

A.C.A. - Associazione Cernuschese Astrofili

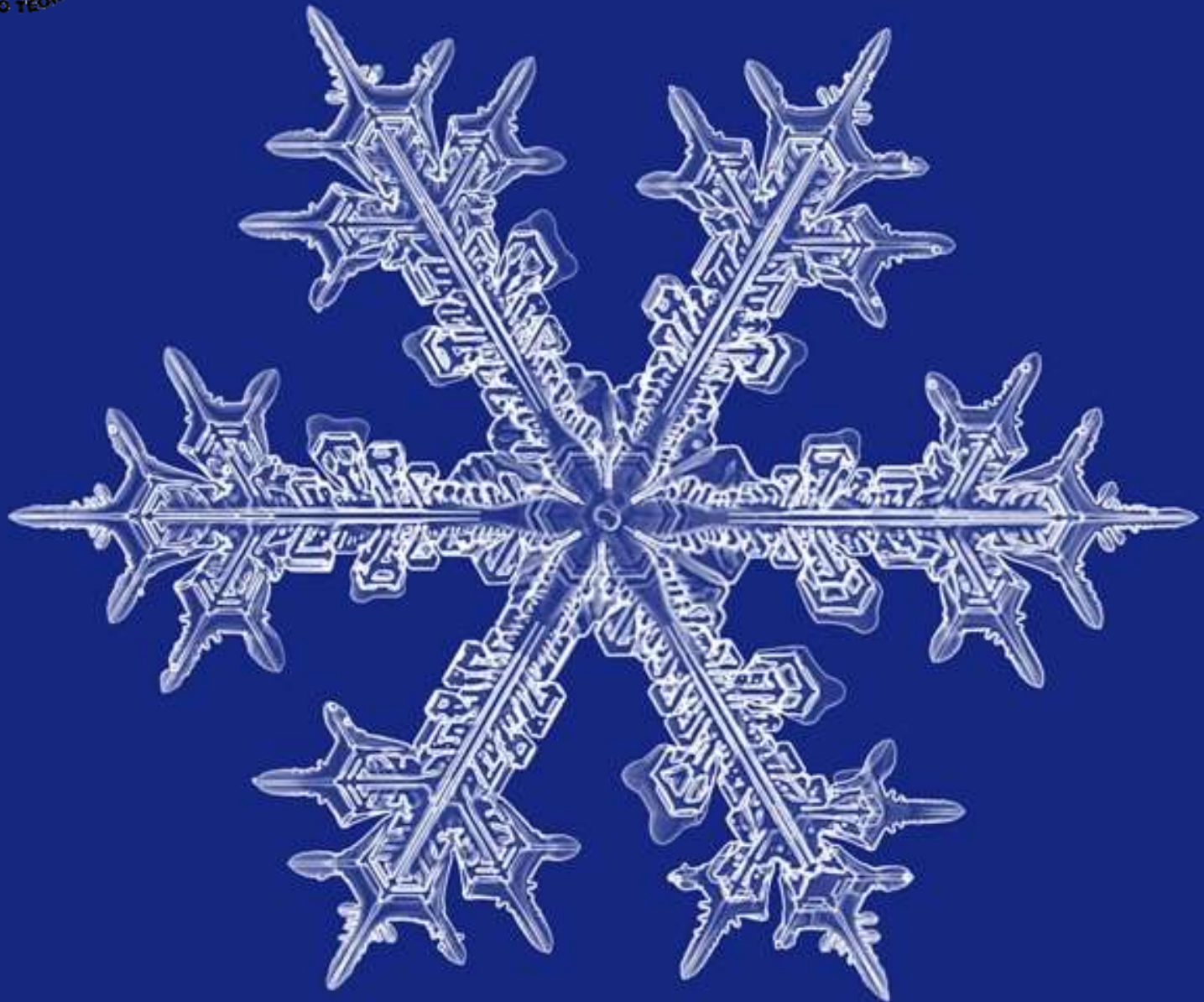
SIMMETRIE

Alla ricerca della bellezza
nascosta della Natura



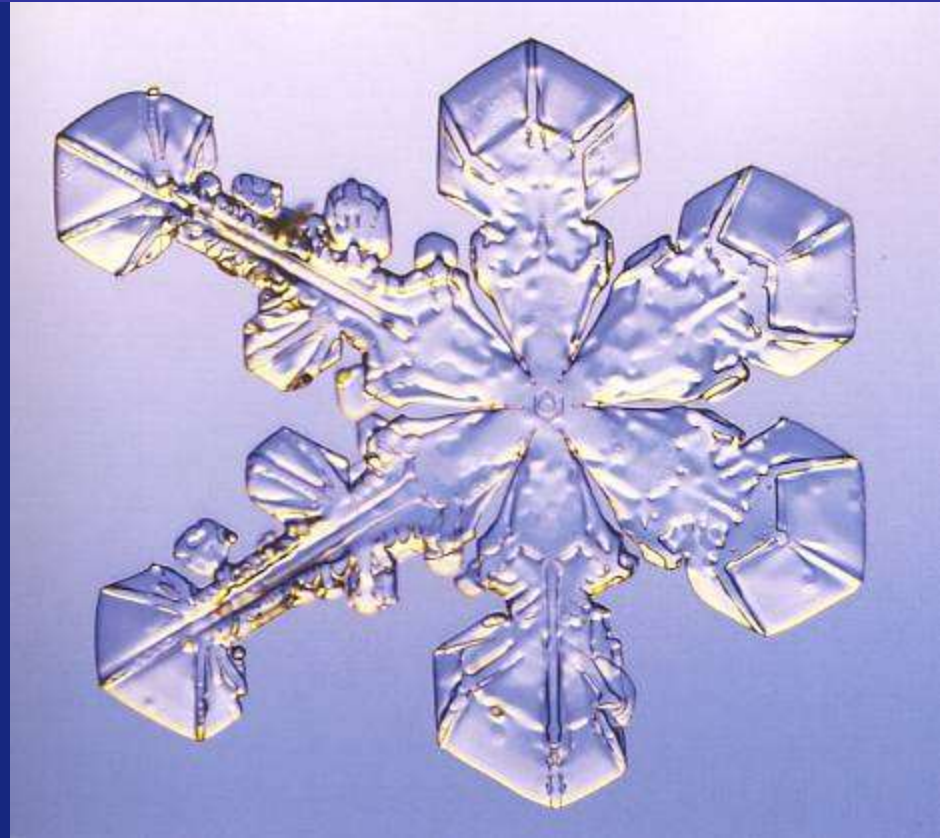
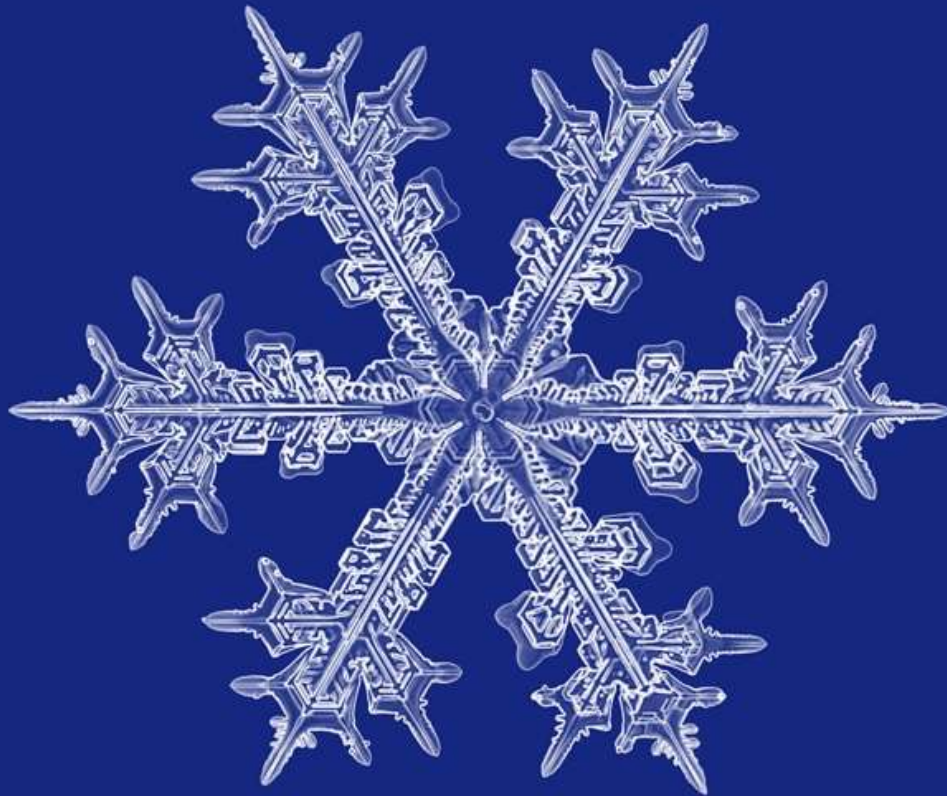
by Andrea Grieco

LA SOLITA IMMAGINE



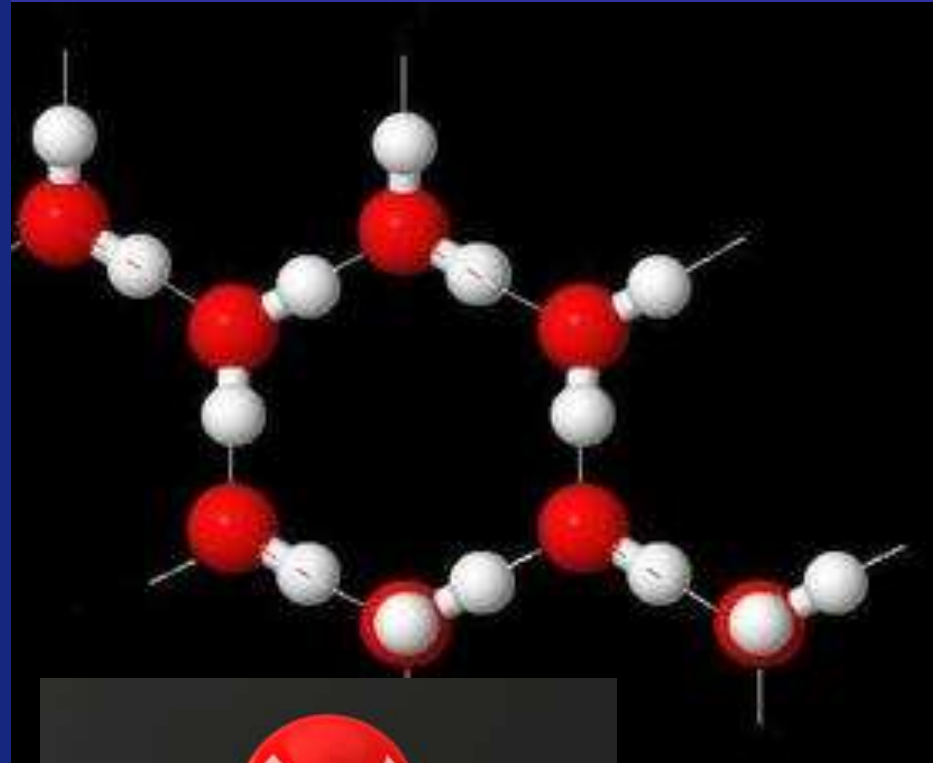
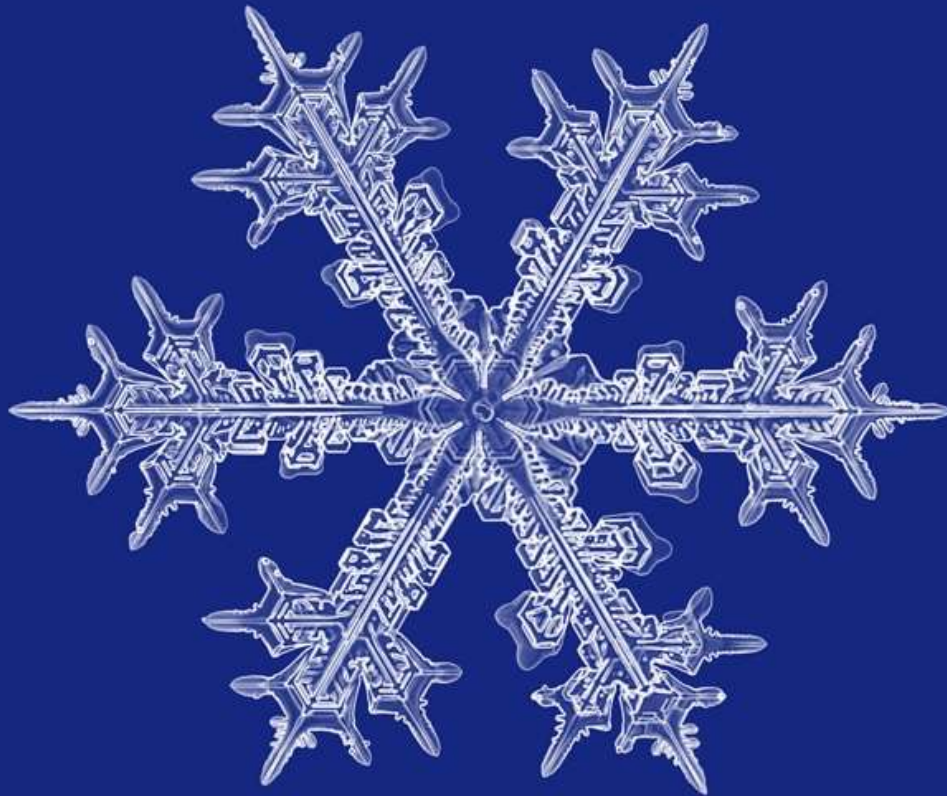


BELLEZZA E SIMMETRIA



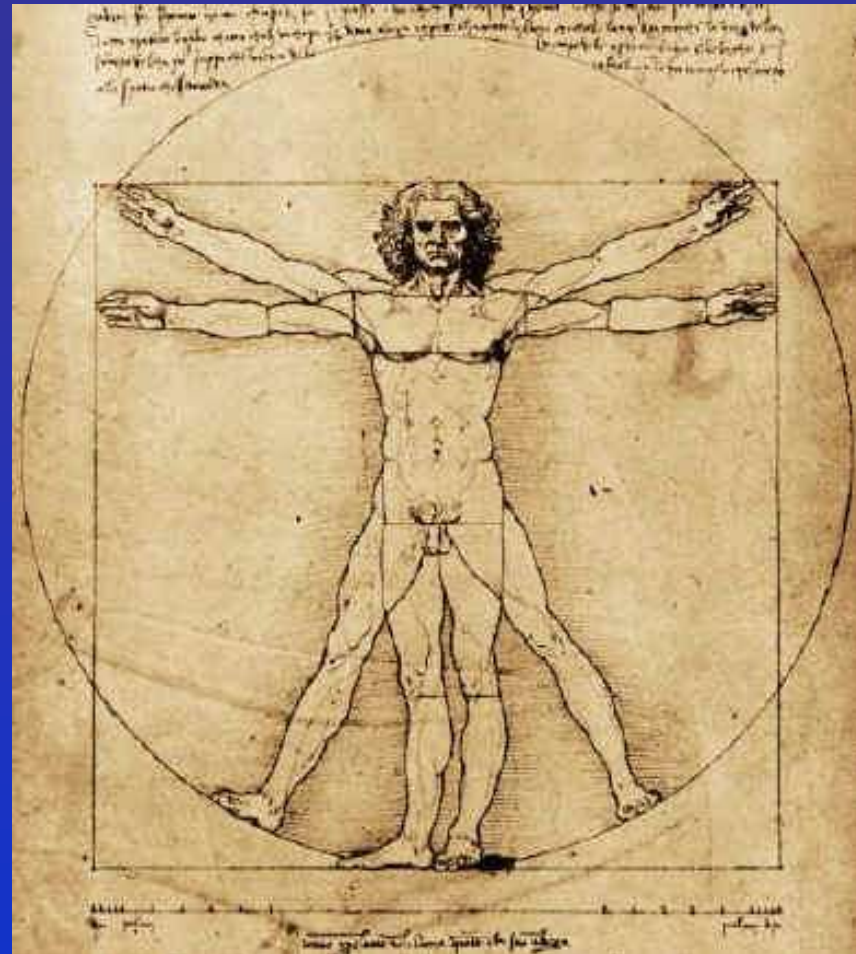


SIMMETRIA NASCOSTA



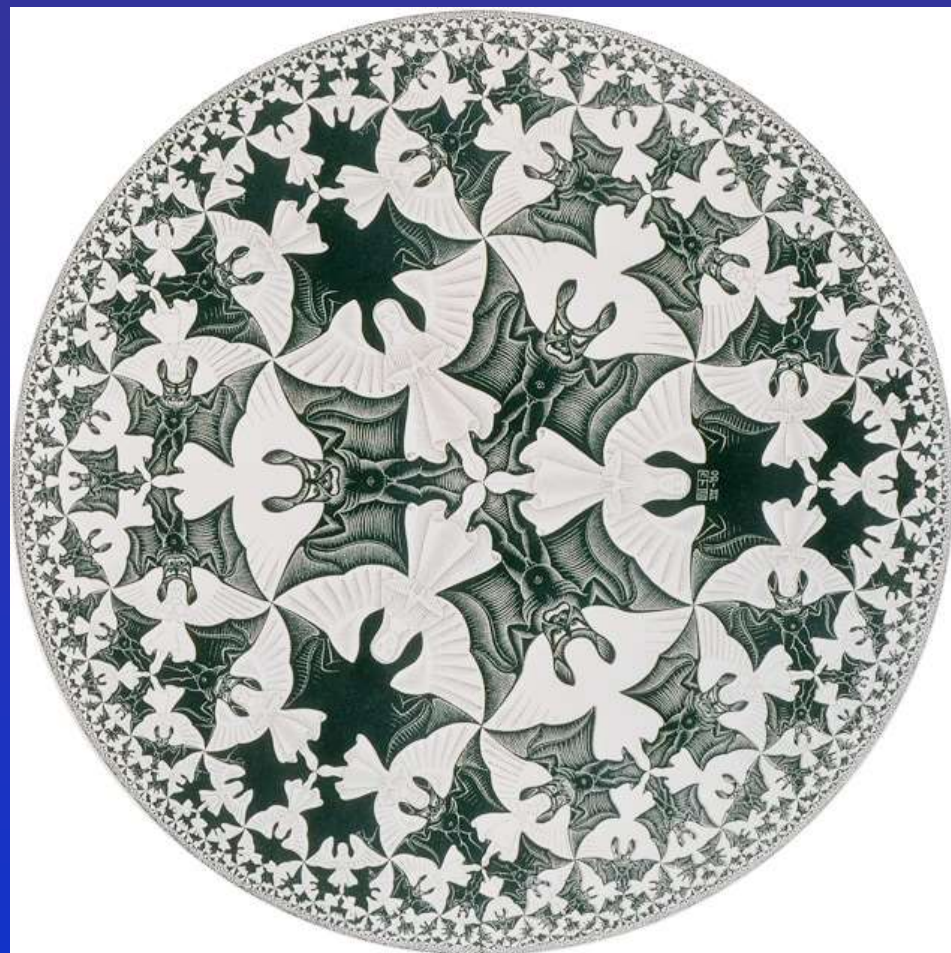
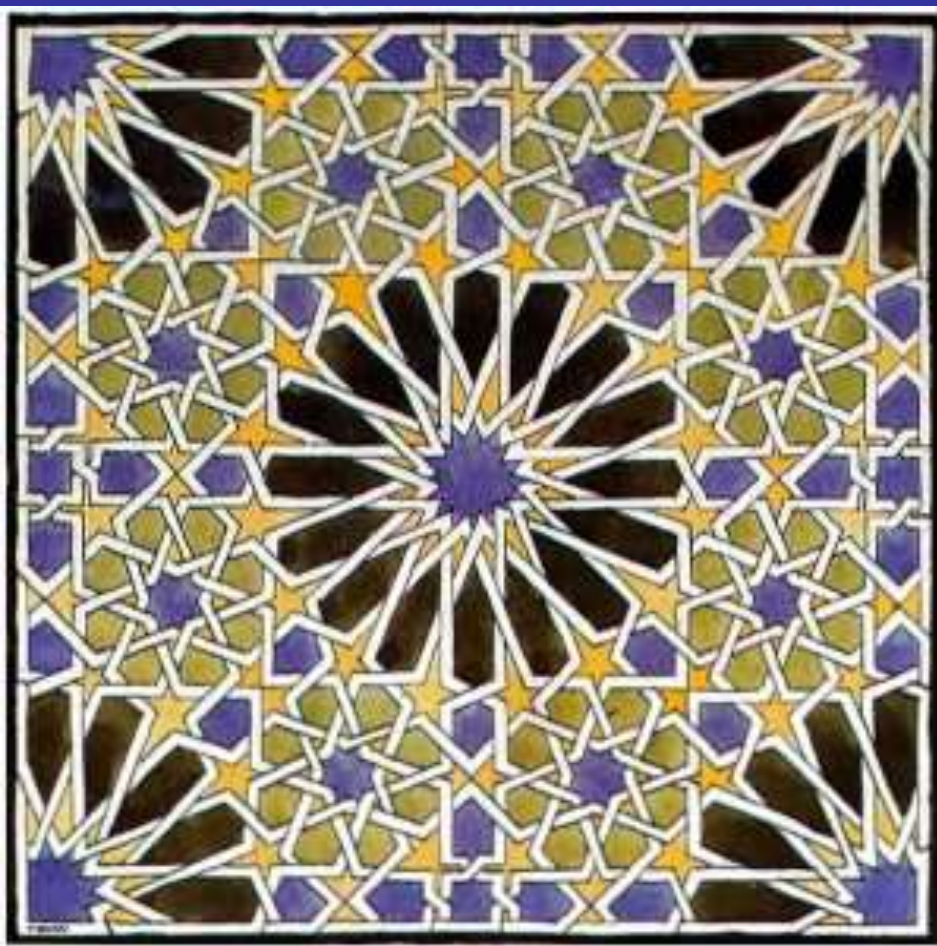


FASCINO SENZA TEMPO



ROSA CAMUNA E UOMO VITRUVIANO

ARTE

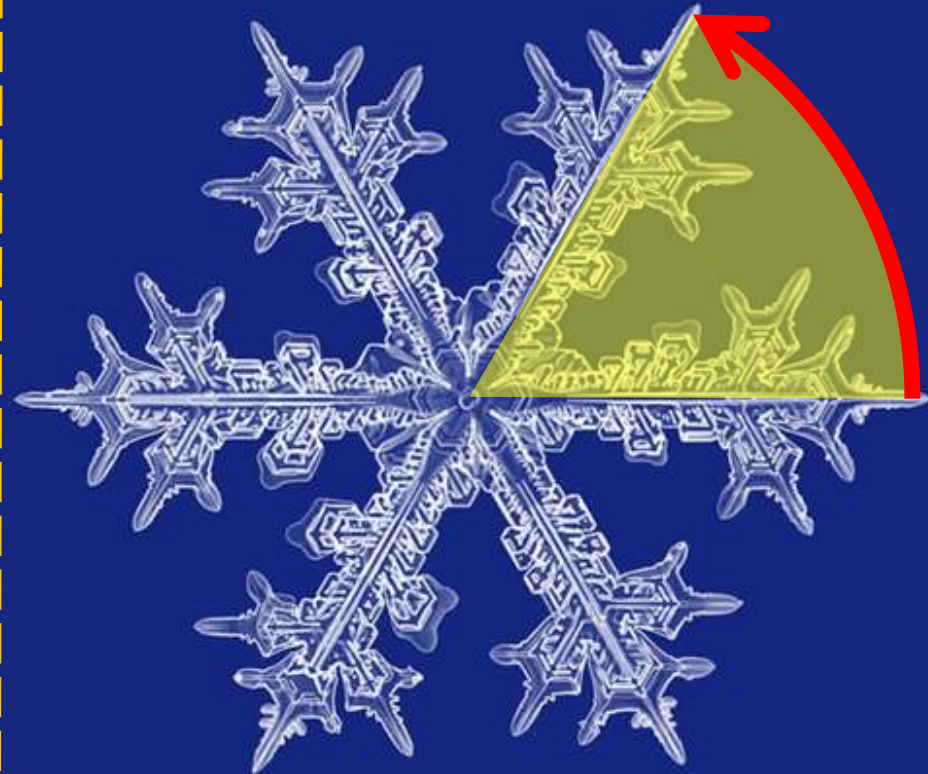
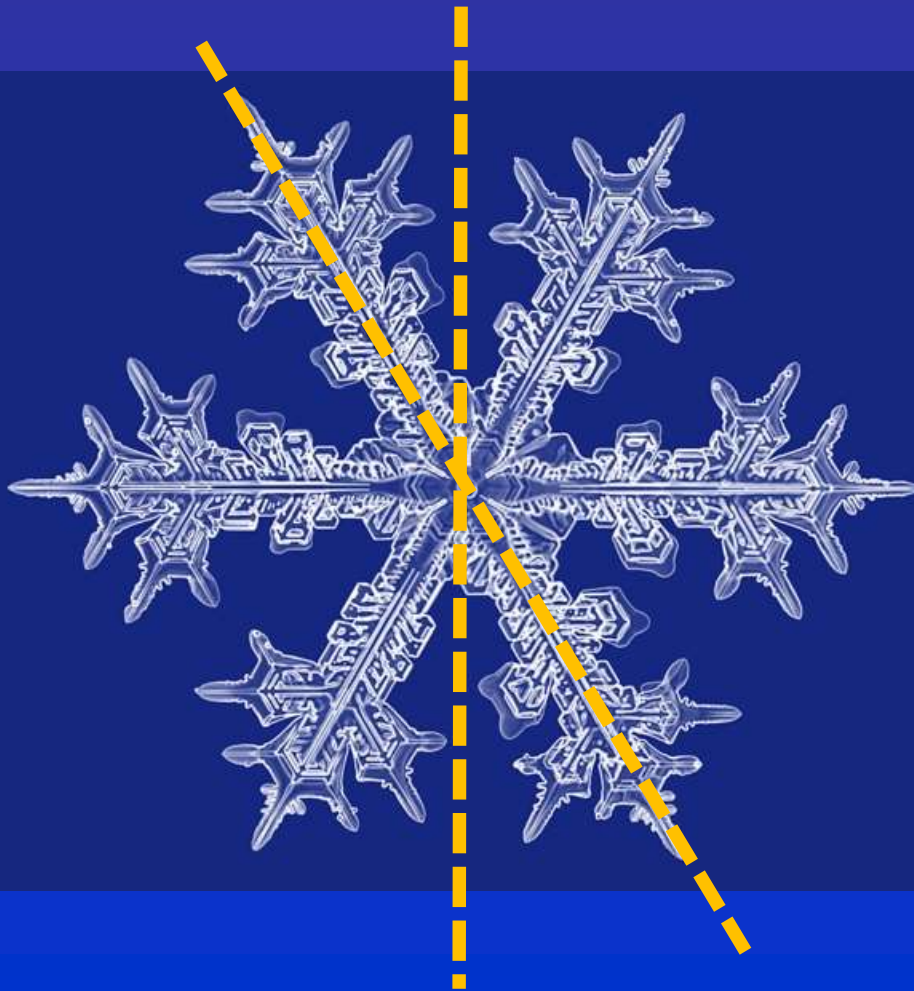


MOSAICO DELL'ALHAMBRA E OPERA DI ESCHER



COS'E' UNA SIMMETRIA

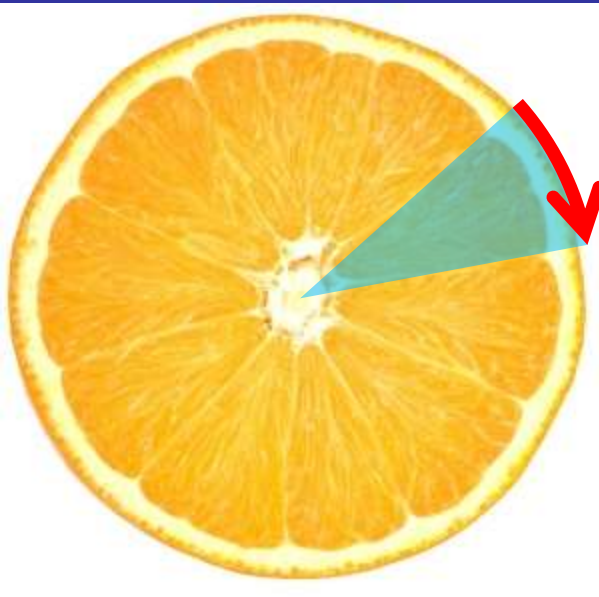
VI E' SIMMETRIA SE UN OGGETTO RIMANE INALTERATO DOPO L'ESECUZIONE DI UNA CERTA OPERAZIONE



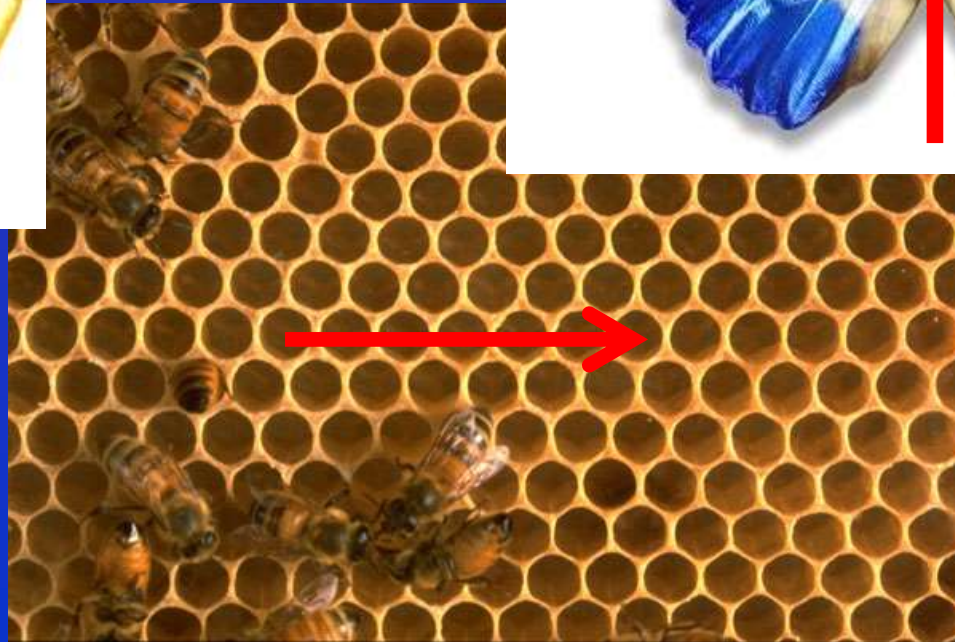
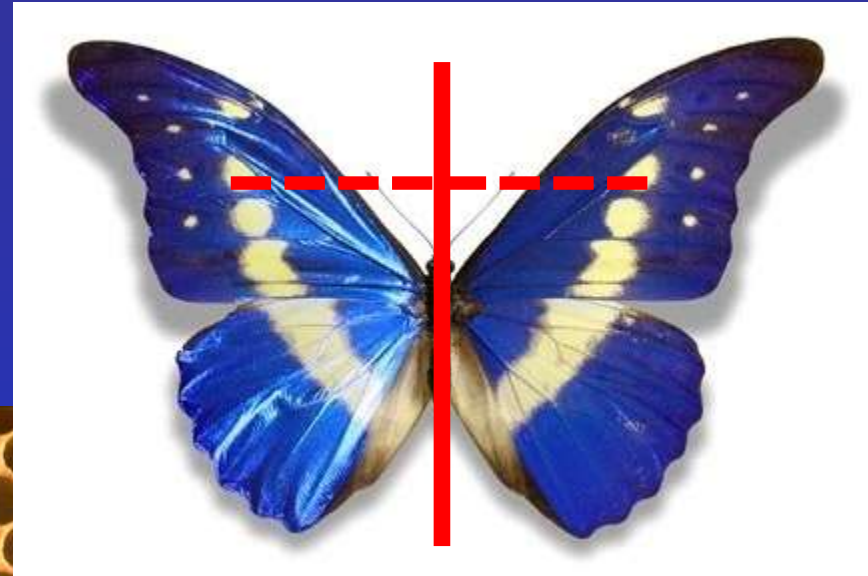


SIMMETRIE GEOMETRICHE

ROTAZIONE



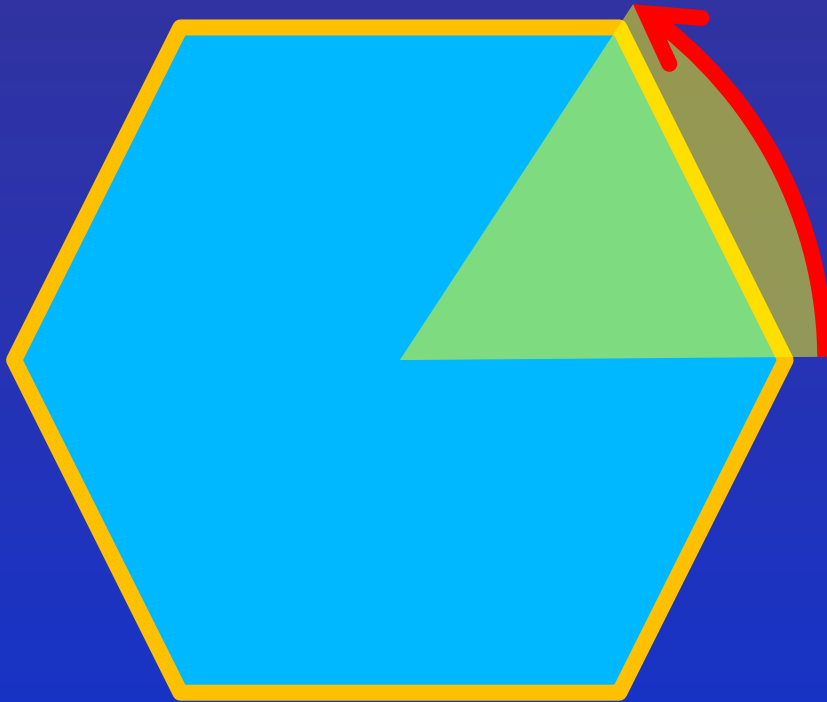
RIFLESSIONE



TRASLAZIONE



DISCRETO E CONTINUO



SIMMETRIA DISCRETA DI
ROTAZIONE PER ANGOLI
MULTIPLI DI 60°



SIMMETRIA CONTINUA
DI ROTAZIONE PER
ANGOLI QUALSIASI

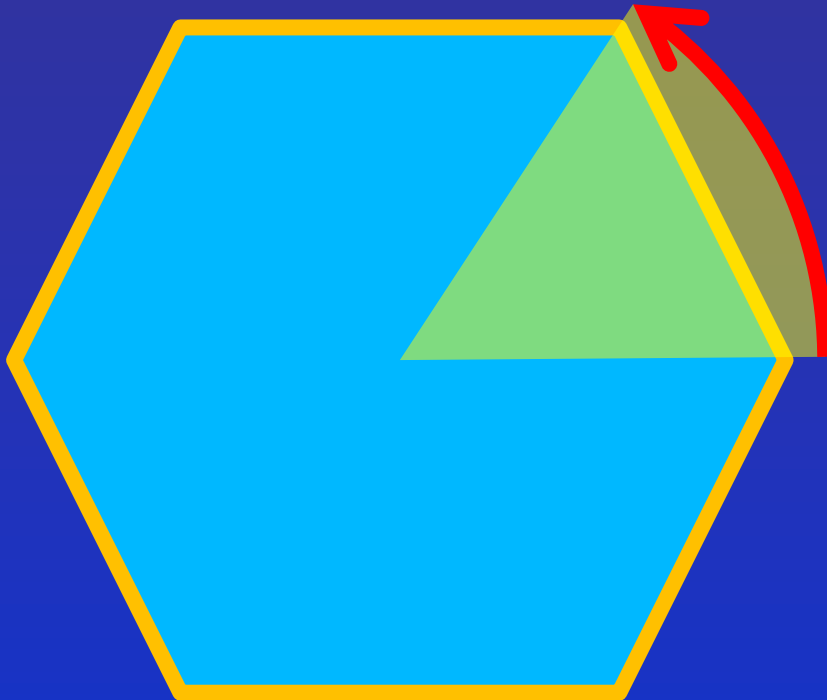


GRUPPI

SIMMETRIA



GRUPPO



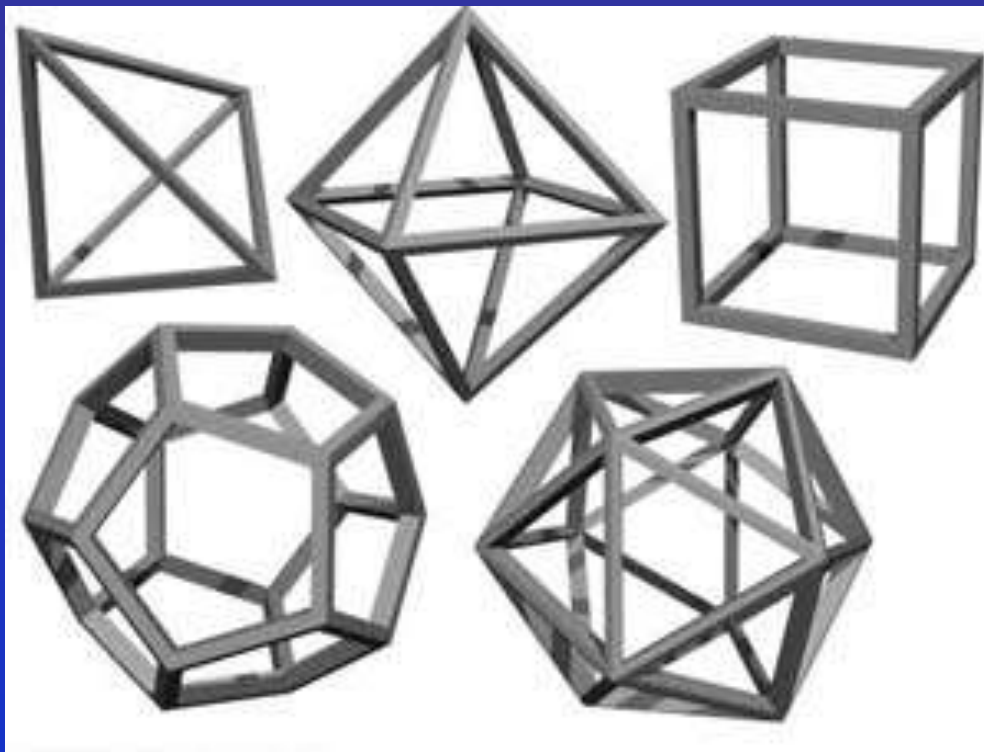
GRUPPO DISCRETO DI
ROTAZIONI DI ANGOLI
 $0^\circ, 60^\circ, 120^\circ, 180^\circ, 240^\circ, 300^\circ$



GRUPPO CONTINUO DI
ROTAZIONI DI ANGOLI
QUALSIASI



SIMMETRIA PERFETTA



**SOLIDI
PLATONICI**

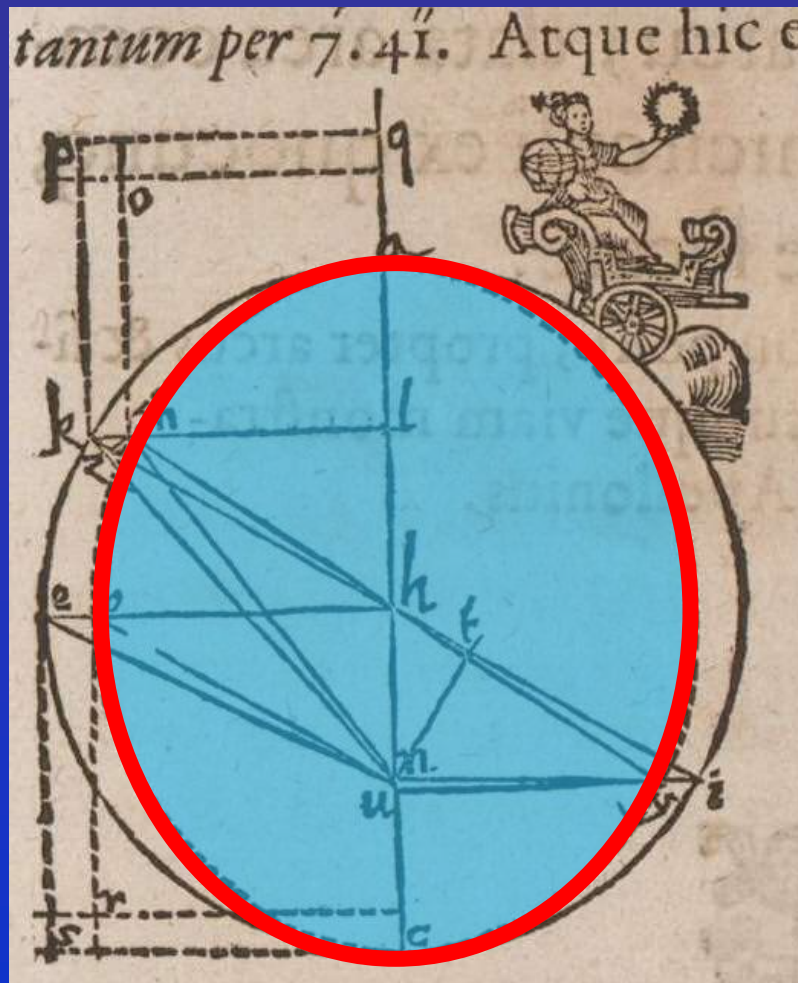


SFERA

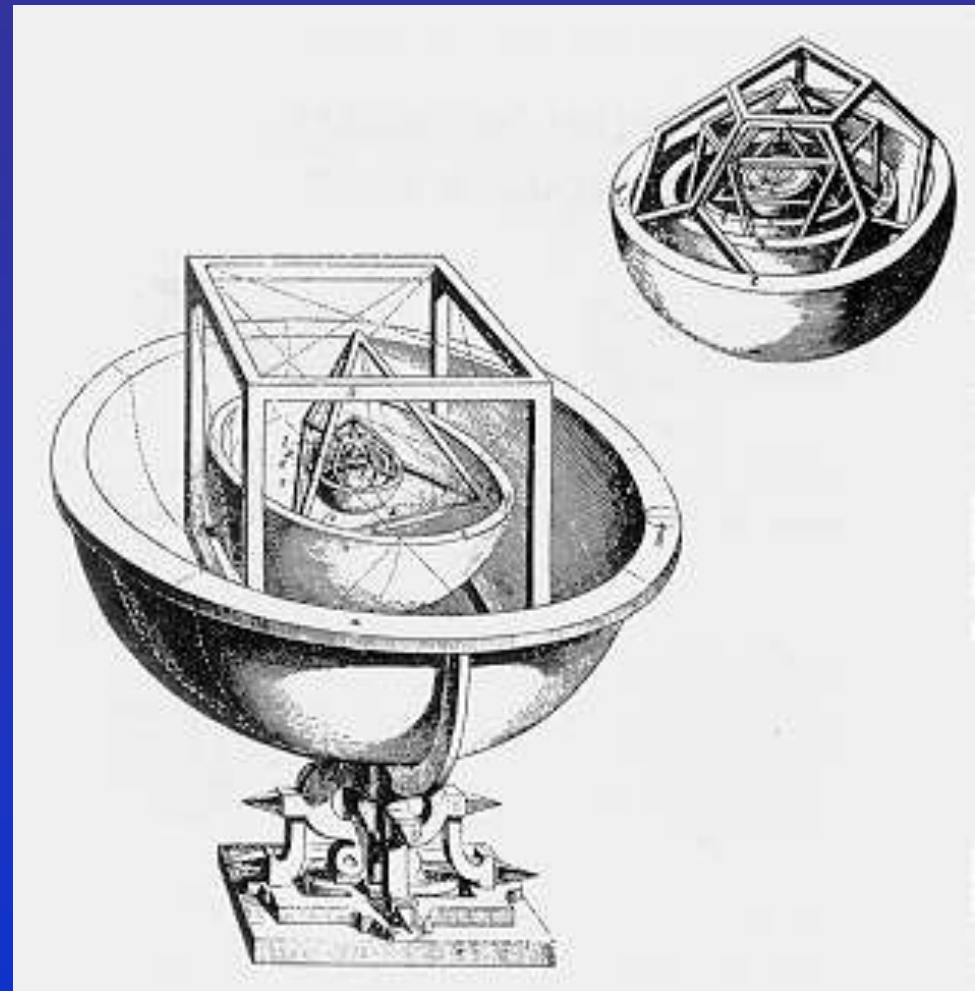




SIMMETRIA INFRANTA



ORBITE ELLITTICHE



SISTEMA KEPLERIANO



LEGGI SIMMETRICHE



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

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

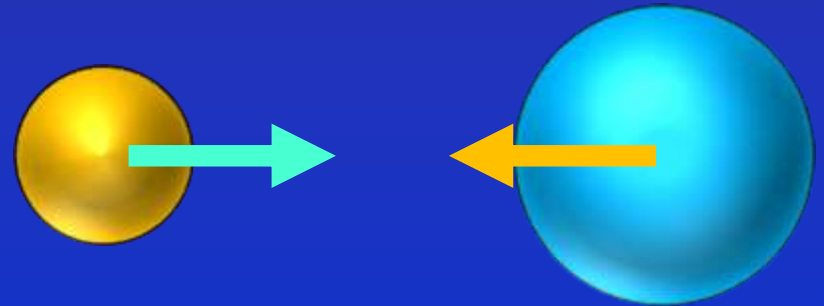
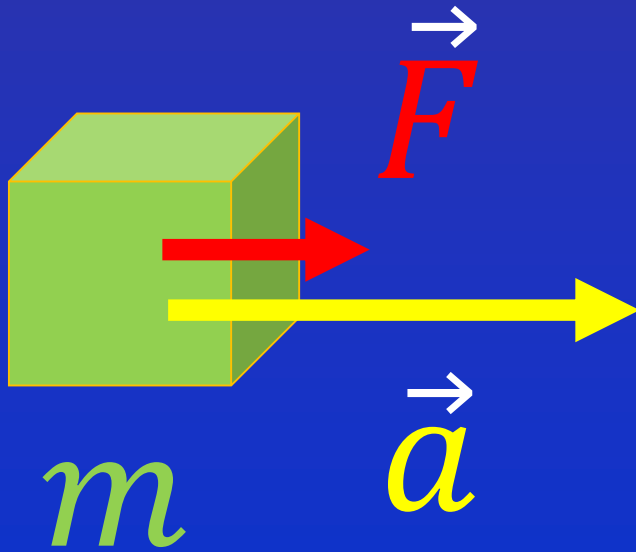
NEWTON ELABORA LE LEGGI DELLA MECCANICA E DI
GRAVITAZIONE UNIVERSALE



LEGGI DI FORZA

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

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



$$\vec{F}_{12} = -\vec{F}_{21}$$



UNIVERSALITA'

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

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



SIMMETRIA DELLE LEGGI

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

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

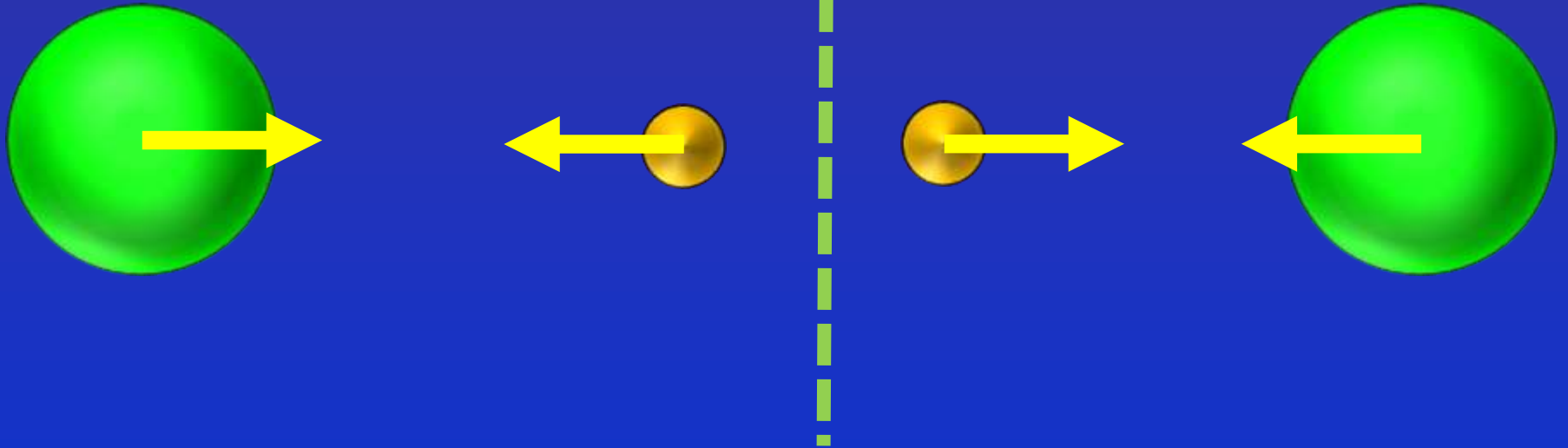
SIMMETRIE IMPLICITE NELLE LEGGI DI NEWTON

VALIDITA'	SIMMETRIA
OVUNQUE	TRASLAZIONALE
OGNI DIREZIONE	ROTAZIONALE
SEMPRE	TEMPORALE



SCAMBIO

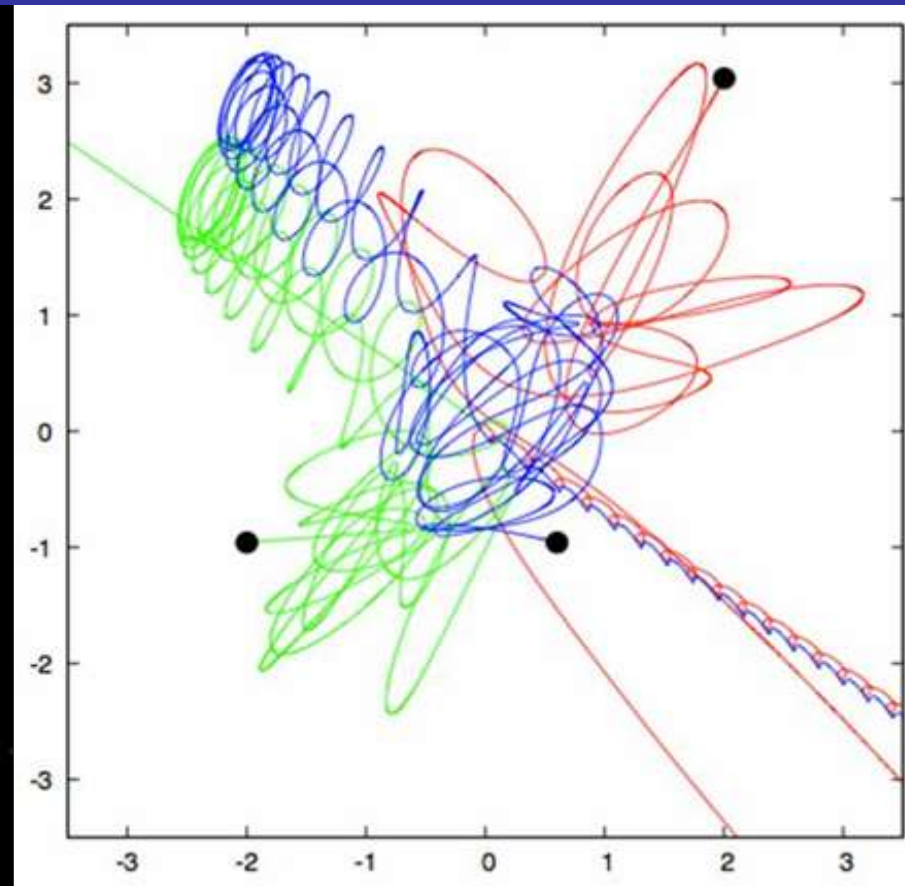
$$F = G \frac{m_1 m_2}{r^2}$$



SCAMBIARE LE MASSE LASCIA INALTERATE LE FORZE
NON SI PUO' ESTENDERE A PIU' MASSE

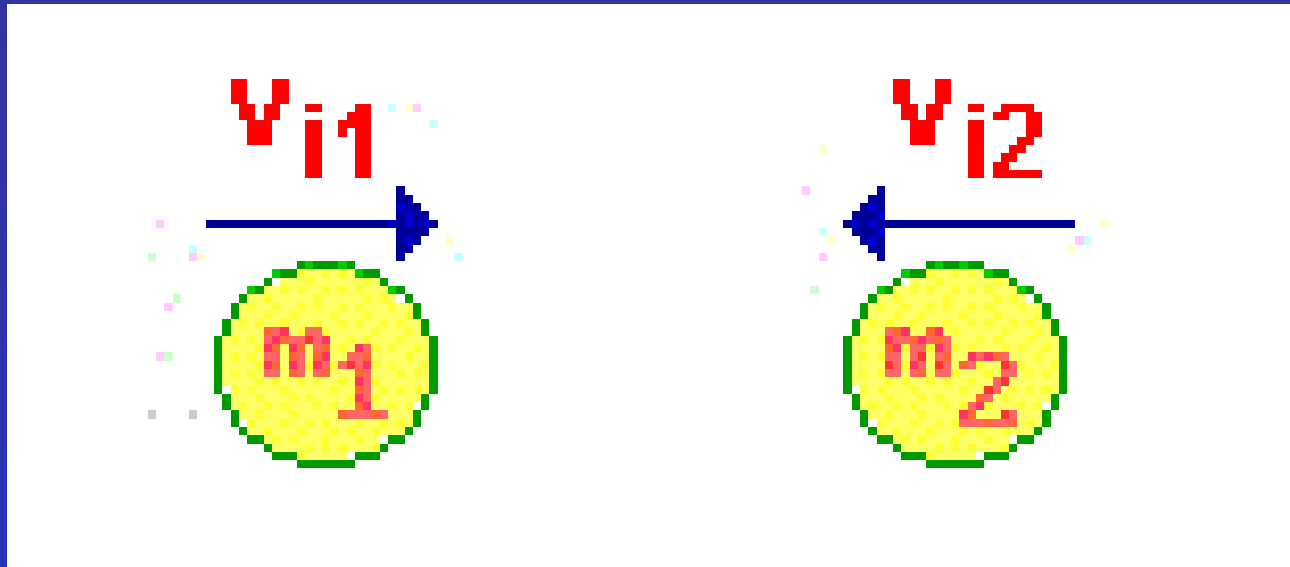


SIMMETRIA NASCOSTA



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

CONSERVAZIONE 1



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

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

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



CONSERVAZIONE 2

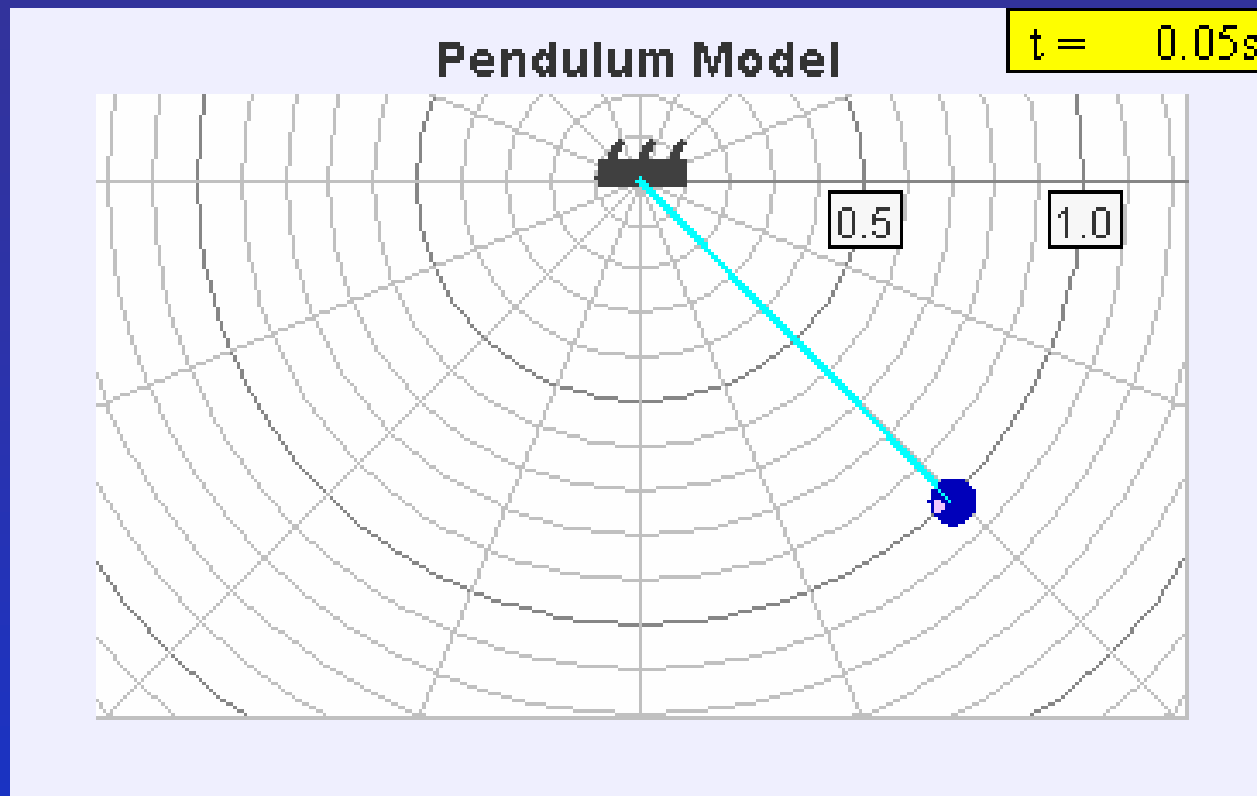


$$\vec{L}_{tot} = \text{cost.}$$

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



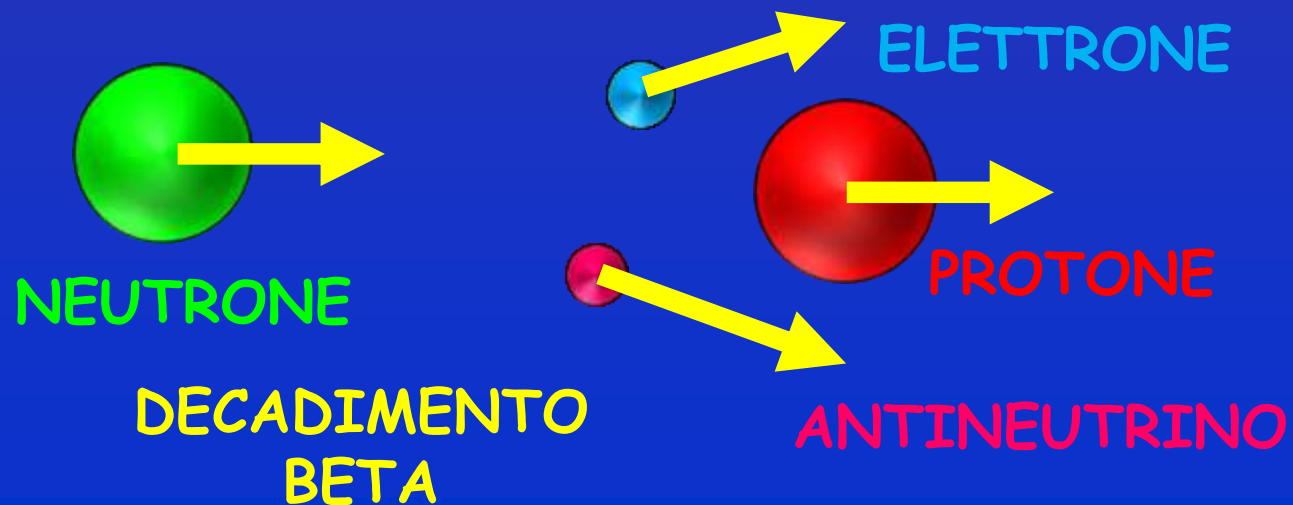
IL TEOREMA DI EMMY

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

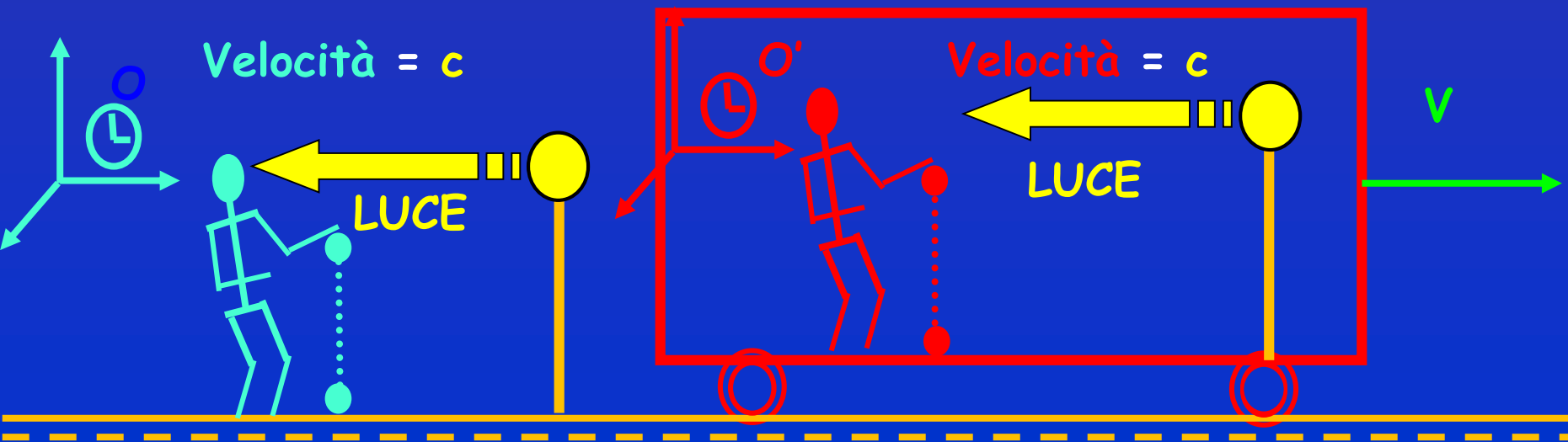
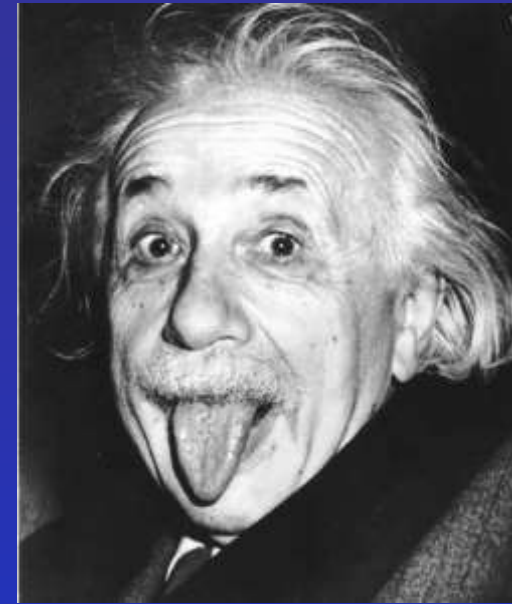




RELATIVITA'

SISTEMI INERZIALI

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



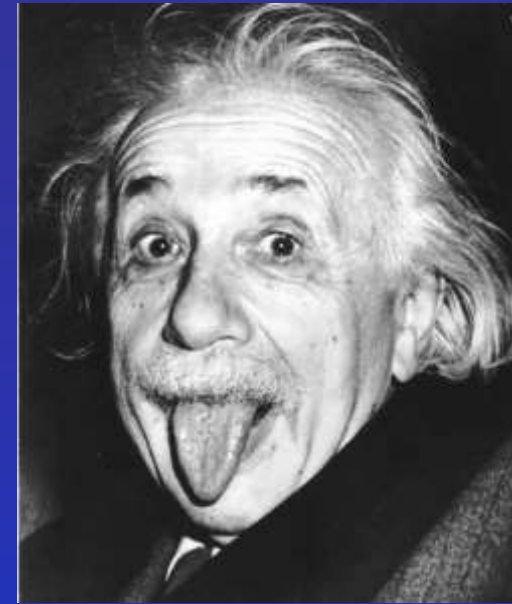


INVARIANTI



INVARIANTI:
LUNGHEZZA,
DURATA E
MASSA

VELOCITA'
DELLA LUCE
RELATIVA



INVARIANTE:
VELOCITA'
DELLA LUCE

LUNGHEZZE,
DURATE E
MASSE
RELATIVE



INVARIANTI



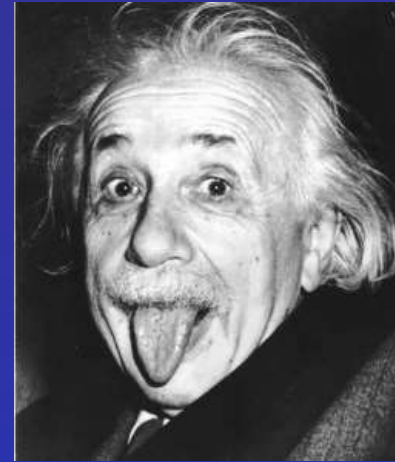
INVARIANTI:
LUNGHEZZA,
DURATA E
MASSA

GRUPPO DI GALILEO

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



INVARIANTE:
VELOCITA'
DELLA LUCE

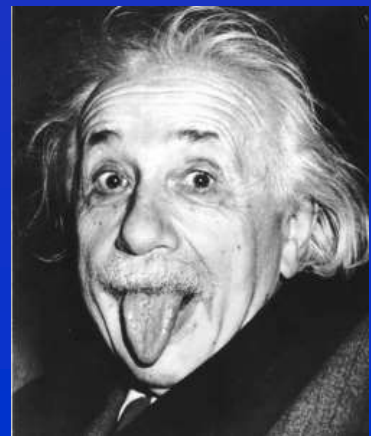
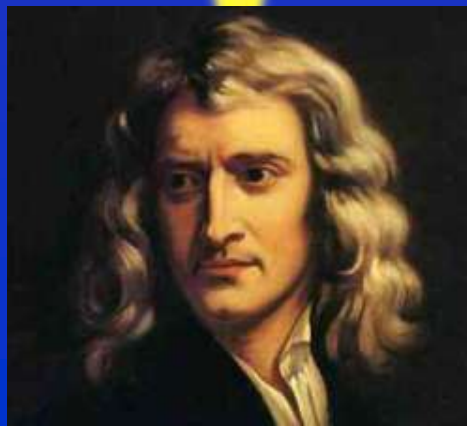


GRUPPO DI LORENTZ

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



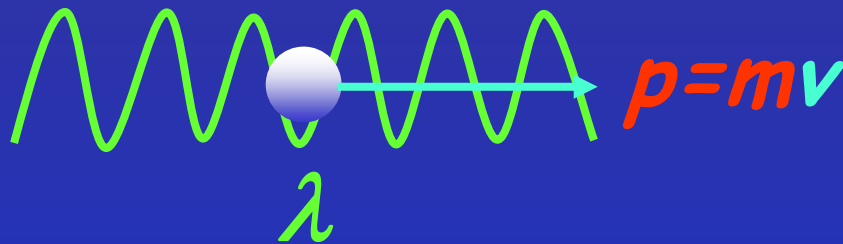
OSSERVATORI





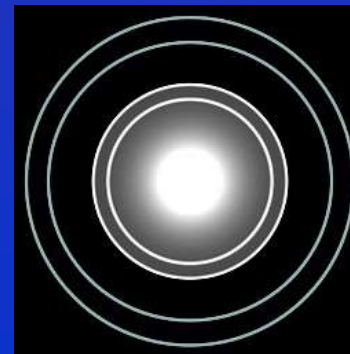
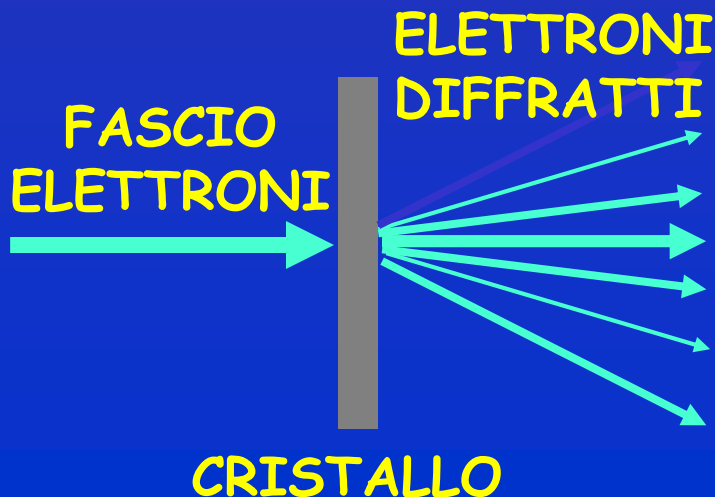
ONDE DI MATERIA

AD OGNI PARTICELLA IN MOTO E' ASSOCIATA UN'ONDA

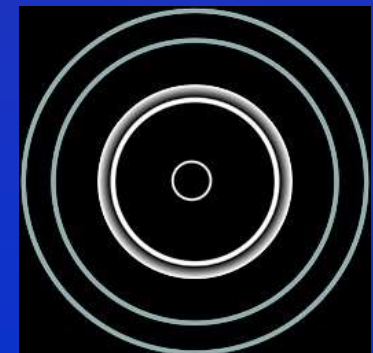


$$\lambda = \frac{h}{p}$$

1927 DAVISSON, GERMER, THOMSON DIFFRAZIONE ELETTRONI



ELETTRONI



RAGGI X

NANOSTRUTTURE

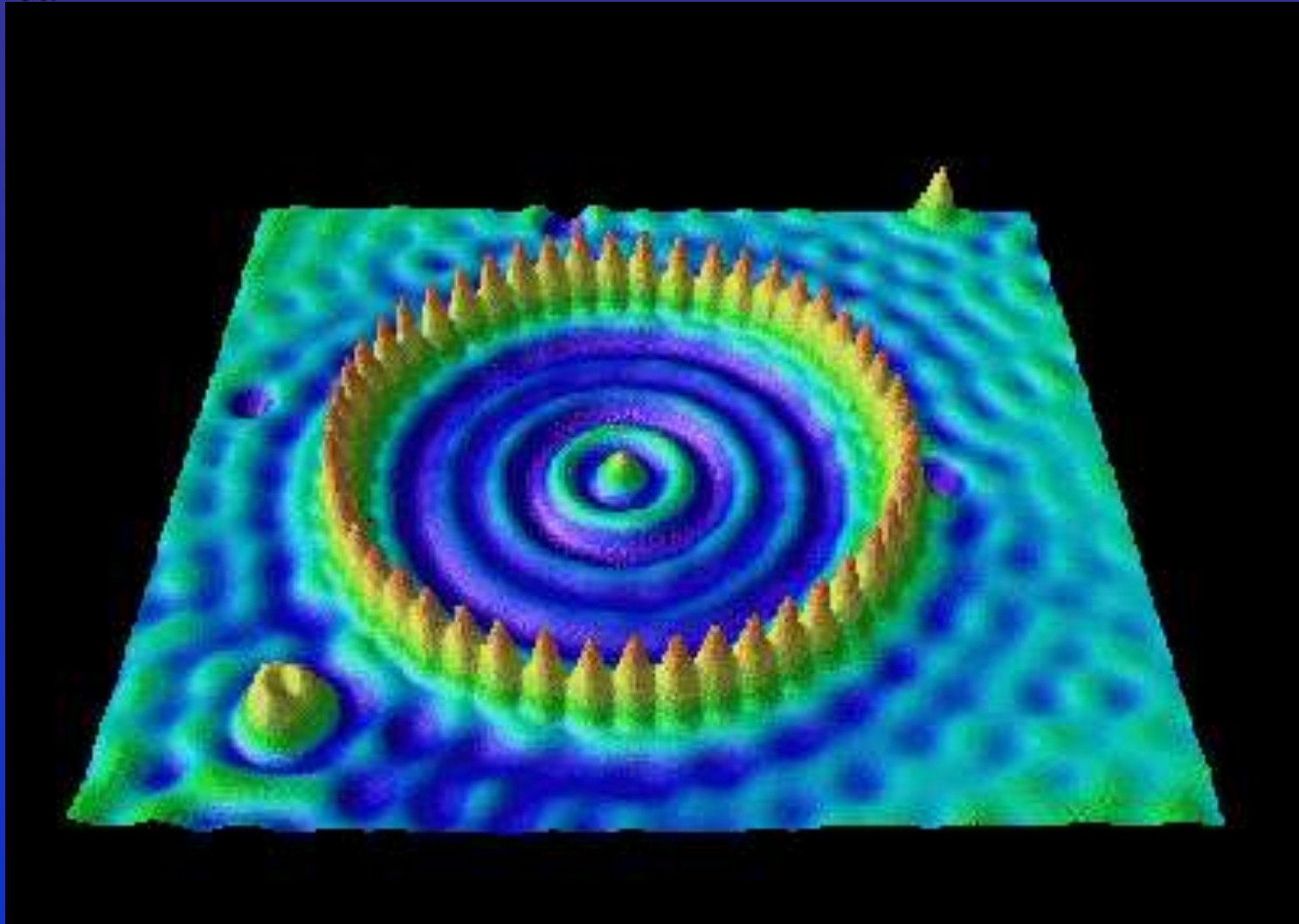


IMMAGINE STM DI UN «QUANTUM CORRAL» DI ATOMI DI FERRO CON FUNZIONE D'ONDA ELETTRONICA AL CENTRO

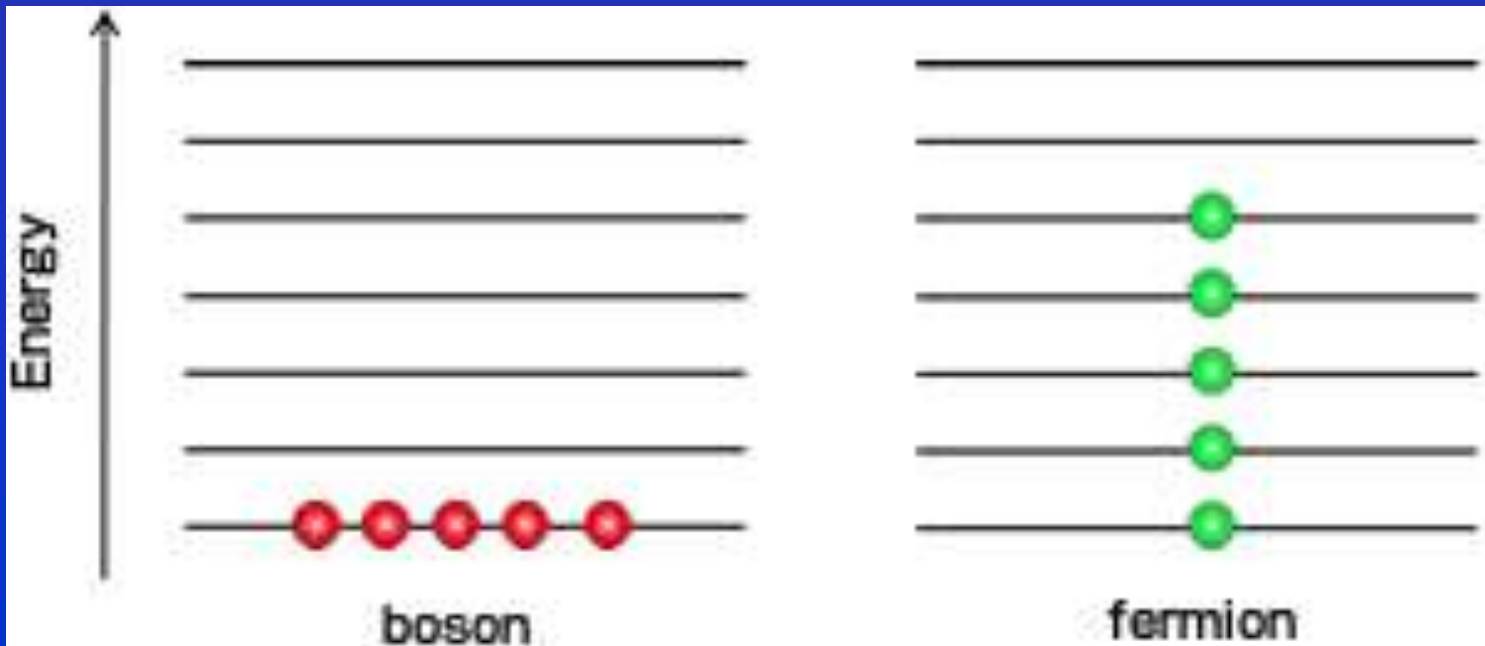


FUNZIONE D'ONDA

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

+ **SIMMETRICA**

- **ANTISIMMETRICA**



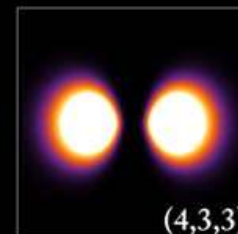
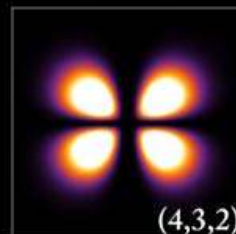
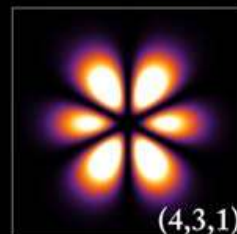
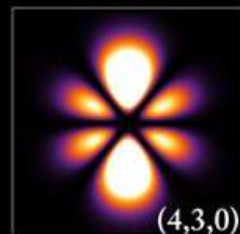
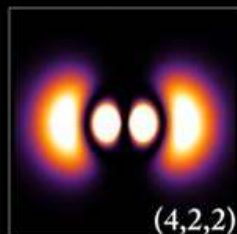
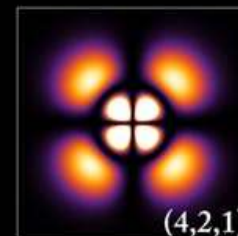
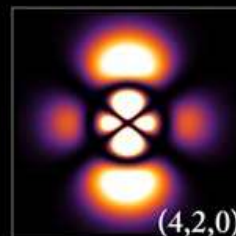
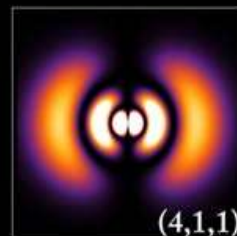
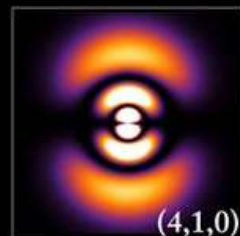
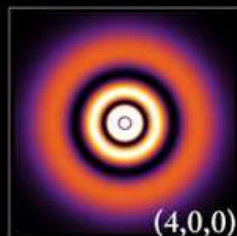
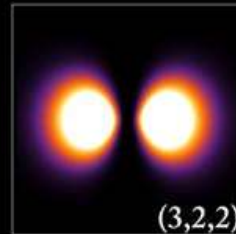
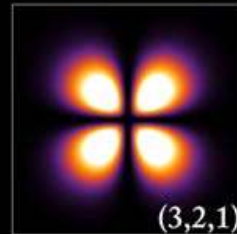
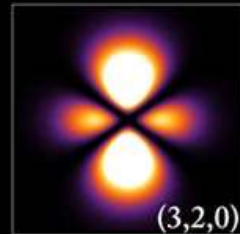
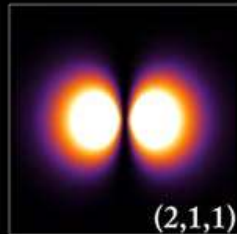
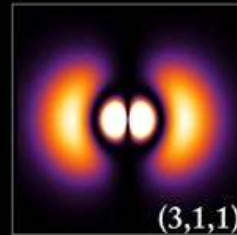
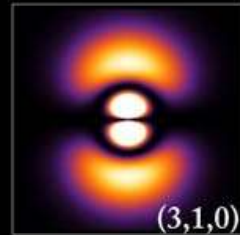
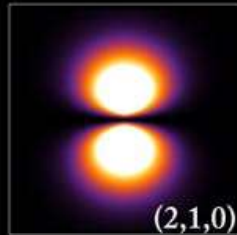
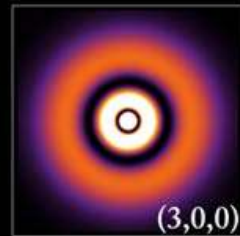
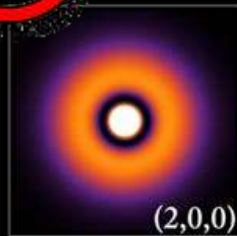


ATOMI

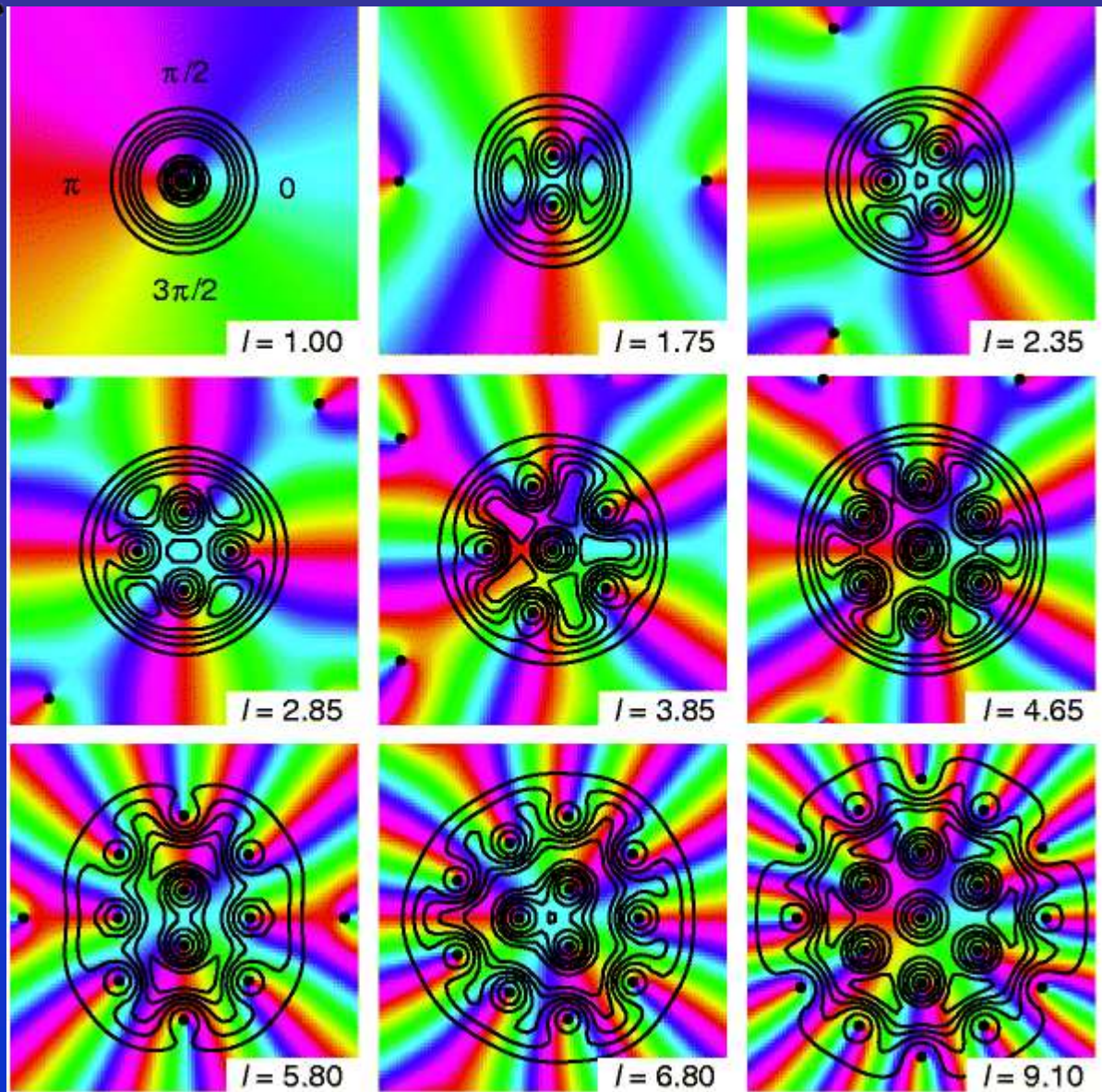
Hydrogen Wave Function

Probability density plots.

$$\psi_{nlm}(r, \vartheta, \varphi) = \sqrt{\left(\frac{2}{na_0}\right)^3 \frac{(n-l-1)!}{2n[(n+l)!]}} e^{-\rho/2} \rho^l L_{n-l-1}^{2l+1}(\rho) \cdot Y_{lm}(\vartheta, \varphi)$$

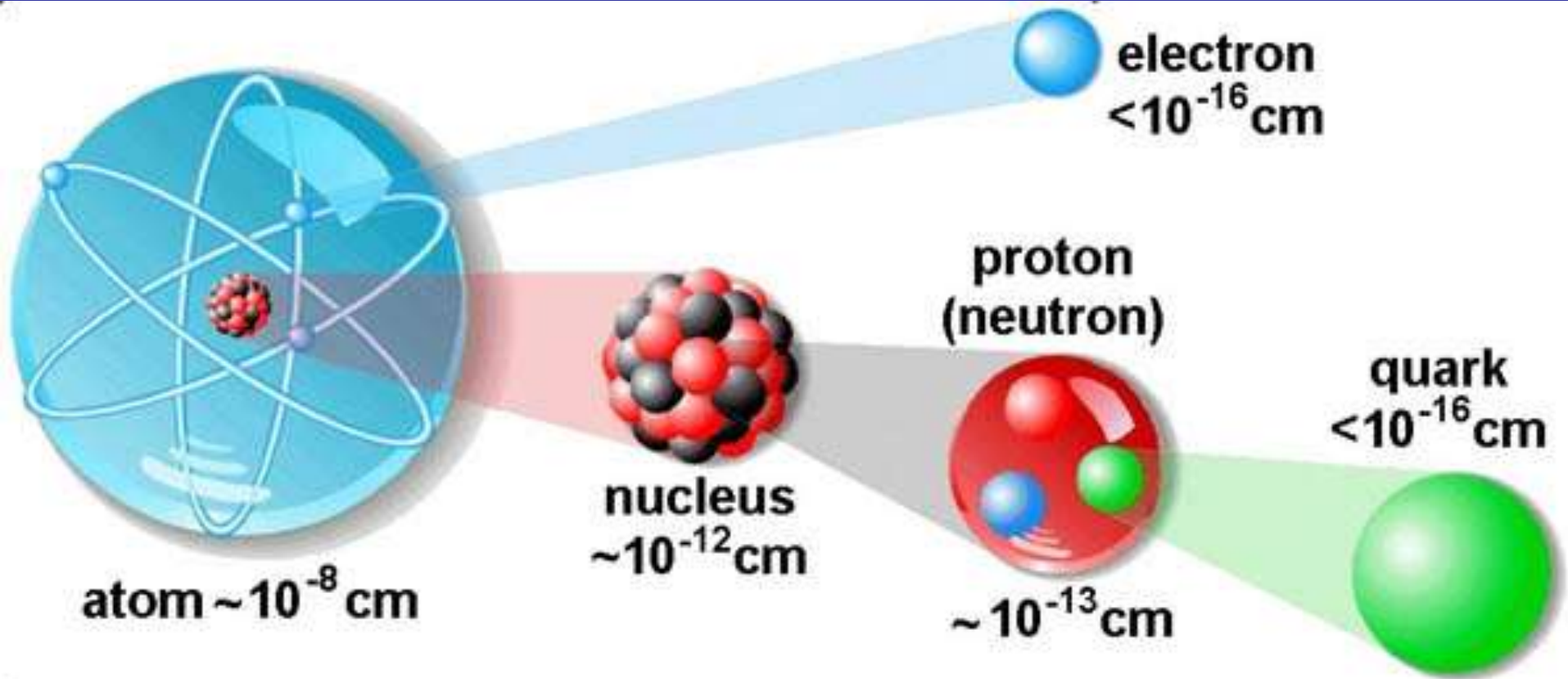


CONDENSATO



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

MATRIOSKE





MODELLO STANDARD

STANDARD MODEL OF ELEMENTARY PARTICLES

Q
U
A
R
K
S

UP mass $2,3 \text{ MeV}/c^2$ charge $\frac{2}{3}$ spin $\frac{1}{2}$ 	CHARM $1,275 \text{ GeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$ 	TOP $173,07 \text{ GeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$ 
DOWN $4,8 \text{ MeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$ 	STRANGE $95 \text{ MeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$ 	BOTTOM $4,18 \text{ GeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$ 

L
E
P
T
O
N
S

ELECTRON $0,511 \text{ MeV}/c^2$ -1 $\frac{1}{2}$ 	MUON $105,7 \text{ MeV}/c^2$ -1 $\frac{1}{2}$ 	TAU $1,777 \text{ GeV}/c^2$ -1 $\frac{1}{2}$ 
ELECTRON NEUTRINO $<2,2 \text{ eV}/c^2$ 0 $\frac{1}{2}$ 	MUON NEUTRINO $<0,17 \text{ MeV}/c^2$ 0 $\frac{1}{2}$ 	TAU NEUTRINO $<15,5 \text{ MeV}/c^2$ 0 $\frac{1}{2}$ 

G
A
U
G
E
B
O
S
O
N
S

GLUON 0 0 1 	PHOTON 0 0 1 	Z BOSON $91,2 \text{ GeV}/c^2$ 0 1 	W BOSON $80,4 \text{ GeV}/c^2$ ± 1 1 
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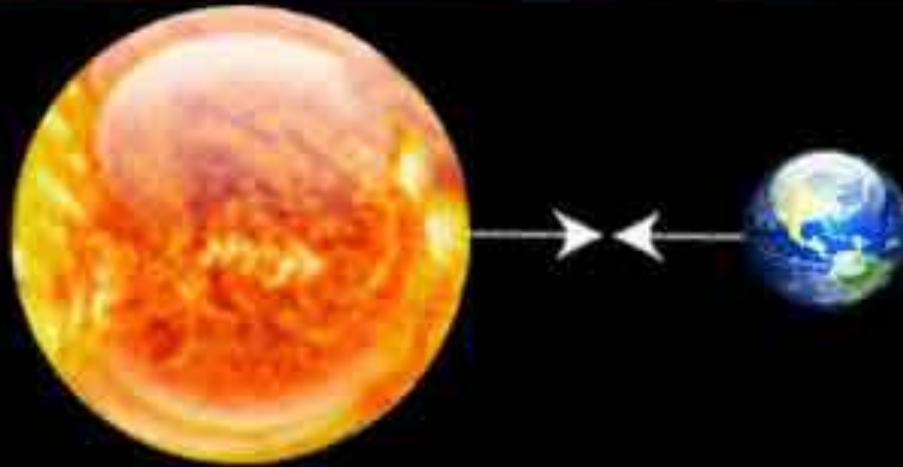
HIGGS BOSON $126 \text{ GeV}/c^2$ 0 0 0 

ANTIMATERIA

Quarks	$\frac{1}{2}$ $\frac{2}{3}$ u up	$\frac{1}{2}$ $\frac{2}{3}$ c charm	$\frac{1}{2}$ $\frac{2}{3}$ t top
	$\frac{1}{2}$ $-\frac{1}{3}$ d down	$\frac{1}{2}$ $-\frac{1}{3}$ s strange	$\frac{1}{2}$ $-\frac{1}{3}$ b bottom
Leptons	$\frac{1}{2}$ 0 ν_e electron neutrino	$\frac{1}{2}$ 0 ν_μ muon neutrino	$\frac{1}{2}$ 0 ν_τ tau neutrino
	$\frac{1}{2}$ -1 e^- electron	$\frac{1}{2}$ -1 μ^- muon	$\frac{1}{2}$ -1 τ^- tau

Antiquarks	$\frac{1}{2}$ $-\frac{2}{3}$ $\bar{t}$ top	$\frac{1}{2}$ $-\frac{2}{3}$ $\bar{c}$ charm	$\frac{1}{2}$ $-\frac{2}{3}$ $\bar{u}$ up
	$\frac{1}{2}$ $-\frac{1}{3}$ $\bar{b}$ bottom	$\frac{1}{2}$ $-\frac{1}{3}$ $\bar{s}$ strange	$\frac{1}{2}$ $-\frac{1}{3}$ $\bar{d}$ down
Antilepton	$\frac{1}{2}$ 0 $\bar{\nu}_\tau$ tau antineutrino	$\frac{1}{2}$ 0 $\bar{\nu}_\mu$ muon antineutrino	$\frac{1}{2}$ 0 $\bar{\nu}_e$ electron antineutrino
	$\frac{1}{2}$ 1 τ^+ tau	$\frac{1}{2}$ 1 μ^+ muon	$\frac{1}{2}$ 1 e^+ positron

FORZE



Gravity



Electromagnetism

4 Fundamental Forces



Weak Nuclear Force

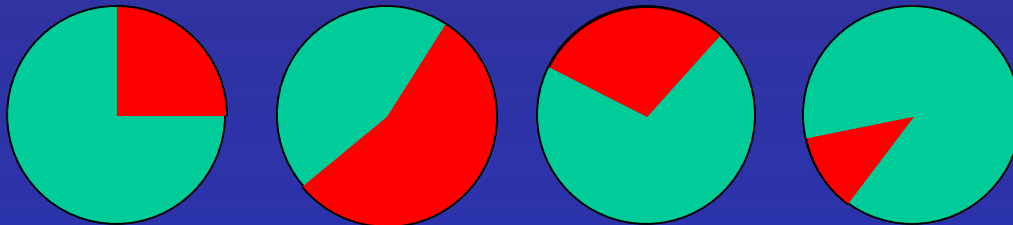


Strong Nuclear Force

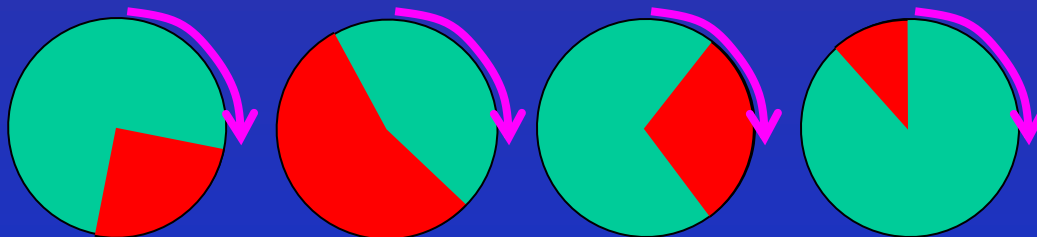


SIMMETRIE GLOBALI E LOCALI

PROPRIETA' FISICA $\rightarrow$ AMPIEZZA SETTORE ROSSO

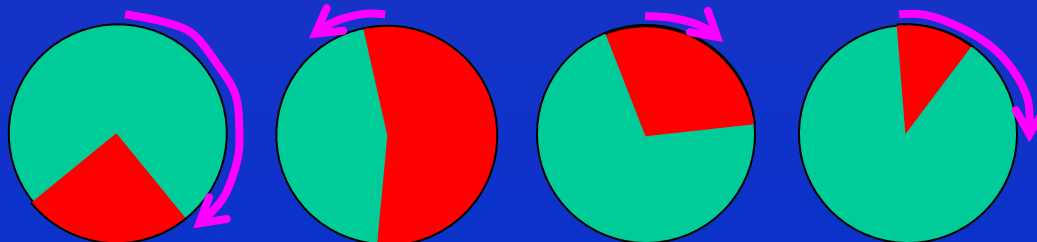


NESSUNA ROTAZIONE



ROTAZIONE GLOBALE

SIMMETRIA
GLOBALE

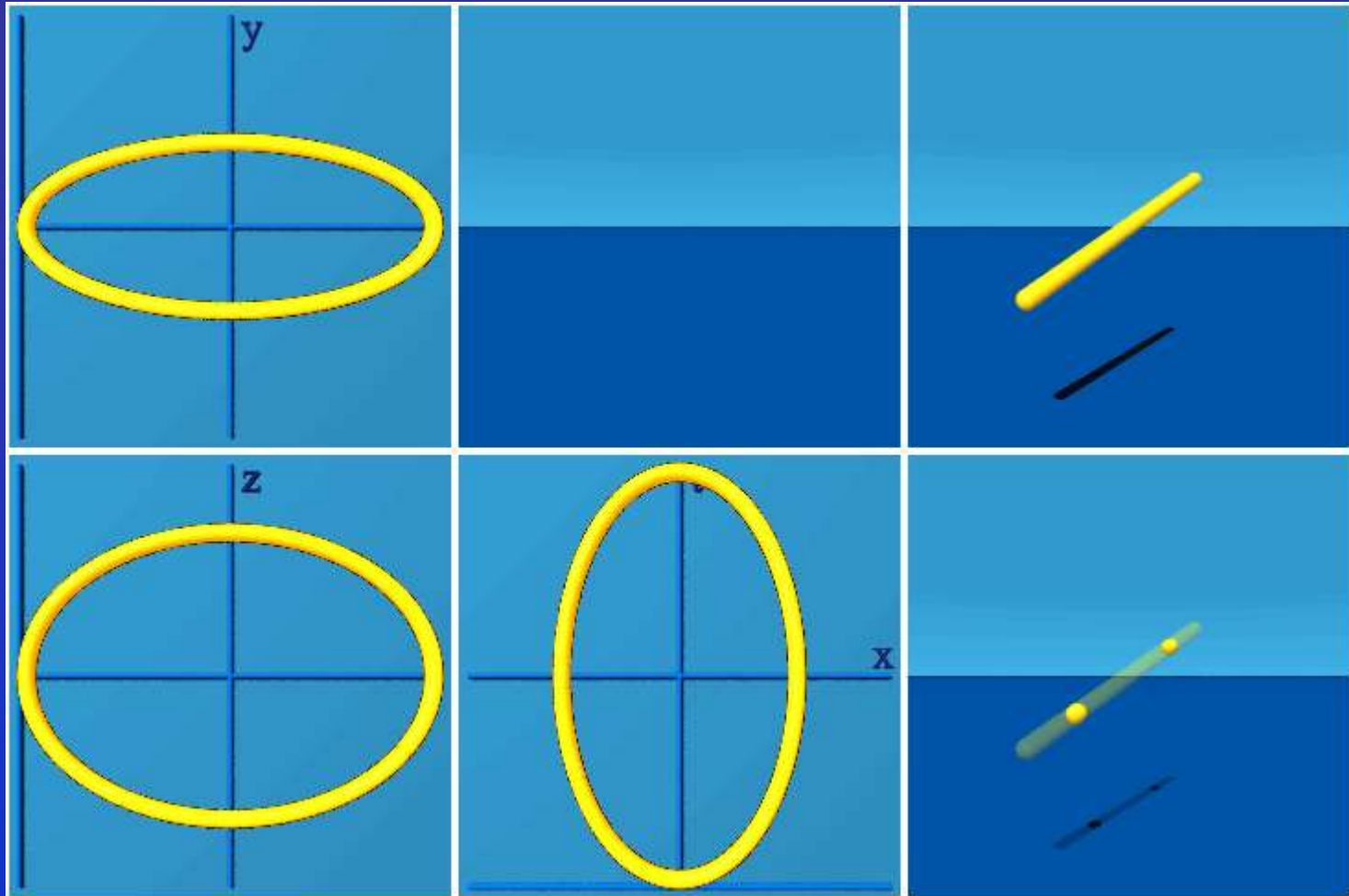


ROTAZIONE LOCALE

SIMMETRIA
DI GAUGE



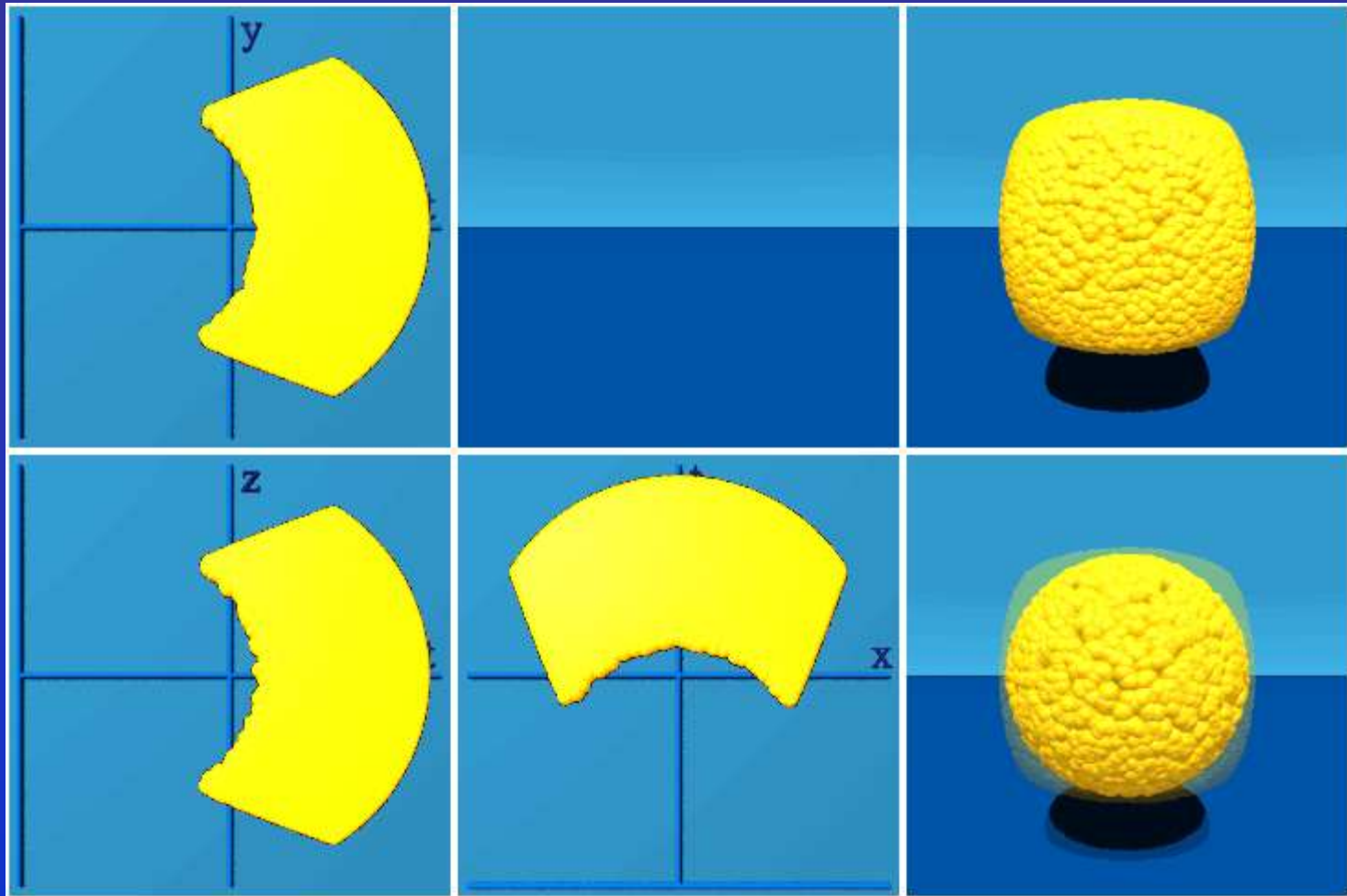
ELETTROMAGNETISMO



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



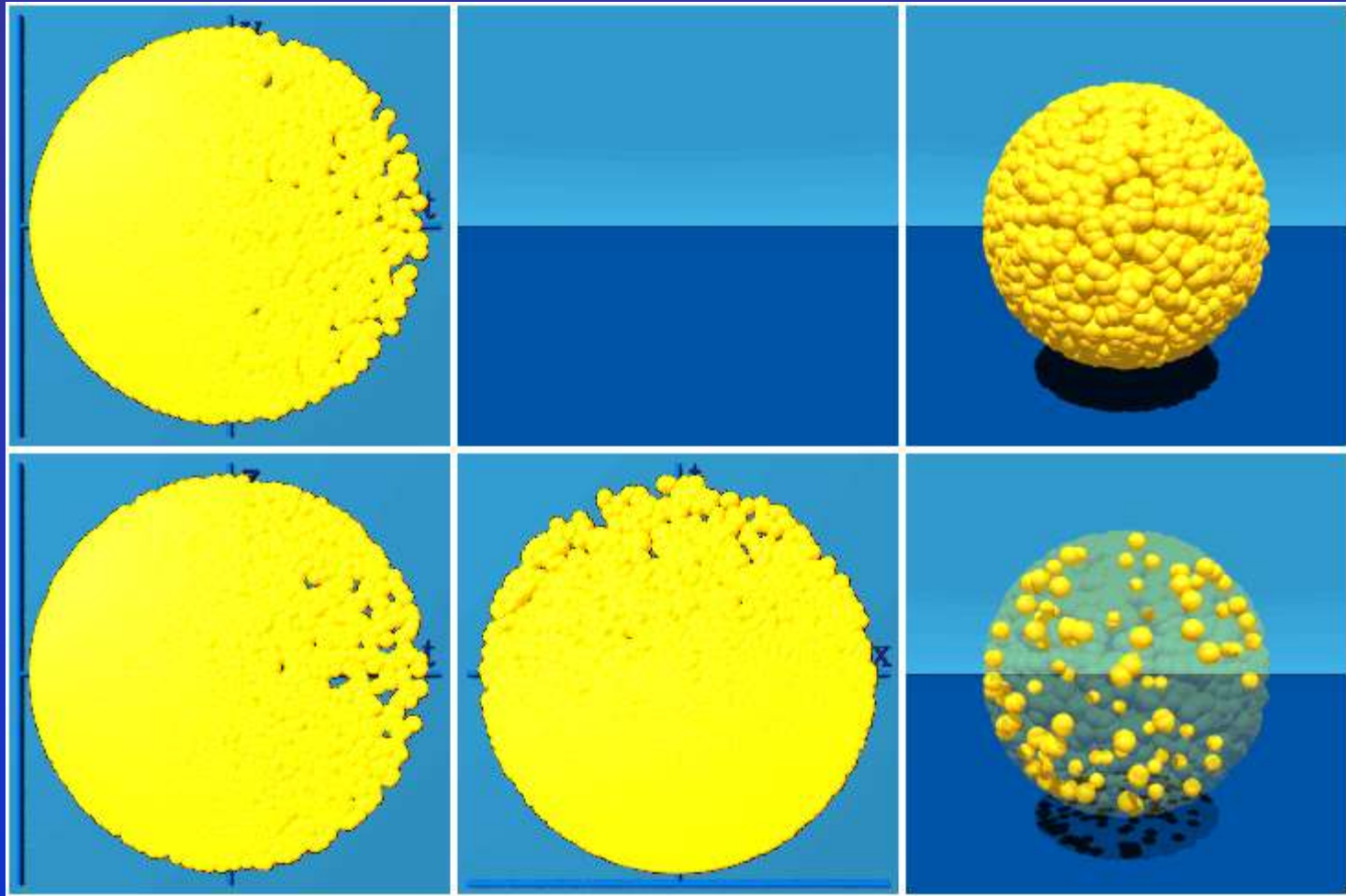
FORZA NUCLEARE DEBOLE



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



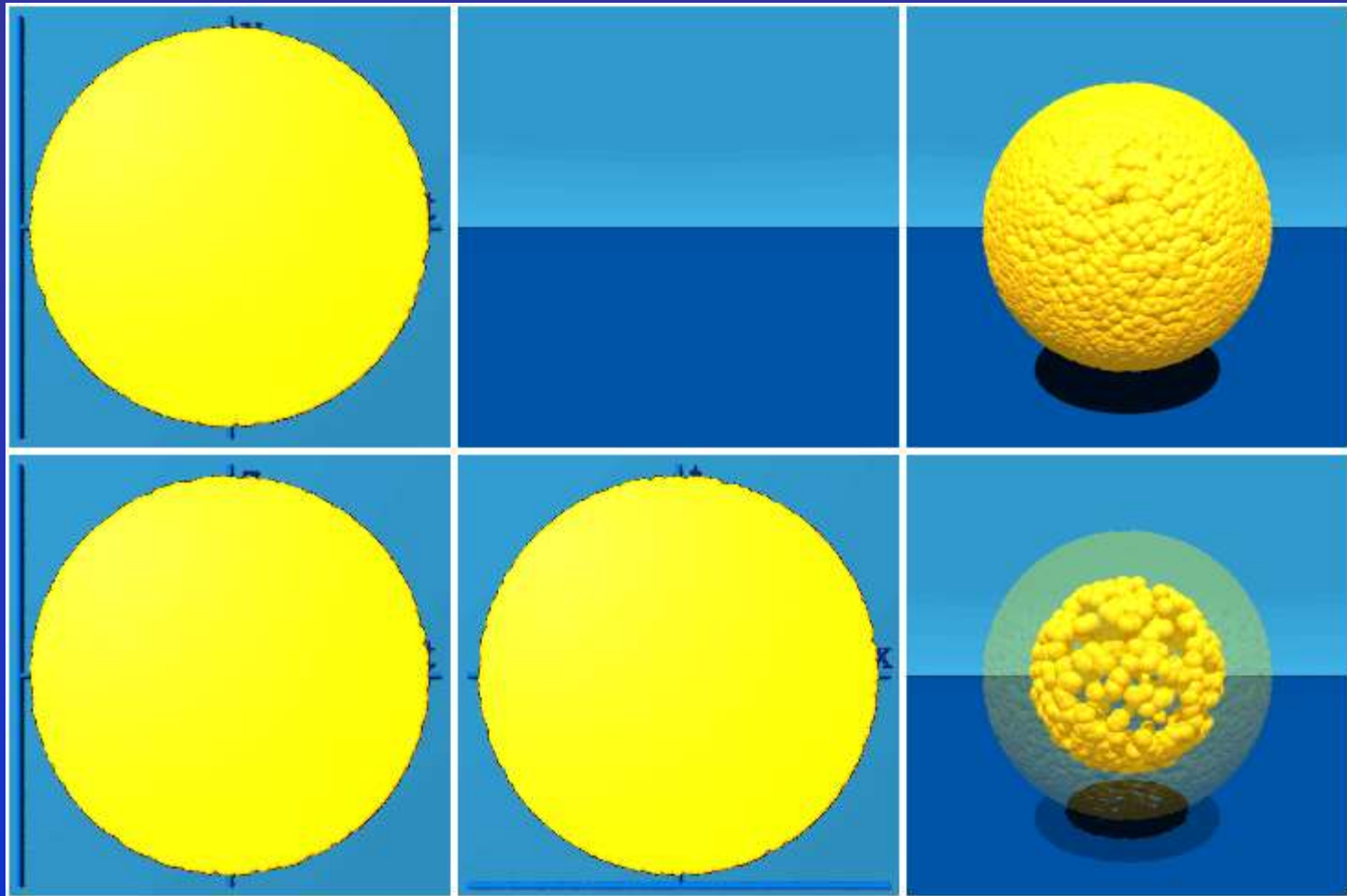
ELETTRODEBOLE



$U(1) \times SU(2)$ E' IL GRUPPO DELLA FORZA ELETTRODEBOLE



FORZA NUCLEARE FORTE

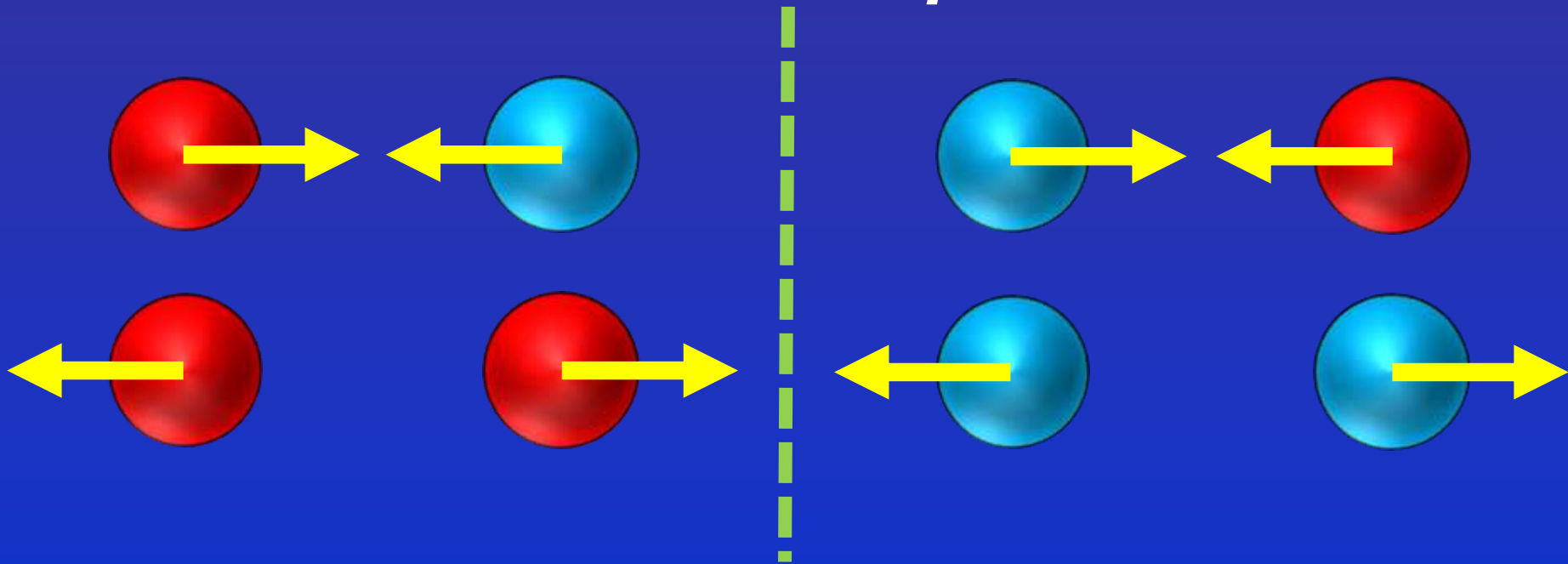


SU(3) E' IL GRUPPO DELLA FORZA NUCLEARE FORTE



CONIUGAZIONE DI CARICA

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



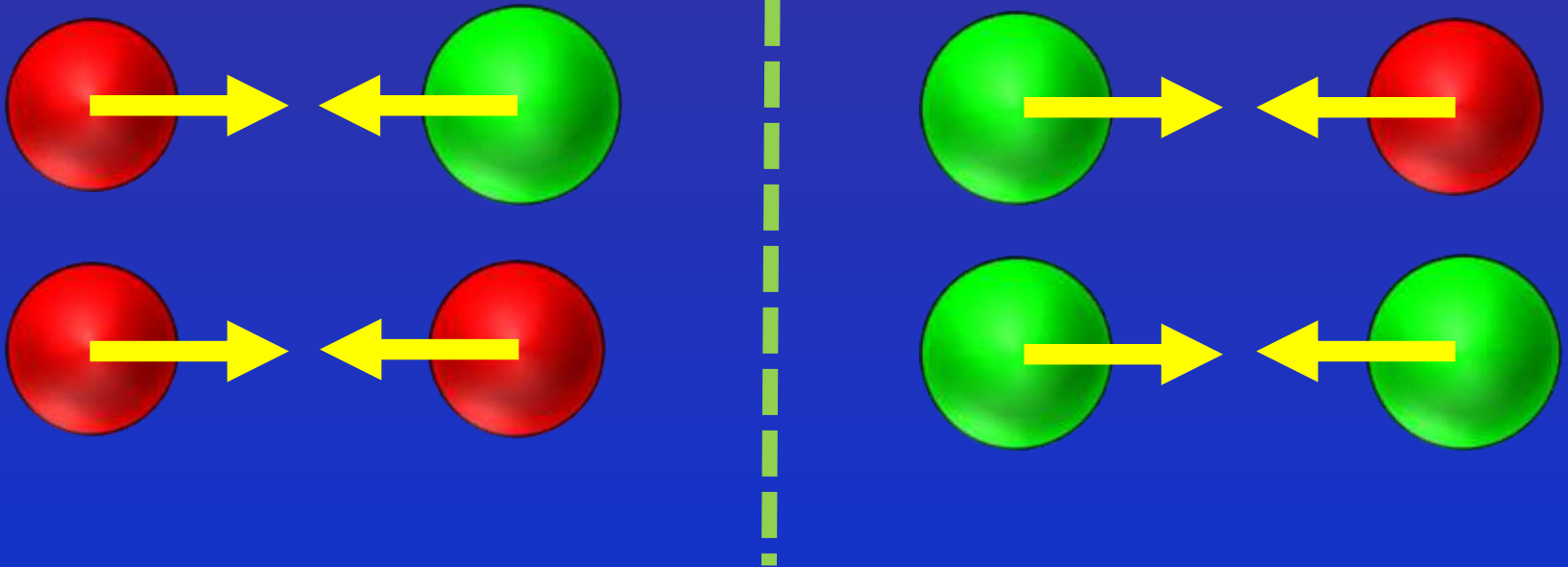
CAMBIARE IL SEGNO DI TUTTE LE CARICHE ELETTRICHE
LASCIA INALTERATE LE FORZE

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

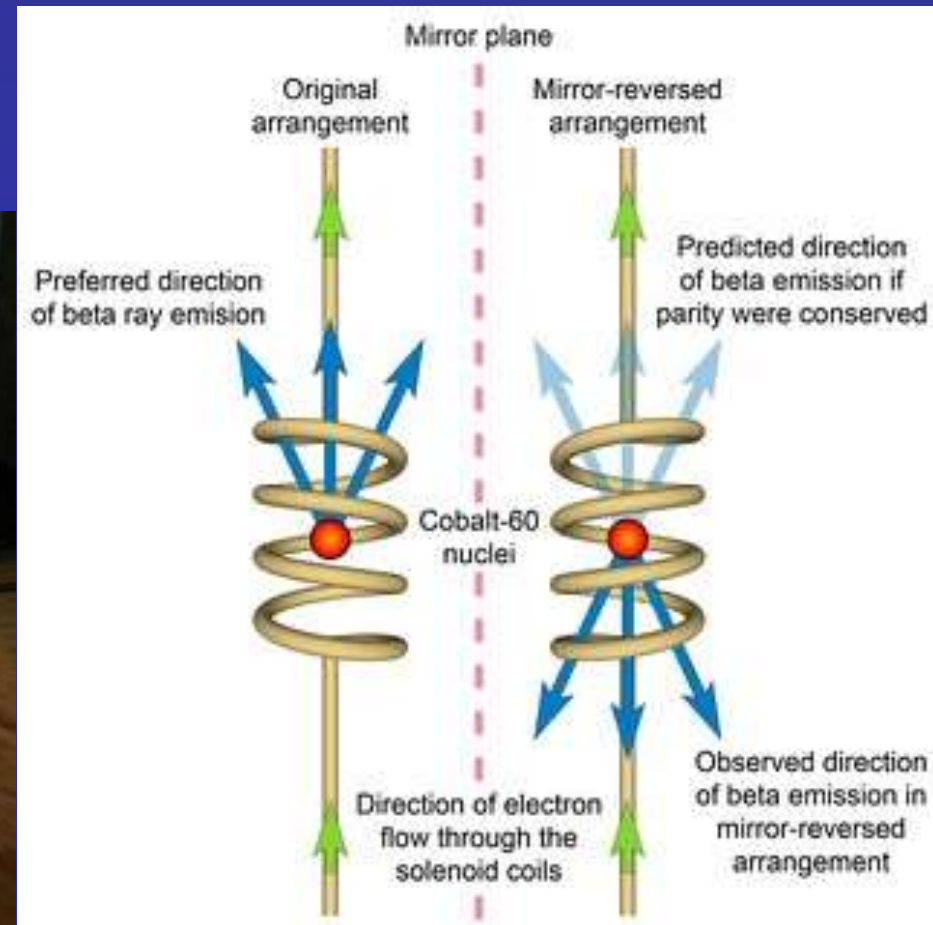


SPECCHIO

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

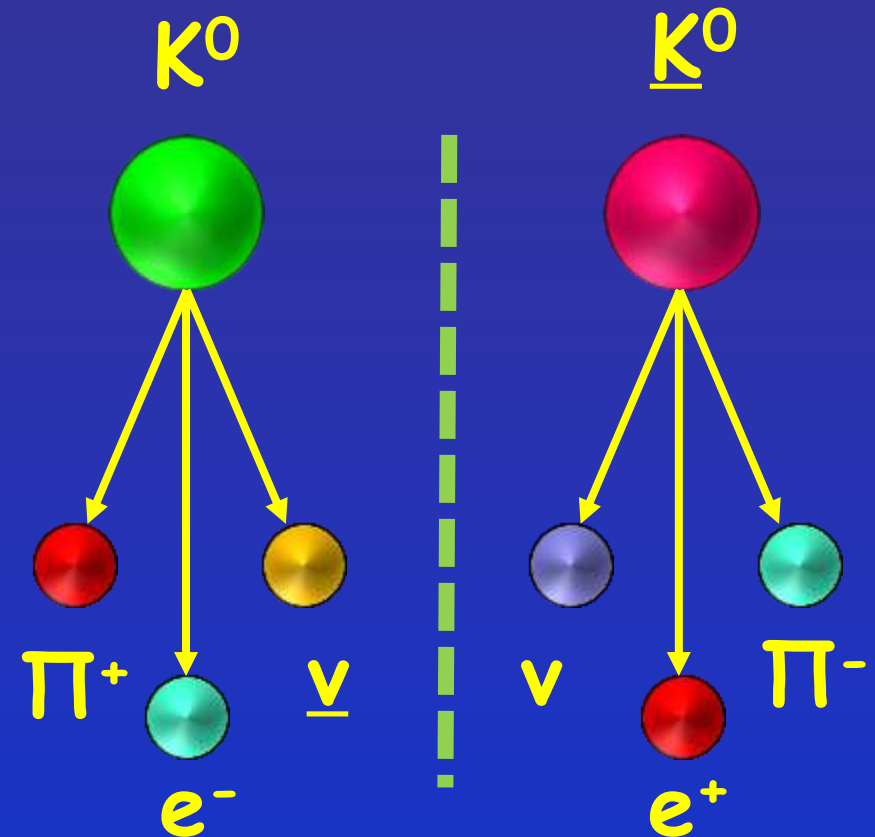


ANTISPECCHIO

ESISTE L'ANTIMONDO NELLO
SPECCHIO?



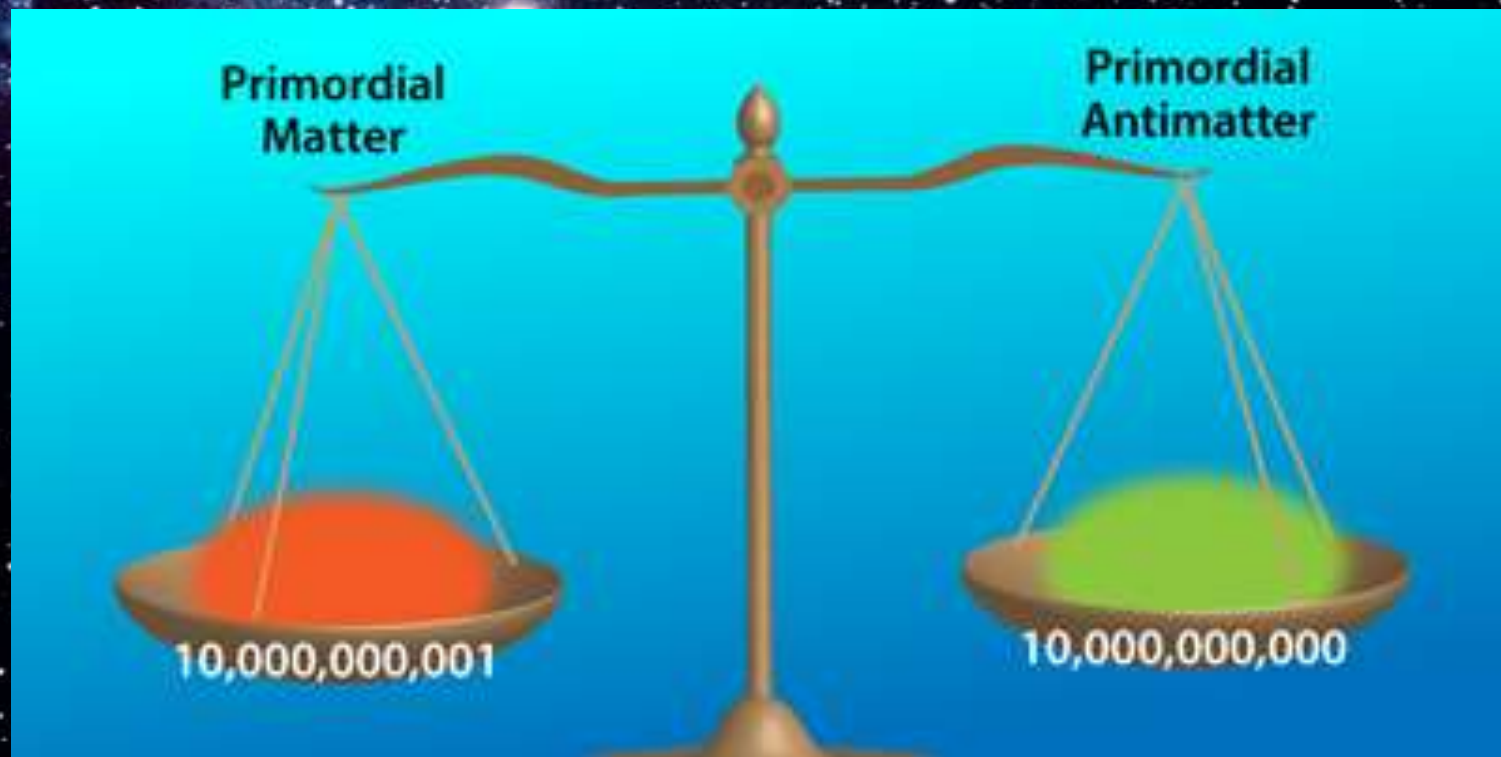
CP NON E' UNA SIMMETRIA
DELLA NATURA



CP NON E' UNA
SIMMETRIA PER LA FORZA
NUCLEARE DEBOLE



MATERIA





CPT

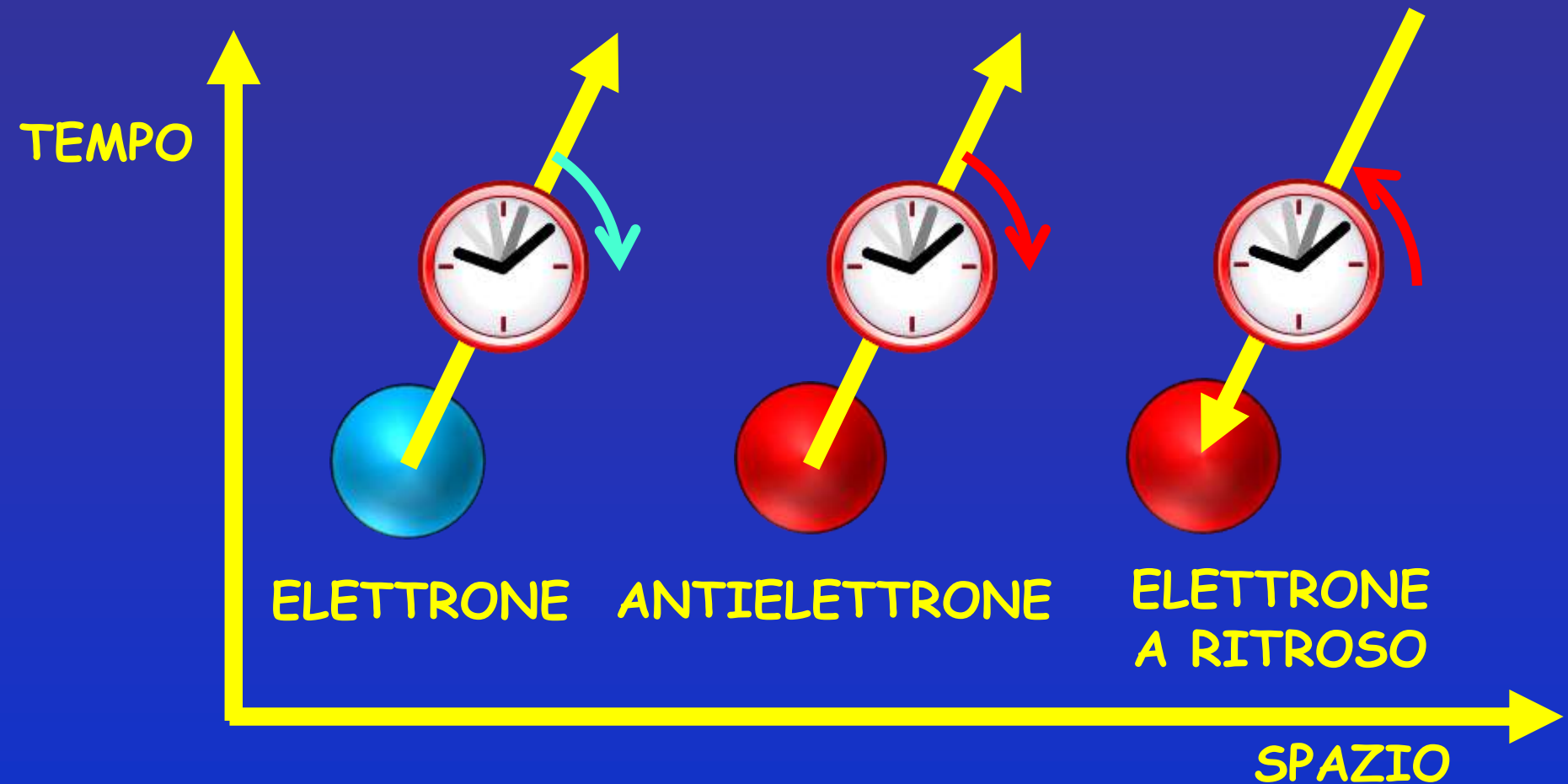
CPT SEMBRA ESSERE UNA SIMMETRIA DELLA NATURA



CPT E' LEGATA ALL'INVARIANZA DI LORENTZ



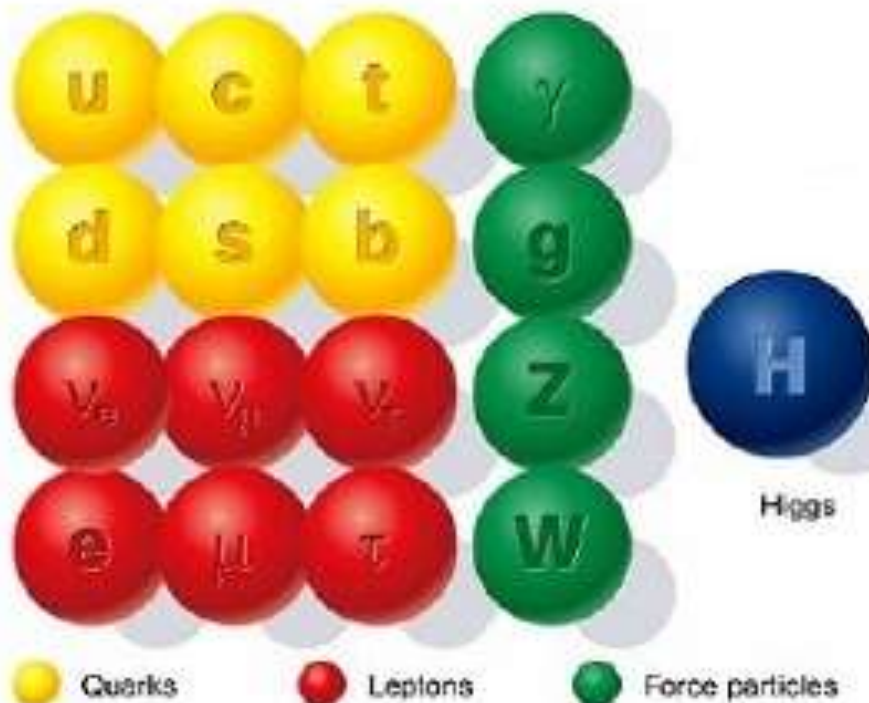
RITORNO AL PASSATO



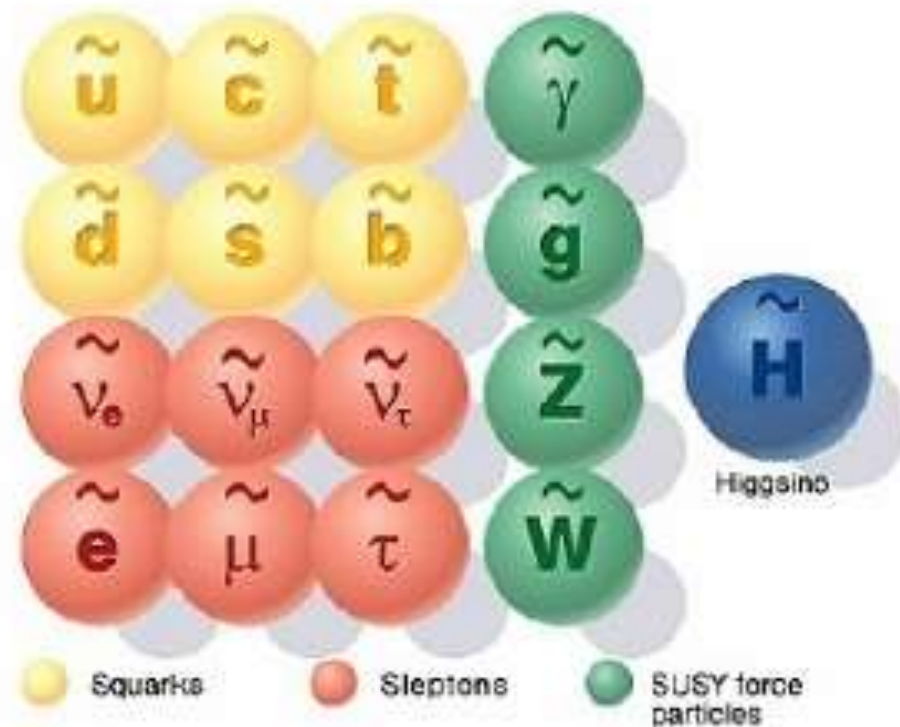
LE ANTIPARTICELLE EQUIVALGONO A PARTICELLE CHE SI MUOVONO A RITROSO NEL TEMPO

SUSY

SUPERSYMMETRY



Standard particles



SUSY particles

E HIGGS?

Quarks



Forces



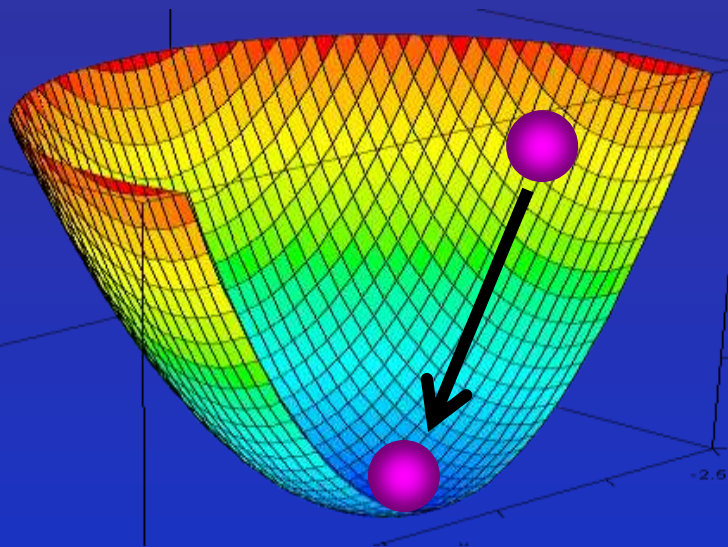
Leptons



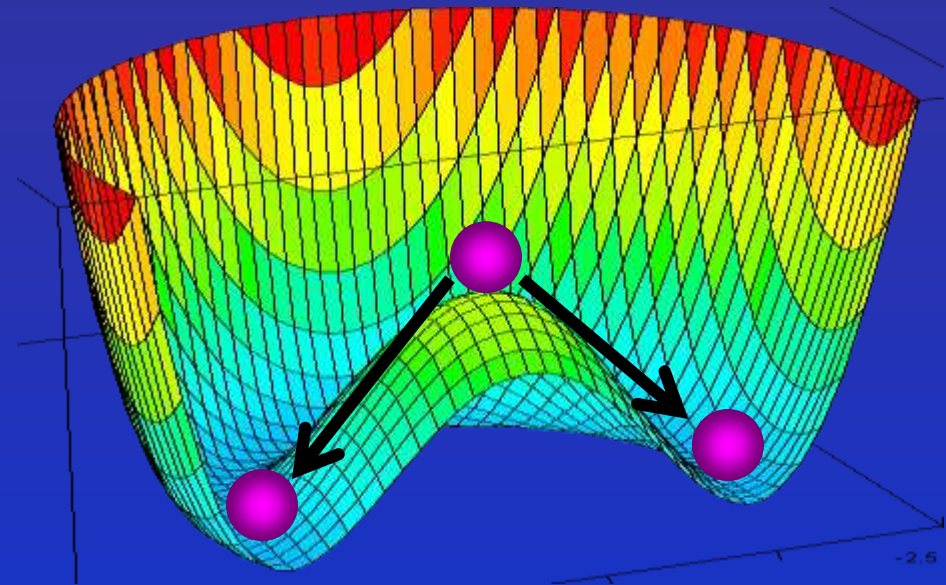


UN BEL SOMBRERO

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



POTENZIALE
SIMMETRICO SENZA
ROTTURA DI SIMMETRIA
DEL CAMPO

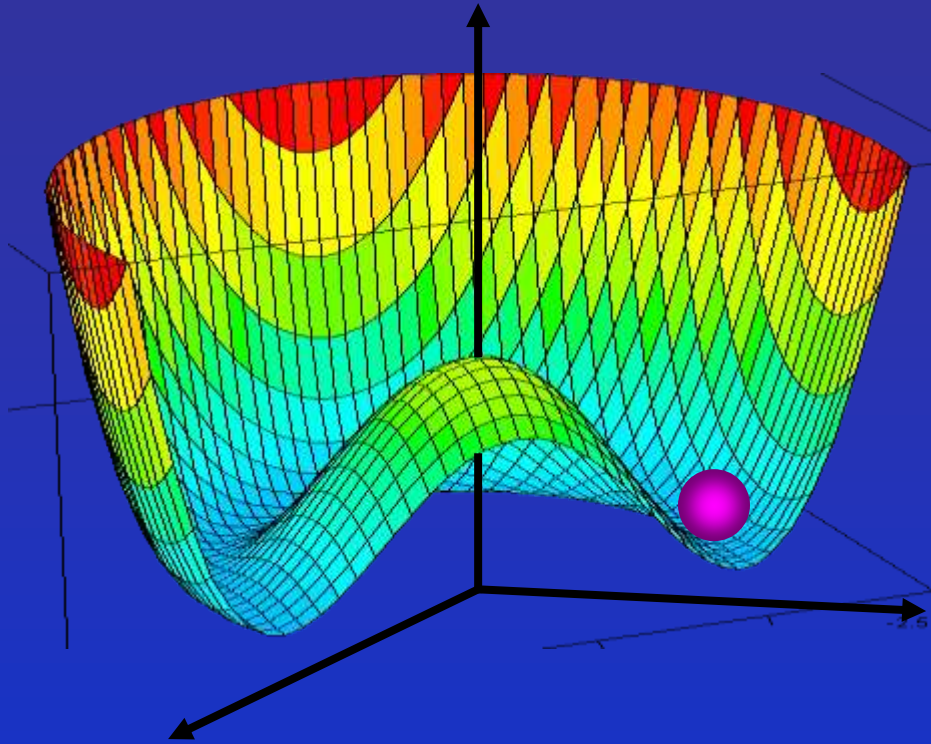


POTENZIALE
SIMMETRICO CON
ROTTURA DI SIMMETRIA
DEL CAMPO



CREARE FORZE

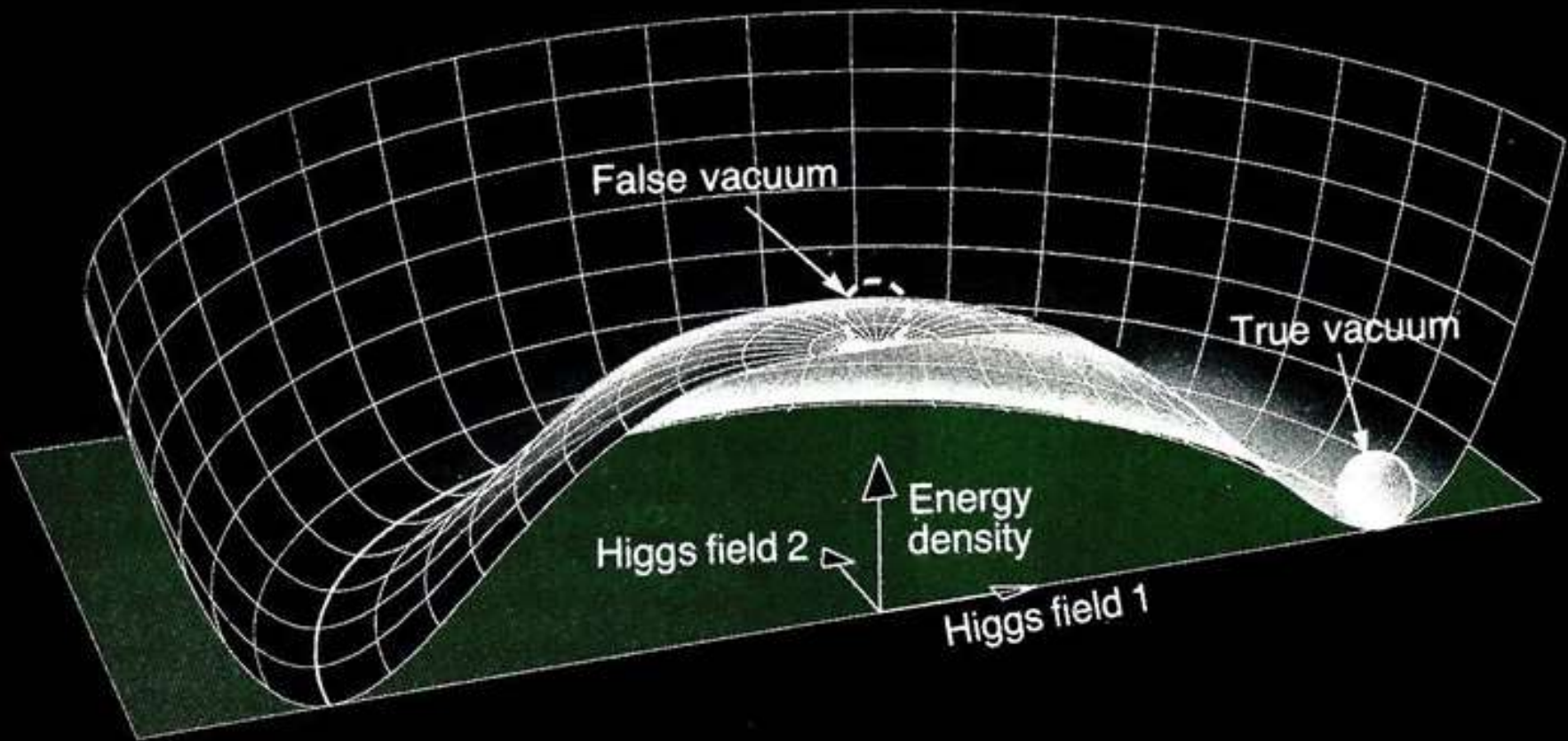
LA ROTTURA DI SIMMETRIA PRODUCE BOSONI PRIVI DI MASSA



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?