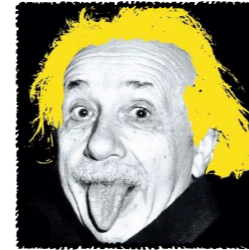


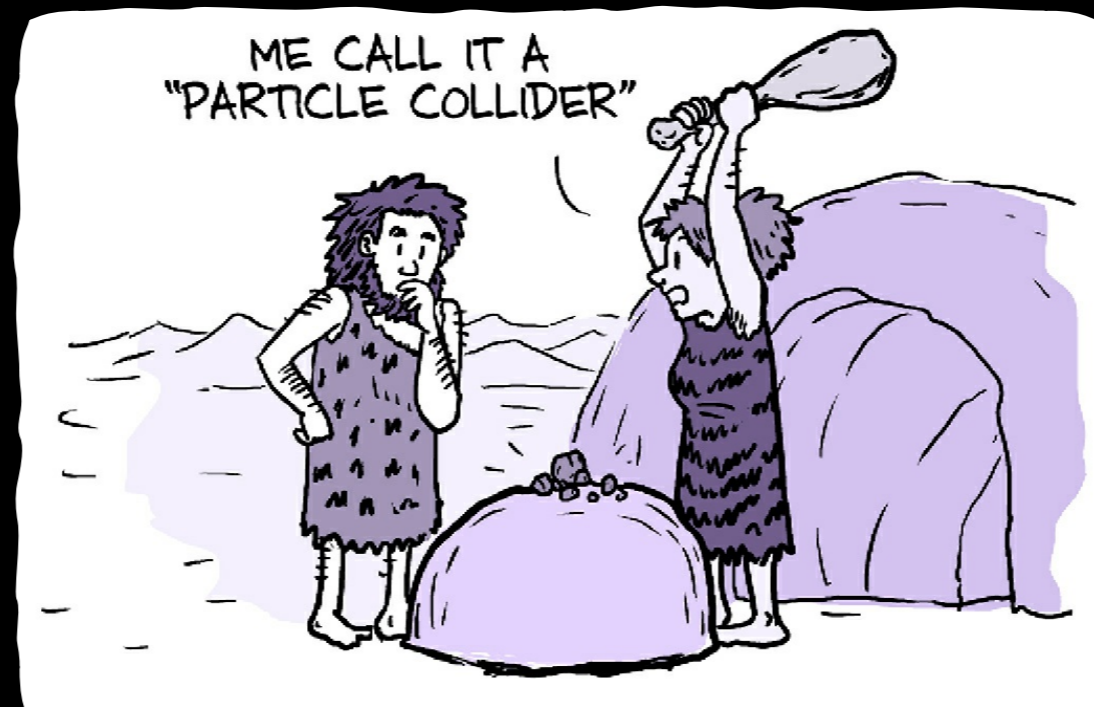
Fisica delle Particelle, in Teoria ...



MAURO VALLI

INFN Rome





FISICI DELLE PARTICELLE AGLI ALBORI ...



... TEORICO?



... SPERIMENTALE!

BIG QUESTIONS

- QUALE E' IL SIGNIFICATO DELL'ESISTENZA?
- COSA CI SARA' MAI OLTRE LA VITA?

CLASSICI DEL PENSIERO

Immanuel Kant

**Critica della
ragion pura**

a cura di Gustavo Bontadini



Scholés

BIG QUESTIONS

- QUALE E' IL SIGNIFICATO DELL'ESISTENZA?
- COSA CI SARA' MAI OLTRE LA VITA?
- LA VITA E' UN SOGNO ...
... O I SOGNI AIUTANO A VIVERE?

**GIGI
MARZULLO**

Non ho capito la domanda

365 DUBBI E ROVELLI
PER TUTTO L'ANNO

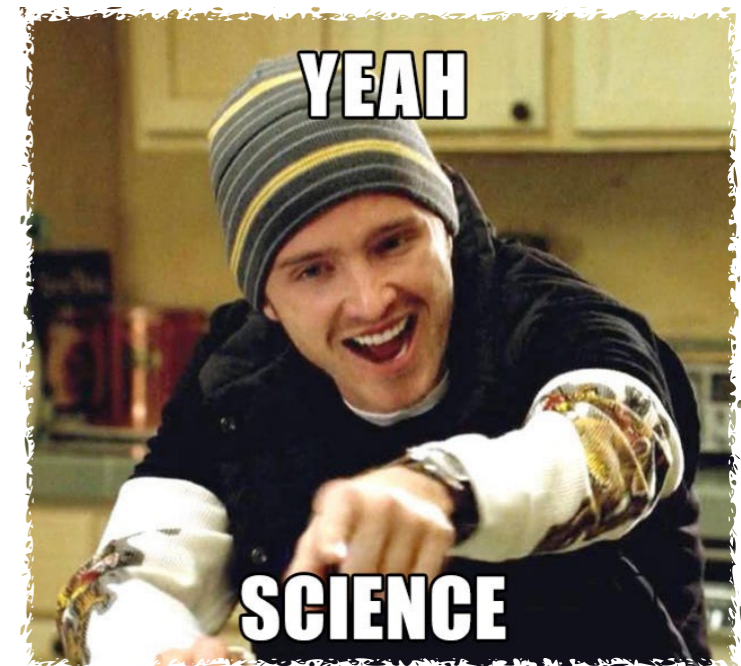


Rai Libri

BIG QUESTIONS

- QUALE E' IL SIGNIFICATO DELL'ESISTENZA?
- COSA CI SARA' MAI OLTRE LA VITA?
- LA VITA E' UN SOGNO ...
... O I SOGNI AIUTANO A VIVERE?

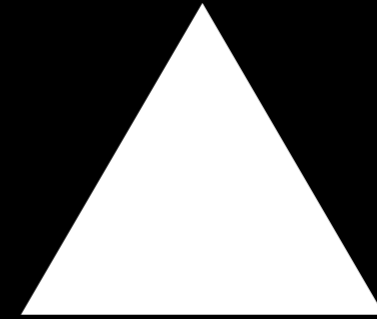
- DI CHE COSA E' FATTO QUELLO CHE CI CIRCONDA?
- COME E' ORIGINATO E SI E' EVOLUTO L'UNIVERSO?



IL METODO SCIENTIFICO

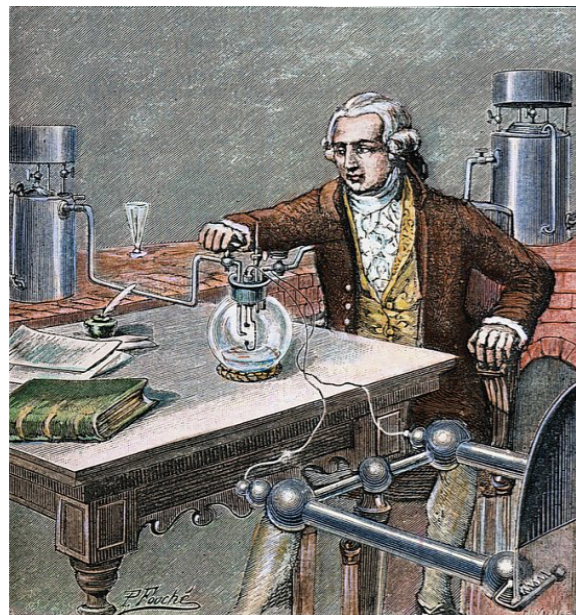


CONOSCENZA / PROGRESSO



TEORIA /
PREDIZIONI

DATI /
ESPERIMENTI



LAVOISIER : UN ELEMENTO
E' UNA SOSTANZA NON
SCOMPONIBILE NELLE VARIE
REAZIONI CHIMICHE ...

L'enorme varietà intorno a noi ... viene da solo un centinaio di elementi chimici!

THE UNIVERSE:

- Me.
- You.
- That rock.
- That other rock.
- Those rocks over there.
- Etc.



THE PERIODIC TABLE OF THE ELEMENTS (TETRIS VERSION)

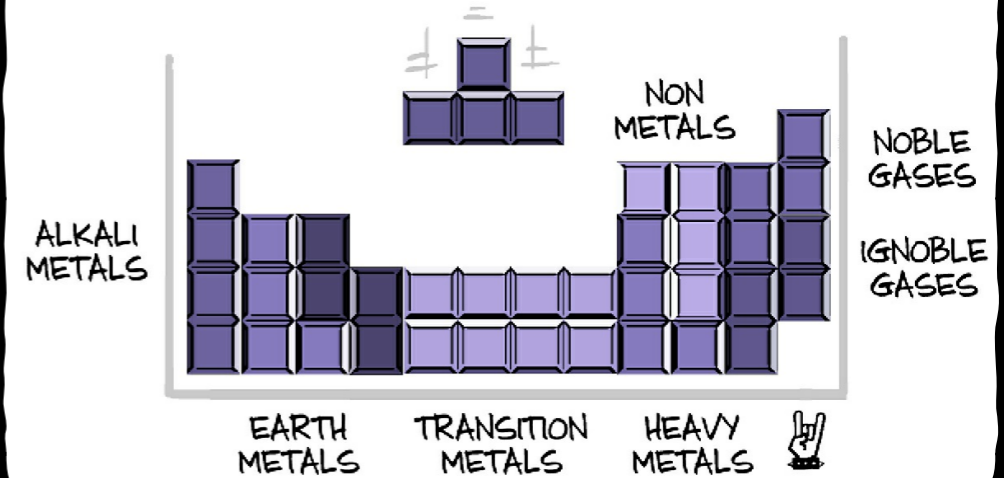
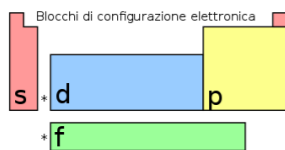


Tavola Periodica degli Elementi

Gruppo 1																	18	
Periodo 1	1.008 1312.0 2.20 1 H Idrogeno 1s ¹																	4.0026 2372.3 2 He Elio 1s ²
2	6.94 520.2 0.98 3 Li Litio 1s ² 2s ¹	9.0122 899.5 1.57 4 Be Berillio 1s ² 2s ²															20.180 2080.7 10 Ne Neon 1s ² 2s ² 2p ⁶	
3	22.990 495.8 0.93 11 Na Sodio (Ne) 3s ¹	24.305 737.7 1.31 12 Mg Magnesio (Ne) 3s ²															39.948 1520.6 18 Ar Argon (Ne) 3s ² 3p ⁶	
4	39.098 418.8 0.82 19 K Potassio (Ar) 4s ¹	40.078 589.8 1.00 20 Ca Calcio (Ar) 4s ²	44.956 633.1 1.36 21 Sc Scandio (Ar) 3d ¹ 4s ²	47.867 658.8 1.54 22 Ti Titanio (Ar) 3d ² 4s ²	50.942 650.9 1.63 23 V Vanadio (Ar) 3d ³ 4s ²	51.996 652.9 1.66 24 Cr Cromo (Ar) 3d ⁵ 4s ¹	54.938 717.3 1.55 25 Mn Manganese (Ar) 3d ⁵ 4s ²	55.845 762.5 1.83 26 Fe Ferro (Ar) 3d ⁶ 4s ²	58.933 726.5 1.83 27 Co Cobalto (Ar) 3d ⁷ 4s ²	58.693 737.1 1.88 28 Ni Nichelio (Ar) 3d ⁸ 4s ²	63.546 745.5 1.90 29 Cu Rame (Ar) 3d ¹⁰ 4s ¹	65.38 906.4 1.65 30 Zn Zinco (Ar) 3d ¹⁰ 4s ²	69.723 578.8 1.81 31 Ga Gallio (Ar) 3d ¹⁰ 4s ² 4p ¹	72.630 762.0 2.01 32 Ge Germanio (Ar) 3d ¹⁰ 4s ² 4p ²	74.922 947.0 2.18 33 As Arsenico (Ar) 3d ¹⁰ 4s ² 4p ³	78.971 941.0 2.55 34 Se Selenio (Ar) 3d ¹⁰ 4s ² 4p ⁴	79.904 1139.9 2.96 35 Br Bromo (Ar) 3d ¹⁰ 4s ² 4p ⁵	83.798 1350.8 3.00 36 Kr Kriptone (Ar) 3d ¹⁰ 4s ² 4p ⁶
5	85.468 403.0 0.82 37 Rb Rubidio (Kr) 5s ¹	87.62 549.5 0.95 38 Sr Stronzio (Kr) 5s ²	88.906 600.0 1.22 39 Y Ittrio (Kr) 4d ¹ 5s ²	91.224 640.1 1.33 40 Zr Zirconio (Kr) 4d ² 5s ²	92.906 652.1 1.60 41 Nb Niobio (Kr) 4d ⁴ 5s ¹	95.95 684.3 2.16 42 Mo Molibdeno (Kr) 4d ⁵ 5s ¹	(98) 702.0 1.90 43 Tc Tecnezio (Kr) 4d ⁵ 5s ²	101.07 712.3 1.55 44 Ru Rutenio (Kr) 4d ⁷ 5s ¹	102.91 719.7 2.28 45 Rh Rodio (Kr) 4d ⁸ 5s ¹	106.42 804.4 2.20 46 Pd Palladio (Kr) 4d ¹⁰	107.87 731.0 1.93 47 Ag Argento (Kr) 4d ¹⁰ 5s ¹	112.41 867.8 1.69 48 Cd Cadmio (Kr) 4d ¹⁰ 5s ²	114.82 558.3 1.78 49 In Indio (Kr) 4d ¹⁰ 5s ² 5p ¹	118.71 708.6 1.96 50 Sn Stagno (Kr) 4d ¹⁰ 5s ² 5p ²	121.76 834.0 2.05 51 Sb Antimonio (Kr) 4d ¹⁰ 5s ² 5p ³	127.60 869.3 2.10 52 Te Tellurio (Kr) 4d ¹⁰ 5s ² 5p ⁴	126.90 1008.4 2.66 53 I Iodio (Kr) 4d ¹⁰ 5s ² 5p ⁵	131.29 1170.4 2.60 54 Xe Xenone (Kr) 4d ¹⁰ 5s ² 5p ⁶
6	132.91 375.7 0.79 55 Cs Cesio (Xe) 6s ¹	137.33 502.9 0.89 56 Ba Bario (Xe) 6s ²	174.97 523.5 1.27 71 Lu Lutezio (Xe) 4f ¹⁴ 5d ¹ 6s ²	178.49 658.5 1.30 72 Hf Afrio (Xe) 4f ¹⁴ 5d ² 6s ²	180.95 761.0 1.50 73 Ta Tantalio (Xe) 4f ¹⁴ 5d ³ 6s ²	183.84 770.0 2.36 74 W Tungsteno (Xe) 4f ¹⁴ 5d ⁴ 6s ²	186.21 760.0 1.90 75 Re Renio (Xe) 4f ¹⁴ 5d ⁵ 6s ²	190.23 840.0 2.20 76 Os Osmio (Xe) 4f ¹⁴ 5d ⁶ 6s ²	192.22 880.0 2.28 77 Ir Iridio (Xe) 4f ¹⁴ 5d ⁷ 6s ²	195.08 870.0 2.28 78 Pt Platino (Xe) 4f ¹⁴ 5d ⁹ 6s ¹	196.97 890.1 2.54 79 Au Oro (Xe) 4f ¹⁴ 5d ¹⁰ 6s ¹	200.59 1007.1 2.00 80 Hg Mercurio (Xe) 4f ¹⁴ 5d ¹⁰ 6s ²	204.38 589.4 1.62 81 Tl Tallio (Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ¹	207.2 715.6 2.33 82 Pb Piombo (Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ²	208.98 703.0 2.02 83 Bi Bismuto (Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ³	(210) 812.1 2.00 84 Po Polonio (Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁴	(210) 890.0 2.20 85 At Astatio (Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁵	(220) 1037.0 86 Rn Radone (Xe) 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁶
7	(223) 380.0 0.70 87 Fr Francio (Rn) 7s ¹	(226) 509.3 0.90 88 Ra Radio (Rn) 7s ²	(262) 470.0 103 Lr Laurenzio (Rn) 5f ¹⁴ 6d ¹ 7p ¹	(261) 580.0 104 Rf Rutherfordio (Rn) 5f ¹⁴ 6d ² 7s ²	(262) 580.0 105 Db Dubnio (Rn) 5f ¹⁴ 6d ³ 7s ²	(266) 580.0 106 Sg Seaborgio (Rn) 5f ¹⁴ 6d ⁴ 7s ²	(264) 580.0 107 Bh Bohrio (Rn) 5f ¹⁴ 6d ⁵ 7s ²	(277) 580.0 108 Hs Hassio (Rn) 5f ¹⁴ 6d ⁶ 7s ²	(268) 580.0 109 Mt Meitnerio (Rn) 5f ¹⁴ 6d ⁷ 7s ²	(271) 580.0 110 Ds Darmstadtio (Rn) 5f ¹⁴ 6d ⁸ 7s ²	(272) 580.0 111 Rg Roentgenio (Rn) 5f ¹⁴ 6d ⁹ 7s ²	(285) 580.0 112 Cn Copernicio (Rn) 5f ¹⁴ 6d ¹⁰ 7s ²	(284) 580.0 113 Nh Nihonio (Rn) 5f ¹⁴ 6d ¹⁰ 7s ² 7p ¹	(289) 580.0 114 Fl Flerovio (Rn) 5f ¹⁴ 6d ¹⁰ 7s ² 7p ²	(288) 580.0 115 Mc Moscovio (Rn) 5f ¹⁴ 6d ¹⁰ 7s ² 7p ³	(292) 580.0 116 Lv Livermorio (Rn) 5f ¹⁴ 6d ¹⁰ 7s ² 7p ⁴	(294) 580.0 117 Ts Tennesso (Rn) 5f ¹⁴ 6d ¹⁰ 7s ² 7p ⁵	(294) 580.0 118 Og Oganesson (Rn) 5f ¹⁴ 6d ¹⁰ 7s ² 7p ⁶

peso atomico standard o numero di massa più stabile: 55.845
 prima energia di ionizzazione in kJ/mol: 762.5 1.83
 simbolo chimico: Fe
 nome: Ferro
 configurazione elettronica: [Ar] 3d⁶ 4s²
 numero atomico: 26
 elettronegatività: +5, +4, +3, +2, +1, -1, -2
 stati di ossidazione: elementi più comuni sono in grassetto

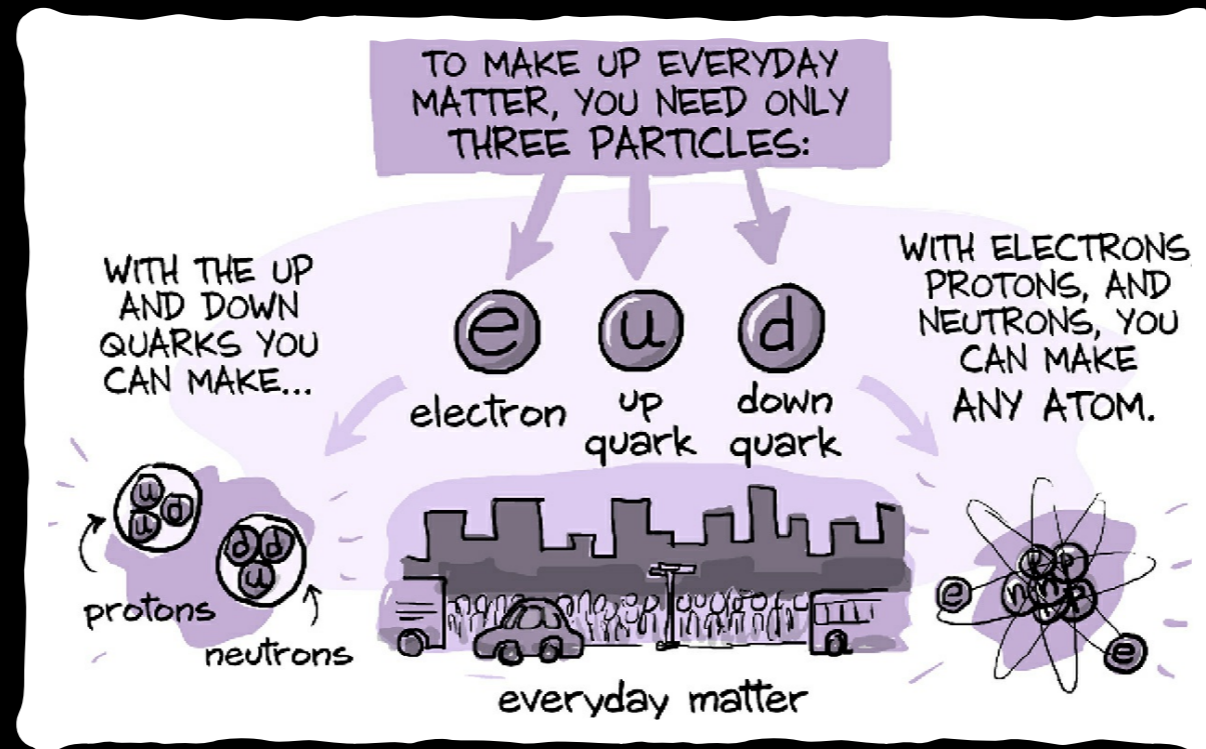
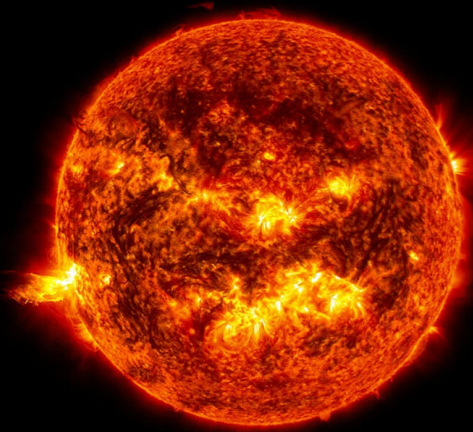


Note

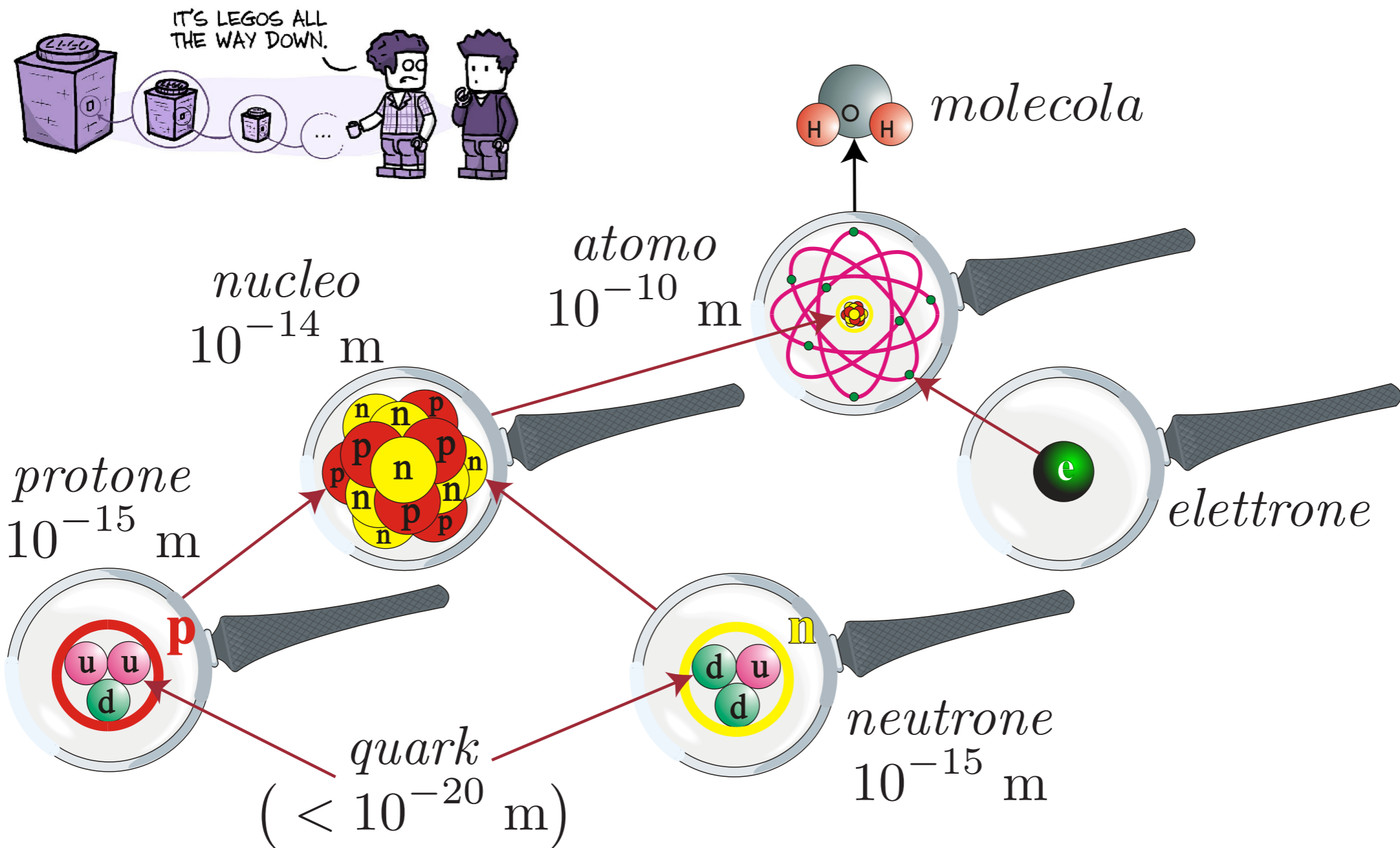
- 1 kJ/mol ≈ 0.0103636 eV
- tutti gli elementi sono impliciti a avere l'ossidazione di zero.

■ metalli alcalini ■ metalli alcalino terrosi ■ lantanoidi ■ attinoidi ■ metalli di transizione ■ proprietà sconosciute ■ metalli di post-transizione ■ metalloidi ■ non metalli reattivi ■ gas nobili

MATERIA << ORDINARIA >>



DALLA MATERIA << ORDINARIA >> ...



... ALLA FISICA DELLE PARTICELLE!

L'ENORME VARIETÀ INTORNO A NOI ...
... VIENE SOLO DA 3 PARTICELLE!

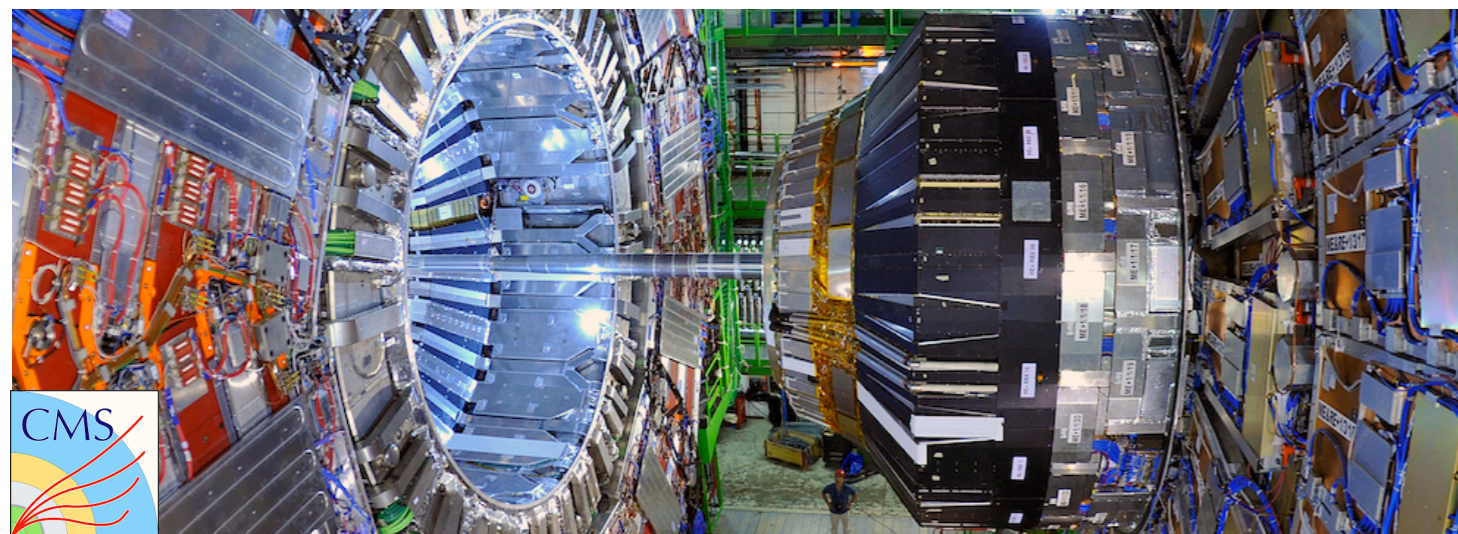
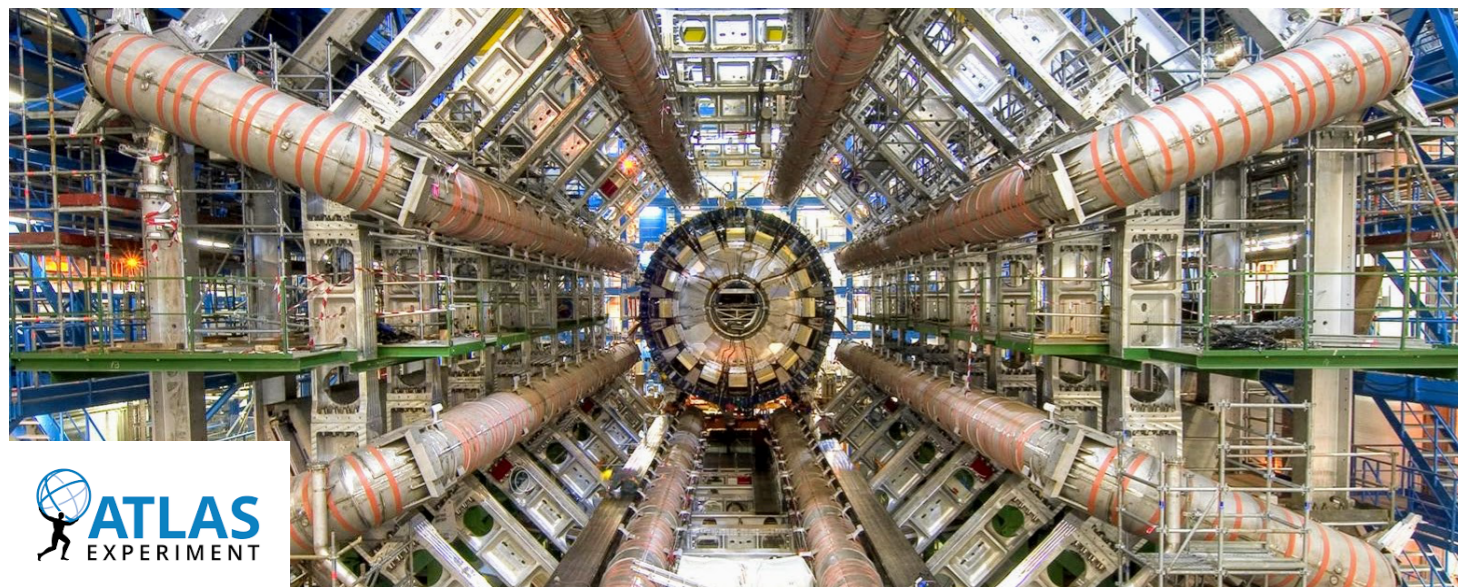


... UH-UUUH, MIITICO!!!

... BEH, SI' ... PERO', A DIRE IL VERO ... NON PROPRIO ...

















LA TAVOLA PERIODICA (QUELLA AGGIORNATA)



	$massa \rightarrow \approx 2.3 \text{ MeV}/c^2$ $carica \rightarrow \frac{2}{3}$ $spin \rightarrow \frac{1}{2}$	$\approx 1.275 \text{ GeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$	$\approx 173.07 \text{ GeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$
	u	c	t
	<i>up</i>	<i>charm</i>	<i>top</i>
Quark	$\approx 4.8 \text{ MeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$	$\approx 95 \text{ MeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$	$\approx 4.18 \text{ GeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$
	d	s	b
	<i>down</i>	<i>strange</i>	<i>bottom</i>
	$0.511 \text{ MeV}/c^2$ -1 $\frac{1}{2}$	$105.7 \text{ MeV}/c^2$ -1 $\frac{1}{2}$	$1.777 \text{ GeV}/c^2$ -1 $\frac{1}{2}$
	e	μ	τ
	<i>elettrone</i>	<i>muone</i>	<i>tauone</i>
Leptoni	$< 2.2 \text{ eV}/c^2$ 0 $\frac{1}{2}$	$< 0.17 \text{ MeV}/c^2$ 0 $\frac{1}{2}$	$< 15.5 \text{ MeV}/c^2$ 0 $\frac{1}{2}$
	ν_e	ν_μ	ν_τ
	<i>neutrino elettronico</i>	<i>neutrino muonico</i>	<i>neutrino tauonico</i>

THE "FUNDAMENTAL" MATTER PARTICLES

1st GENERATION 2nd GENERATION 3rd GENERATION CHARGE

QUARKS: 	UP 	CHARM 	TOP 	+2/3
	DOWN 	STRANGE 	BOTTOM 	-1/3
LEPTONS: 	ELECTRON 	MUON 	TAU 	-1
	ν_{ELECTRON} 	ν_{MUON} 	ν_{TAU} 	0

SOME MASS → MORE MASS → EVEN MORE MASS →

i) E' LA TABELLA << DEFINITIVA >> ?

ii) PERCHE' BEN DUE COPIE IN PIU' ?

... copie pesanti ... ed ancora più pesanti?!

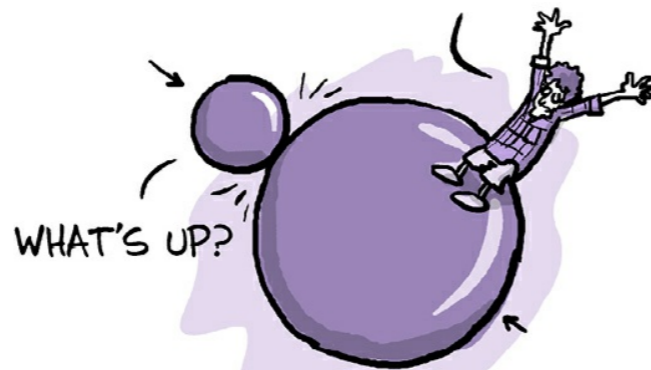
... particelle quark con carica frazionaria ?!

SONO QUESTI I MATTONCINI FONDAMENTALI
PER COSTRUIRE IL NOSTRO UNIVERSO?

Beh ... non ci scordiamo delle 4 FORZE FONDAMENTALI!

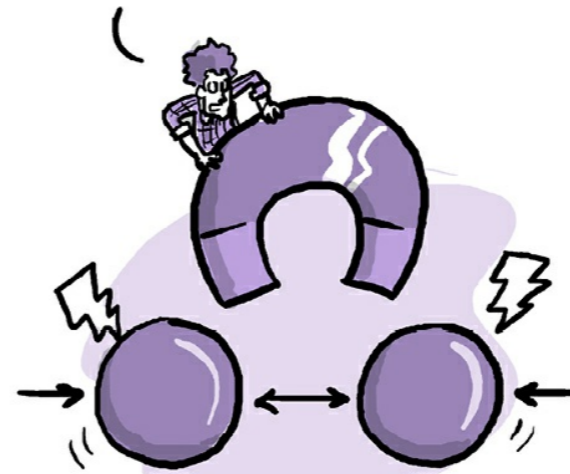
THE 4 MAJOR WAYS THAT THINGS INTERACT:

IF YOU HAVE ANY MASS AT ALL, THINGS GET ATTRACTED.



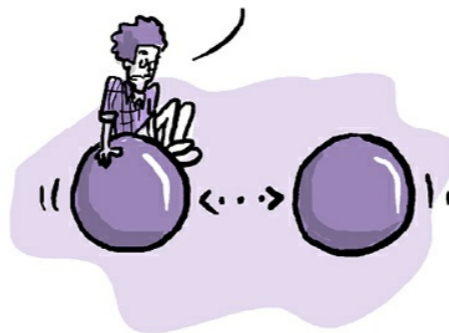
GRAVITY

TWO CHARGES ATTRACT OR REPEL EACH OTHER.



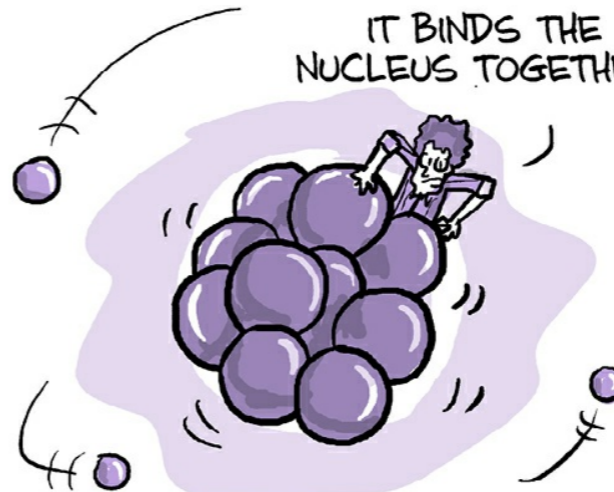
ELECTROMAGNETISM

IT'S LIKE ELECTROMAGNETIC FORCES, BUT MUCH, MUCH WEAKER.



WEAK FORCE

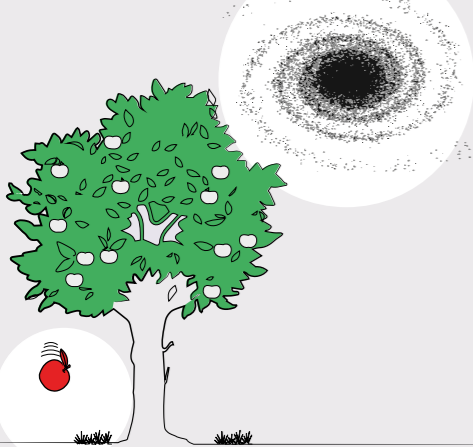
IT BINDS THE NUCLEUS TOGETHER.



STRONG FORCE

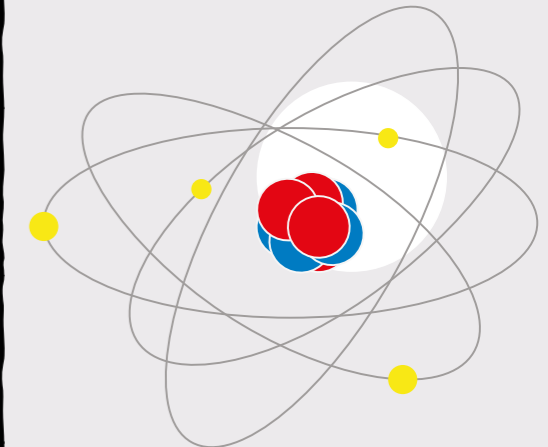
INTERAZIONE GRAVITAZIONALE

Raggio d'azione infinito



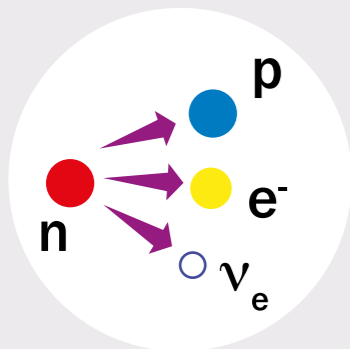
INTERAZIONE ELETTROMAGNETICA

Raggio d'azione infinito



INTERAZIONE DEBOLE

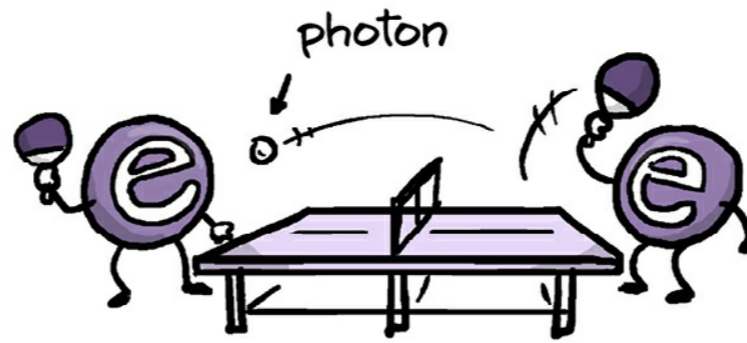
Raggio d'azione 10^{-17} m



INTERAZIONE FORTE




Raggio d'azione 10^{-15} m



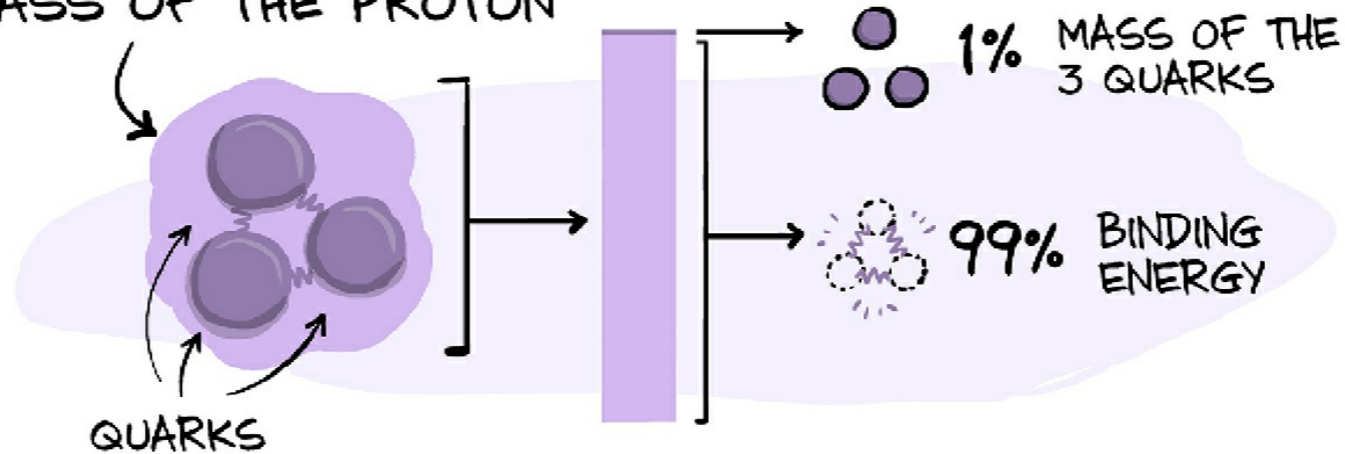


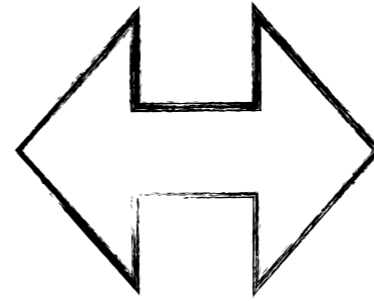
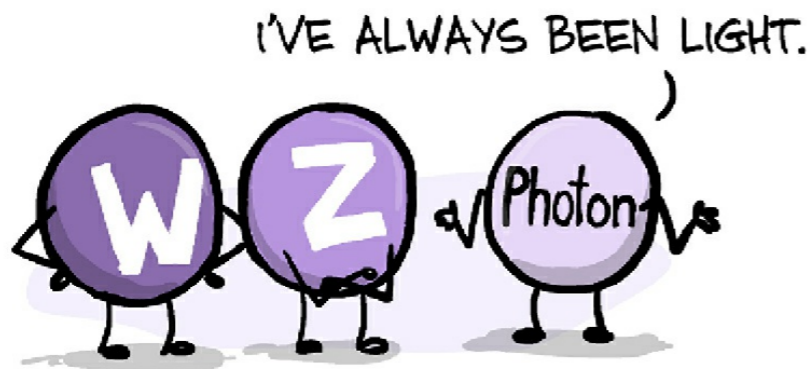
A NOT-THAT-INACCURATE DEPICTION OF PARTICLE FORCE INTERACTION

FORCE CARRIER PARTICLES

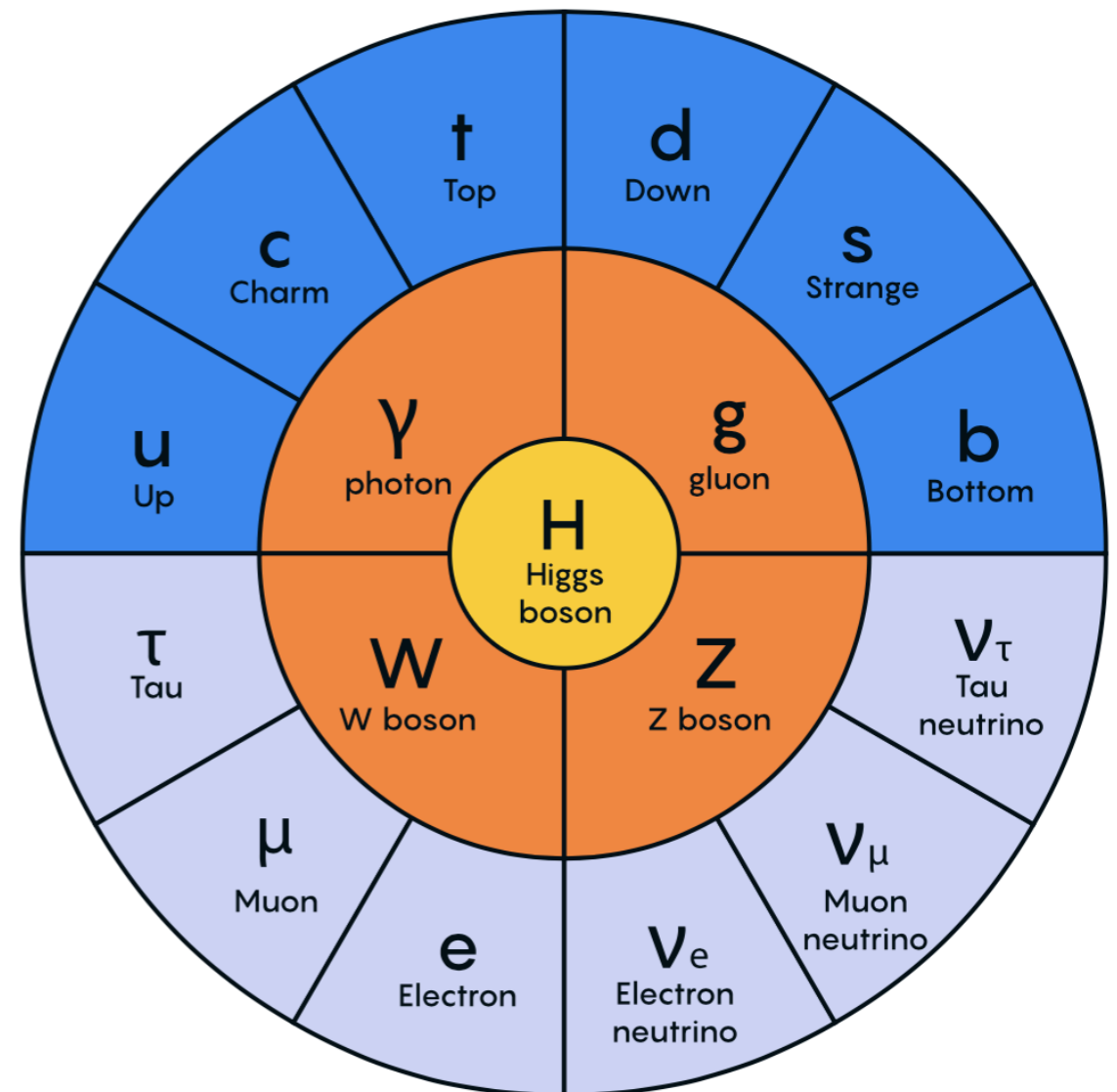
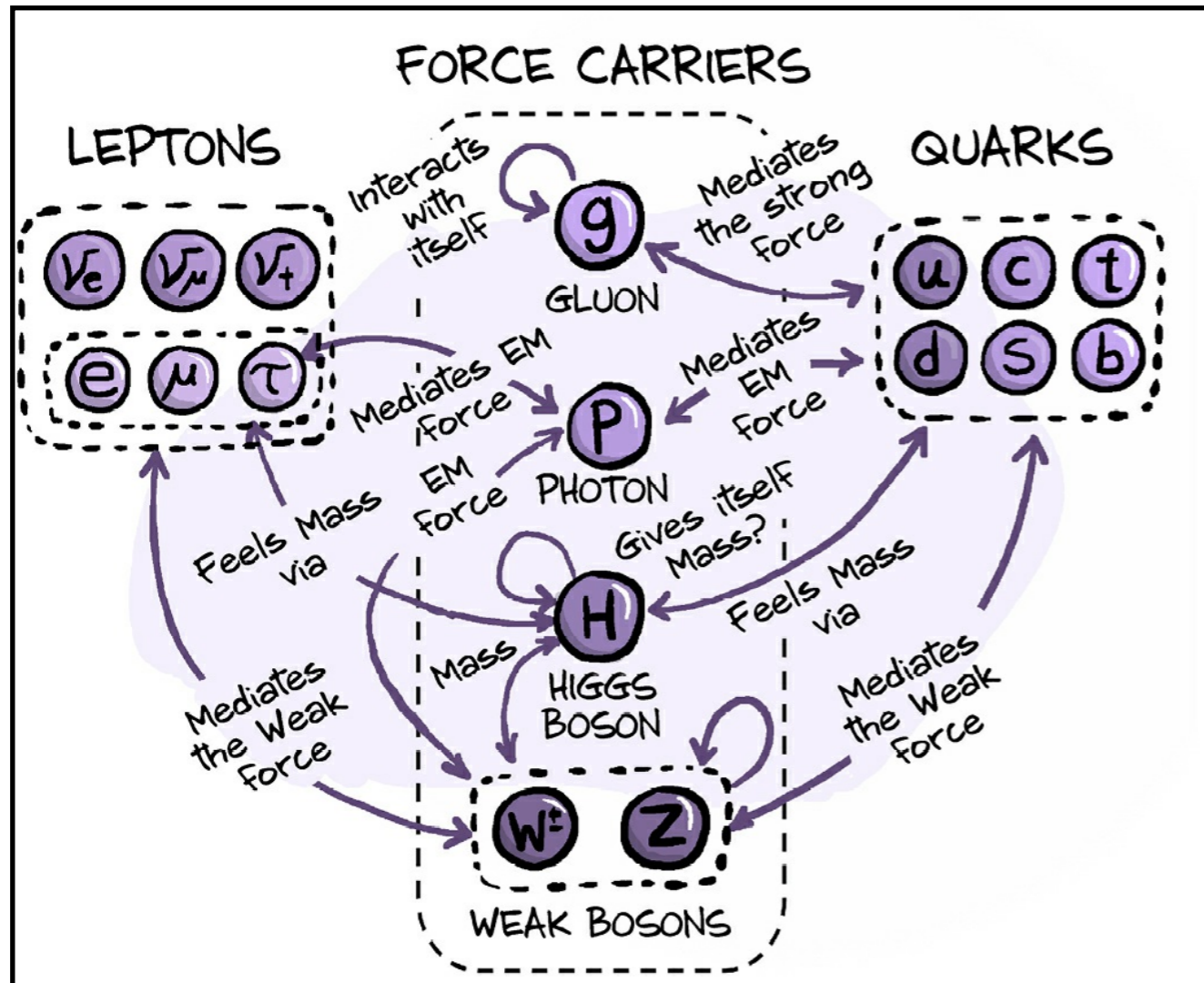
FORCE PARTICLE	FORCE IT TRANSMITS
 PHOTON	ELECTROMAGNETIC FORCE
 W, Z BOSONS	WEAK FORCE
 GLUON	STRONG FORCE

MASS OF THE PROTON





IL BOSONE DI HIGGS COMPLETA IL MODELLO STANDARD!



ALLA BASE DEL MODELLO STANDARD, LE SIMMETRIE

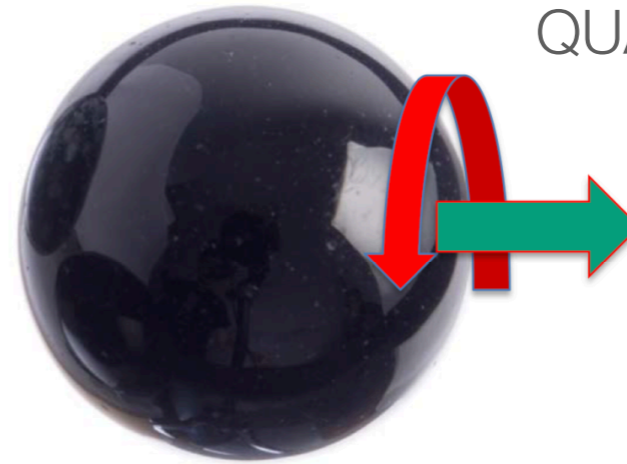


**SIMMETRIA
CILINDRICA**

INVARIANZA
SOTTO
ROTAZIONI
INTORNO
ALL'ASSE
DEL CILINDRO

**SIMMETRIA
SFERICA**

INVARIANZA
SOTTO ROTAZIONI
INTORNO A UN
QUALUNQUE ASSE



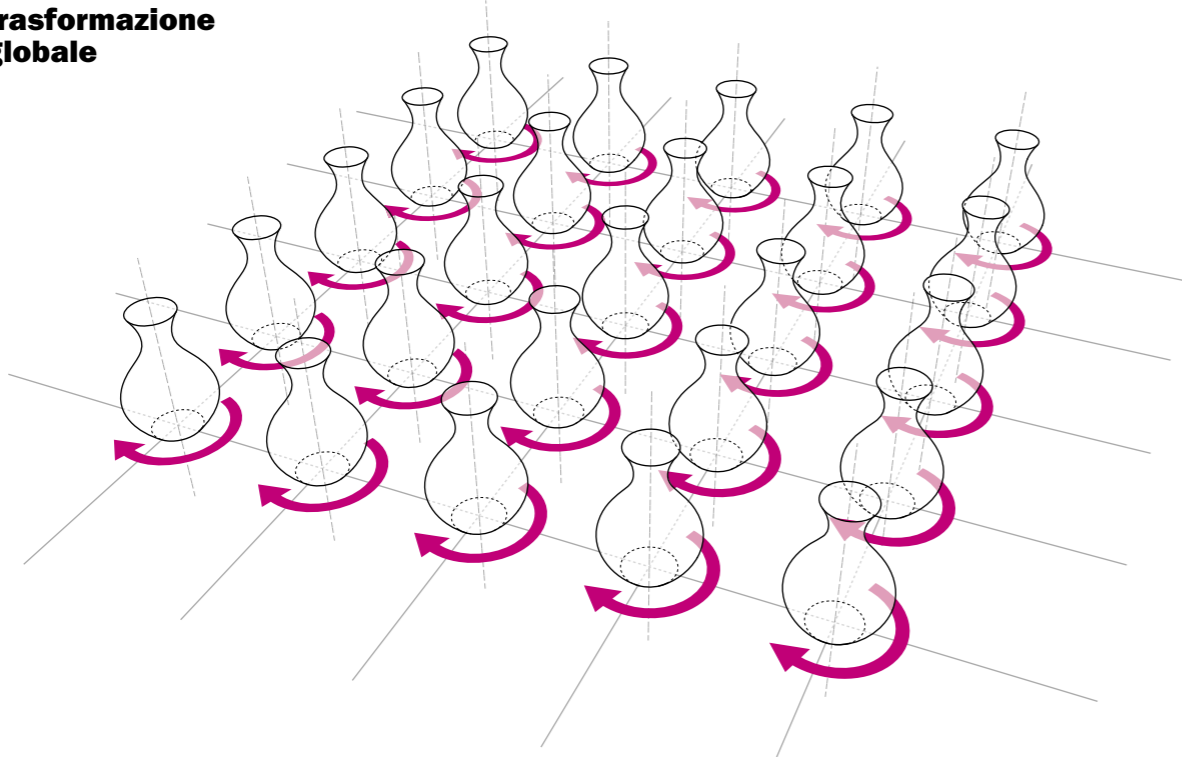
M
I
L
E
V
A



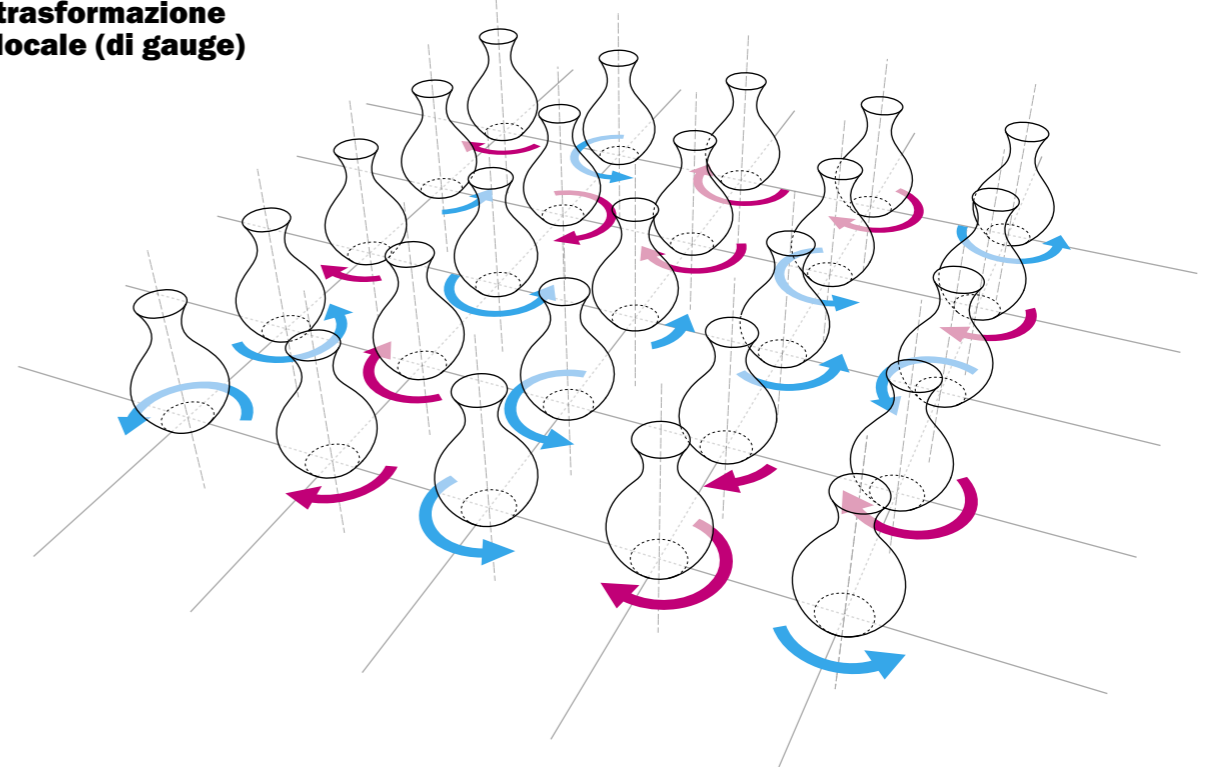
M
A
R
I
C

ALLA BASE DEL MODELLO STANDARD, LE SIMMETRIE

trasformazione globale



trasformazione locale (di gauge)

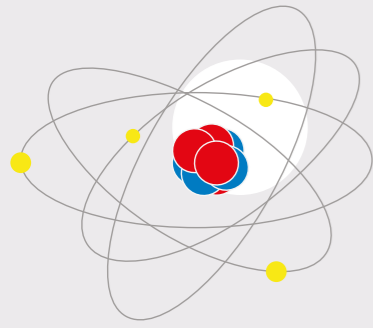


M
I
L
E
V
A

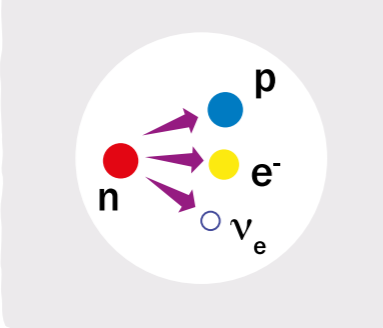


M
A
R
I
C

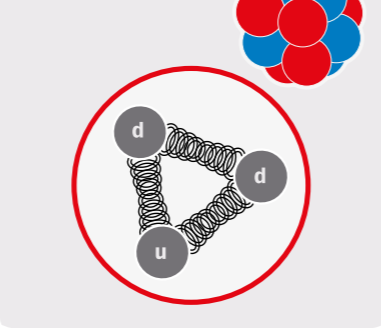
INTERAZIONE ELETTROMAGNETICA
Raggio d'azione infinito



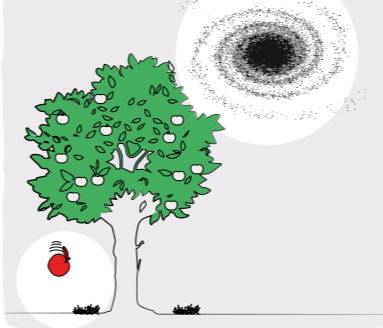
INTERAZIONE DEBOLE
Raggio d'azione 10^{-17} m



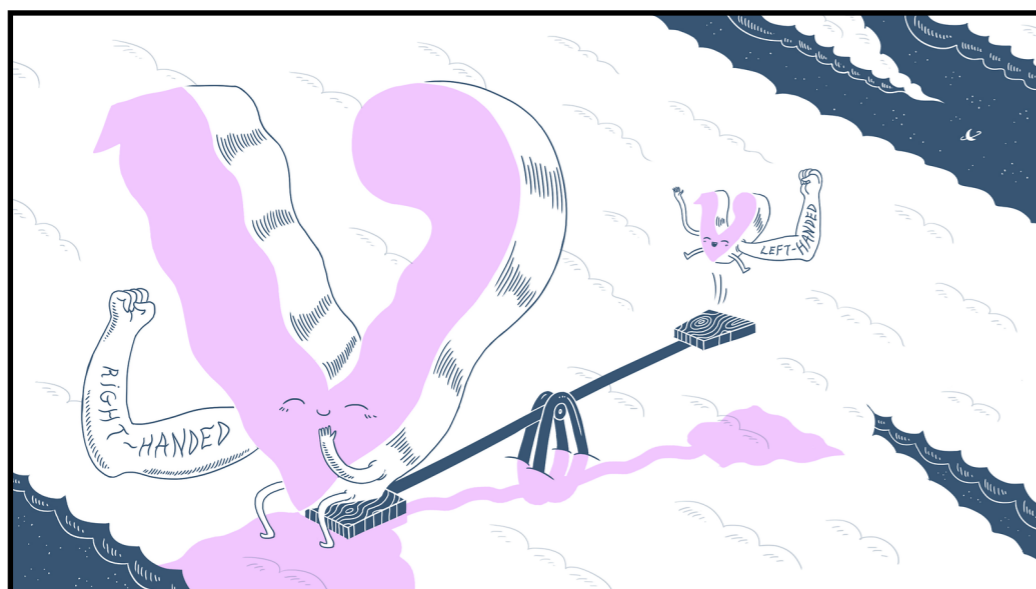
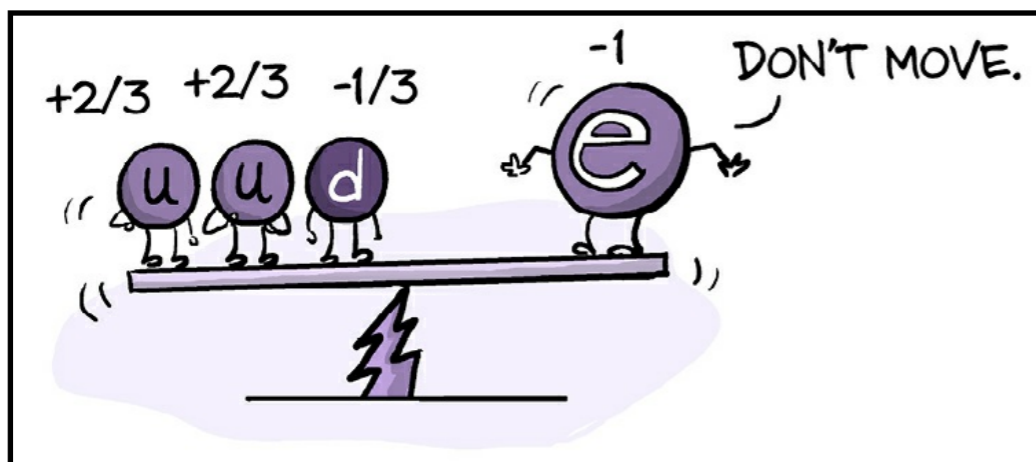
INTERAZIONE FORTE
Raggio d'azione 10^{-15} m



INTERAZIONE GRAVITAZIONALE
Raggio d'azione infinito



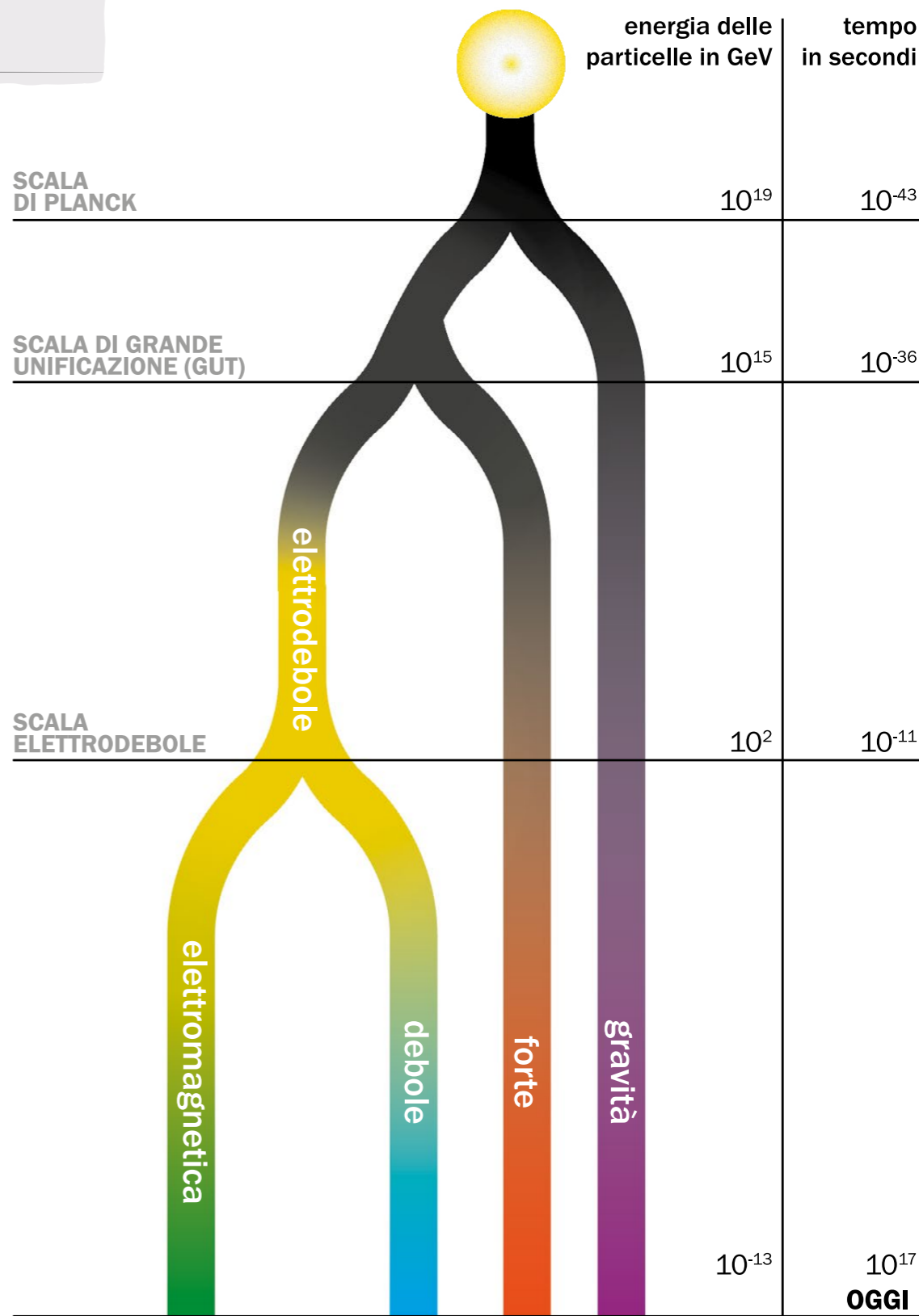
OLTRE IL MODELLO STANDARD: LA GRANDE UNIFICAZIONE

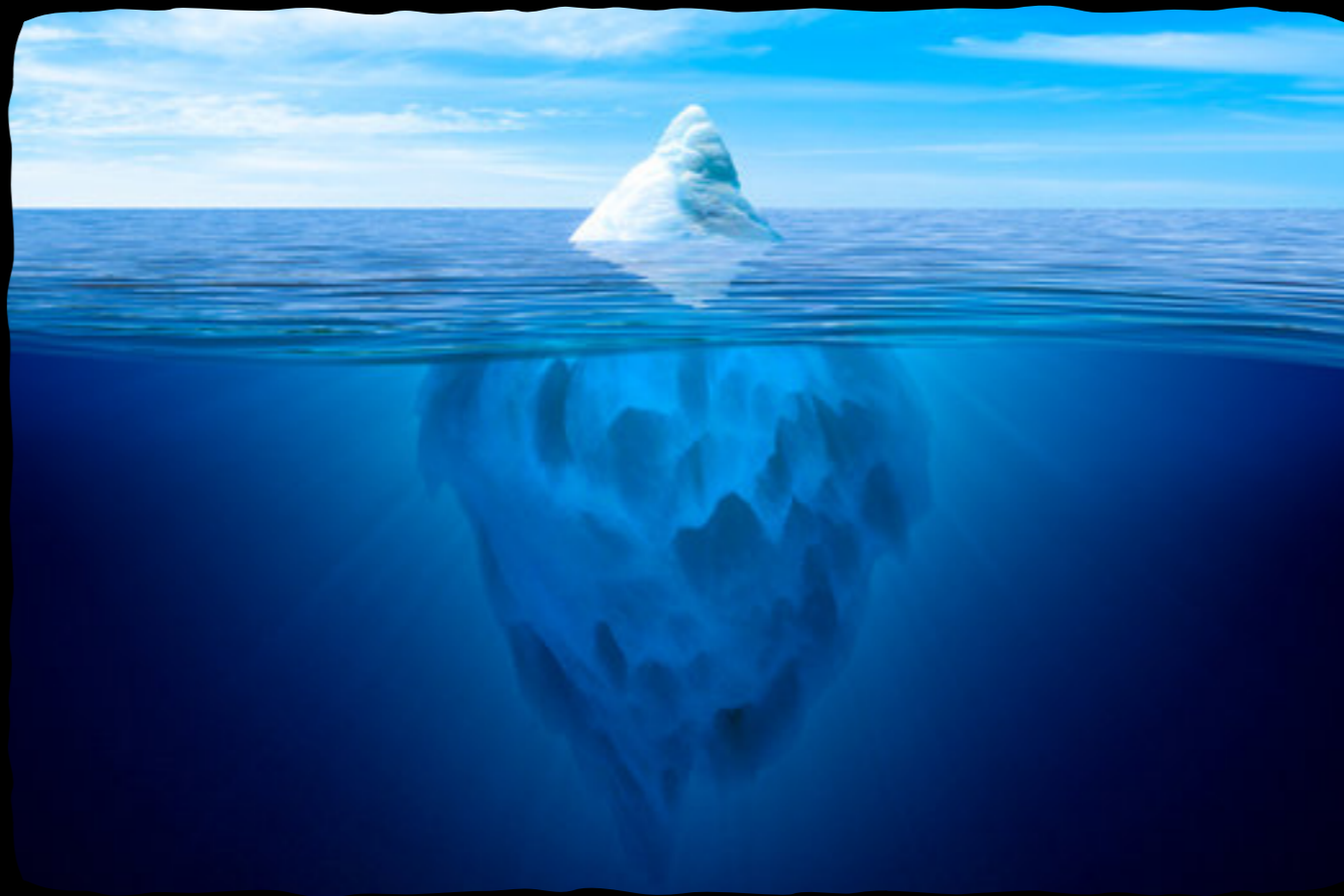


SCALA DI PLANCK

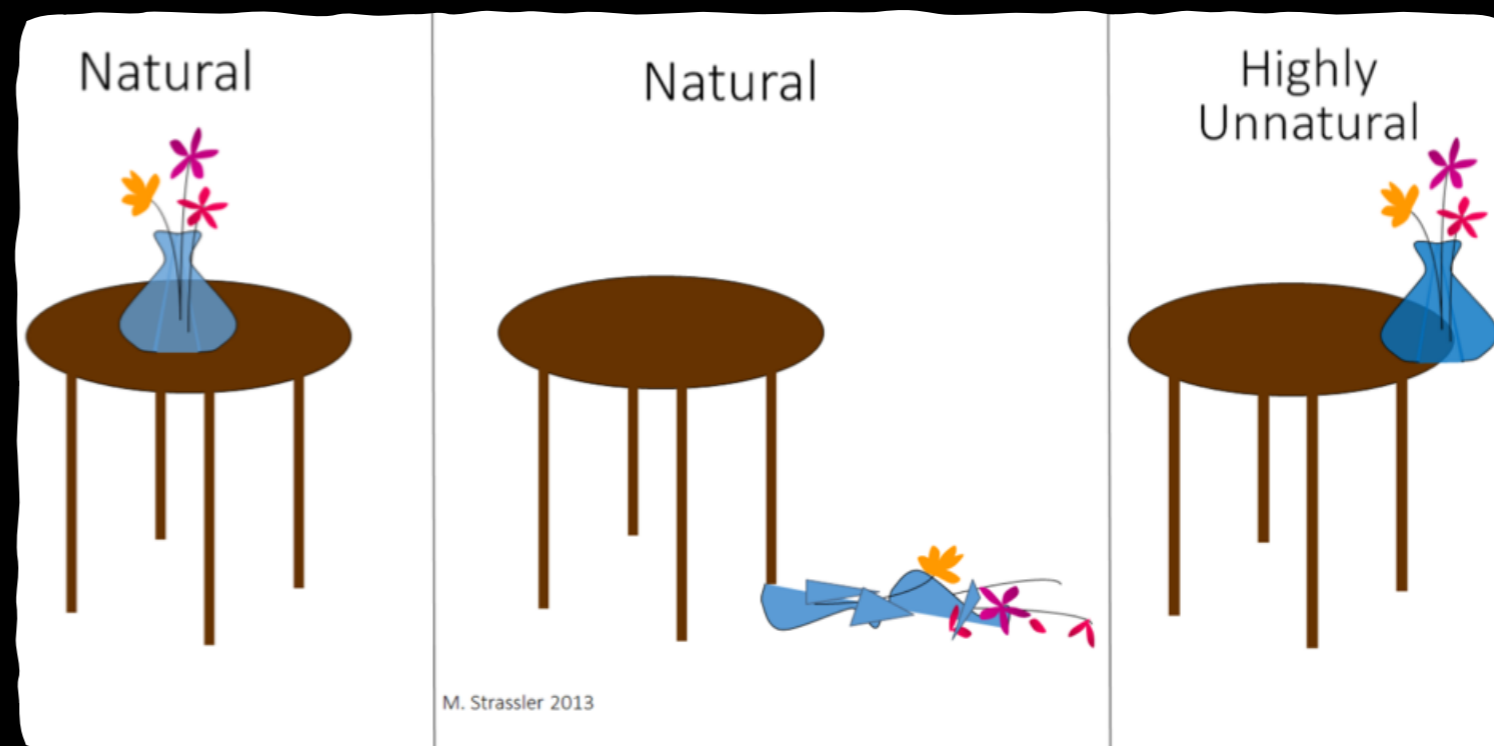
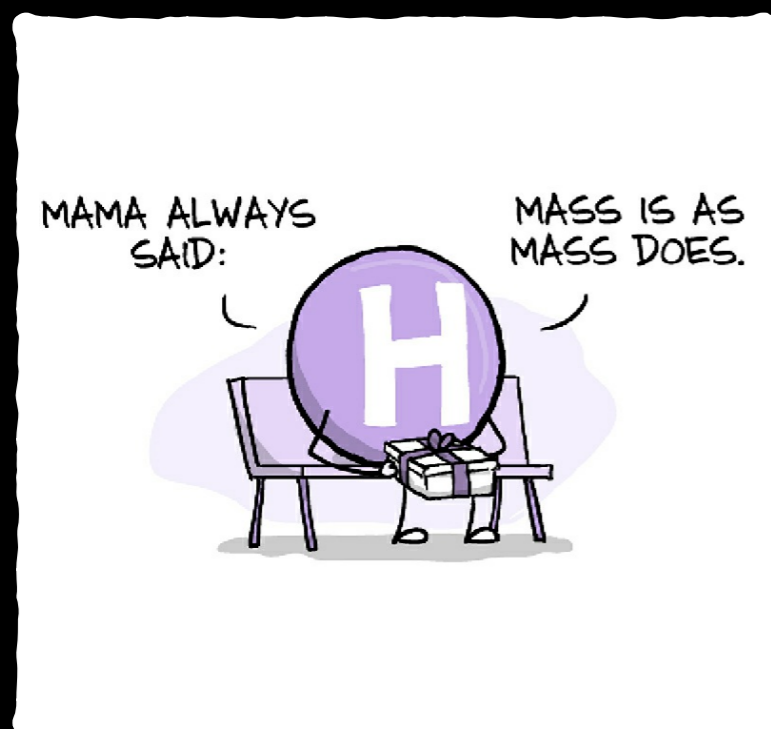
SCALA DI GRANDE UNIFICAZIONE (GUT)

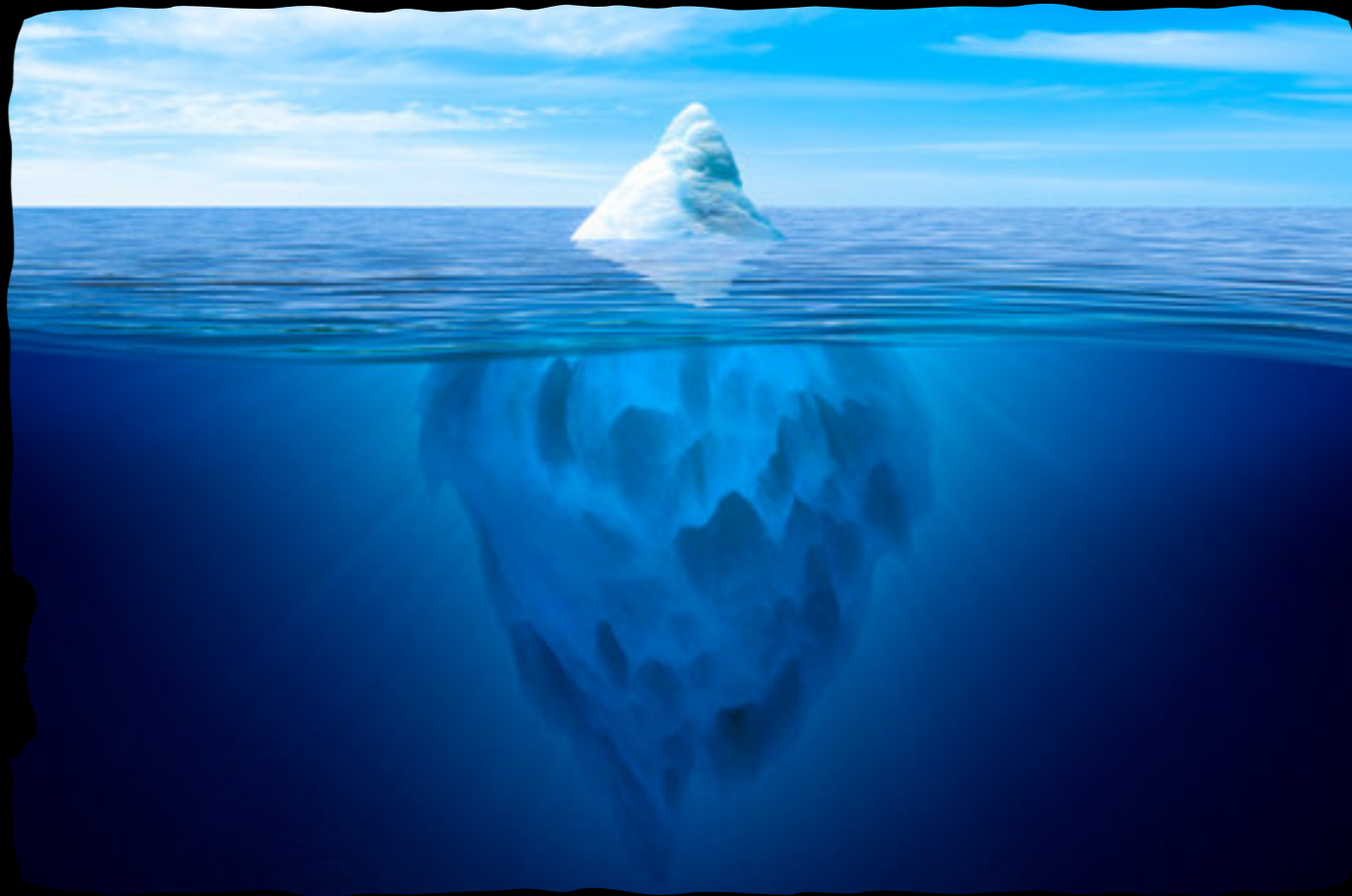
SCALA ELETTRODEBOLE





IL MODELLO STANDARD: SOLO LA PUNTA DI UN ICEBERG?

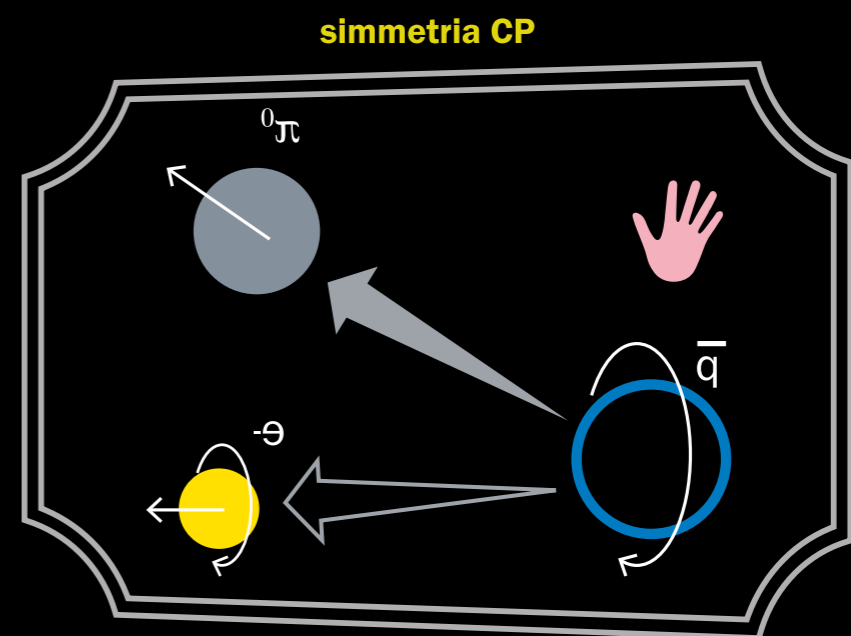
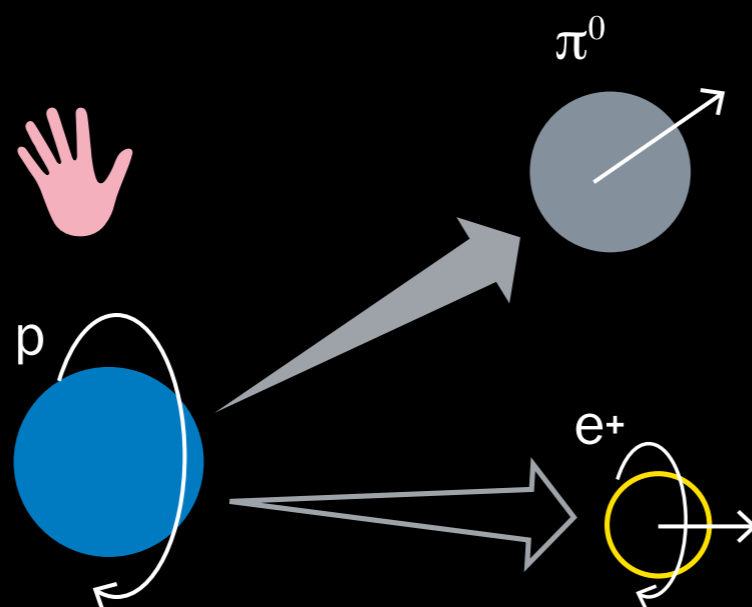


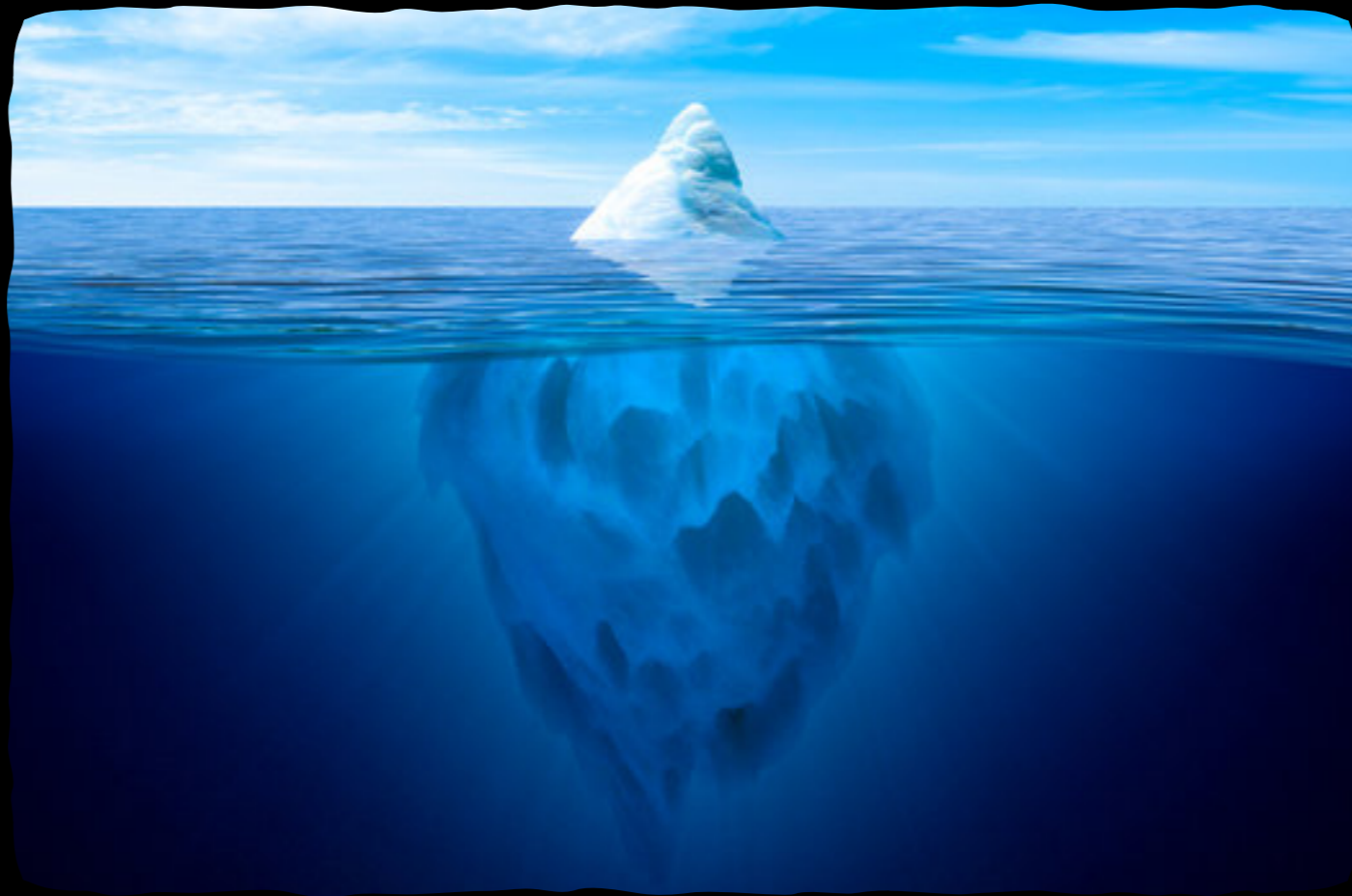


IL MODELLO STANDARD: SOLO LA PUNTA DI UN ICEBERG?

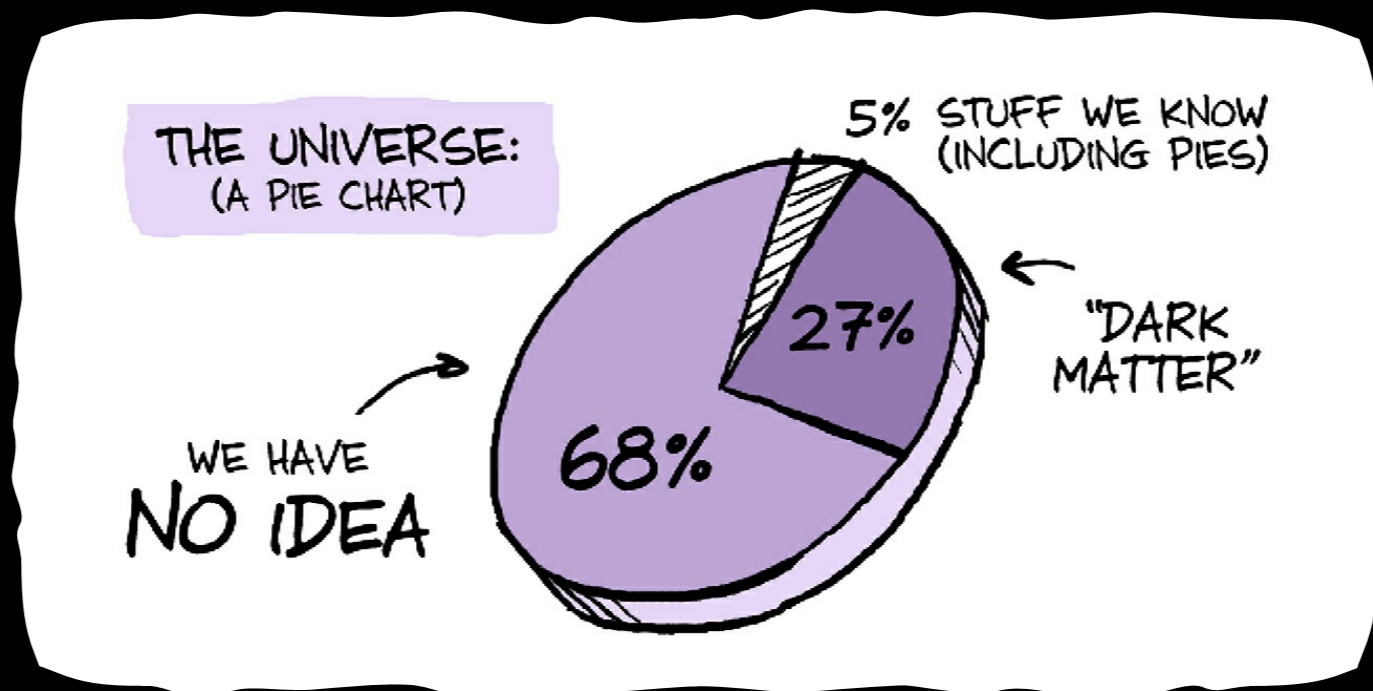


A. Sakharov





IL MODELLO STANDARD: SOLO LA PUNTA DI UN ICEBERG?
PROBABILMENTE SÌ!!!

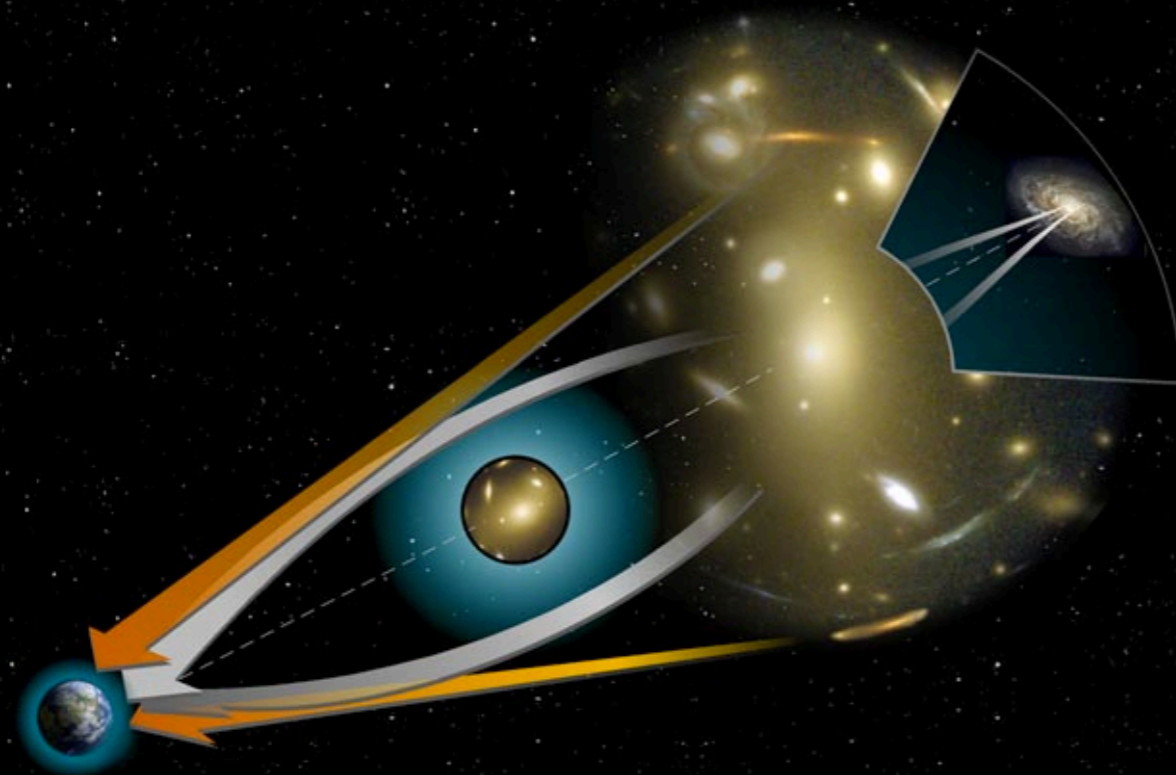
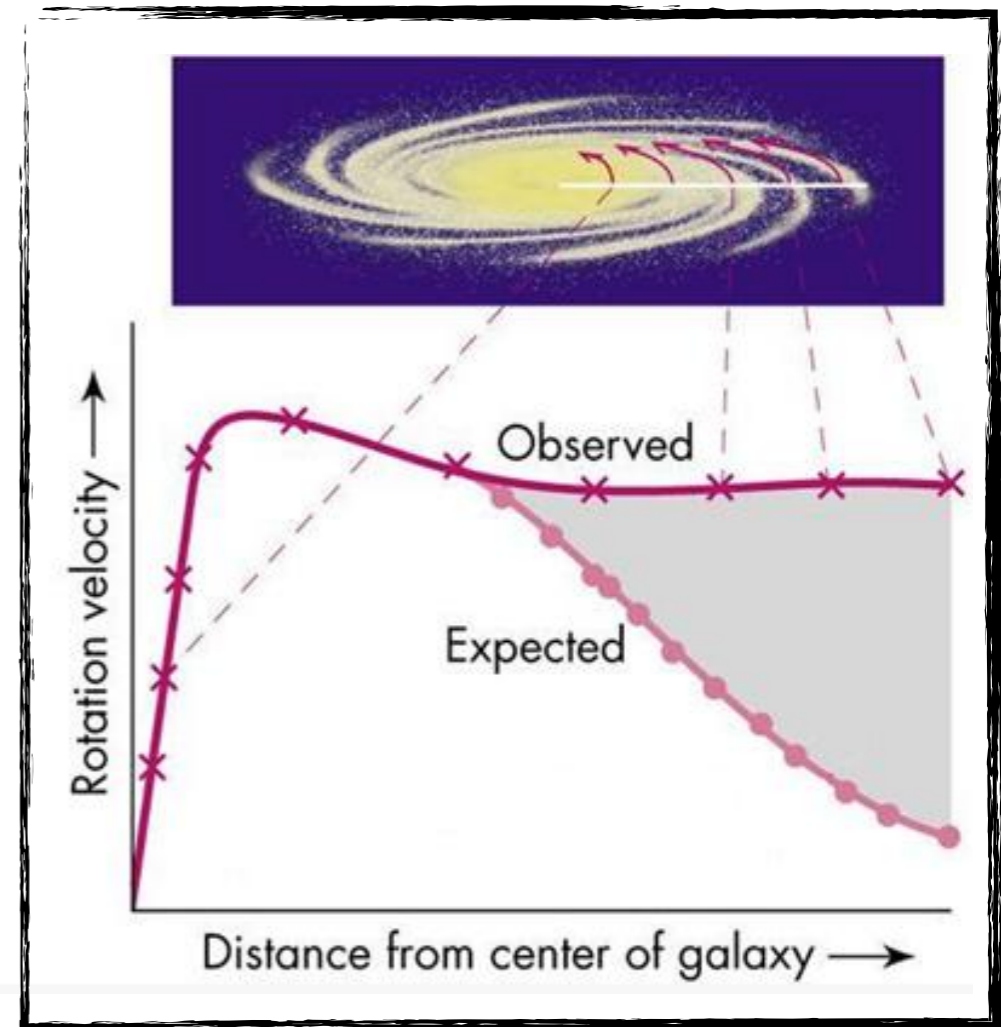


COSA E' LA MATERIA OSCURA?

Un mistero ancora tutto da scoprire ...



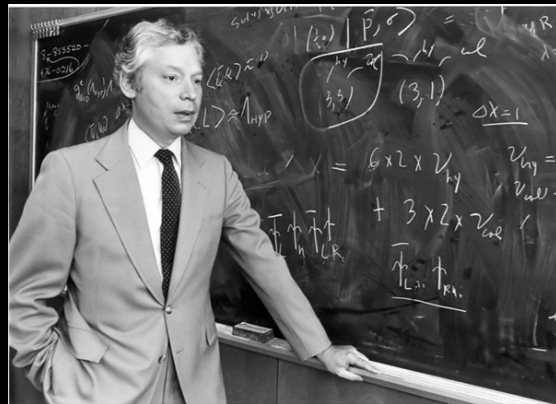
#MANTRA-DI-OGGI: **CERCARE OVUNQUE!**



DARK MATTER

- GRAVITY
- ELECTROMAGNETISM
- WEAK FORCE
- STRONG FORCE





Lo sforzo di capire l'universo è tra le pochissime cose che innalzano la vita umana al di sopra del livello di una farsa, conferendole un po' della dignità di una tragedia.

Steven Weinberg

