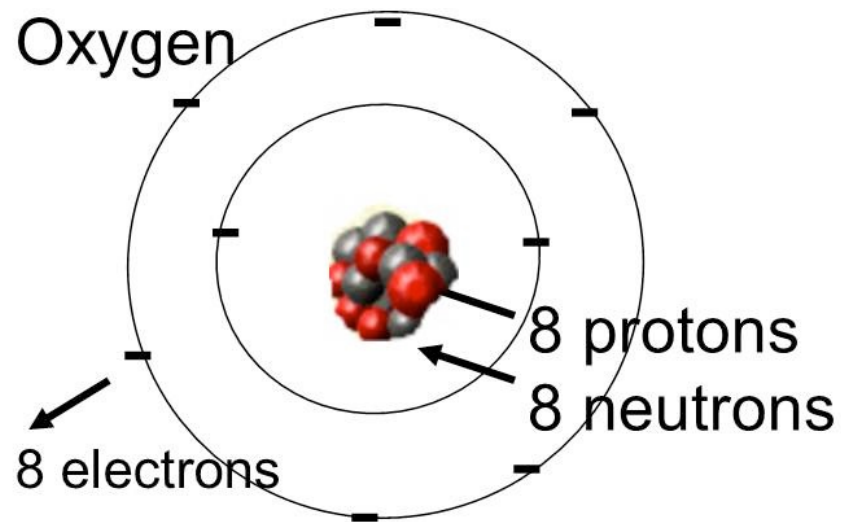
Carbon



Nitrogen

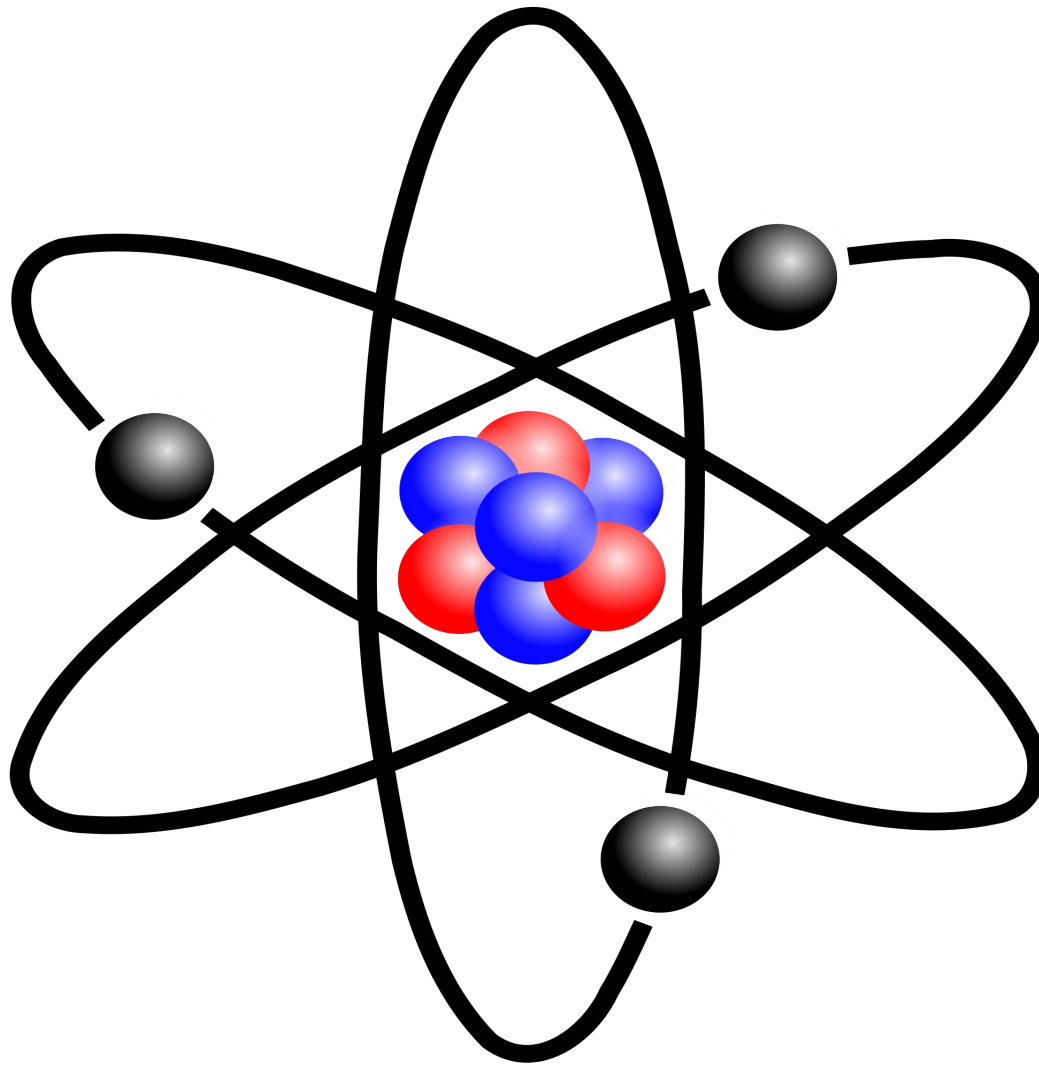


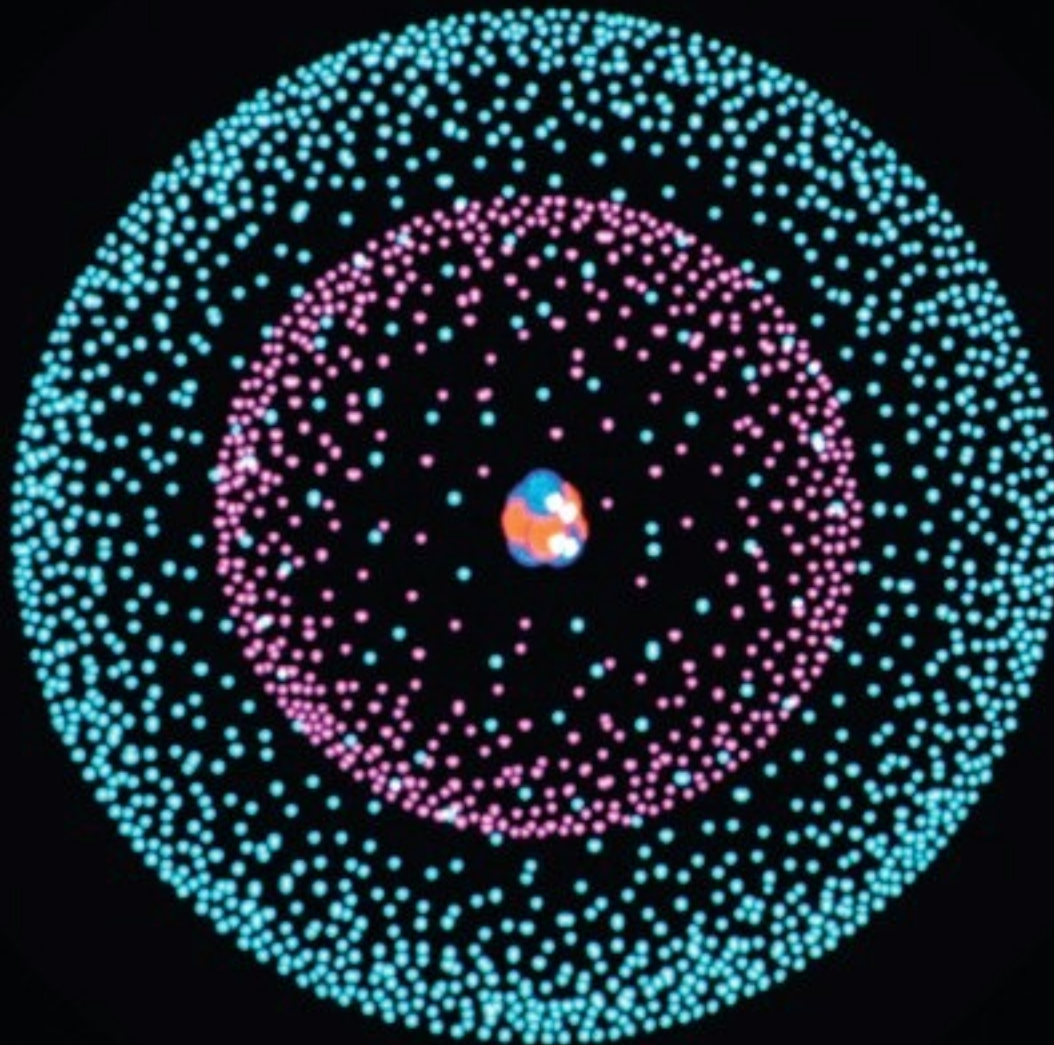
Oxygen



Principio di esclusione di Pauli



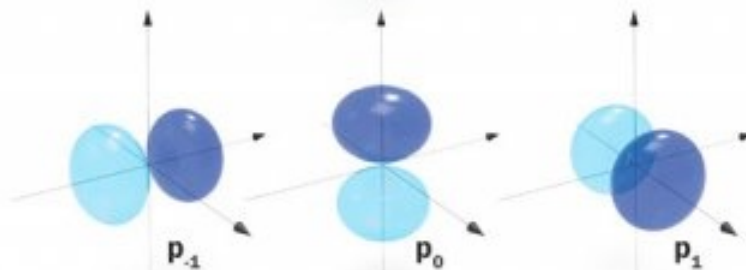




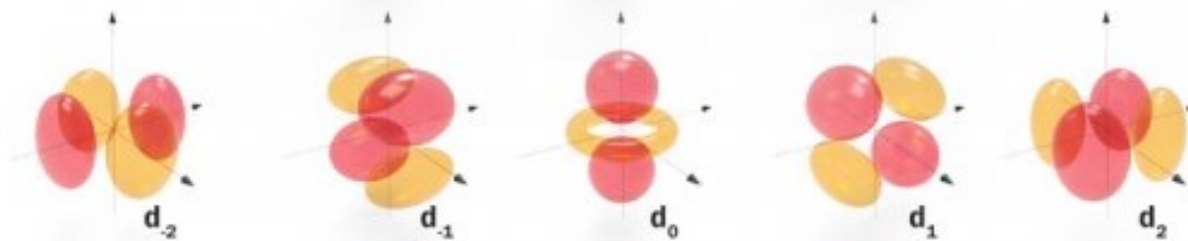
$l=0$



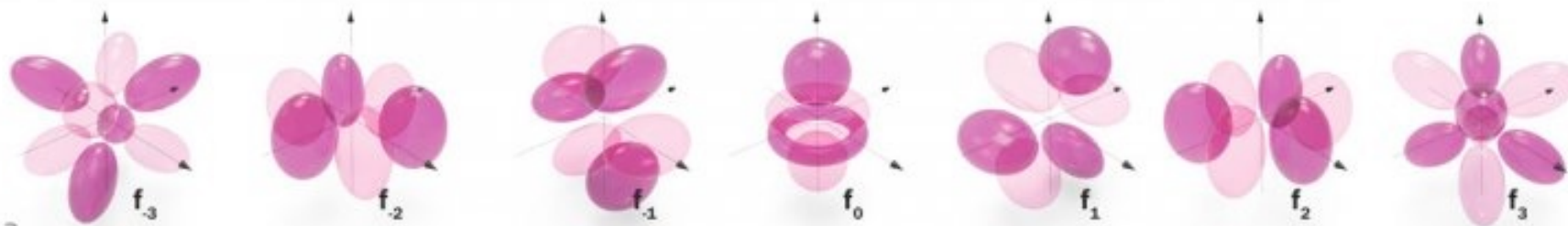
$l=1$



$l=2$



$l=3$



	s ($l = 0$)	p ($l = 1$)			d ($l = 2$)					f ($l = 3$)						
	$m_l = 0$	$m_l = 0$	$m_l = \pm 1$		$m_l = 0$	$m_l = \pm 1$		$m_l = \pm 2$		$m_l = 0$	$m_l = \pm 1$		$m_l = \pm 2$		$m_l = \pm 3$	
	s	p_z	p_x	p_y	d_{z^2}	d_{xz}	d_{yz}	d_{xy}	$d_{x^2-y^2}$	f_{z^3}	f_{xz^2}	f_{yz^2}	f_{xyz}	$f_{z(x^2-y^2)}$	$f_{x(x^2-3y^2)}$	$f_{y(3x^2-y^2)}$
$n = 1$																
$n = 2$																
$n = 3$																
$n = 4$																
$n = 5$										-	-	-	-	-	-	-
$n = 6$					-	-	-	-	-	-	-	-	-	-	-	-
$n = 7$		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The Standard Model of particle physics

Years from concept to discovery

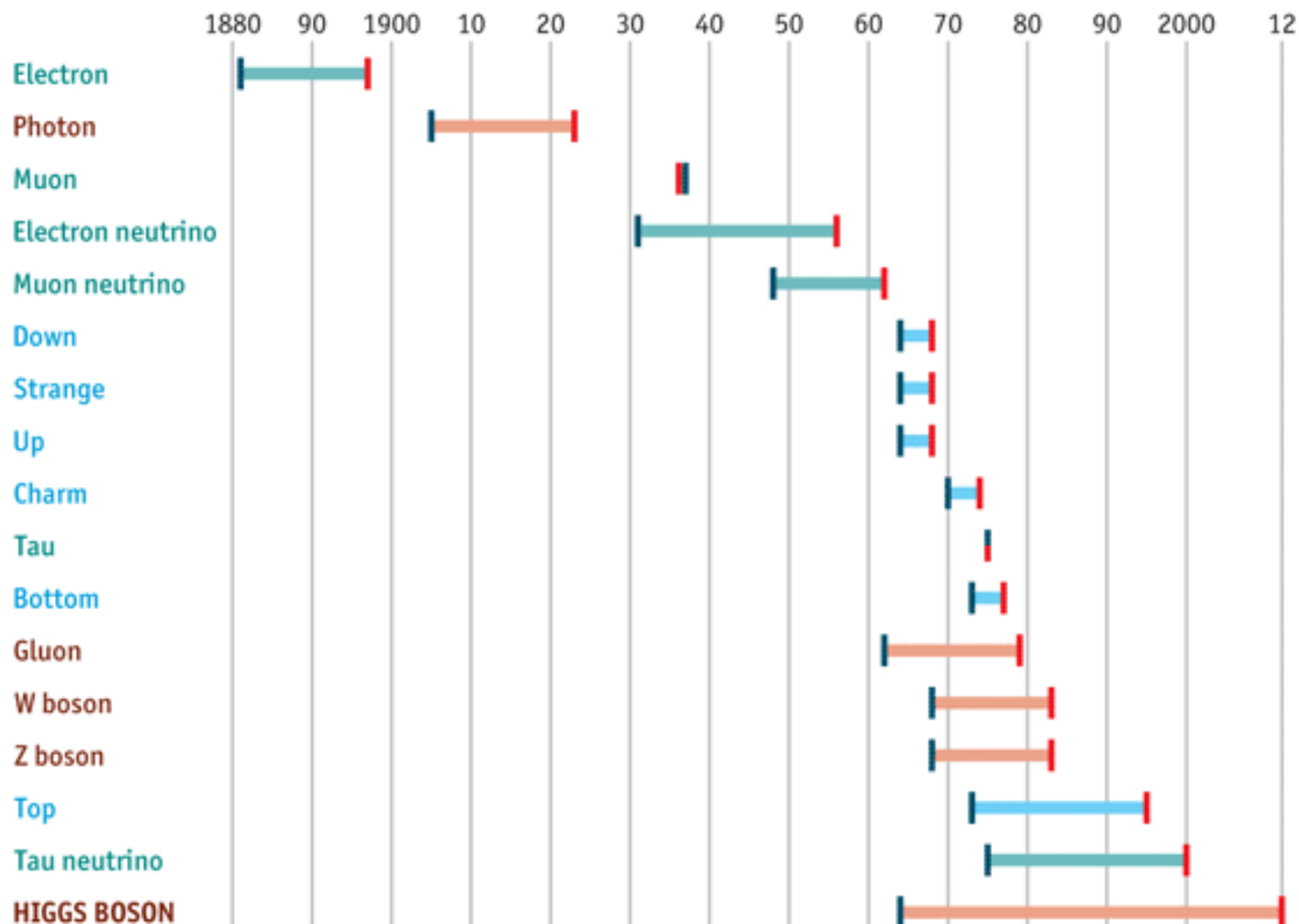
Leptons

Bosons

Quarks

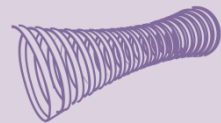
Theorised/explained

Discovered



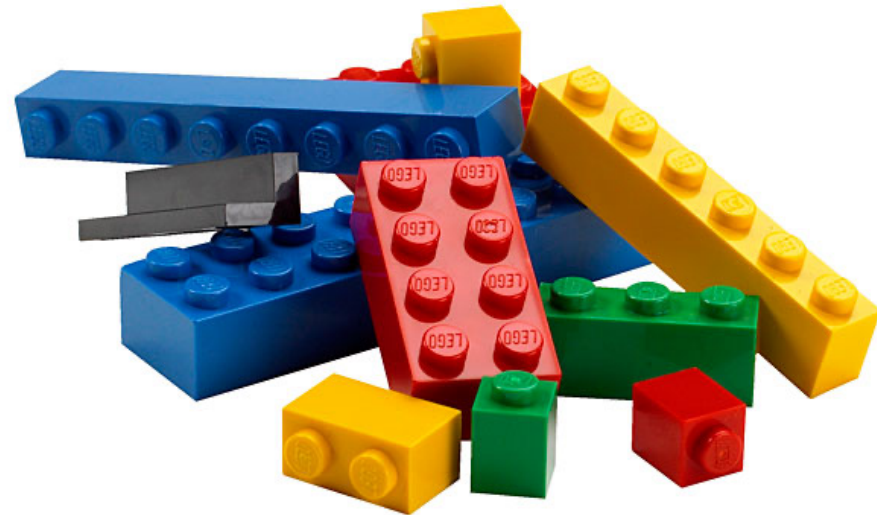
Source: *The Economist*

Un'altra tavola periodica

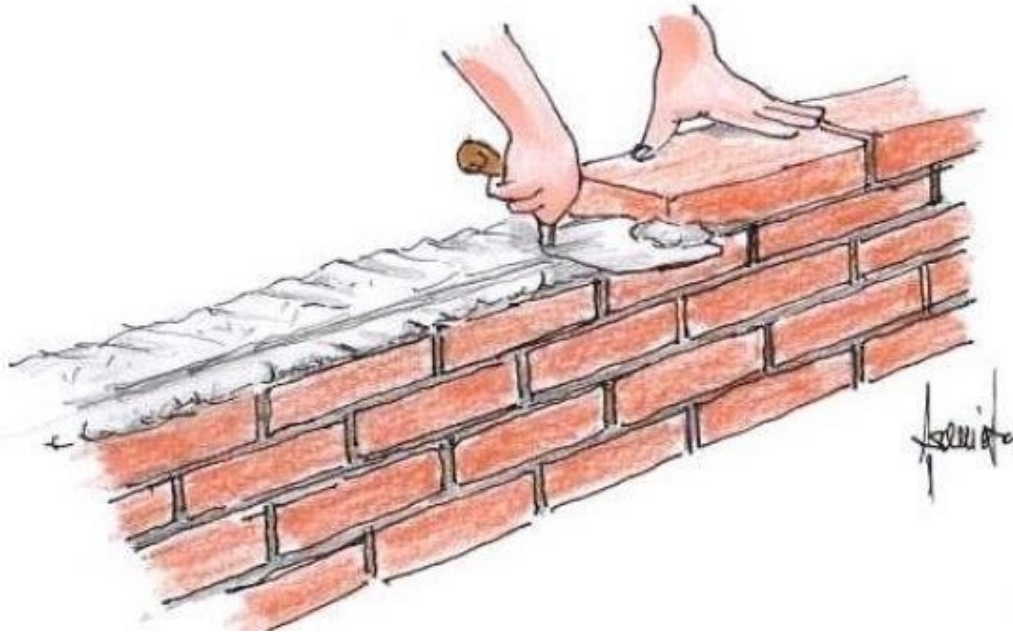
QUARK	up	u	charm	c	top	t	MEDIATORI	gluone	g	bosone Higgs H					
	carica elettrica $2/3$														
	down	d	strange	s	beauty	b		fotone	γ						
	carica elettrica $-1/3$														
LEPTONI	ν_e	ν_{μ}	ν_{τ}					bosone W	$W^{\pm}$						
	carica elettrica 0														
	e	μ	τ												
	carica elettrica -1														
								bosone Z	Z						
															

QUARK	up u	charm c	top t
	carica elettrica 2/3		
	down d	strange s	beauty b
	carica elettrica -1/3		

LEPTONI	ν_e	ν_μ	ν_τ
	carica elettrica 0		
	e	μ	τ
	carica elettrica -1		

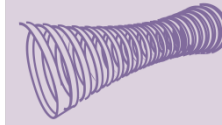


Forze o interazioni



MEDIATORI

gluone g



fotone γ



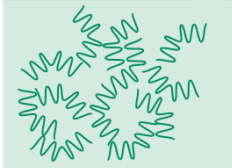
bosone W $W^\pm$



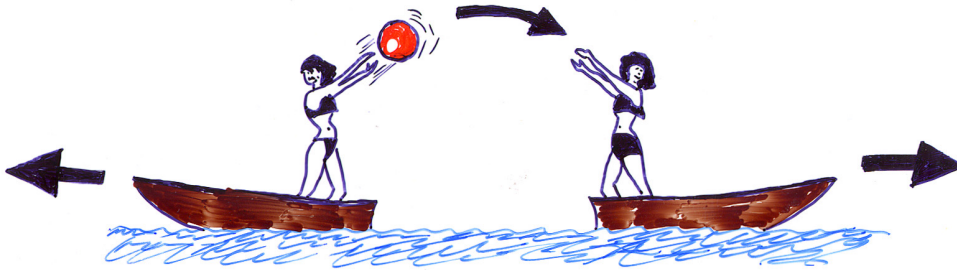
bosone Z Z

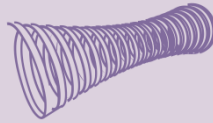


bosone Higgs H



Mediatori delle forze



gluone	g
	
fotone	γ
	
bosone W	$W^{\pm}$
	
bosone Z	Z
	

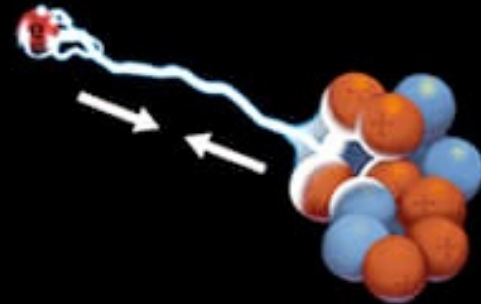
Le 4 forze fondamentali



Gravità



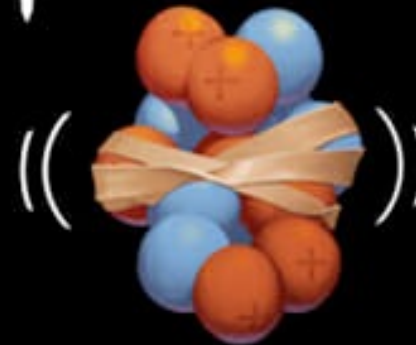
Elettro
Magnetismo



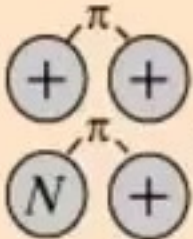
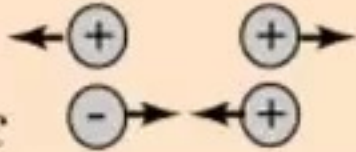
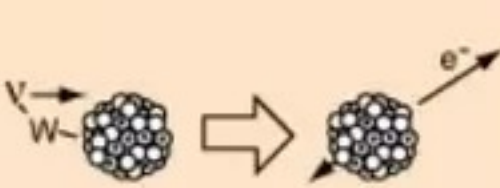
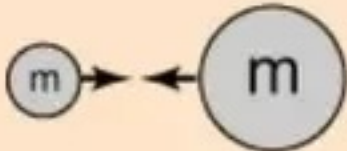
Debole



Forte



Le 4 forze fondamentali

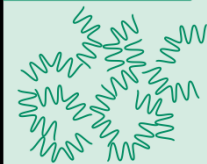
<i>Strong</i>	 Force which holds nucleus together	Strength 1	Range (m) 10^{-15} (diameter of a medium sized nucleus)
<i>Electro-magnetic</i>		Strength $\frac{1}{137}$	Range (m) Infinite
<i>Weak</i>	 neutrino interaction induces beta decay	Strength 10^{-6}	Range (m) 10^{-18} (0.1% of the diameter of a proton)
<i>Gravity</i>		Strength 6×10^{-39}	Range (m) Infinite

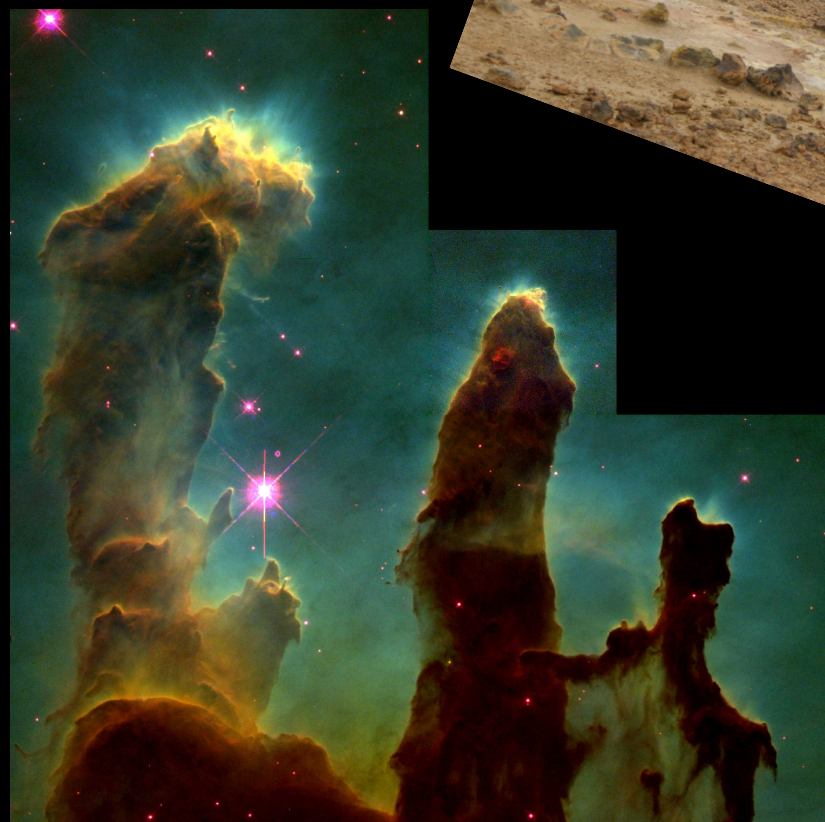
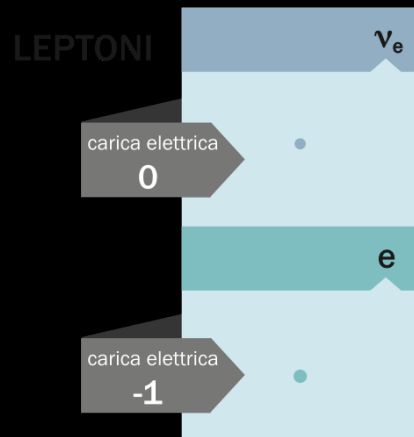
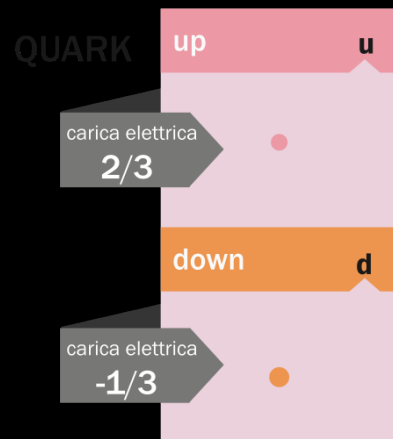
SAY GOD PARTICLE



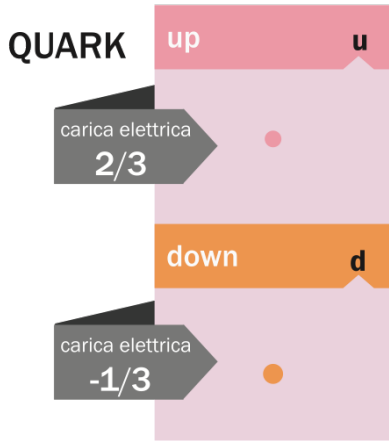
**ONE MORE
GODDAMN TIME**

bosone Higgs H





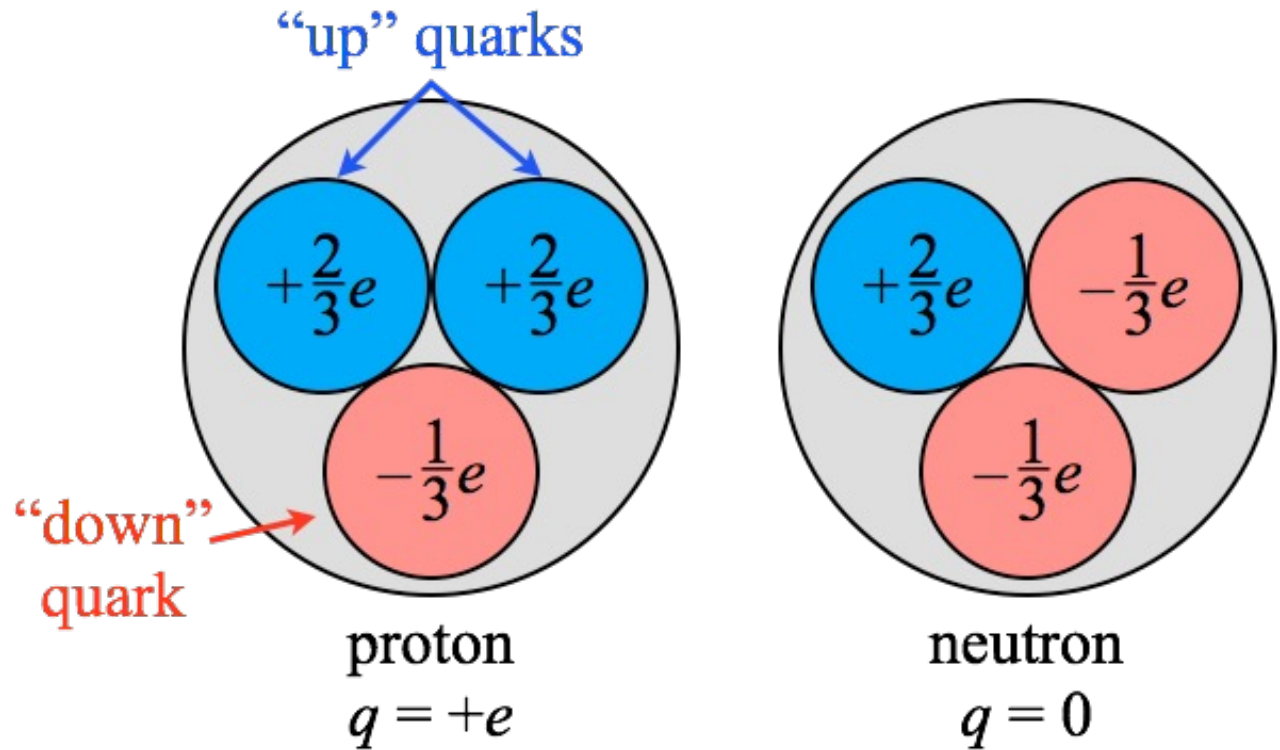
Quark up e down



“pezzi” di carica elettrica:

quark up (u): carica $+\frac{2}{3}$

quark down (d): carica $-\frac{1}{3}$

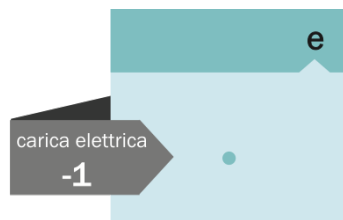
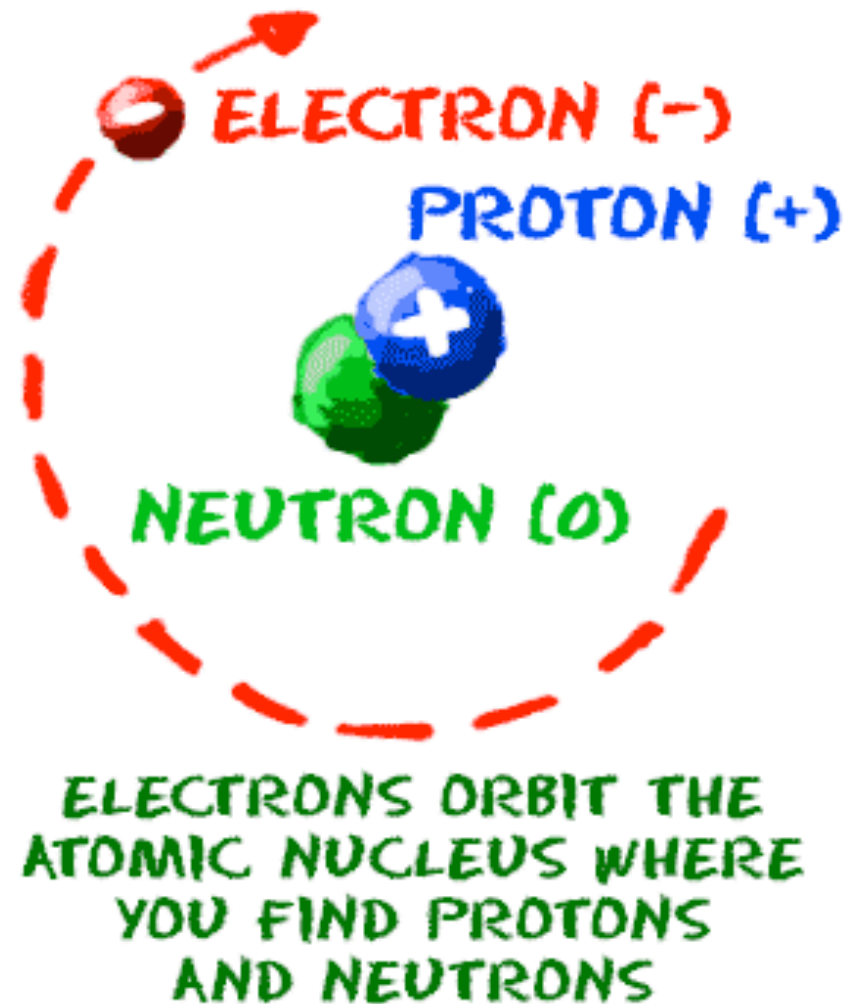
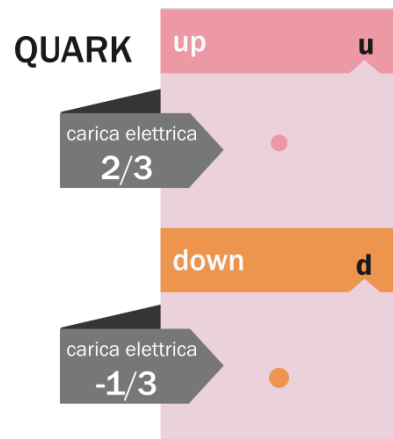


Quanto «pesa» un protone?

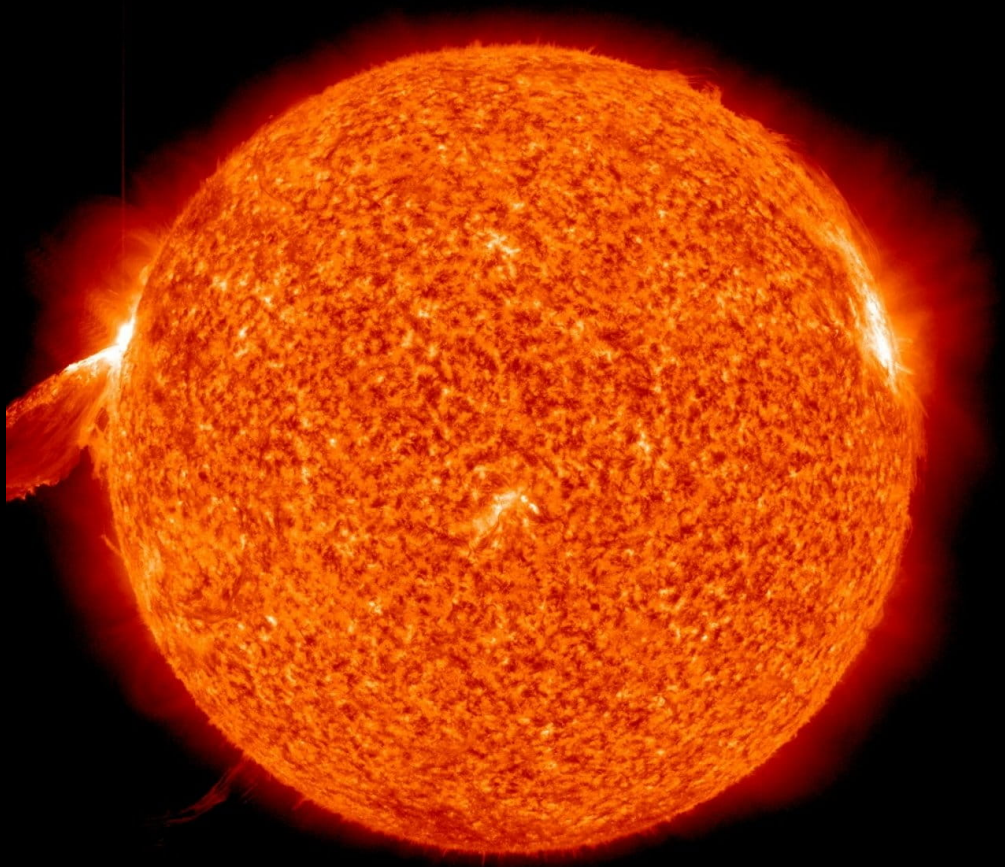
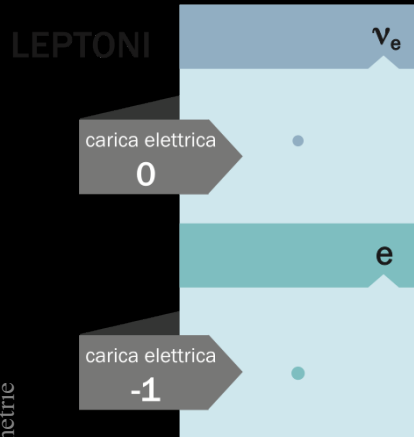
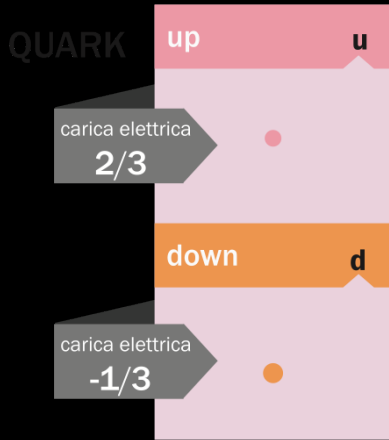


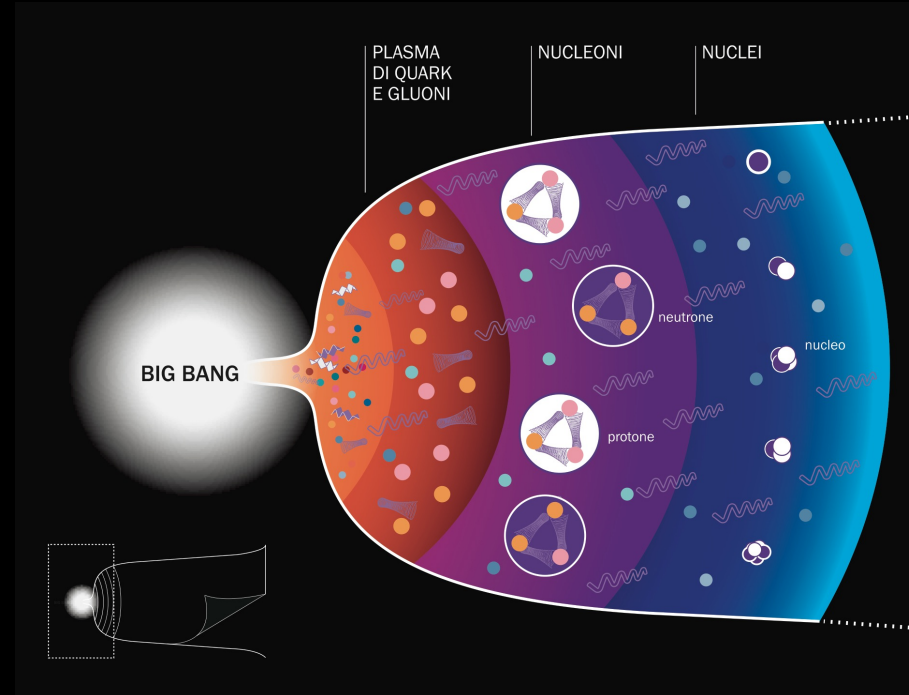
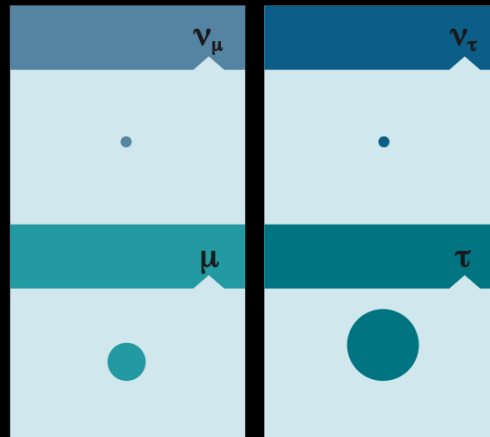
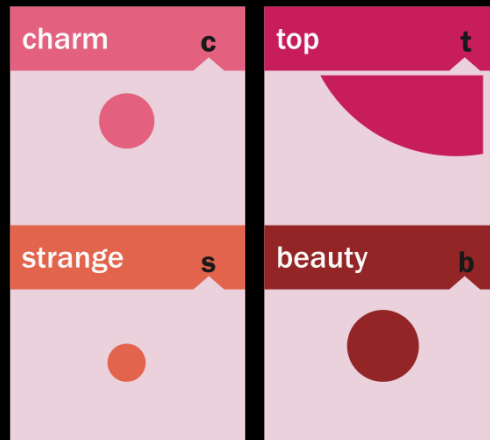
Protone: 938 MeV ($1,67 \times 10^{-27}$ kg)
 Quark up: 2,3 MeV
 Quark down: 4,8 MeV

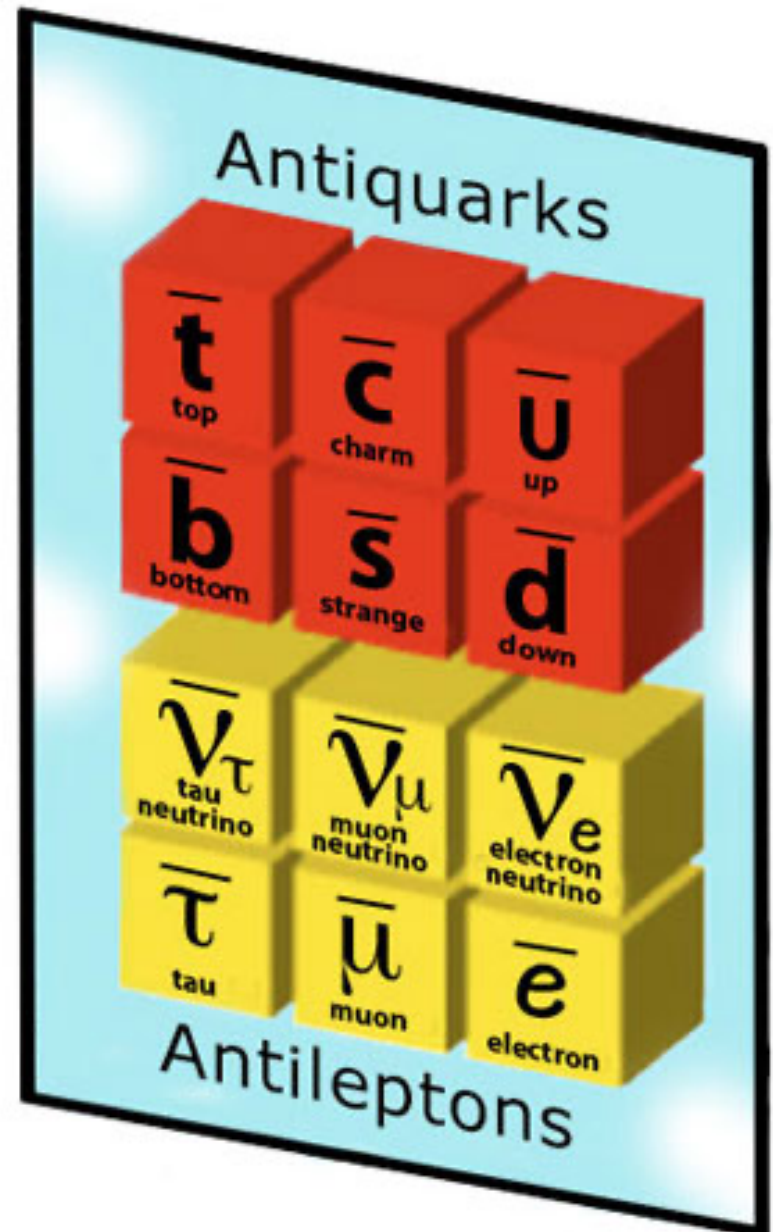
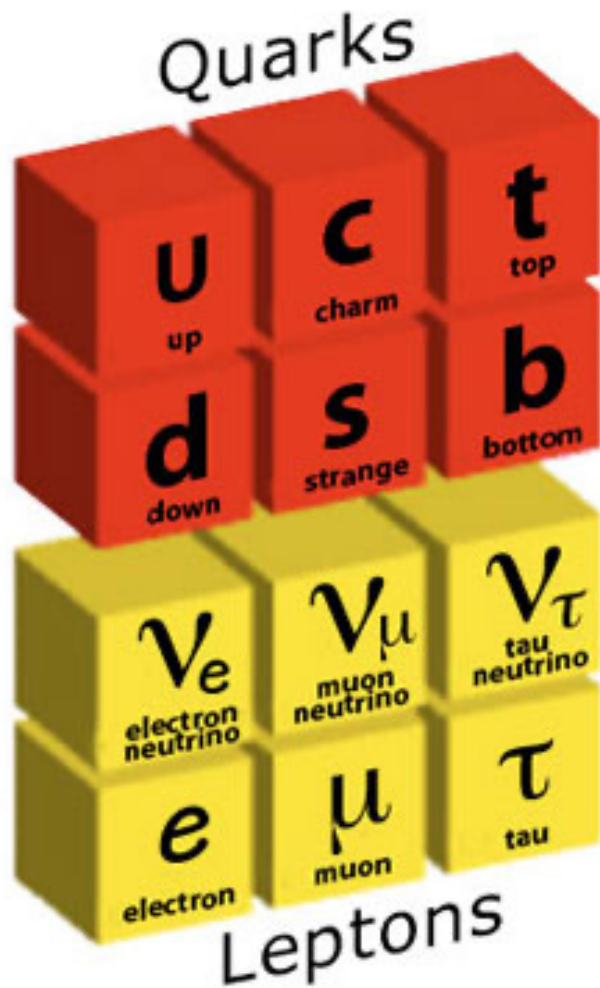




Neutrino elettronico







Antimateria!

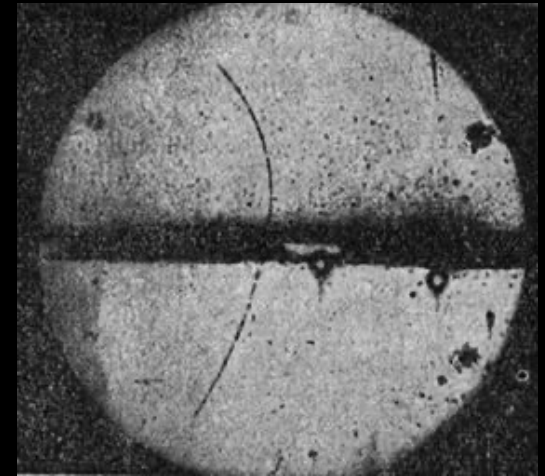


Dirac

$$(i\gamma^\mu \partial_\mu - m)\psi = 0$$



Anderson



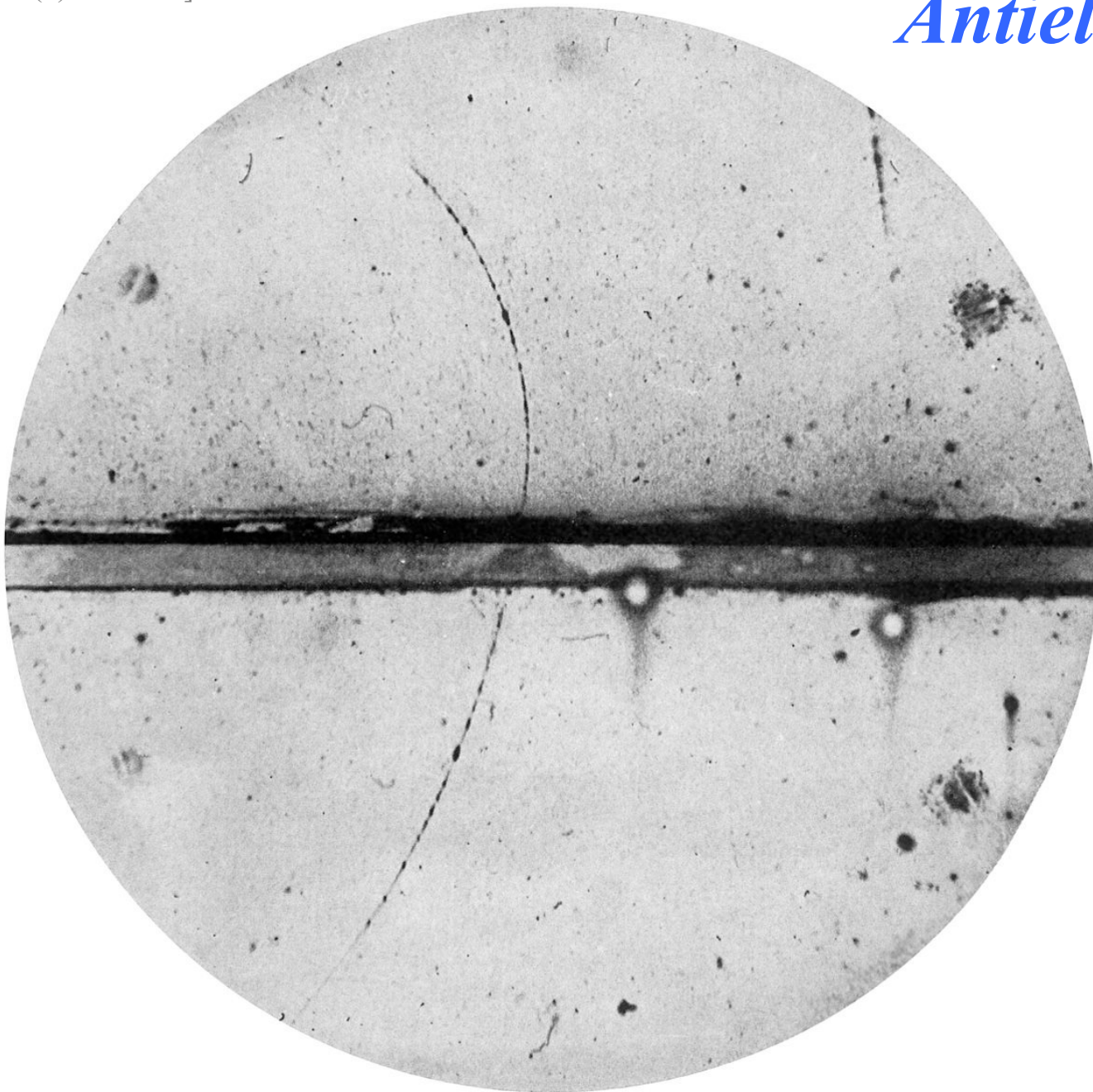
Bonus track: «le equazioni»

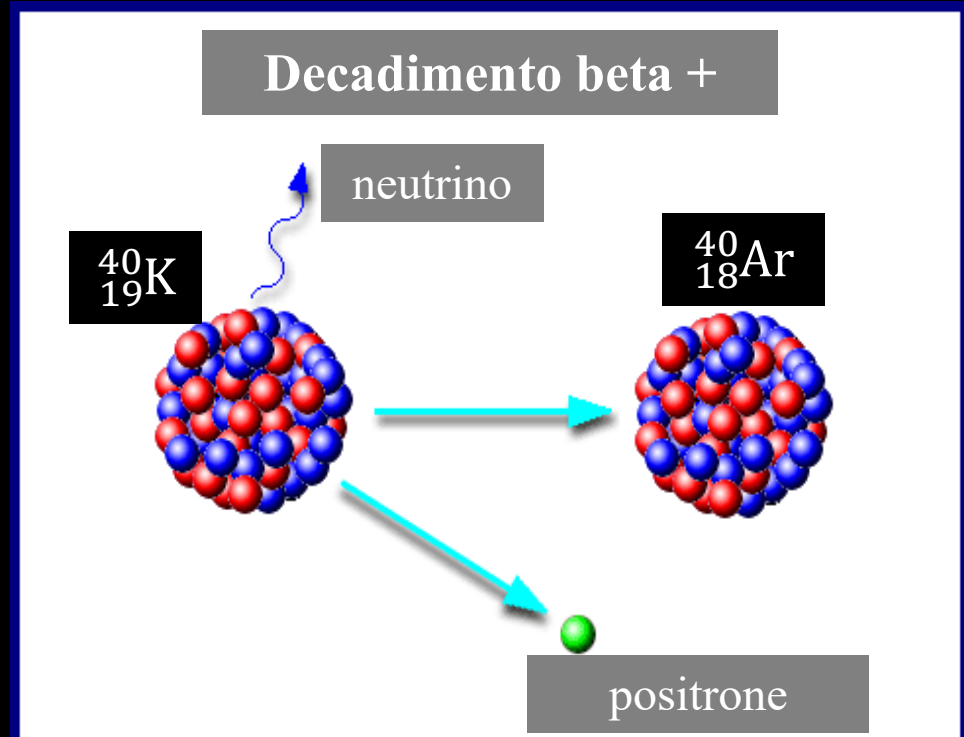


Symmetries $\leftrightarrow$ Conservation laws

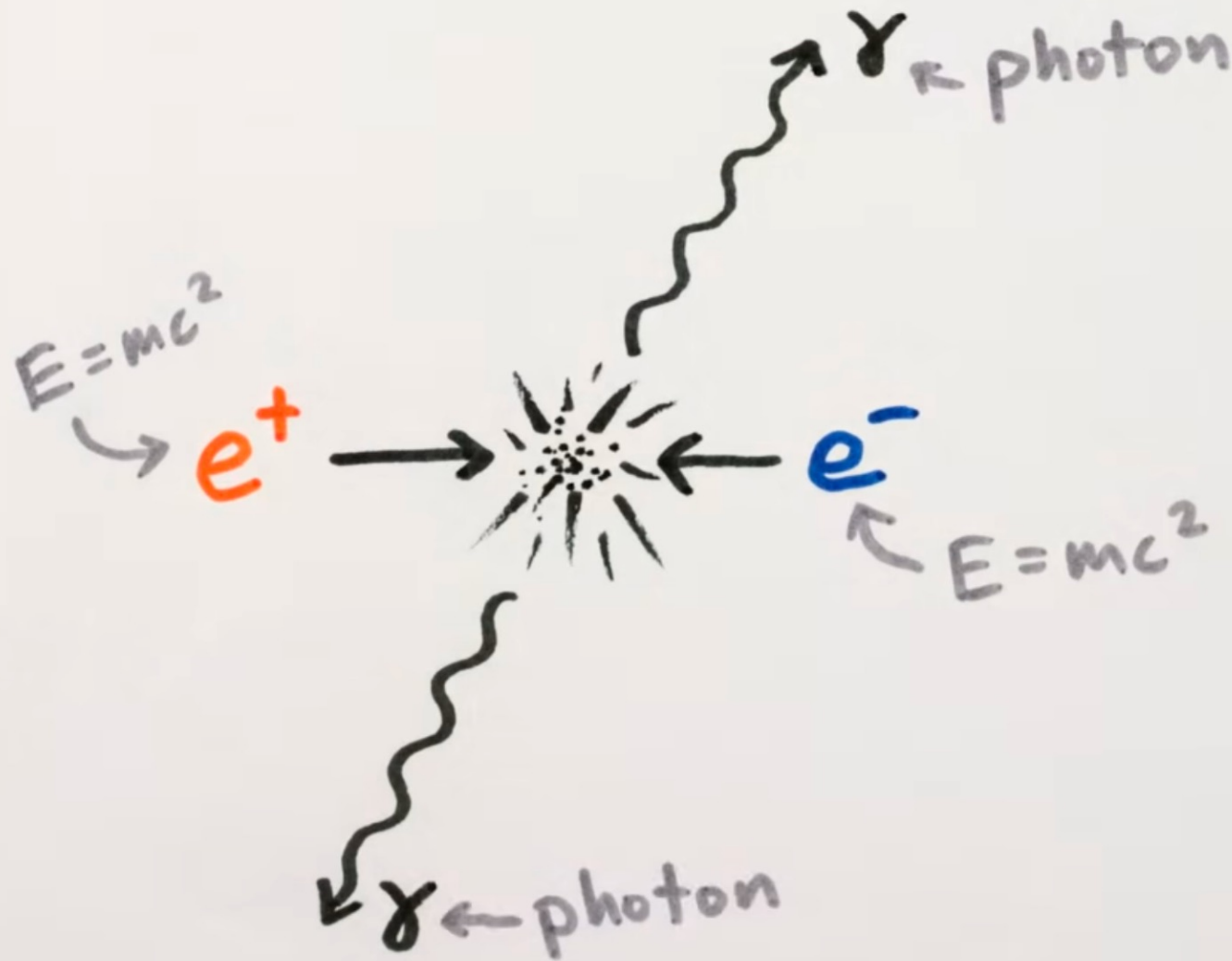
Symmetry		Conservation law
Rotation	$\leftrightarrow$	Angular momentum
Space translation	$\leftrightarrow$	Momentum
Time translation	$\leftrightarrow$	Energy

On YouTube “The most beautiful idea in physics”:
<https://www.youtube.com/watch?v=CxIHLqJ9I0A>

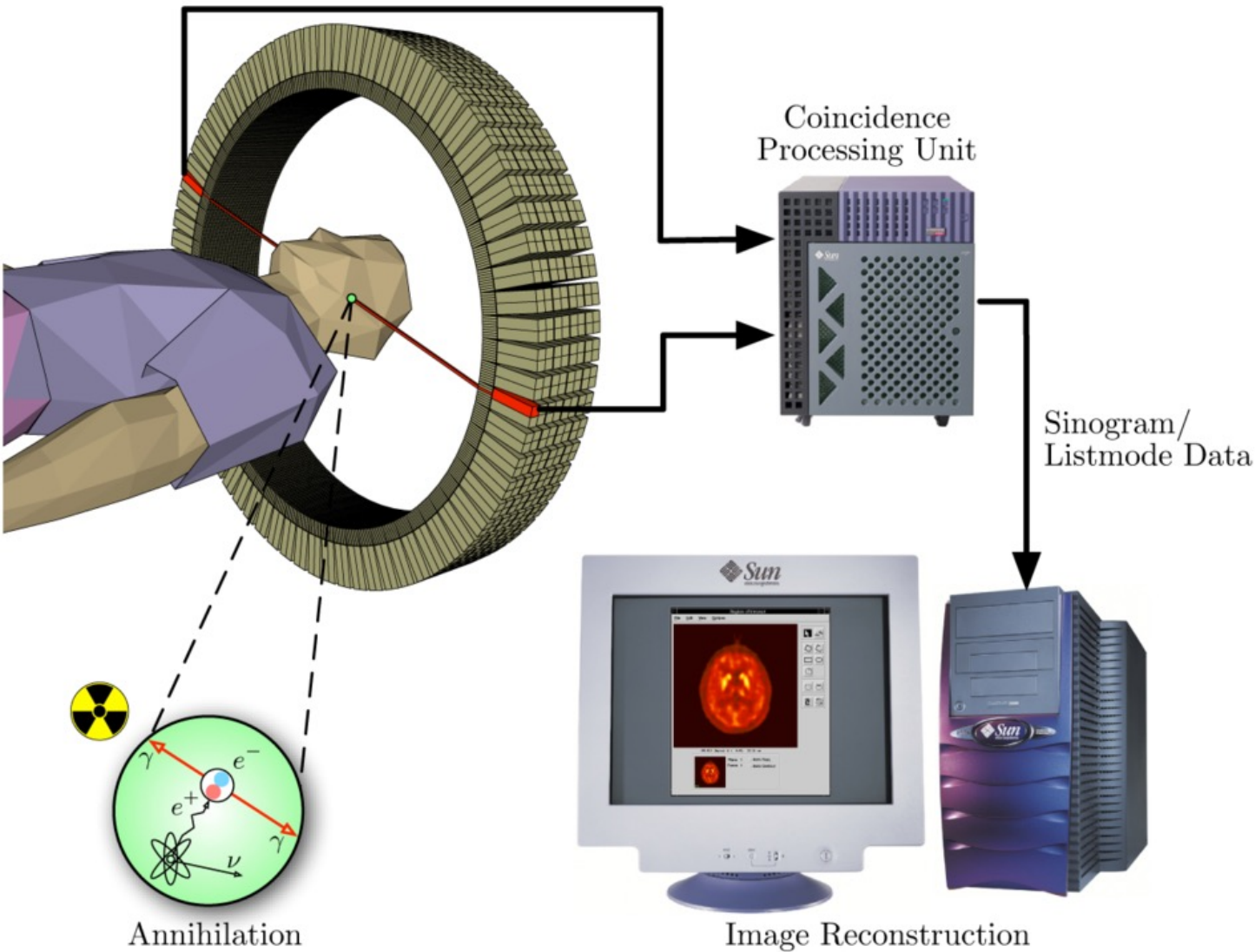




Materia e Antimateria

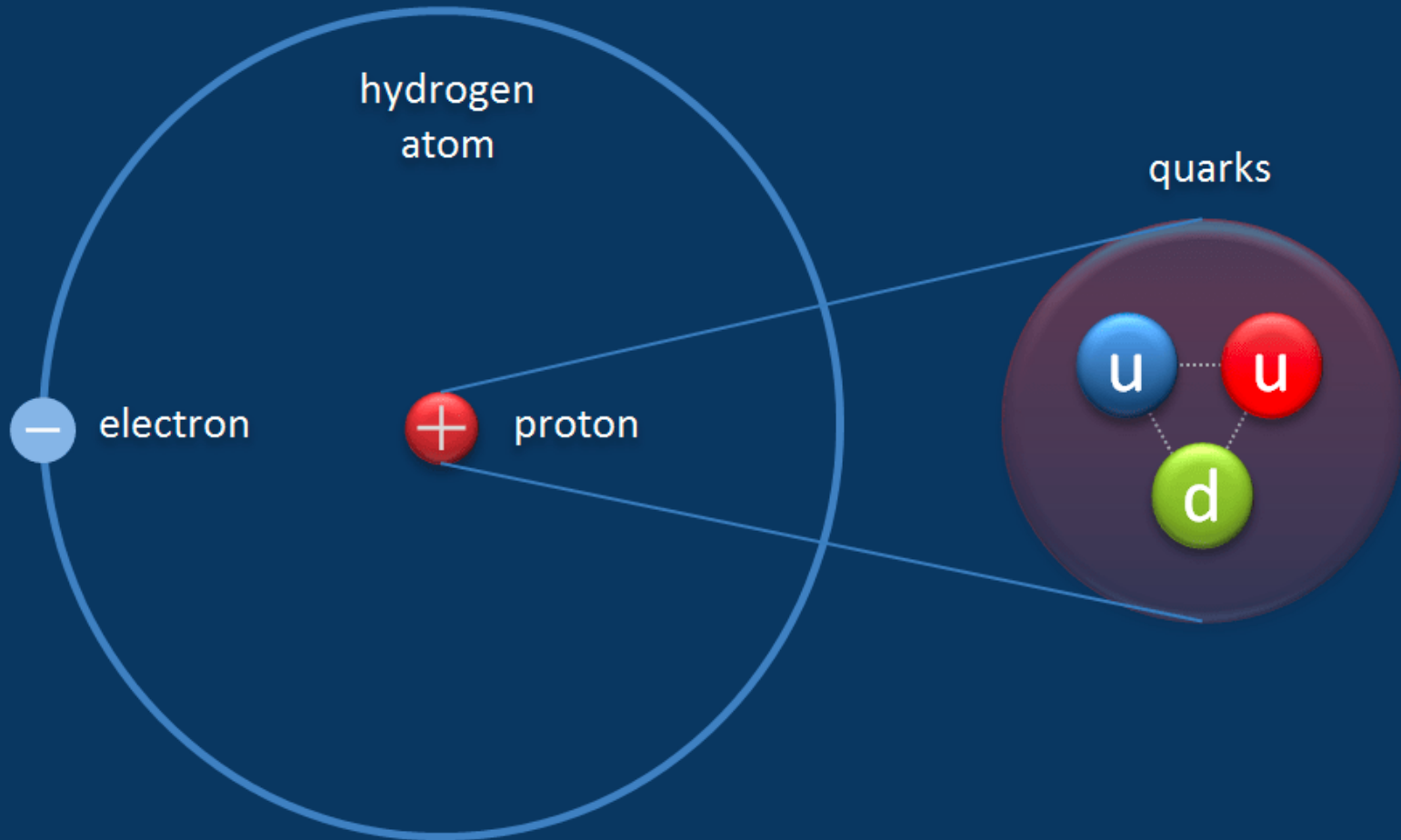


Positron Emission Tomography - PET



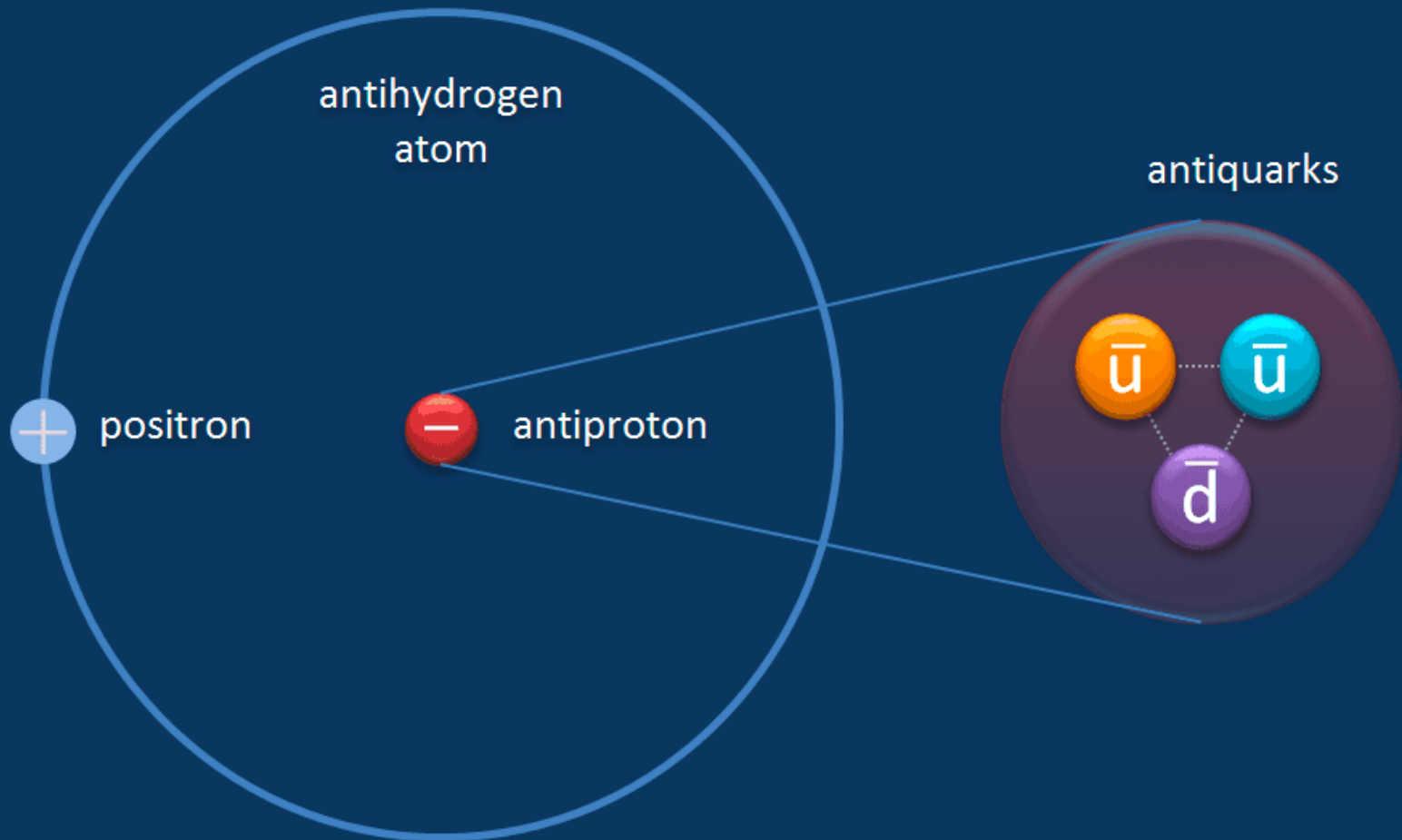
[By Jens Maus (<http://jens-maus.de/>) - own work - Public Domain, <https://commons.wikimedia.org/w/index.php?curid=401252>]

Matter



www.nuclear-power.net

Antimatter



www.nuclear-power.net

Materia e Antimateria

-1

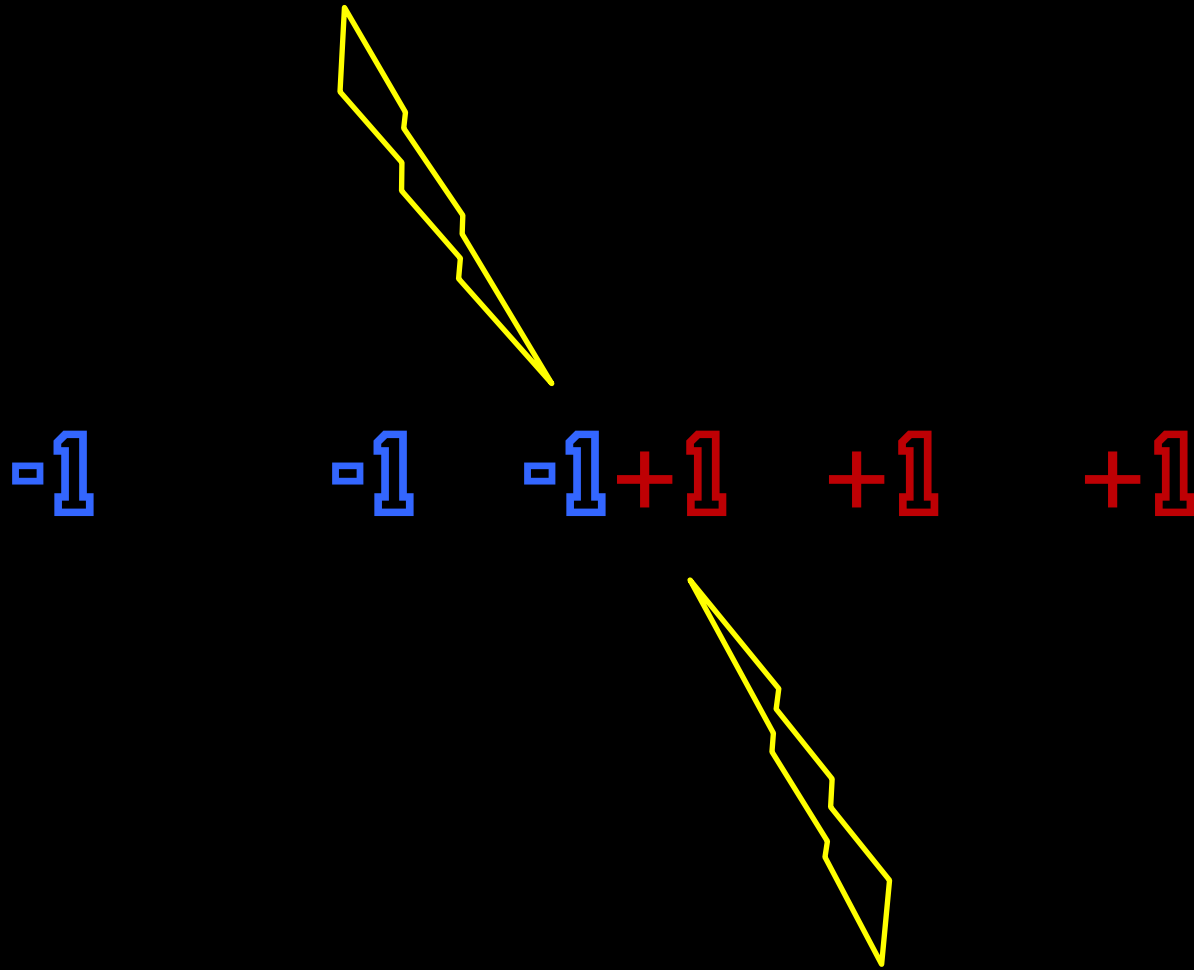
-1

0

+1

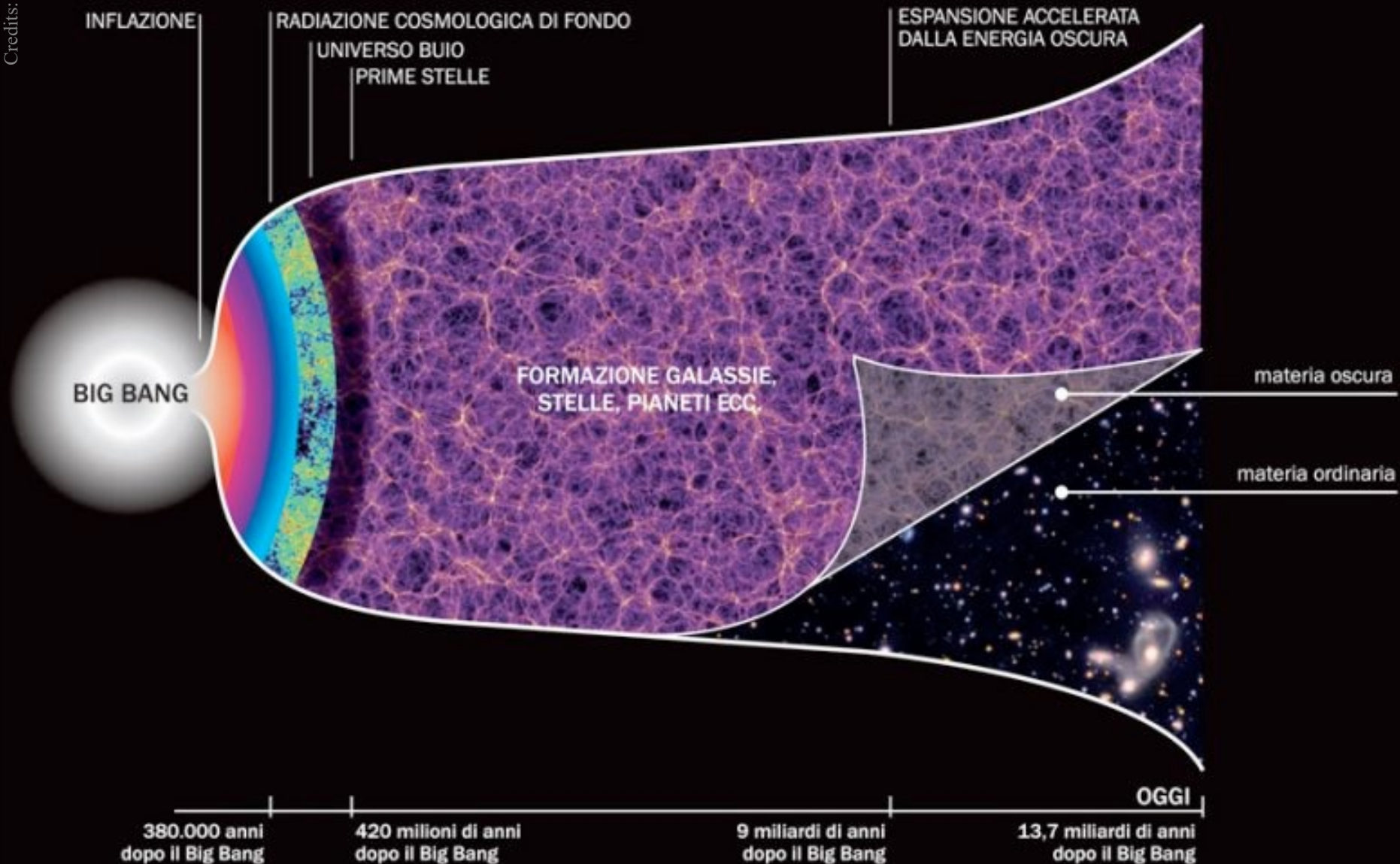
+1

Materia e Antimateria

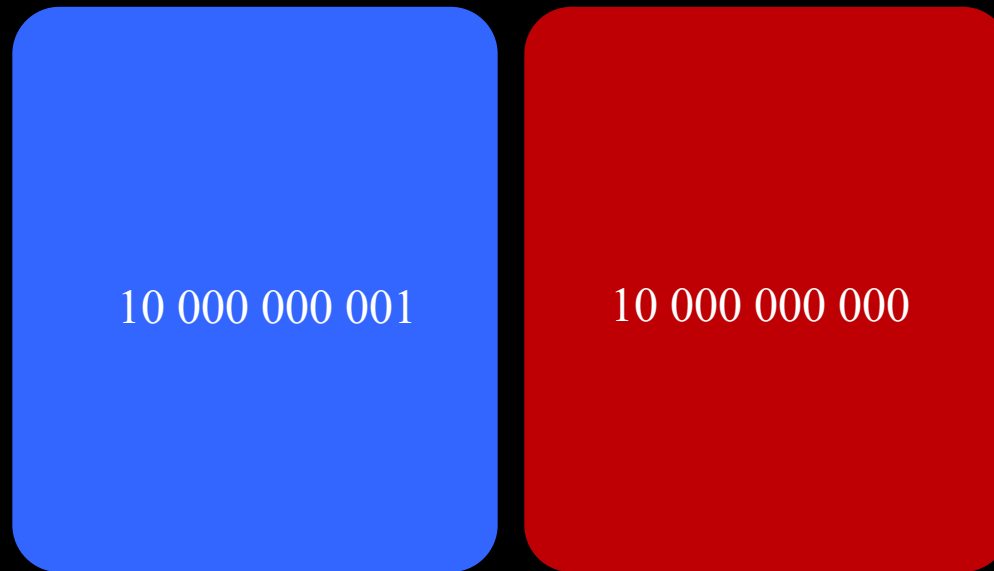


Modello Standard Cosmologico

Credits: Asimmetrie



Materia e Antimateria



Materia

Antimateria

Materia e Antimateria

1

Noi

Credits: Hitoshi Murayama

Andrei Sakharov



[Christian Hirou/Gamma-Rapho, via Getty Images]

Le condizioni di Sakharov

[proposte nel 1967]



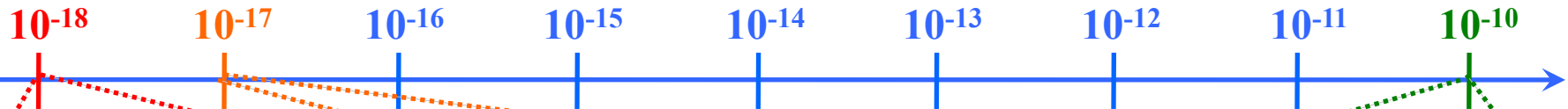
Necessary for evolution of matter-dominated universe, from symmetric state

(1) baryon number violation

(2) C and CP violation

(3) thermal inequilibrium

“Deve esserci una differenza tra materia e antimateria”



$\sim 10^{-18}$

Se si assume che
l'Universo non distingue
tra materia e antimateria

$\sim 10^{-17}$

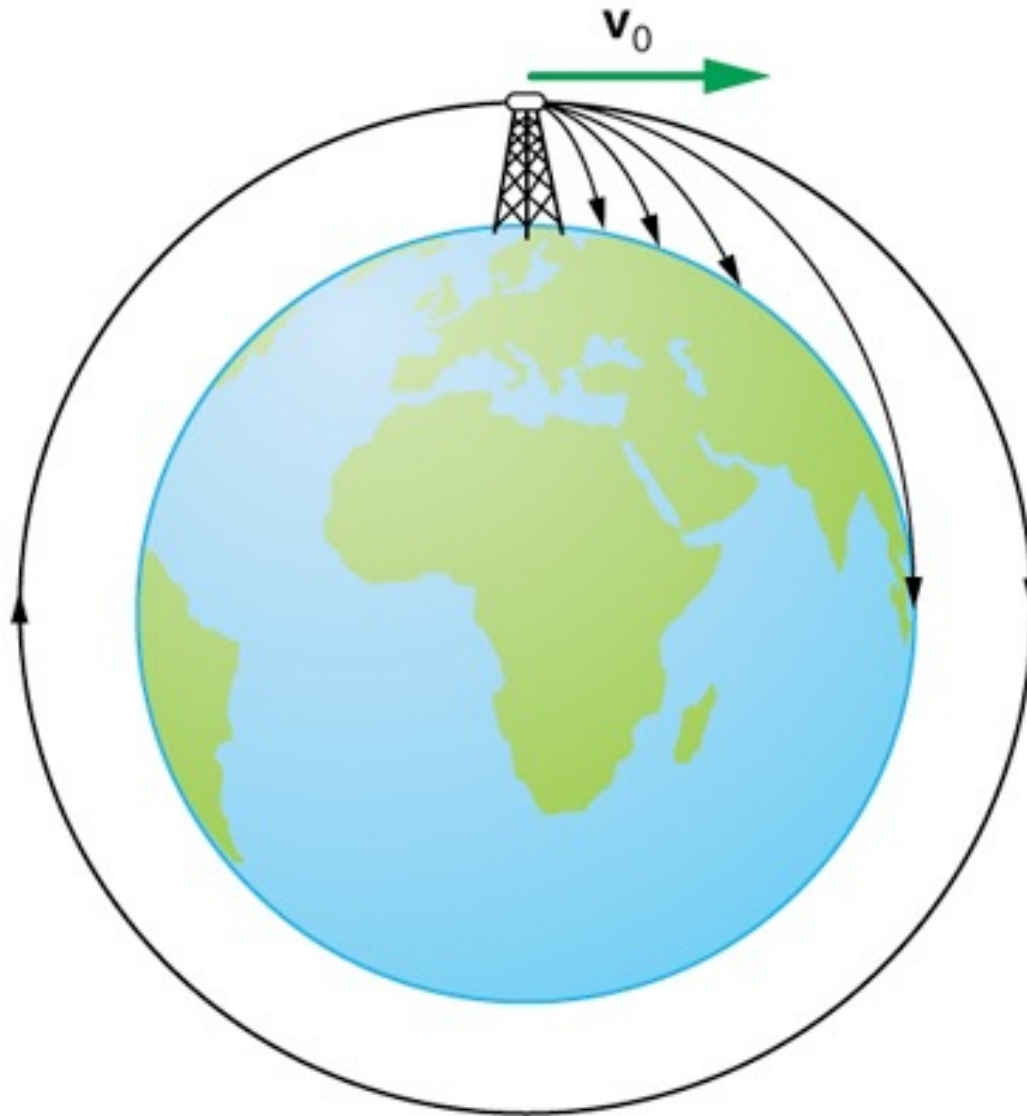
Dalla differenza tra
materia e antimateria
che misuriamo a terra.

$\sim 6 \times 10^{-10}$

Dalla differenza tra
materia e antimateria
necessaria al Big Bang

Illustrazioni di Agostino Iacurci







Coma cluster [Abell 1656]







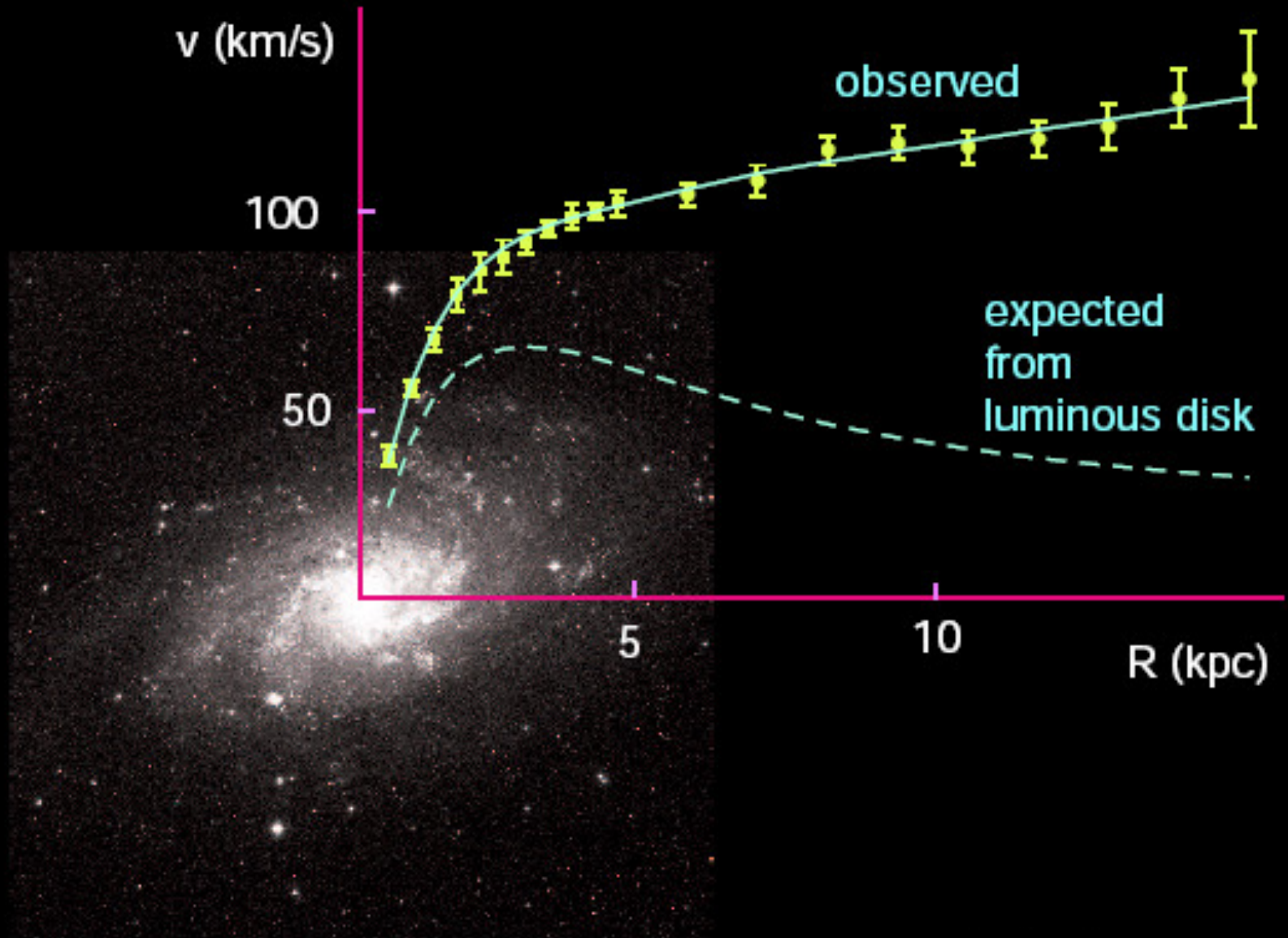
La signora dell'oscurità



Vera Rubin, 1928 - 2016

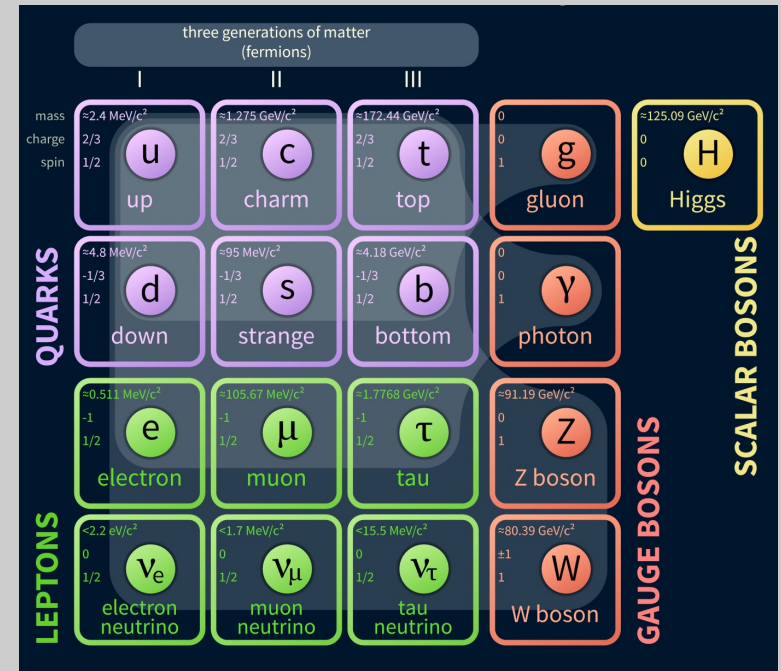
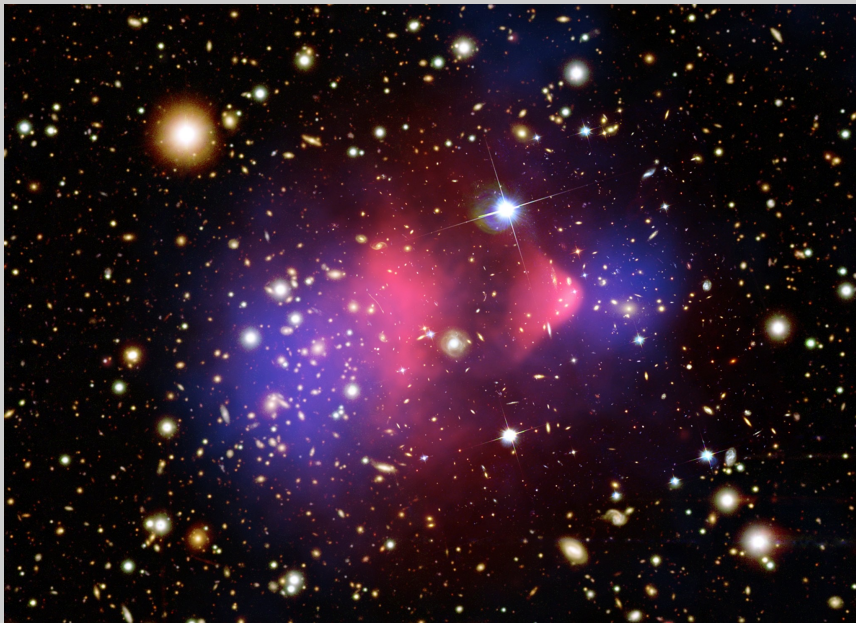


Curve di rotazione [galassia M33]



Open points: SM (and beyond)

- No explanation for the quark hierarchy
- Why are there 3 families/generations?
- No real explanation for CP violation
- Why is it only found in the weak interaction?
- Mass value of the Higgs boson
- EW and strong unification
- ...



- No explanation for baryogenesis
- Dark matter and dark energy
- Neutrino masses
- Gravity
- ...



Riferimenti e approfondimenti

Viaggio «dal capello ai quark»: <https://videos.cern.ch/record/2307613>

«Potenze di 10»: https://www.youtube.com/watch?v=kn_r7QxpMYc

Canale YouTube dei LNF: <https://www.youtube.com/@INFNLNF>

<https://www.lnf.infn.it/edu/kids/da-qui-al-big-bang.php>

Playlist «L'Universo in tasca» (YouTube LNF):

https://www.youtube.com/playlist?list=PLRuUrPCVPFIrw_os9-4avm88c-0gSLfmM

<https://www.asimmetrie.it/>

<https://www.youtube.com/c/AmedeoBalbi>

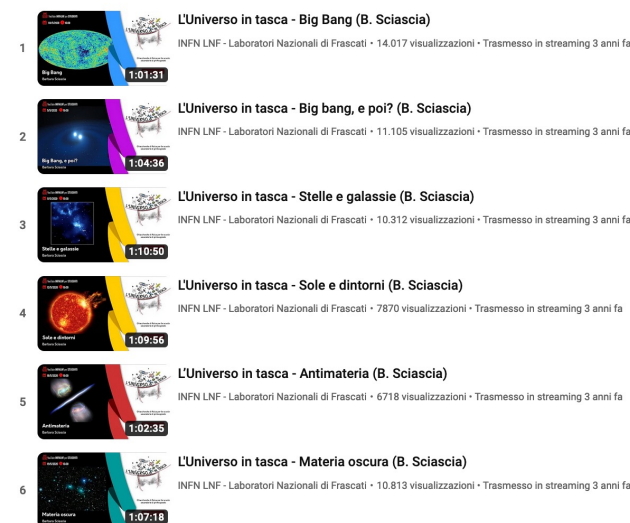
Tavole periodiche:

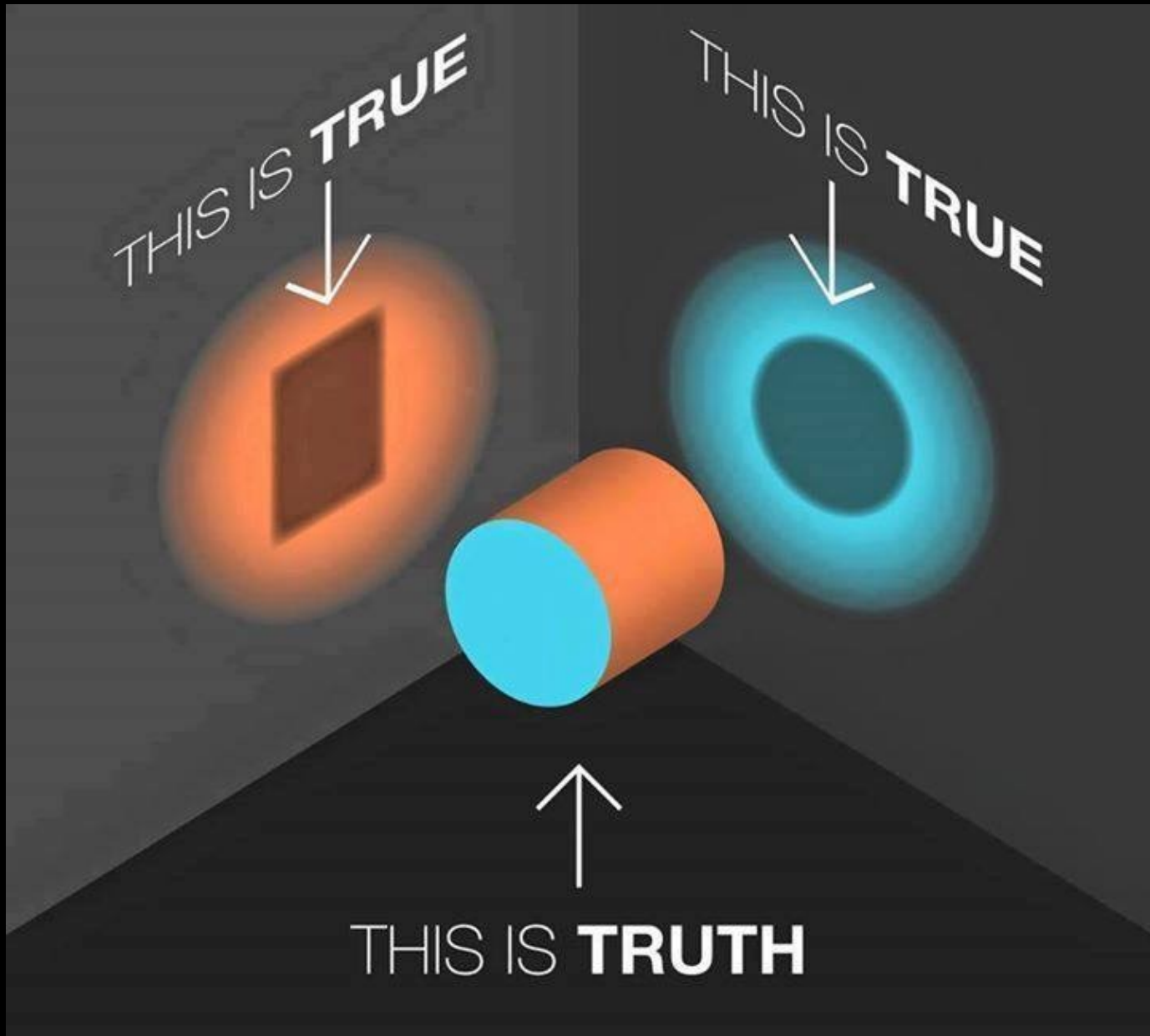
- <https://elements.wlonk.com/> (non aggiornata)

- <https://periodictable.com/>

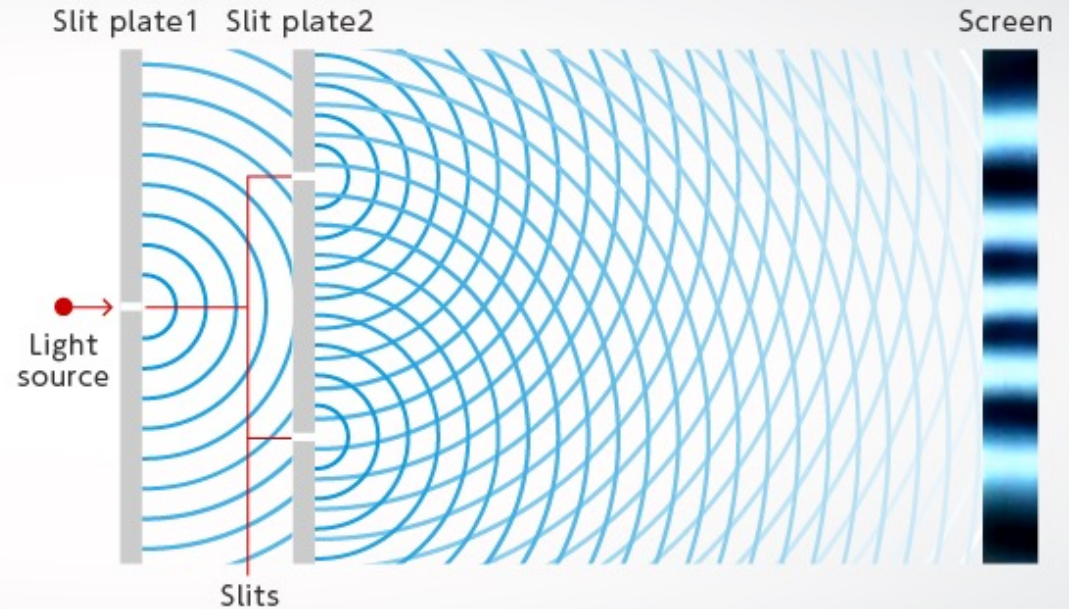
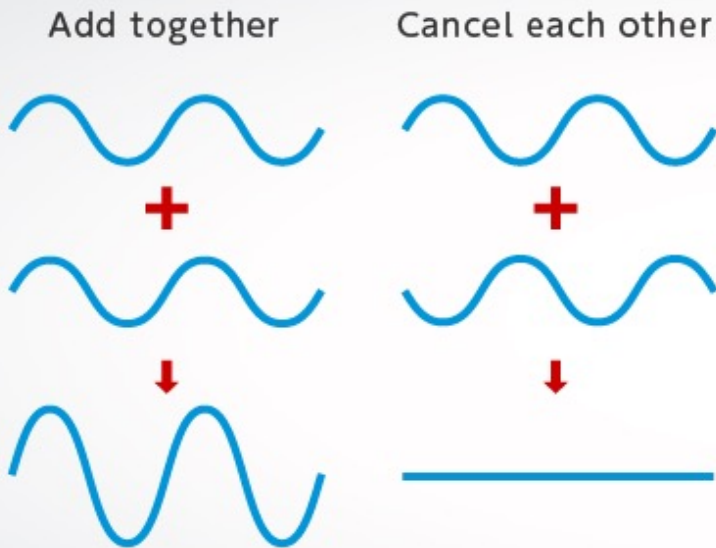
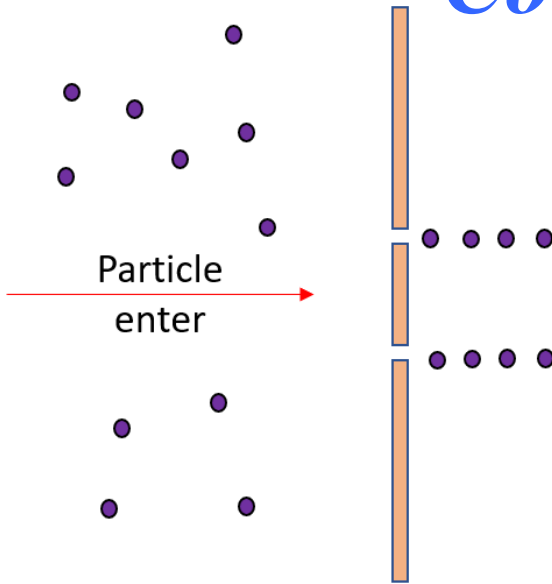
<https://www.ilpost.it/episodes/podcasts/mai-piu/>

Le prime ~100 pagine de «L'universo elegante», Brian Greene, Einaudi





Comportamento di onde e particelle



Antimateria primordiale



CP violation, key dates

