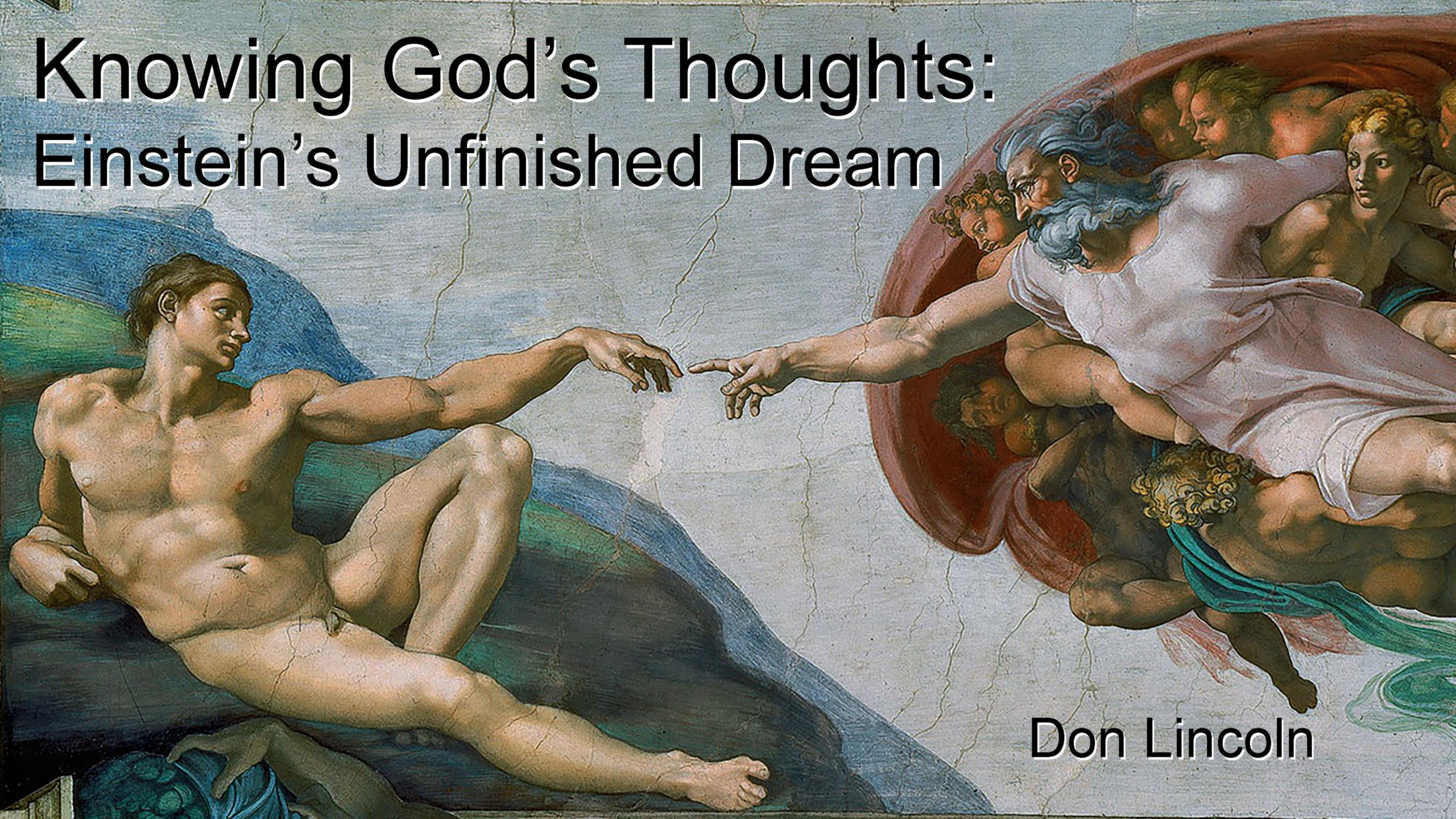
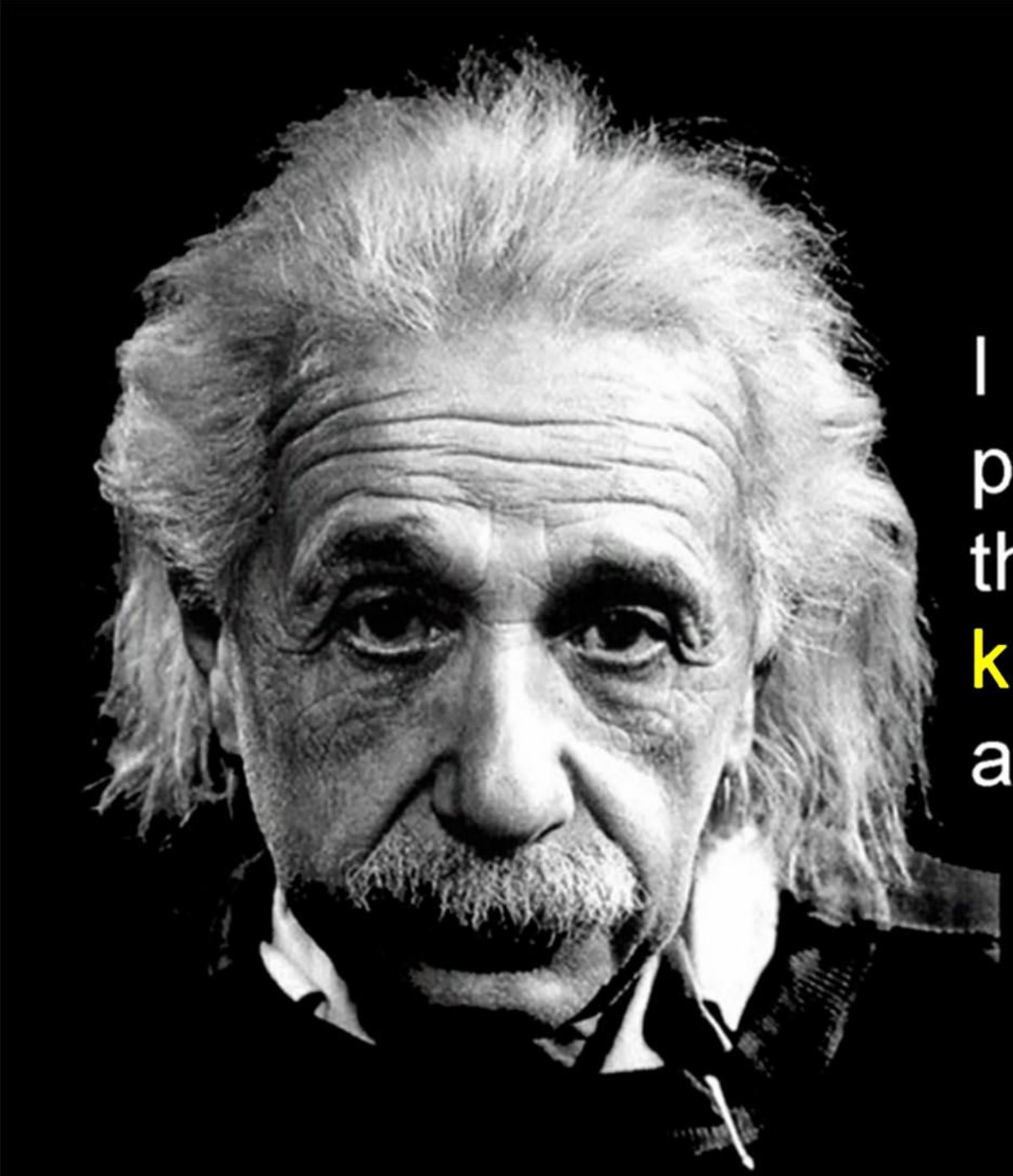
Knowing God's Thoughts:
Einstein's Unfinished Dream



Don Lincoln



I am not interested in this or that phenomenon, in the spectrum of this or that element; I want to know God's thoughts; the rest are just details.

Author: Esther Salaman
Journal: Listener
Date: 1955

A Theory of Everything

- Determine the smallest building blocks of the universe.
- Work out the forces that make the universe tick and do they have a single origin?
- Figure out how the universe came into existence and how it will end.
- How does *everything* hang together?

A Theory of Everything

- Determine the smallest building blocks of the universe.
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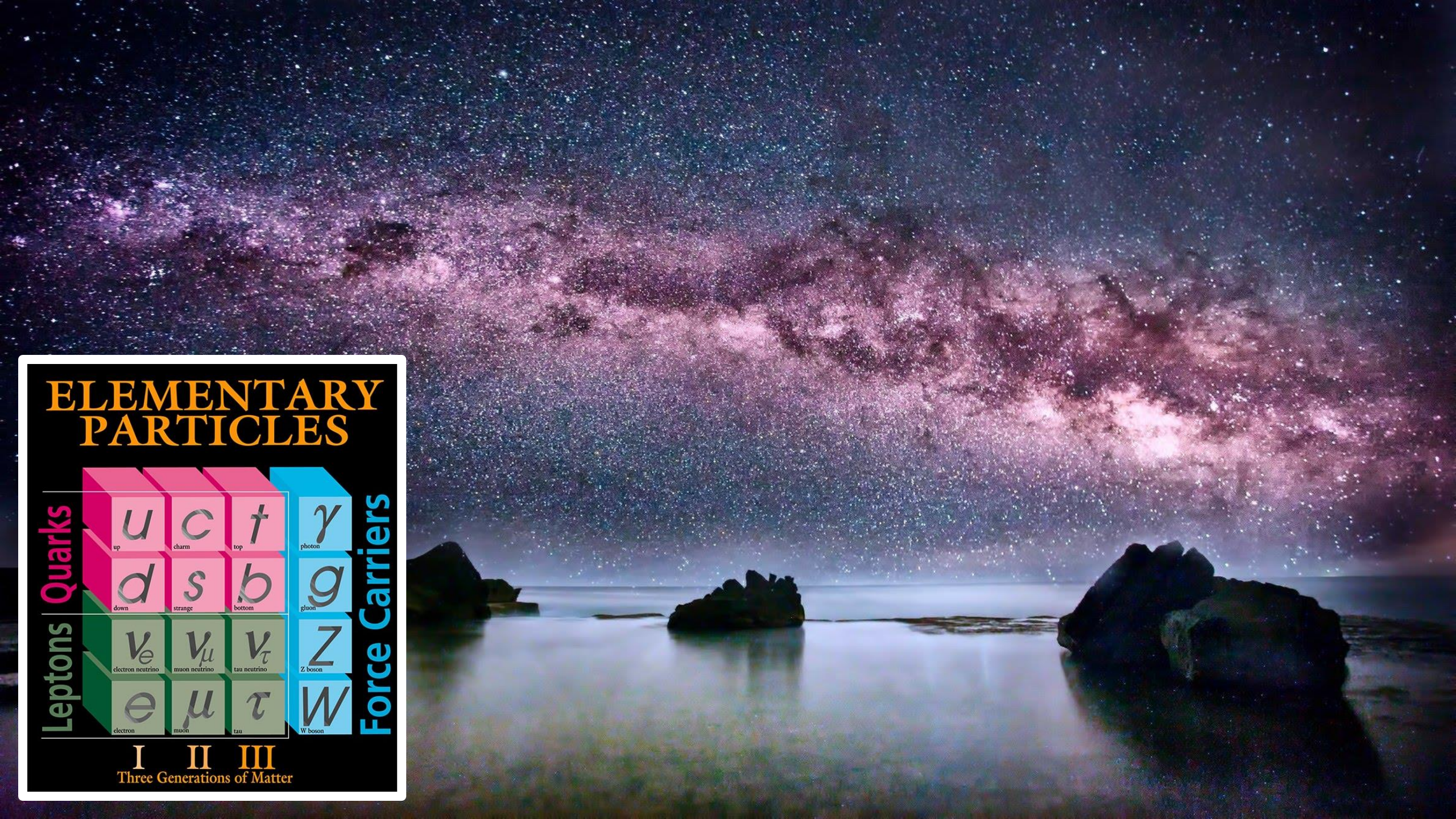
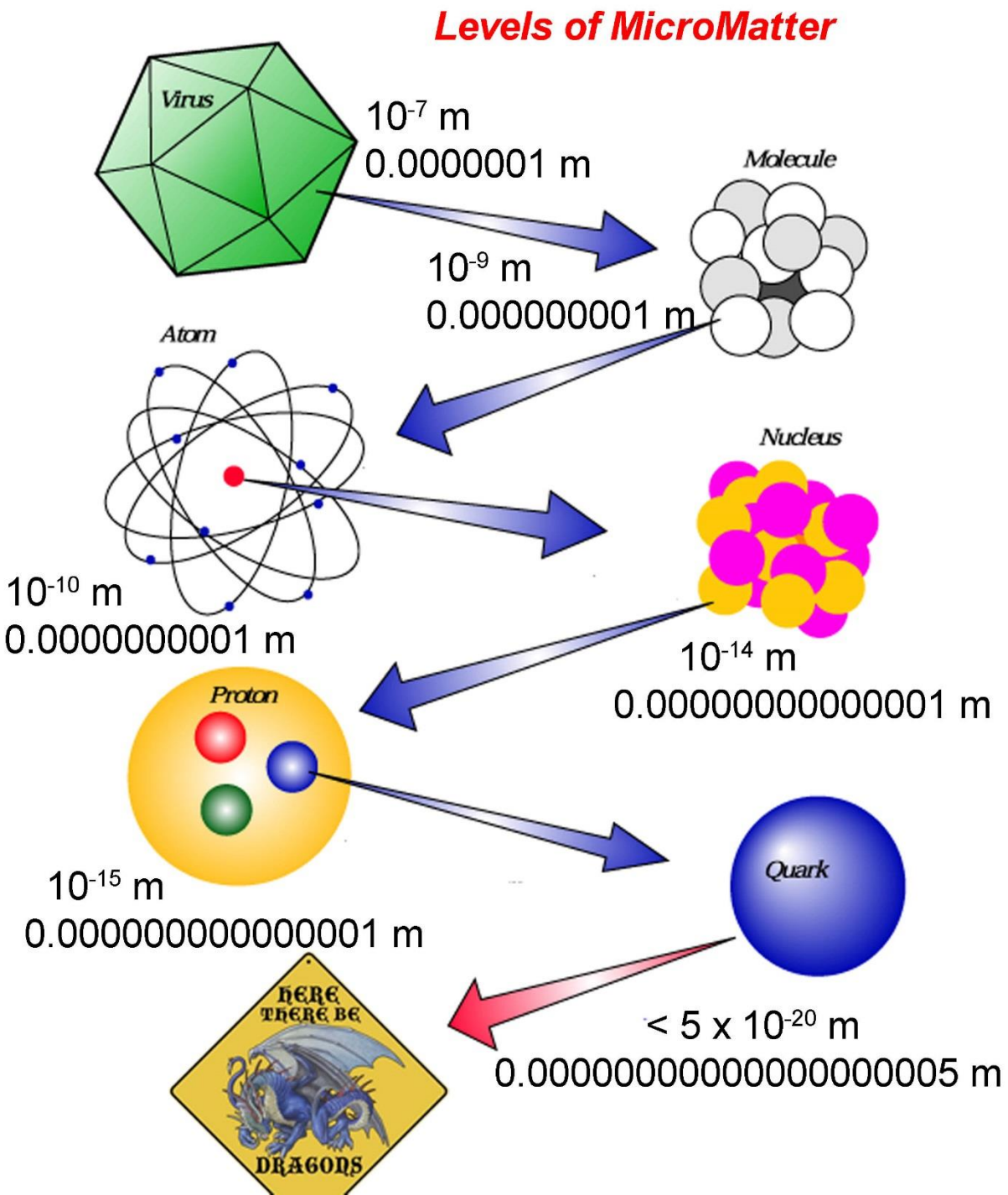
- How does *everything* hang together?

What do I mean by ***everything***?


ELEMENTARY PARTICLES
Quarks
Leptons
Force Carriers
u
up
c
charm
t
top
γ
photon
d
down
s
strange
b
bottom
g
gluon
ν_e
electron neutrino
ν_μ
muon neutrino
ν_τ
tau neutrino
Z
Z boson
e
electron
μ
muon
τ
tau
W
W boson
I II III
Three Generations of Matter



Remember the Journey

Big things are built from smaller things.

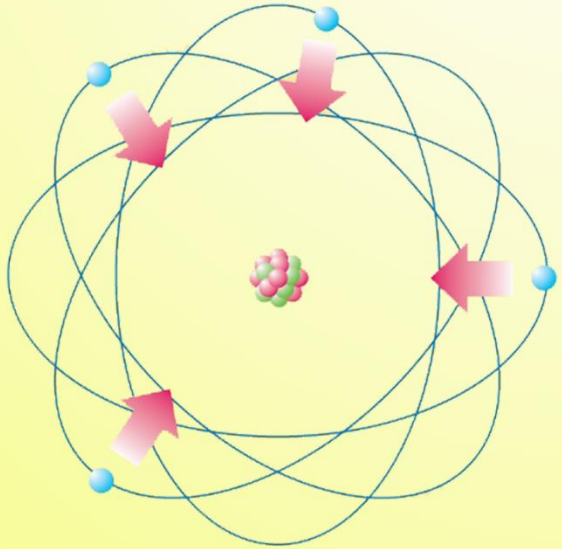
Those smaller things are governed by laws that we've discovered.

Seemingly disparate phenomena arise from common origins.

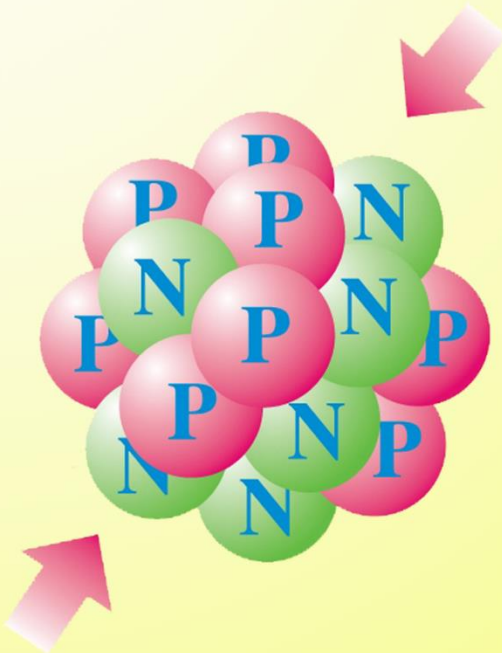
Four Fundamental Forces

Gravitation

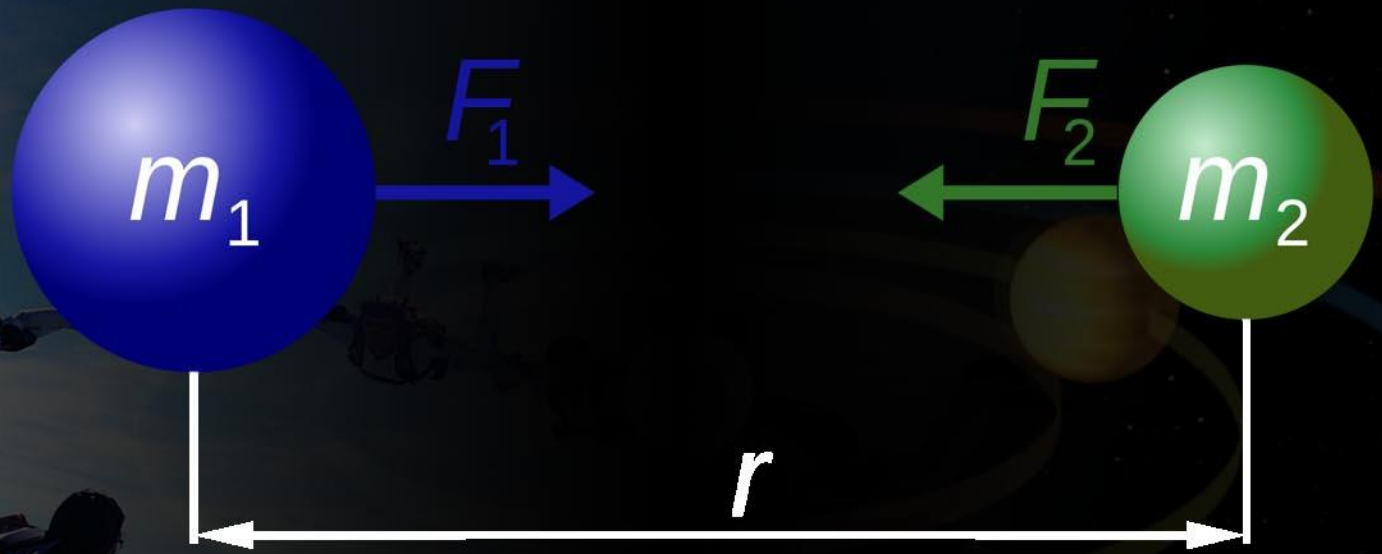
Electro-magnetism



Strong Force

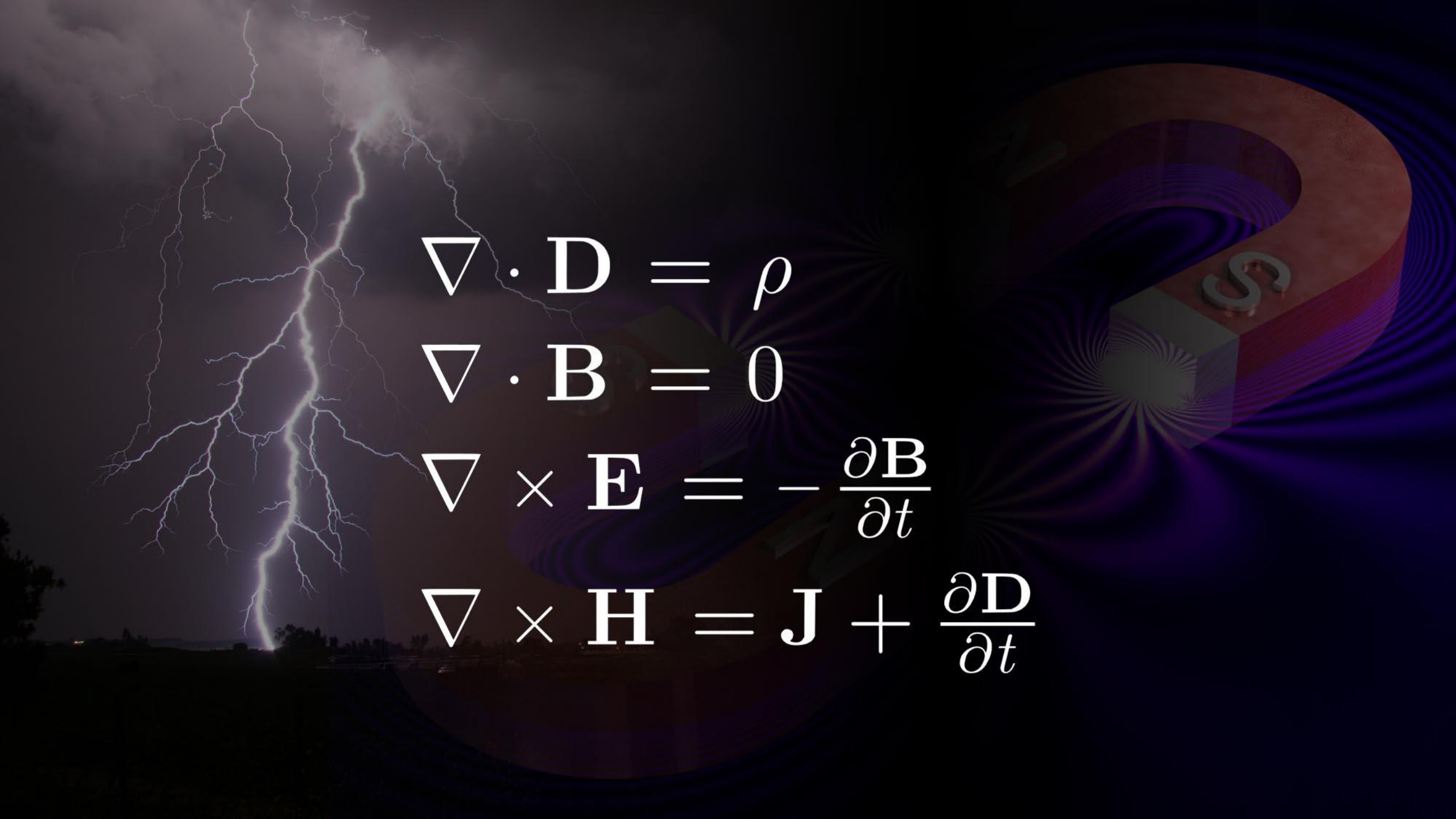


Weak Force

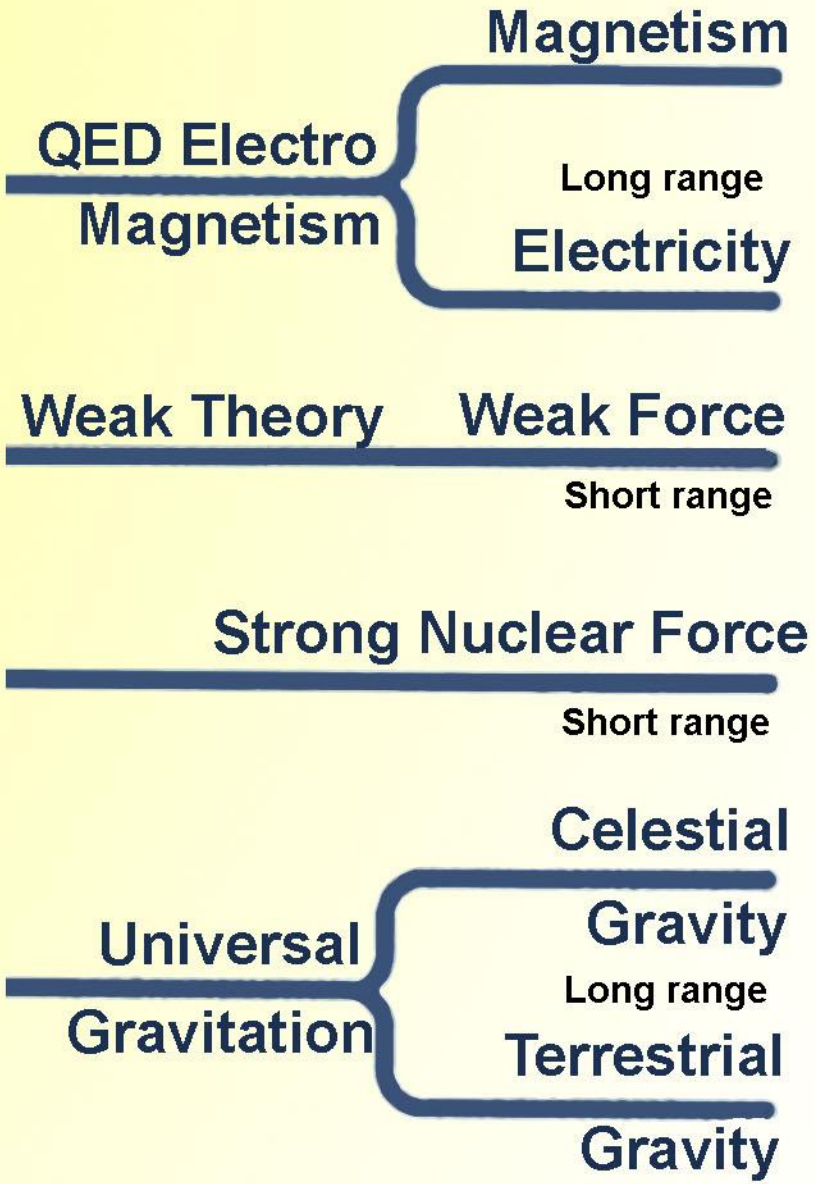


$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$


N
S
S
N

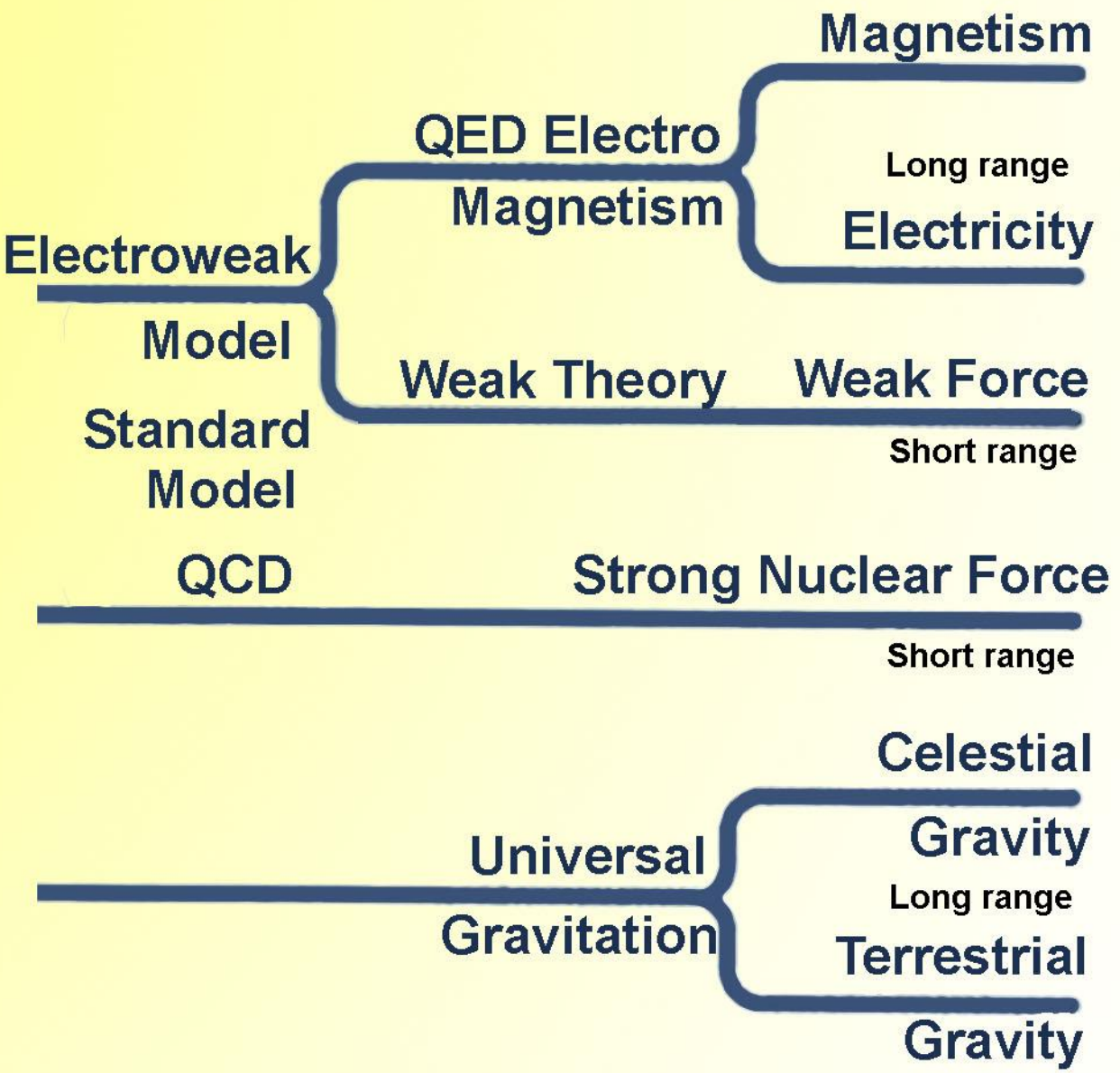

$\nabla \cdot \mathbf{D} = \rho$
$\nabla \cdot \mathbf{B} = 0$
$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$
$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$

Can all forces be unified?



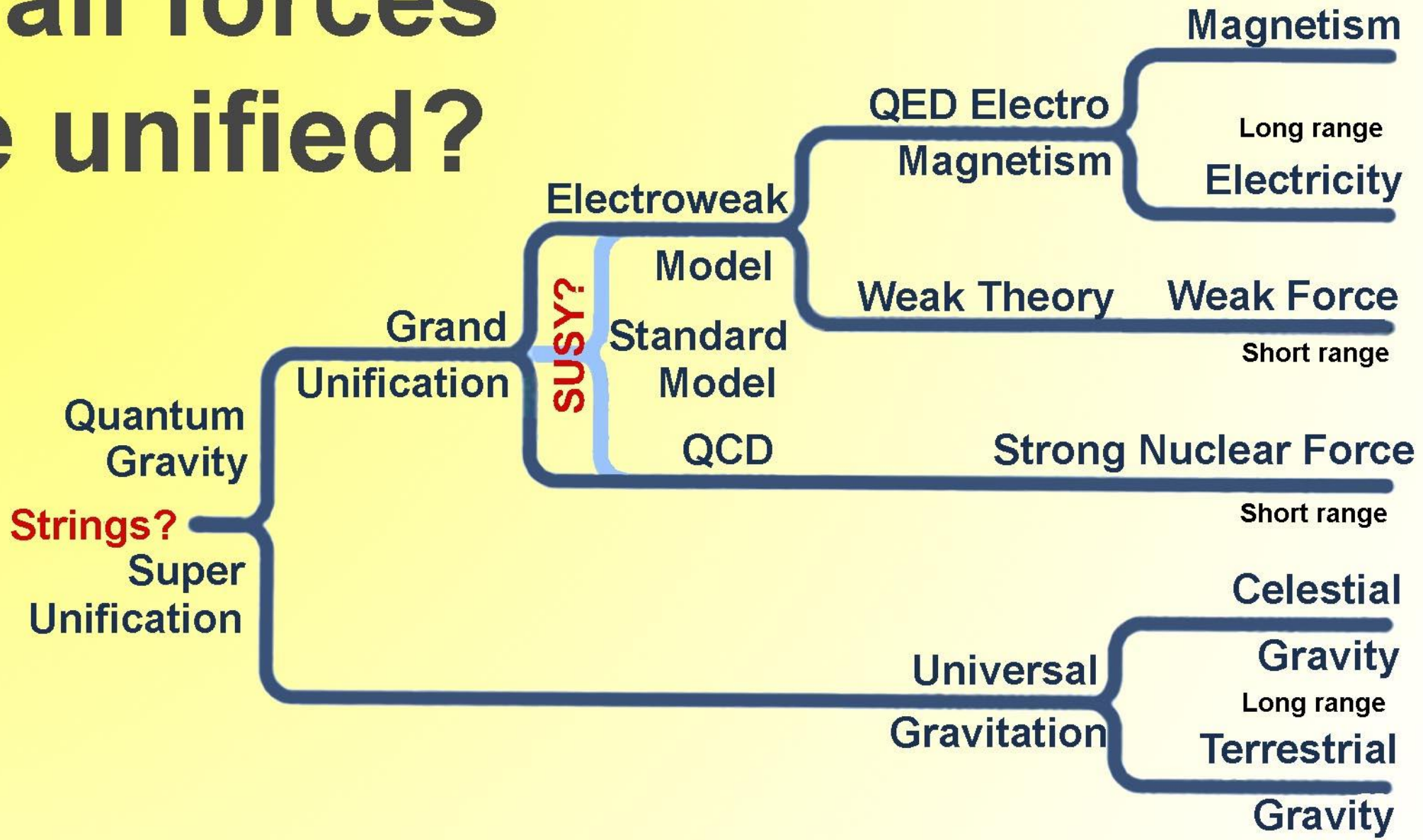
1960

Can all forces be unified?

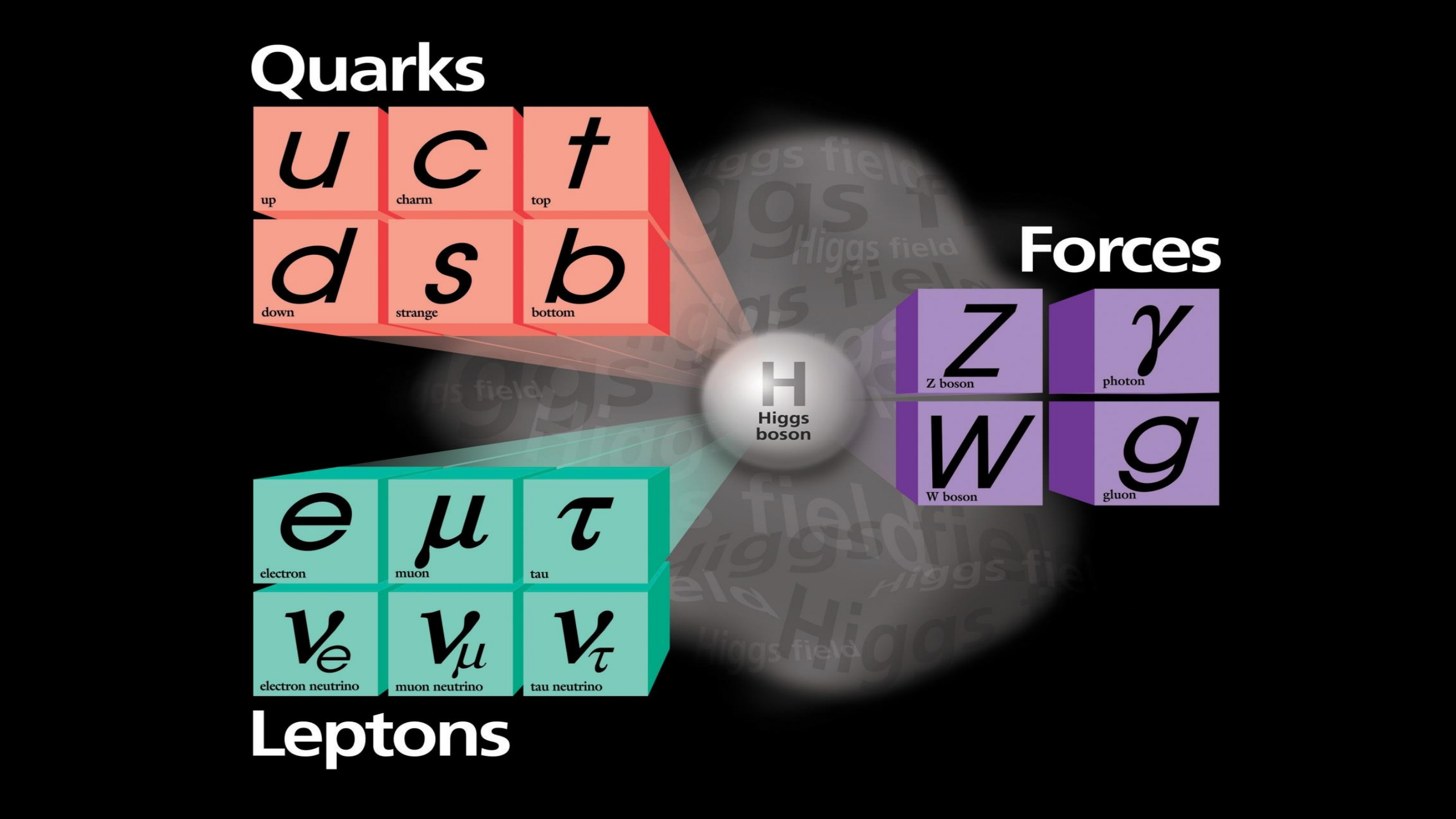


2023

Can all forces be unified?



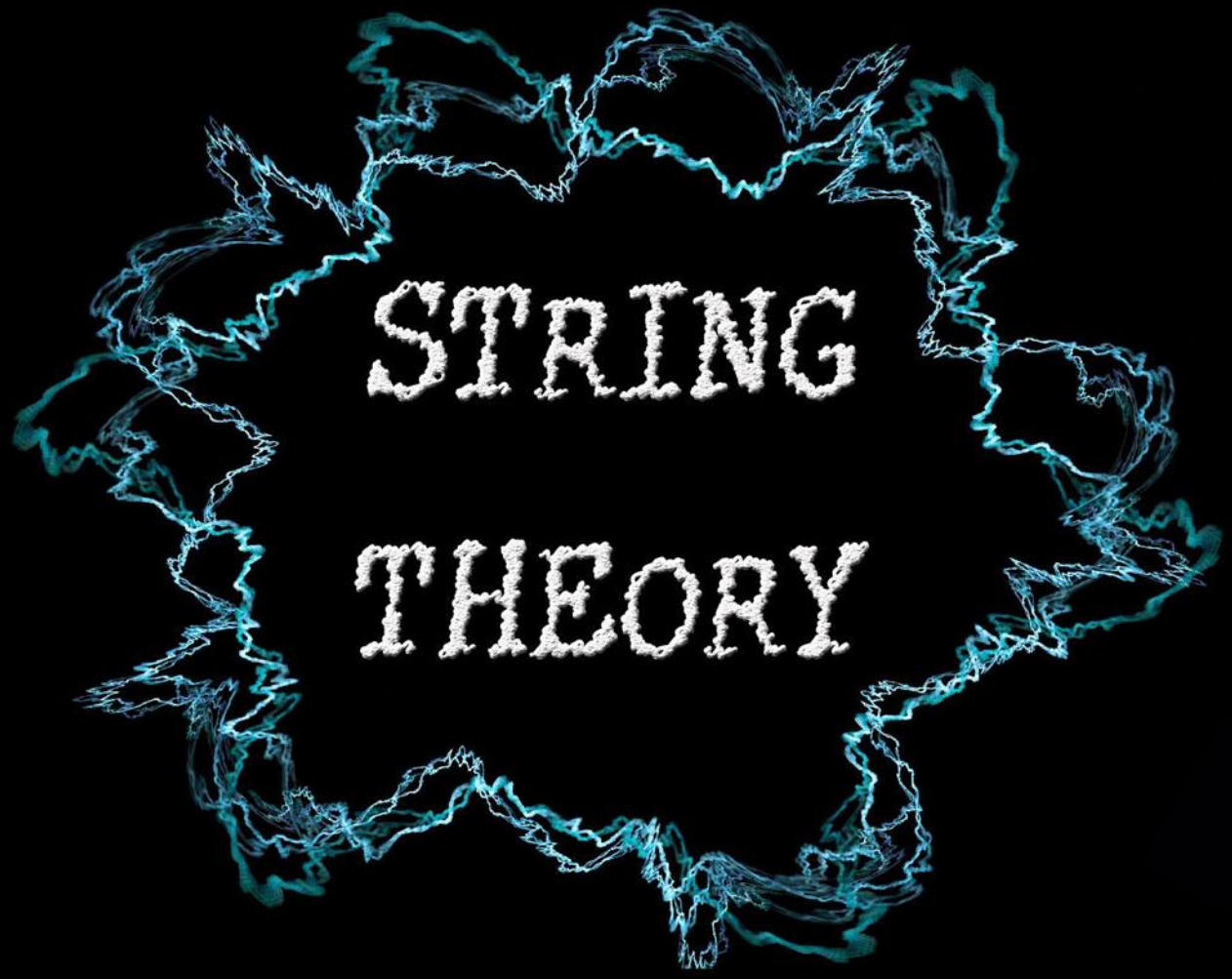
Future?

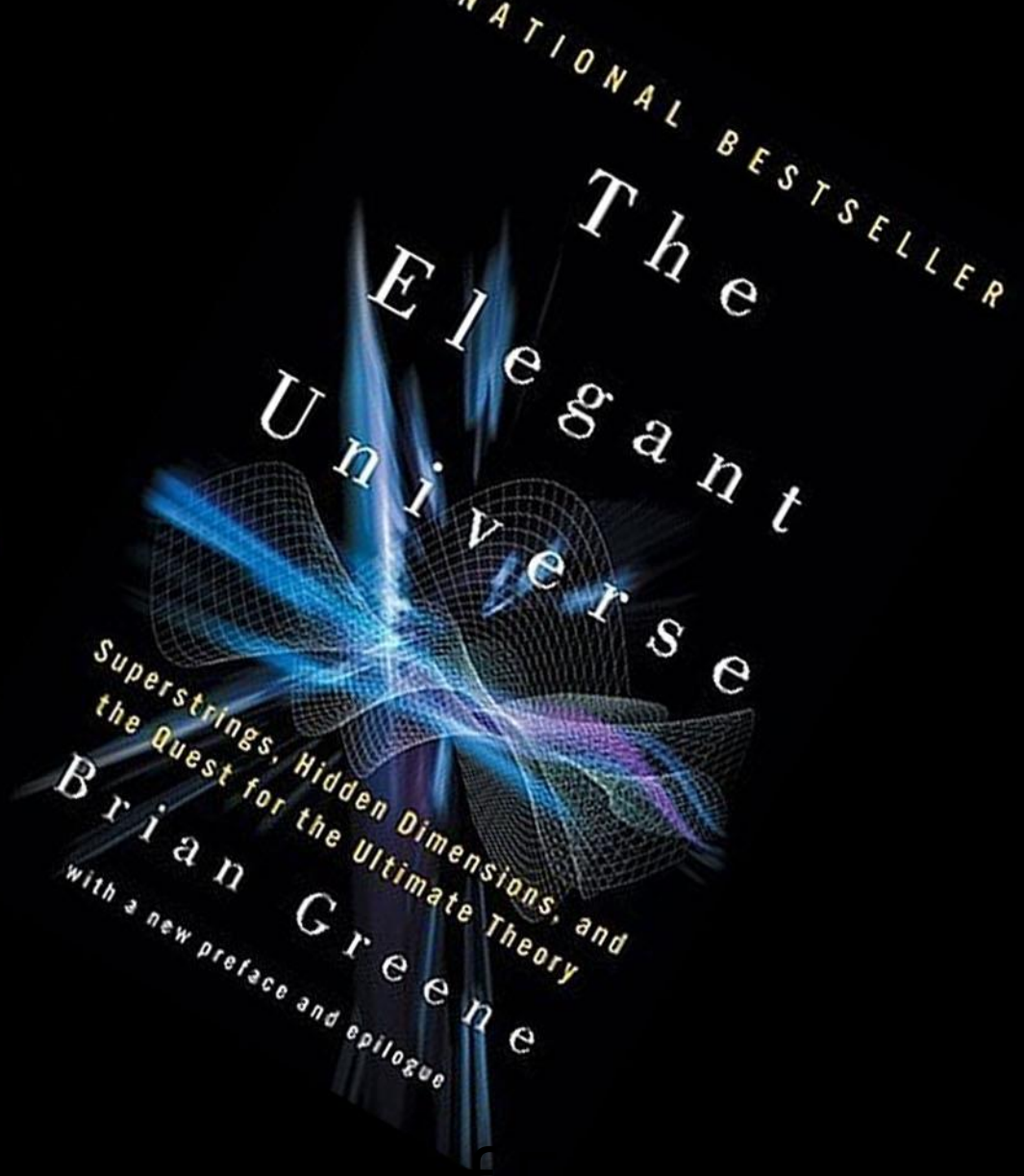

Quarks
u
up
c
charm
t
top
d
down
s
strange
b
bottom
Forces
H
Higgs boson
Z
Z boson
γ
photon
W
W boson
g
gluon
e
electron
μ
muon
τ
tau
νe
electron neutrino
νμ
muon neutrino
ντ
tau neutrino
Leptons
Higgs field

But....

Is the Standard Model a Theory of Everything?

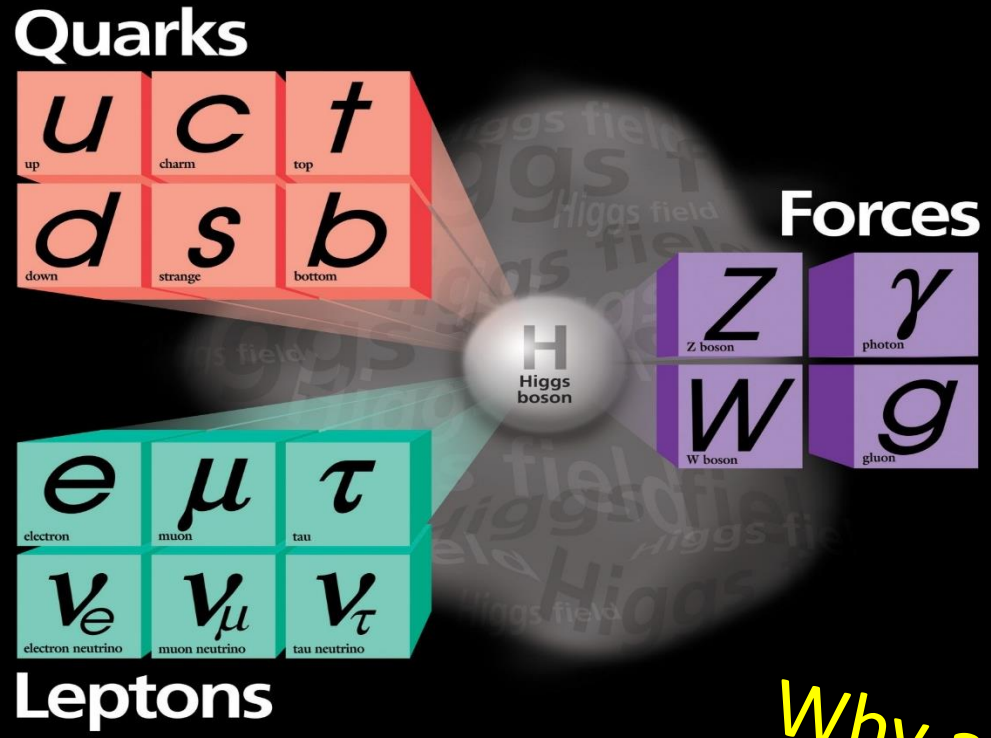
Candidate Theory of Everything





Candidate Theory of Everything

Things the Standard Model Doesn't Explain



Why quarks?

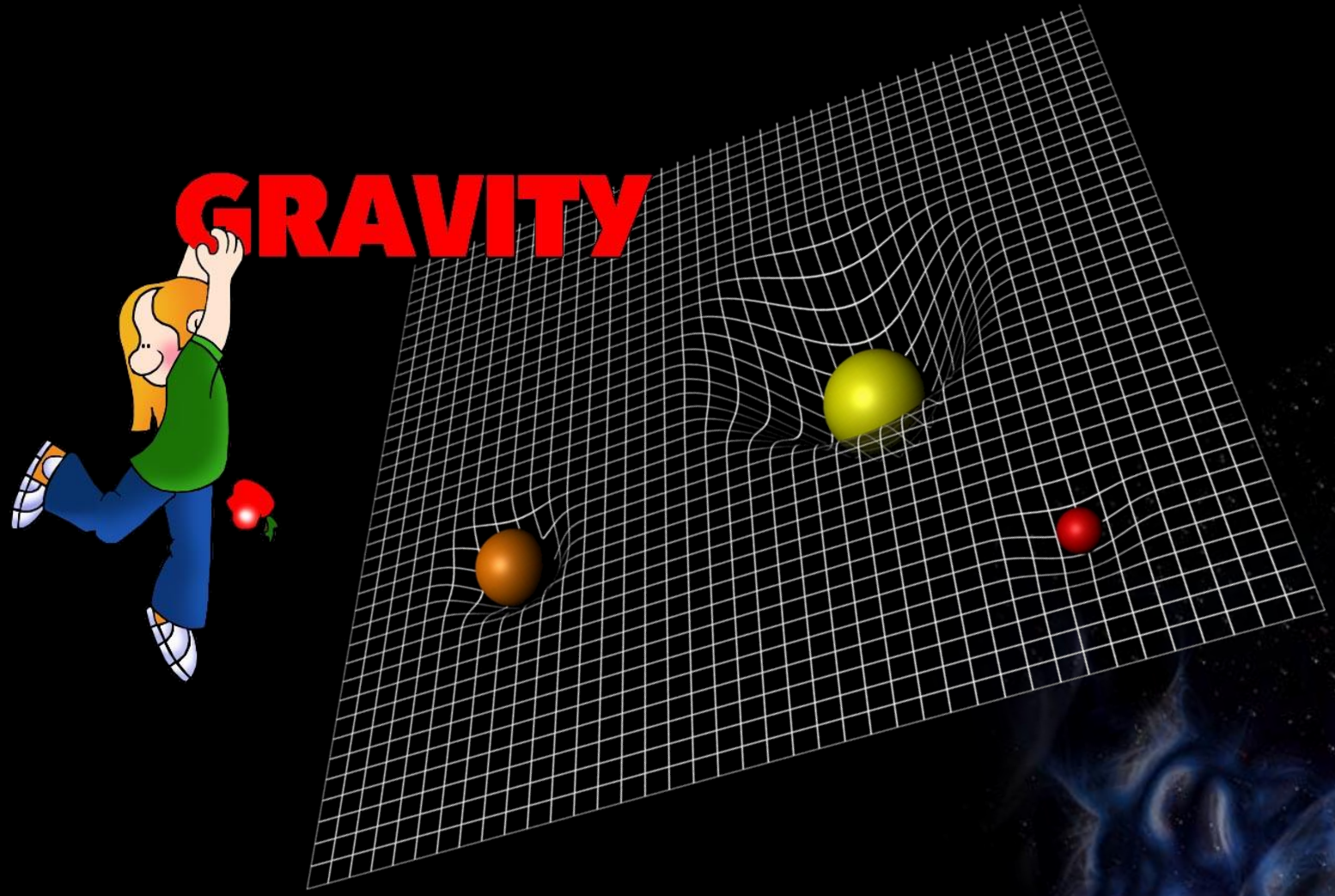
Why four forces?

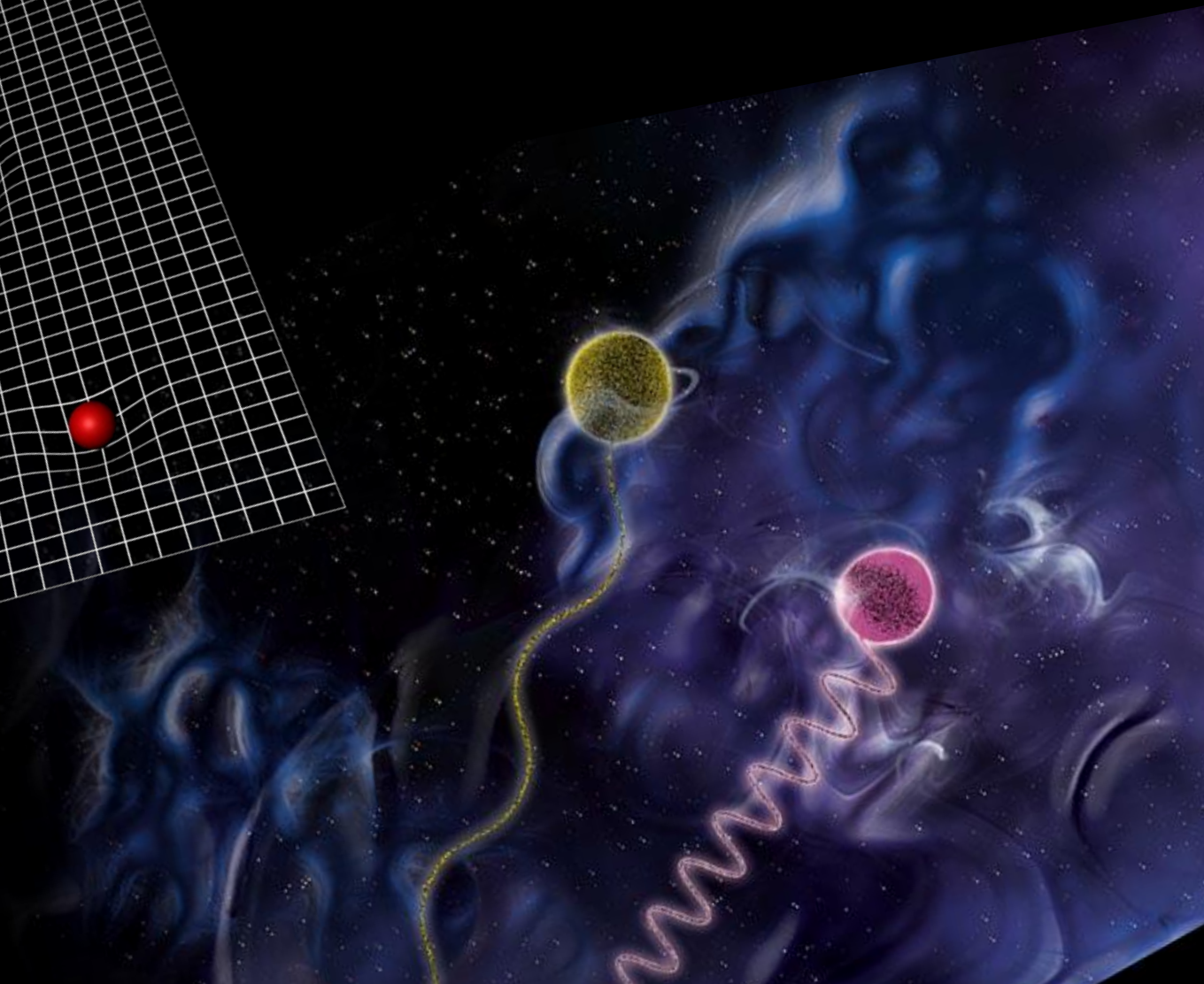
Why leptons?

Why a Higgs field?

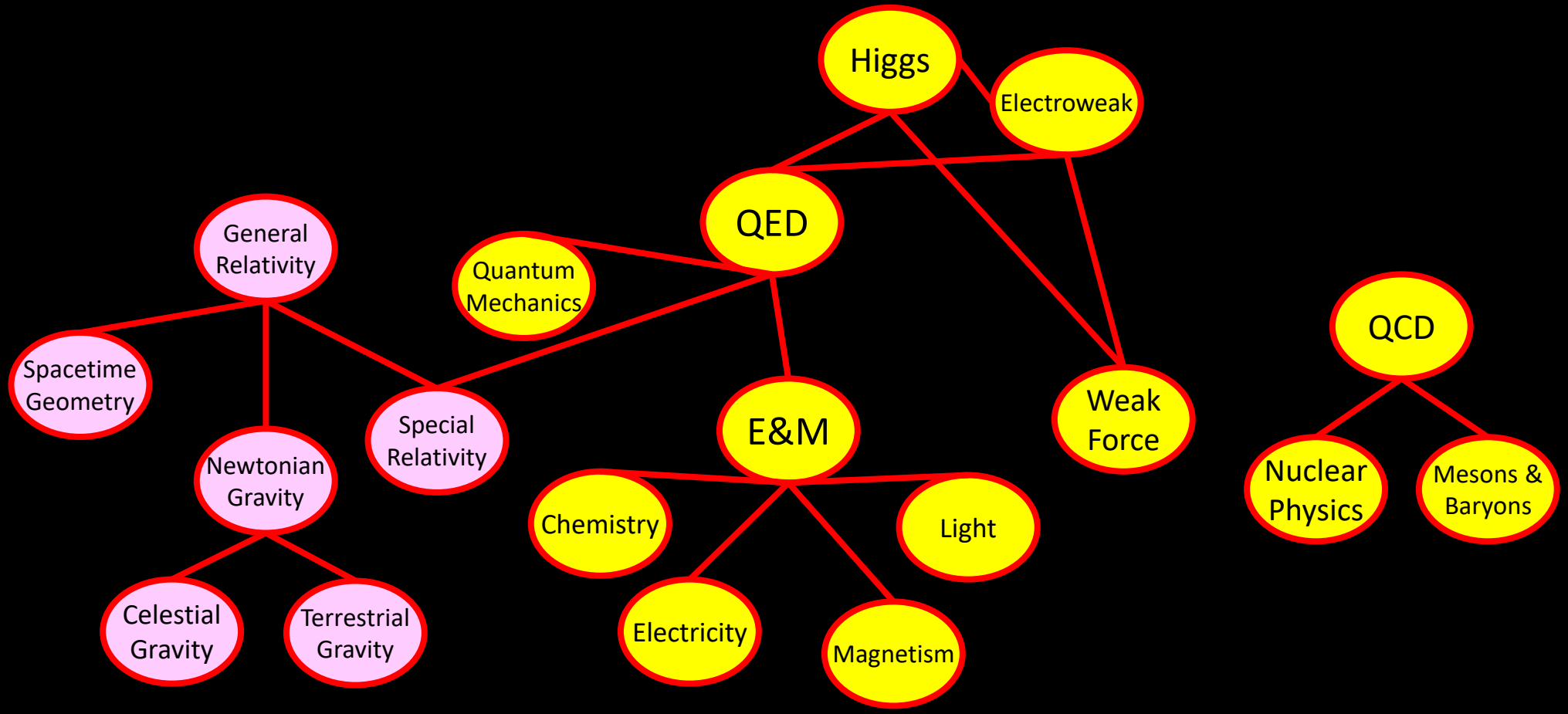
Why three generations?

Things the Standard Model Doesn't Explain

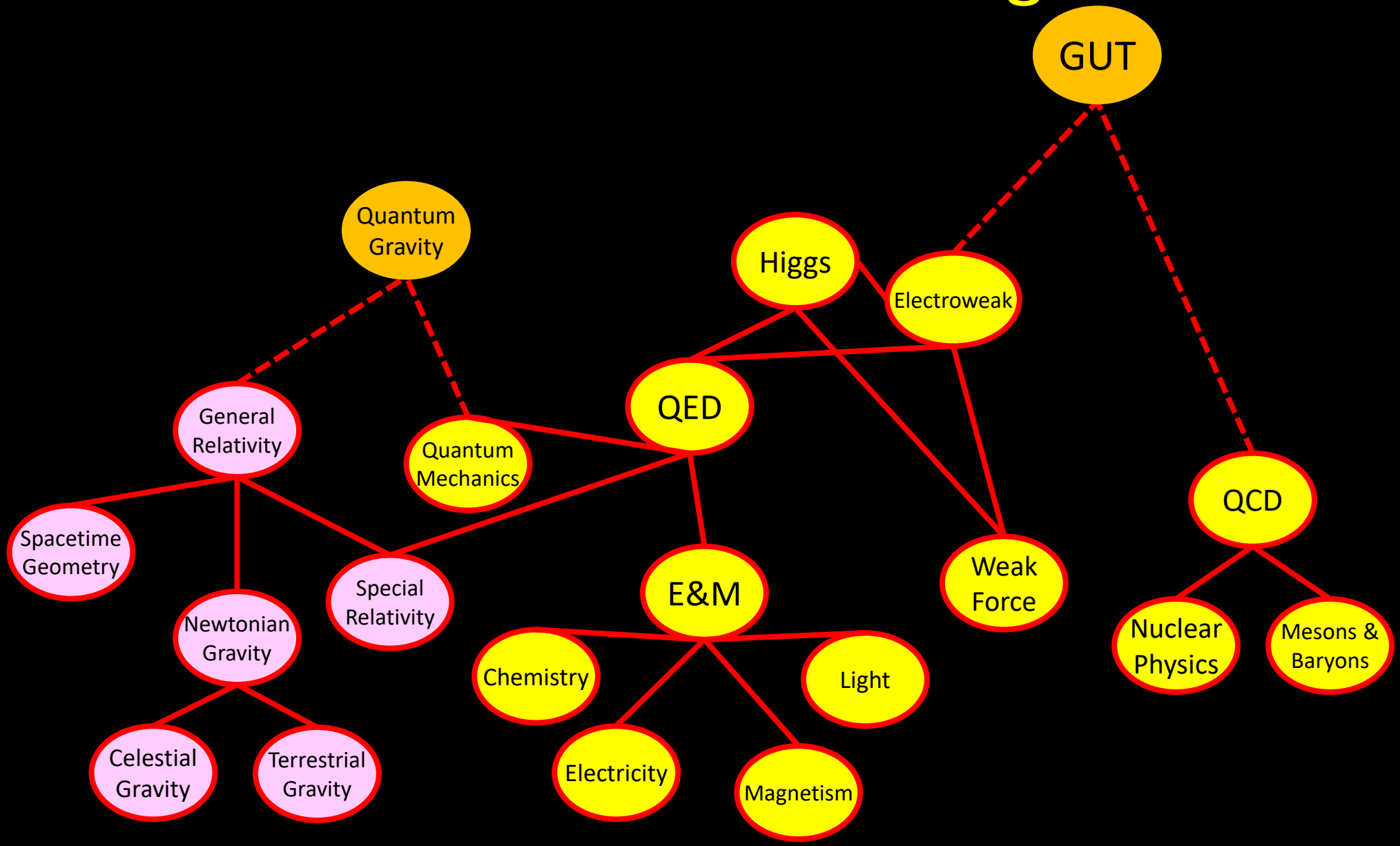




Connections: Known and Imagined



Connections: Known and Imagined



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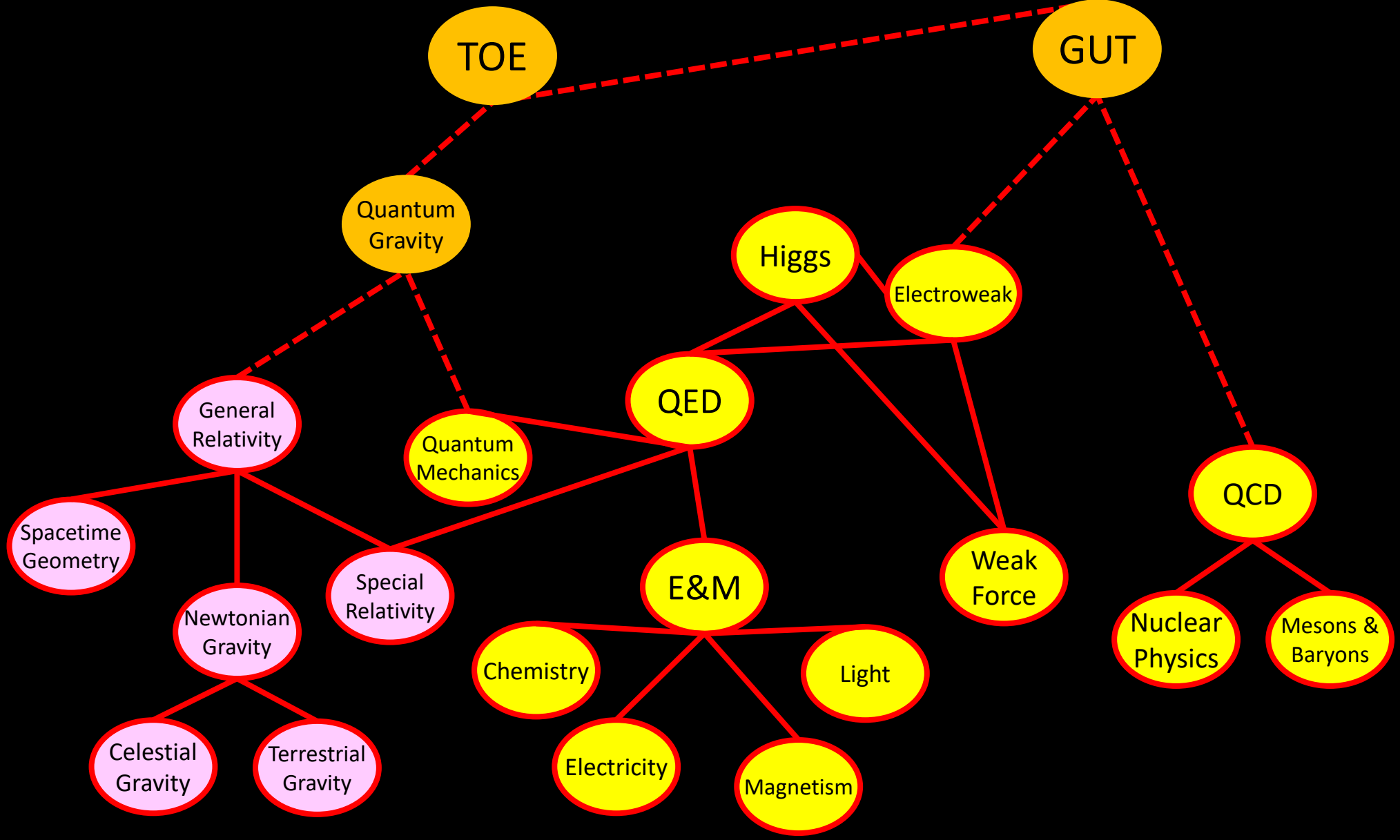
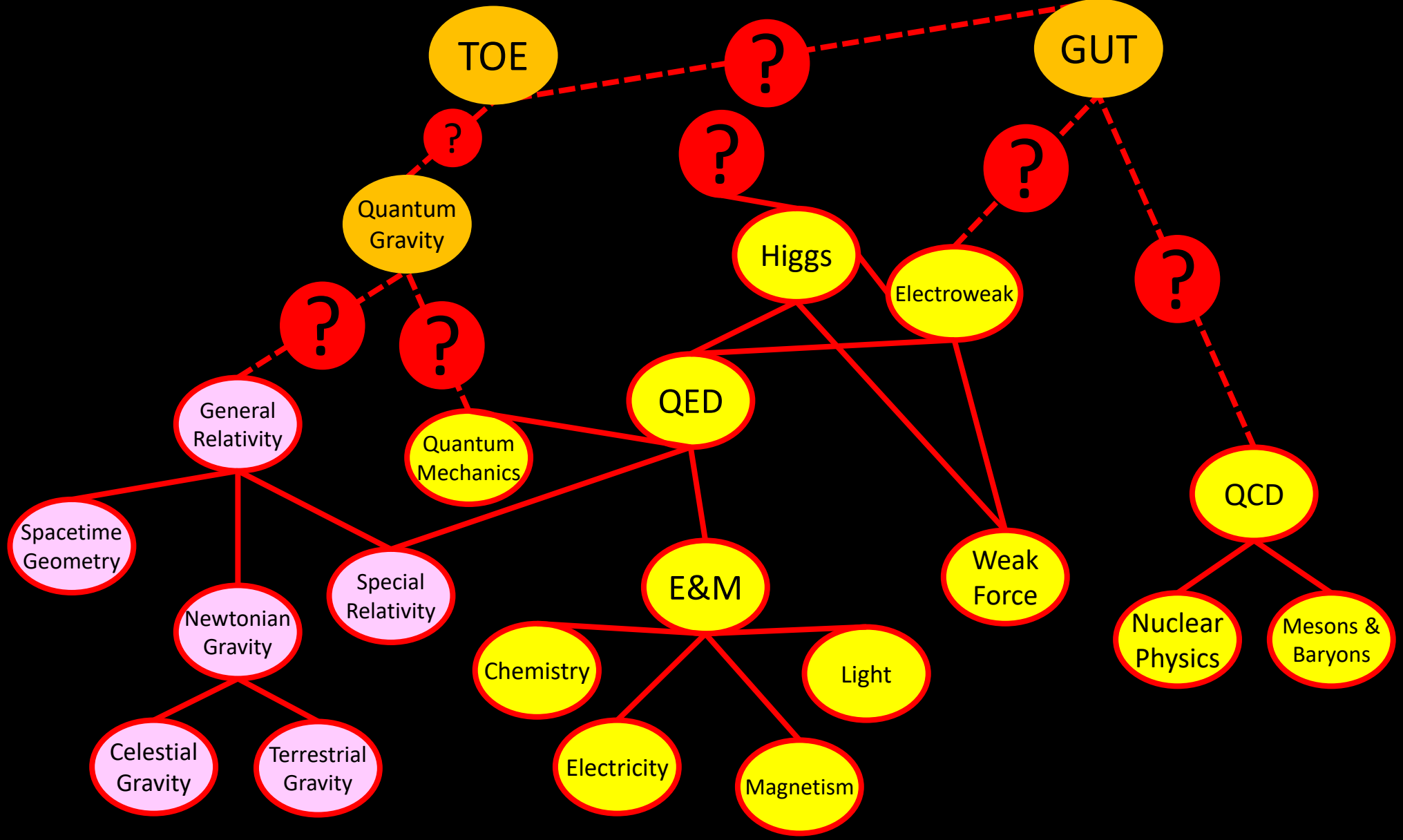
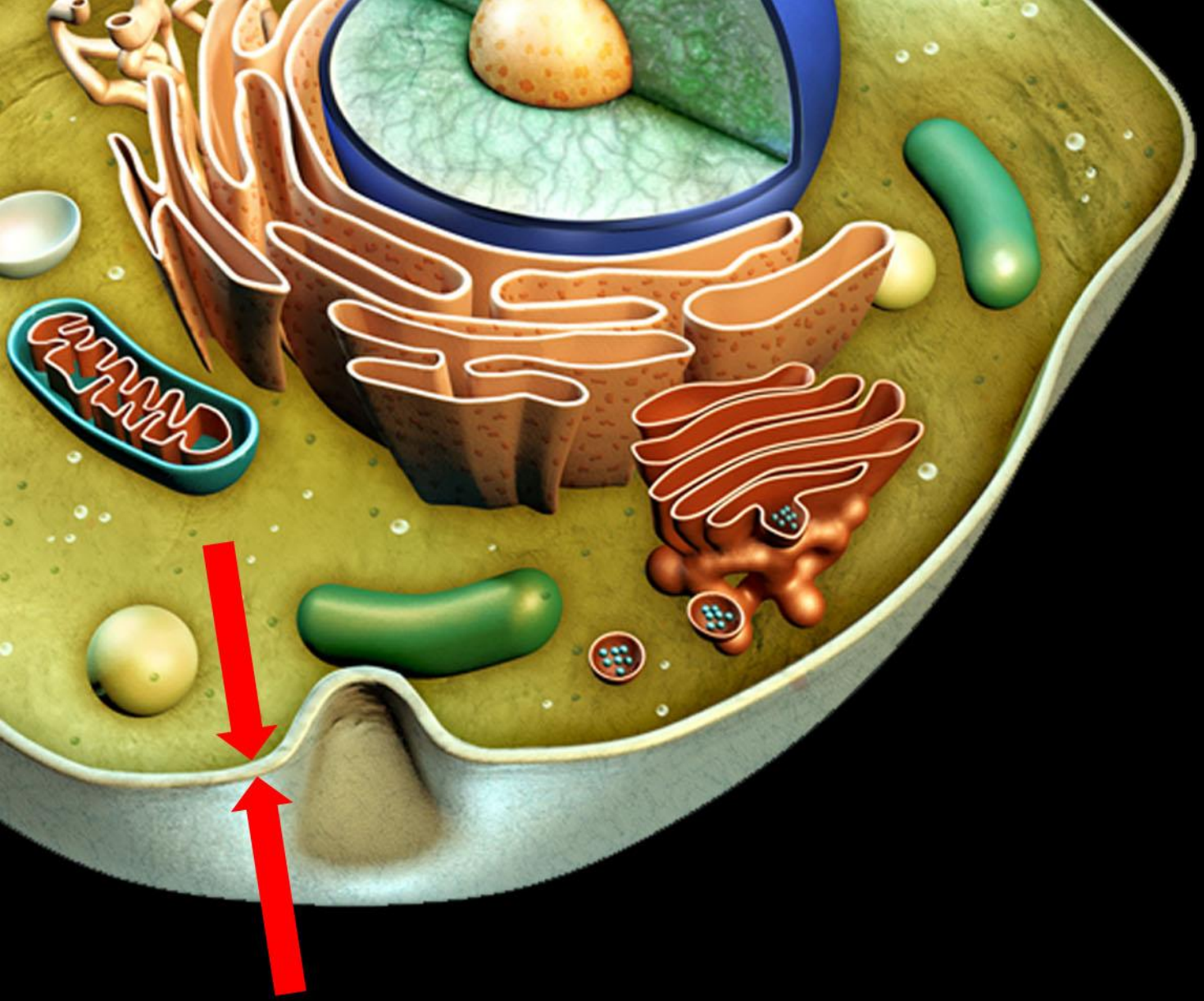
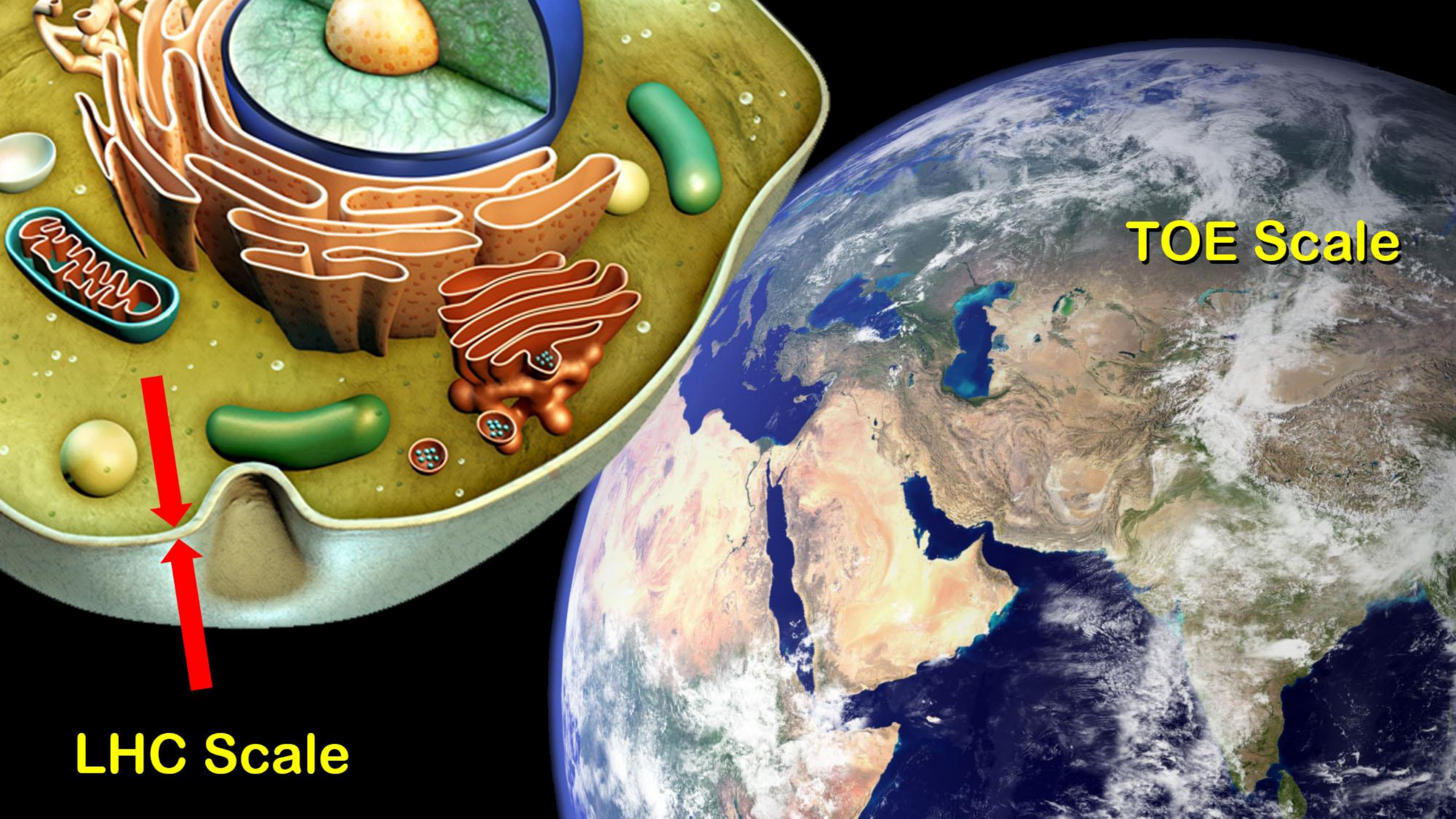


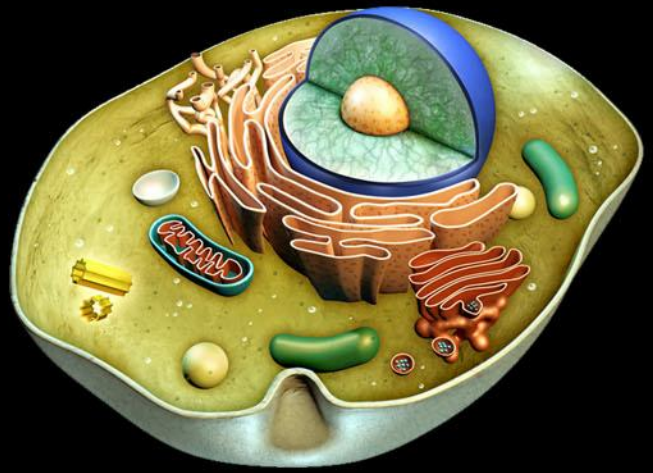
Connections: Known and Imagined





LHC Scale


TOE Scale
LHC Scale




Atlantis
United States

Currently Accessible Scale ~ 10^4 GeV

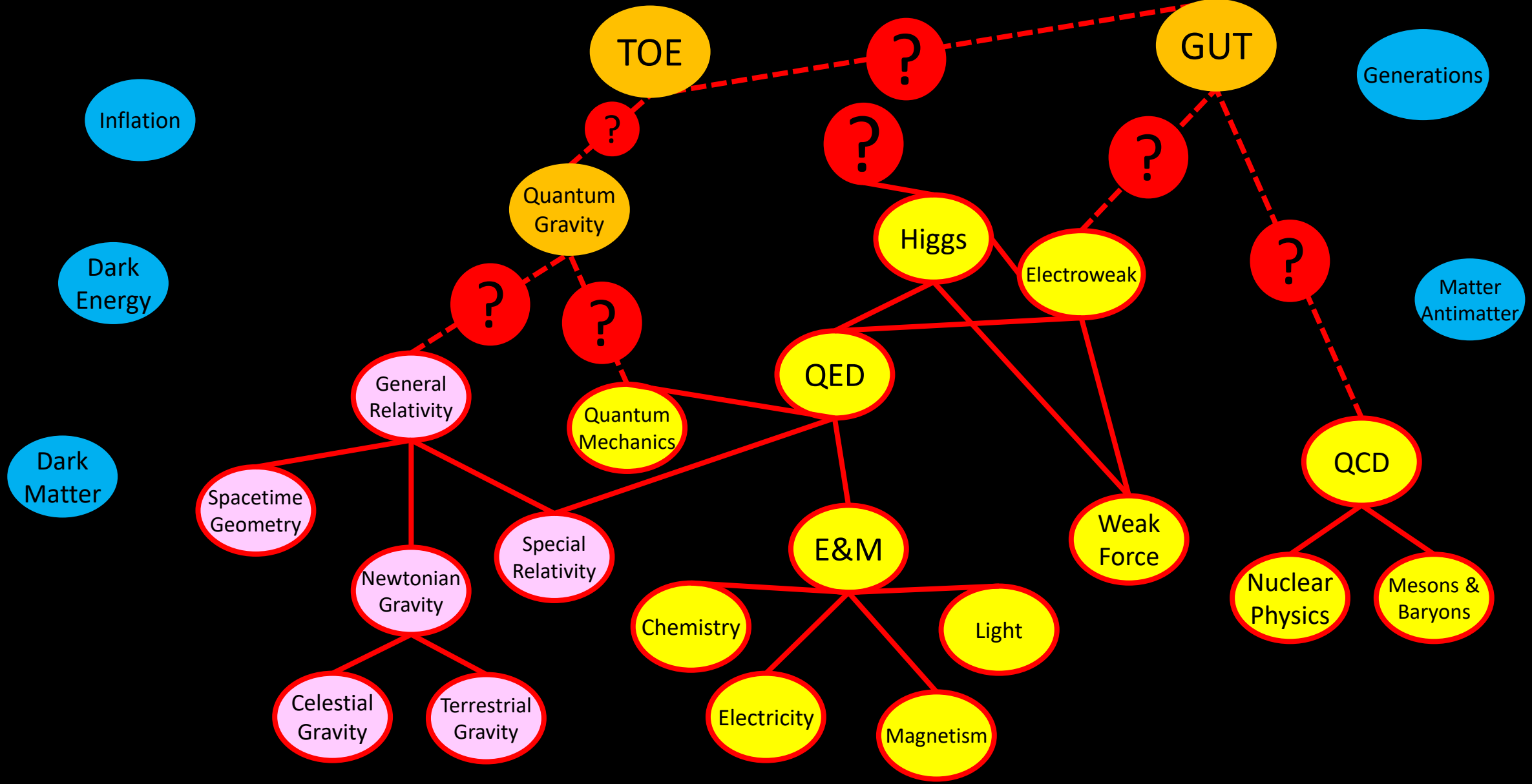
TOE Scale ~ 10^{19} GeV

Fifteen orders of magnitude!

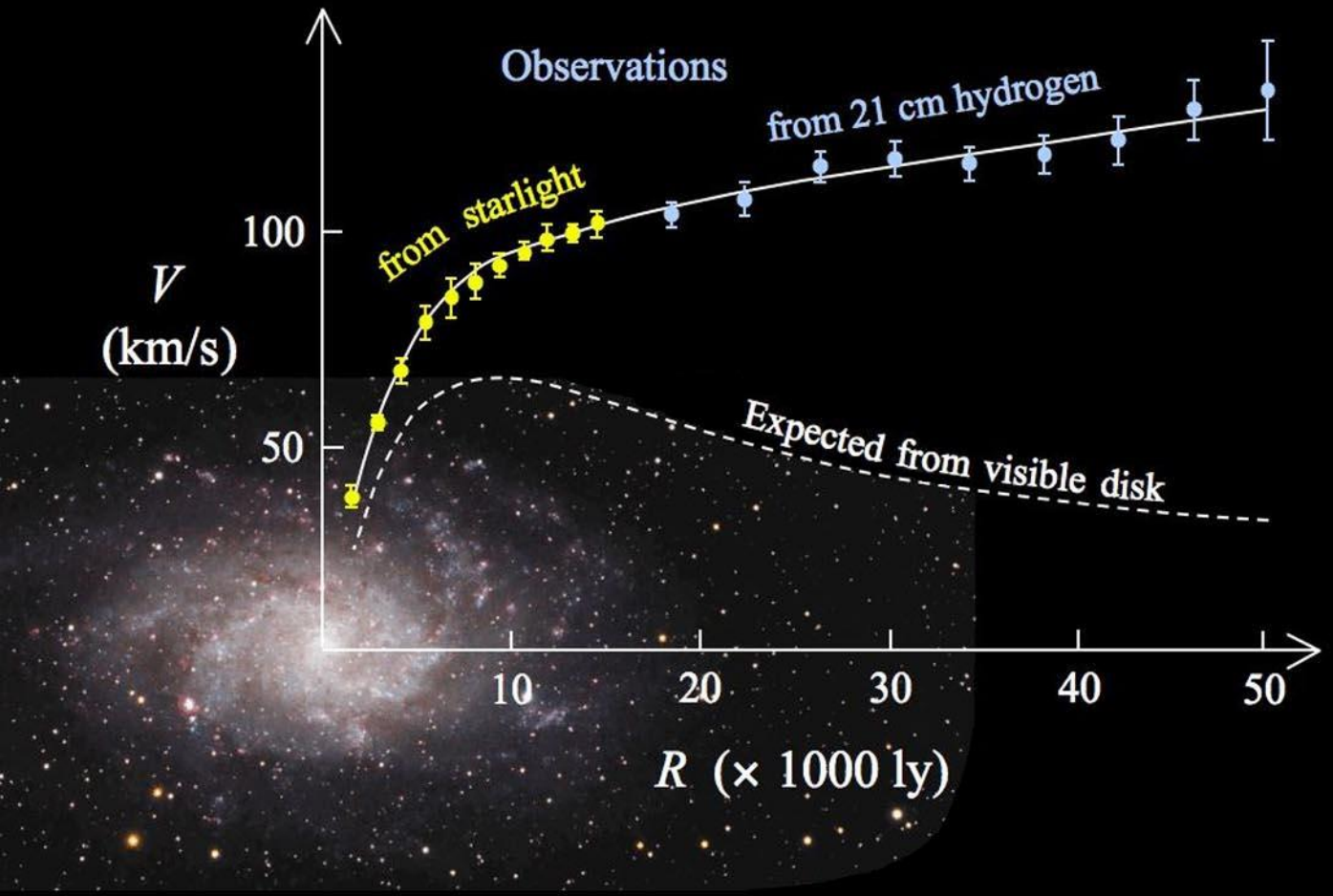
(proton to human scale)

(e.g. ×1,000,000,000,000,000)

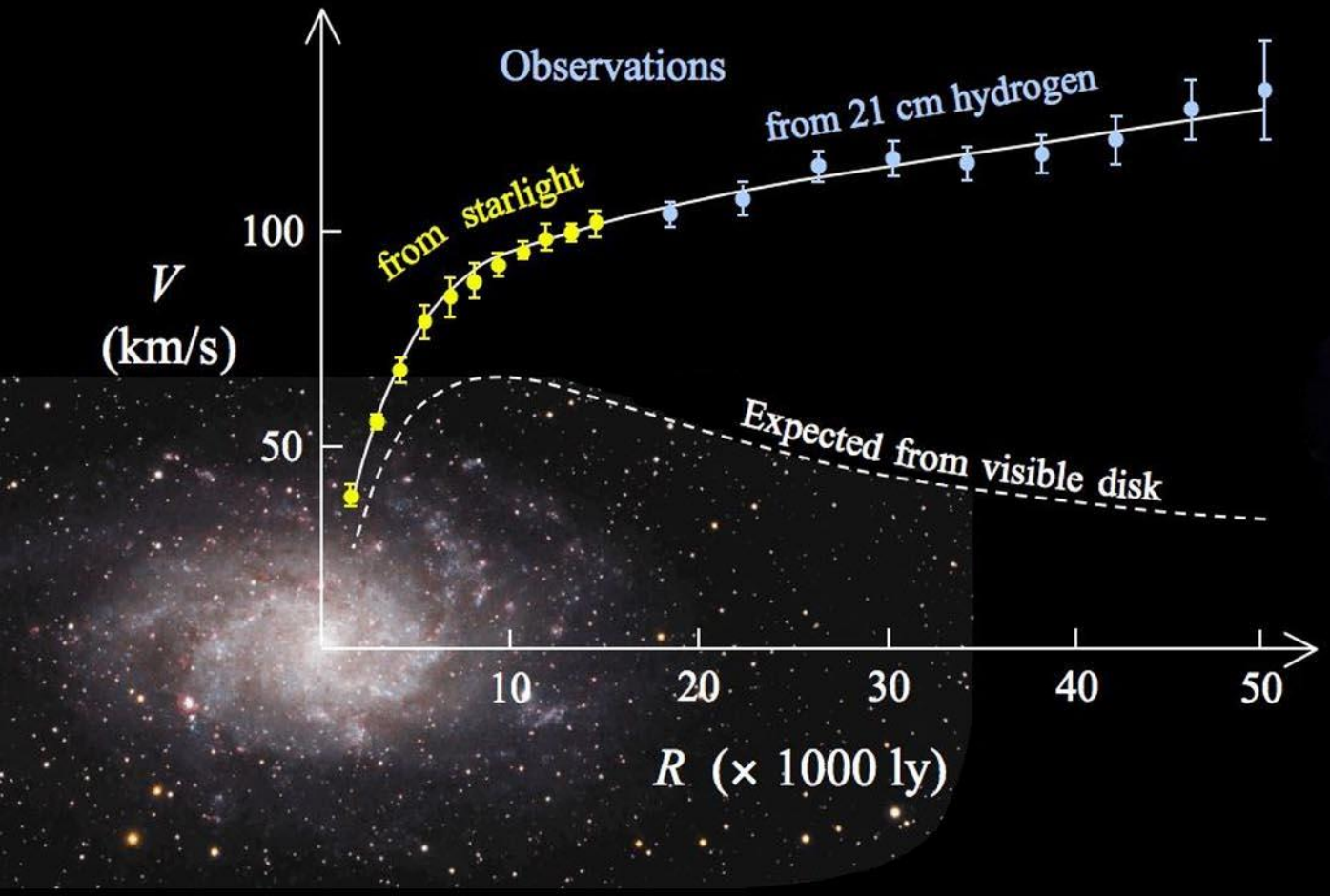
Connections: Known and Imagined

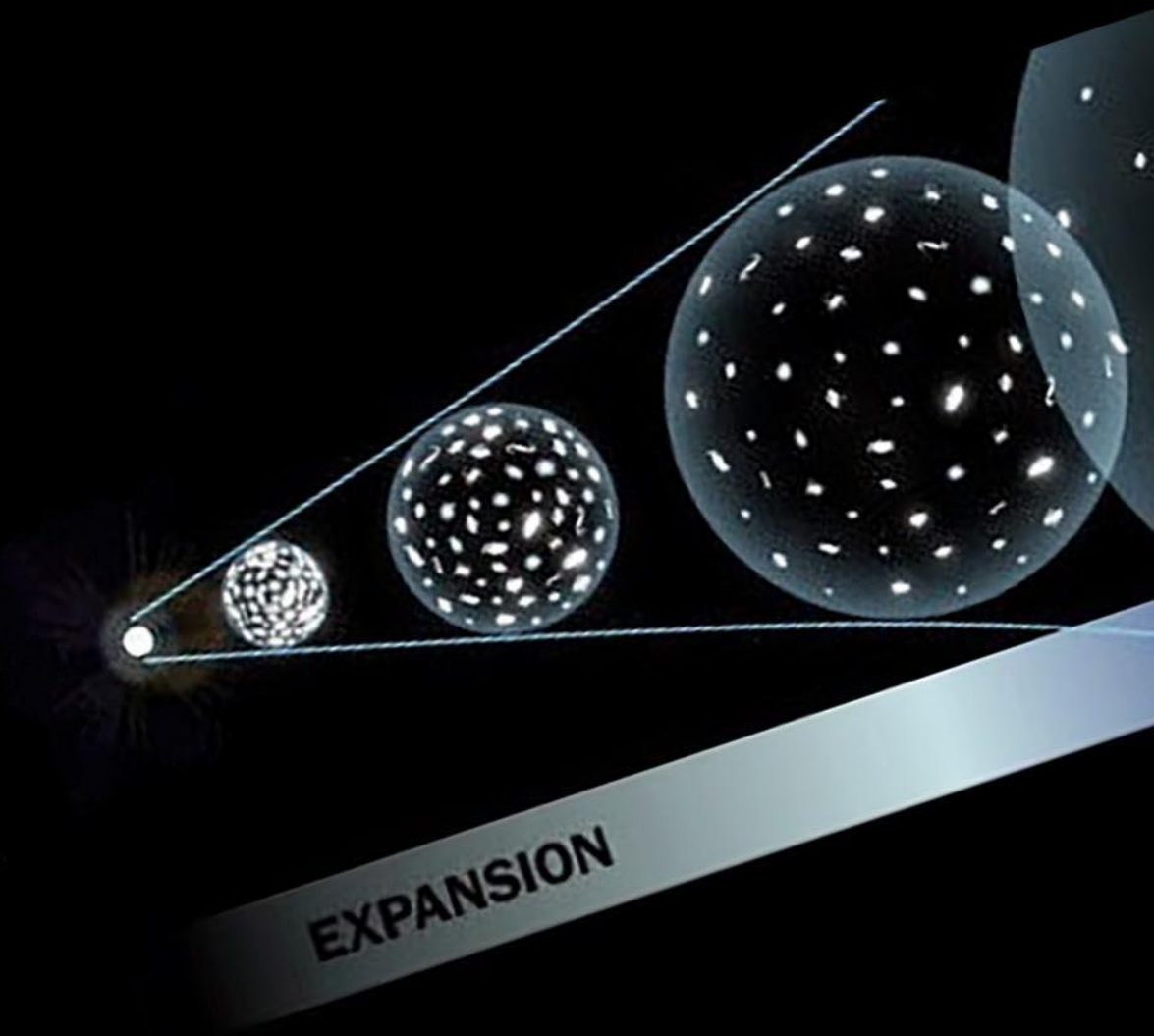


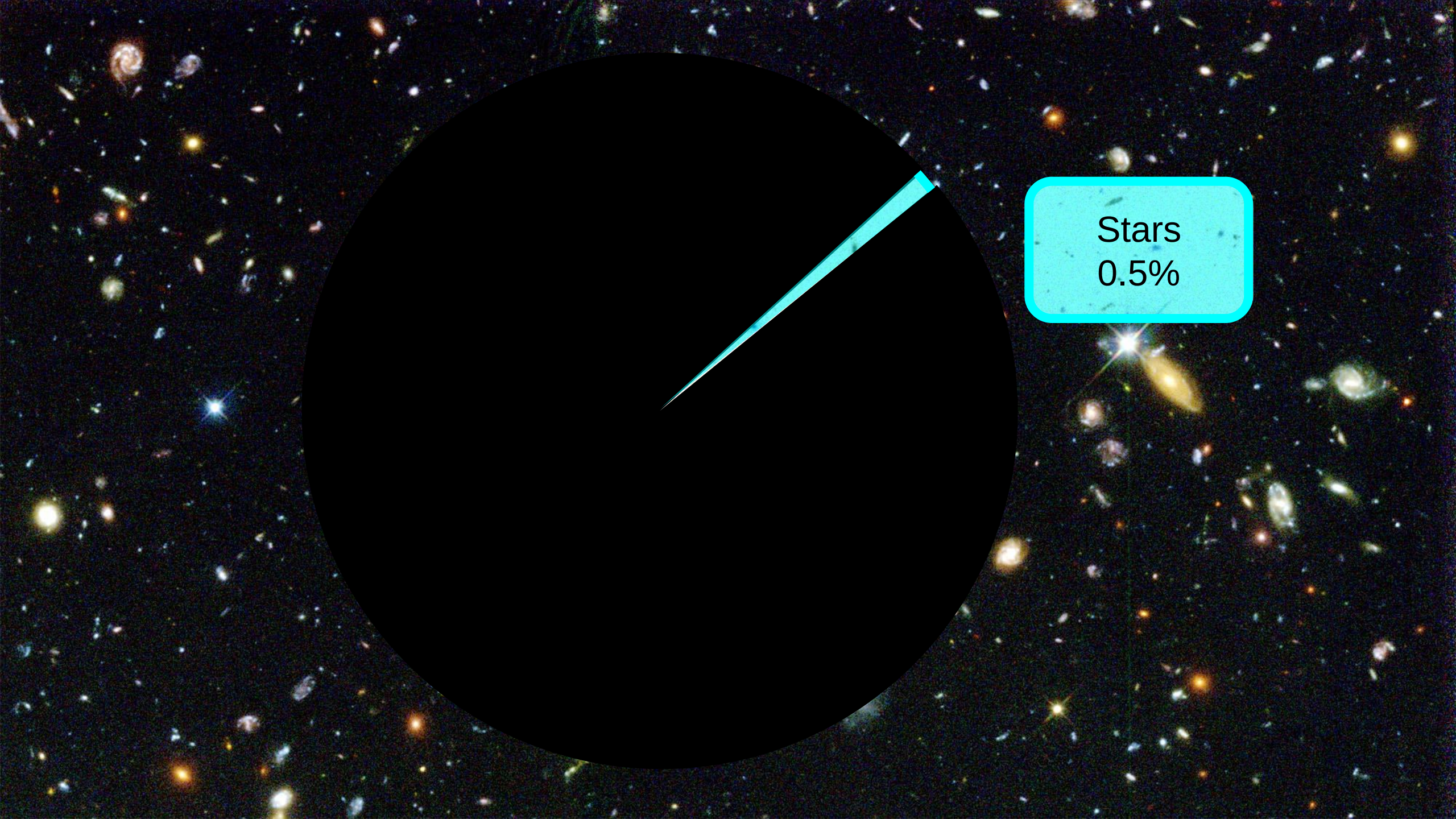
Observations from the Cosmos

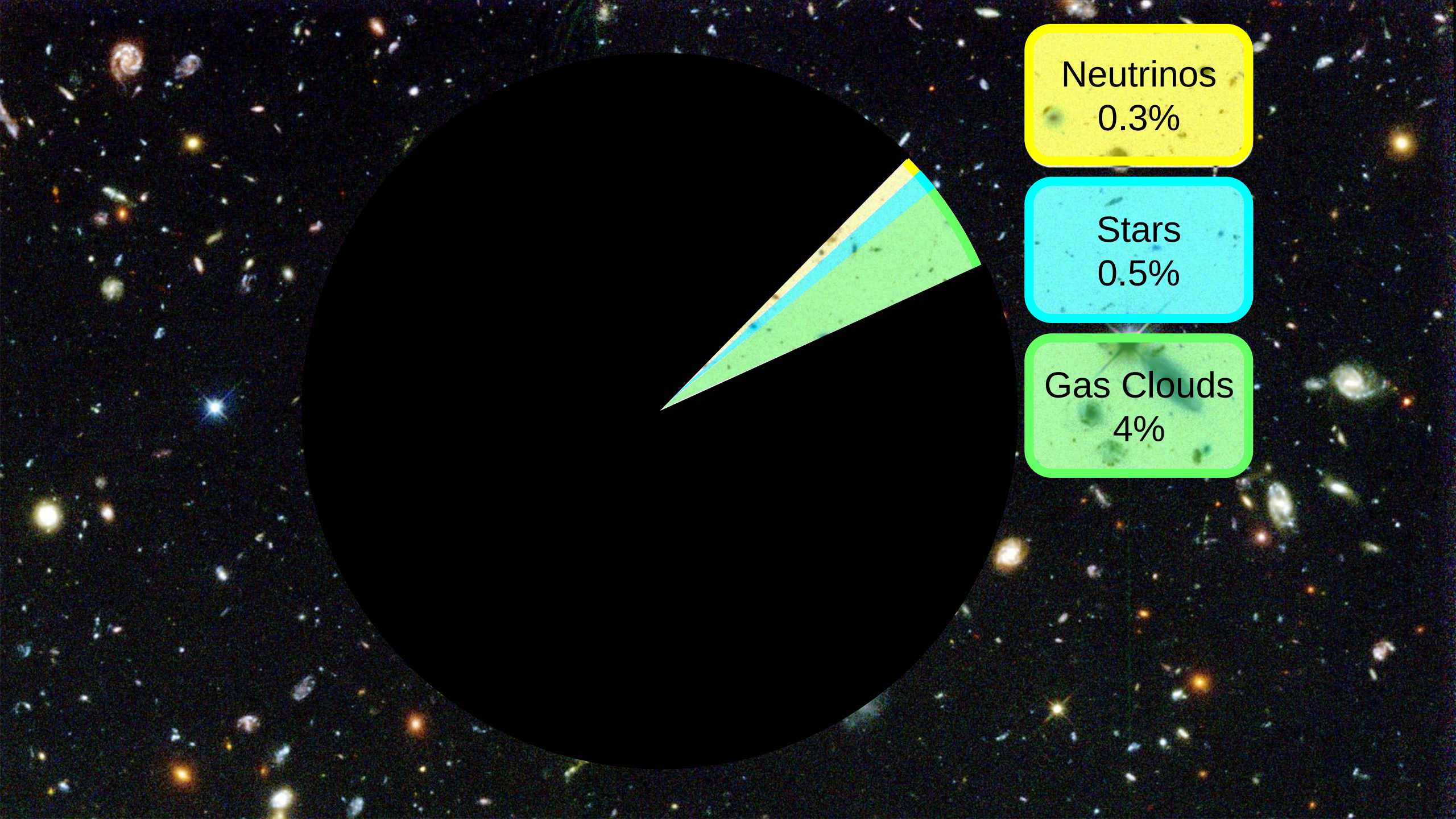


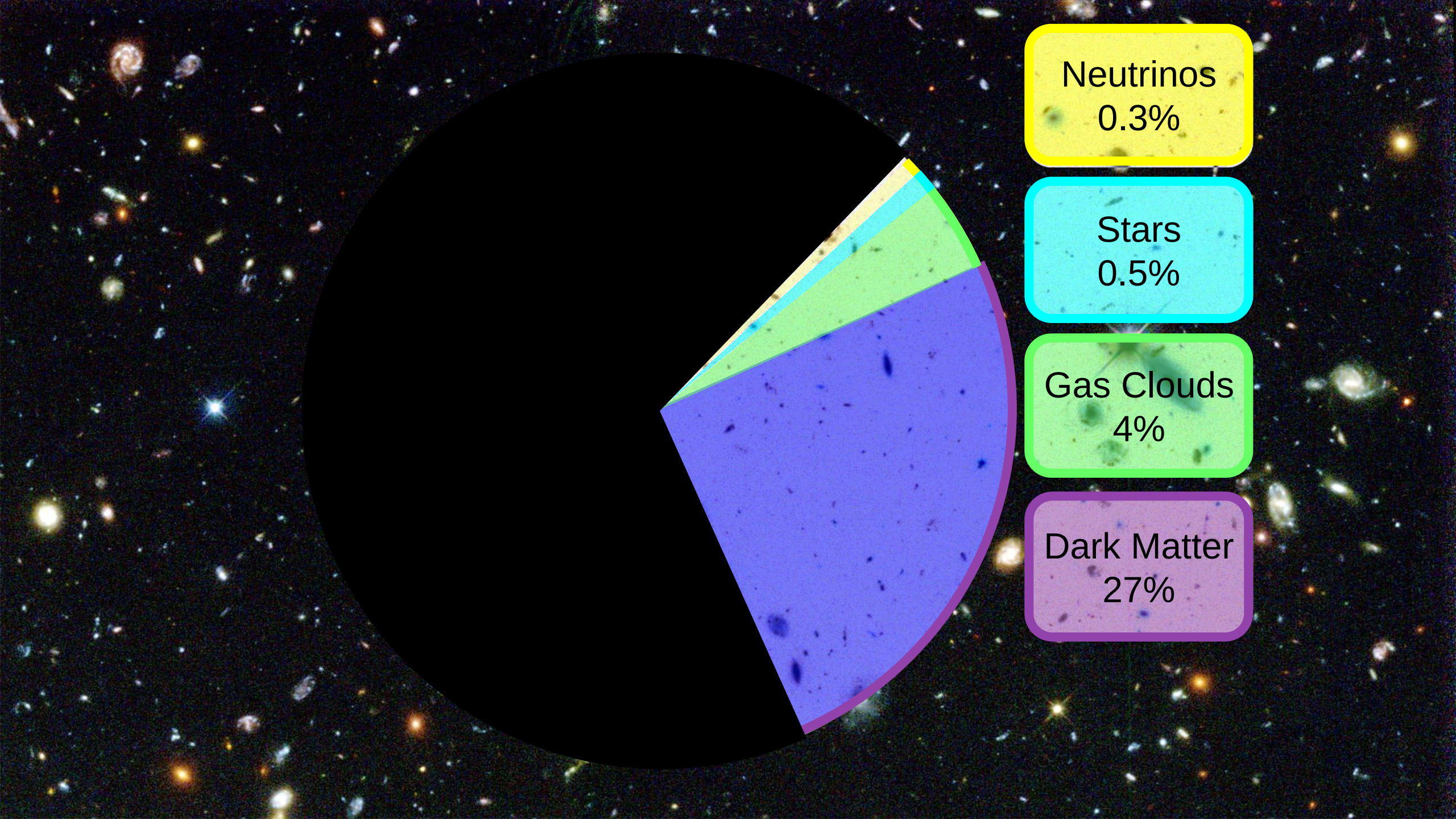
Observations from the Cosmos

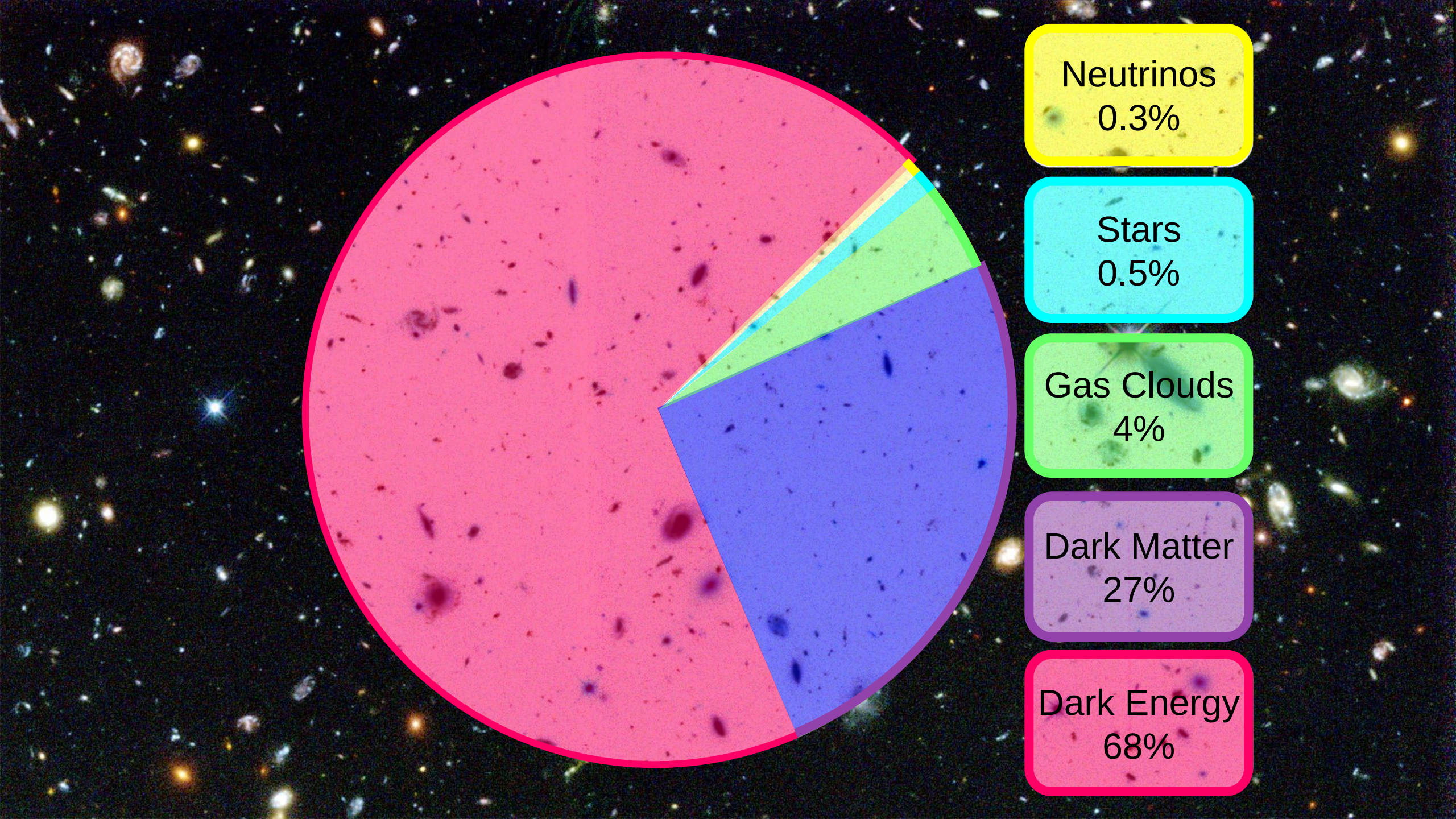





Stars
0.5%


Neutrinos
0.3%
Stars
0.5%
Gas Clouds
4%


Neutrinos
0.3%
Stars
0.5%
Gas Clouds
4%
Dark Matter
27%


Neutrinos
0.3%
Stars
0.5%
Gas Clouds
4%
Dark Matter
27%
Dark Energy
68%

Dark matter

May or may not exist (probably does)

If particulate
10^{-5} eV < M < $m_{asteroid}$

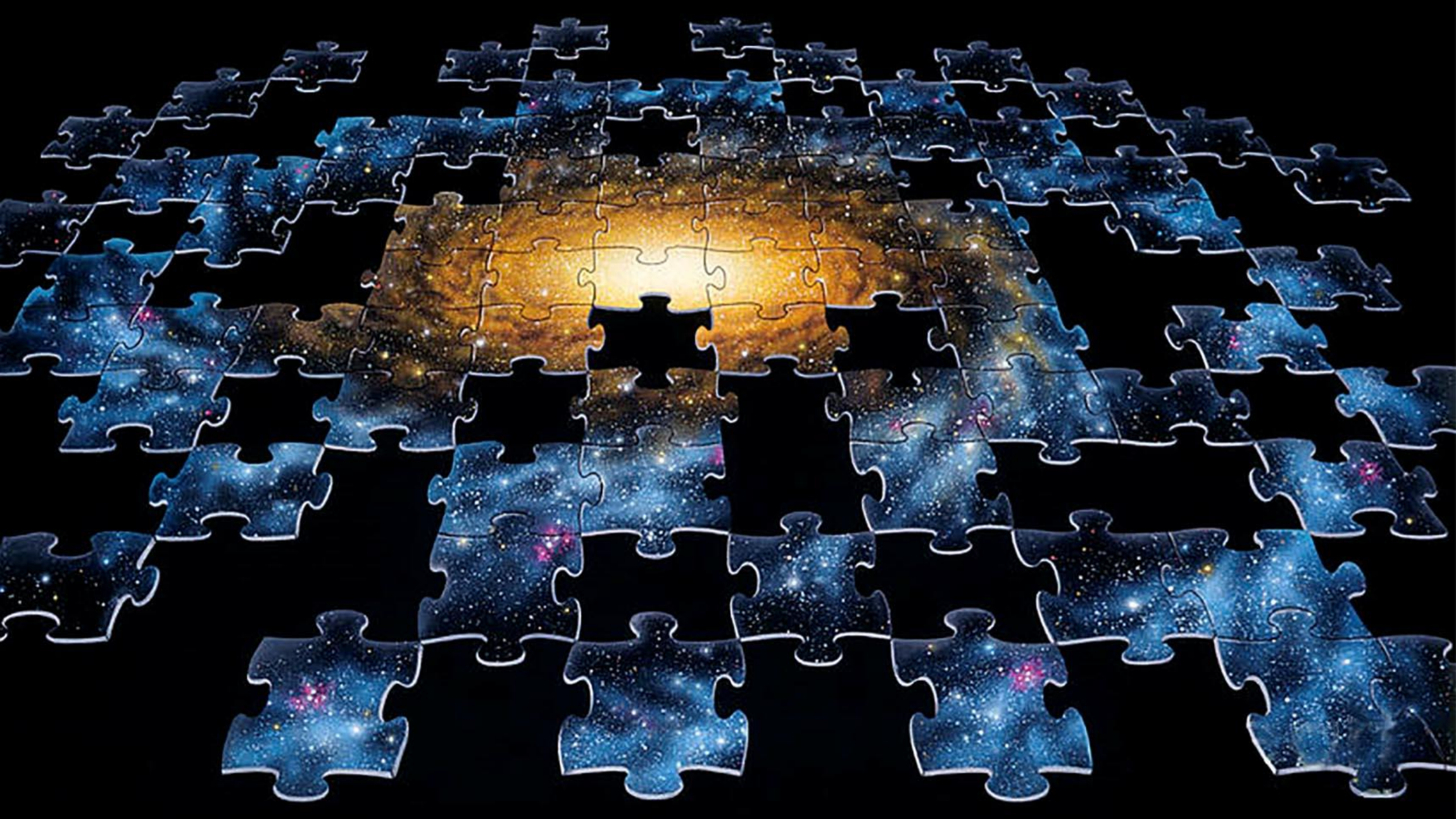
Does not experience weak force

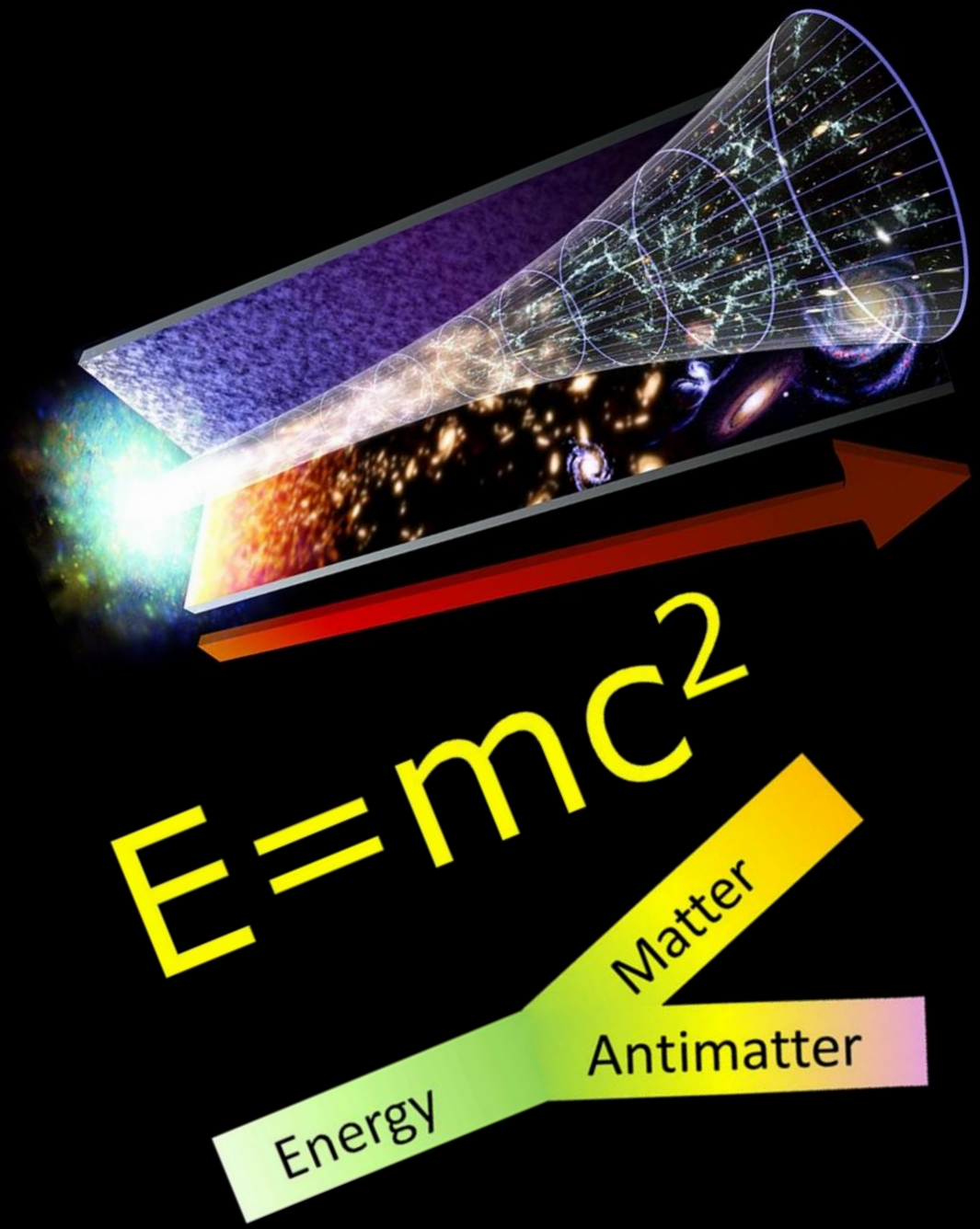
Dark energy

Expansion is accelerating

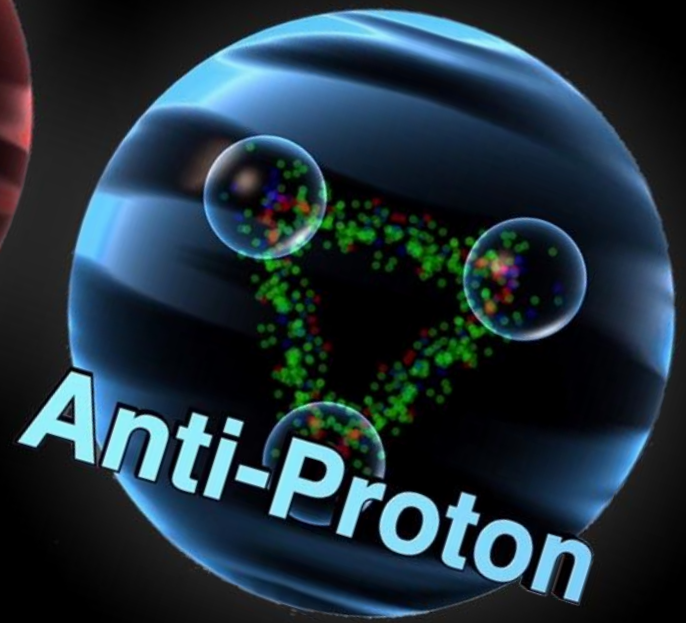
Origin is unknown, although it appears to be constant

The amount of dark energy disagrees with QFT predictions by a staggering fact 10^{120}.





Where did the antimatter go?

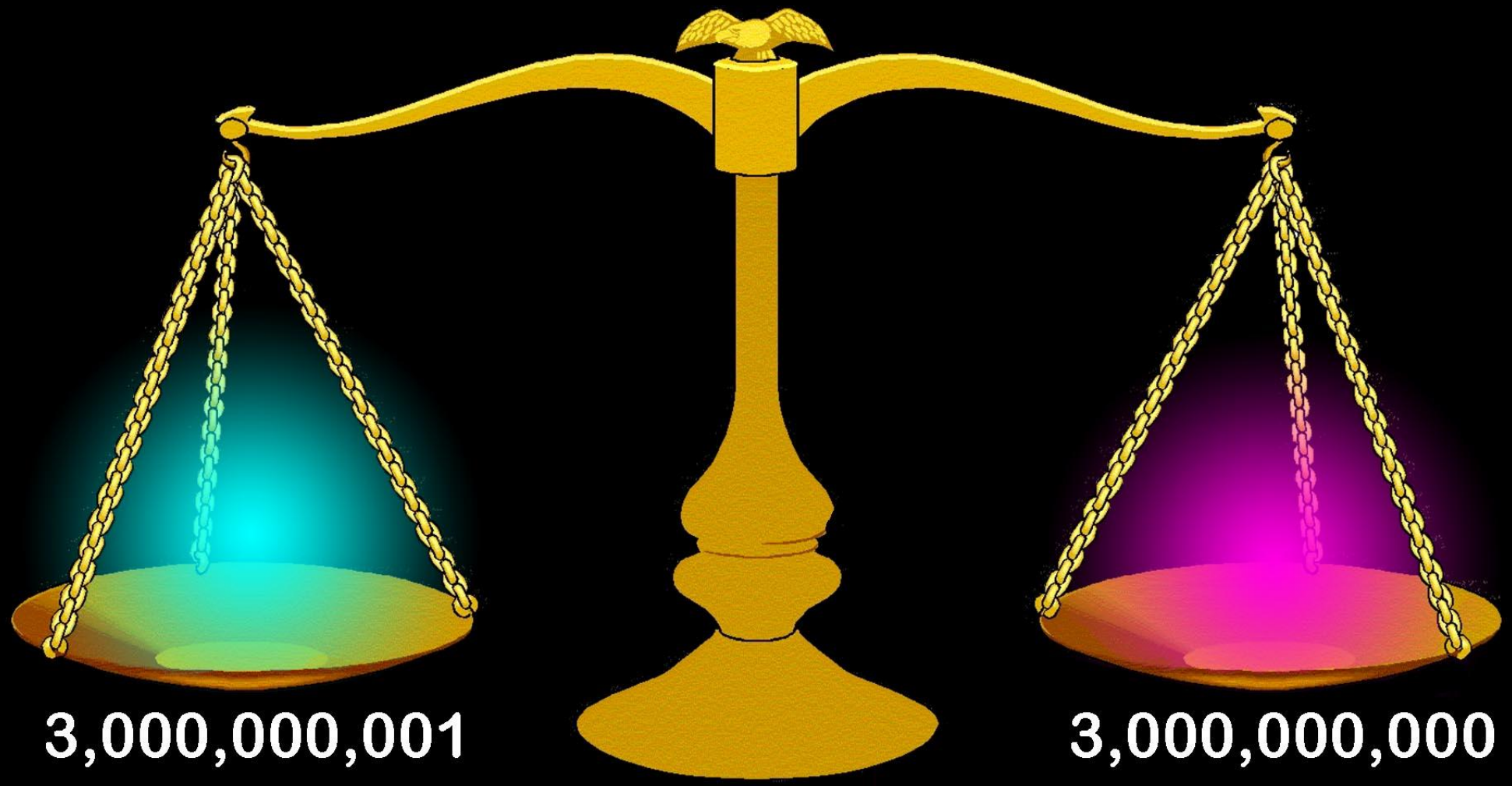


Primordial Matter

Primordial Antimatter

Primordial Matter

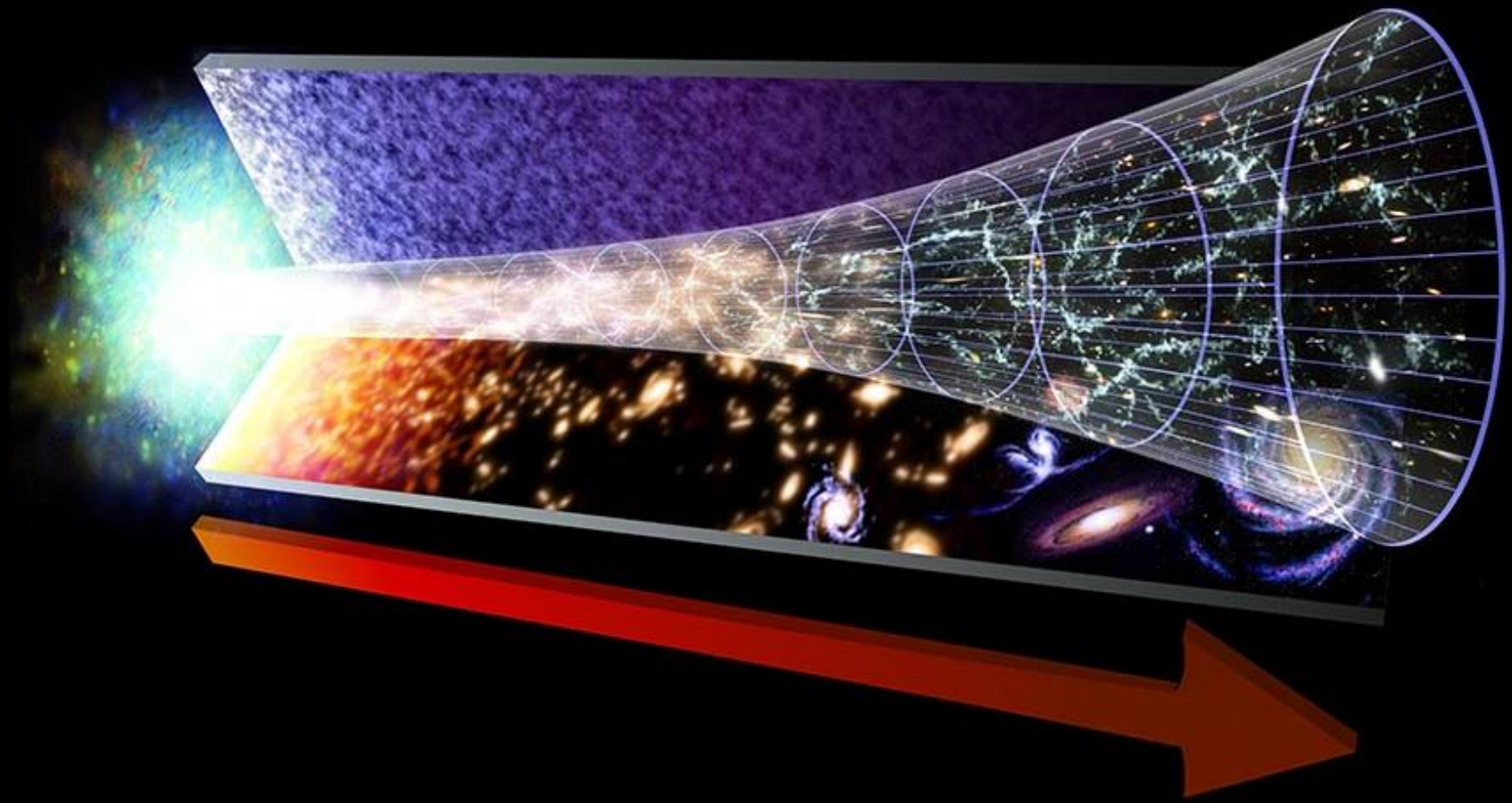
Primordial Antimatter



3,000,000,001

3,000,000,000

The Big Bang: What started it?

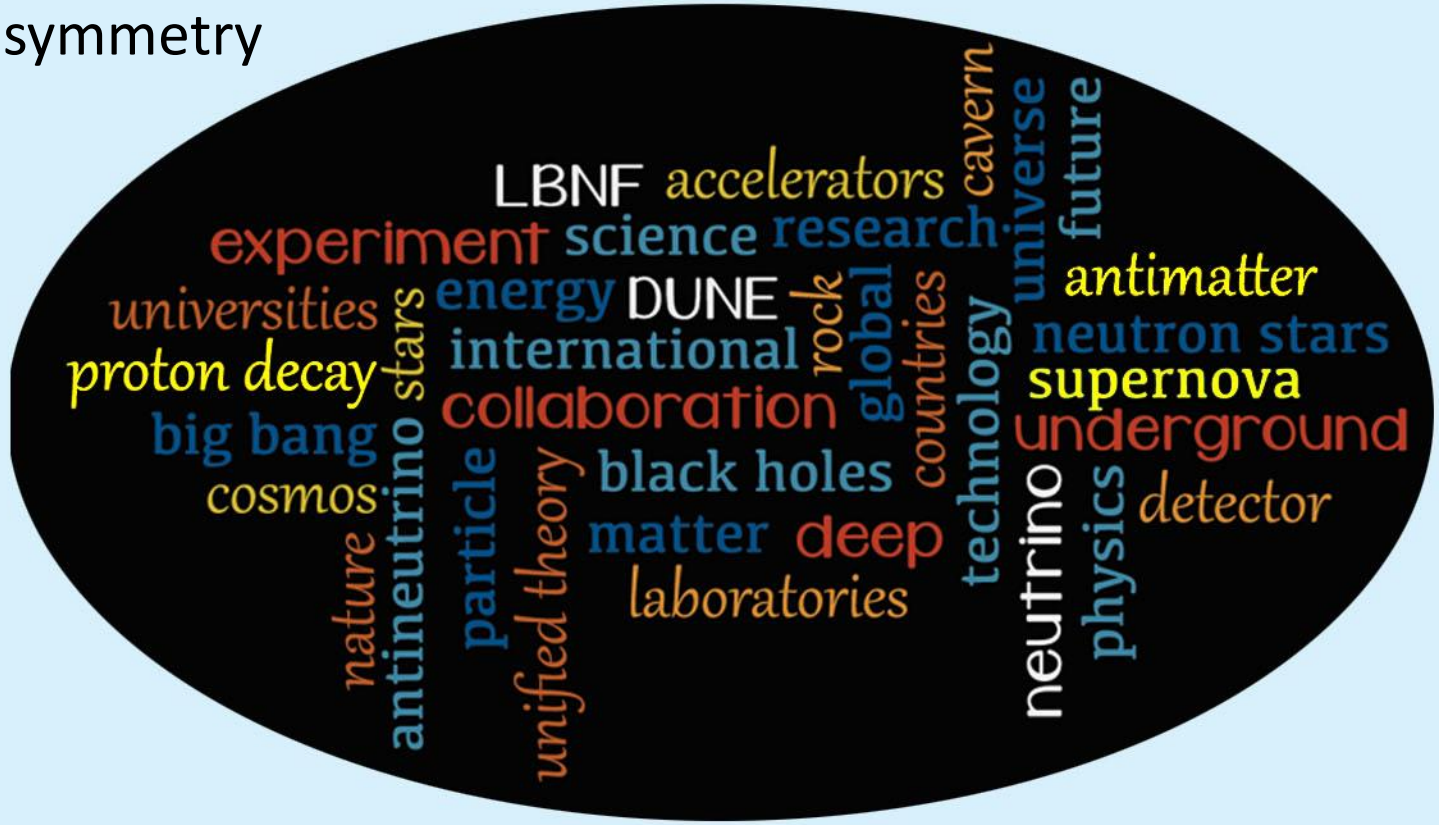


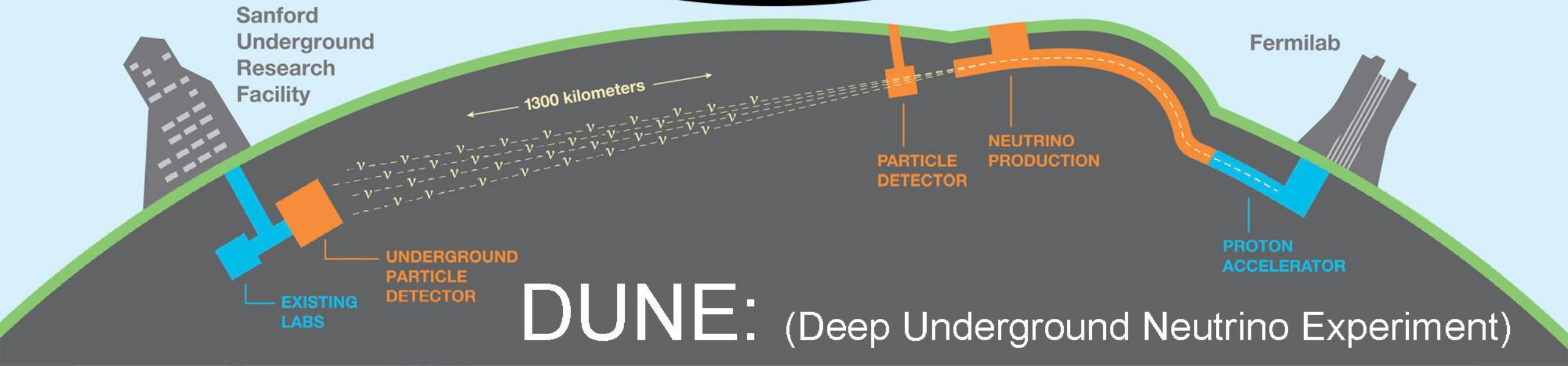
Was there a “before?”

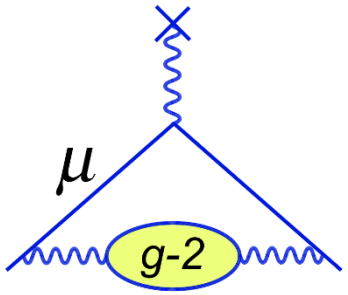
The Large Hadron Collider

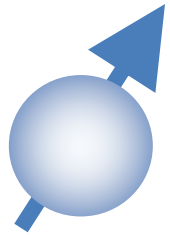
Unification
Dark Matter
New Forces
New particles
Hint of what's next

Matter/antimatter asymmetry
Proton decay









Theory

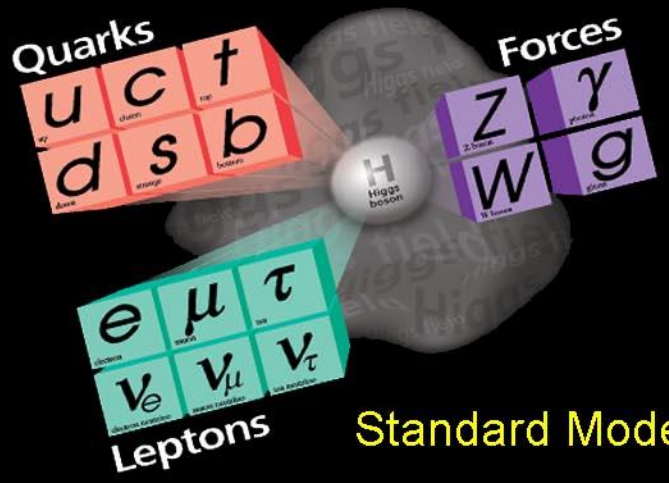
Measurement

First beam: May 31, 2017

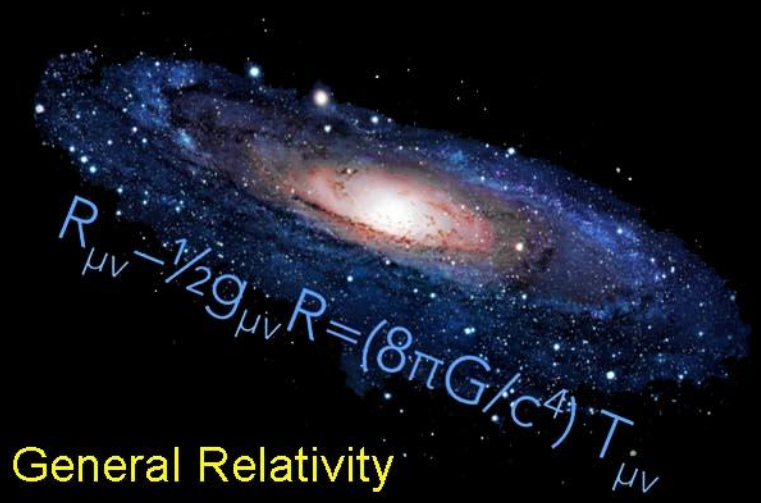
Next result: Summer 2023


DESI
LZ

What we know and what we don't

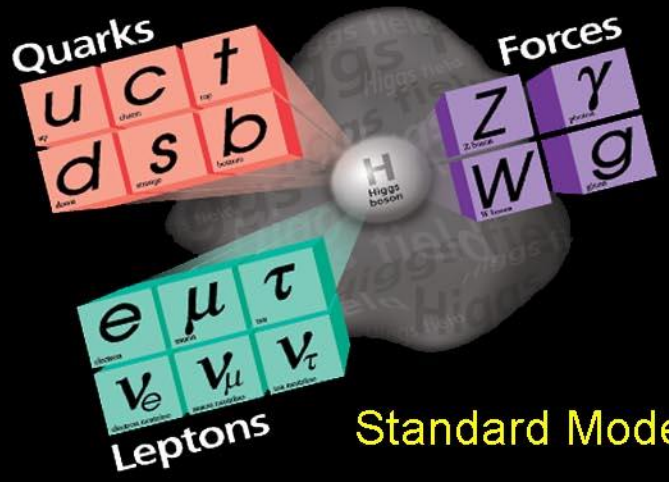


Standard Model



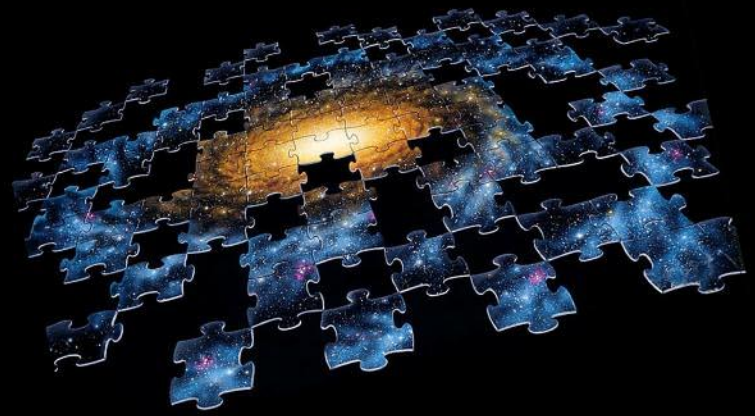
General Relativity

What we know and what we don't

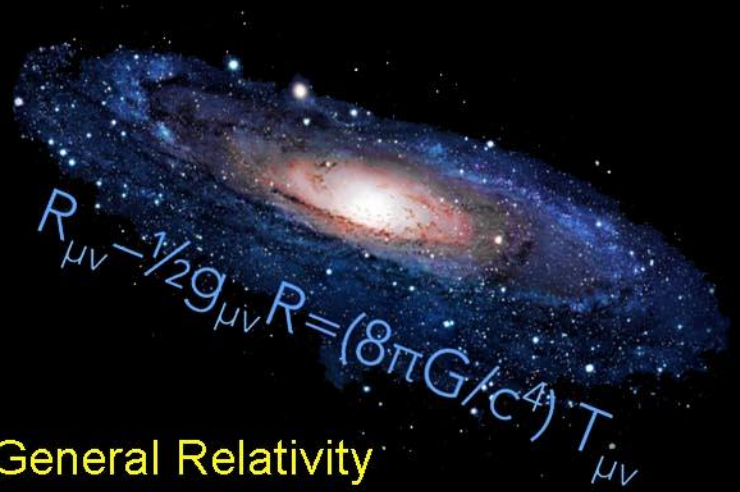


Standard Model

Dark Universe

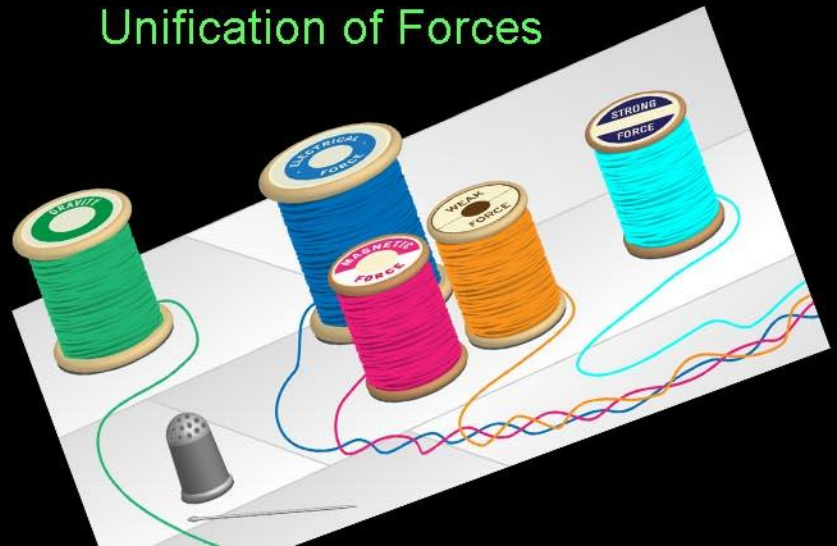


Details of the Big Bang



General Relativity

Unification of Forces



Antimatter disappearance

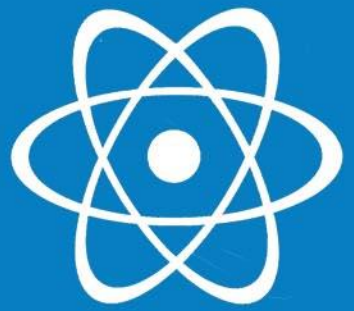
And others!


The Theory of Everything
Quantum Gravity
Grand Unified Theory
General Relativity
QCD
Electroweak
Weak Theory
QED
Newtonian Gravity
Electromagnetism

Perspective

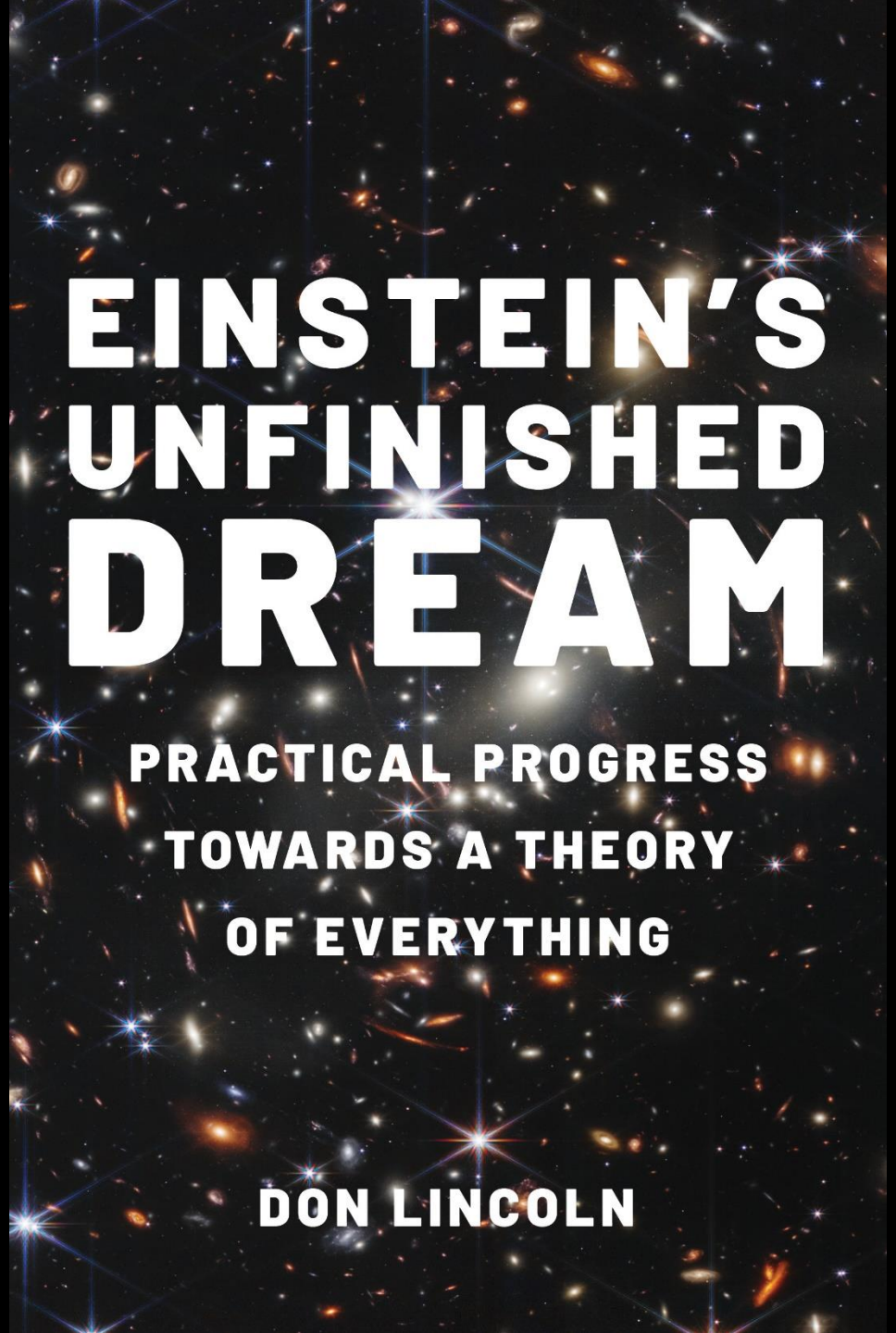
- Unification is a slow process
  - ~ 1680 – Newton merged celestial & terrestrial gravity
  - ~ 1880 – Maxwell merged electricity & magnetism
  - ~ 1970 – Higgs and many others merged E&M & weak force

- Many experiments are ongoing, looking for clues
  - Particle accelerators are exploring high energy and high precision
  - Dark matter experiments deep underground
  - Extraordinary telescopes look far away and back in time.



KEEP
CALM
AND
COLLECT
MORE DATA

http://www.facebook.com/Dr.Don.Lincoln


EINSTEIN'S
UNFINISHED
DREAM
PRACTICAL PROGRESS
TOWARDS A THEORY
OF EVERYTHING
DON LINCOLN