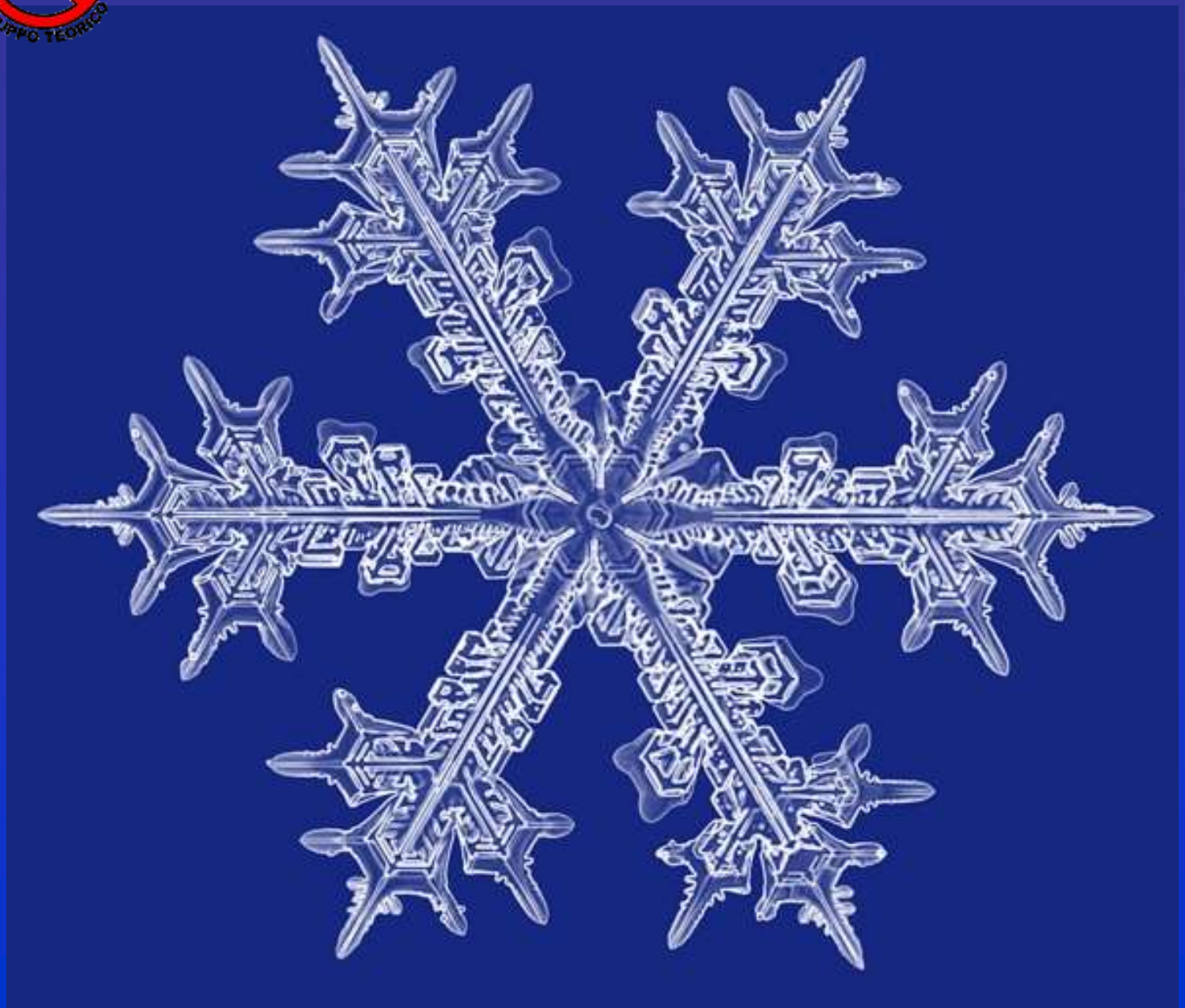
A.C.A. – Associazione Cernuschese Astrofili

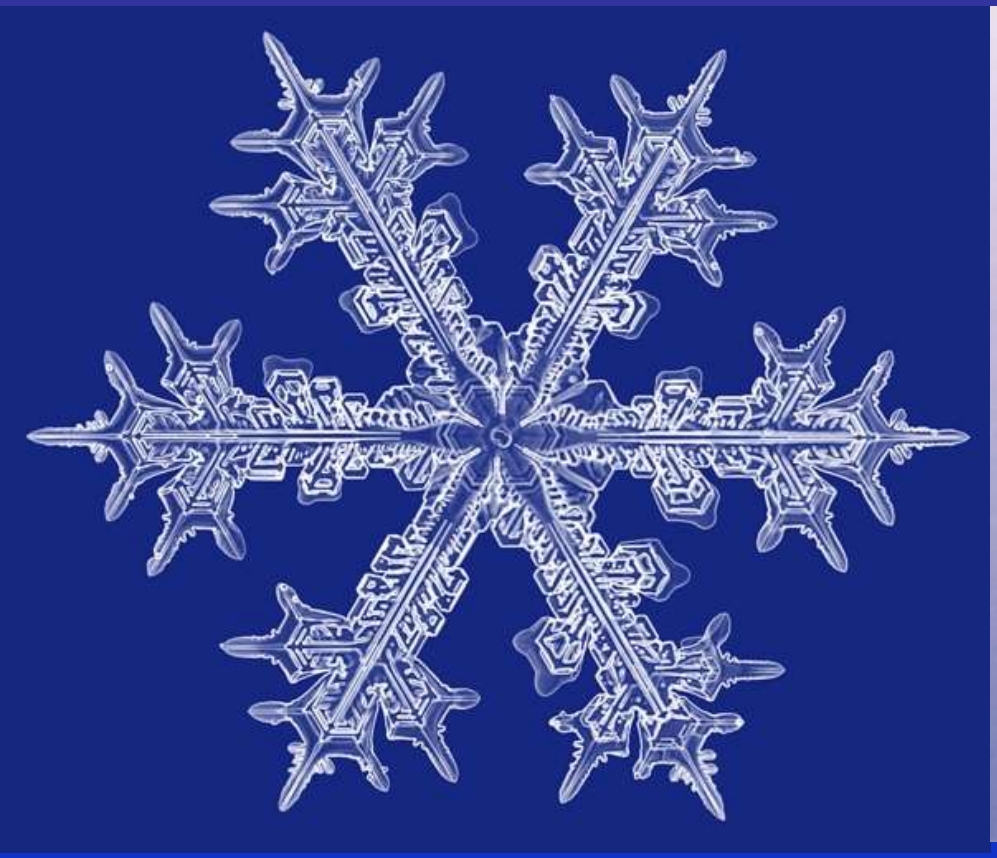
SIMMETRIE
Alla ricerca della bellezza nascosta della Natura

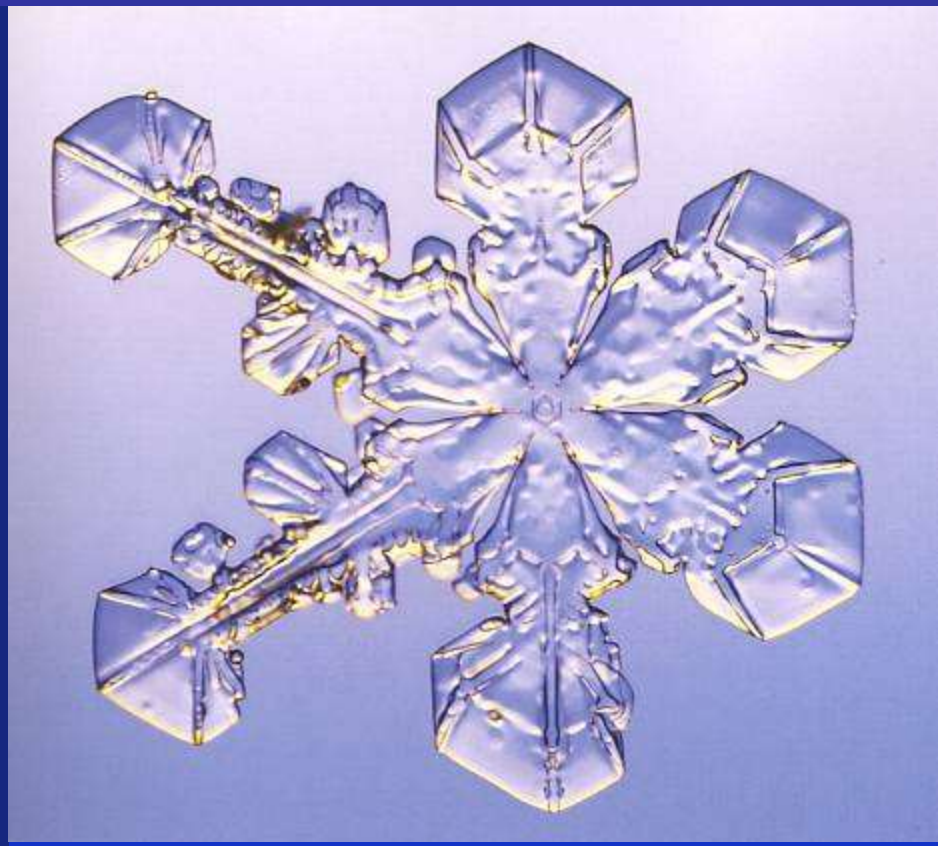
by Andrea Grieco

LA SOLITA IMMAGINE

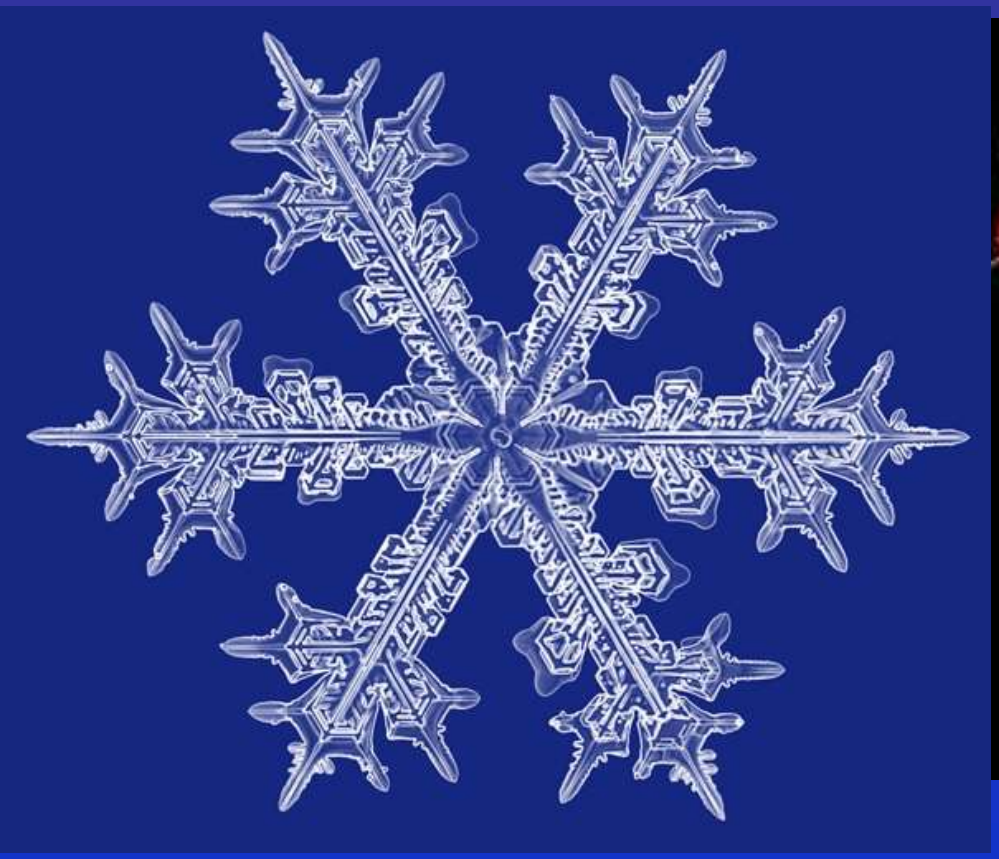


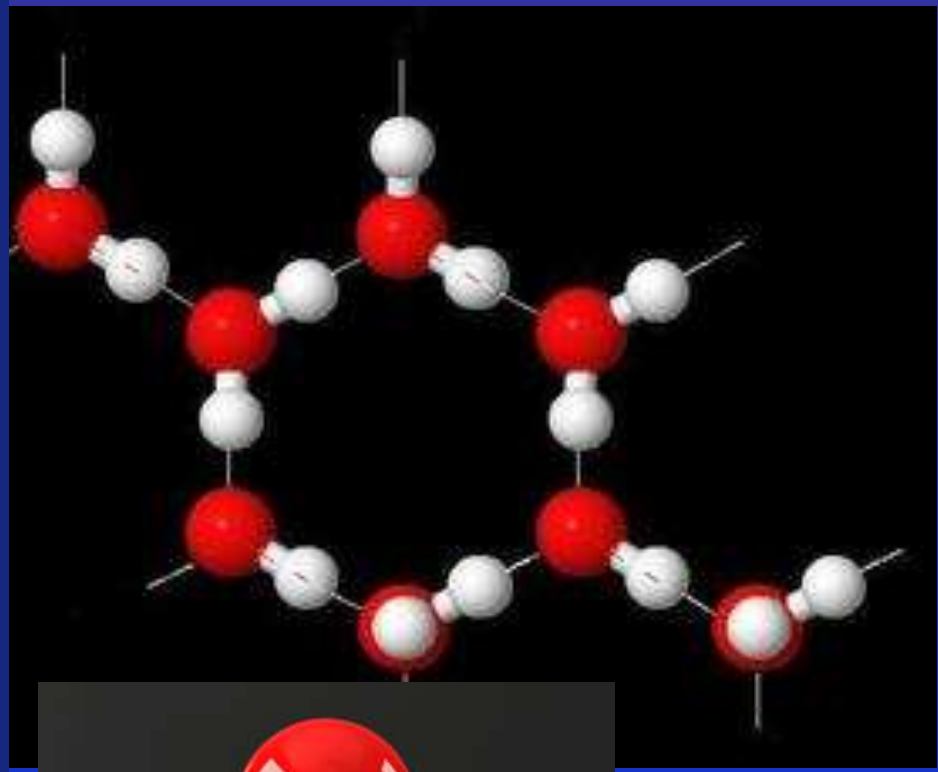
BELLEZZA E SIMMETRIA



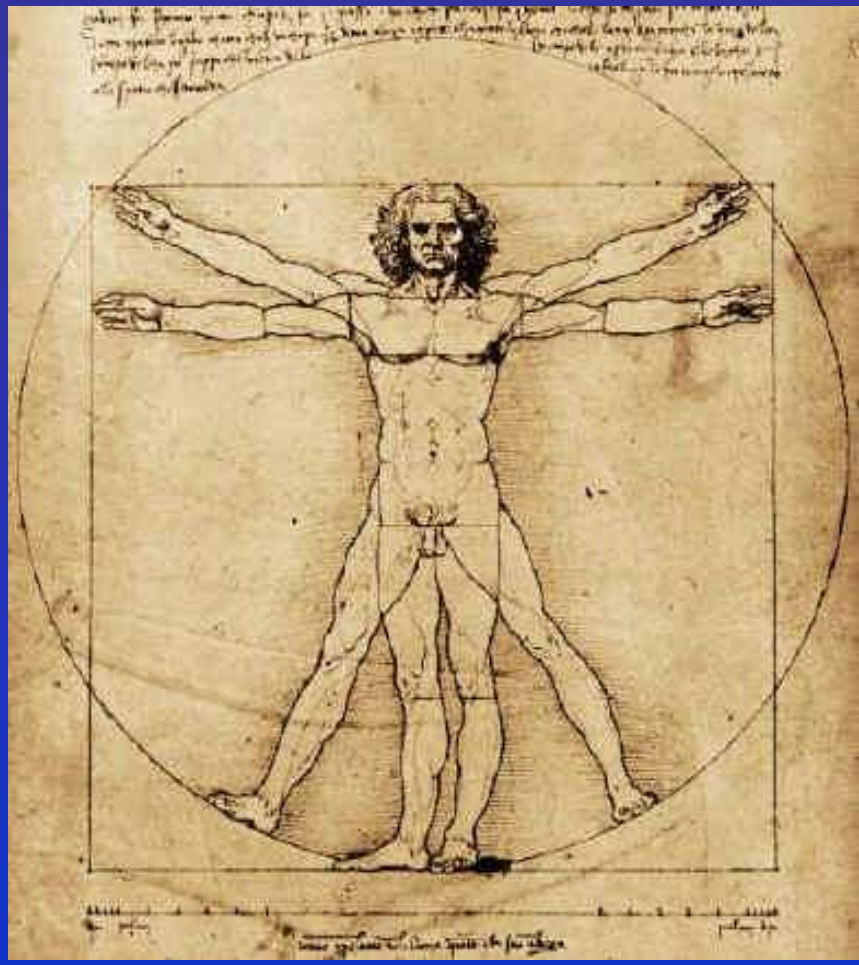


SIMMETRIA NASCOSTA



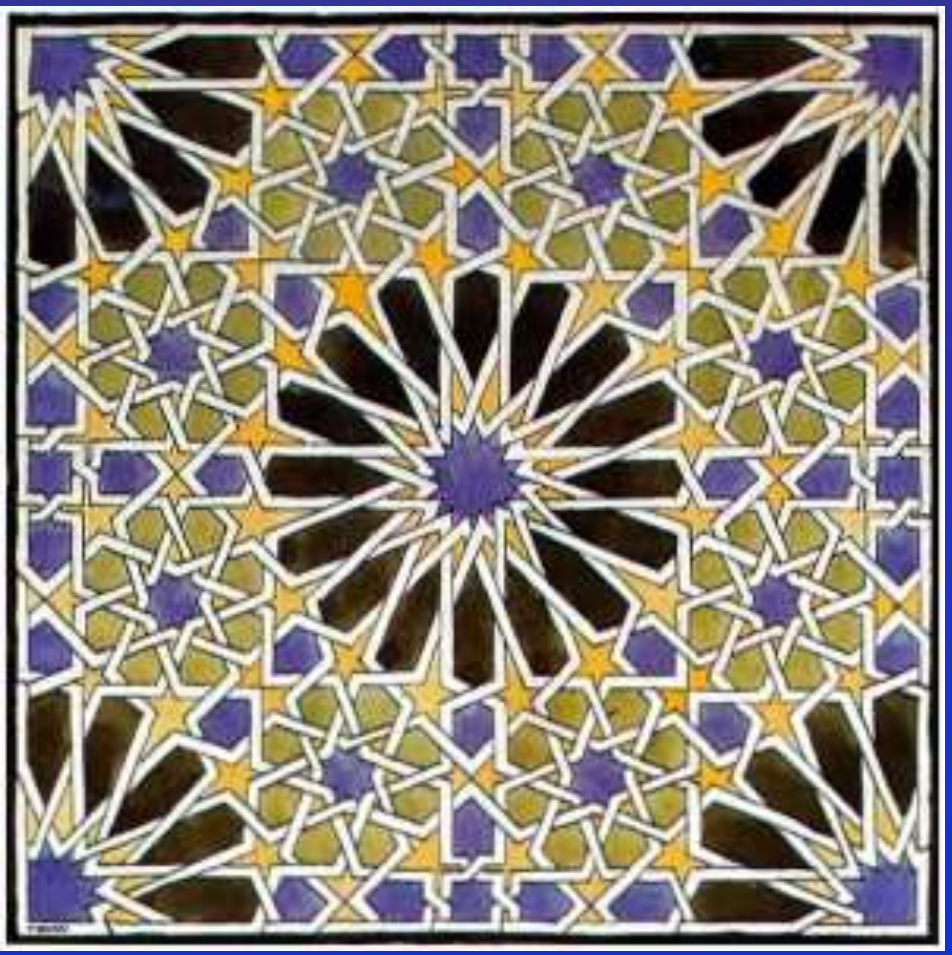


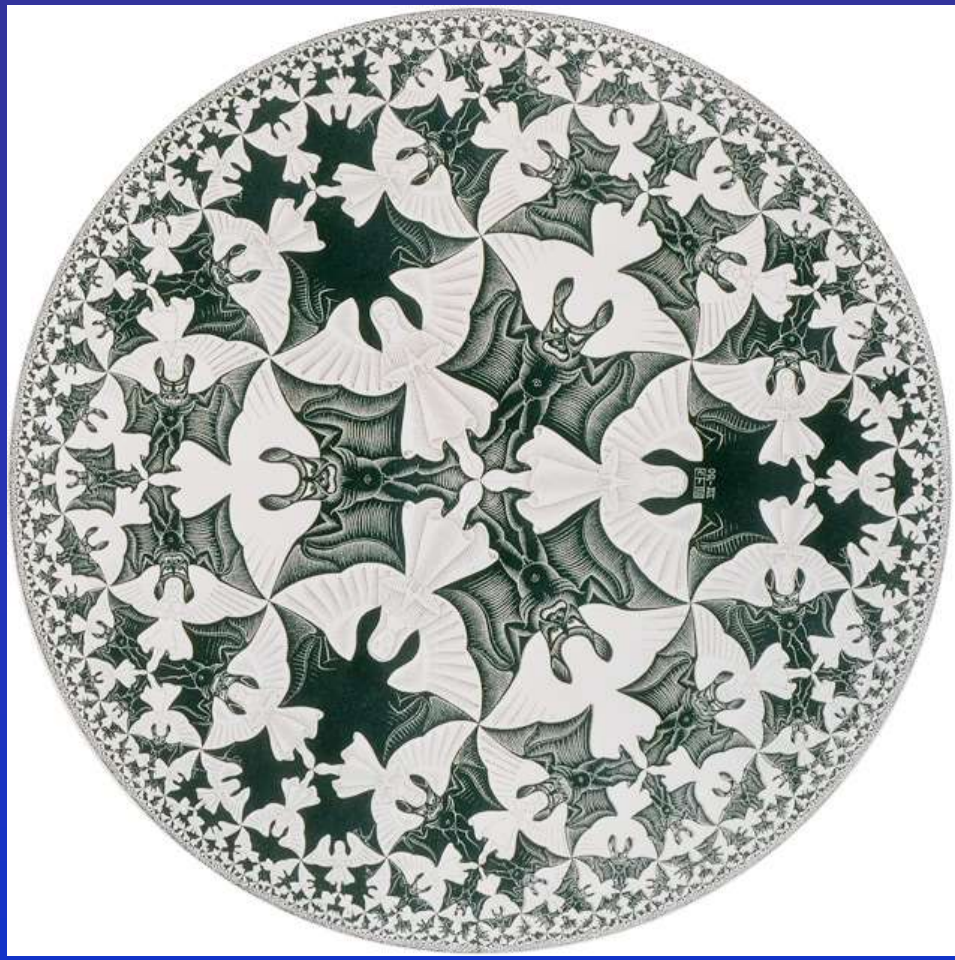
FASCINO SENZA TEMPO



ROSA CAMUNA E UOMO VITRUVIANO

ARTE

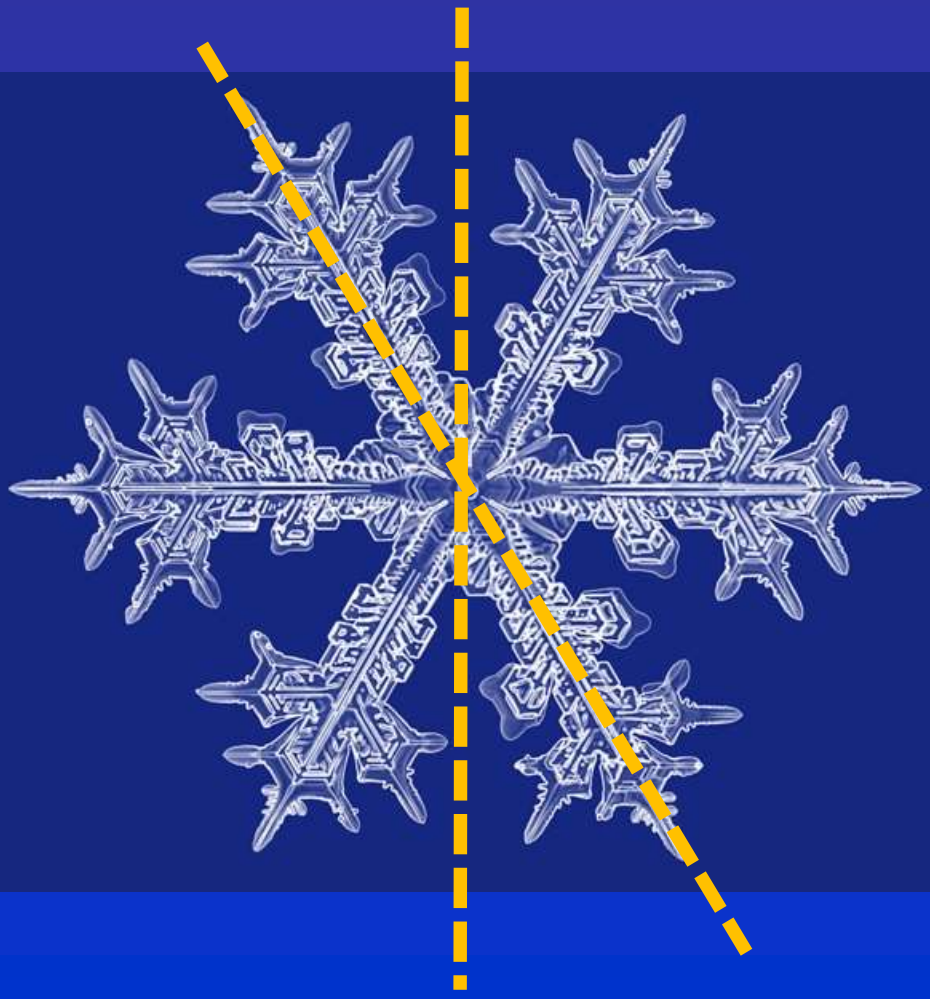


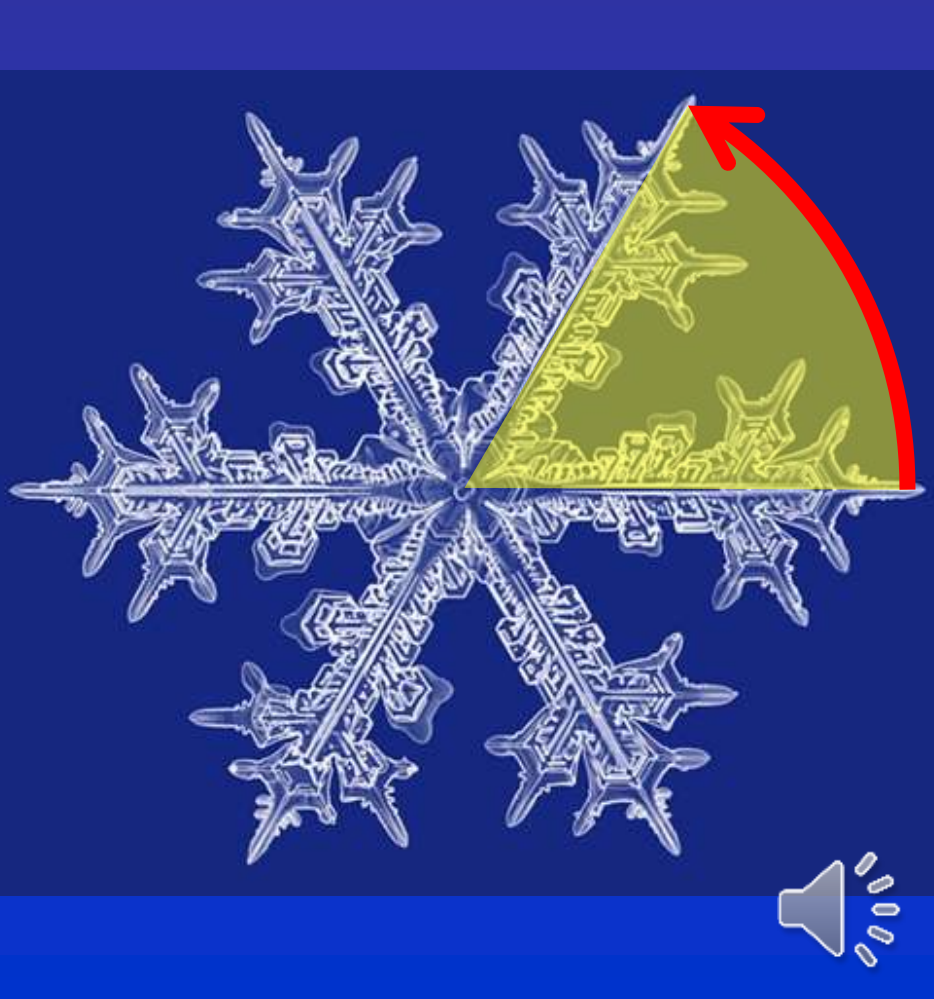


MOSAICO DELL'ALHAMBRA E OPERA DI ESCHER

COS'E' UNA SIMMETRIA

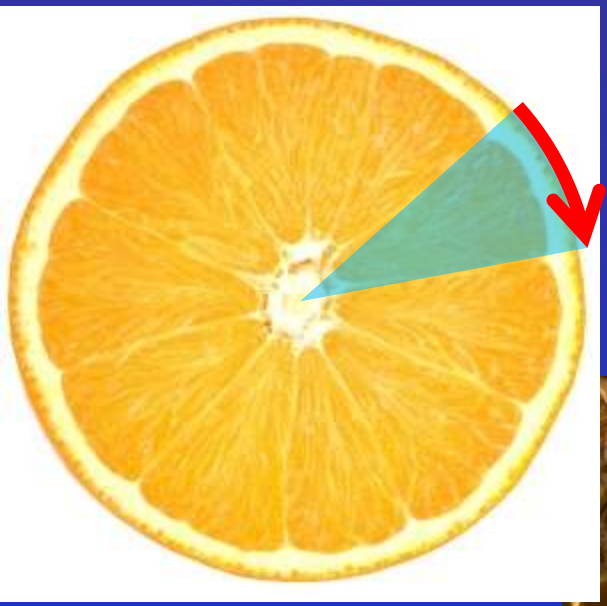
VI E' SIMMETRIA SE UN OGGETTO RIMANE INALTERATO DOPO L'ESECUZIONE DI UNA CERTA OPERAZIONE



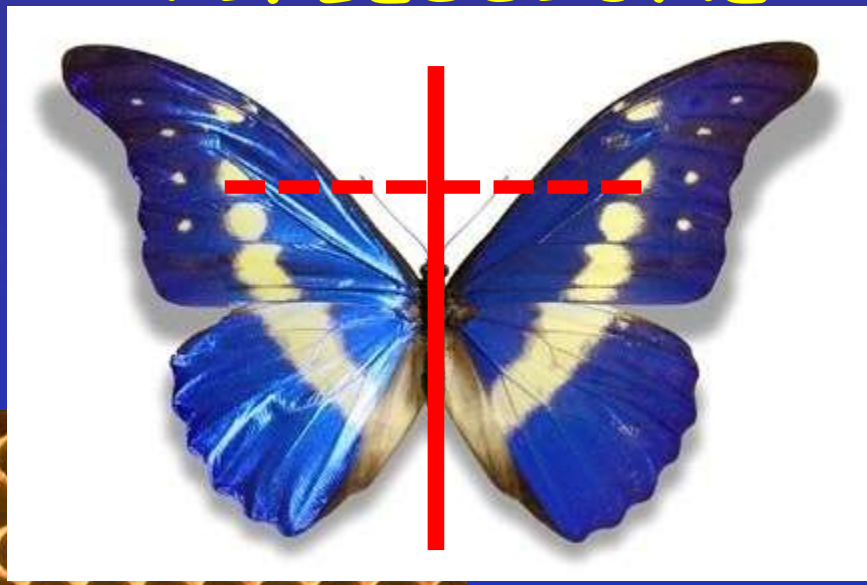


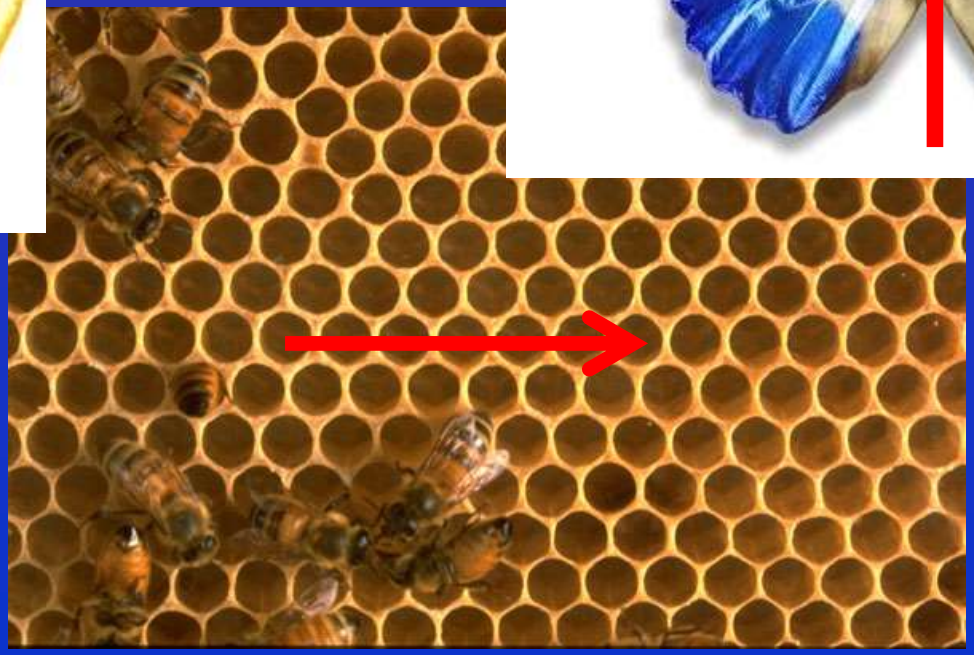
SIMMETRIE GEOMETRICHE

ROTAZIONE



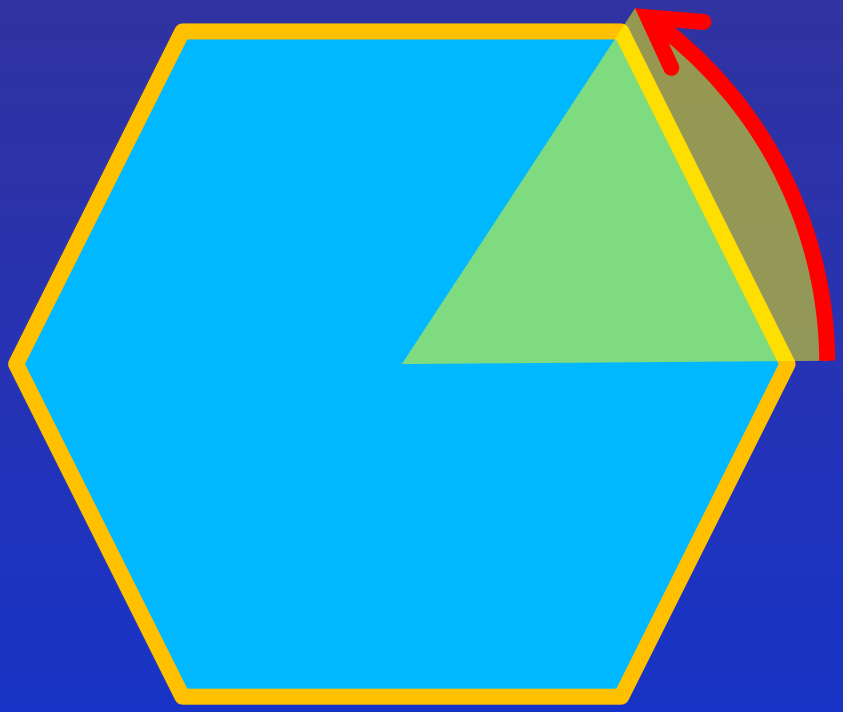
RIFLESSIONE



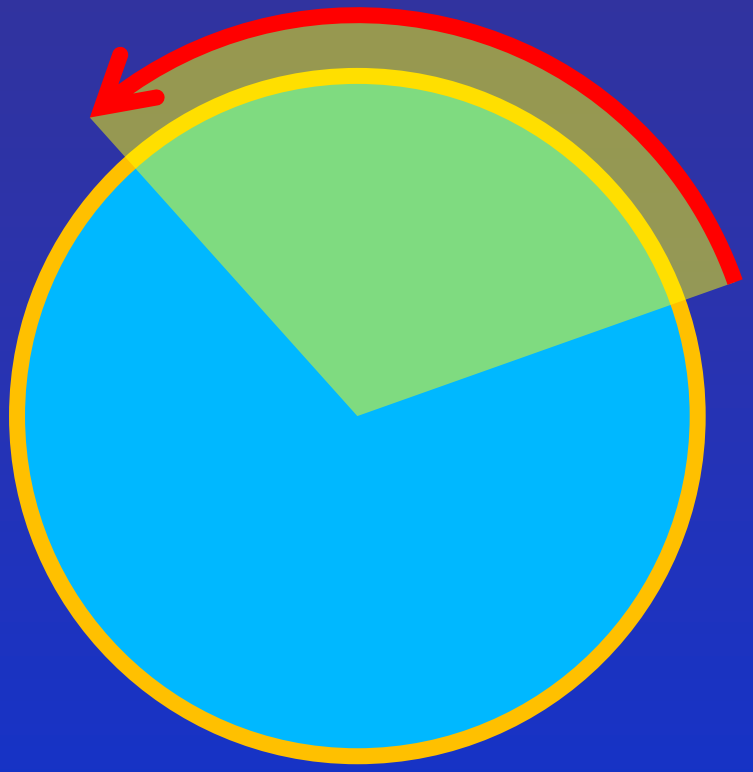


TRASLAZIONE

DISCRETO E CONTINUO



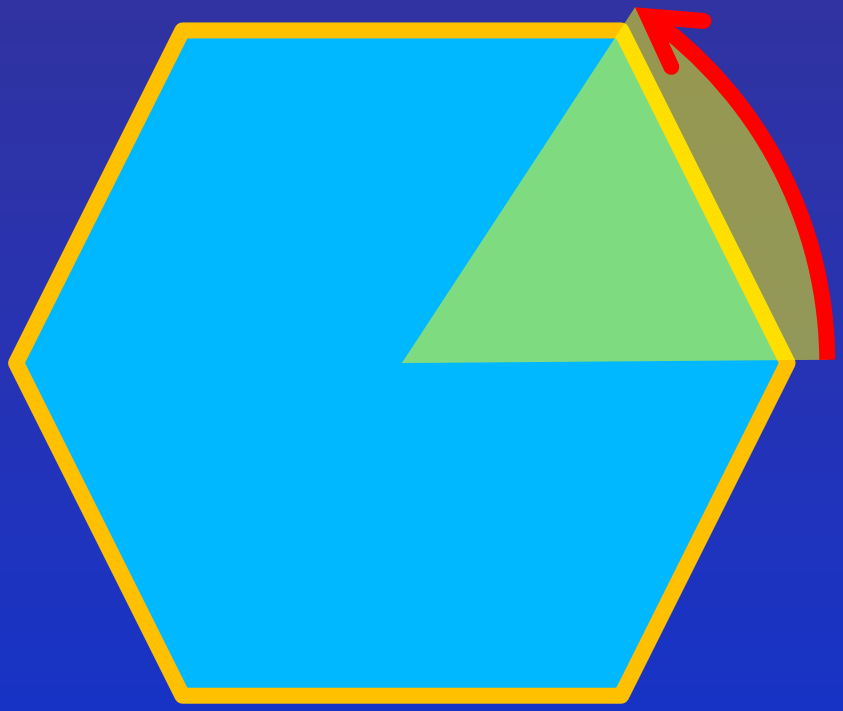
SIMMETRIA DISCRETA DI ROTAZIONE PER ANGOLI MULTIPLI DI 60°



SIMMETRIA CONTINUA DI ROTAZIONE PER ANGOLI QUALSIASI

GRUPPI

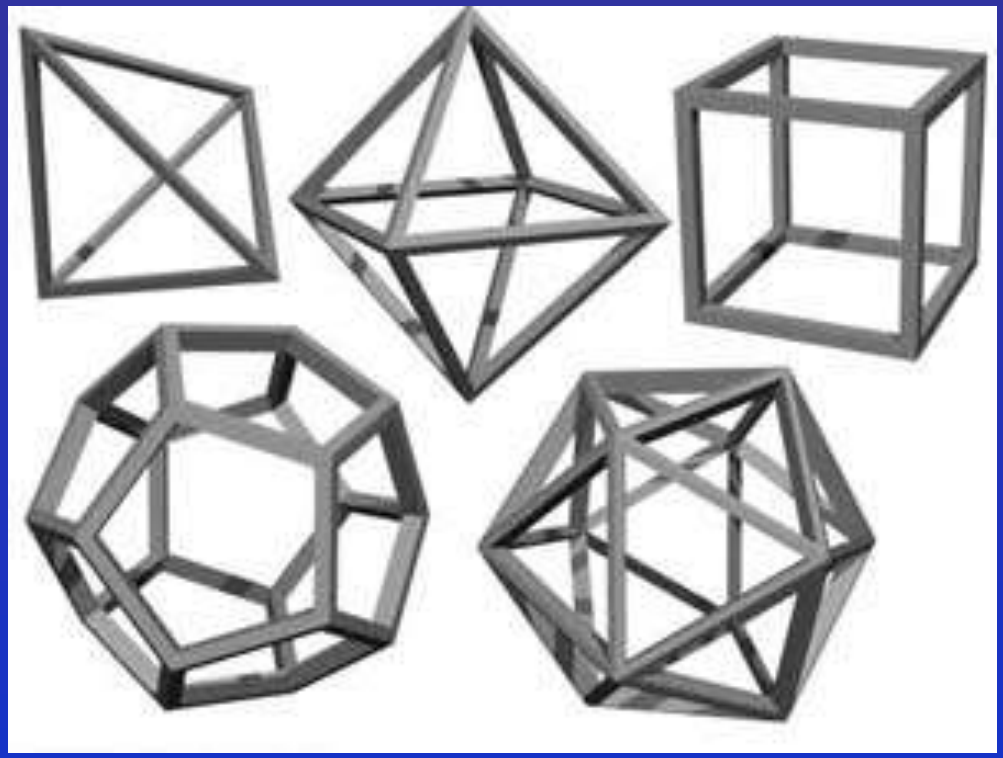
SIMMETRIA ⟺ GRUPPO



GRUPPO DISCRETO DI ROTAZIONI DI ANGOLI 0°,60°,120°,180°,240°,300°

GRUPPO CONTINUO DI ROTAZIONI DI ANGOLI QUALSIASI

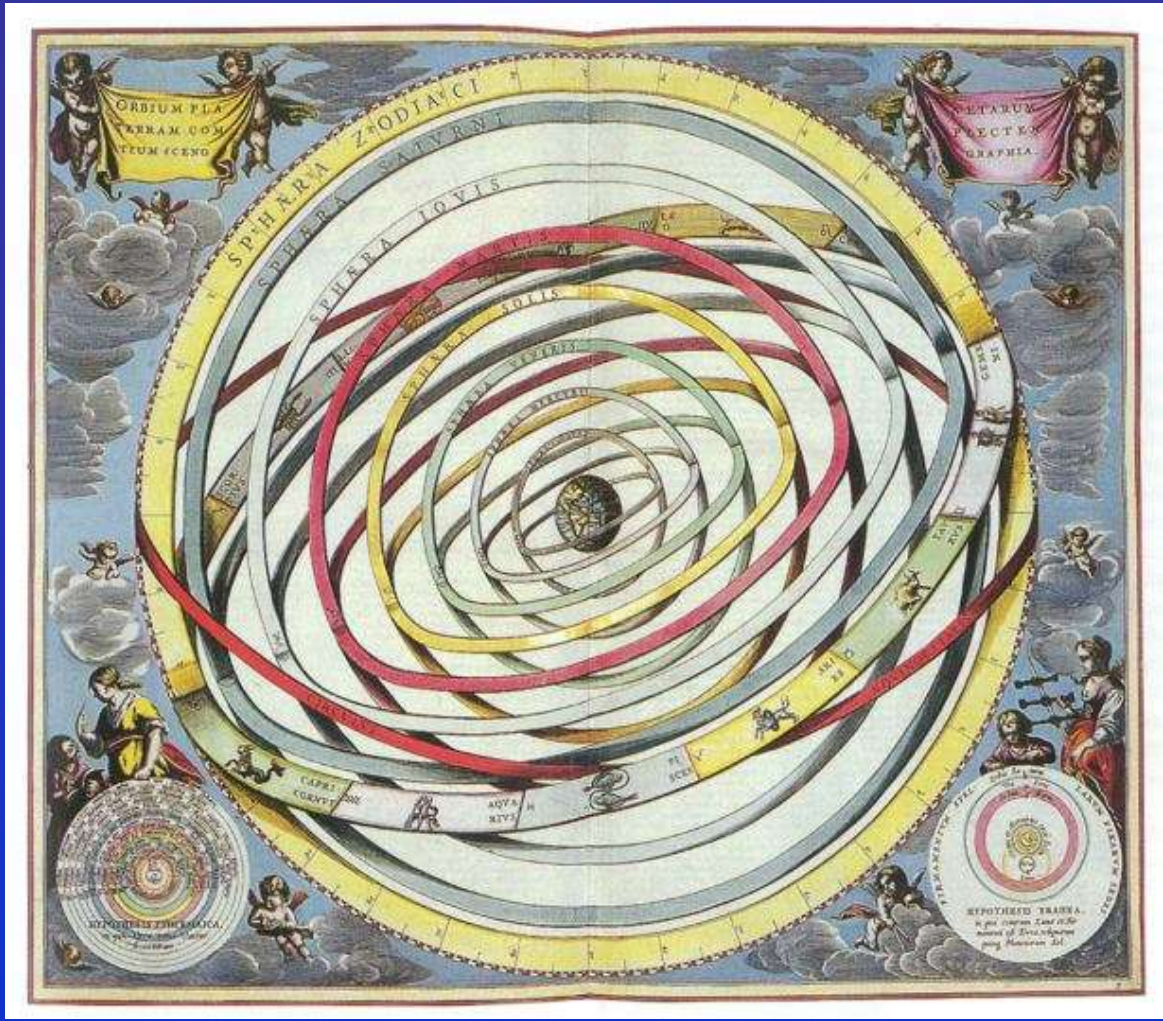
SIMMETRIA PERFETTA



SOLIDI PLATONICI

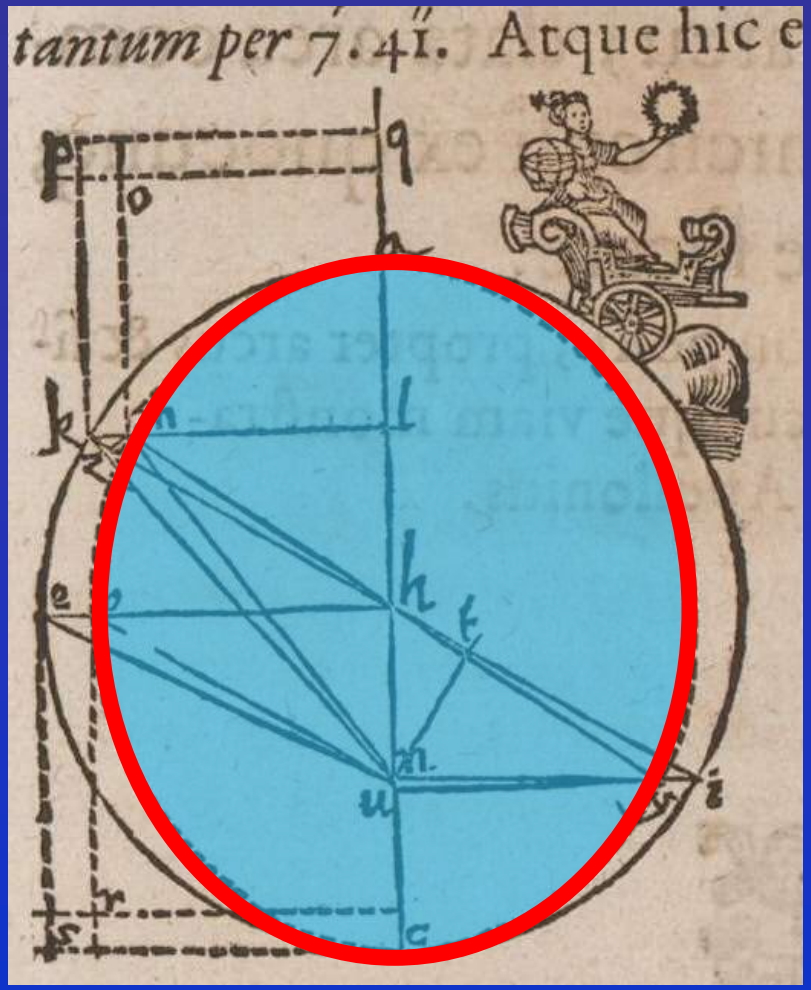
SFERA

L'UNIVERSO PERFETTO

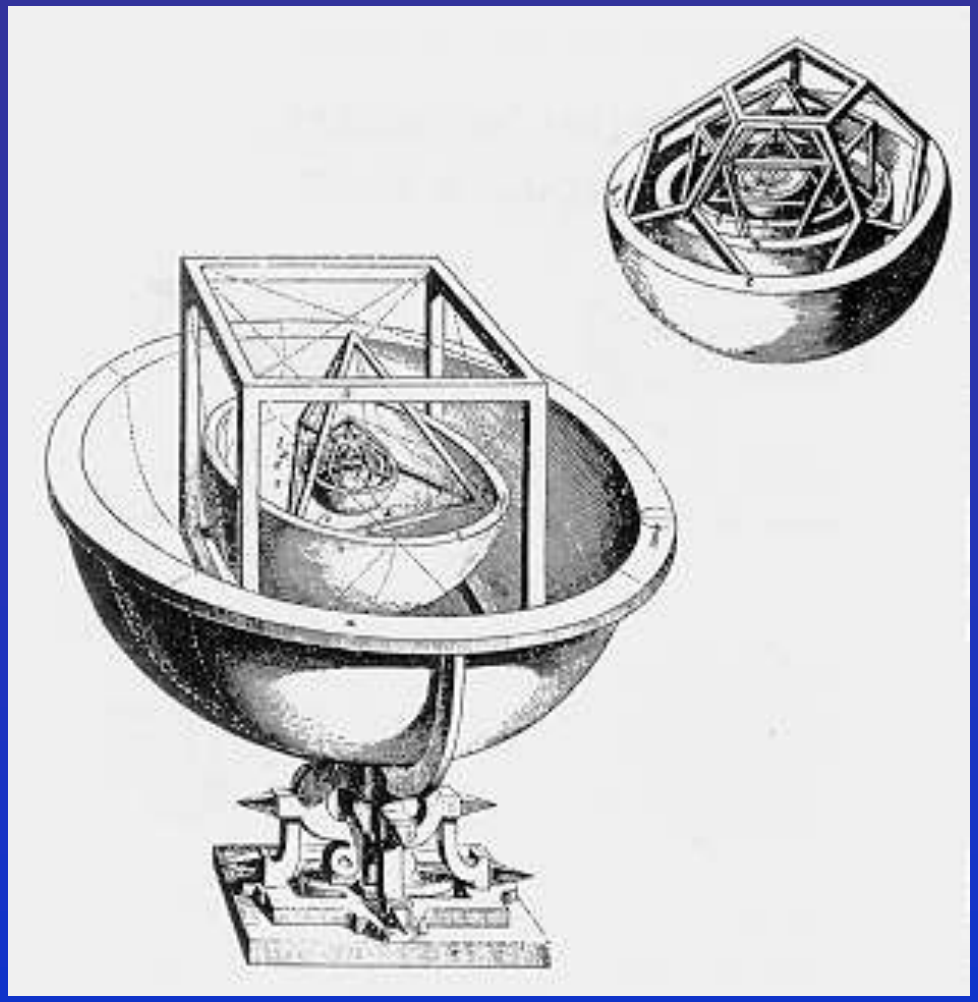


SISTEMA DELLE SFERE CELESTI Andreas Cellarius
Harmonia Macrocosmica (1660)

SIMMETRIA INFRANTA



ORBITE ELLITTICHE



SISTEMA KEPLERIANO

LEGGI SIMMETRICHE

$$\vec{F} = m\vec{a}$$

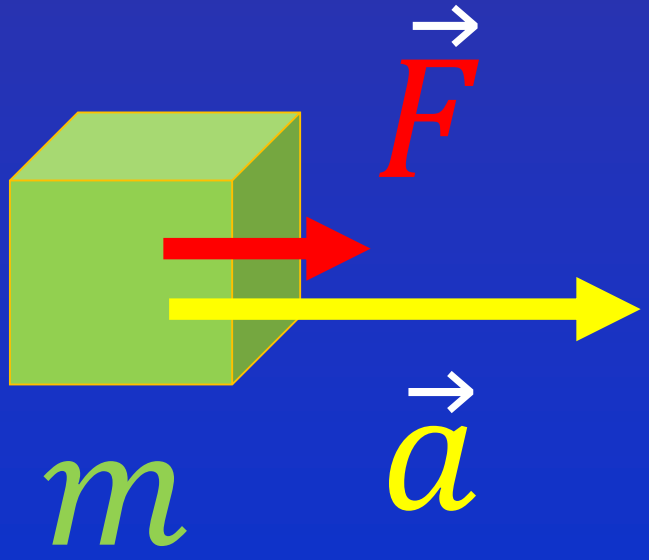
$$F = G\frac{m_1 m_2}{r^2}$$

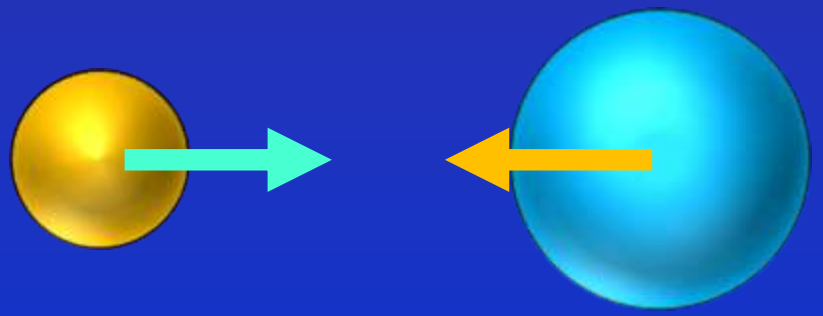
NEWTON ELABORA LE LEGGI DELLA MECCANICA E DI GRAVITAZIONE UNIVERSALE

LEGGI DI FORZA

$$\vec{F} = m\vec{a}$$

$$F = G\frac{m_1 m_2}{r^2}$$





$$\vec{F}_{12} = -\vec{F}$$

UNIVERSALITA'

$$\vec{F} = m\vec{a} \qquad \vec{F}_{12} = -\vec{F}_{21}$$

$$F = G\frac{m_1 m_2}{r^2}$$

Credit NASA

SIMMETRIA DELLE LEGGI

$$\vec{F} = m\vec{a}$$

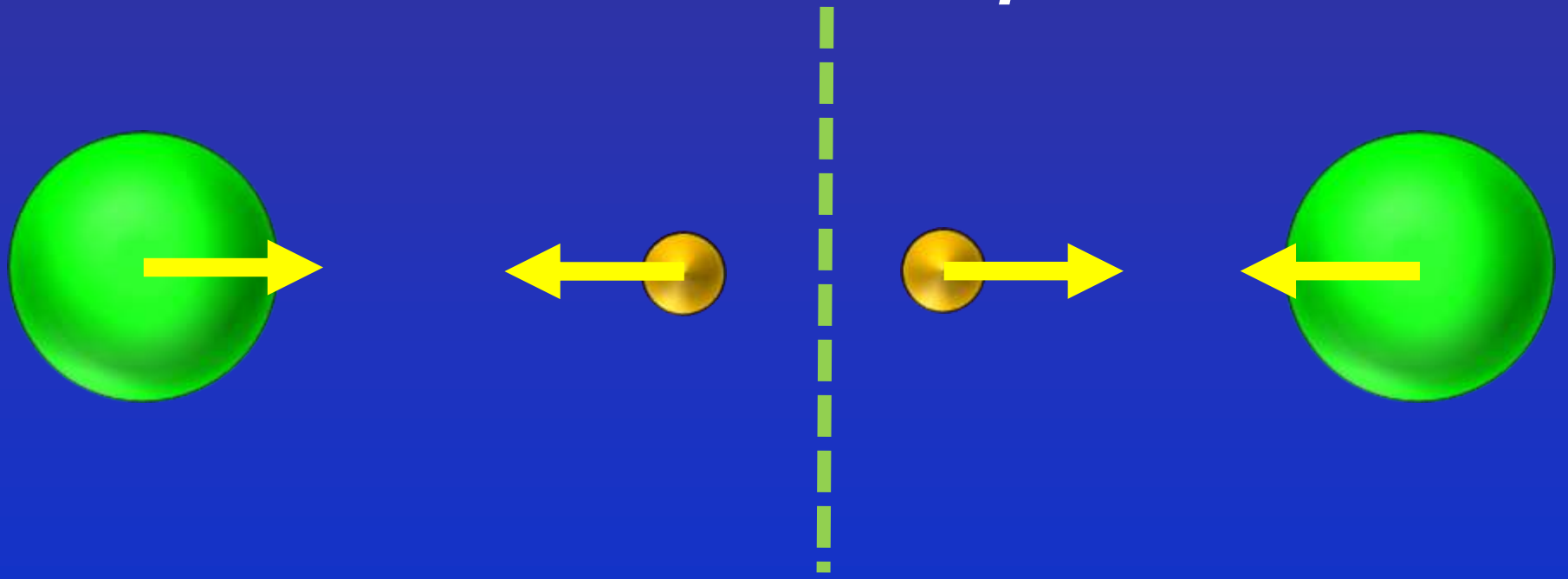
$$F = G\frac{m_1 m_2}{r^2}$$

SIMMETRIE IMPLICITE NELLE LEGGI DI NEWTON

VALIDITA'	SIMMETRIA
OVUNQUE	TRASLAZIONALE
OGNI DIREZIONE	ROTAZIONALE
SEMPRE	TEMPORALE

SCAMBIO

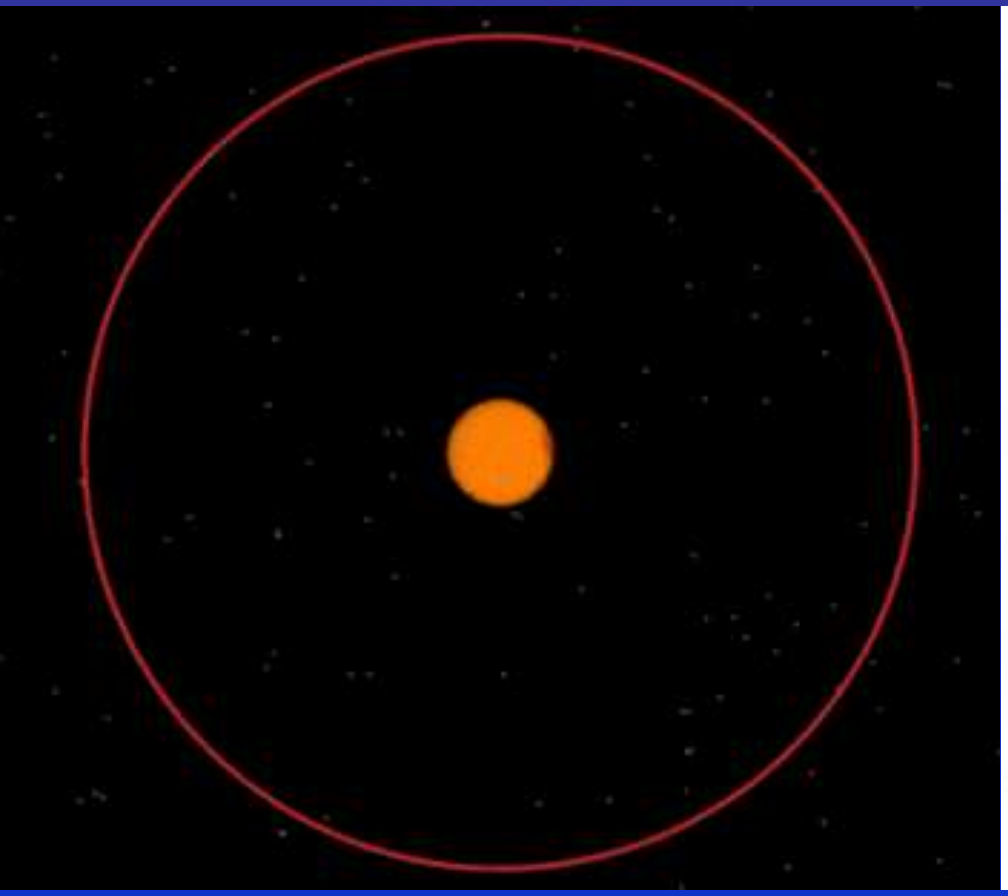
$$F = G\frac{m_1 m_2}{r^2}$$

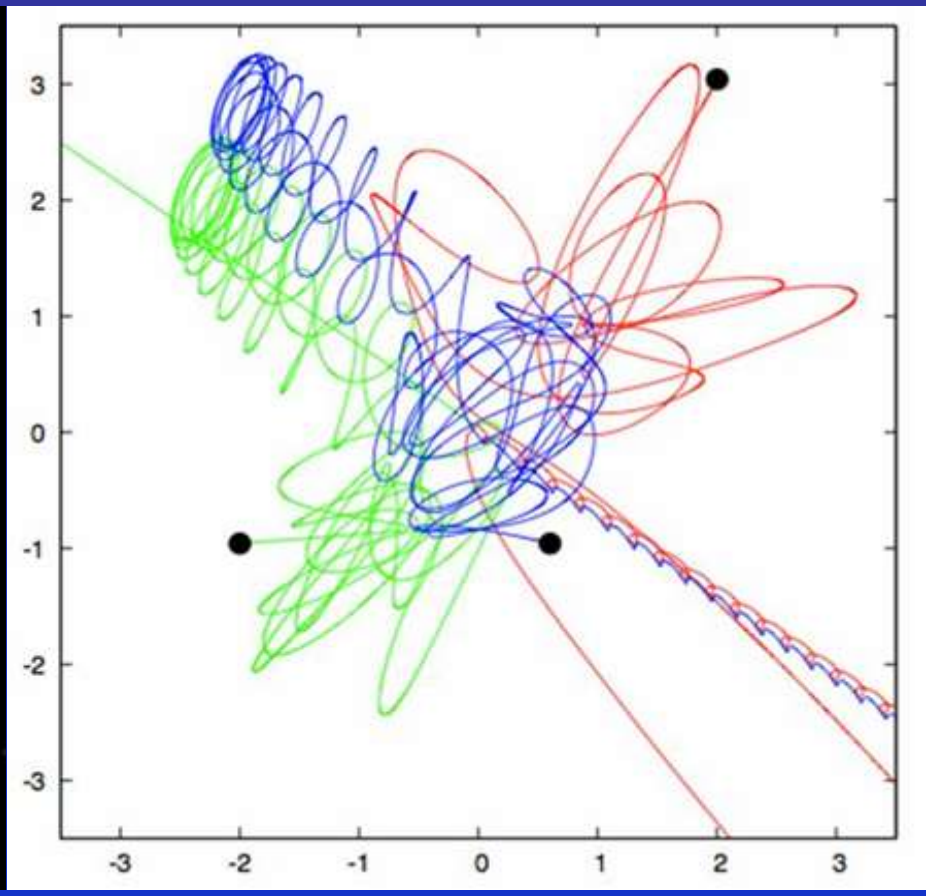


SCAMBIARE LE MASSE LASCIA INALTERATE LE FORZE

NON SI PUO' ESTENDERE A PIU' MASSE

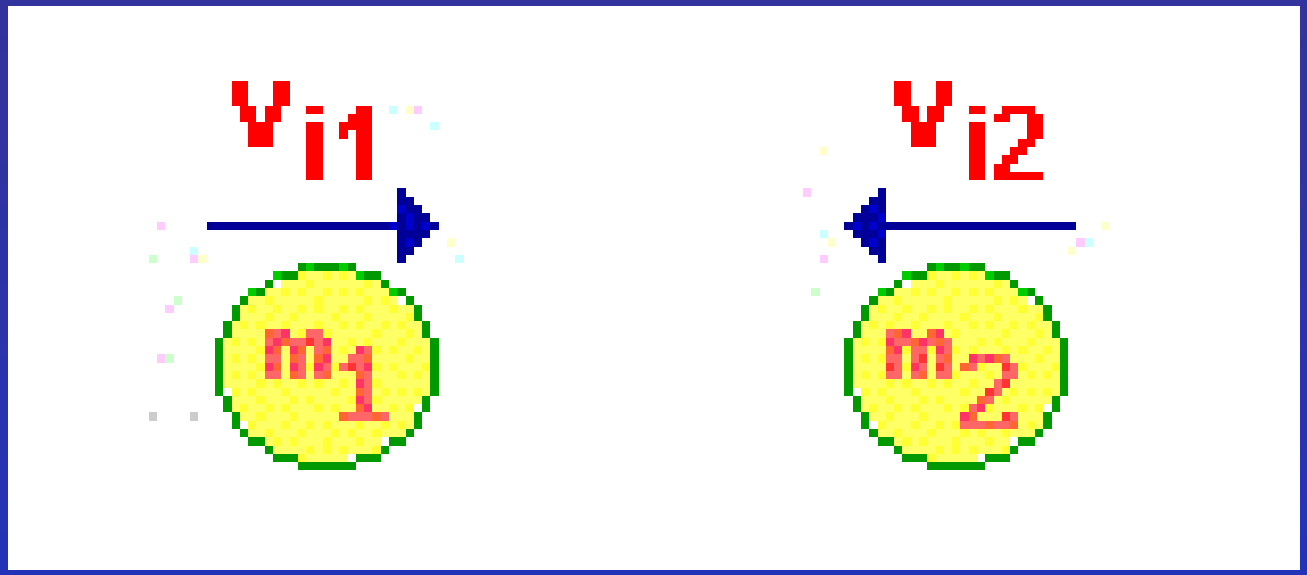
SIMMETRIA NASCOSTA





L'ORBITA CIRCOLARE E LE TRAIETTORIE CAOTICHE SOTTENDONO LA STESSA LEGGE SIMMETRICA

CONSERVAZIONE 1



$$\vec{p}_{tot} = m_1\vec{V}_1 + m_2\vec{V}_2$$

$$\vec{p}_{tot} = cost.$$

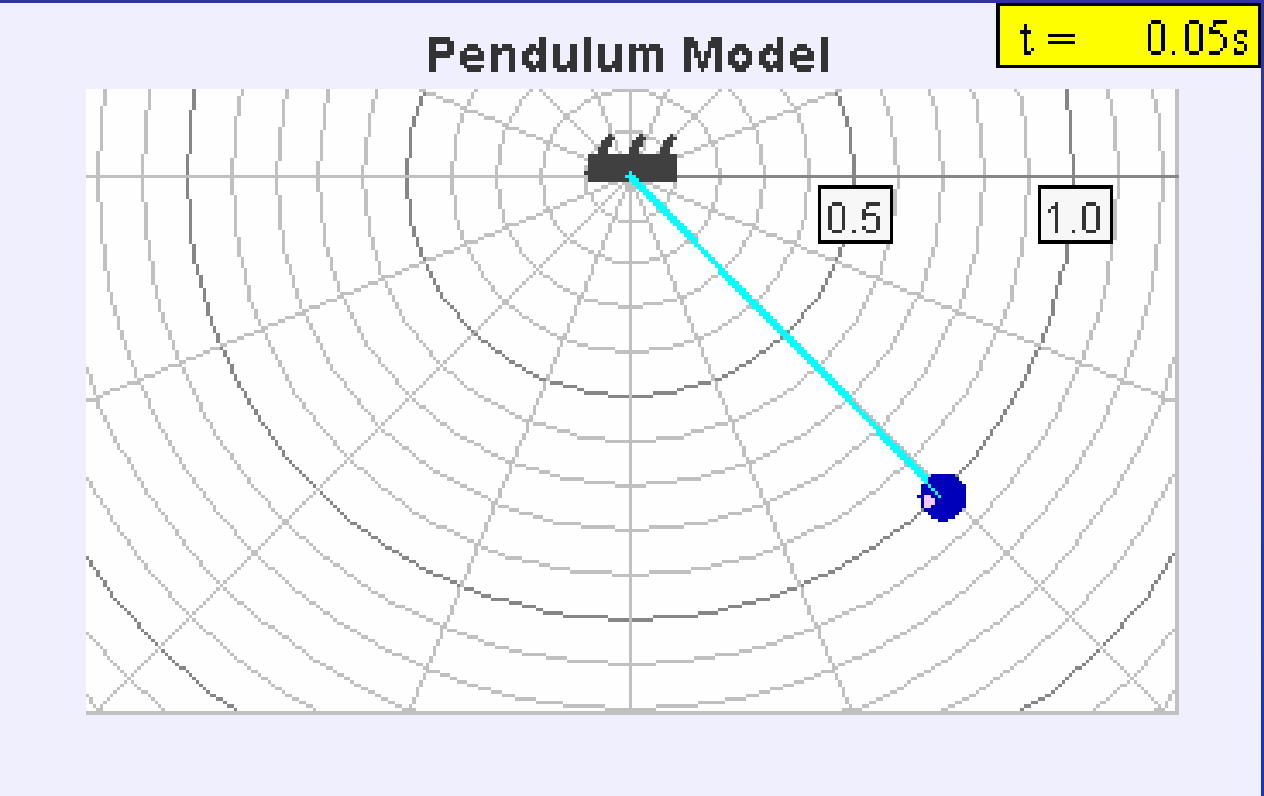
IN UN SISTEMA ISOLATO SI CONSERVA LA QUANTITA' DI MOTO TOTALE

CONSERVAZIONE 2

$$\vec{L}_{tot} = cost.$$

IN UN SISTEMA ISOLATO SI CONSERVA IL MOMENTO ANGOLARE TOTALE

CONSERVAZIONE 3



$$E_{tot} = K + U = cost.$$

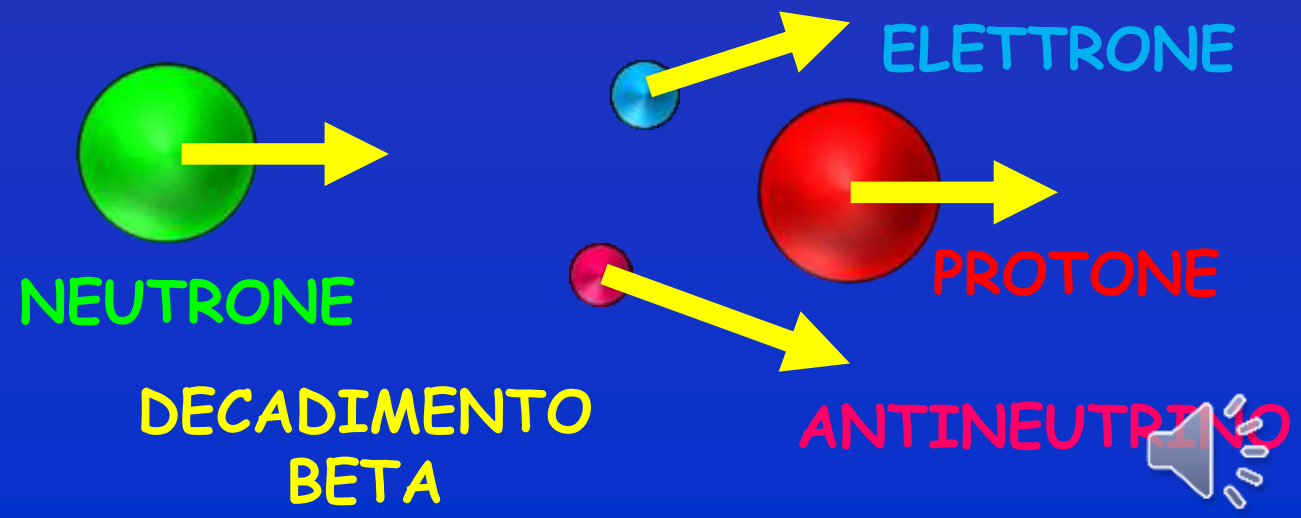
IN UN SISTEMA ISOLATO SI CONSERVA L'ENERGIA TOTALE

IL TEOREMA DI EMMY

1918 TEOREMA DI NOETHER: AD OGNI SIMMETRIA CORRISPONDE UNA LEGGE DI CONSERVAZIONE

E. NOETHER
1882-1935

SIMMETRIA	CONSERVAZIONE
TRASLAZIONALE	QUANTITA' DI MOTO
ROTAZIONALE	MOMENTO ANGOLARE
TEMPORALE	ENERGIA

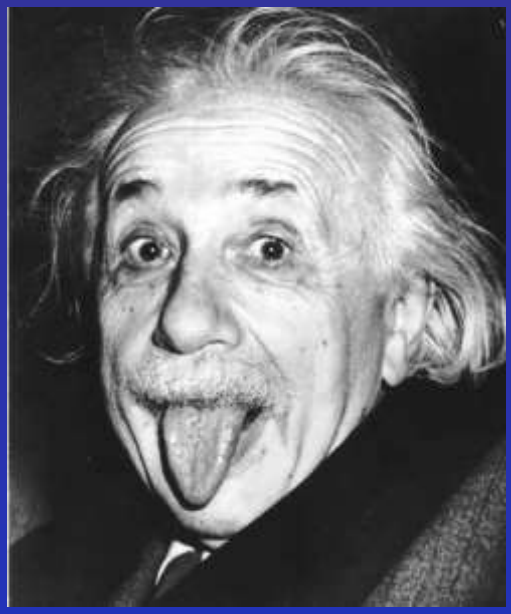


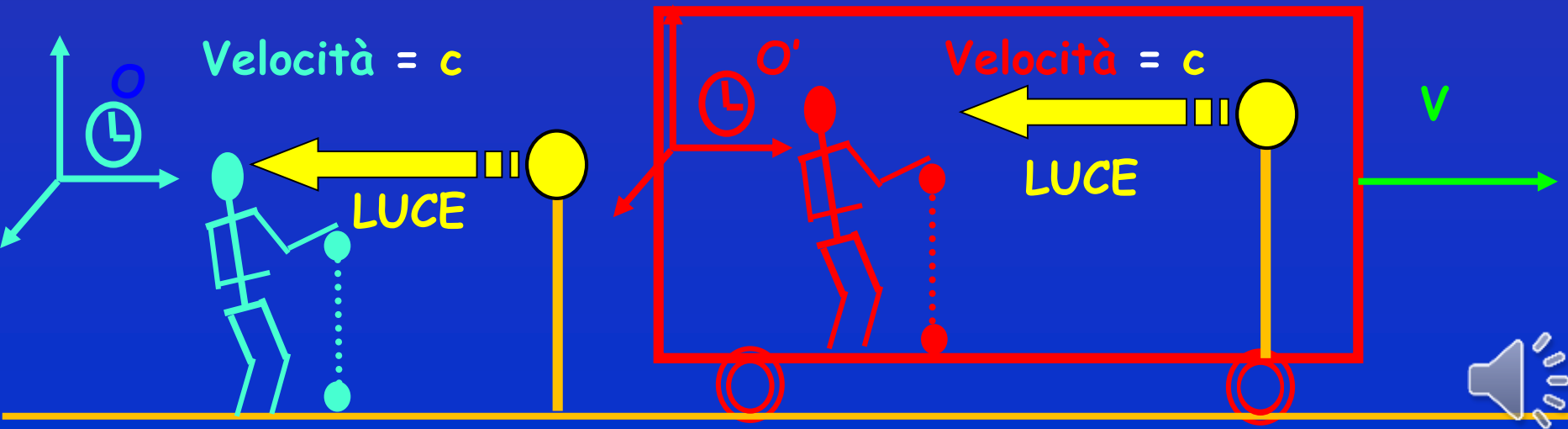
DECADIMENTO BETA

RELATIVITA'

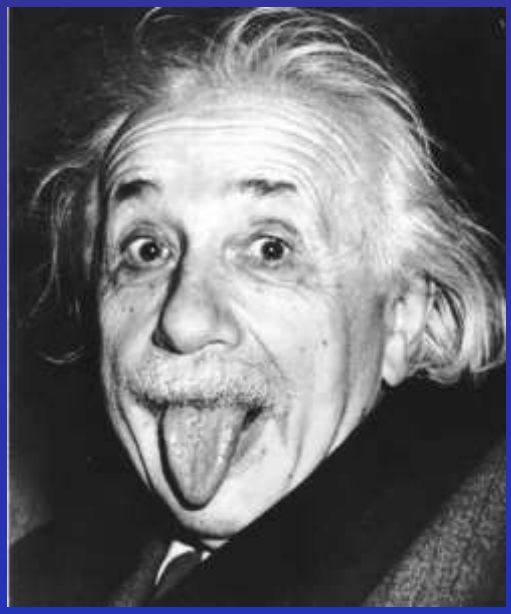
SISTEMI INERZIALI

PRINCIPIO DI RELATIVITA' (RISTRETTA): LE LEGGI DELLA FISICA DEVONO ESSERE LE STESSE (COVARIANTI) IN QUALUNQUE SISTEMA INERZIALE





INVARIANTI



INVARIANTI: LUNGHEZZA, DURATA E MASSA

VELOCITA' DELLA LUCE RELATIVA

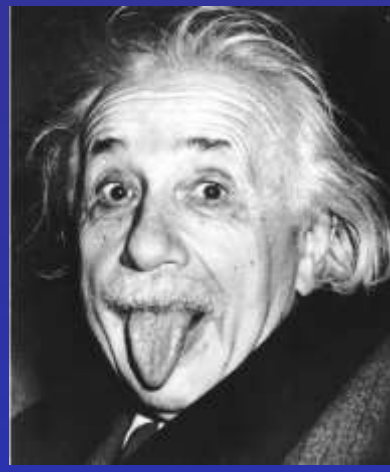
INVARIANTE: VELOCITA' DELLA LUCE

LUNGHEZZE, DURATE E MASSE RELATIVE

INVARIANTI

INVARIANTI: LUNGHEZZA, DURATA E MASSA

INVARIANTE: VELOCITA' DELLA LUCE



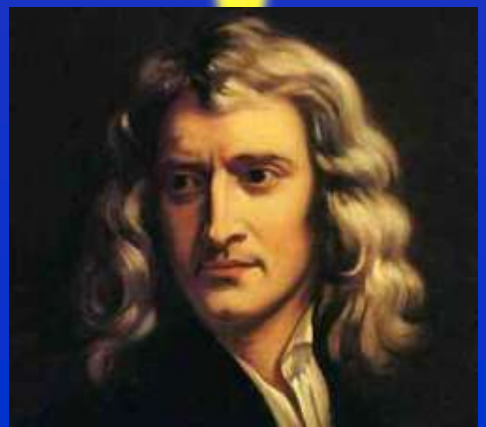
GRUPPO DI GALILEO

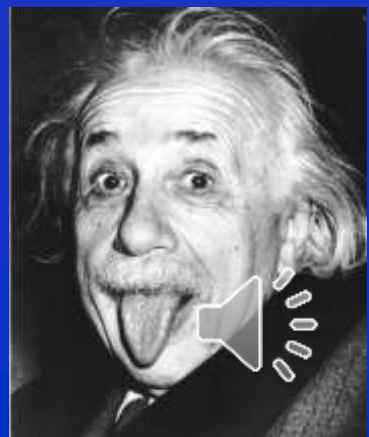
$$\begin{cases} x' = x - Vt \\ y' = y \\ z' = z \\ t' = t \end{cases}$$

GRUPPO DI LORENTZ

$$\begin{cases} x' = \dfrac{x - Vt}{\sqrt{1 - V^2/c^2}} \\ y' = y \\ z' = z \\ t' = \dfrac{t - Vx/c^2}{\sqrt{1 - V^2/c^2}} \end{cases}$$

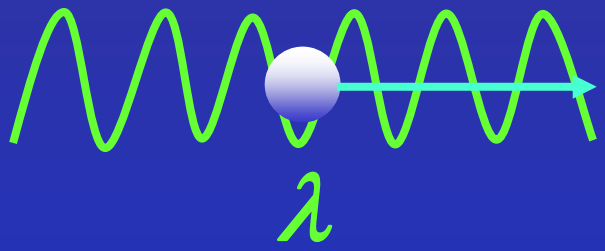
OSSERVATORI





ONDE DI MATERIA

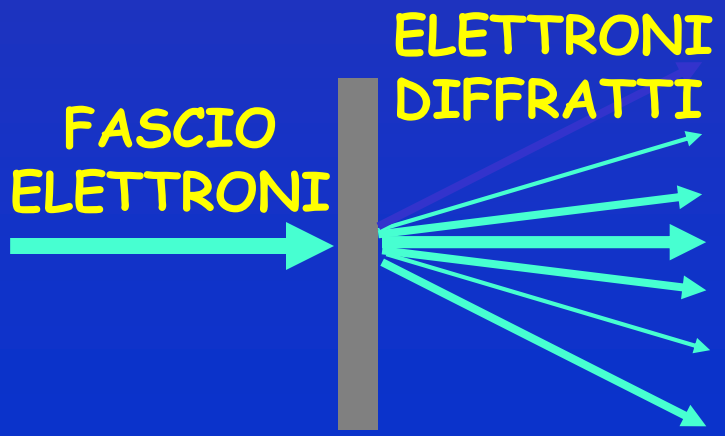
AD OGNI PARTICELLA IN MOTO E' ASSOCIATA UN'ONDA

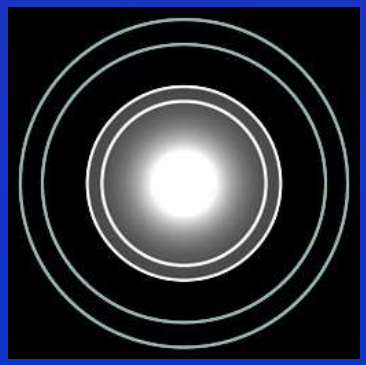


$p = mv$

$$\lambda = \frac{h}{p}$$

1927 DAVISSON, GERMER, THOMSON DIFFRAZIONE ELETTRONI





ELETTRONI

RAGGI X

NANOSTRUTTURE

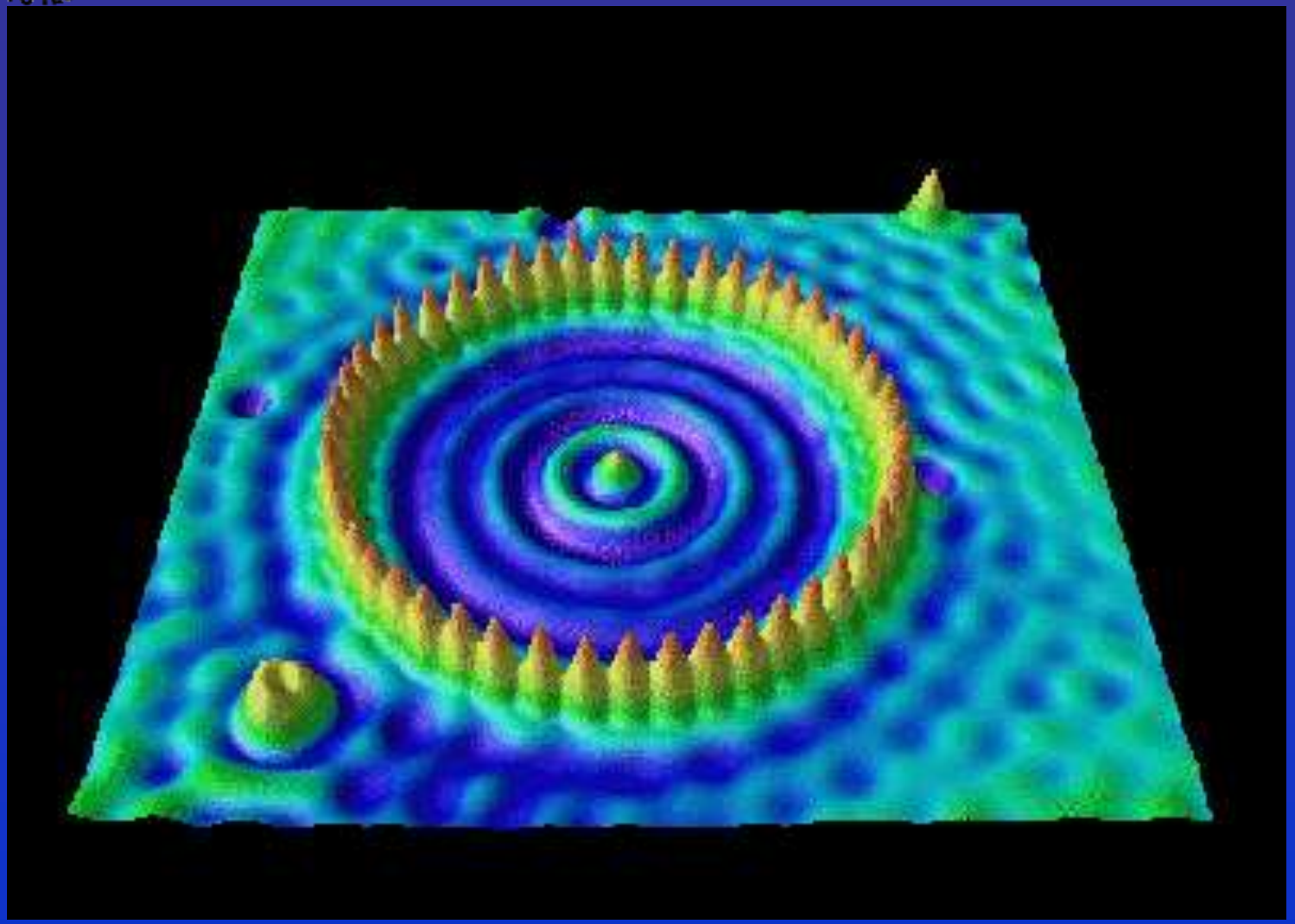
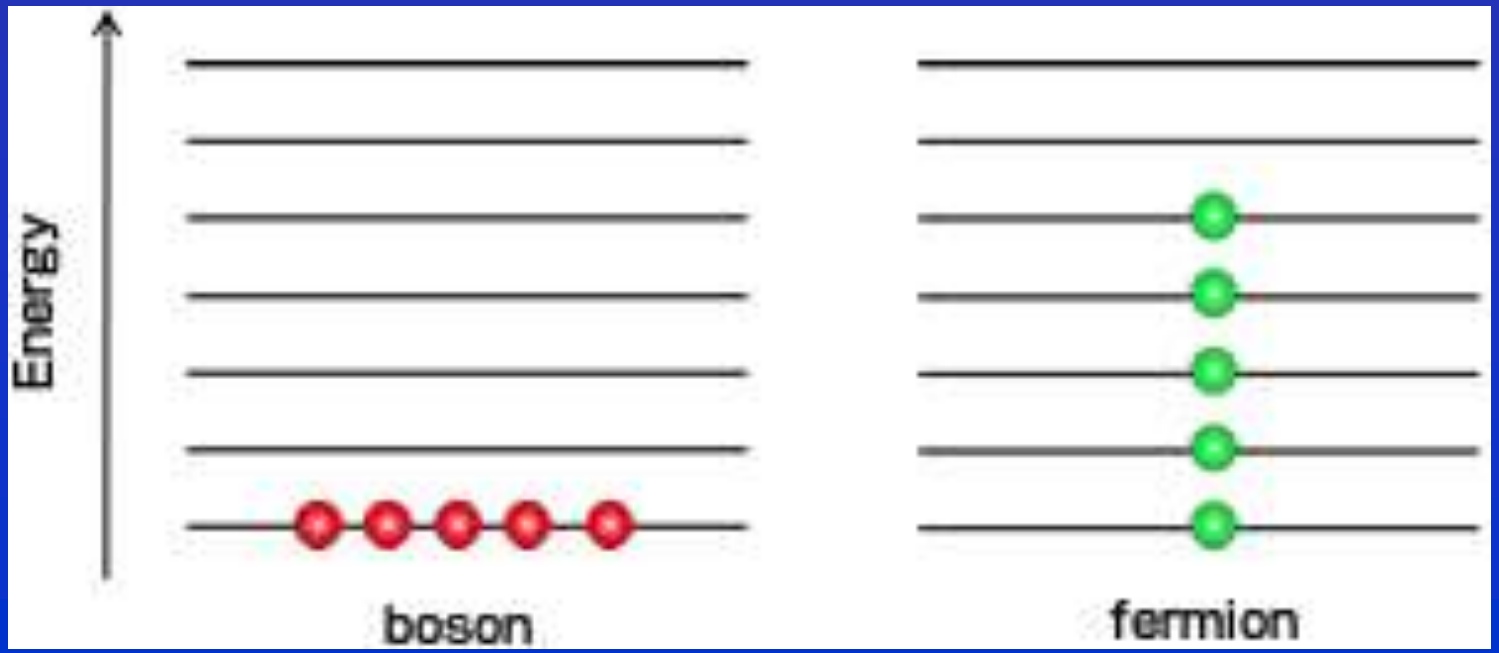


IMMAGINE STM DI UN «QUANTUM CORRAL» DI ATOMI DI FERRO CON FUNZIONE D'ONDA ELETTRONICA AL CENTRO

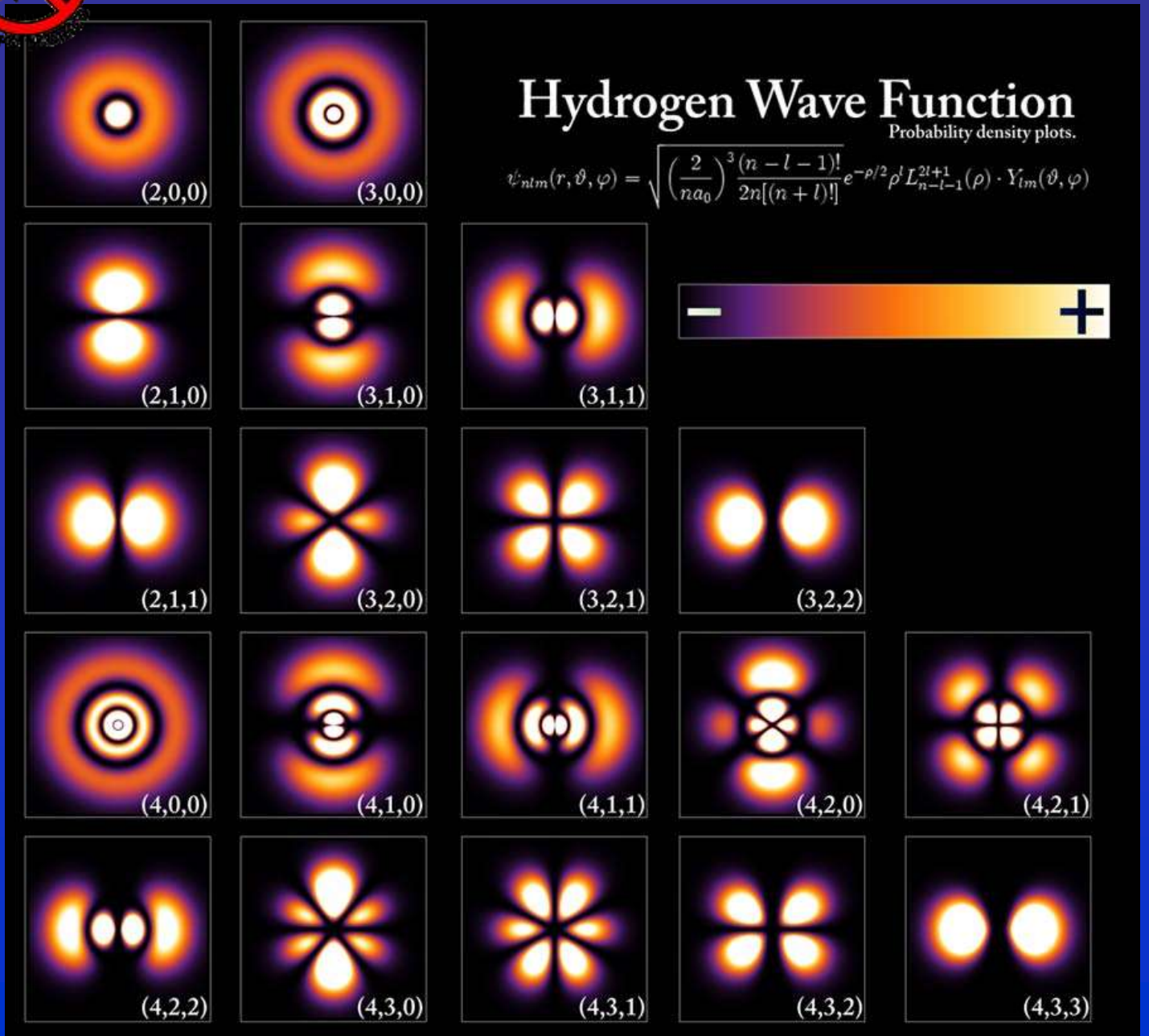
FUNZIONE D'ONDA

$$\Psi = \Psi_1(a)\Psi_2(b) \pm \Psi_1(b)\Psi_2(a)$$

+ SIMMETRICA **- ANTISIMMETRICA**



ATOMI


Hydrogen Wave Function
Probability density plots.
$\psi_{nlm}(r,\vartheta,\varphi) = \sqrt{\left(\frac{2}{na_0}\right)^3 \frac{(n-l-1)!}{2n[(n+l)!]}} e^{-\rho/2} \rho^l L_{n-l-1}^{2l+1}(\rho) \cdot Y_{lm}(\vartheta,\varphi)$
(2,0,0)
(3,0,0)
(2,1,0)
(3,1,0)
(3,1,1)
−
+
(2,1,1)
(3,2,0)
(3,2,1)
(3,2,2)
(4,0,0)
(4,1,0)
(4,1,1)
(4,2,0)
(4,2,1)
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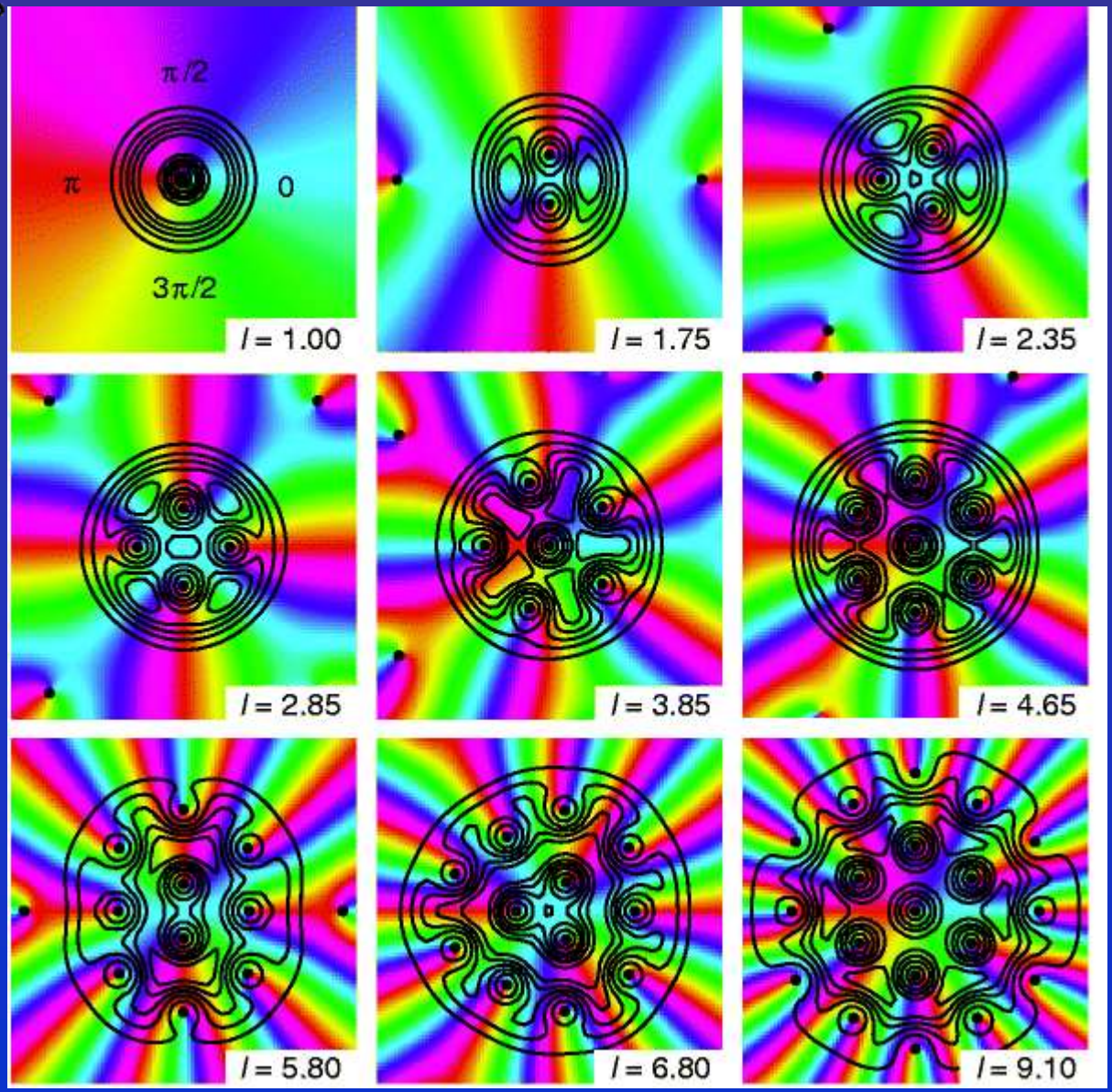
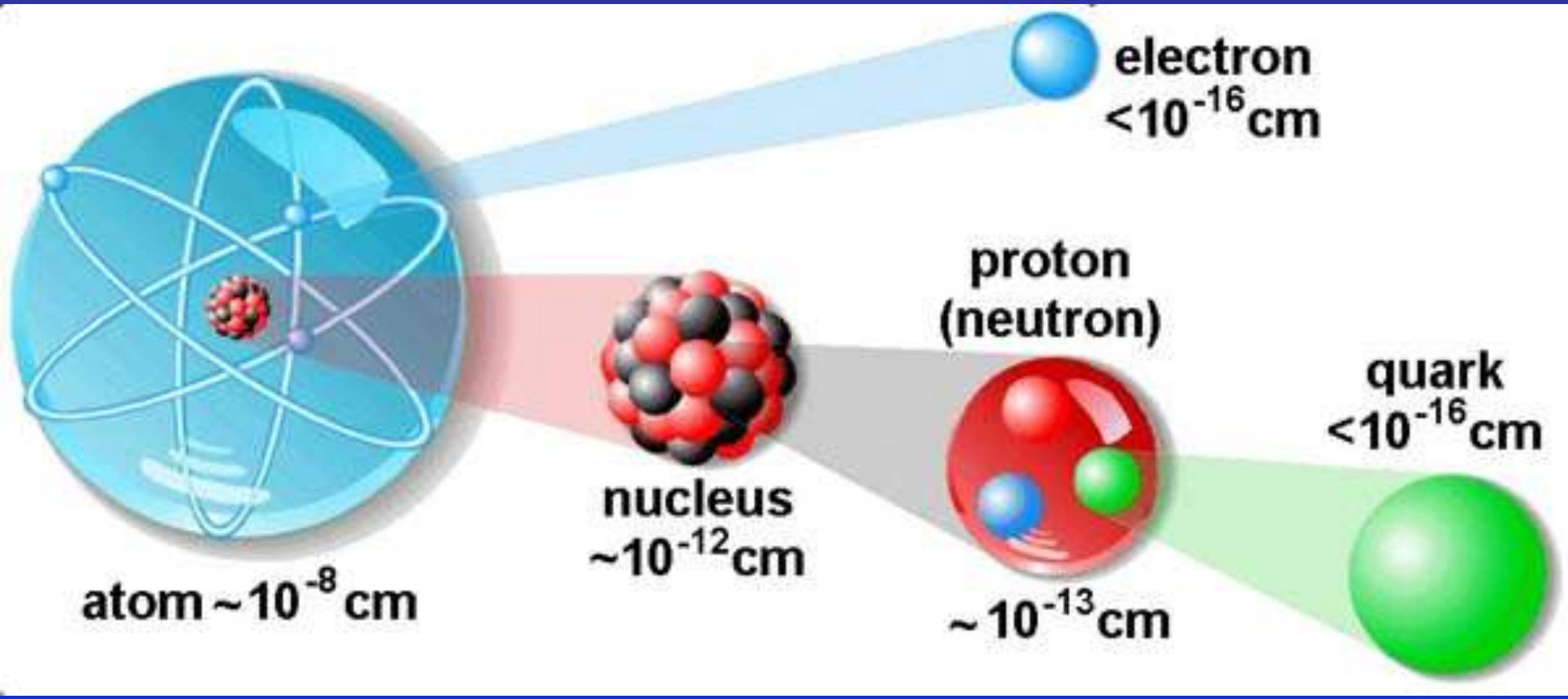
(4,3,0)
(4,3,1)
(4,3,2)
(4,3,3)

CONDENSATO

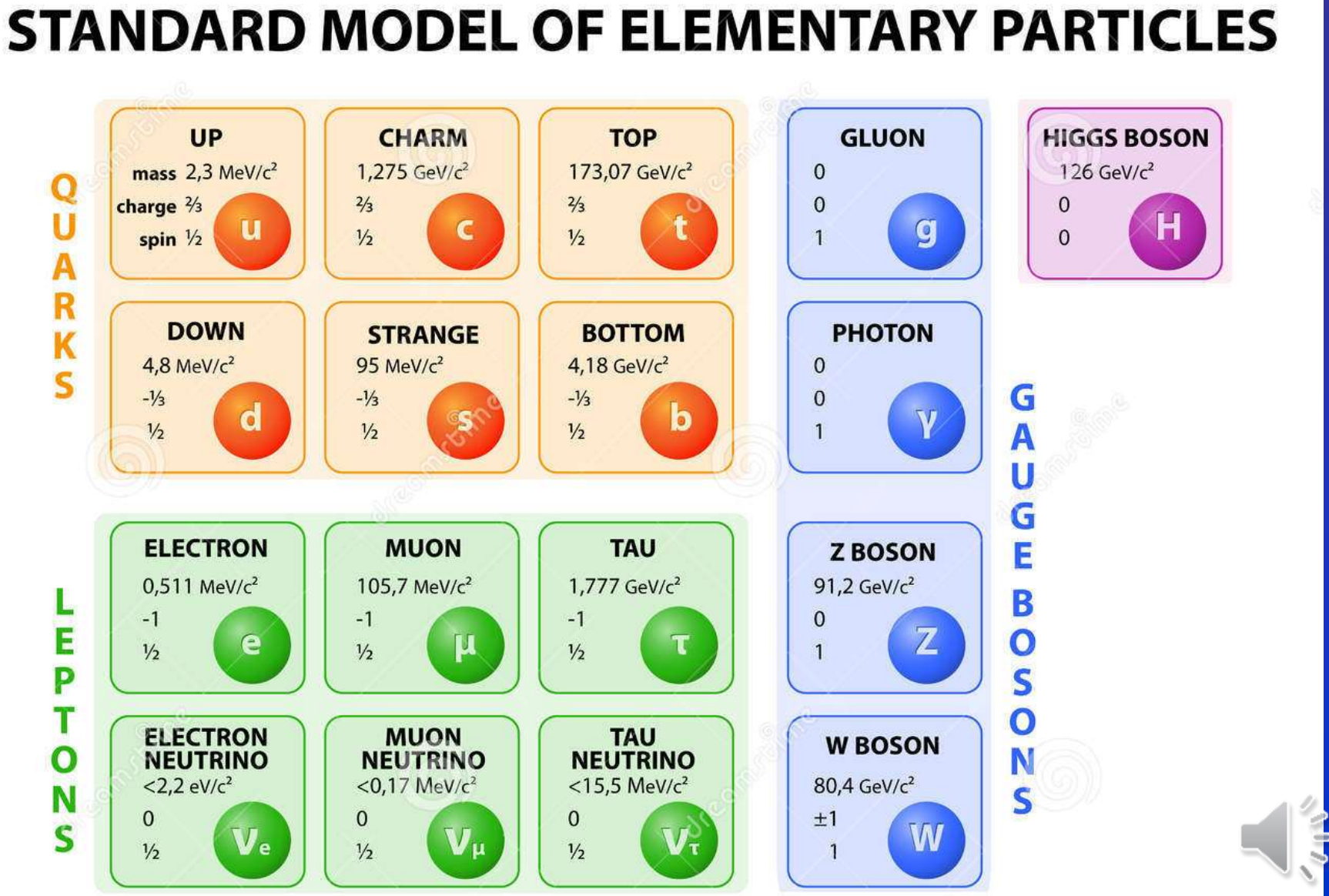


Credit: D. A. Butts and D. S. Rokhsar Nature

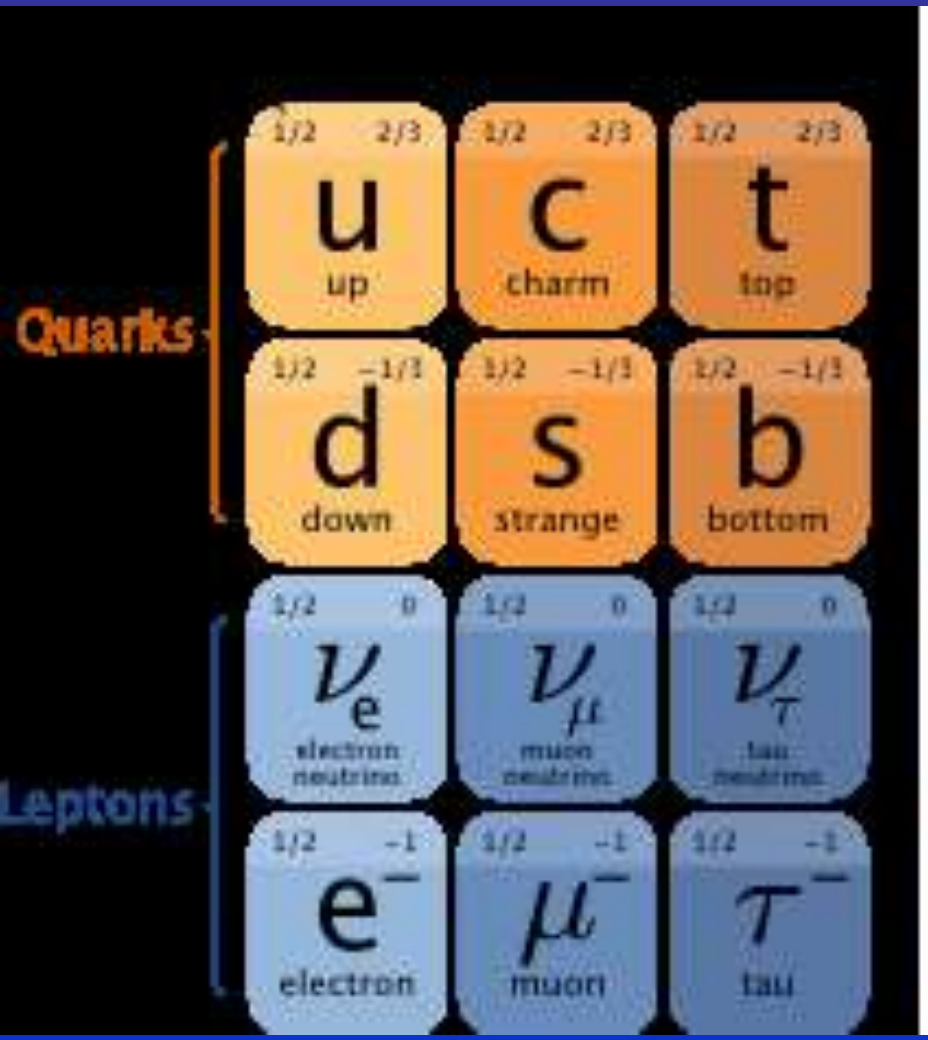
MATRIOSKE


electron
<10^-16 cm
proton
(neutron)
quark
<10^-16 cm
nucleus
~10^-12 cm
atom ~10^-8 cm
~10^-13 cm

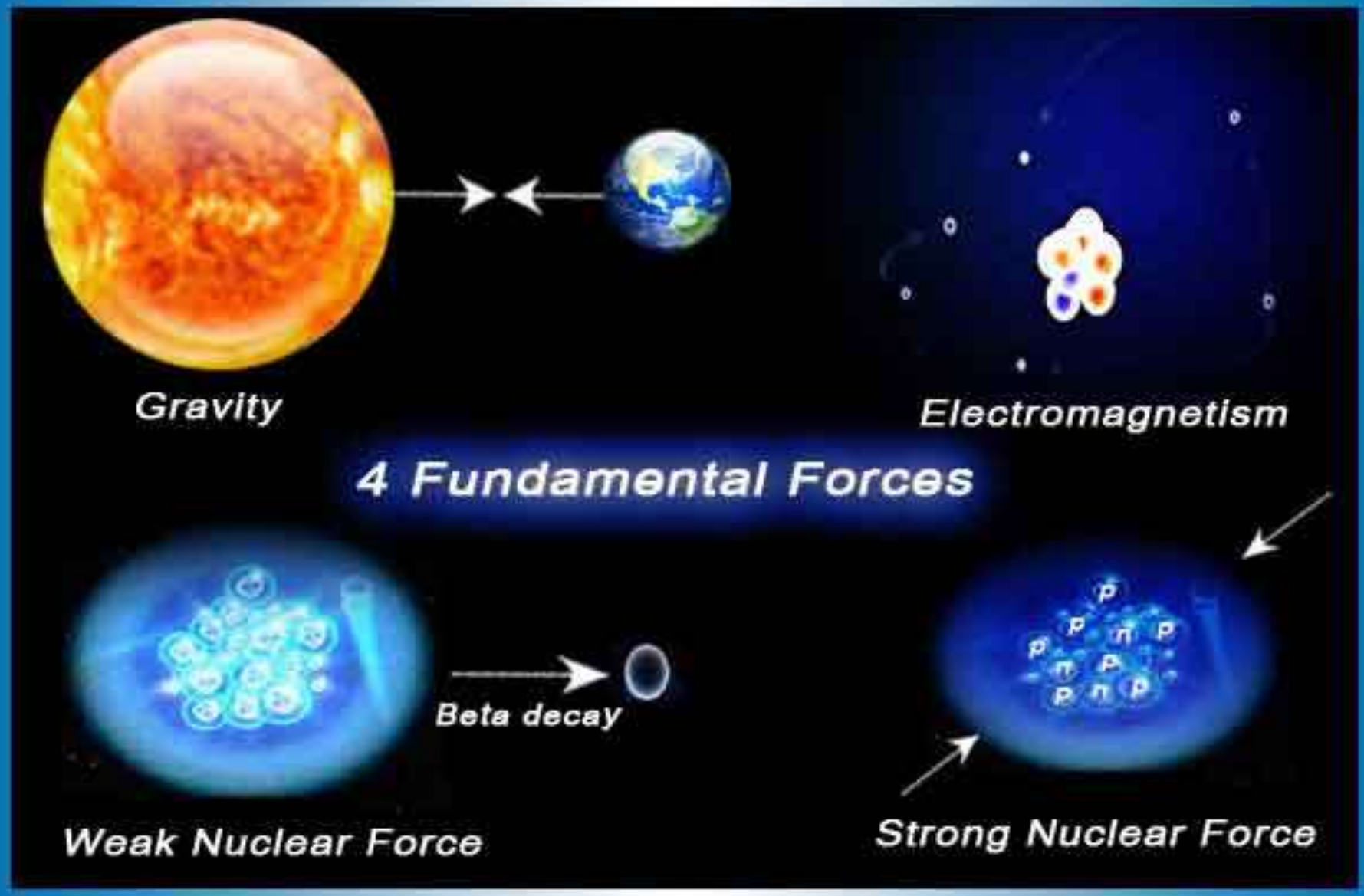
MODELLO STANDARD



ANTIMATERIA

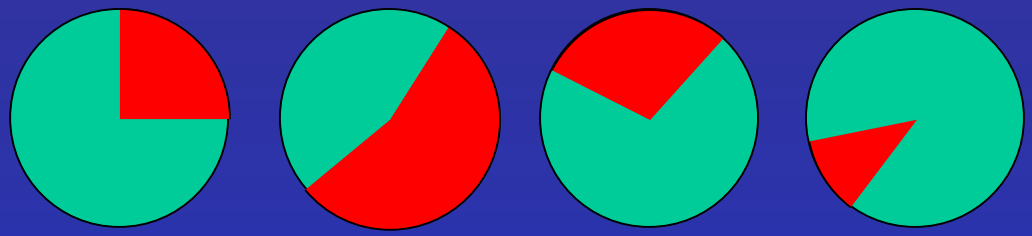


FORZE

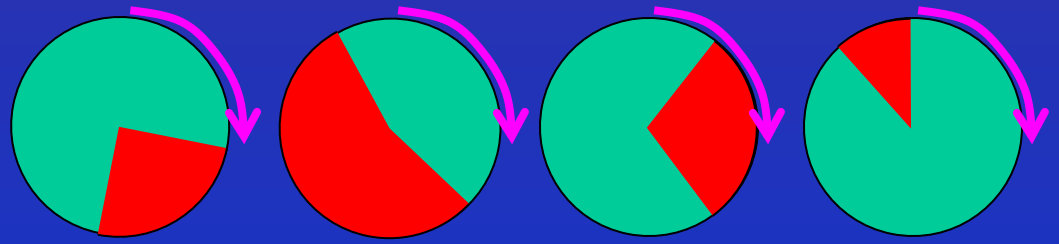

Gravity
Electromagnetism
4 Fundamental Forces
Beta decay
Weak Nuclear Force
Strong Nuclear Force

SIMMETRIE GLOBALI E LOCALI

PROPRIETA' FISICA → AMPIEZZA SETTORE ROSSO

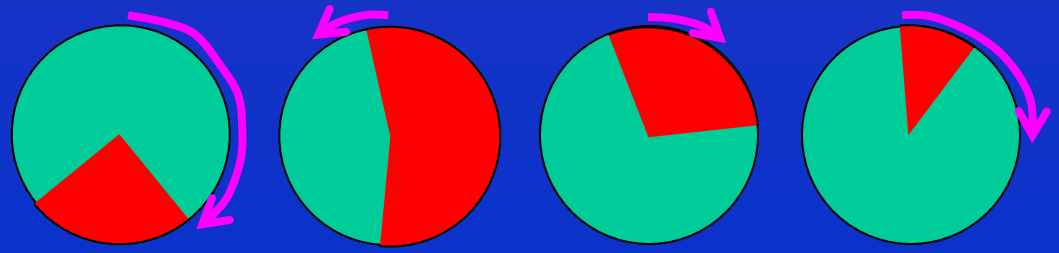


NESSUNA ROTAZIONE



ROTAZIONE GLOBALE

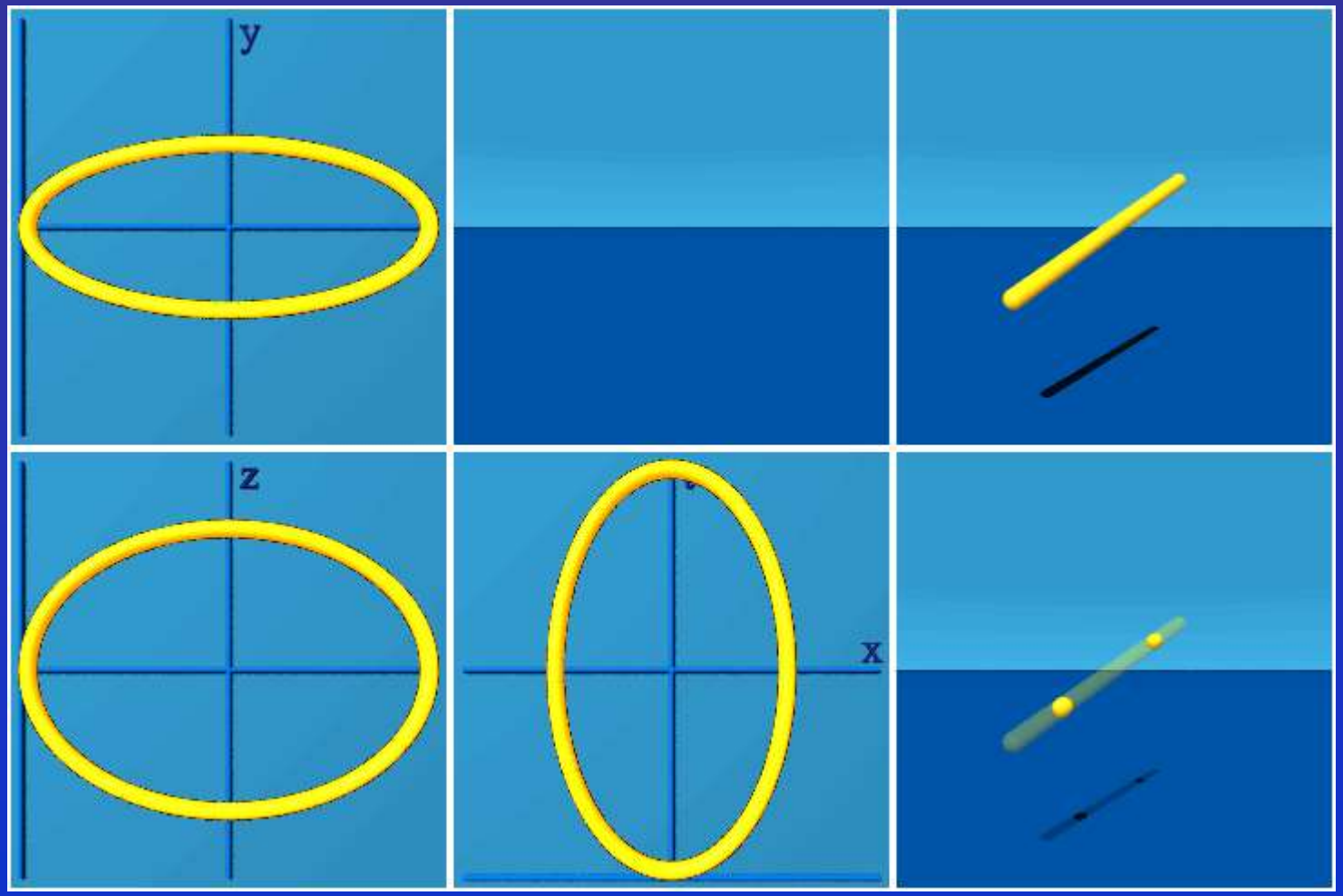
SIMMETRIA GLOBALE



ROTAZIONE LOCALE

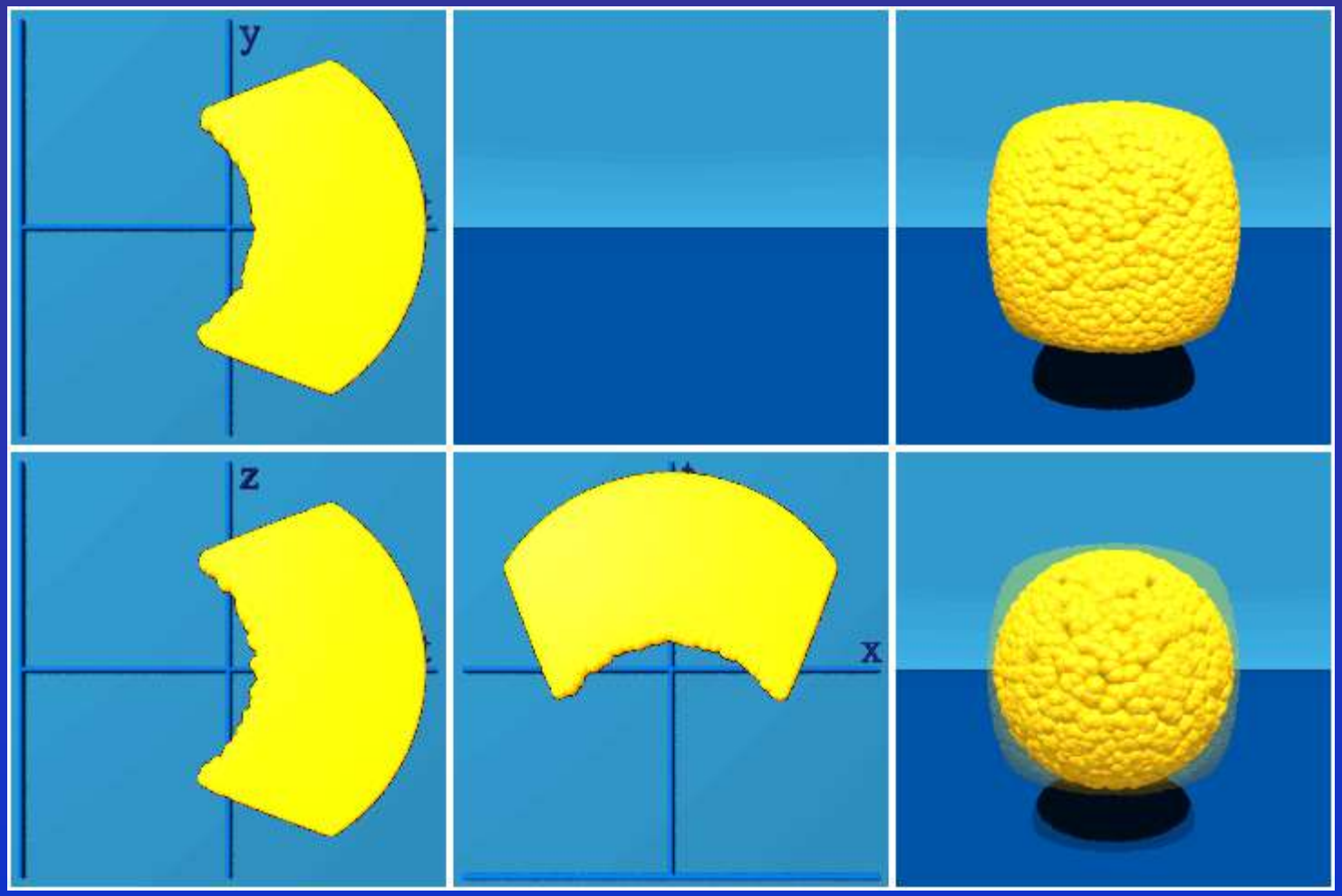
SIMMETRIA DI GAUGE

ELETTROMAGNETISMO



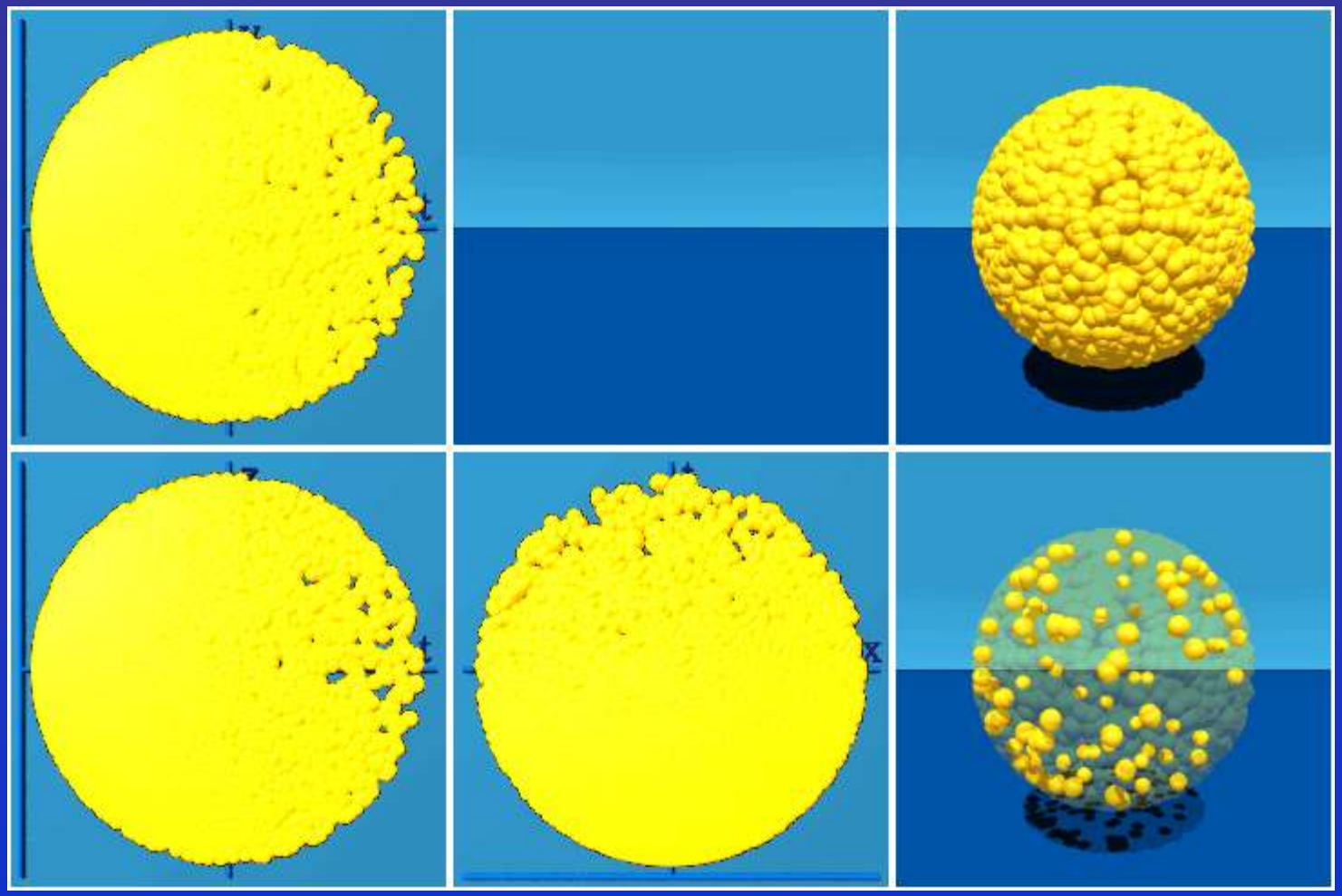
U(1) E' IL GRUPPO DI SIMMETRIA PER L'ELETTROMAGNETISMO

FORZA NUCLEARE DEBOLE



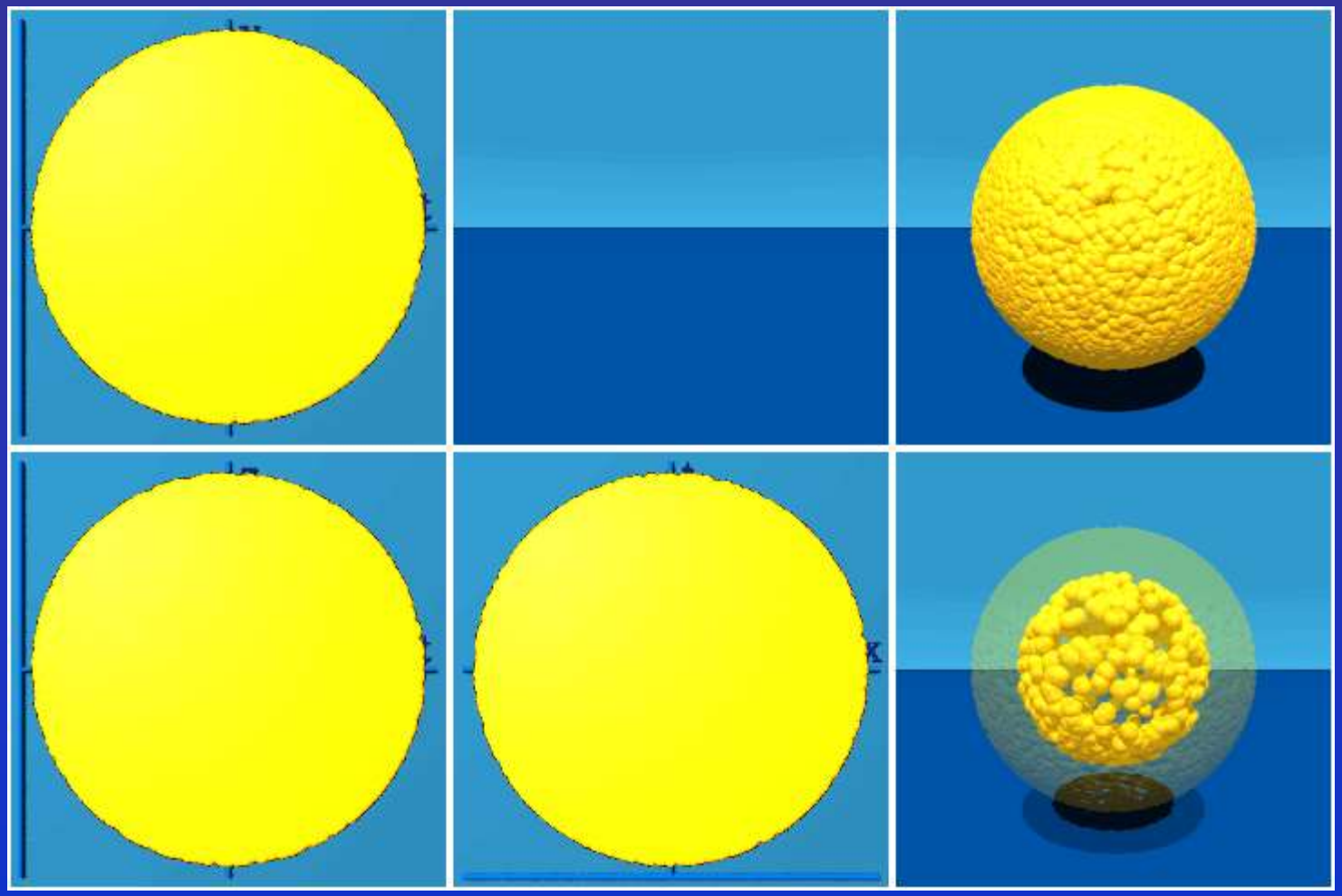
SU(2) E' IL GRUPPO DELLA FORZA NUCLEARE DEBOLE

ELETTRODEBOLE



U(1)xSU(2) E' IL GRUPPO DELLA FORZA ELETTRODEBOLE

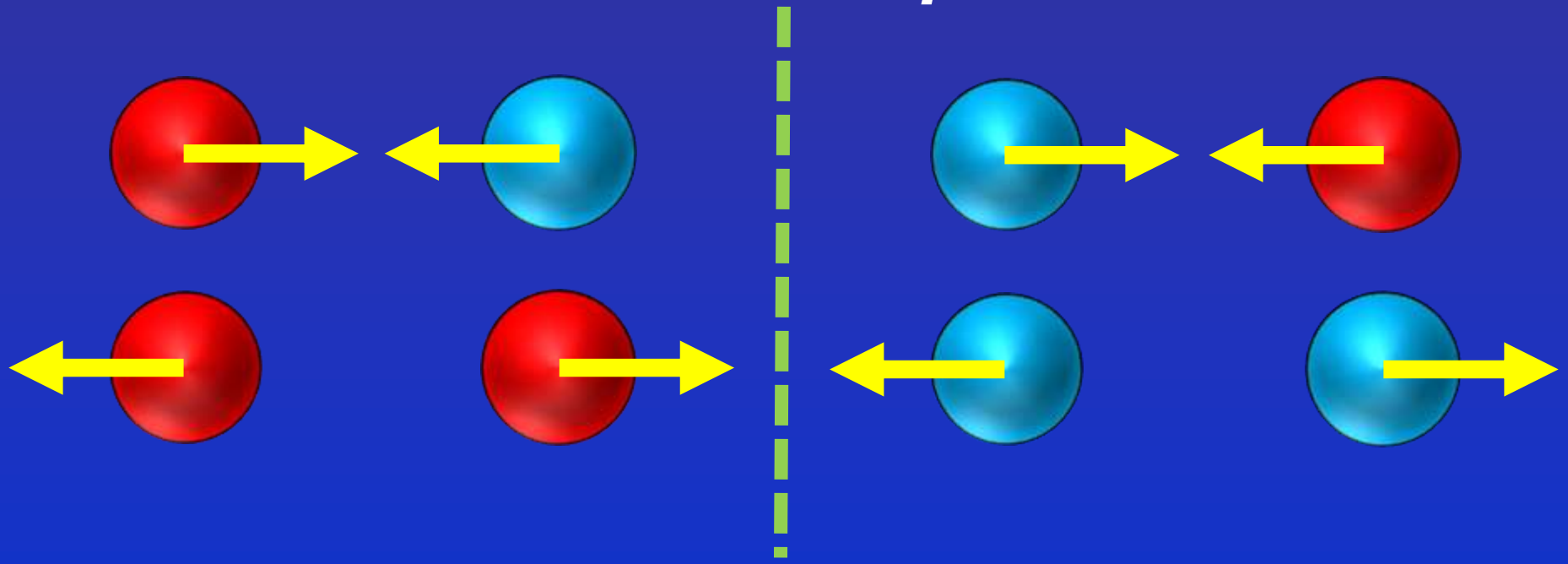
FORZA NUCLEARE FORTE



SU(3) E' IL GRUPPO DELLA FORZA NUCLEARE FORTE

CONIUGAZIONE DI CARICA

$$F = k\frac{q_1 q_2}{r^2}$$

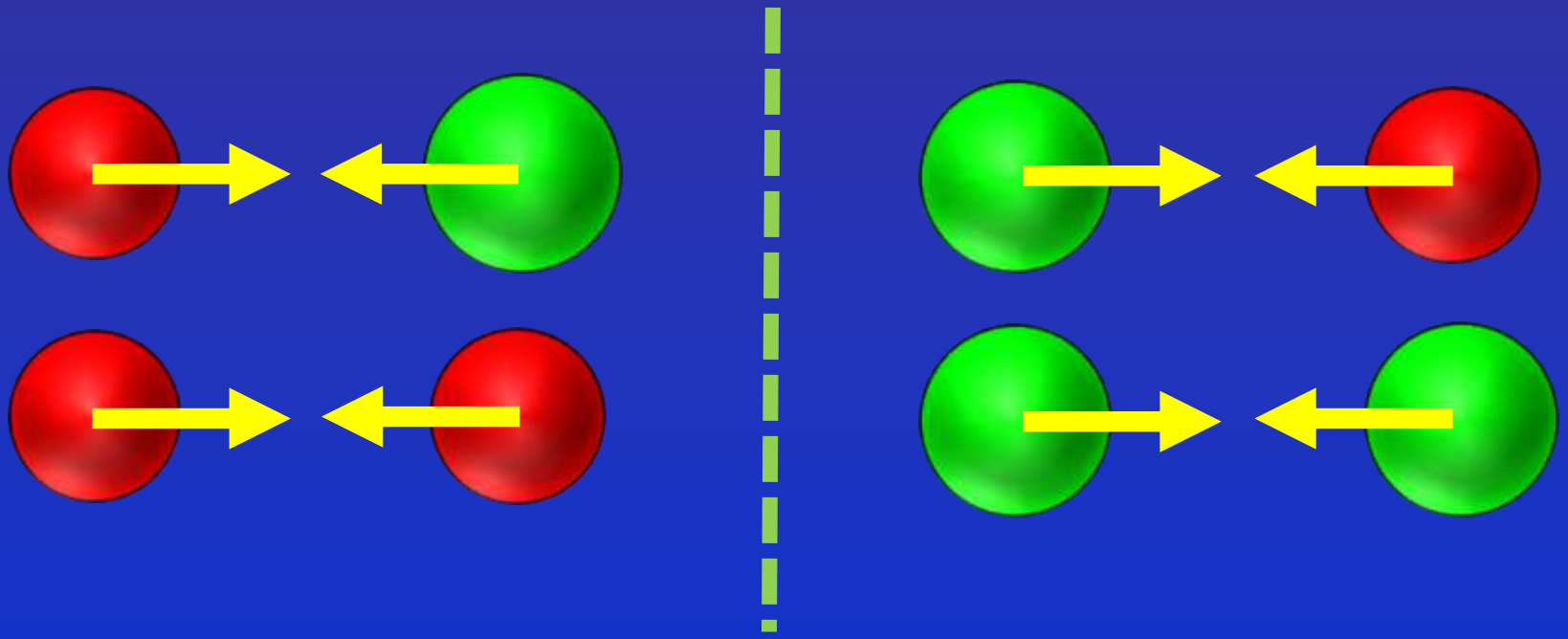


CAMBIARE IL SEGNO DI TUTTE LE CARICHE ELETTRICHE LASCIA INALTERATE LE FORZE

SI PUO' ESTENDERE A n CARICHE

ISOSPIN

PROTONI E NEUTRONI SEMBRANO STATI DIVERSI DI UNA STESSA PARTICELLA

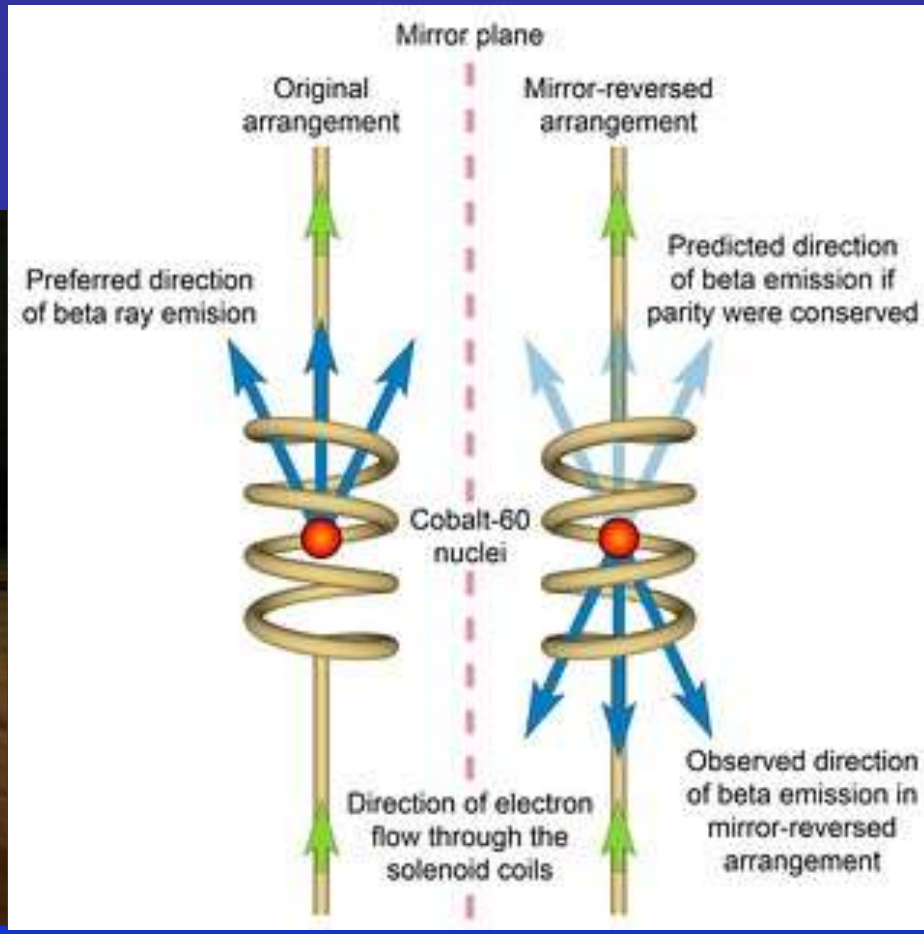


SCAMBIARE PROTONI E NEUTRONI LASCIA INALTERATA LA FORZA NUCLEARE FORTE

SI PUO' ESTENDERE A n PARTICELLE

SPECCHIO

ESISTE IL MONDO NELLO SPECCHIO?

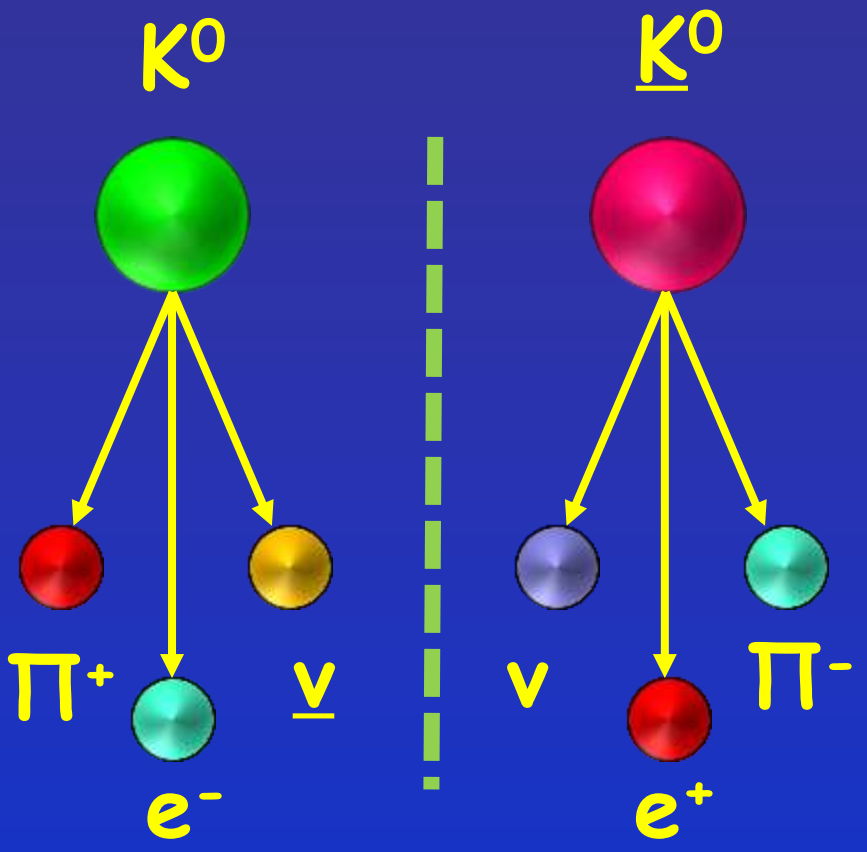


LA PARITA' P NON E' UNA SIMMETRIA DELLA NATURA

LA PARITA' P NON E' UNA SIMMETRIA PER LA FORZA NUCLEARE DEBOLE

ANTISPECCHIO

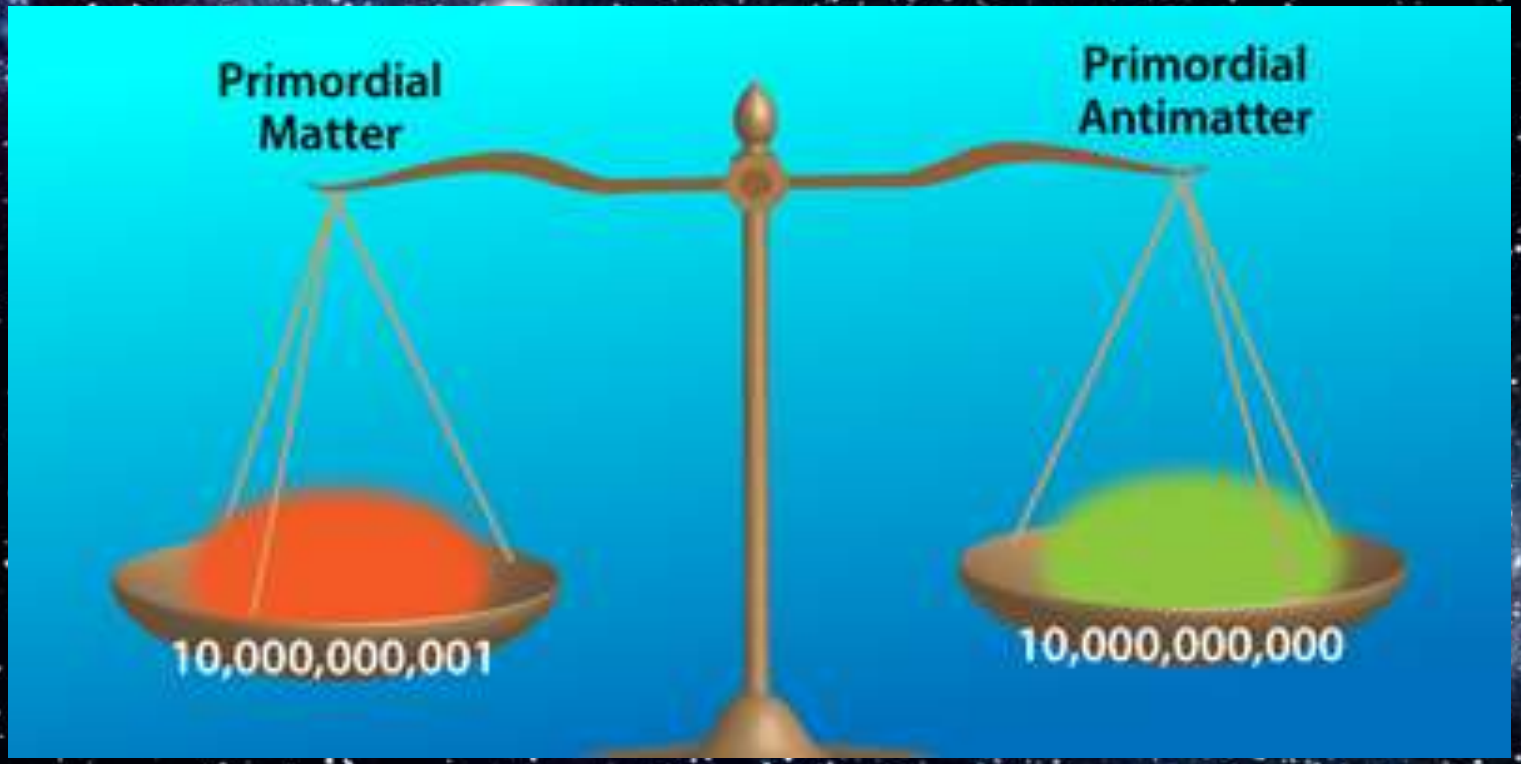
ESISTE L'ANTIMONDO NELLO SPECCHIO?



CP NON E' UNA SIMMETRIA DELLA NATURA

CP NON E' UNA SIMMETRIA PER LA FORZA NUCLEARE DEBOLE

MATERIA

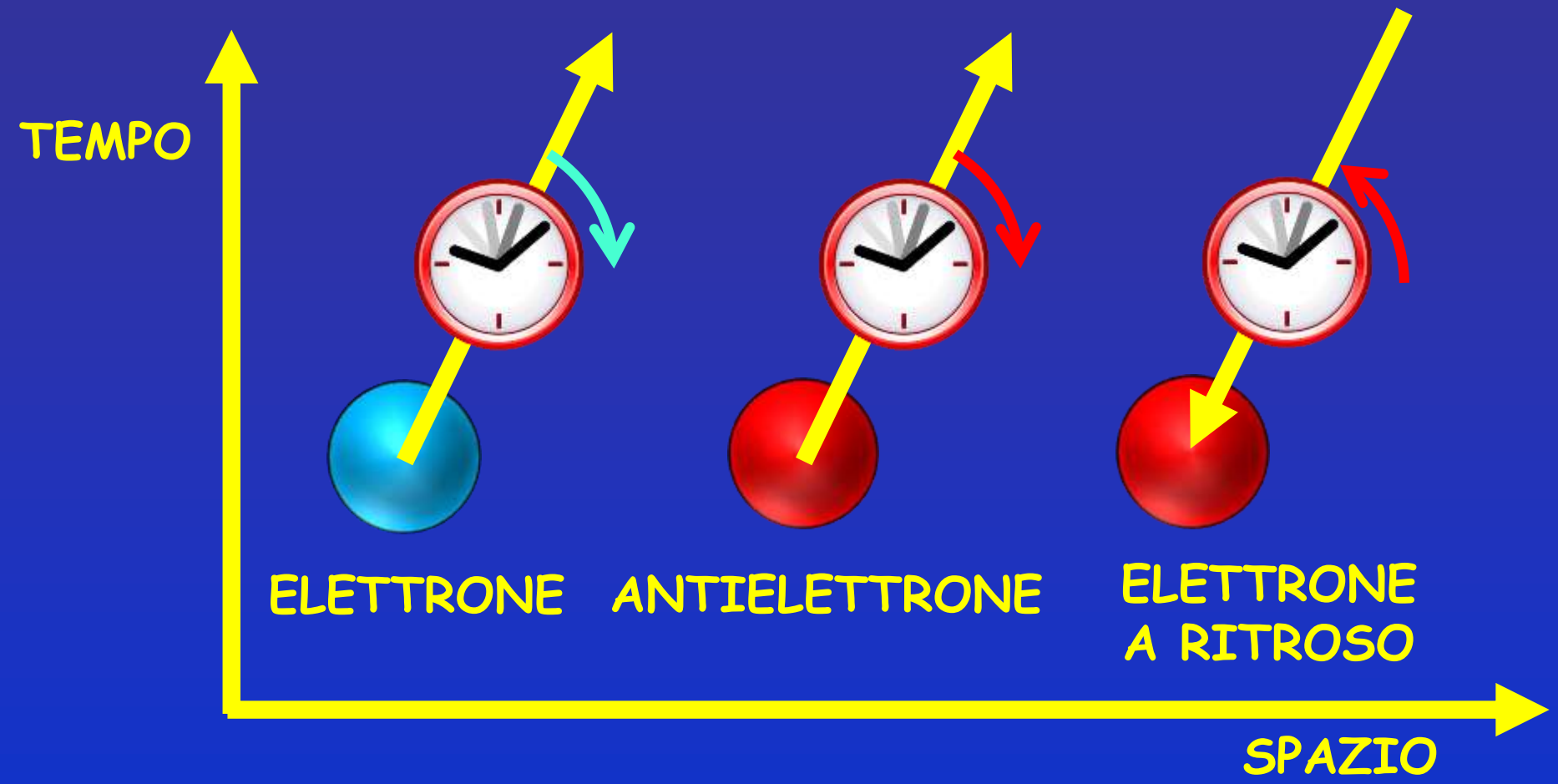

Primordial
Matter
Primordial
Antimatter
10,000,000,001
10,000,000,000

CPT

CPT SEMBRA ESSERE UNA SIMMETRIA DELLA NATURA

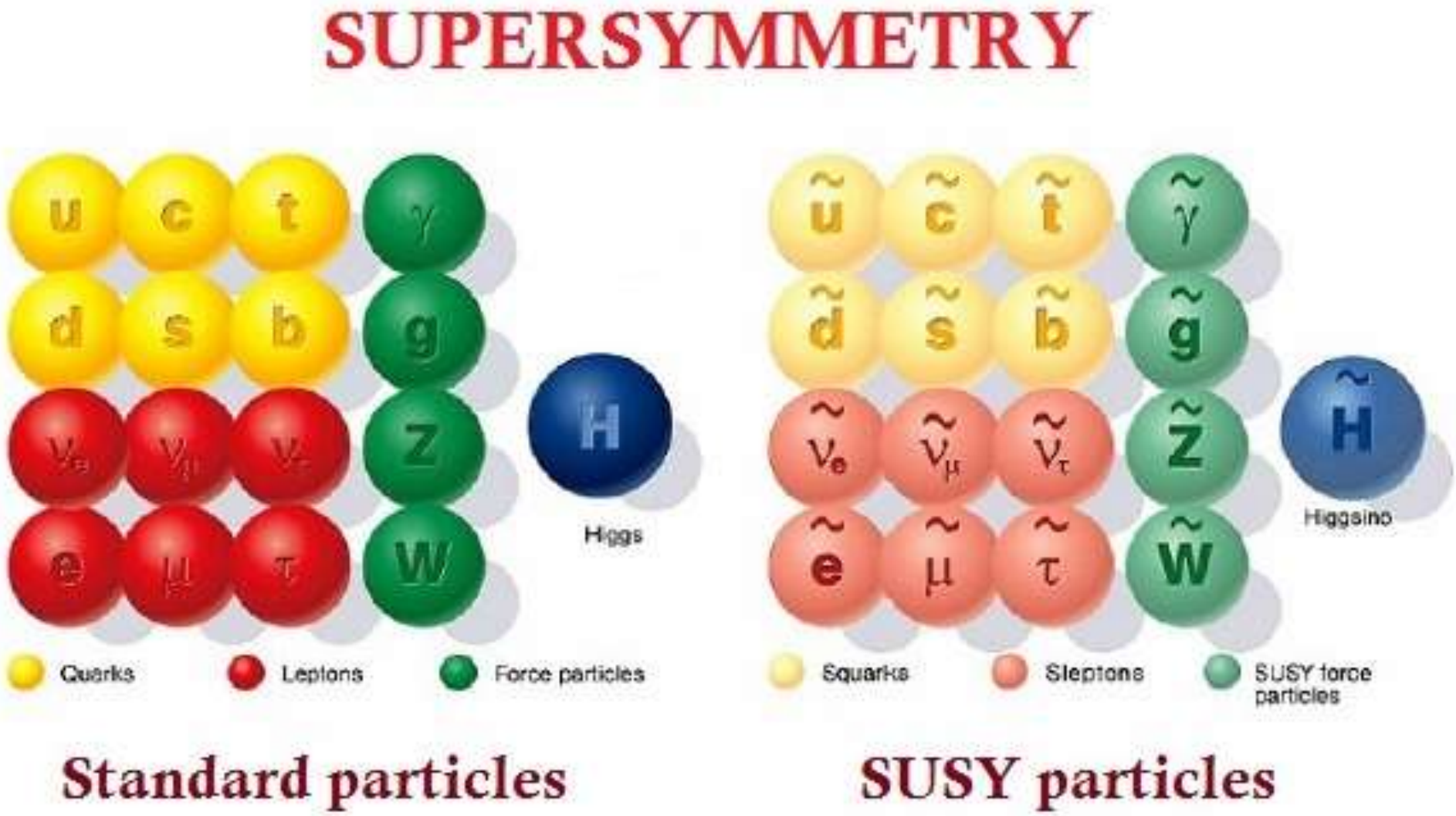
CPT E' LEGATA ALL'INVARIANZA DI LORENTZ

RITORNO AL PASSATO



LE ANTIPARTICELLE EQUIVALGONO A PARTICELLE CHE SI MUOVONO A RITROSO NEL TEMPO

SUSY


SUPERSYMMETRY
u c t γ
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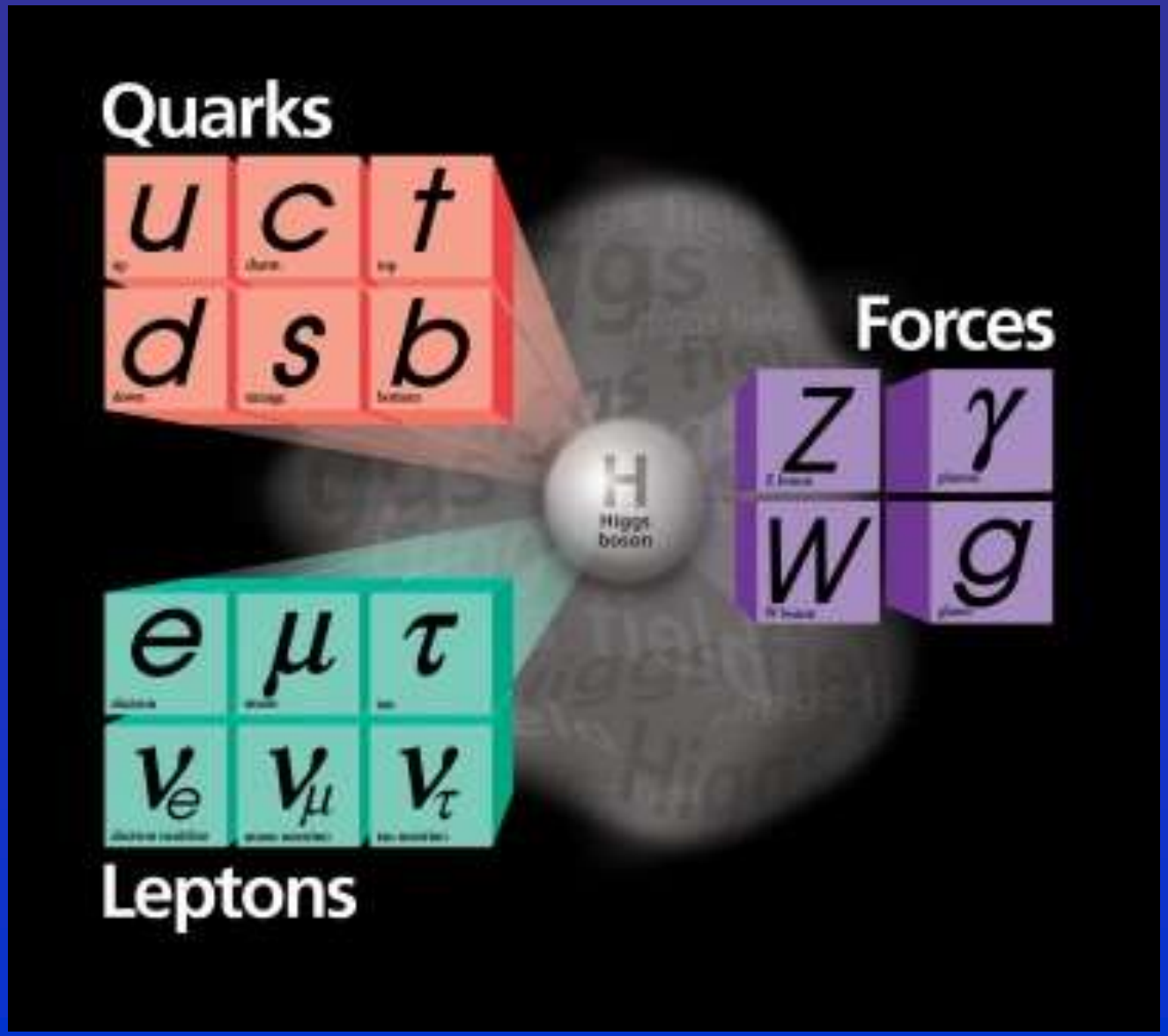
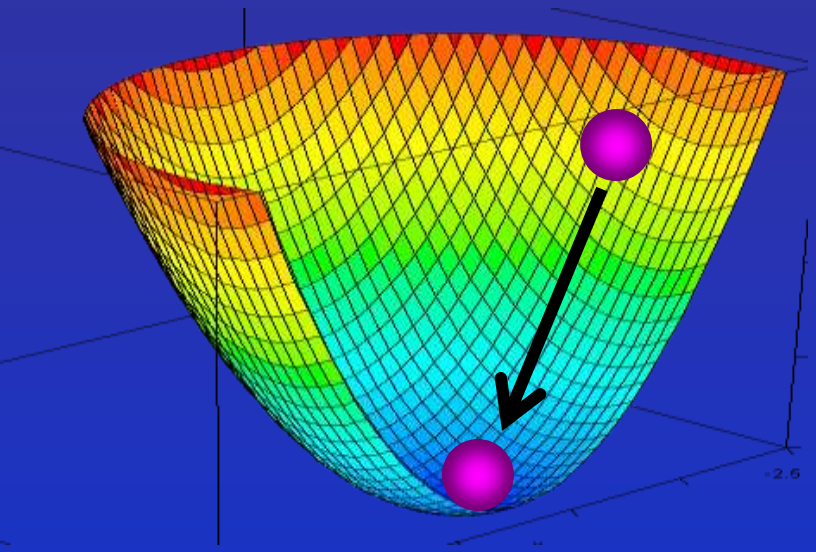
Higgs
Quarks
Leptons
Force particles
Standard particles
Higgsino
Squarks
Sleptons
SUSY force particles
SUSY particles

E HIGGS?

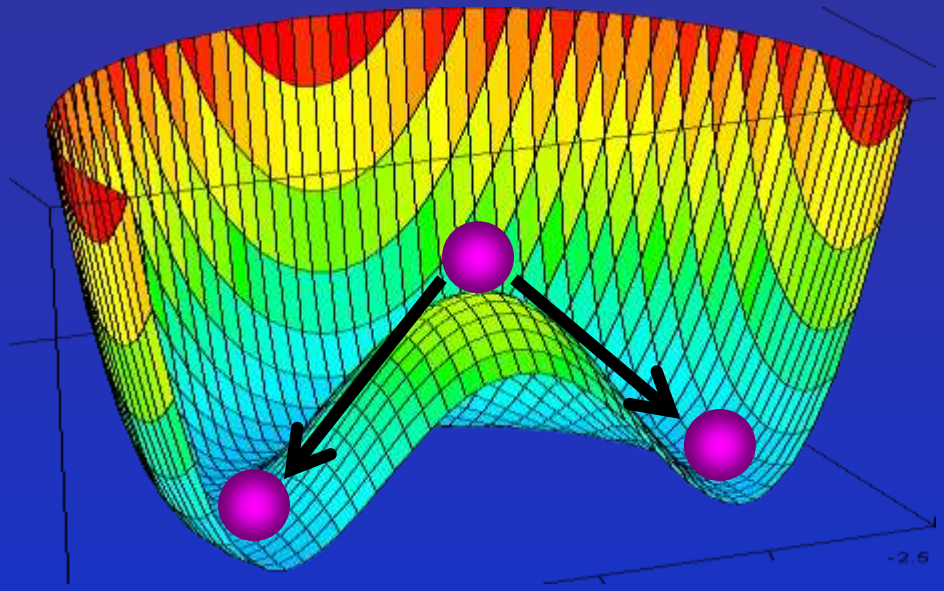


UN BEL SOMBRERO

IN TEORIA QUANTISTICA DEI CAMPI SI HANNO POTENZIALI SIMMETRICI CHE PORTANO A UNA ROTTURA DI SIMMETRIA



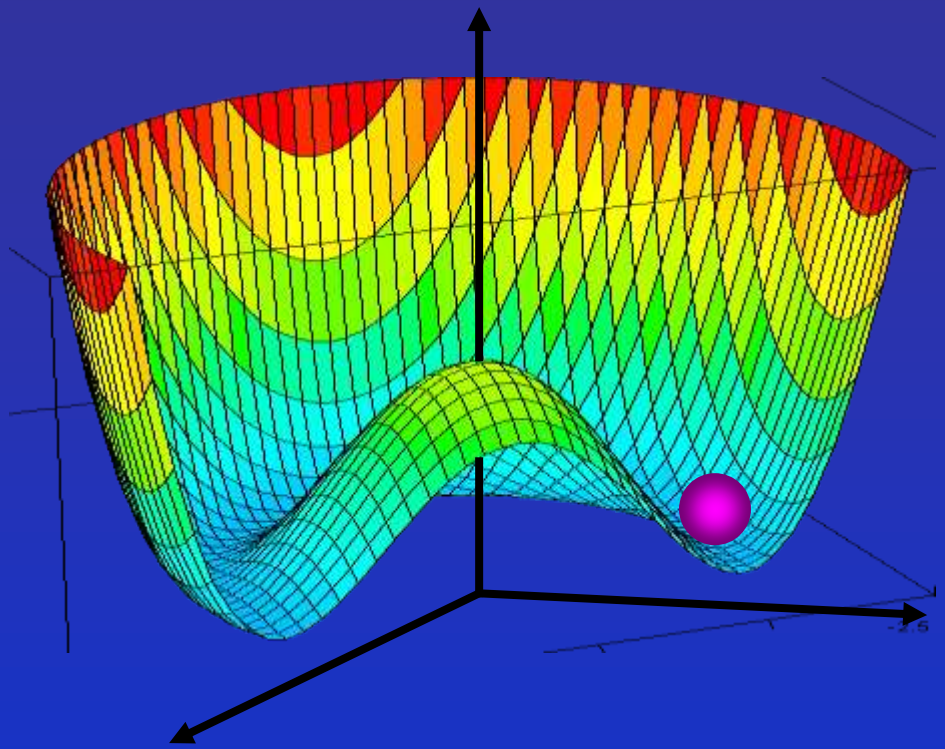
POTENZIALE SIMMETRICO SENZA ROTTURA DI SIMMETRIA DEL CAMPO



POTENZIALE SIMMETRICO CON ROTTURA DI SIMMETRIA DEL CAMPO

CREARE FORZE

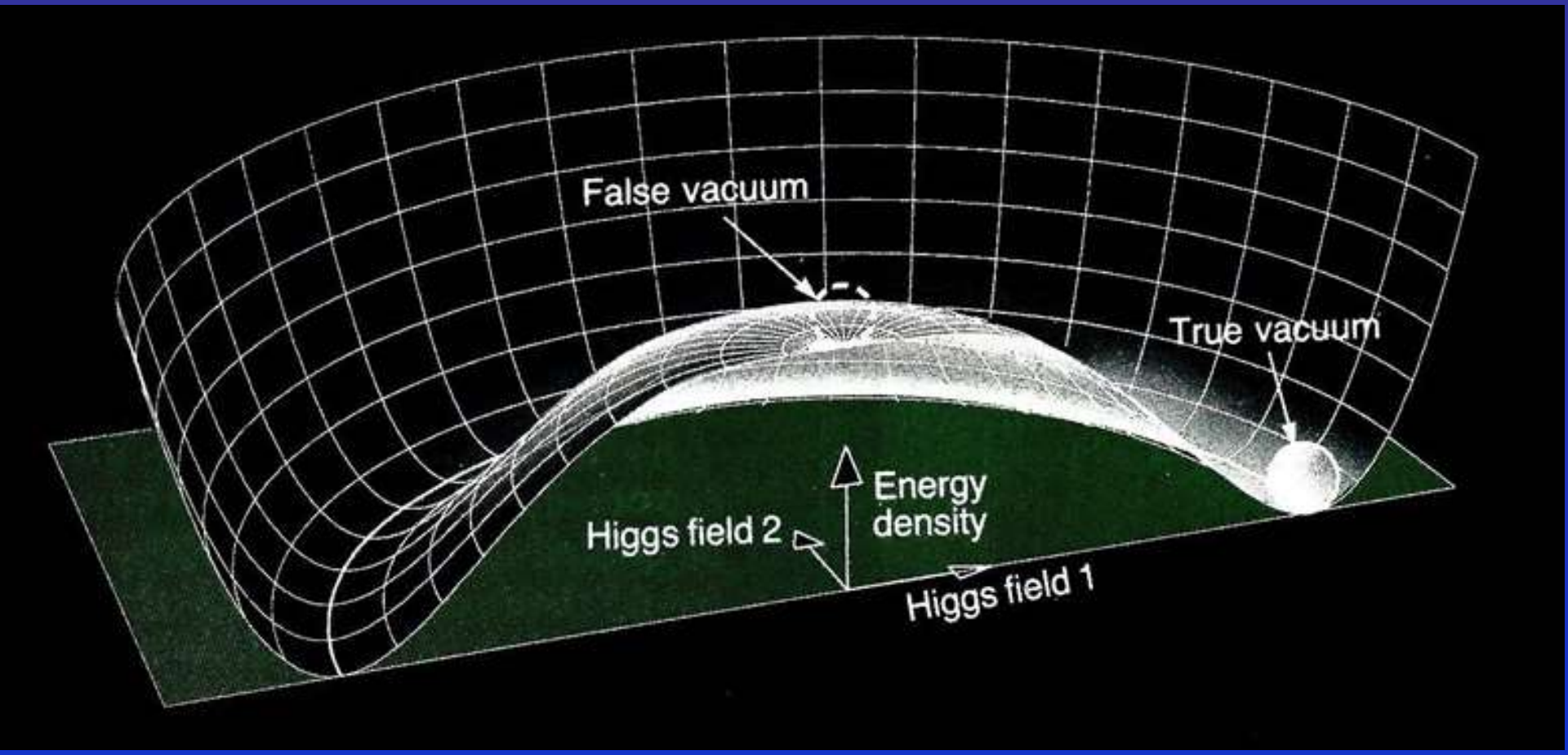
LA ROTTURA DI SIMMETRIA PRODUCE BOSONI PRIVI DI MASSA



BOSONE PRIVO DI MASSA MEDIATORE DI UNA FORZA

IN CASI PARTICOLARI LA ROTTURA DI SIMMETRIA PRODUCE BOSONI MASSIVI

IL VUOTO DECADE



LA ROTTURA SPONTANEA DI SIMMETRIA LIBERA UN'ENORME QUANTITA' DI ENERGIA

GRAZIE PER L'ATTENZIONE!!!

DOMANDE?