

Romanian Educators to CMS

Standard Model

part 2

Cristina-Andreea Alexe

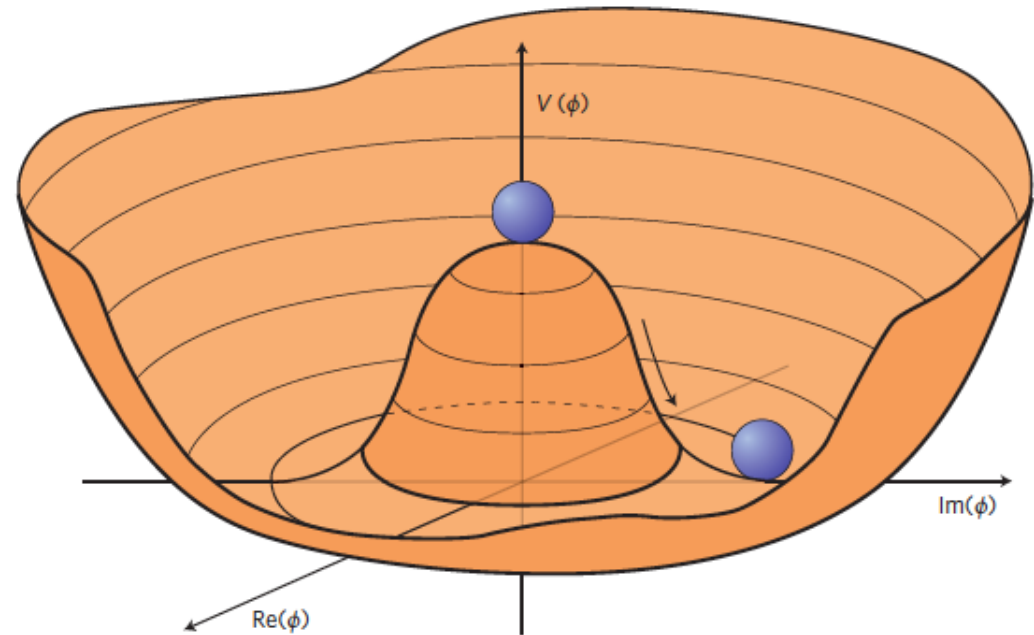
18 Apr 2023



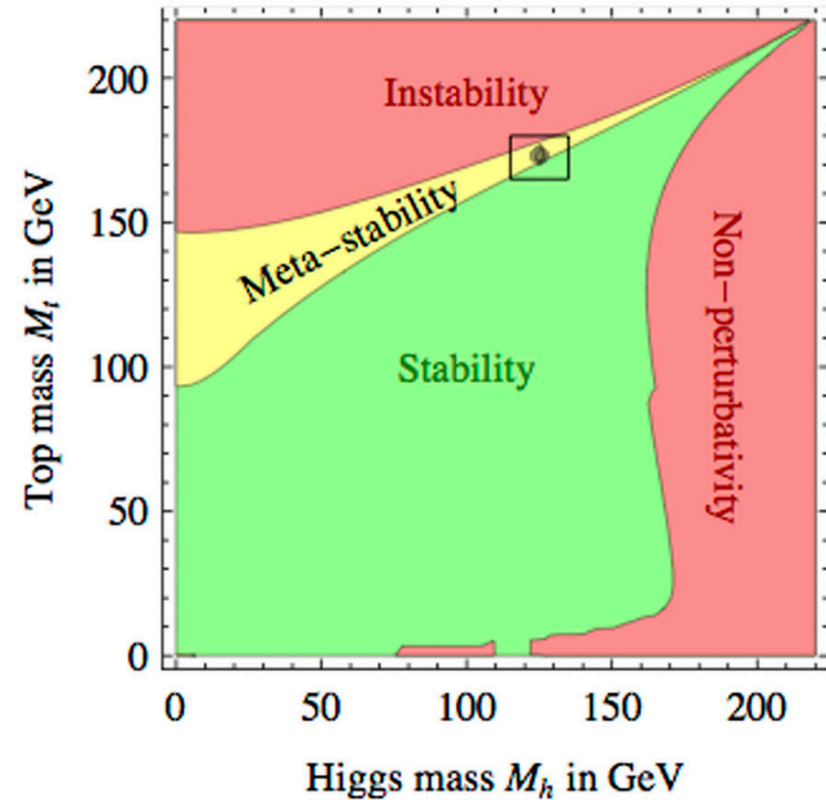
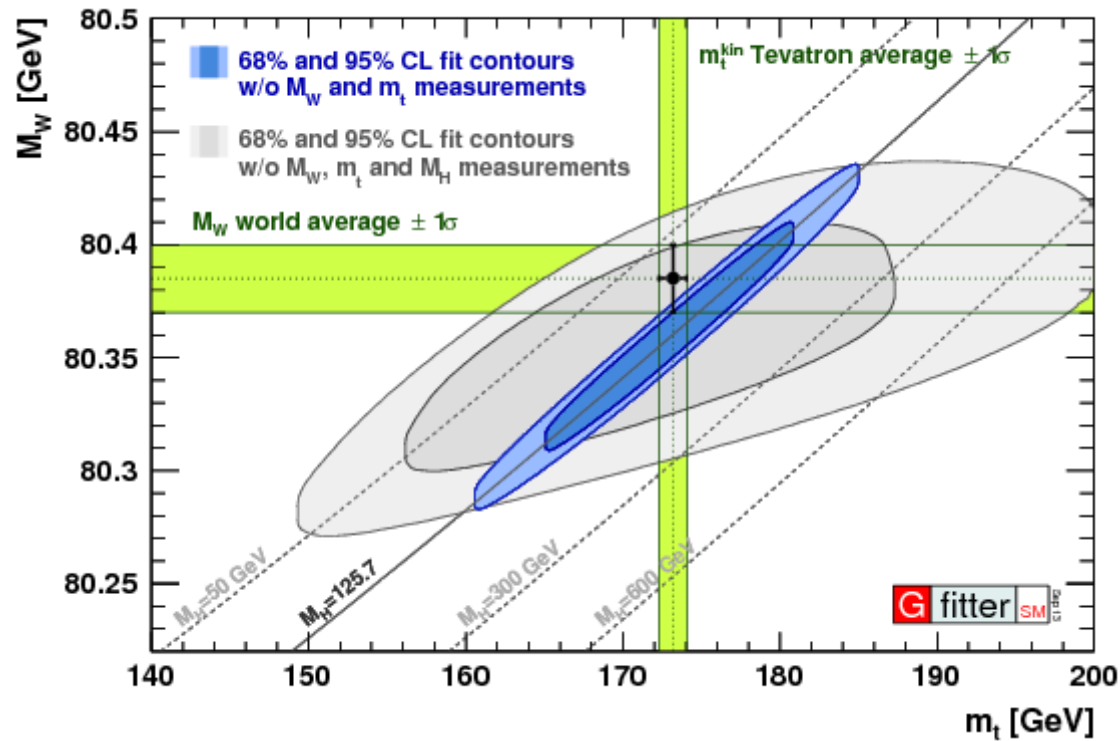
Conținut

- Higgs
- Simetrii și încălcarea sarcină-paritate
- Fizica aromei grele
- Oscilațiile cuarcilor
- Neutrini
- Dincolo de Modelul Standard
- Resurse

Ce studiem la CERN: bosonul Higgs

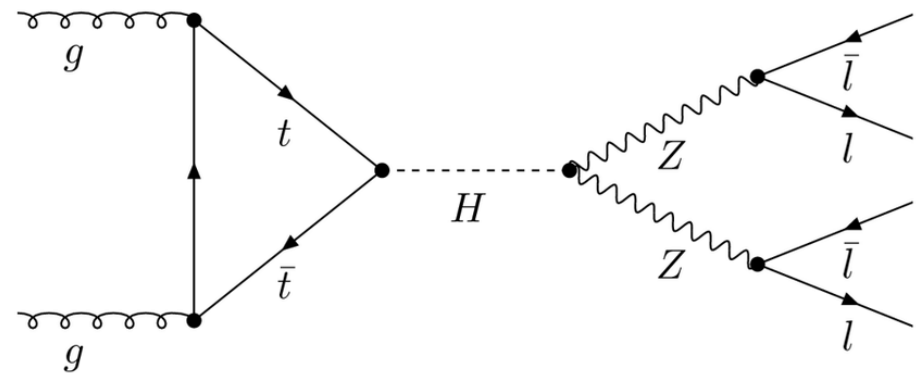
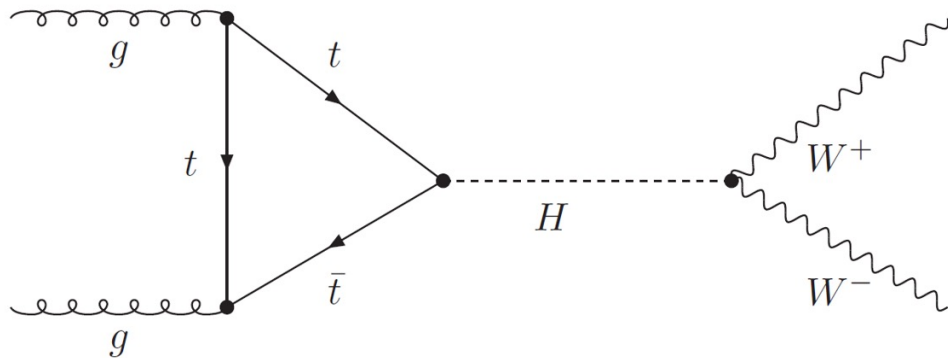


Ce studiem la CERN: bosonul Higgs



Ce studiem la CERN: bosonul Higgs

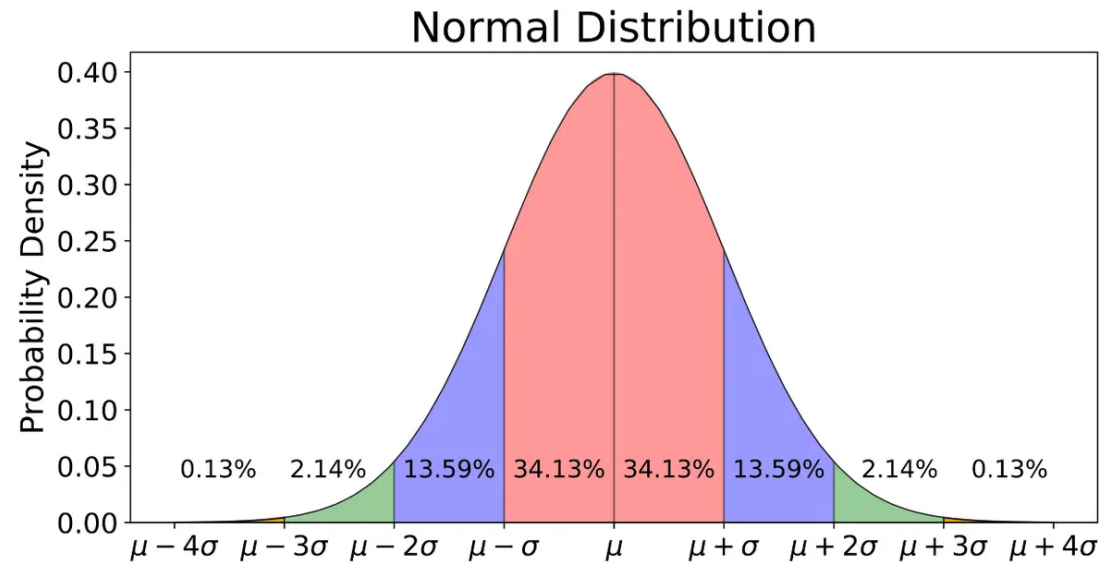
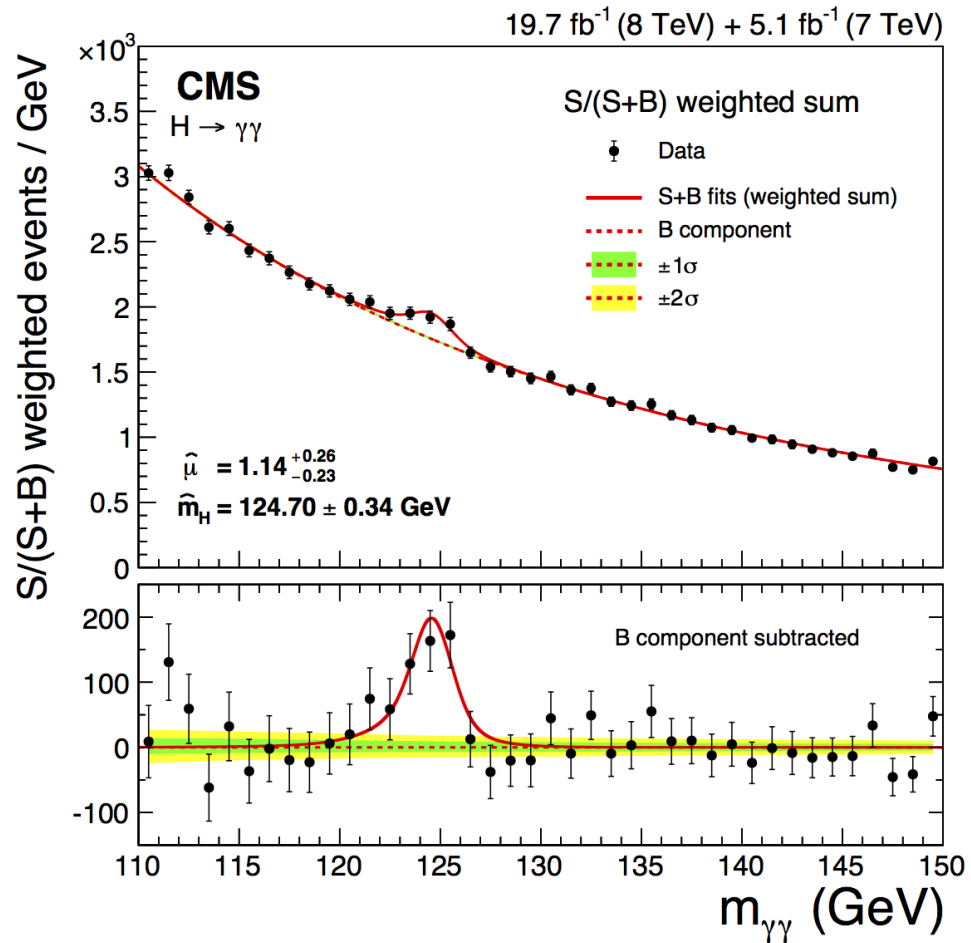
Din punctul de vedere al experimentalistului, ce diagramă preferați?



Cum suntem siguri de o descoperire?



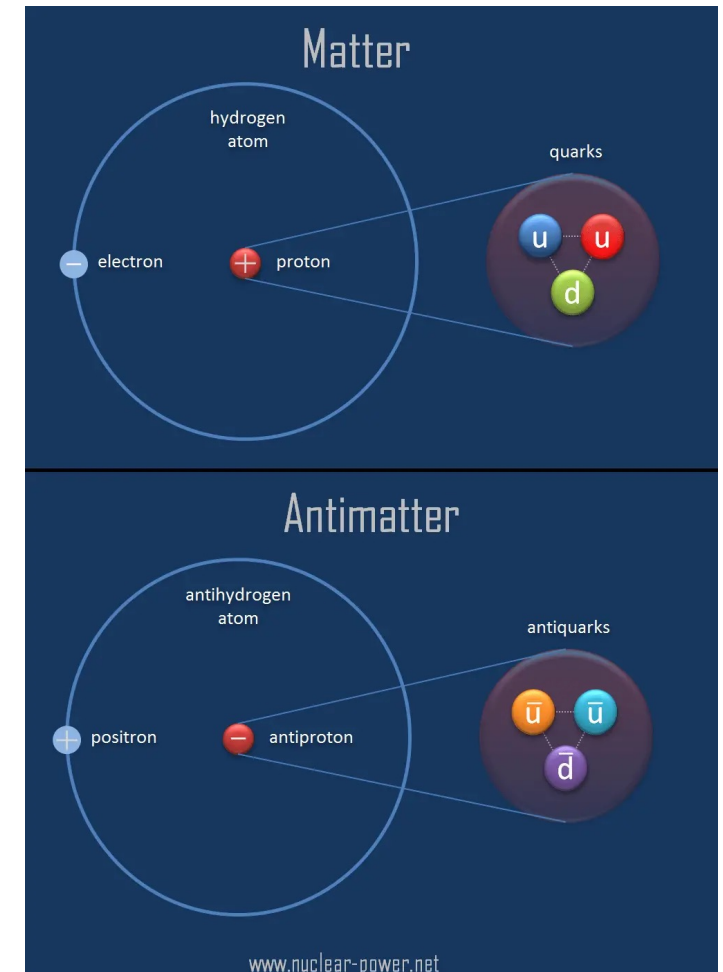
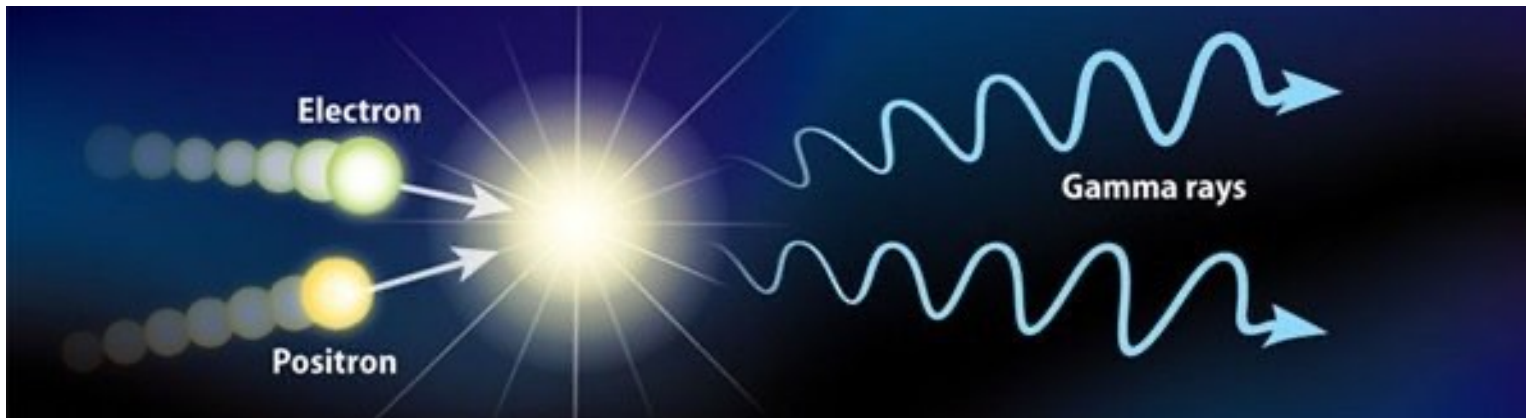
Cum suntem siguri de o descoperire?



5σ -> probabilitate de 1 la un milion
de a fi coincidență!!

Antimateria

- Fiecare fermion are un anti-fermion de aceeași masă și sarcină electrică (și spin) opus -> soluția negativă a unei ecuații cuadratică
- Când materia și antimateria se întâlnesc se anihilează emițând energie
- La începutul universului materia și antimateria au fost produse în mod egal



Antimateria

- Costă \$62 trilioane/gram

Antimatter Examples



Lightning



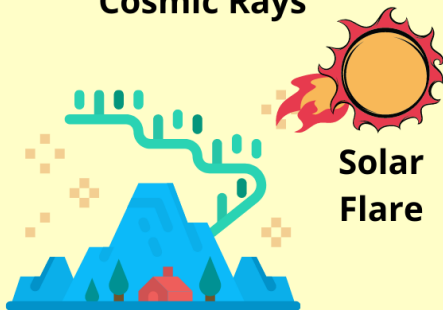
Cosmic Rays



Potassium Decay
in Bananas



Black Hole



Solar
Flare

Aurora

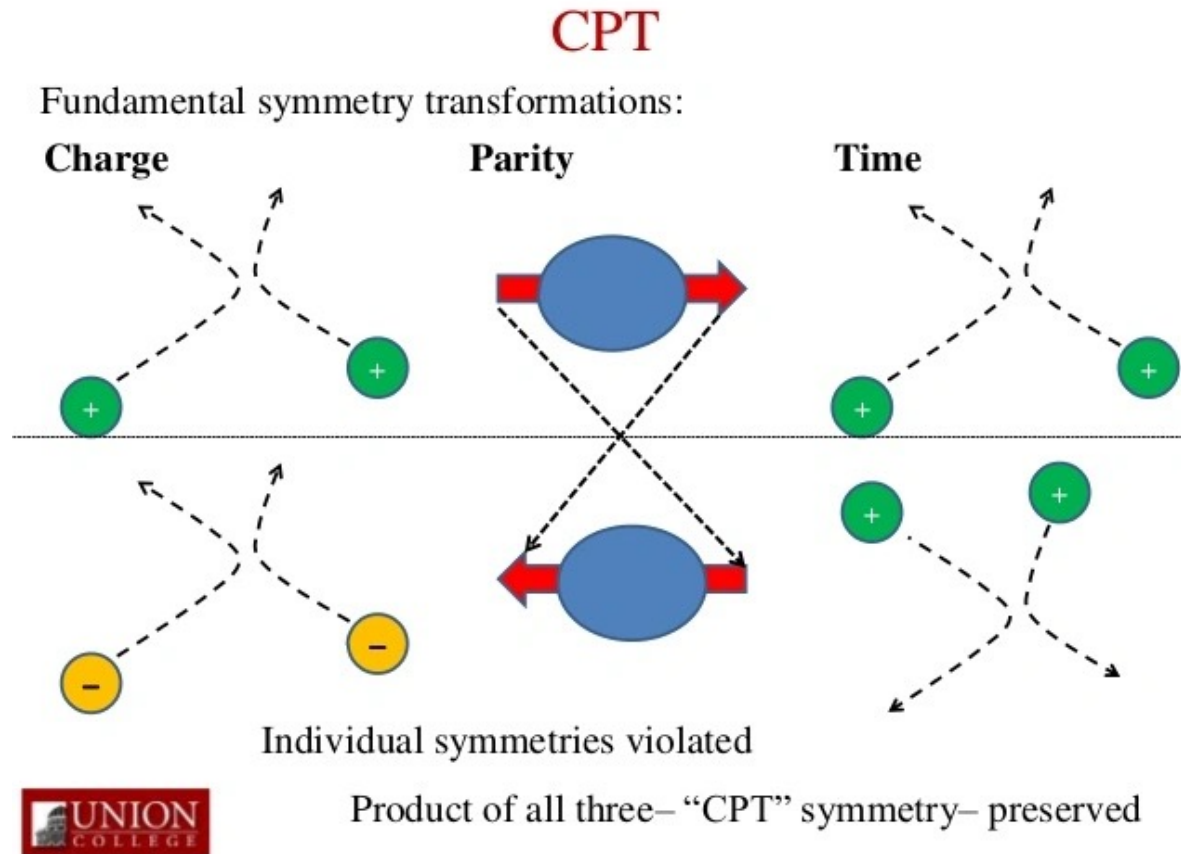


PET Scan

sciencenotes.org

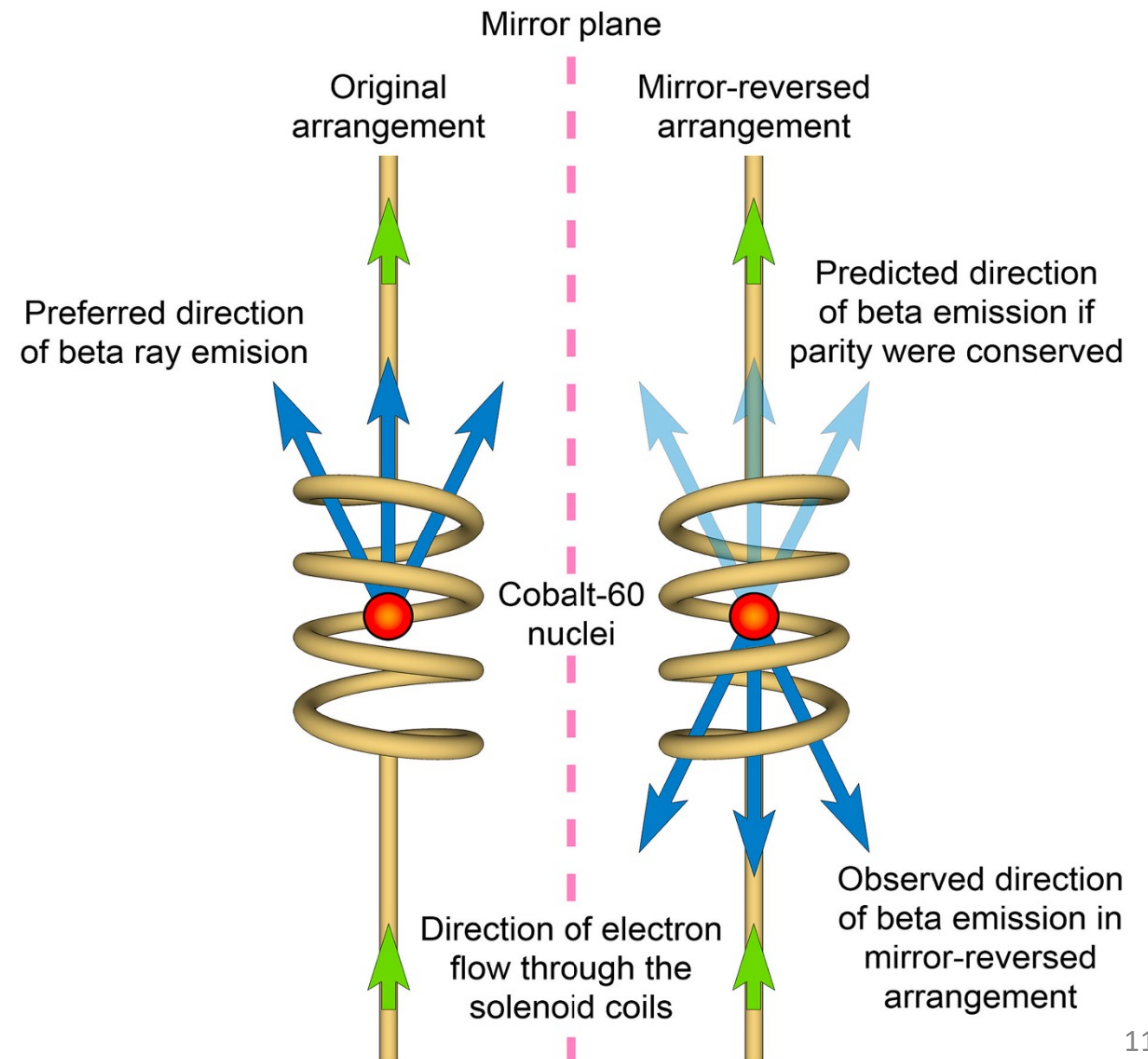
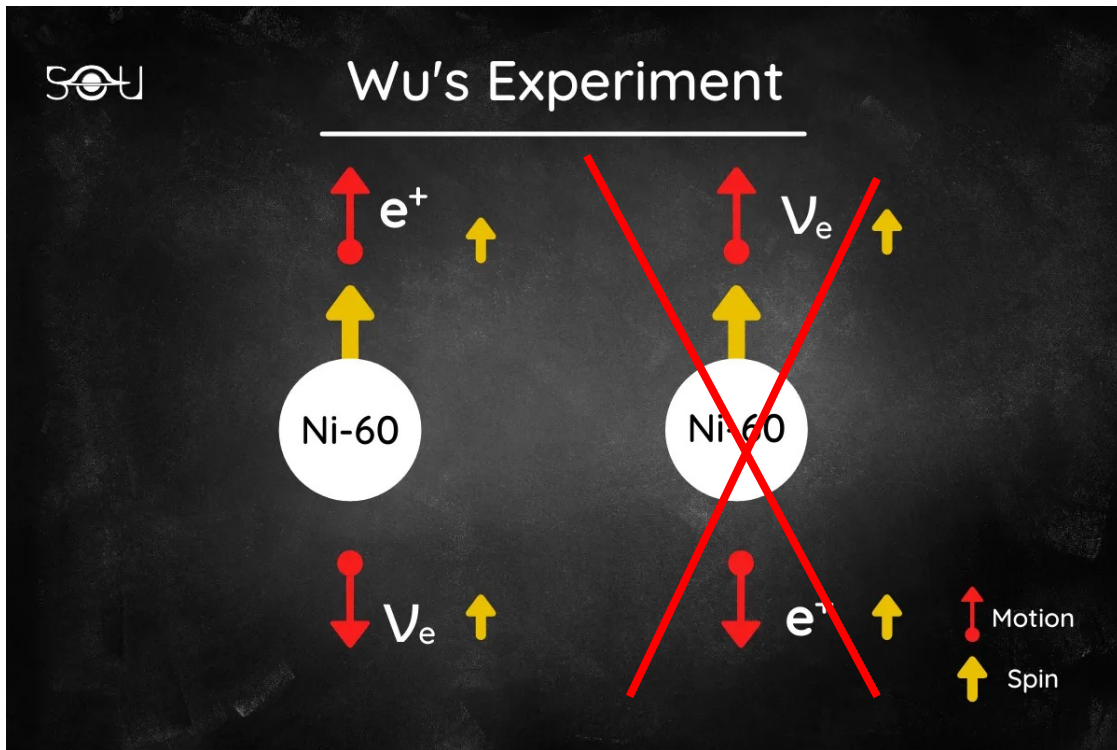


Simetrii



Un proces fizic este neschimbat după aplicarea unei transformări sarcină-paritate-timp

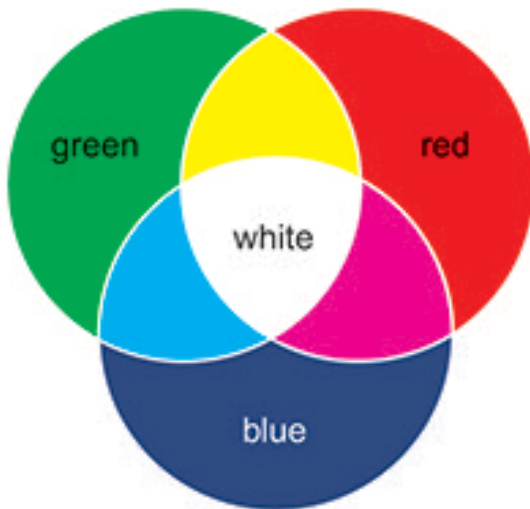
Încălcarea sarcină-paritate



Cromodinamică cuantică

Într-o grupare de cuarci, fiecăruia îi este asociată o culoare astfel încât combinația tuturor cuarcilor să fie albă -> de exemplu mesonul η_c are compoziție $c\bar{c}$

cuarci



(a)

anti-cuarci

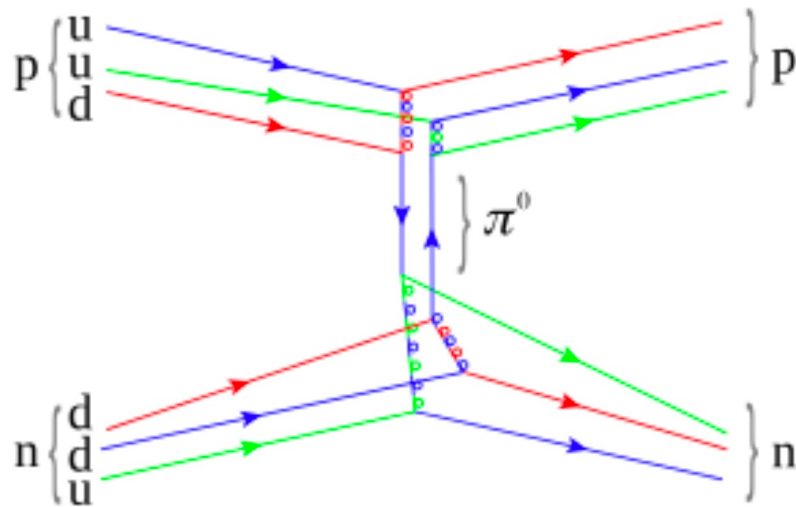


(b)

Quiz: ce grupare nu e posibilă?

- A. uud
- B. u \bar{u} d
- C. udc

Mesoni



Mesons $q\bar{q}$					
Mesons are bosonic hadrons					
These are a few of the many types of mesons.					
Symbol	Name	Quark content	Electric charge	Mass GeV/c^2	Spin
π^+	pion	$u\bar{d}$	+1	0.140	0
K^-	kaon	$s\bar{u}$	-1	0.494	0
ρ^+	rho	$u\bar{d}$	+1	0.776	1
B^0	B-zero	$d\bar{b}$	0	5.279	0
η_c	eta-c	$c\bar{c}$	0	2.980	0

Oscilațiile cuarcilor

- Cuarzii pe care îi observăm sunt de fapt superpoziții ale aromelor posibile de cuarci u, d, s ...

probabilitatea tranziției d → u

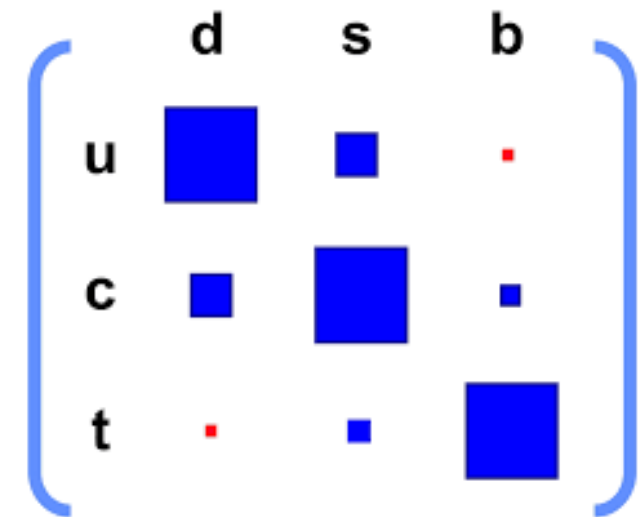
$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} = V_{CKM} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

	·
mass	≈2.2 MeV/c ²	≈1.28 GeV/c ²	≈173.1 GeV/c ²
charge	2/3	2/3	2/3
spin	1/2	1/2	1/2
	u up	c charm	t top
	·
	≈4.7 MeV/c ²	≈96 MeV/c ²	≈4.18 GeV/c ²
	-1/3	-1/3	-1/3
	1/2	1/2	1/2
	d down	s strange	b bottom

QUARKS

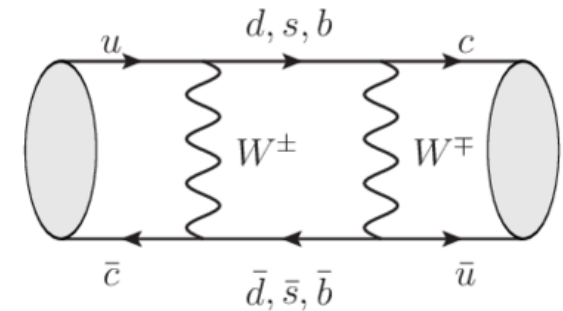
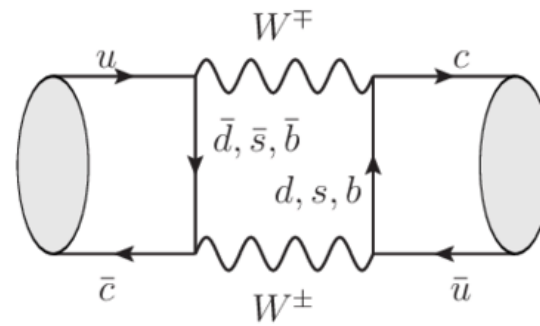
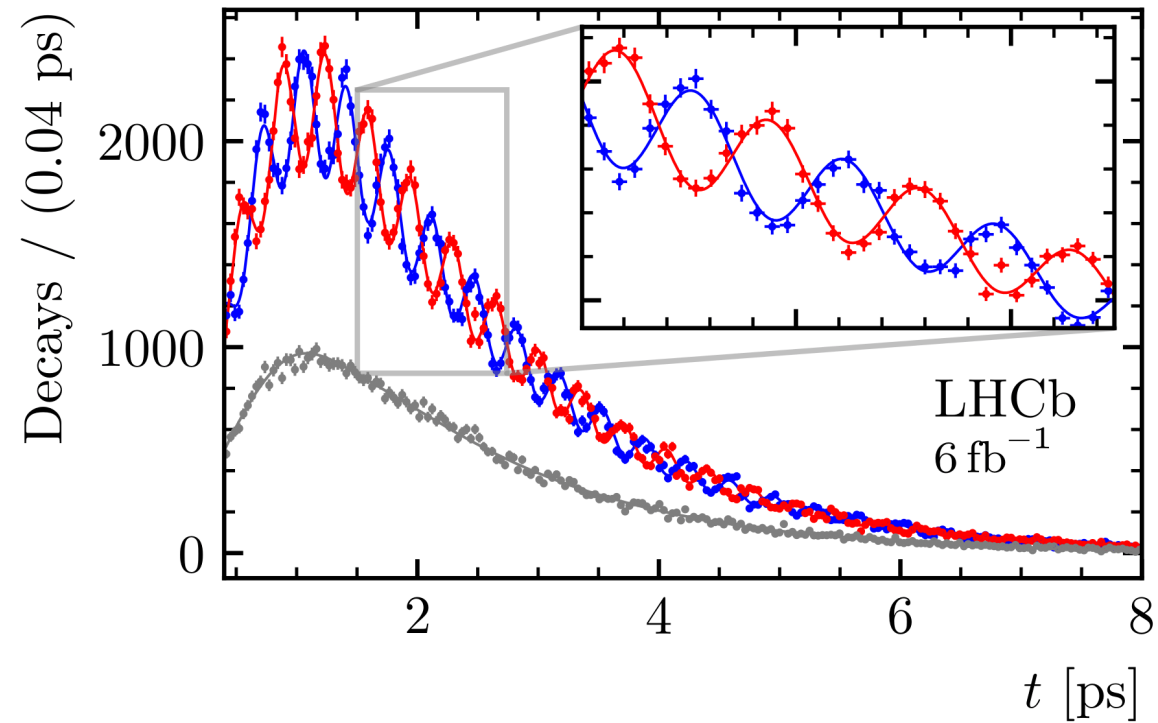
Oscilațiile cuarcilor

$$\begin{bmatrix} |V_{ud}| & |V_{us}| & |V_{ub}| \\ |V_{cd}| & |V_{cs}| & |V_{cb}| \\ |V_{td}| & |V_{ts}| & |V_{tb}| \end{bmatrix} \approx \begin{bmatrix} 0.974 & 0.225 & 0.003 \\ 0.225 & 0.973 & 0.041 \\ 0.009 & 0.040 & 0.999 \end{bmatrix}$$



Oscilațiile mesonilor

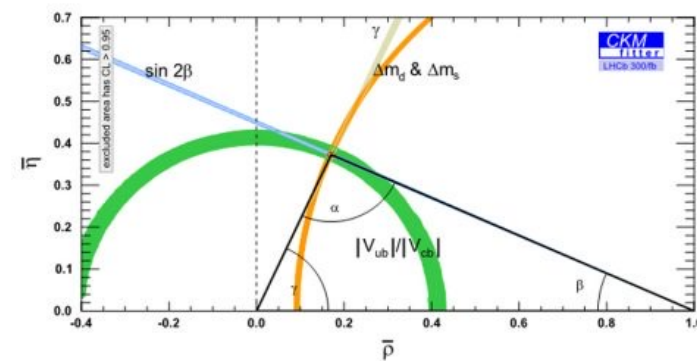
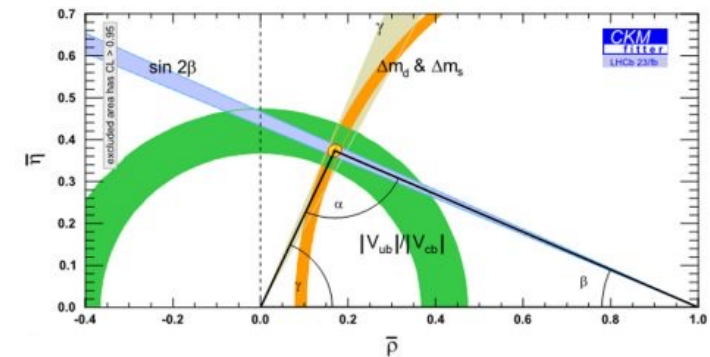
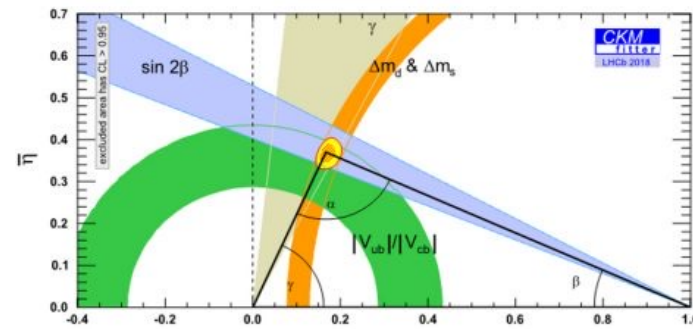
— $B_s^0 \rightarrow D_s^- \pi^+$
 — $\bar{B}_s^0 \rightarrow D_s^- \pi^+$
 — Untagged



Încălcarea sarcină-paritate

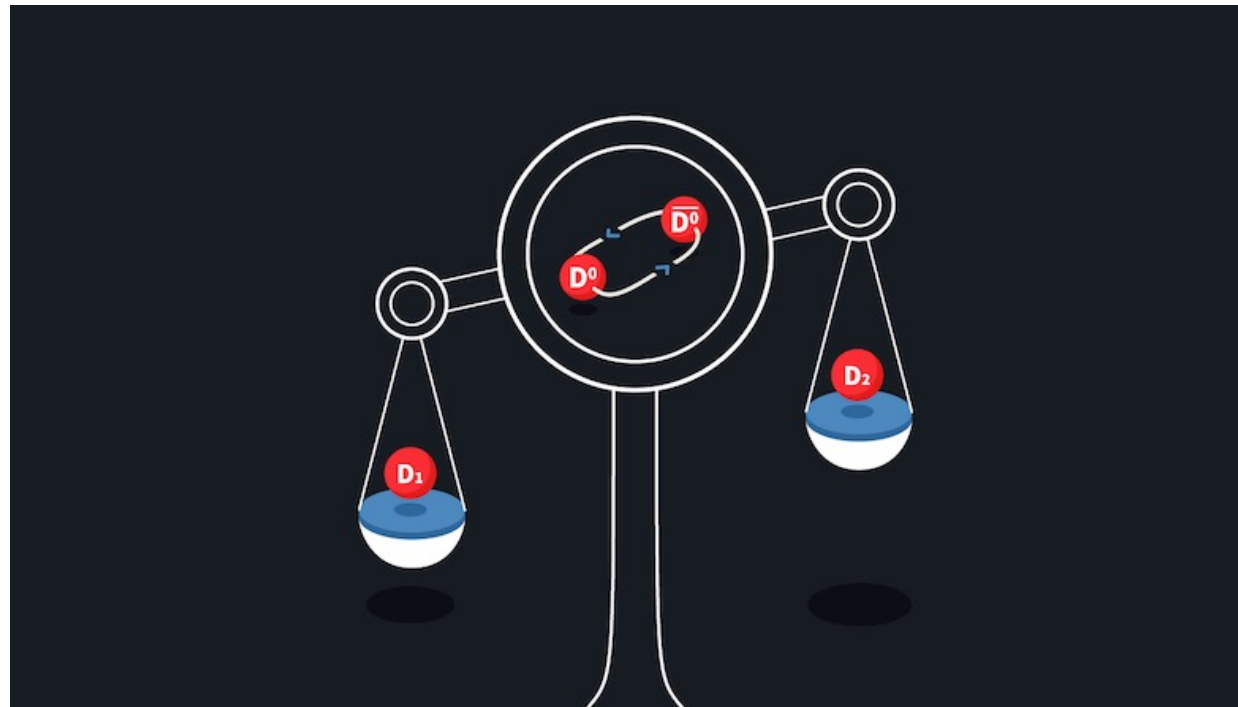


Descoperire 2019: mesonii D^0 de tip materie se dezintegrează la o rată diferită de anti-materie



Încălcarea sarcină-paritate

Încă se caută încălcarea sarcină-paritate în oscilații



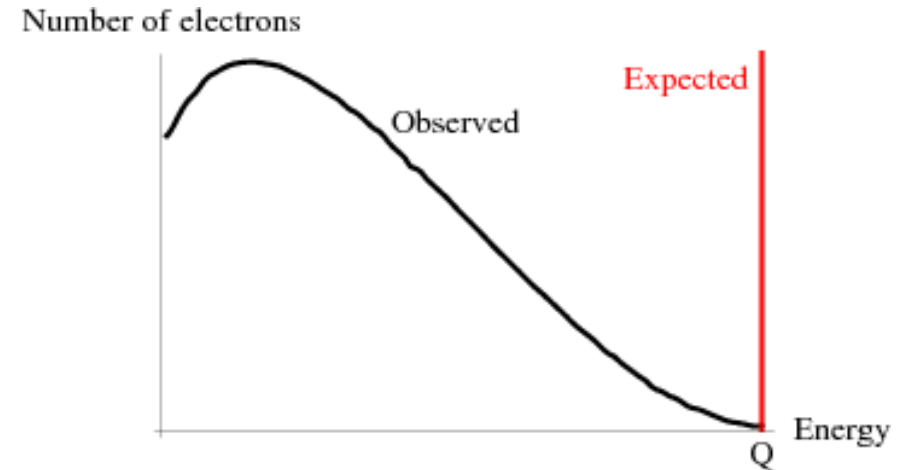
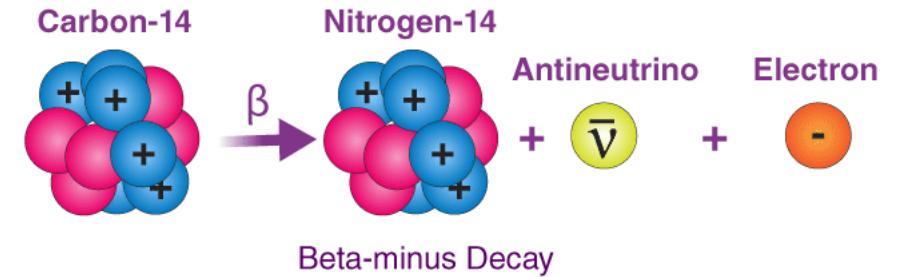
Neutrini

Physikalisches Institut
der Eidg. Technischen Hochschule
Zürich

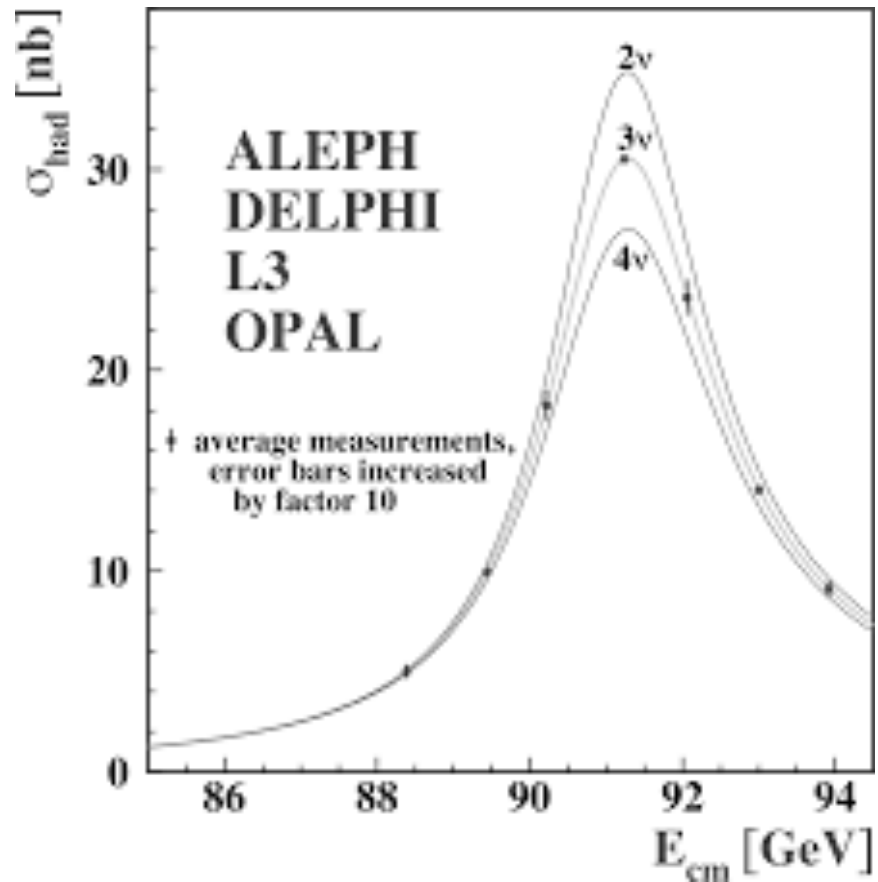
Zürich, 4. Dez. 1930
Gloriastrasse

Liebe Radioaktive Damen und Herren,

Wie der Ueberbringer dieser Zeilen, den ich huldvollst anhören bitte, Ihnen des näheren auseinandersetzen wird, bin ich angesichts der "falschen" Statistik der N- und Li-6 Kerne, sowie des kontinuierlichen beta-Spektrums auf einen verzweifelten Ausweg verfallen um den "Wechselsatz" (1) der Statistik und den Energiesatz zu retten. Nämlich die Möglichkeit, es könnten elektrisch neutrale Teilchen, die ich Neutronen nennen will, in den Kernen existieren, welche den Spin 1/2 haben und das Ausschliessungsprinzip befolgen und sich von Lichtquanten ausserdem noch dadurch unterscheiden, dass sie nicht mit Lichtgeschwindigkeit laufen. Die Masse der Neutronen müsste von derselben Grössenordnung wie die Elektronenmasse sein und jedenfalls nicht grösser als 0,01 Protonenmasse.- Das kontinuierliche beta-Spektrum wäre dann verständlich unter der Annahme, dass beim beta-Zerfall mit dem Elektron jeweils noch ein Neutron emittiert wird, derart, dass die Summe der Energien von Neutron und Elektron konstant ist.



Neutrini

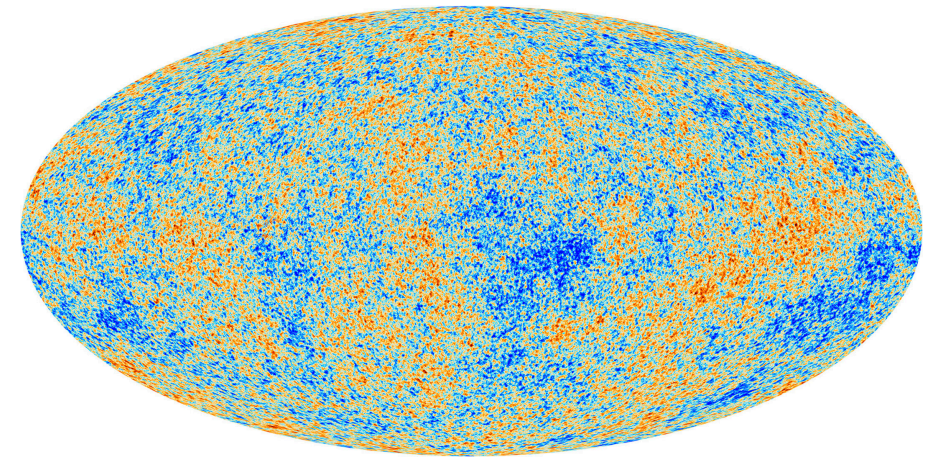
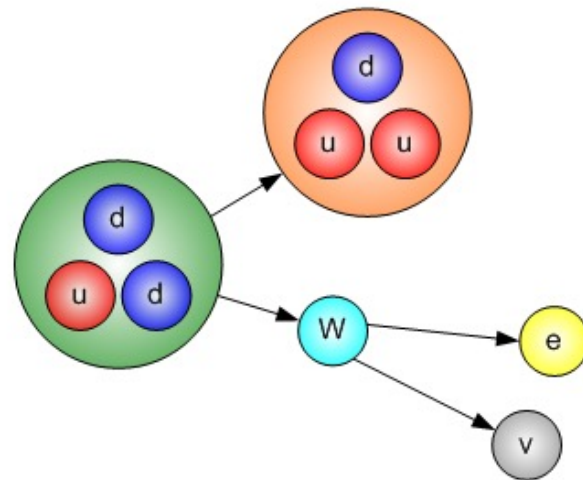
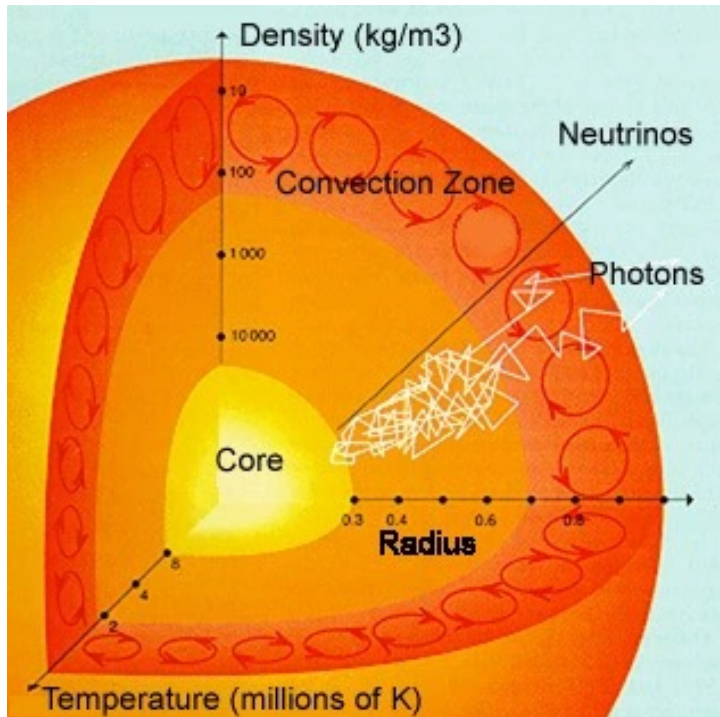


LEPTONS

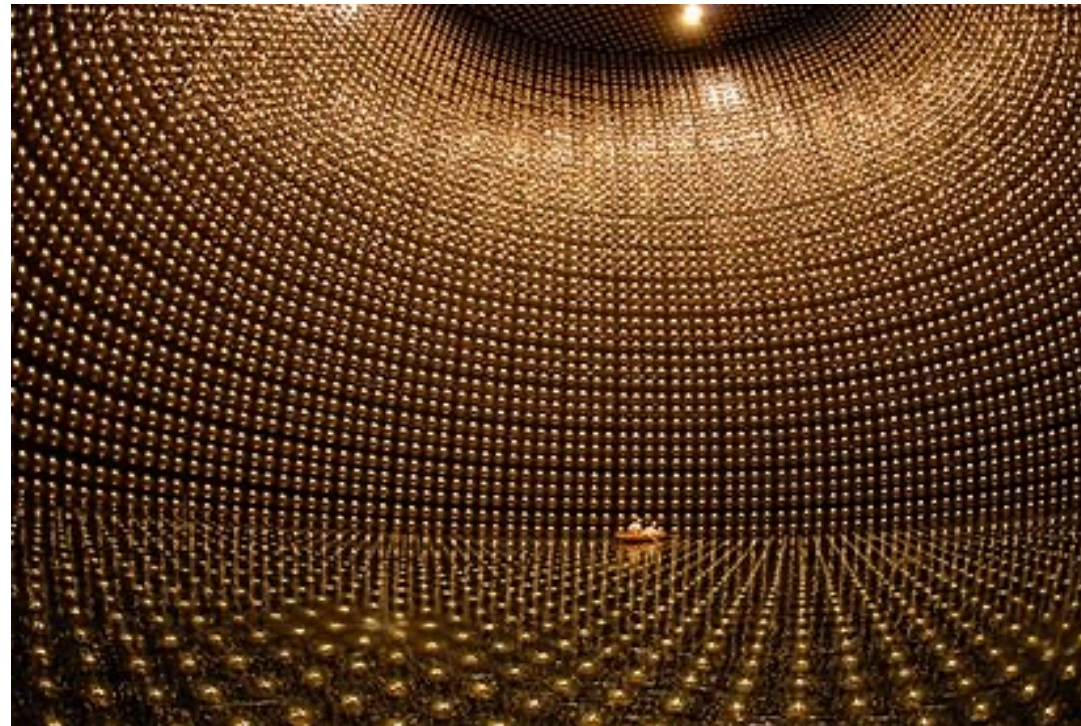
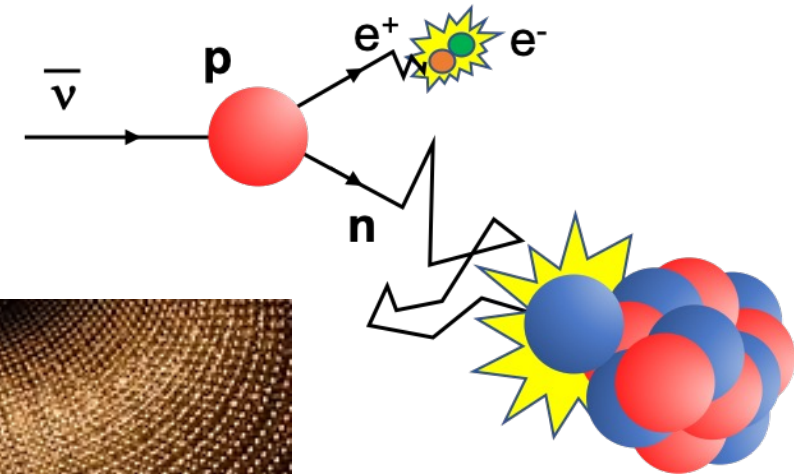
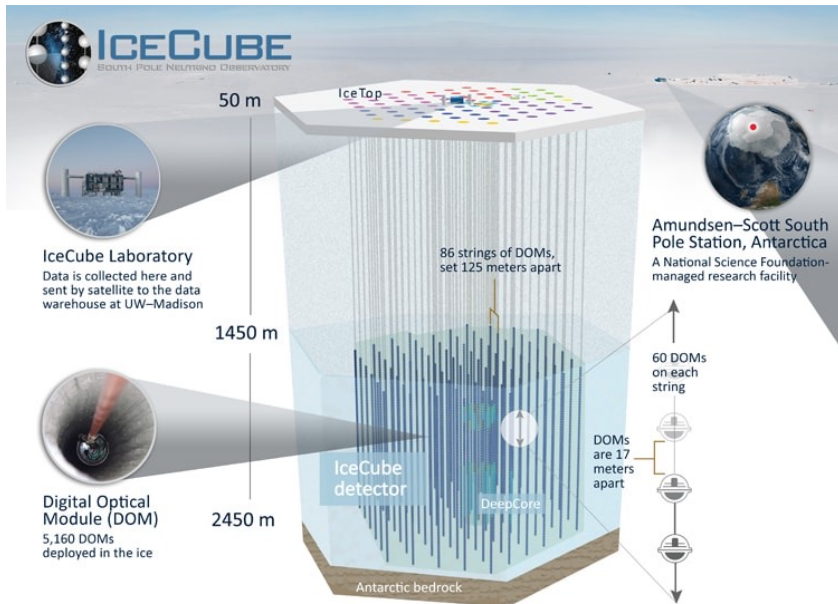
$\approx 0.511 \text{ MeV}/c^2$ -1 $\frac{1}{2}$ e electron	$\approx 105.66 \text{ MeV}/c^2$ -1 $\frac{1}{2}$ μ muon	$\approx 1.7768 \text{ GeV}/c^2$ -1 $\frac{1}{2}$ τ tau
$< 1.0 \text{ eV}/c^2$ 0 $\frac{1}{2}$ ν_e electron neutrino	$< 0.17 \text{ MeV}/c^2$ 0 $\frac{1}{2}$ ν_μ muon neutrino	$< 18.2 \text{ MeV}/c^2$ 0 $\frac{1}{2}$ ν_τ tau neutrino

Neutrini

Aproximativ 100 trilioane de neutrini trec prin corpul nostru în fiecare secundă!
Dar ei interacționează extrem de slab cu materia.



Neutrini detectare

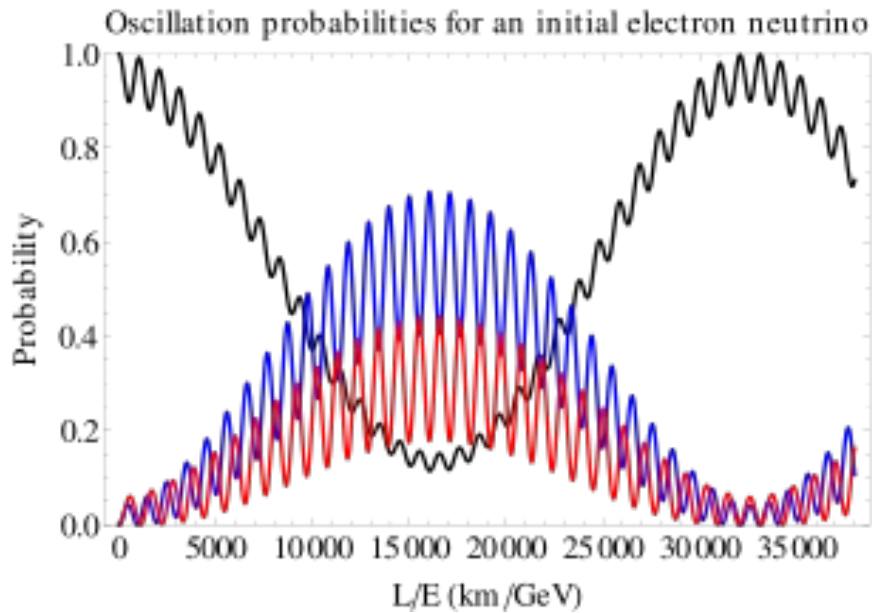


Neutrini

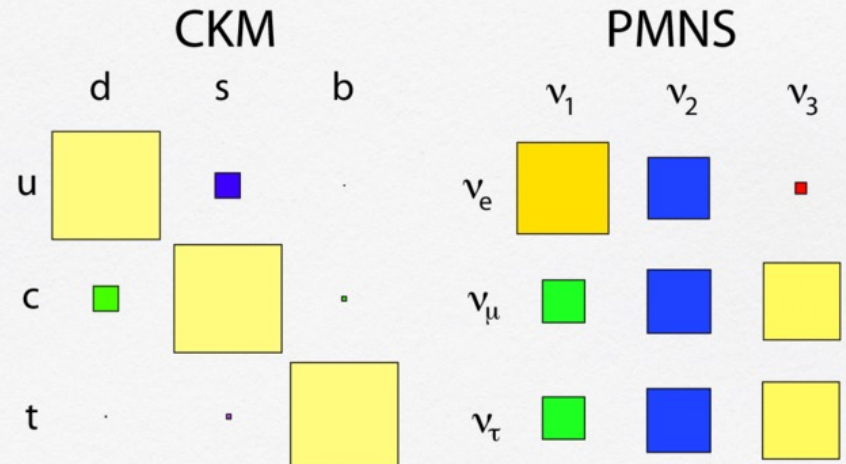
Modelul Standard prezice că neutrinii nu au masa, dar ei oscilează!



Știm că trebuie să existe o teorie mai bună decât Modelul Standard!



What is the origin of Quark and Lepton Mixing?



Dincolo de Modelul Standard

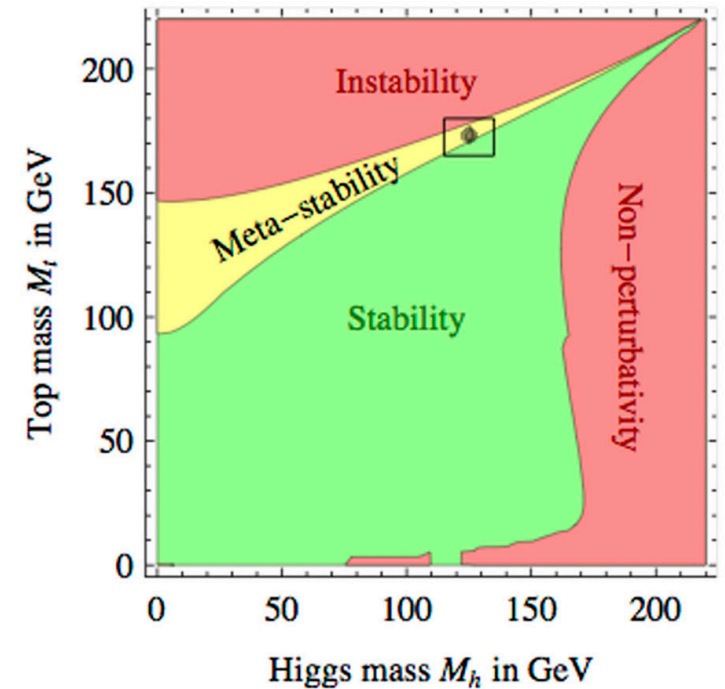
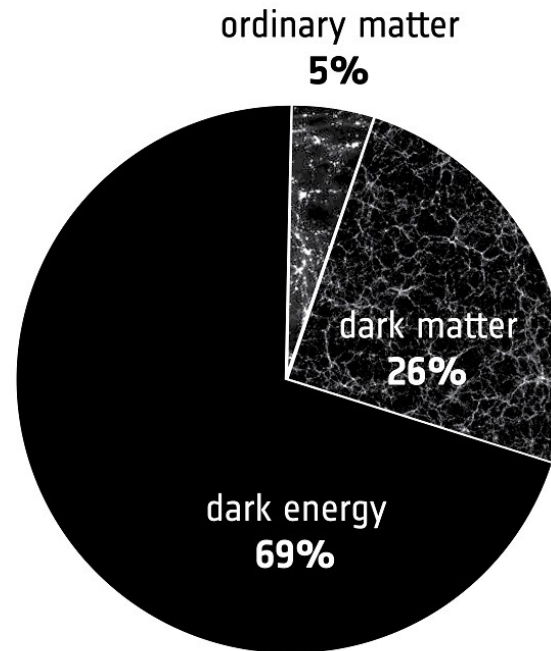
Peste 40 de premii Nobel pentru fizica particulelor



Dincolo de Modelul Standard

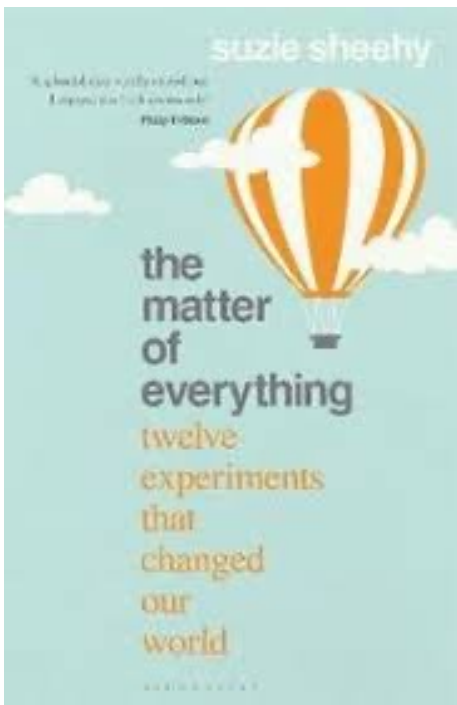
Modelul Standard NU explică:

- Gravitația
- Materia întunecată
- Energia întunecată
- Oscilațiile neutrinelor



De asemenea, de ce este masa bosonului Higgs atât de mică?
Există mai multe procese care încalcă simetria sarcină-paritate?

Recomandări

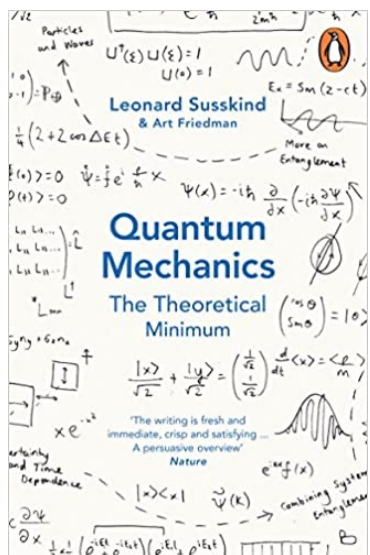


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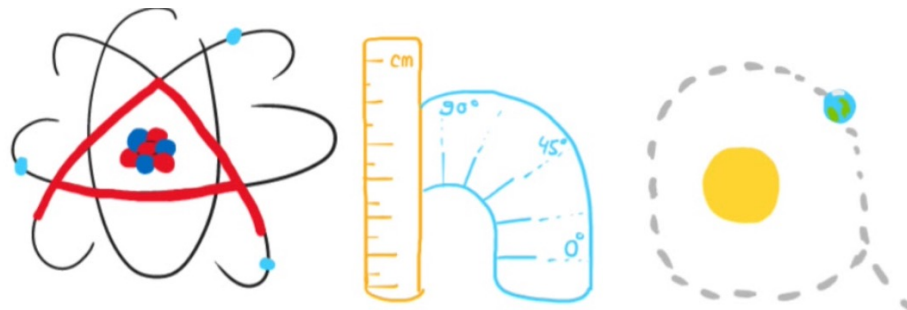
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Bună! Eu sunt Cristina, am studiat fizică teoretică în Manchester și în curâ... >

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