Is SUSY The Guardian Of Our Reality From Oblivion

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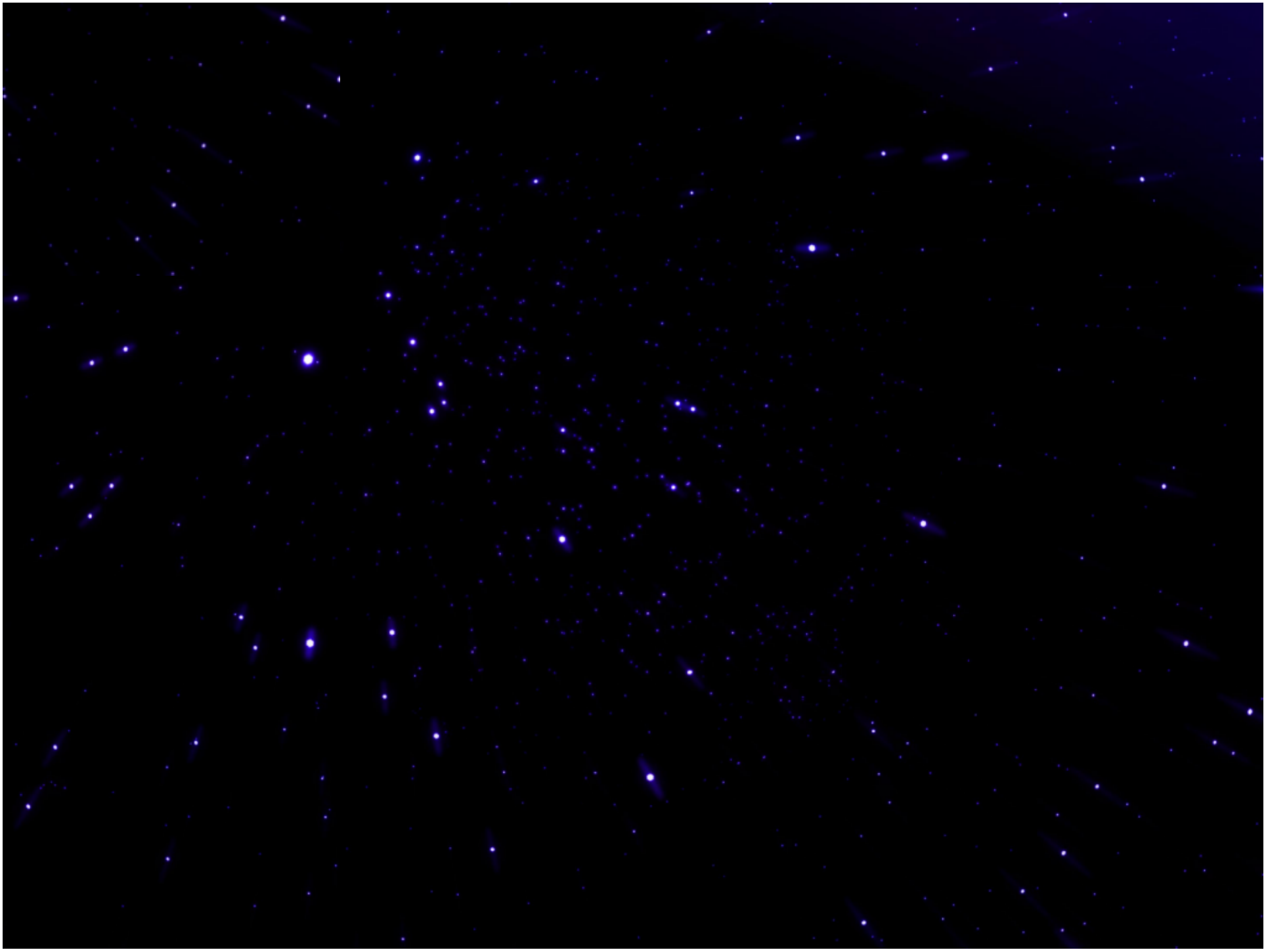
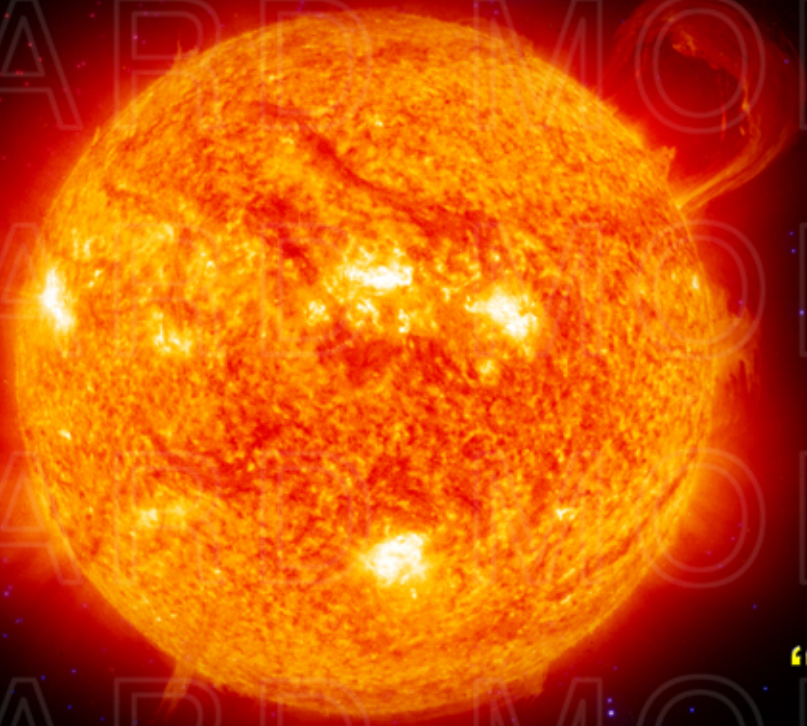
http://umdphysics.umd.edu/people/faculty/135-gates.html



FEBRUARY 19, 1979
$1.25
TIME
ROOTS II
TV's Super Sequel
Rediscovering Einstein
His Centennial Year

Strong Interaction

Our Sun

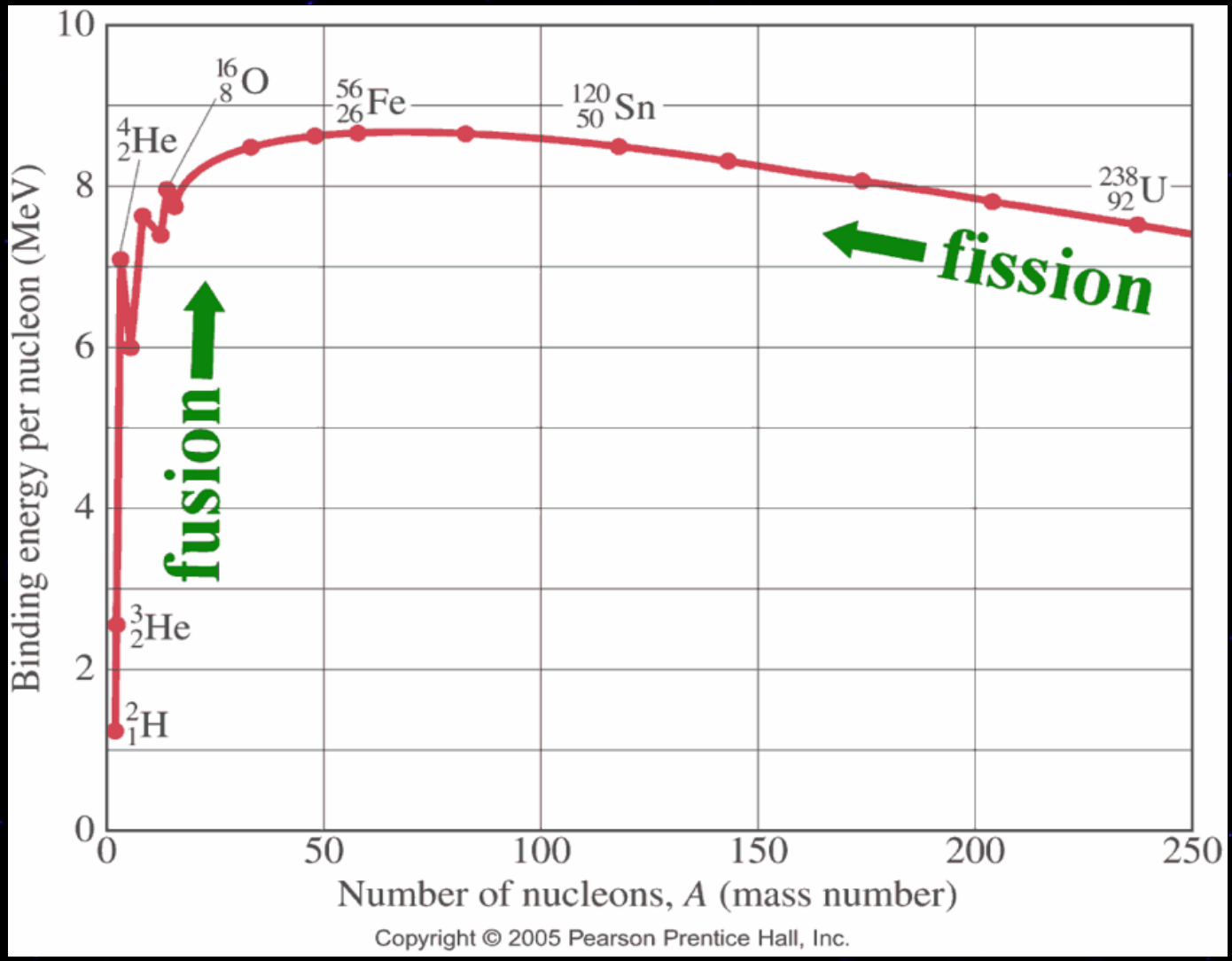


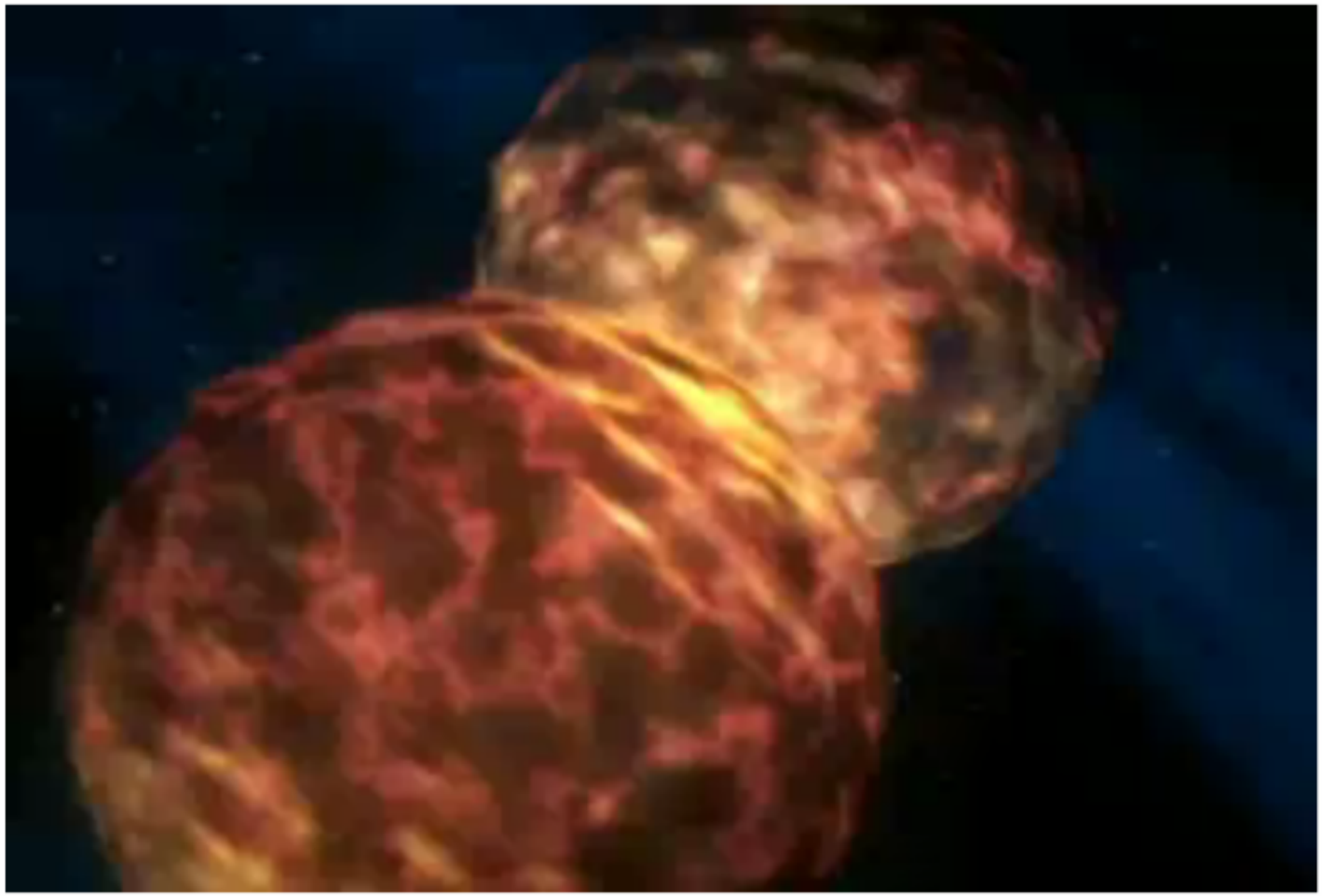
Sunlight

"fat man"

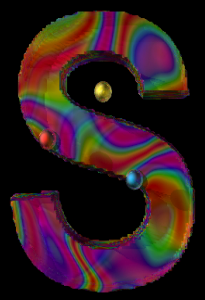
"star stuff"

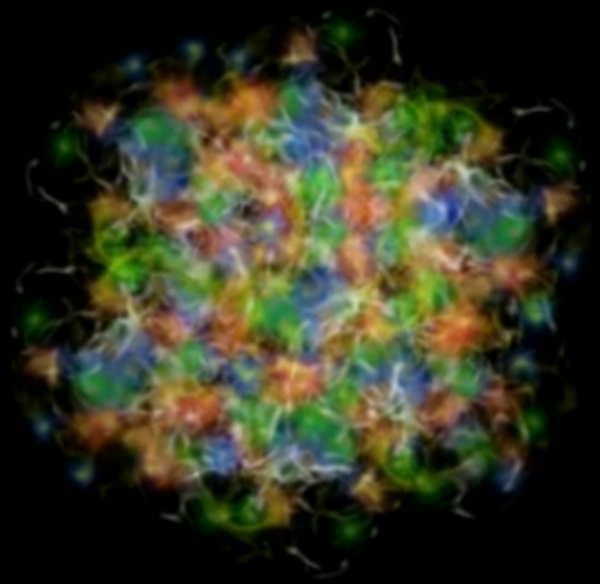
STANDARD MODEL


10
8
6
4
2
0
0
50
100
150
200
250
Binding energy per nucleon (MeV)
Number of nucleons, A (mass number)
$^{16}_{8}O$
$^{56}_{26}Fe$
$^{120}_{50}Sn$
$^{238}_{92}U$
$^{4}_{2}He$
$^{3}_{2}He$
$^{2}_{1}H$
fusion
fission
Copyright © 2005 Pearson Prentice Hall, Inc.

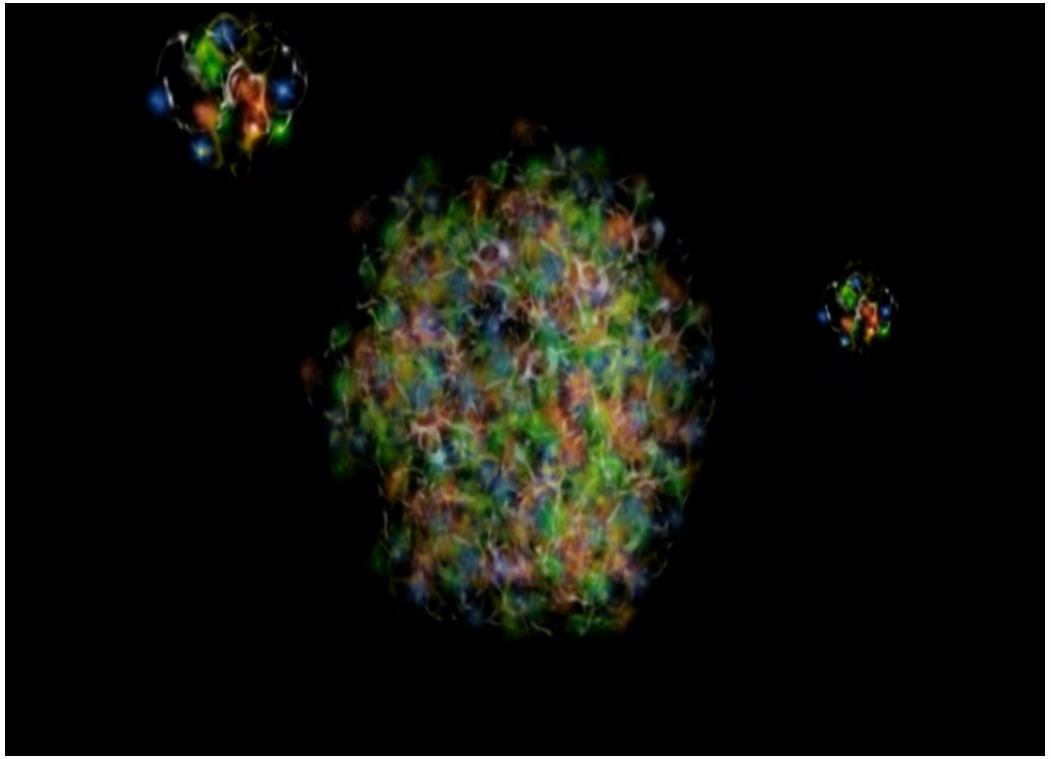


Becquerel & Curie's Legacy

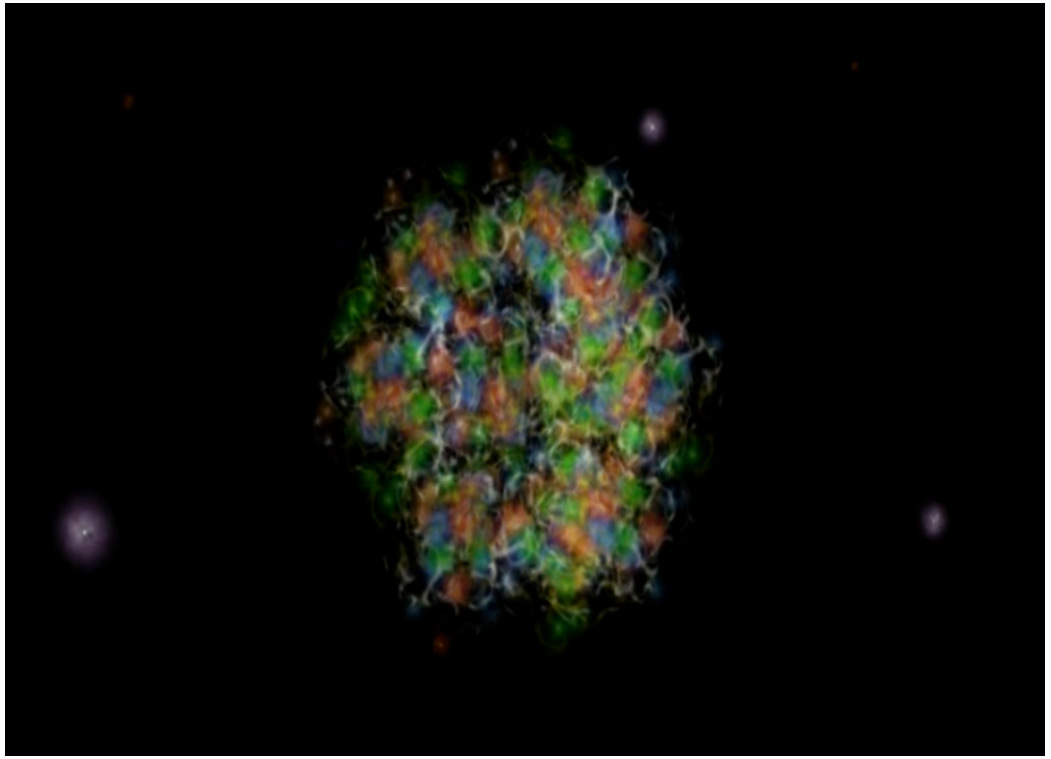




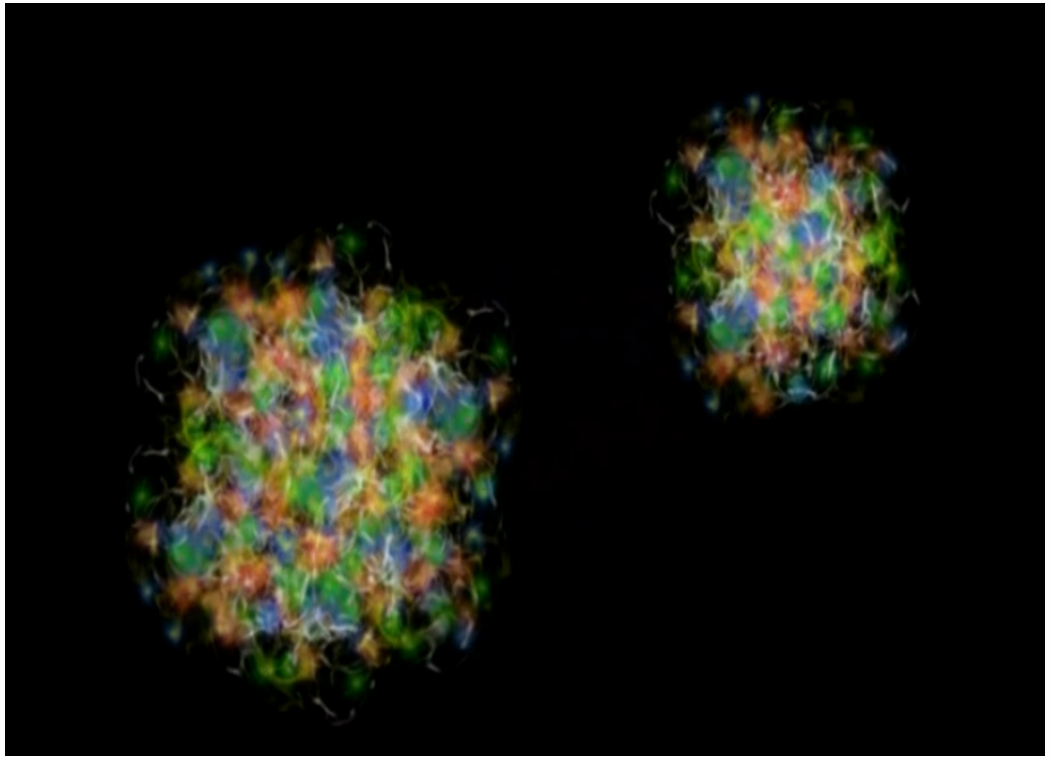
Decay Mode: Alpha-Ray Emission



Decay Mode: Beta-Ray Emission

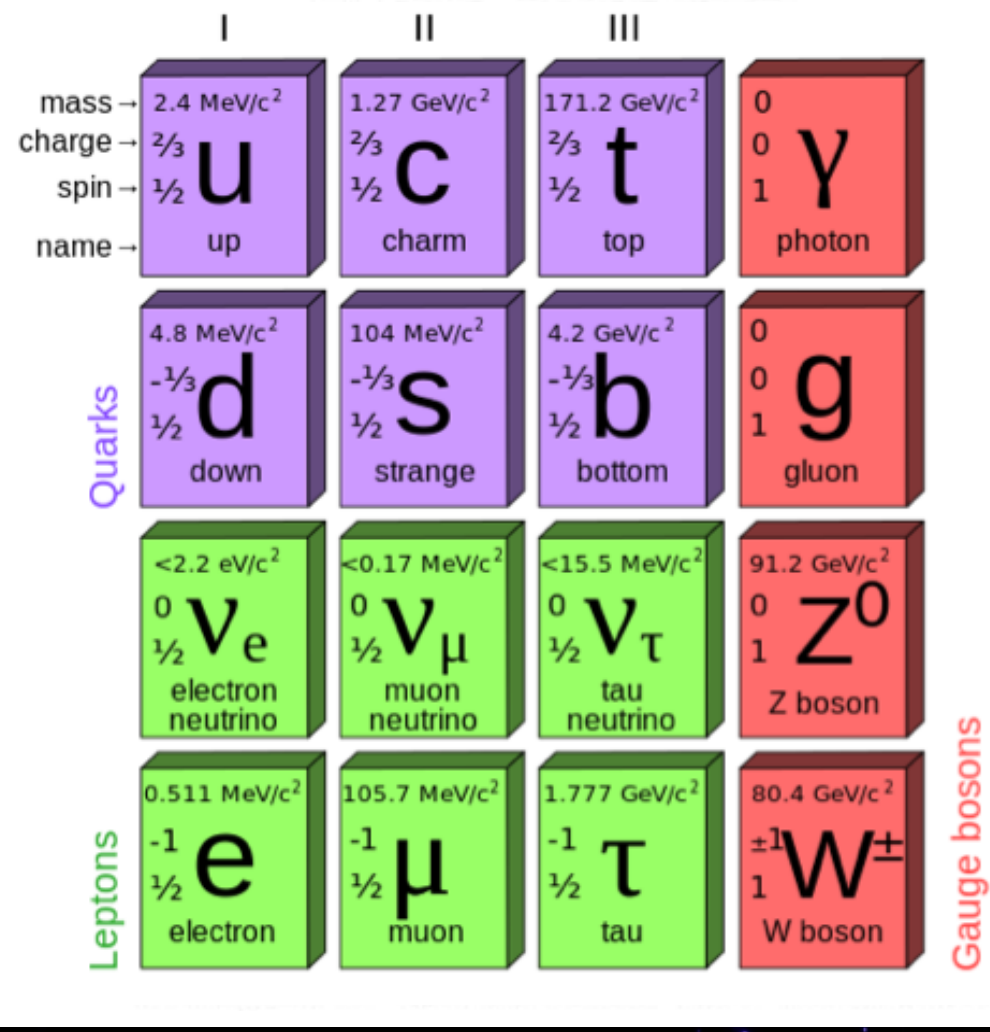


Decay Mode: Fission



A Little Standard
Model Review

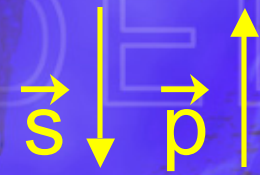
Elementary Particles



Spinning Tops

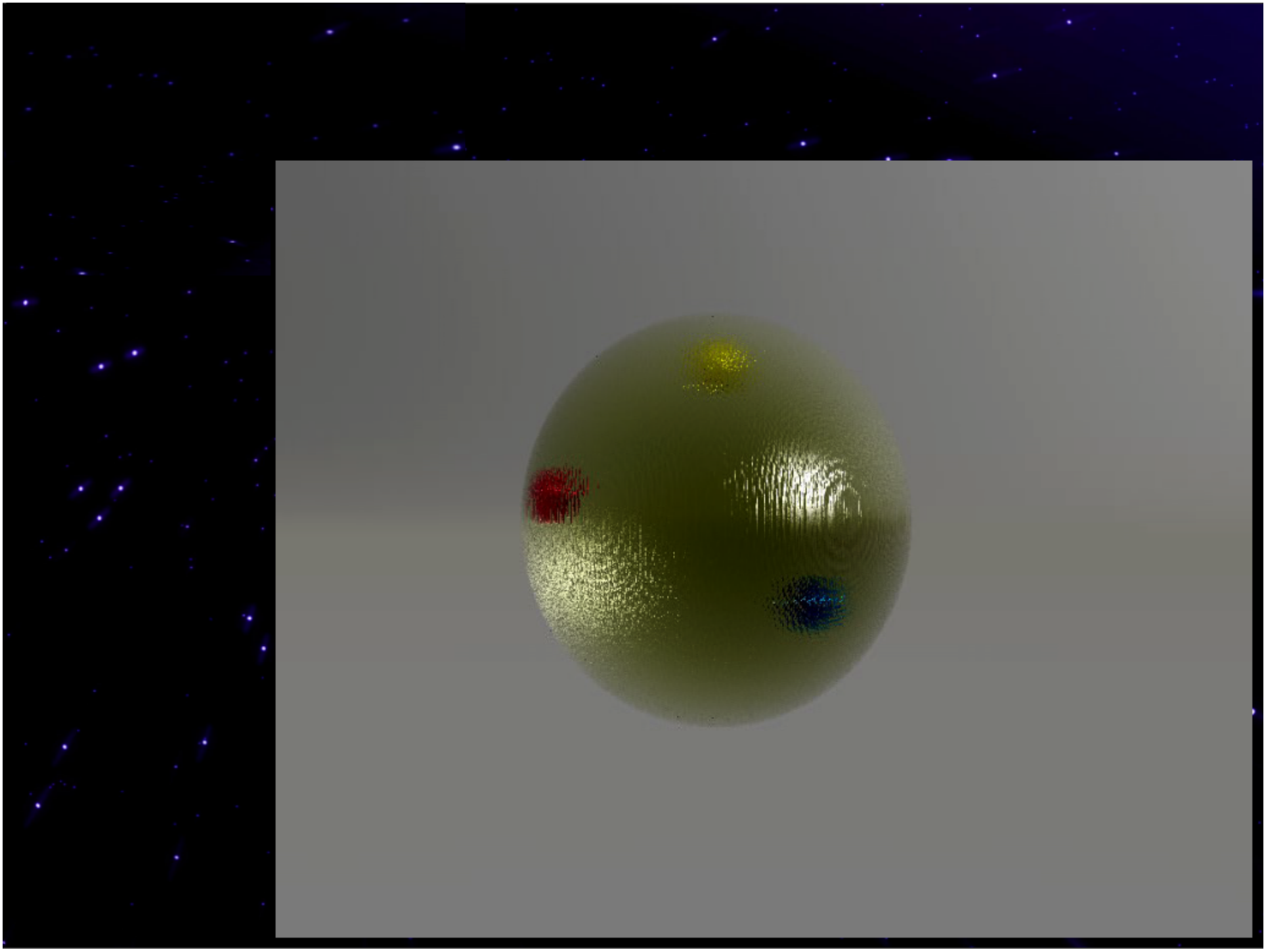
The particles in the SM all spin at a rate where j is equal to either one or one-half. The former are 'bosons' and the latter are 'fermions.'

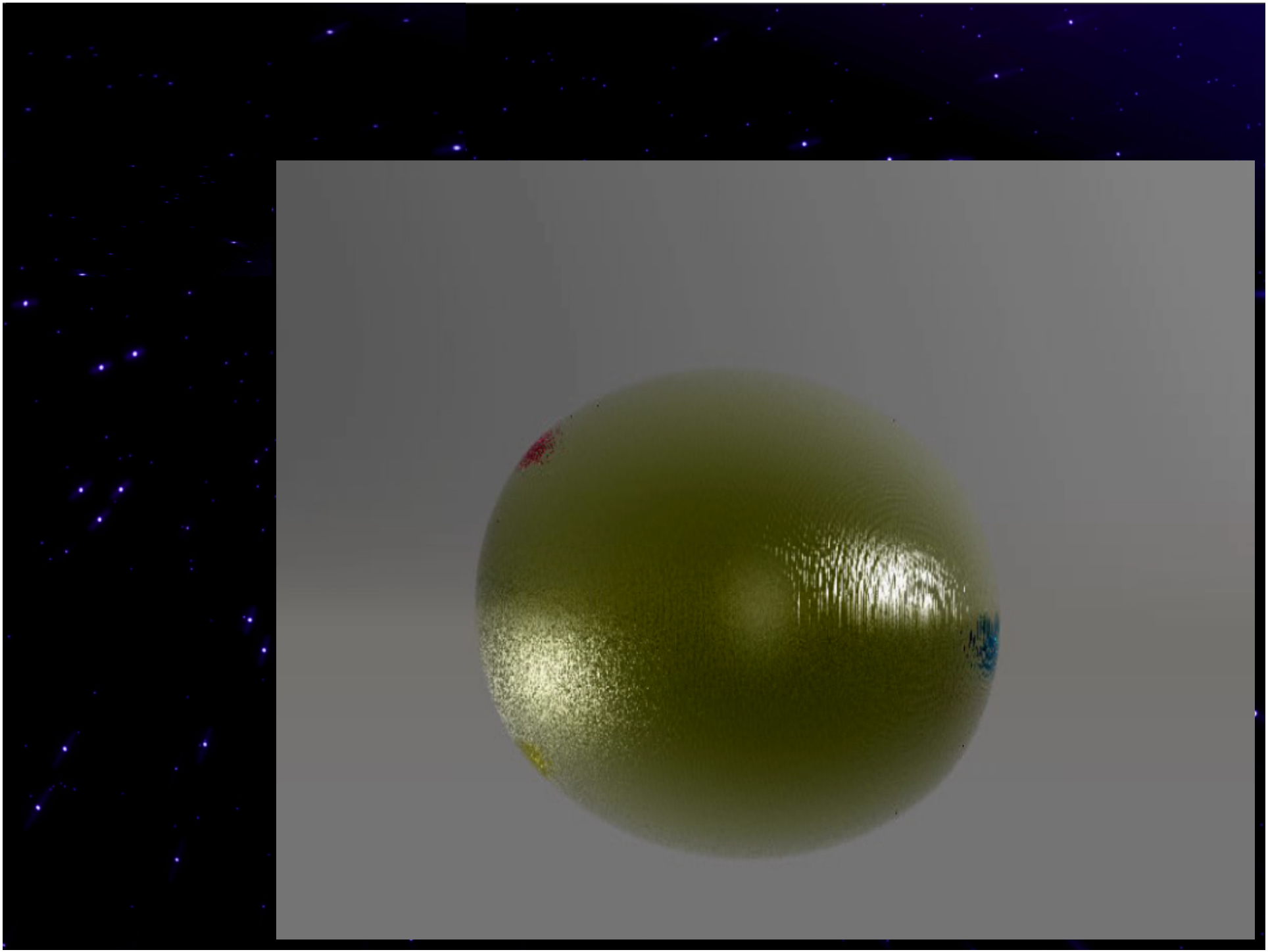
$$|\vec{s}|^2 = j(j+1)\,\hbar^2$$



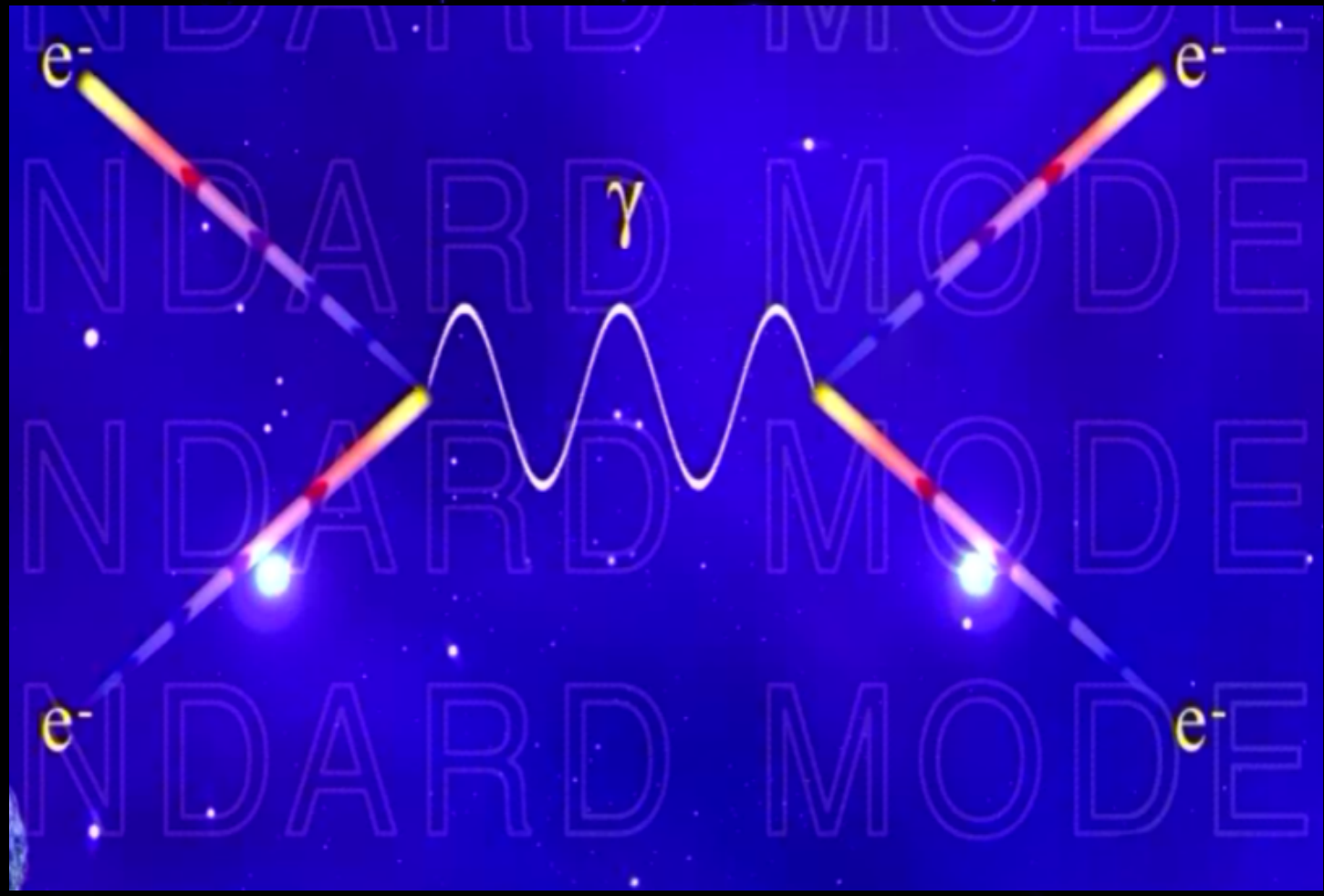
Examples Of Hadronic Matter

Baryons qqq and Antibaryons $\bar{q}\bar{q}\bar{q}$ Baryons are fermionic hadrons. These are a few of the many types of baryons.					
Symbol	Name	Quark content	Electric charge	Mass GeV/c^2	Spin
p	proton	**uud**	1	0.938	1/2
$\bar{\mathbf{p}}$	antiproton	$\bar{\mathbf{u}}\bar{\mathbf{u}}\bar{\mathbf{d}}$	–1	0.938	1/2
n	neutron	**udd**	0	0.940	1/2
Λ	lambda	**uds**	0	1.116	1/2
Ω^-	omega	**sss**	–1	1.672	3/2

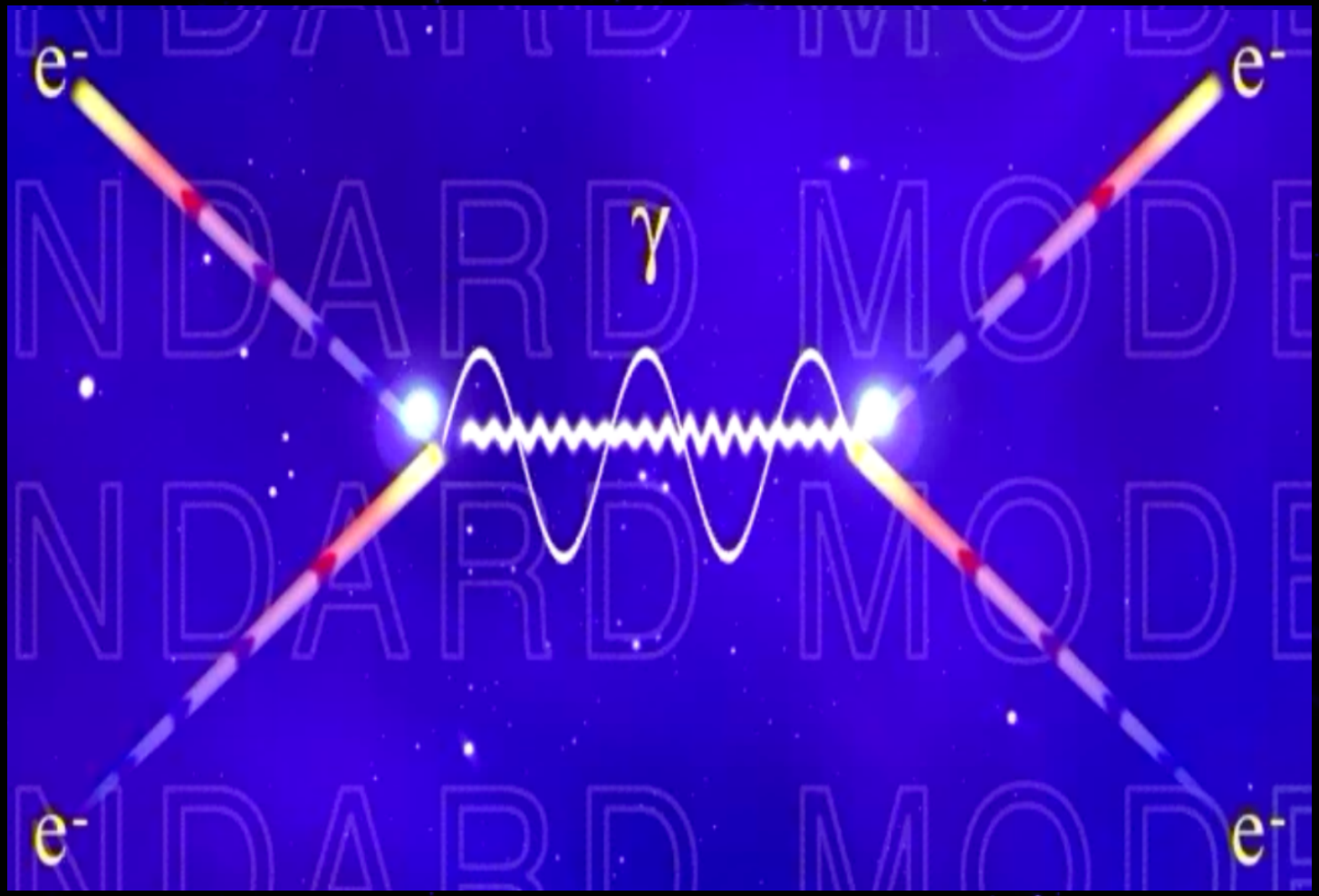




The Interaction Paradigm



The Interaction Paradigm



The Interaction Paradigm

The Interaction Paradigm

The Best Known Number in All of Science

Electron Anomalous Magnetic Moment

Measurement

$$g_e = 2.0023193038$$

Uncertainty

$$\Delta g_e = \pm 0.0000000040$$

Theory

$$g_e = 2.0023193044$$

How The Hunt For
The Higgs Got Started

Maxwell's Equations

$$\vec{\nabla}\cdot\vec{\mathcal{E}} = 4\pi\rho \quad , \quad \vec{\nabla}\cdot\vec{\mathcal{B}} = 0 \quad ,$$

$$\vec{\nabla}\times\vec{\mathcal{B}} - \frac{1}{c}\frac{\partial\vec{\mathcal{E}}}{\partial t} = \frac{4\pi}{c}\vec{J} \quad , \quad \vec{\nabla}\times\vec{\mathcal{E}} + \frac{1}{c}\frac{\partial\vec{\mathcal{B}}}{\partial t} = 0 \quad .$$

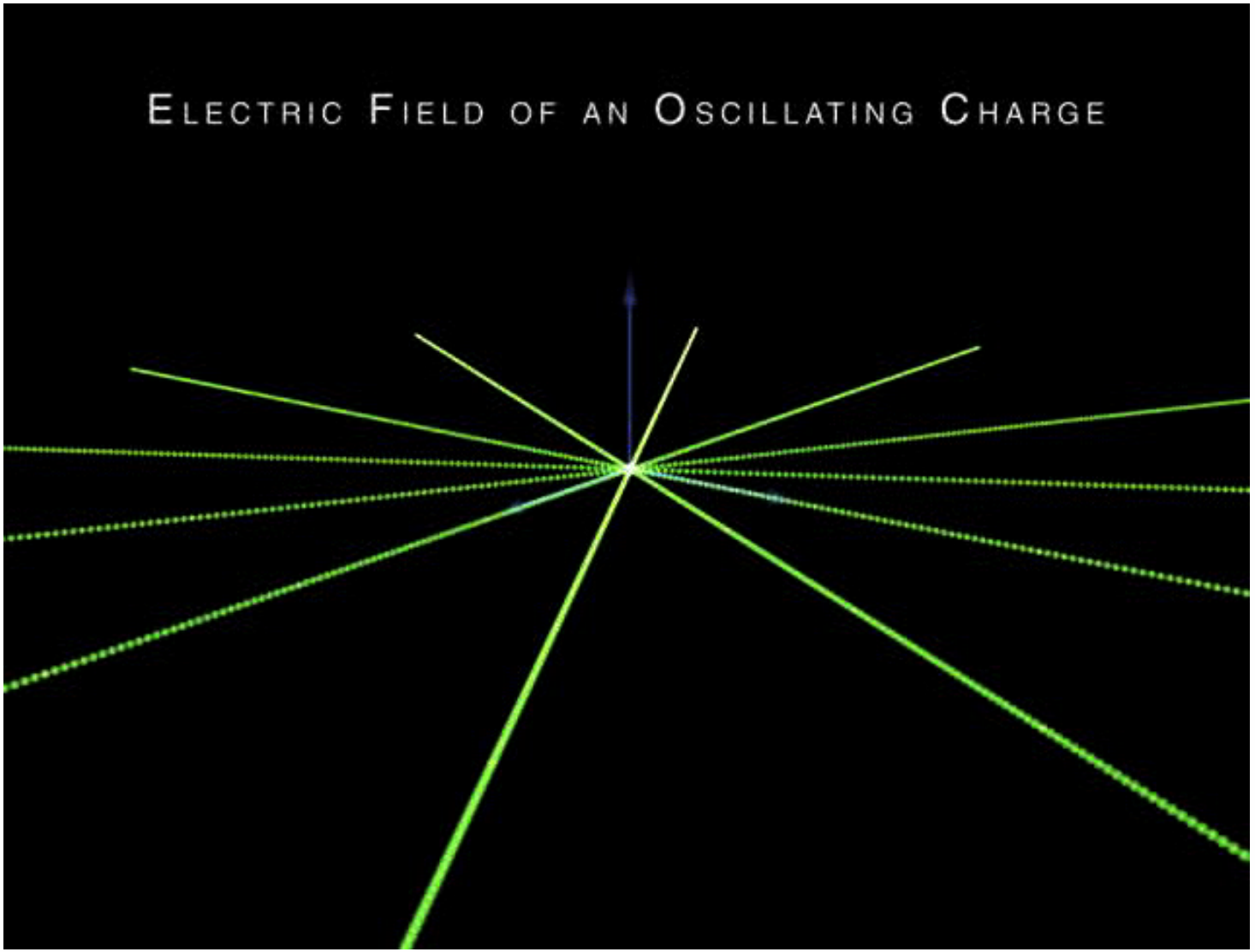
Electromagnetic Potentials

$$\vec{\mathcal{B}} = \vec{\nabla}\times\vec{A} \quad , \quad \vec{\mathcal{E}} = -\vec{\nabla}V - \frac{1}{c}\frac{\partial\vec{A}}{\partial t} \quad .$$

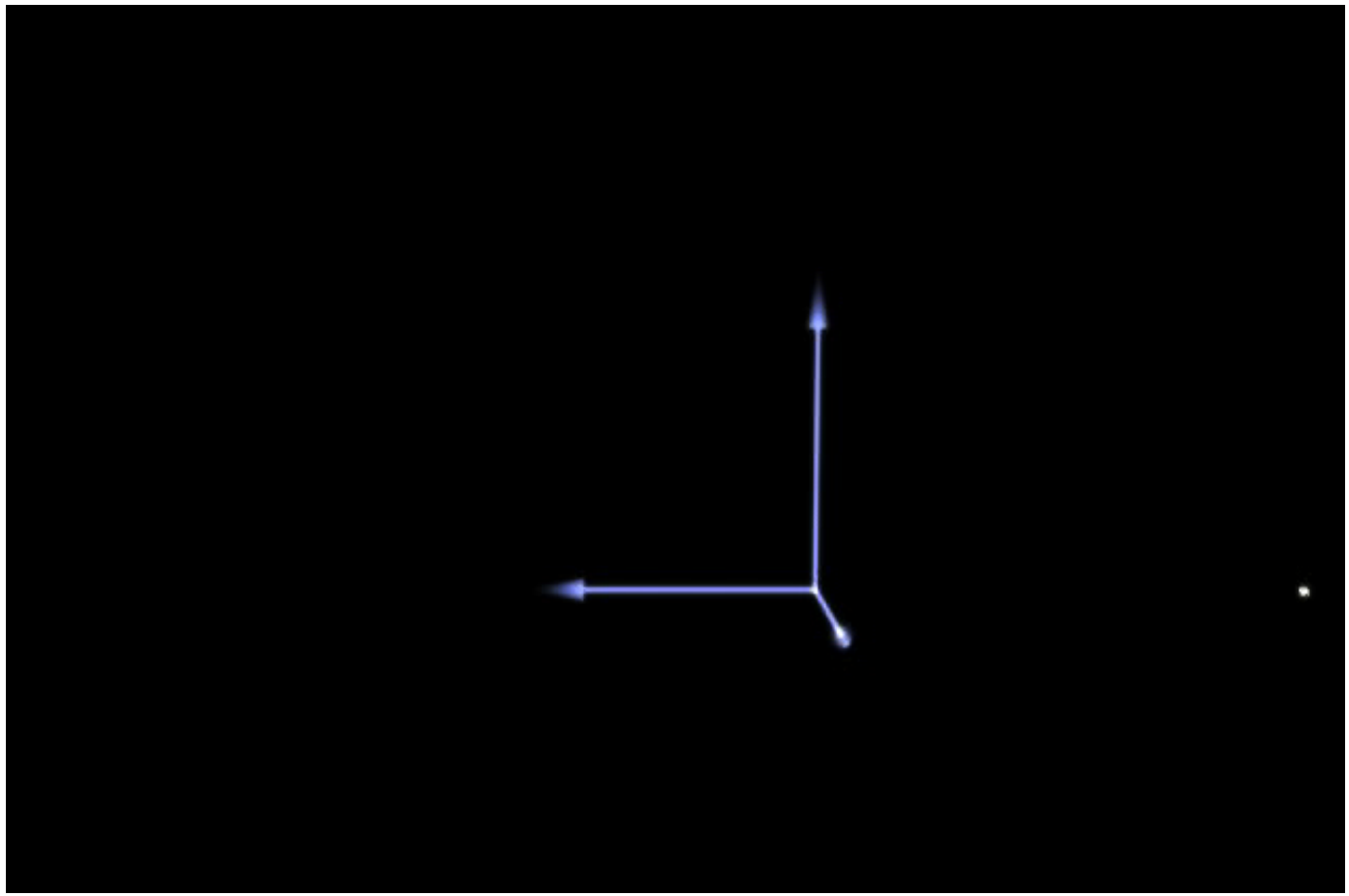
Maxwell's Equations for Potentials

$$\nabla^2 V + \frac{1}{c}\frac{\partial}{\partial t}(\vec{\nabla}\cdot\vec{A}) = -4\pi\rho \quad ,$$

$$\left(\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right)\vec{A} - \vec{\nabla}\left(\vec{\nabla}\cdot\vec{A} + \frac{1}{c}\frac{\partial}{\partial t}V\right) = -\frac{4\pi}{c}\vec{J} \quad .$$


Electric Field of an Oscillating Charge

Cylindrical Coordinate Plane-Wave Description



Maxwell's Equations

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$$\vec{\nabla}\times\vec{\mathcal{B}} - \frac{1}{c}\frac{\partial\vec{\mathcal{E}}}{\partial t} = \frac{4\pi}{c}\vec{J} \quad , \quad \vec{\nabla}\times\vec{\mathcal{E}} + \frac{1}{c}\frac{\partial\vec{\mathcal{B}}}{\partial t} = 0 \quad .$$

$$\vec{\mathcal{B}} = \vec{\nabla}\times\vec{A} \quad , \quad \vec{\mathcal{E}} = -\vec{\nabla}V - \frac{1}{c}\frac{\partial\vec{A}}{\partial t} \quad .$$

$$\nabla^2 V + \frac{1}{c}\frac{\partial}{\partial t}(\vec{\nabla}\cdot\vec{A}) = -4\pi\rho \quad ,$$

$$\left(\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right)\vec{A} - \vec{\nabla}\left(\vec{\nabla}\cdot\vec{A} + \frac{1}{c}\frac{\partial}{\partial t}V\right) = -\frac{4\pi}{c}\vec{J} \quad .$$

Lorentz Gauge Condition Cannot Be Imposed

$$\vec{\nabla}\cdot\vec{A} + \frac{1}{c}\frac{\partial}{\partial t}V = 0 \quad .$$

Proca's Equations

$$\vec{\nabla}\cdot\vec{\mathcal{E}}+\frac{(M\,c)^2}{\hbar^2}V=4\,\pi\,\rho\quad,\quad\vec{\nabla}\cdot\vec{\mathcal{B}}=0\quad,$$

$$\vec{\nabla}\times\vec{\mathcal{B}}-\frac{1}{c}\frac{\partial\vec{\mathcal{E}}}{\partial t}+\frac{(M\,c)^2}{\hbar^2}\vec{A}=\frac{4\,\pi}{c}\vec{J}\quad,\quad\vec{\nabla}\times\vec{\mathcal{E}}+\frac{1}{c}\frac{\partial\vec{\mathcal{B}}}{\partial t}=0\quad.$$

$$\vec{\mathcal{B}}=\vec{\nabla}\times\vec{A}\quad,\quad\vec{\mathcal{E}}=-\vec{\nabla}V-\frac{1}{c}\frac{\partial\vec{A}}{\partial t}\quad.$$

$$\nabla^2 V+\frac{1}{c}\frac{\partial}{\partial t}(\vec{\nabla}\cdot\vec{A})-\frac{(M\,c)^2}{\hbar^2}V=-4\pi\rho\quad,$$

$$\left(\nabla^2-\frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right)\vec{A}-\vec{\nabla}\left(\vec{\nabla}\cdot\vec{A}+\frac{1}{c}\frac{\partial}{\partial t}V\right)-\frac{(M\,c)^2}{\hbar^2}\vec{A}=-\frac{4\,\pi}{c}\vec{J}\quad.$$

Lorentz Gauge Condition Cannot Be Imposed

$$\vec{\nabla}\cdot\vec{A}+\frac{1}{c}\frac{\partial}{\partial t}V=0\quad.$$

ABEGHHKt'H Strike Back!

Five of the six 2010 APS Sakurai Prize Winners – (L to R) Kibble, Guralnik, Hagen, Englert, and Brout

Number six: P. Higgs 2009

(Anderson, Brout, Englert, Guralnik, Hagen, Higgs, Kibble, & 't Hooft)

The ABEGHHK'tH Field

$$f(t, \vec{x}) \;\rightarrow\; \Phi(t, \vec{x}) \;\text{ where } \Phi \text{ is a complex field}$$

$$\Phi(t, \vec{x}) \;=\; [\,\Phi_0 + \mathcal{H}(t, \vec{x})\,]\, exp\,[\,i\Theta(t, \vec{x})\,]$$

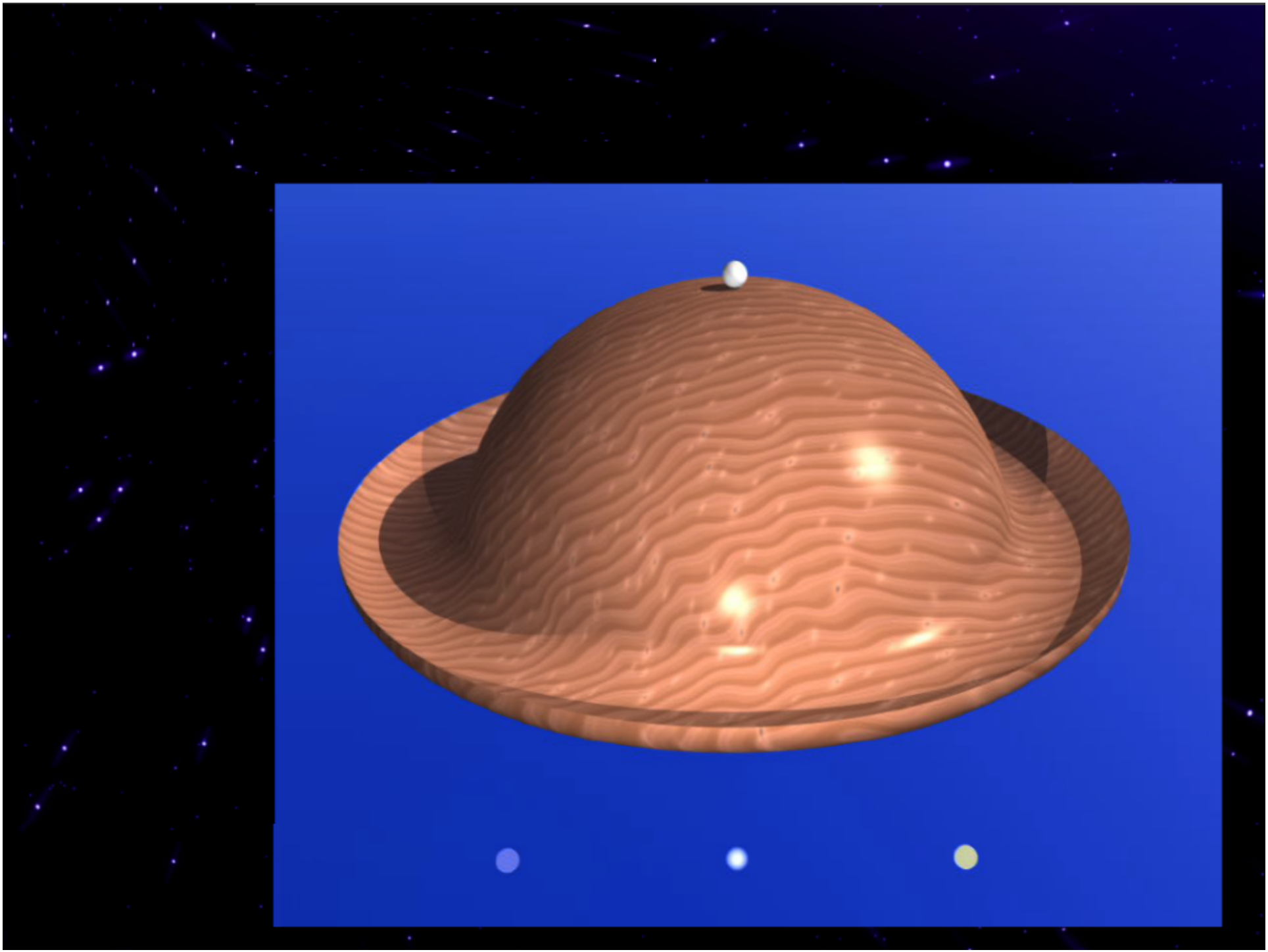
V.E.V. — Higgs Boson — Goldstone Boson

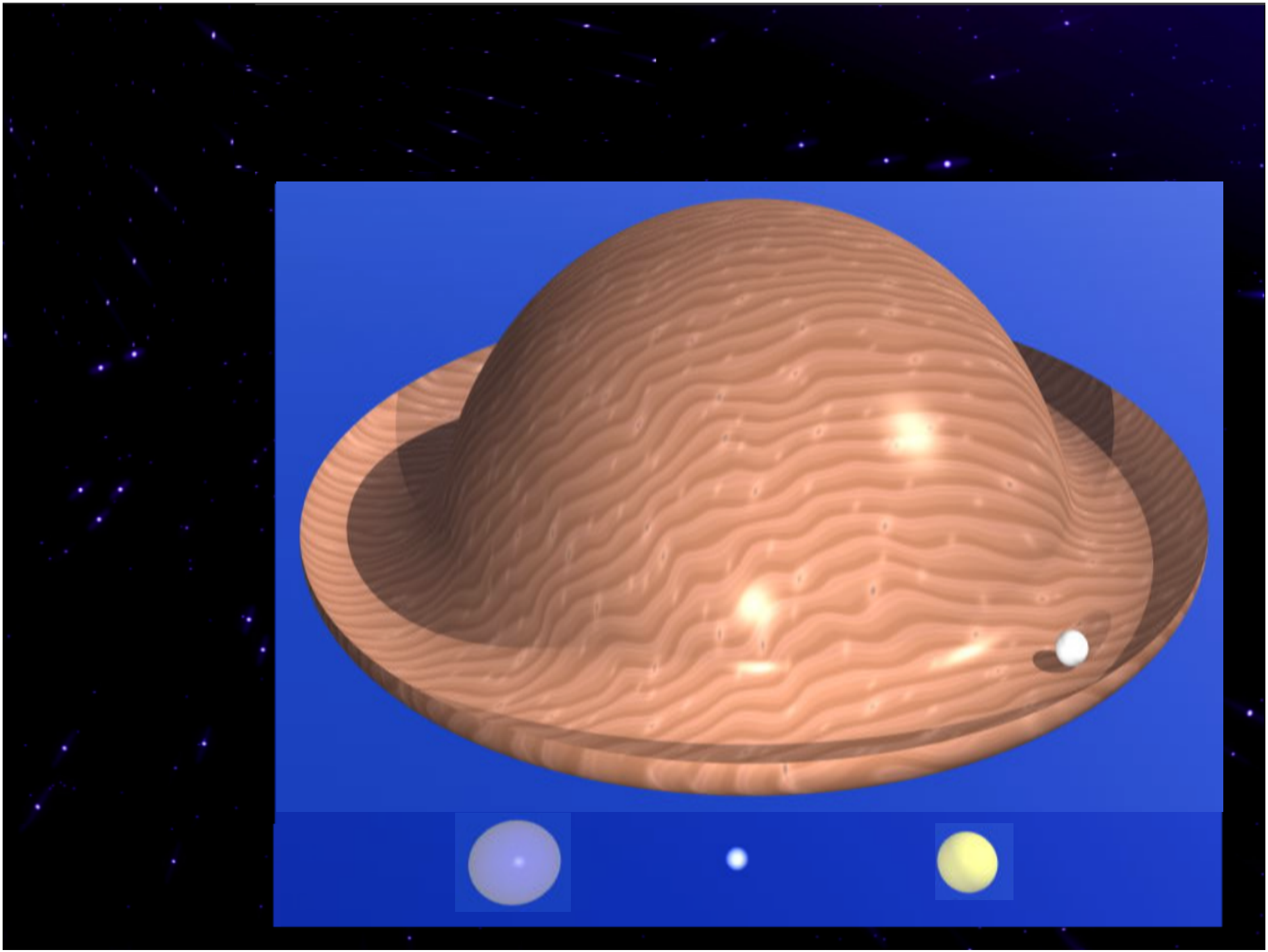
The ABEGHHK'tH Field Equation

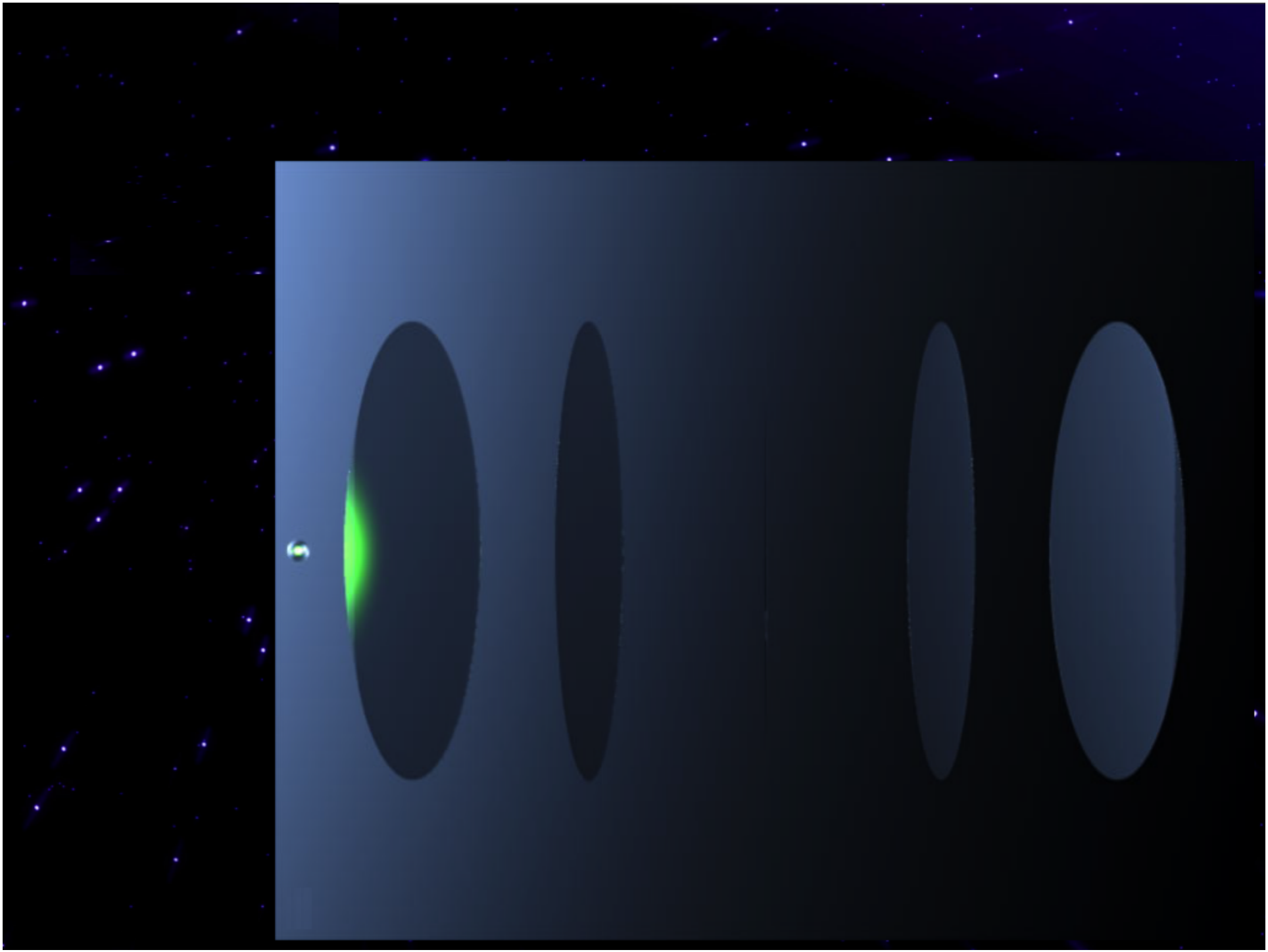
$$\frac{1}{c^2}\frac{\partial^2}{\partial t^2}\Phi = \nabla^2\Phi - U'(\Phi) \quad ,$$

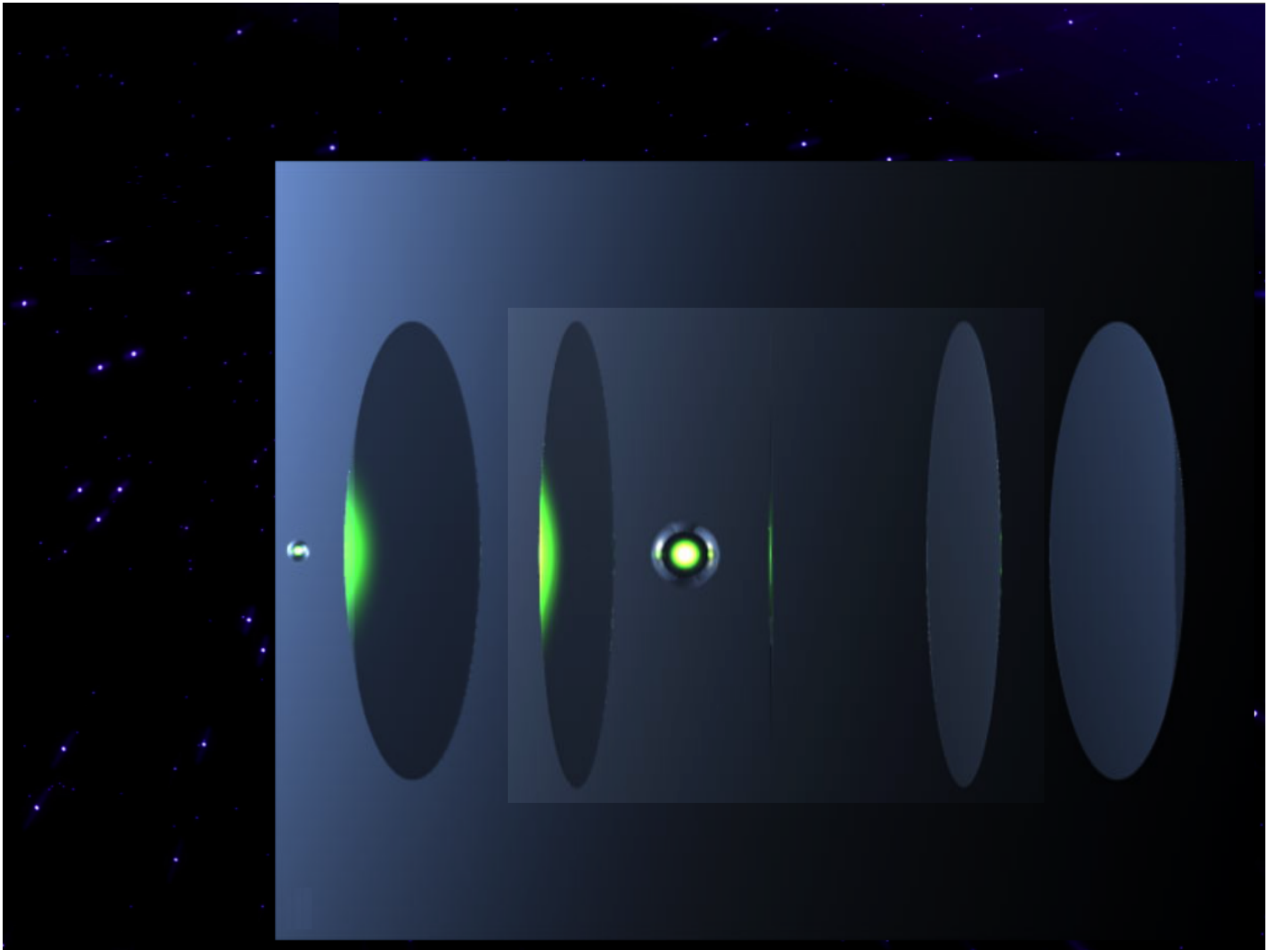
$$U_{\pm}(\Phi) = \tfrac{1}{4}\lambda_0\,(\Phi^*\Phi)^2 \pm \left[\frac{(m\,c)^2}{\hbar^2}\right]\Phi^*\Phi$$

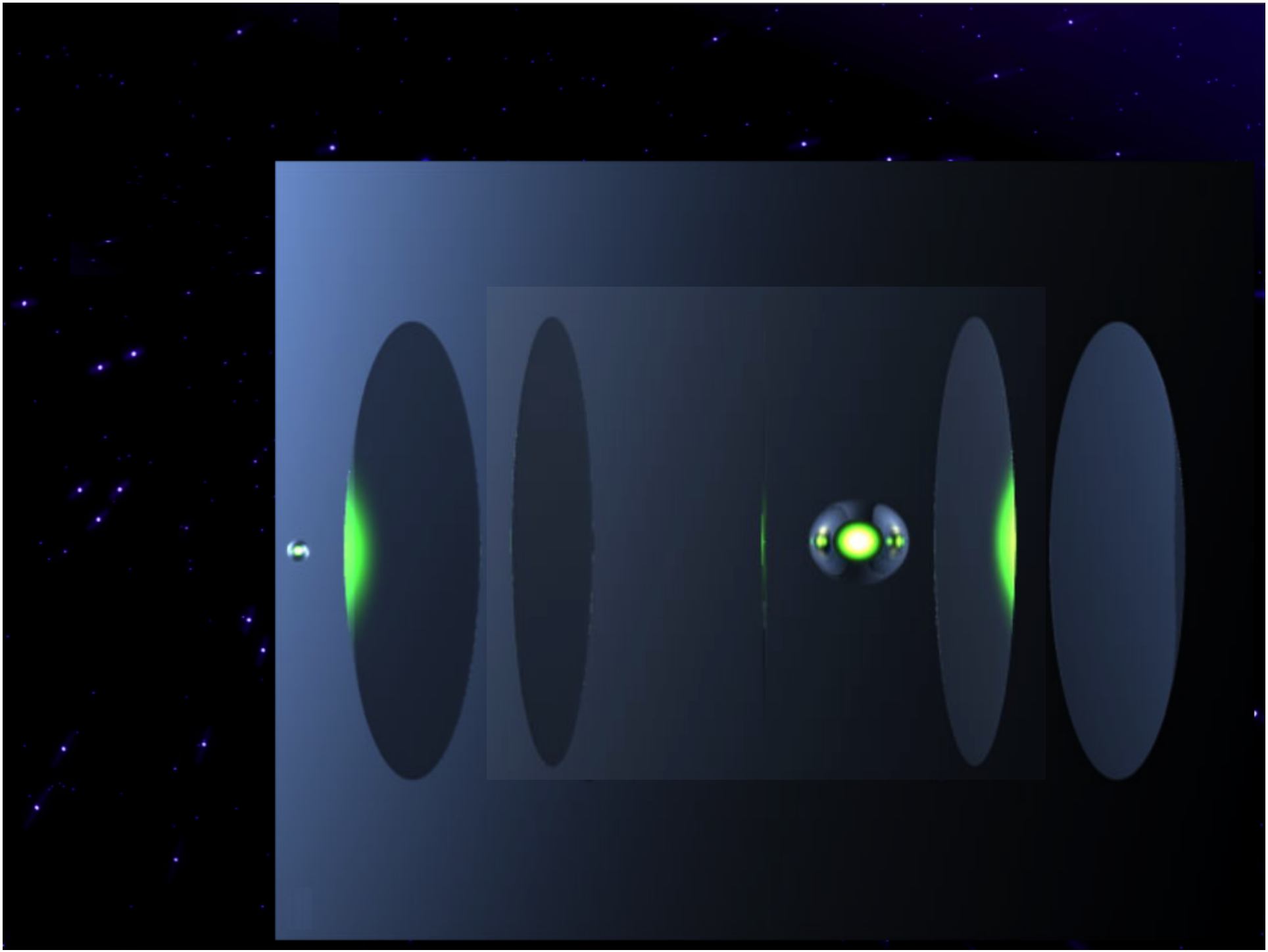
$$U_{\pm}(\Phi) = \tfrac{1}{4}\lambda_0\,[\,\Phi_0 + \mathcal{H}(t, \vec{x})\,]^4 \pm \left[\frac{(m\,c)^2}{\hbar^2}\right][\,\Phi_0 + \mathcal{H}(t, \vec{x})\,]^2$$

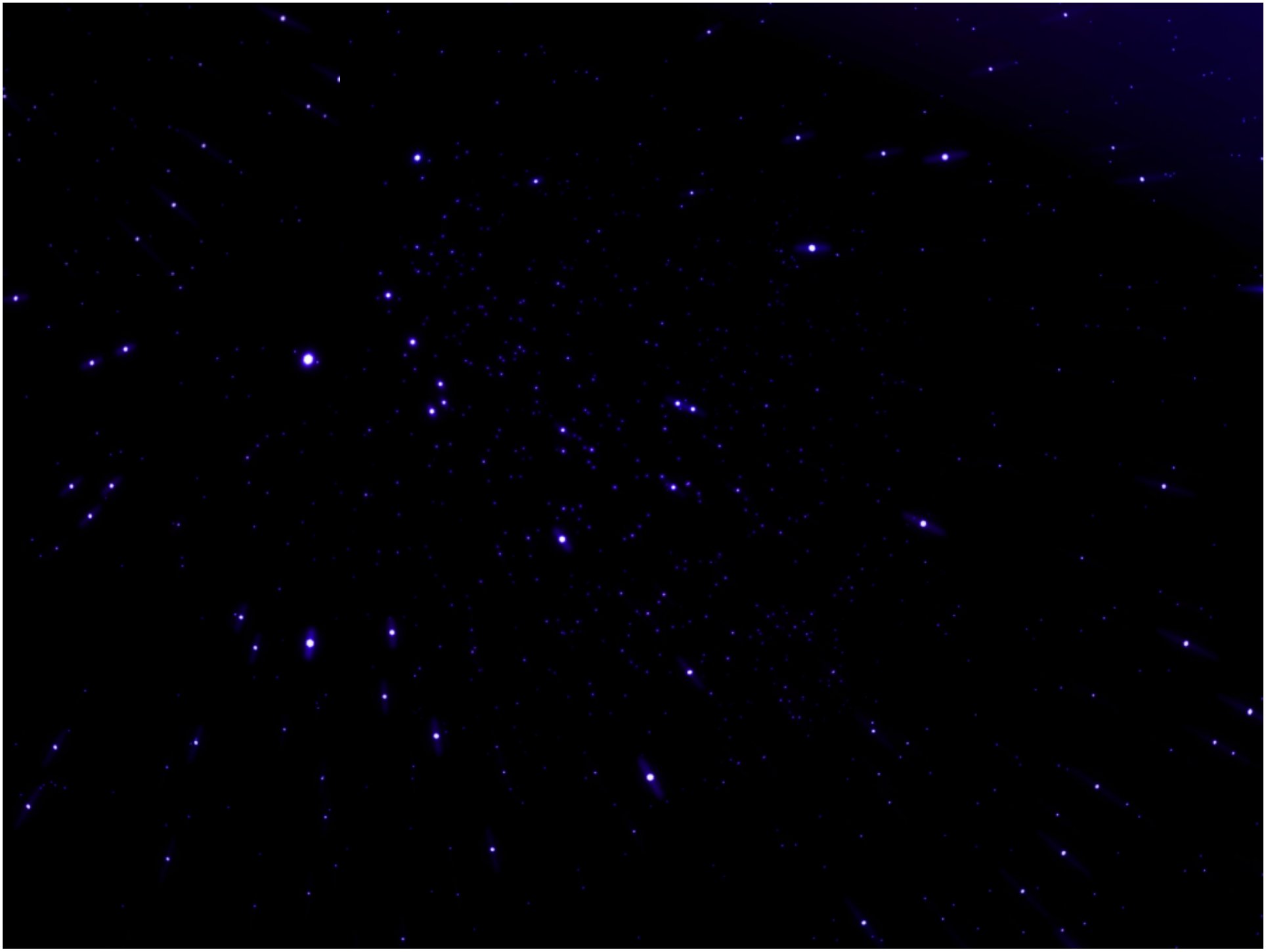








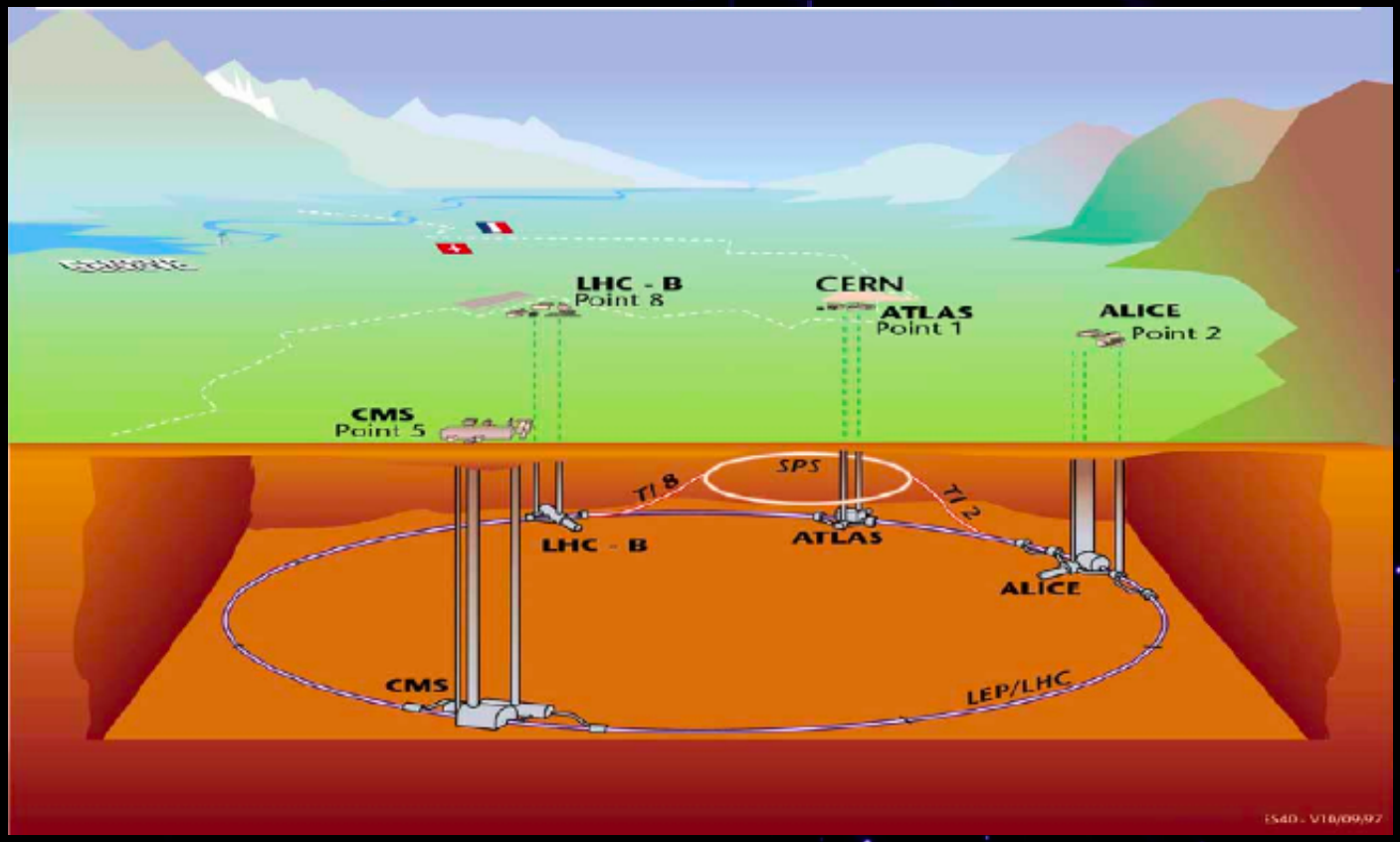




The Large Hadron Collider: The World's Only Higgs Knowledge Factory

The Energy Frontier @ The Large Hadron Collider

Overview of the LHC Knowledge Factory



LHC: The Higgs
Production Factory

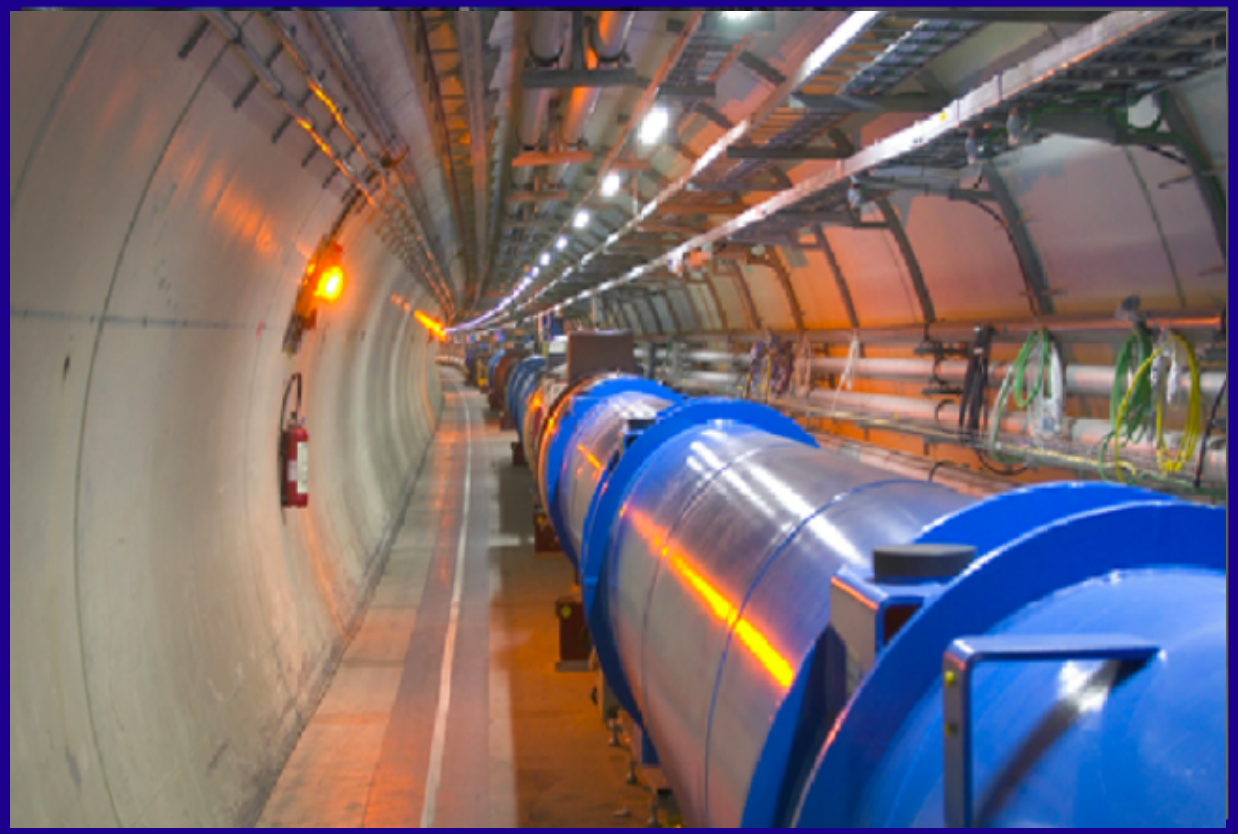
Large Hadron Collider

- Geneva, Switzerland crossing the French border
- P-P Synchrotron Collider (Superconducting)
- Energy of 7 TeV per beam
- 27 Kilometers in circumference at a depth

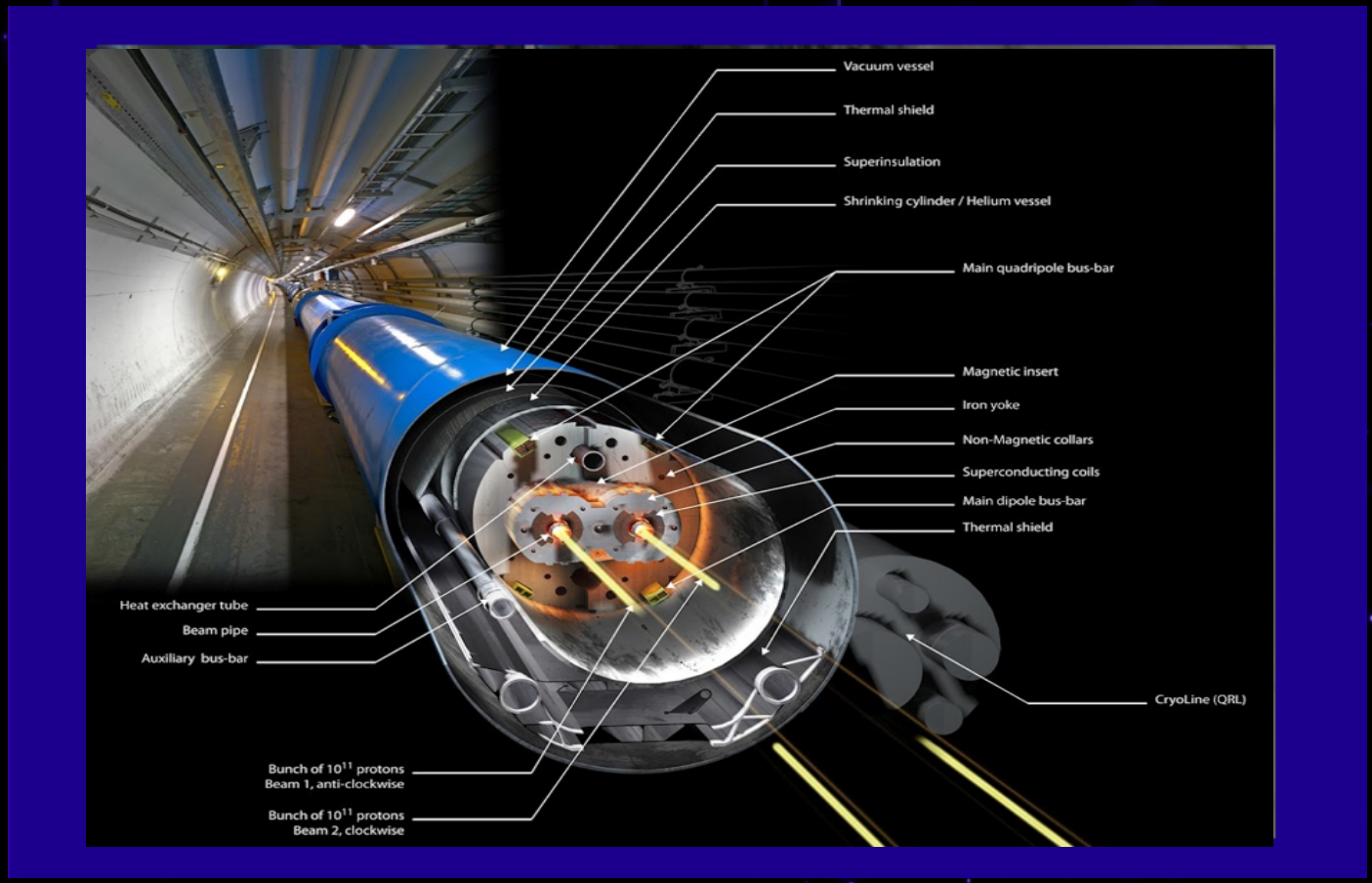
  50meters to 150 meters below ground

Overview of LHC Higgs Production Factory

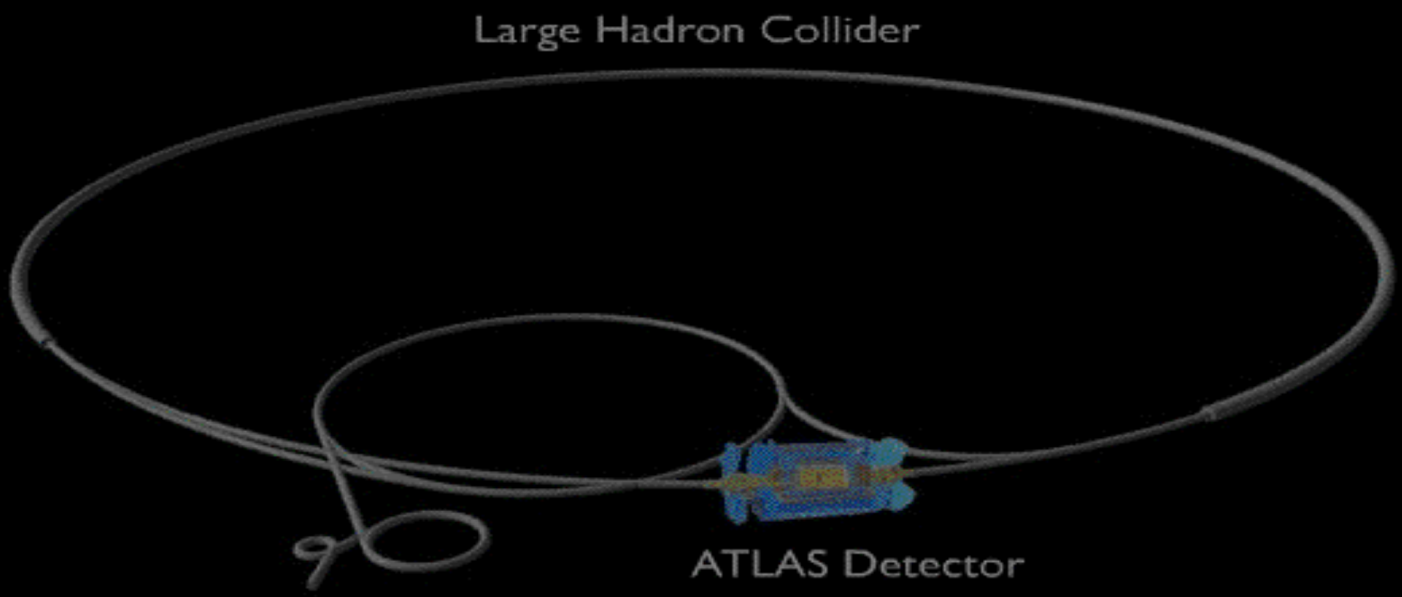
Overview of LHC Higgs Production Factory



Overview of LHC Higgs Production Factory

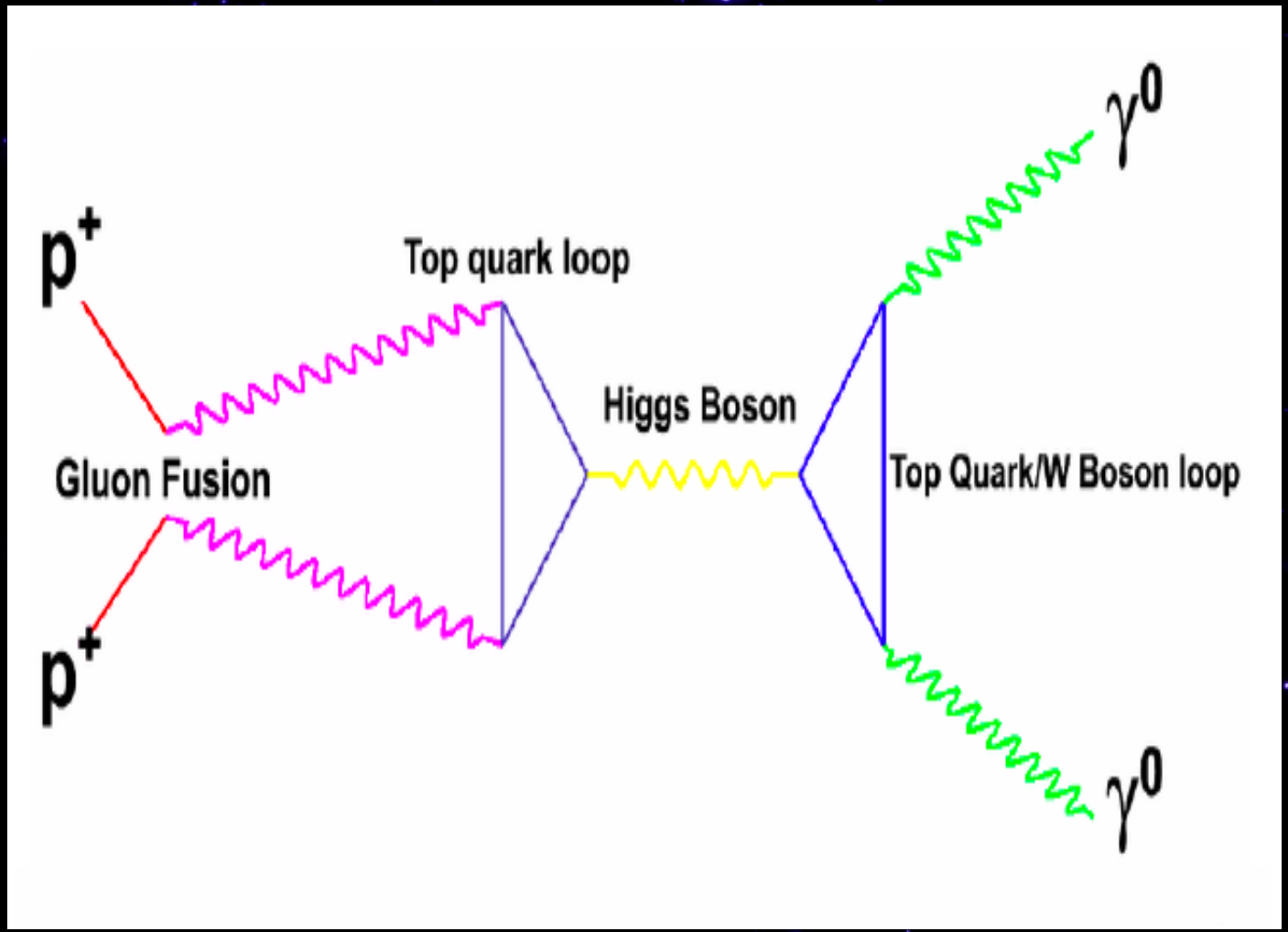


PLAY

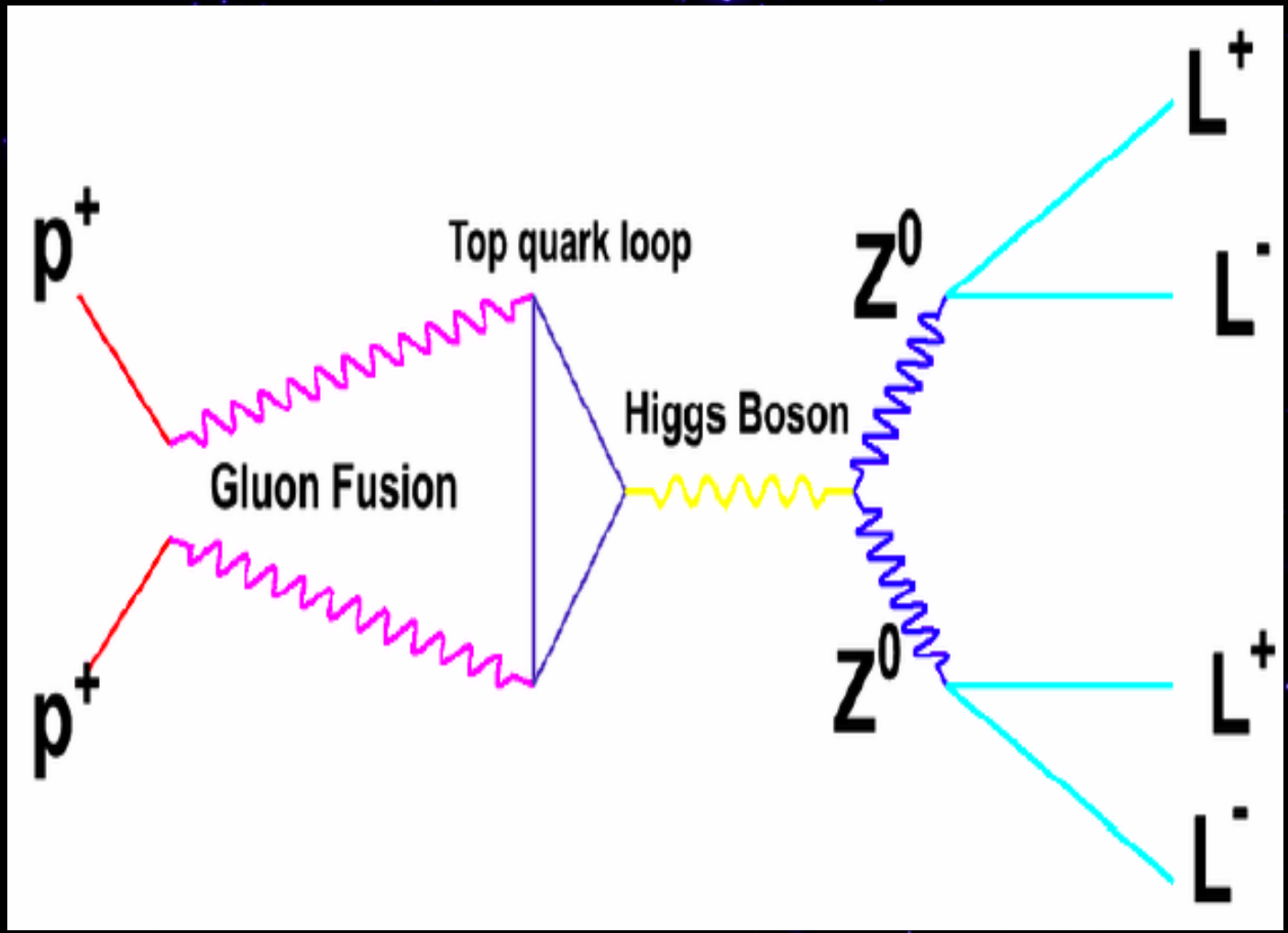


FRANCE
SWITZERLAND

A Higgs Production & Decay Process

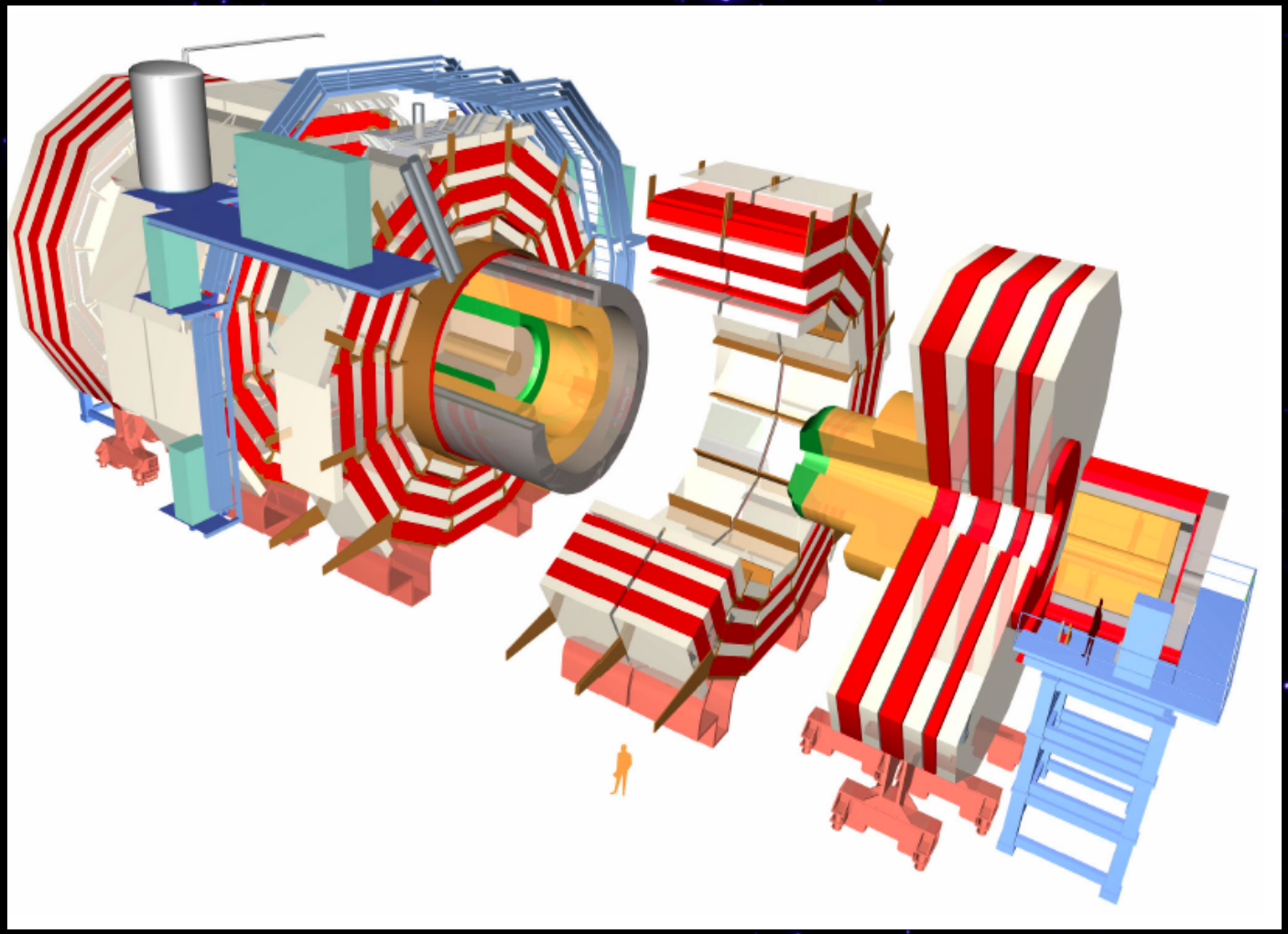


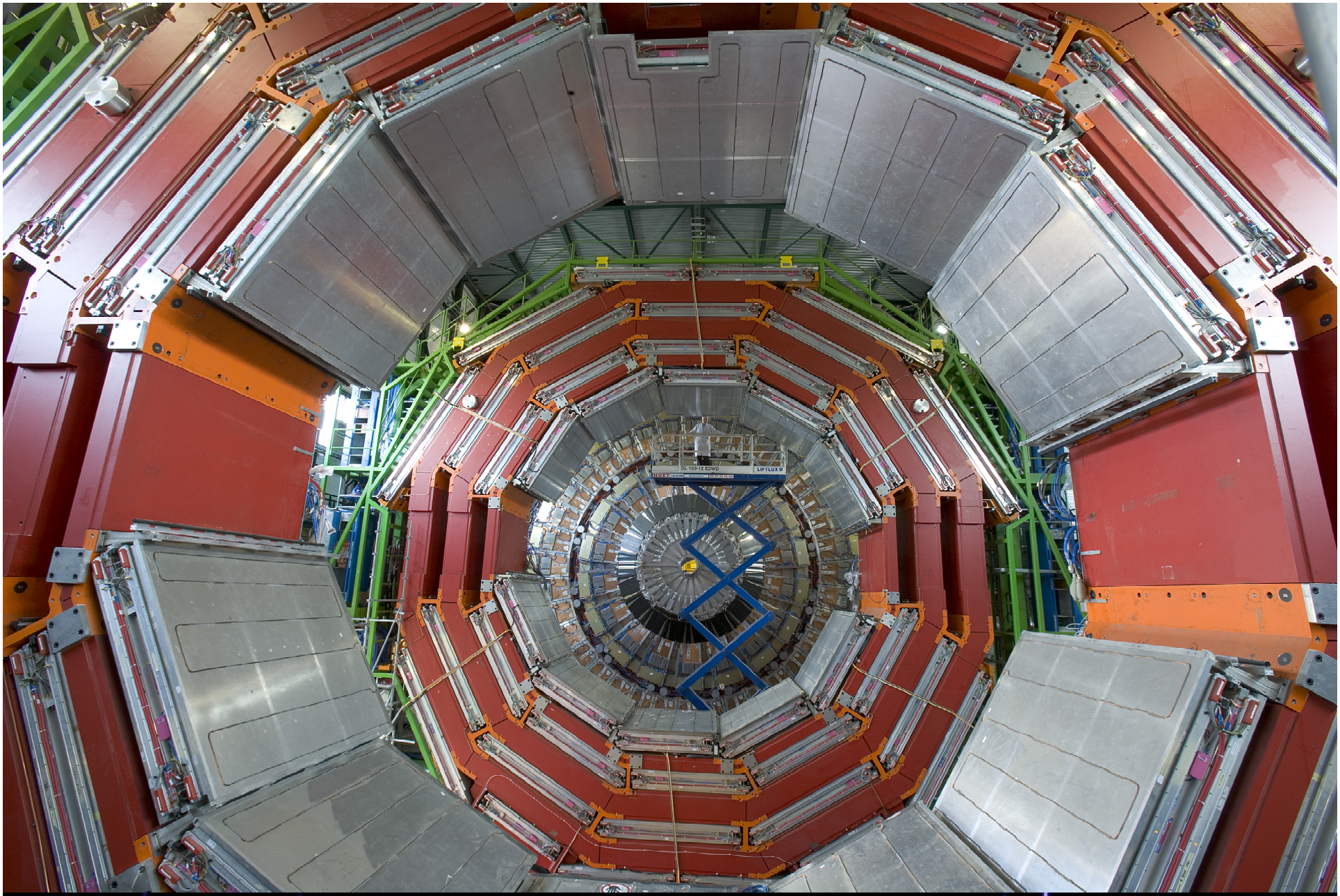
A Higgs Production & Decay Process



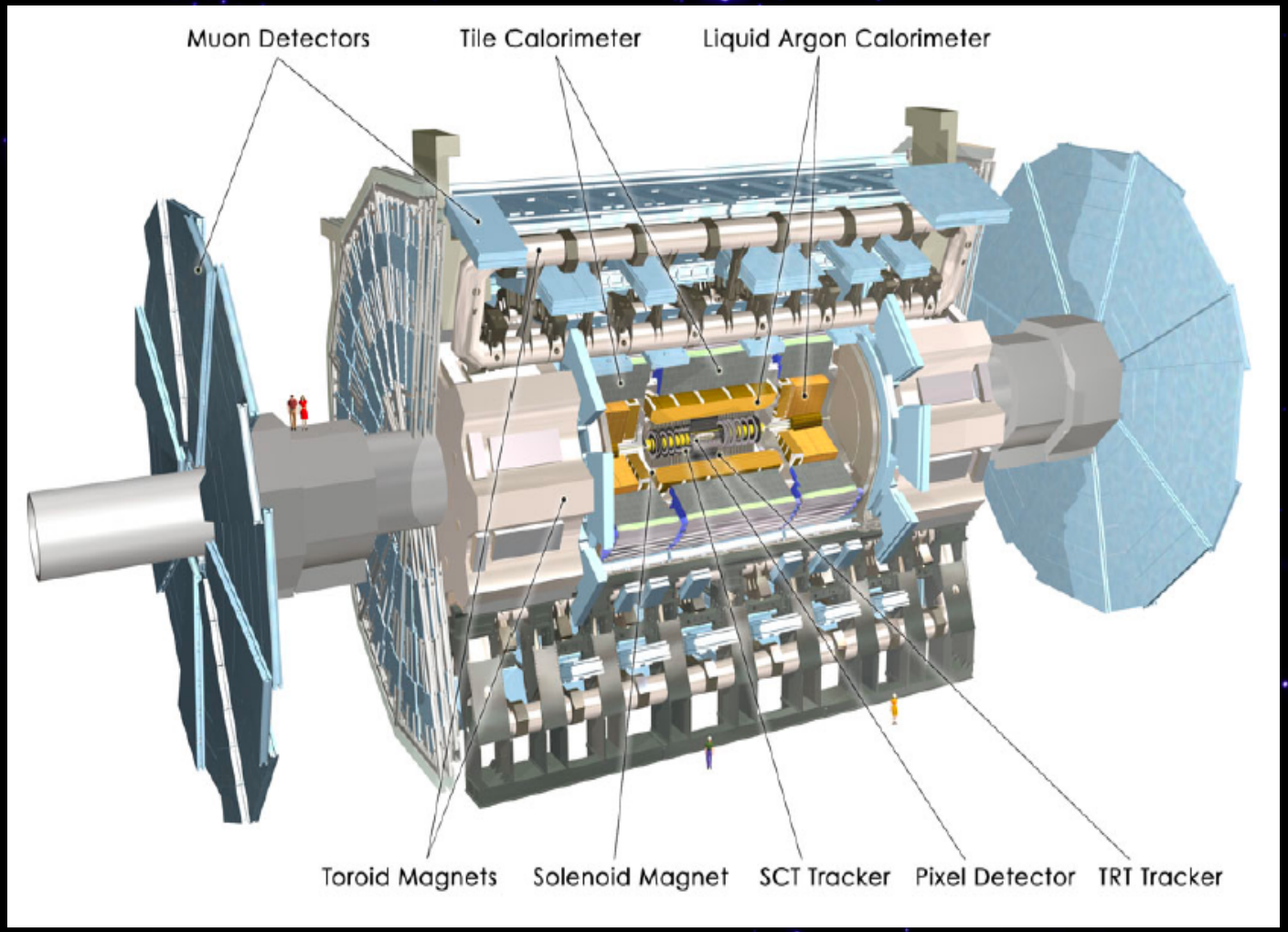
Made In The USA:
The CMS & ATLAS
Detectors

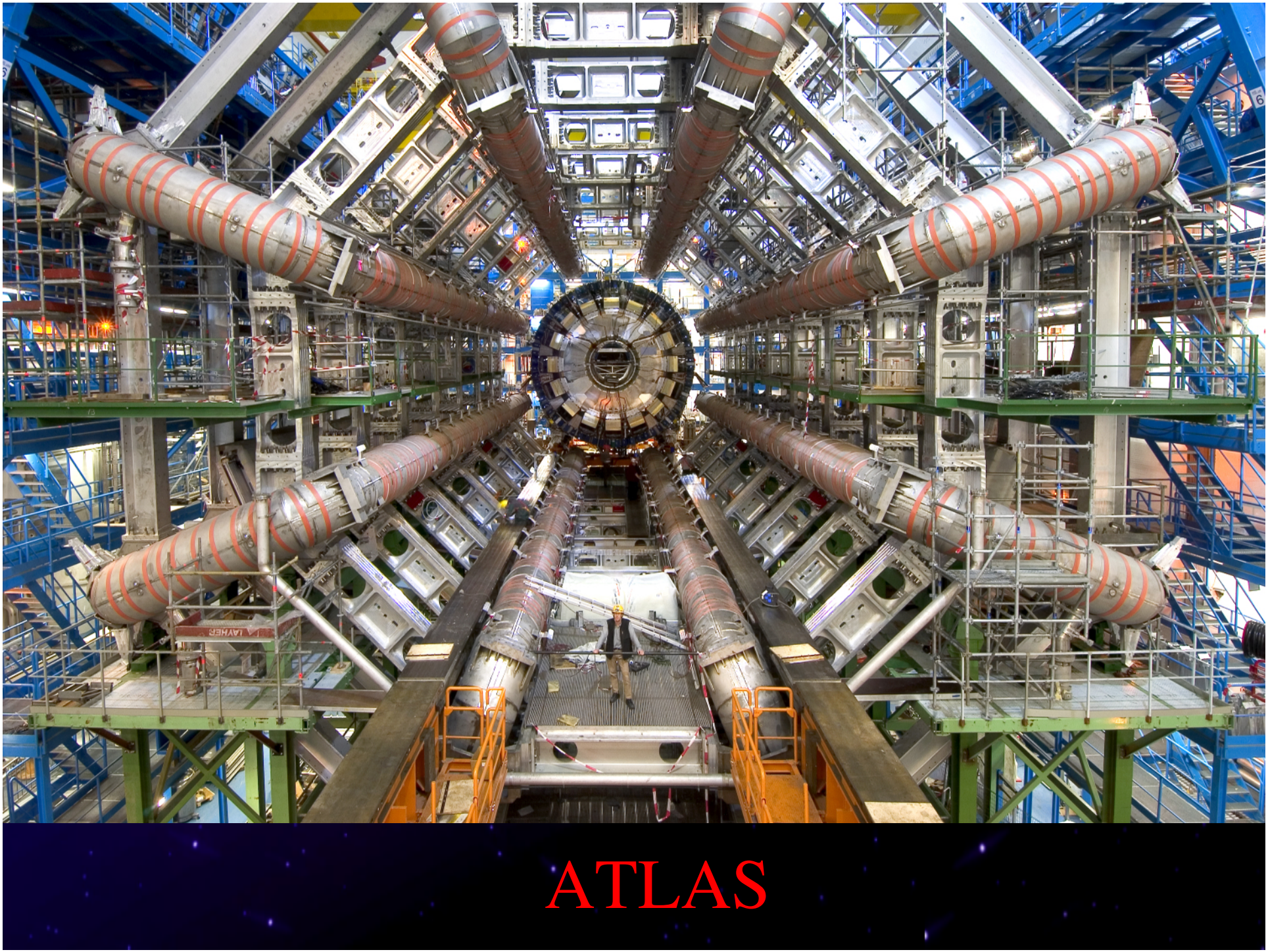
CMS Detector (Compact Muon Solenoid)




CMS

ATLAS Detector (A Toroidal LHC ApparatuS)




ATLAS

Born On The Fourth
Of July

The Standard Model (SM)

FERMIONS

matter constituents
spin = 1/2, 3/2, 5/2, ...

Leptons spin = 1/2

Flavor	Mass GeV/c^2	Electric charge
ν_e electron neutrino	$<1\times10^{-8}$	0
e electron	0.000511	−1
ν_μ muon neutrino	<0.0002	0
μ muon	0.106	−1
ν_τ tau neutrino	<0.02	0
τ tau	1.7771	−1

Quarks spin = 1/2

Flavor	Approx. Mass GeV/c^2	Electric charge
u up	0.003	2/3
d down	0.006	−1/3
c charm	1.3	2/3
s strange	0.1	−1/3
t top	175	2/3
b bottom	4.3	−1/3

BOSONS

force carriers
spin = 0, 1, 2, ...

Unified Electroweak spin = 1

Name	Mass GeV/c^2	Electric charge
γ photon	0	0
W^-	80.4	−1
W^+	80.4	+1
Z^0	91.187	0

Strong (color) spin = 1

Name	Mass GeV/c^2	Electric charge
g gluon	0	0

PROPERTIES OF THE INTERACTIONS

Property \ Interaction	Gravitational	Weak (Electroweak)	Electromagnetic (Electroweak)	Strong: Fundamental	Strong: Residual
Acts on:	Mass – Energy	Flavor	Electric Charge	Color Charge	See Residual Strong Interaction Note
Particles experiencing:	All	Quarks, Leptons	Electrically charged	Quarks, Gluons	Hadrons
Particles mediating:	Graviton (not yet observed)	W^+ W^- Z^0	γ	Gluons	Mesons
Strength relative to electromag for two u quarks at: 10^{-18} m	10^{-41}	0.8	1	25	Not applicable to quarks
Strength relative to electromag for two u quarks at: 3×10^{-17} m	10^{-41}	10^{-4}	1	60	
for two protons in nucleus	10^{-36}	10^{-7}	1	Not applicable to hadrons	20

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BOSONS

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spin = 0, 1, 2, ...

Unified Electroweak spin = 1

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γ photon	0	0
W^-	80.4	−1
W^+	80.4	+1
Z^0	91.187	0
H^0	125	0

Strong (color) spin = 1

Name	Mass GeV/c^2	Electric charge
g gluon	0	0

PROPERTIES OF THE INTERACTIONS

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Acts on:	Mass – Energy	Flavor	Electric Charge	Color Charge	See Residual Strong Interaction Note
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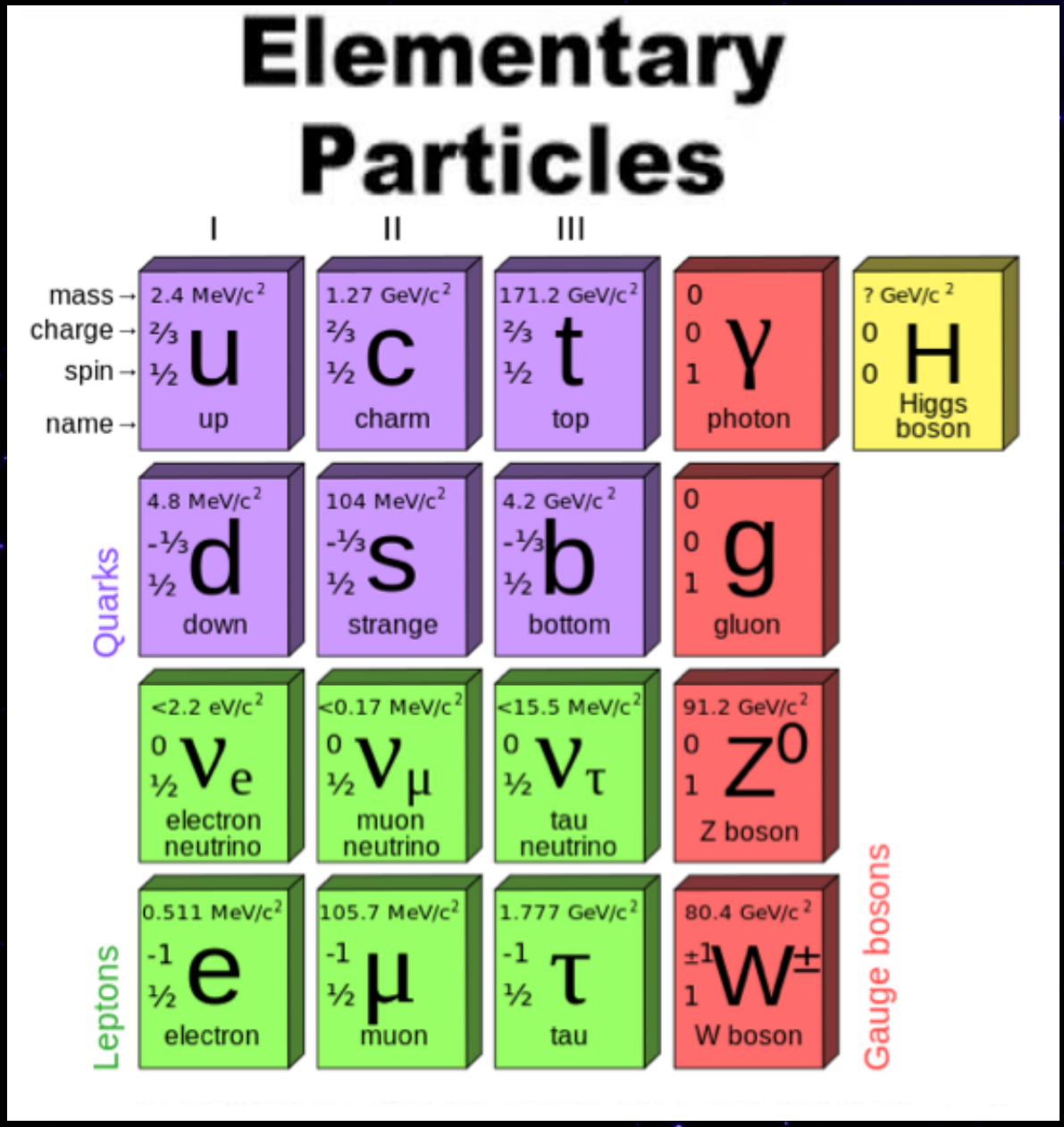
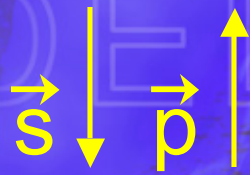

Elementary Particles
I
II
III
mass →
charge →
spin →
name →
2.4 MeV/c²
⅔
½
u
up
1.27 GeV/c²
⅔
½
c
charm
171.2 GeV/c²
⅔
½
t
top
0
0
1
γ
photon
? GeV/c²
0
0
H
Higgs boson
4.8 MeV/c²
-⅓
½
d
down
104 MeV/c²
-⅓
½
s
strange
4.2 GeV/c²
-⅓
½
b
bottom
0
0
1
g
gluon
<2.2 eV/c²
0
½
νe
electron neutrino
<0.17 MeV/c²
0
½
νμ
muon neutrino
<15.5 MeV/c²
0
½
ντ
tau neutrino
91.2 GeV/c²
0
1
Z⁰
Z boson
0.511 MeV/c²
-1
½
e
electron
105.7 MeV/c²
-1
½
μ
muon
1.777 GeV/c²
-1
½
τ
tau
80.4 GeV/c²
±1
1
W±
W boson
Quarks
Leptons
Gauge bosons

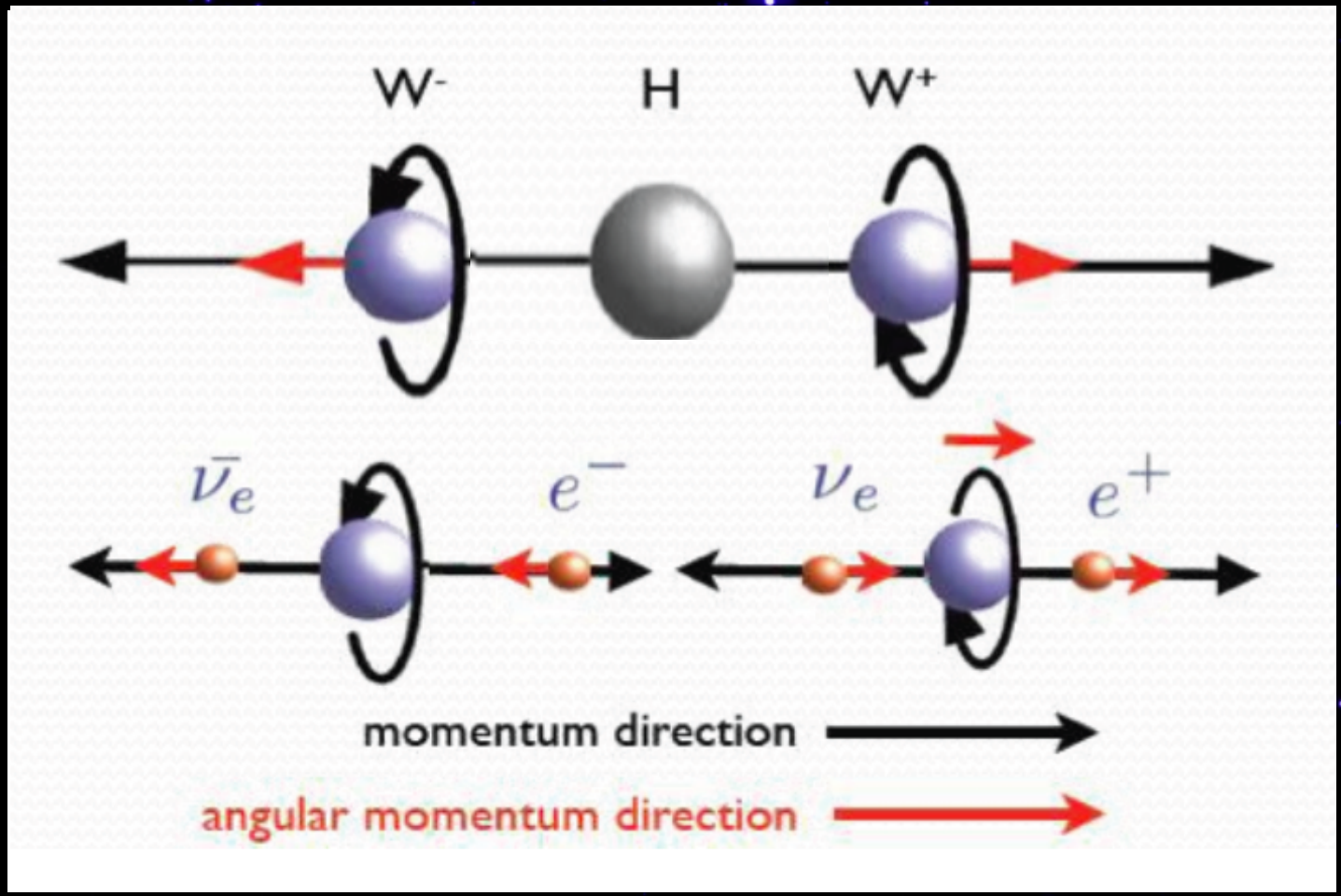
Spinning Tops

The Higgs Boson Is The First Fundamental Particle Found With j = 0!

$$|\vec{s}|^2 = j(j+1)\,\hbar^2$$



Not Putting A Spin On The News



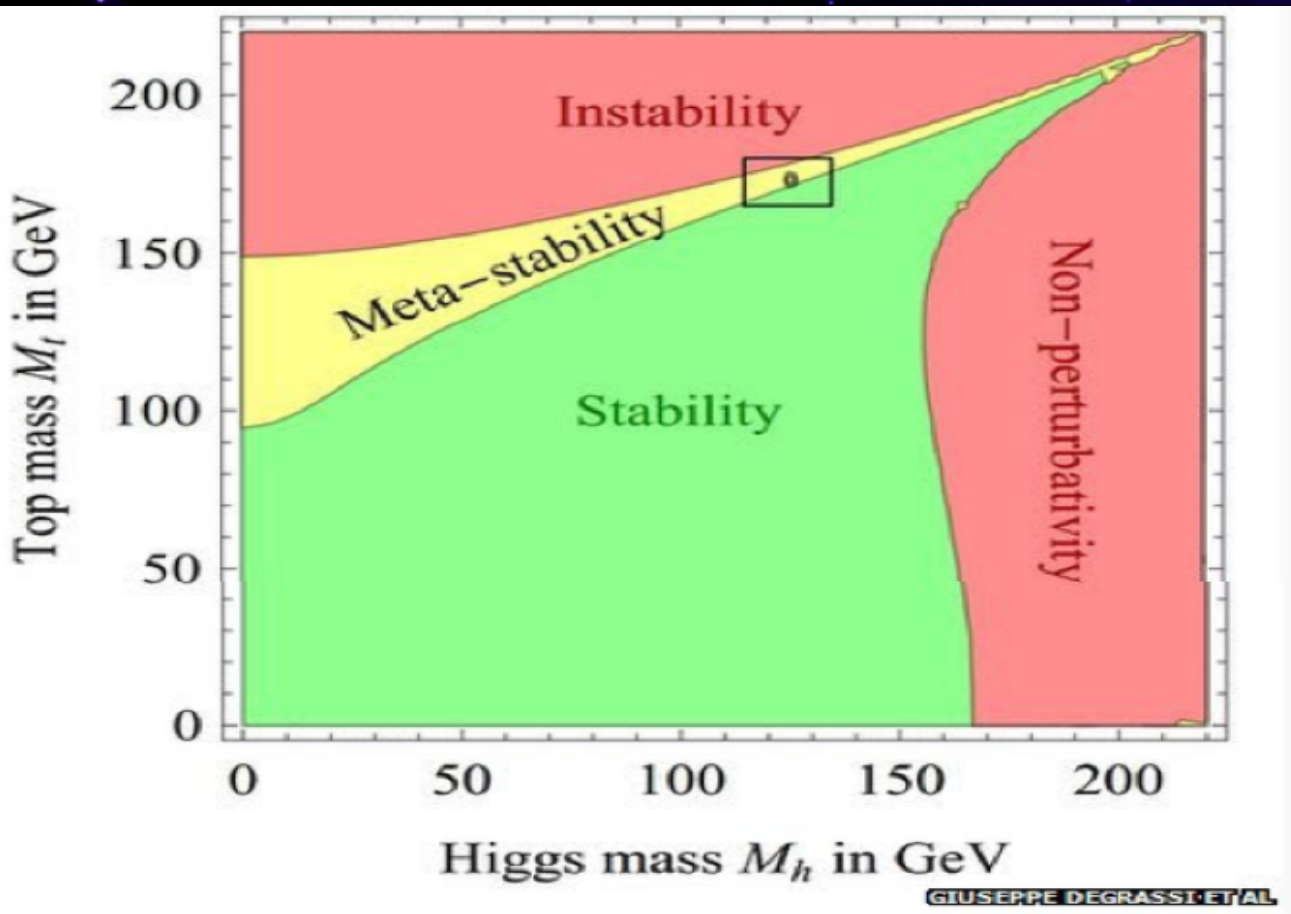
One Theorist's Bucket List

(a.) **Higgs boson(s),**

(b.) Gravity Waves,

(c.) Super-partner's, and

(d.) Superstring/M-Theory



Higgs mass and vacuum stability in the Standard Model at NNLO

Giuseppe Degrassi[a], Stefano Di Vita[a], Joan Elias-Miró[b], José R. Espinosa[b,c], Gian F. Giudice[d], Gino Isidori[d,e], Alessandro Strumia[g,h]

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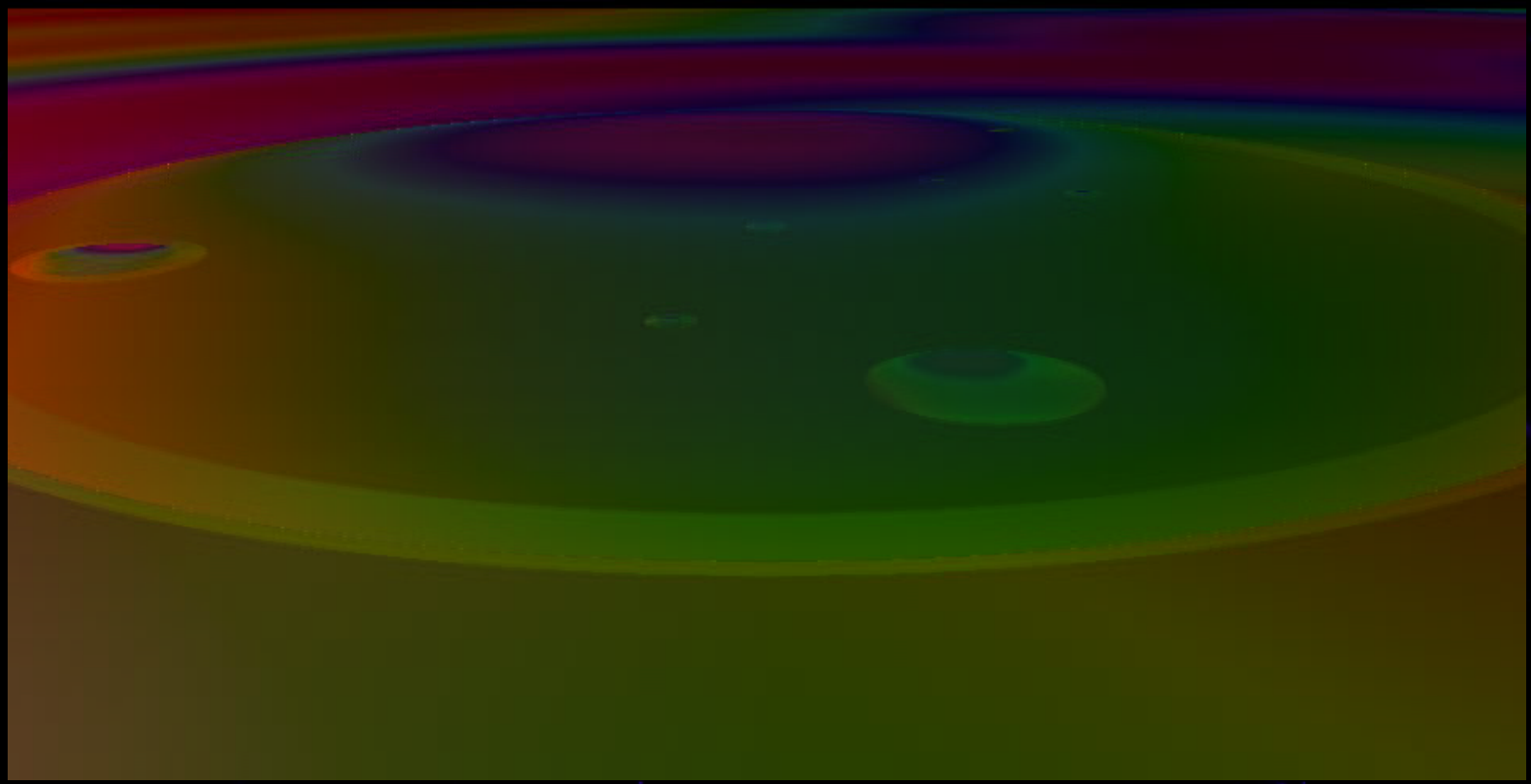
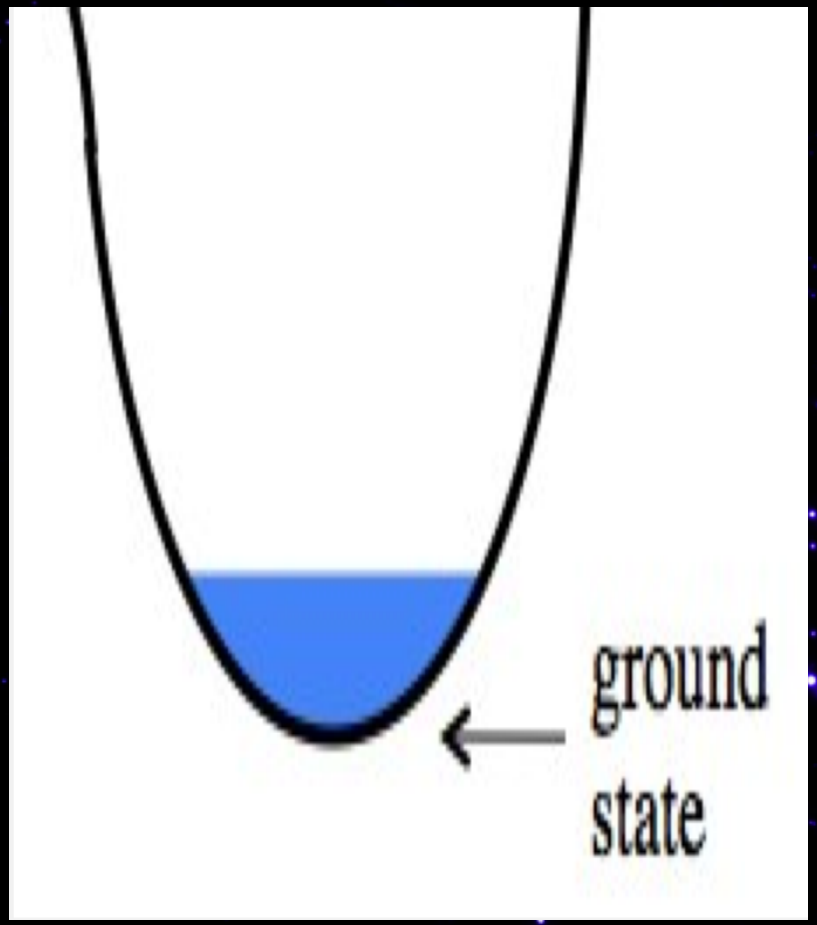
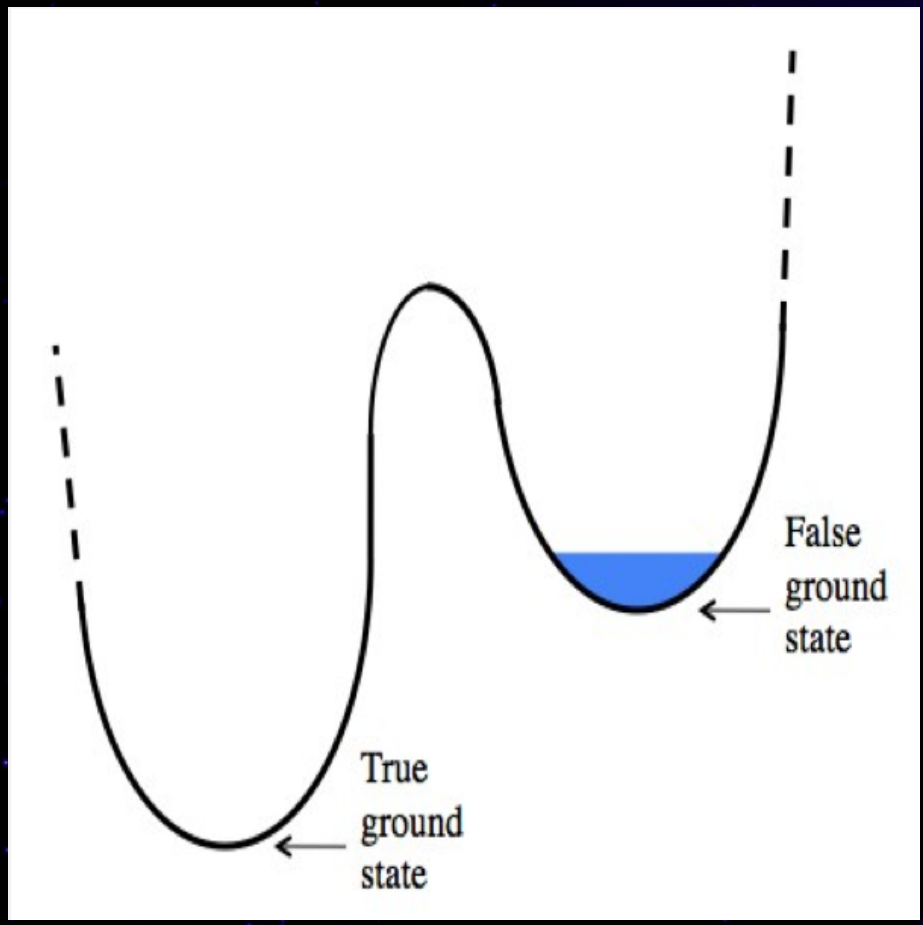
UNITED STATES OF AMERICA

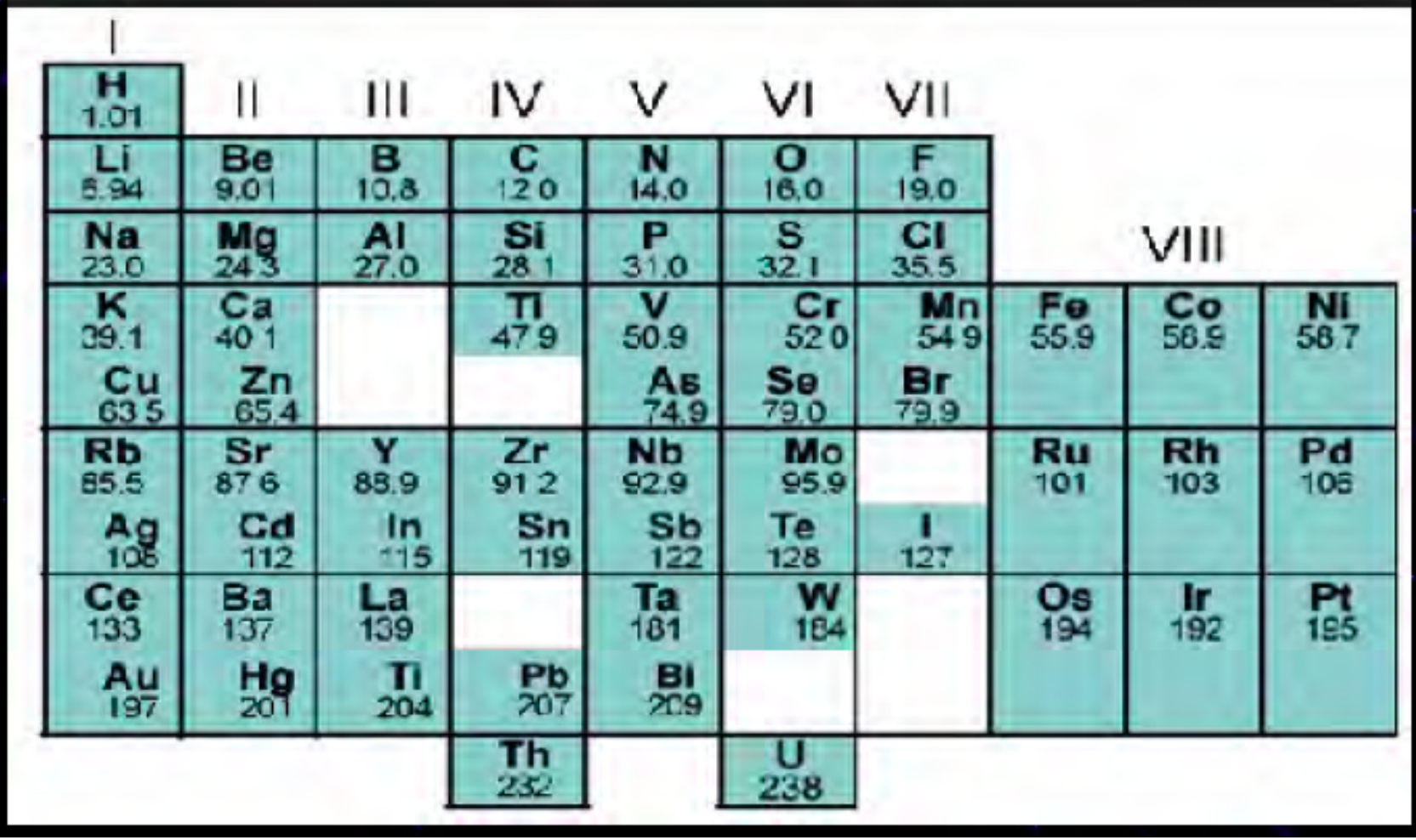




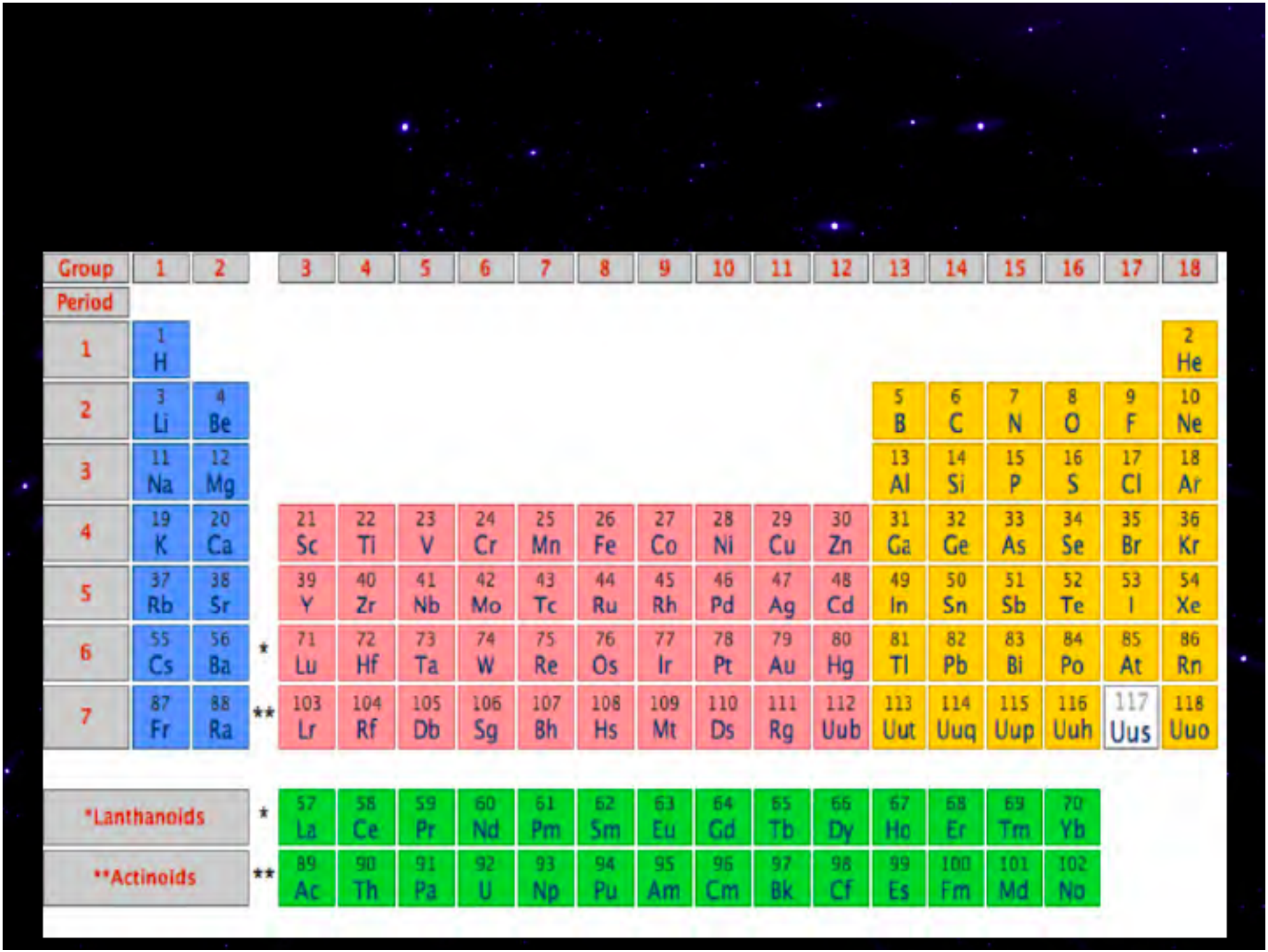


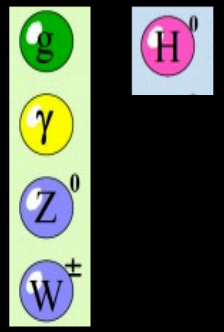
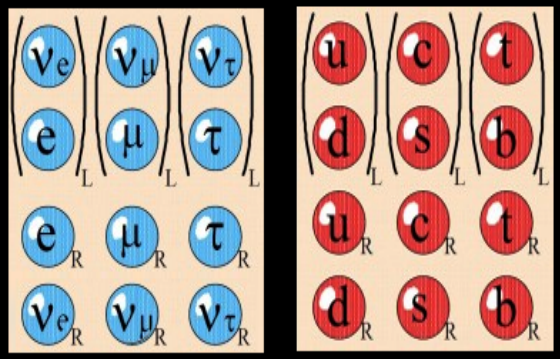
Ask a Mathematician / Ask a Physicist

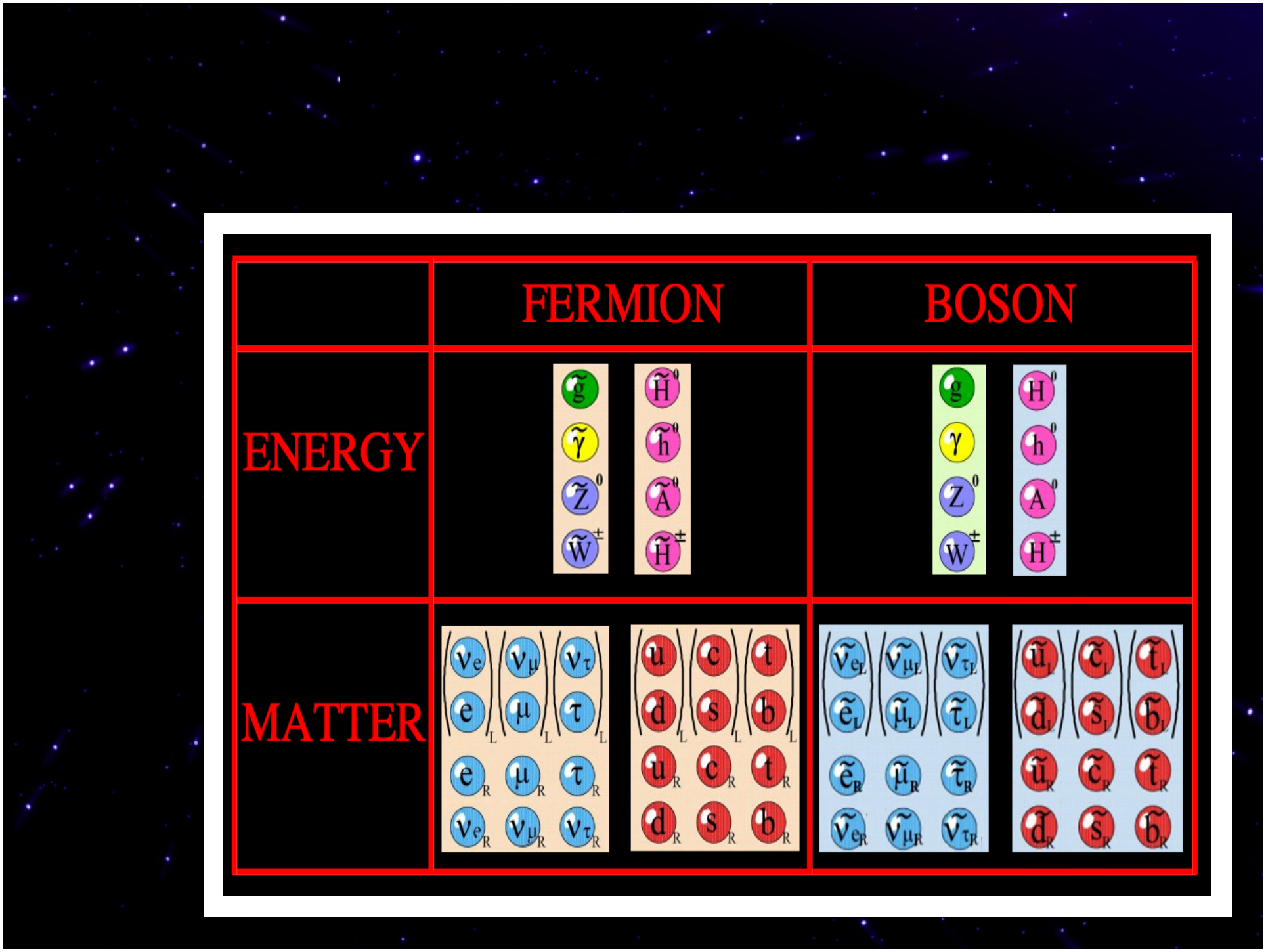
Mendeleev's Missing Elements



I	II	III	IV	V	VI	VII	VIII		
H 1.01									
Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0			
Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5			
K 39.1	Ca 40.1		Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7
Cu 63.5	Zn 65.4			As 74.9	Se 79.0	Br 79.9			
Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9		Ru 101	Rh 103	Pd 106
Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127			
Ce 133	Ba 137	La 139		Ta 181	W 184		Os 194	Ir 192	Pt 195
Au 197	Hg 201	Tl 204	Pb 207	Bi 209					
			Th 232		U 238				


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 * 71 Lu 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 ** 103 Lr 104 Rf 105 Db 106 Sg 107 Bh 108 Hs 109 Mt 110 Ds 111 Rg 112 Uub 113 Uut 114 Uuq 115 Uup 116 Uuh 117 Uus 118 Uuo
*Lanthanoids * 57 La 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
**Actinoids ** 89 Ac 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

	FERMION	BOSON
ENERGY		
MATTER		


FERMION
BOSON
ENERGY
MATTER

SLeptons & Leptons

mass unit $\frac{GeV}{c^2}$

$m_\upsilon \rightarrow 10^{-8}/10^{-4}/10^{-2}$

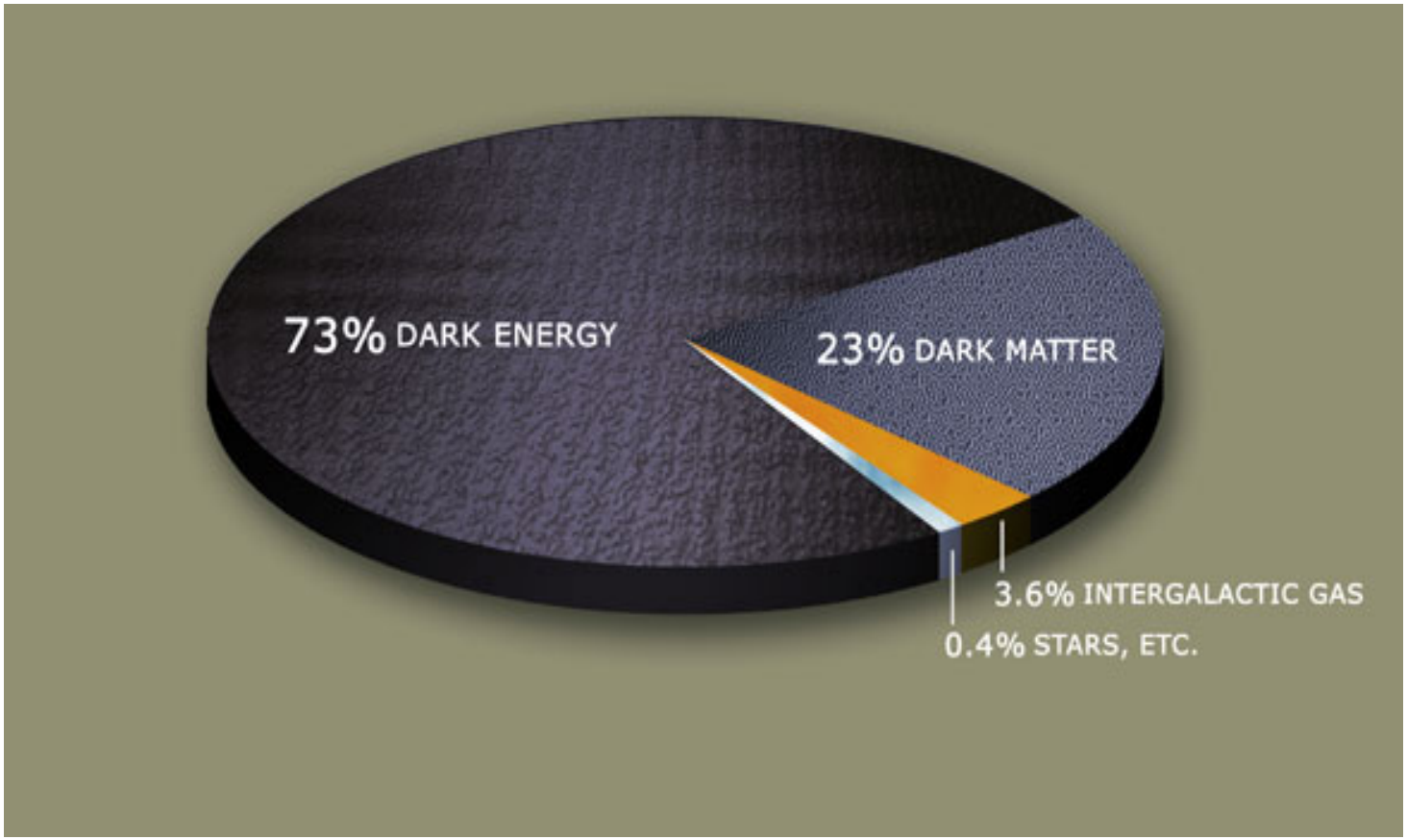
	M	Q	S	
υ_e	~0	0	1/2	
$\tilde{\upsilon}_e$ (e-sneutrino)	?	0	0	
	5×10^{-4}	-1	1/2	e
	?	-1	0	(selectron) $\tilde{e}$
υ_μ	~0	0	1/2	
$\tilde{\upsilon}_\mu$ (μ -sneutrino)	?	0	0	
	0.106	-1	1/2	$\tilde{\mu}$
	?	-1	0	(smuon) μ
υ_τ	~0	0	1/2	
$\tilde{\upsilon}_\tau$ (τ -sneutrino)	?	0	0	
	1.784	-1	1/2	$\tilde{\tau}$
	?	-1	0	(staon) τ

SQuarks & Quarks

	M	Q	S	
u	4×10^{-3}	2/3	1/2	
$\tilde{u}$ (up-squark)	?	2/3	0	
d	7×10^{-3}	-1/3	1/2	
($\tilde{d}$ down-squark)	?	-1/3	0	
c	1.5	2/3	1/2	
$\tilde{c}$ (charmed-squark)	?	2/3	0	
s	0.15	-1/3	1/2	
($\tilde{s}$ strange-squark)	?	-1/3	0	
t	173	2/3	1/2	
$\tilde{t}$ (top-squark)	?	2/3	0	
b	4.7	-1/3	1/2	
($\tilde{b}$ bottom-squark)	?	-1/3	0	

Force Carriers (Gauge Particles)

	M	Q	S	
$g_{\mu\upsilon}$ (graviton)	0	0	2	
Ψ_{μ}^{d} (gravitino)	0	0	3/2	
	80.6	+1	1	(charged IVB) W_{μ}^{+}
	?	+1	1/2	(+charged Wino) $\tilde{W}^{+}$
G_{μ}^{i} (gluon)	0	0	1	
$\tilde{\lambda}^{i}$ (gluino)	0	0	1/2	
	91.2	0	1	(neutral IVB) Z_{μ}^{0}
	?	0	1/2	(neutral Zeno) $\tilde{Z}$
A_{μ} (photon)	0	0	1	
$\tilde{\lambda}$ (photino)	?	0	1/2	
	80.6	-1	1	(charged IVB) W_{μ}^{-}
	?	-1	1/2	(-charged Wino) $\tilde{W}^{-}$


73% DARK ENERGY
23% DARK MATTER
3.6% INTERGALACTIC GAS
0.4% STARS, ETC.

(Shutterstock / Pete Niesen)

Sticking with SUSY

S James Gates, Jr is a theoretical physicist at the University of Maryland, US, e-mail gatess@wam.umd.edu

THANK
YOU

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39 countries -- 169 institutes
3170 scientists & engineers
Search for the Standard Model Higgs with the CMS detector -- KRUGER 2012
Mayda M. Velasco – Dec. 3, 2012
CMS
NORTHWESTERN UNIVERSITY
1851

Superstring Theory: The DNA of Reality

Web:
http://www.teach12.com/ttcx/coursedesclong2.aspx?cid=1284

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"Superstring Theory: The DNA of Reality."

Animations: Copyright 2005 Kenneth A. Griggs.

Acknowledgment

Fission And Fusion

http://www.youtube.com/watch?v=yTkojROg-t8

Becquerel's Discovery of Radioactivity

http://www.youtube.com/watch?v=e7HNAmmSc7U

Marie Curie

http://www.youtube.com/watch?v=3KmJsKuJws4