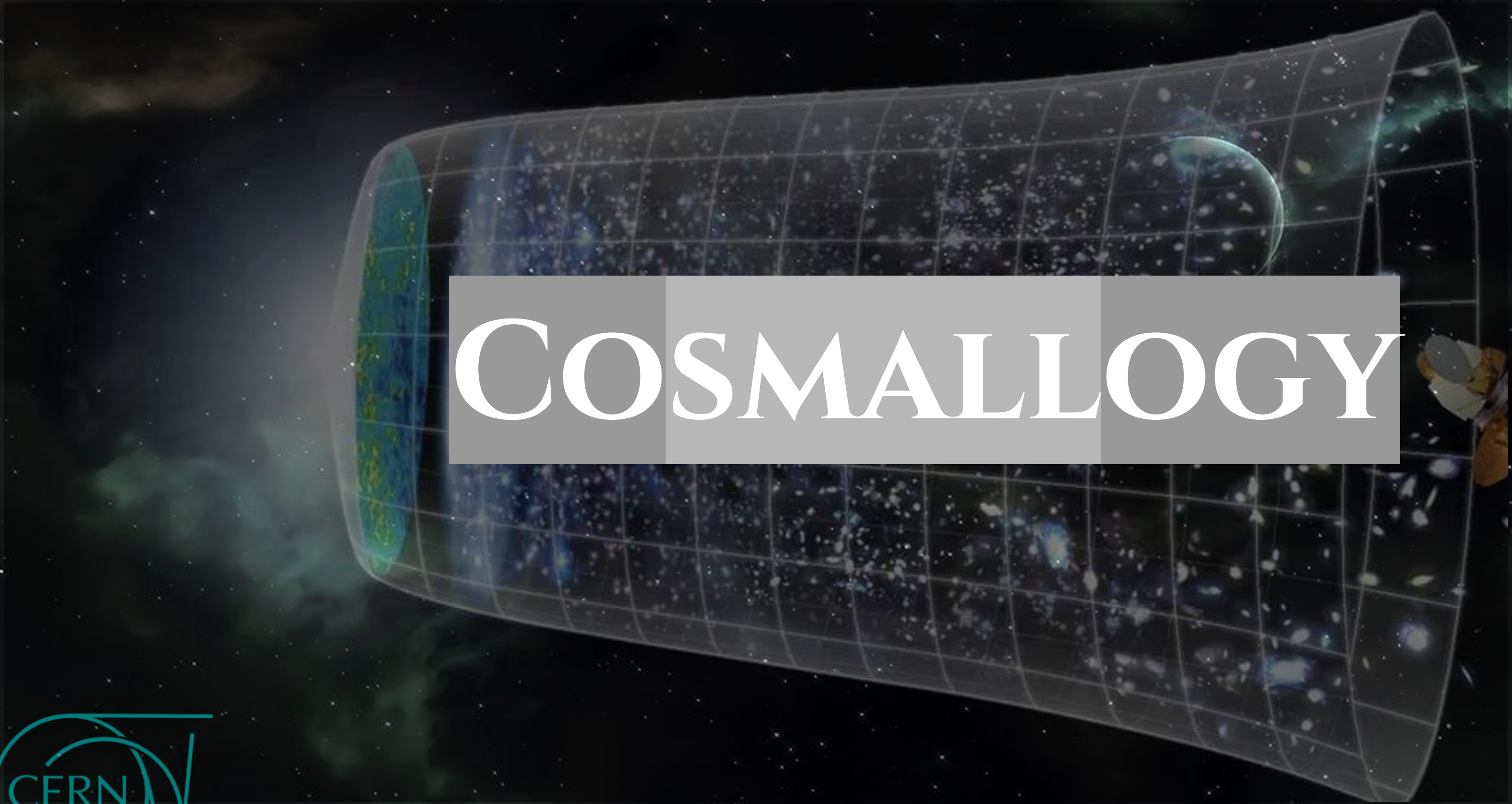
Cosmallogy



Boldureanu Andreea
Bratan Maia

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ok, so basically
im very smol

Main connections between cosmology & particle physics

01 The early universe

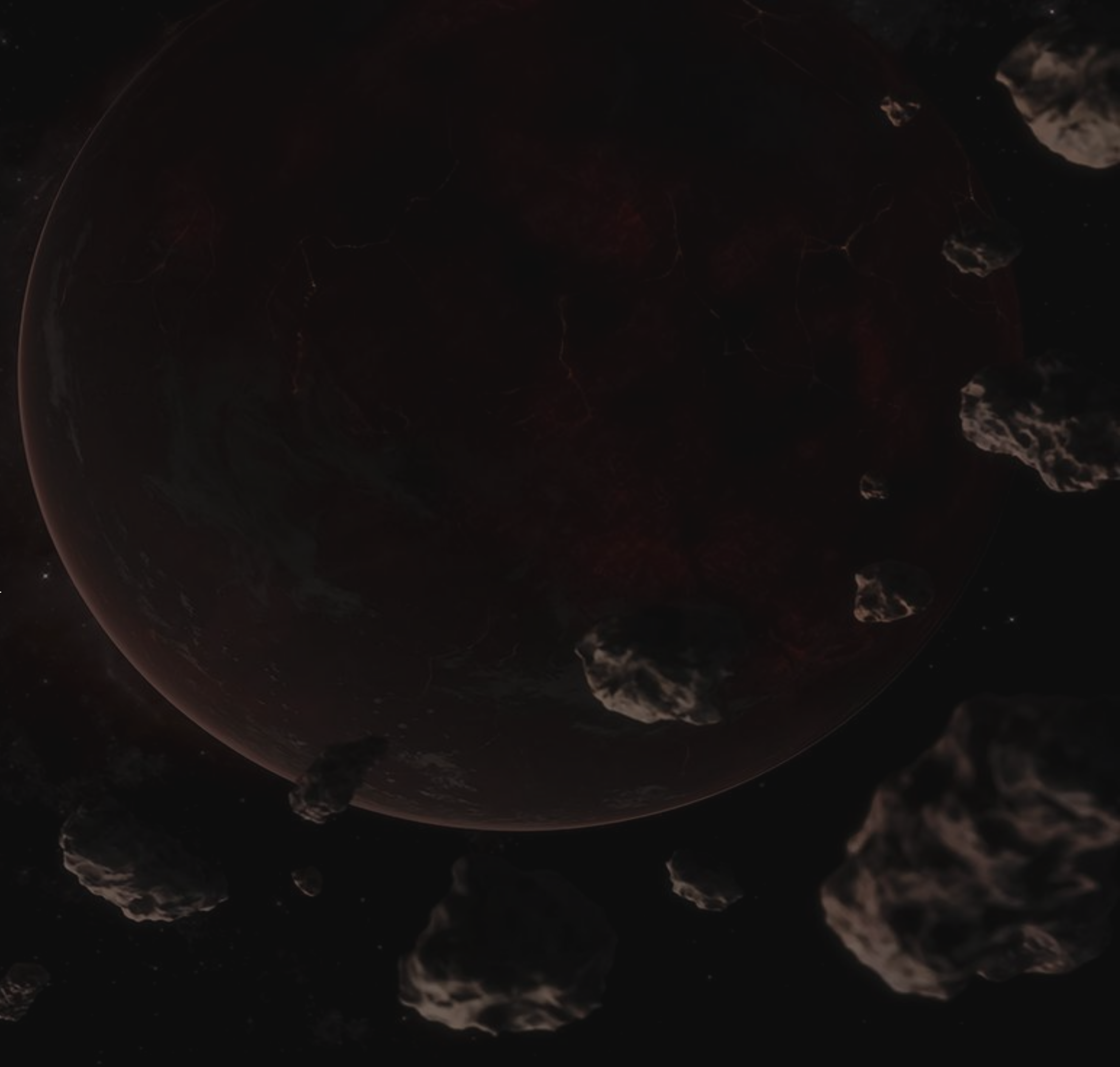
02 ΛCDM model

03 Cosmic Microwave Background

04 CERN experiments

1

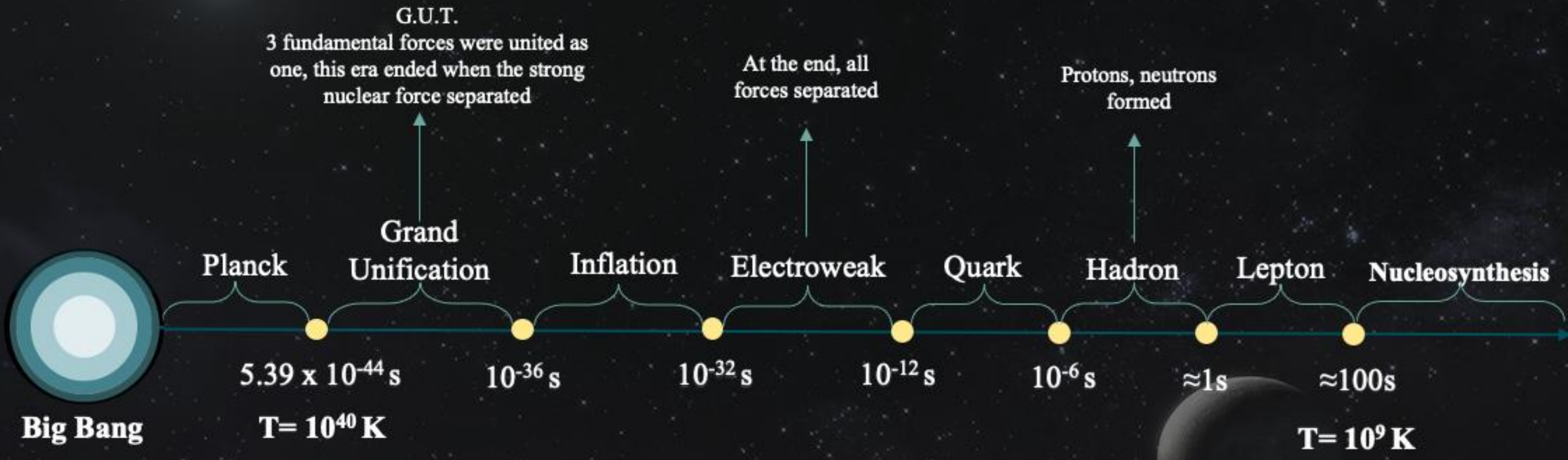
The Early universe



Georges Lemaître
1927
Hypothesis of the Primeval Atom

Edwin Hubble

Radiation Era ≈ 50.000 years



* The strong nuclear force is responsabile for the strong bond between neutrons and protons in atomic nuclei

* Weak nuclear force is responsible for the radioactive decay processes and the nuclear fusion inside stars

Source:
Author's own graph

I. PARTICLE BEHAVIOR IN THE EPOCHS

I. ELECTROWEAK

- Quark-gluon plasma
- Large numbers of exotic particles (W, Z, Higgs Bosons)

II. BETWEEN ELECTROWEAK-QUARK

- Baryogenesis (baryon asymmetry problem—- quarks dominate)

III. QUARK

- Quarks, electrons, neutrinos form
- Quarks not bound in Hadrons!

IV. HADRON

- Protons, neutrons formed

I. PARTICLE BEHAVIOR IN THE EPOCHS

V. LEPTON

- Leptogenesis (dominance of leptons over anti-leptons)

VI. NUCLEAR

- Atomic nuclei formed
- Energy dominated by photons

II. FUNDAMENTAL FORCES

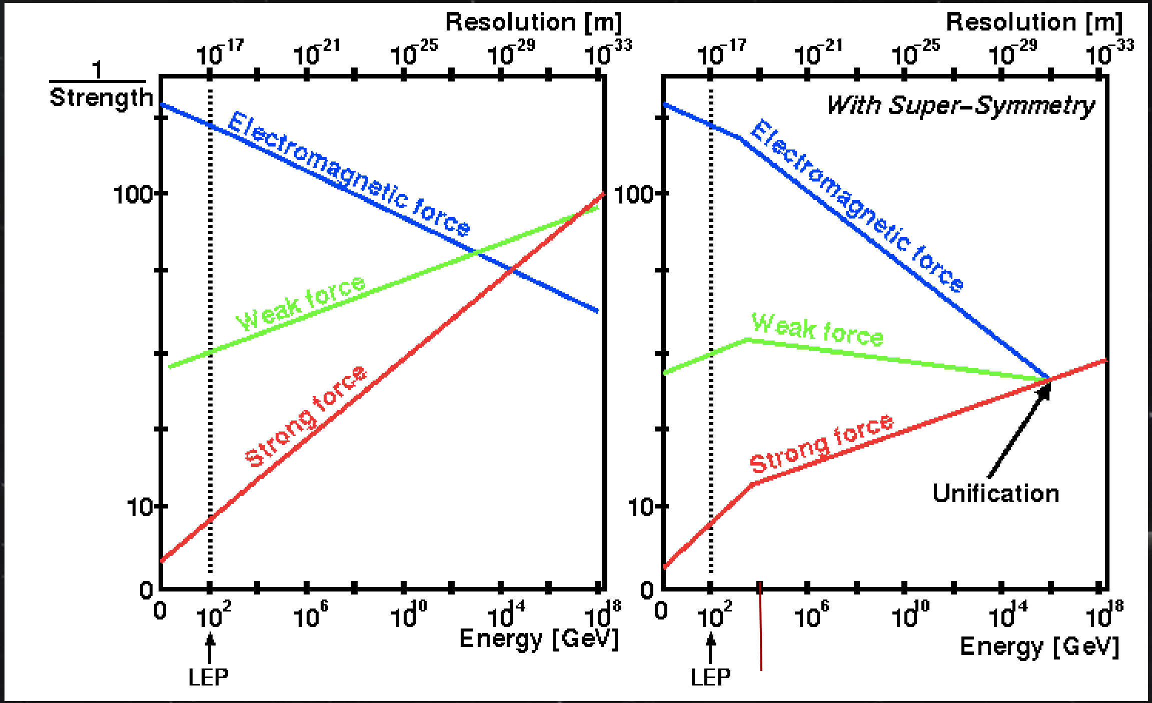
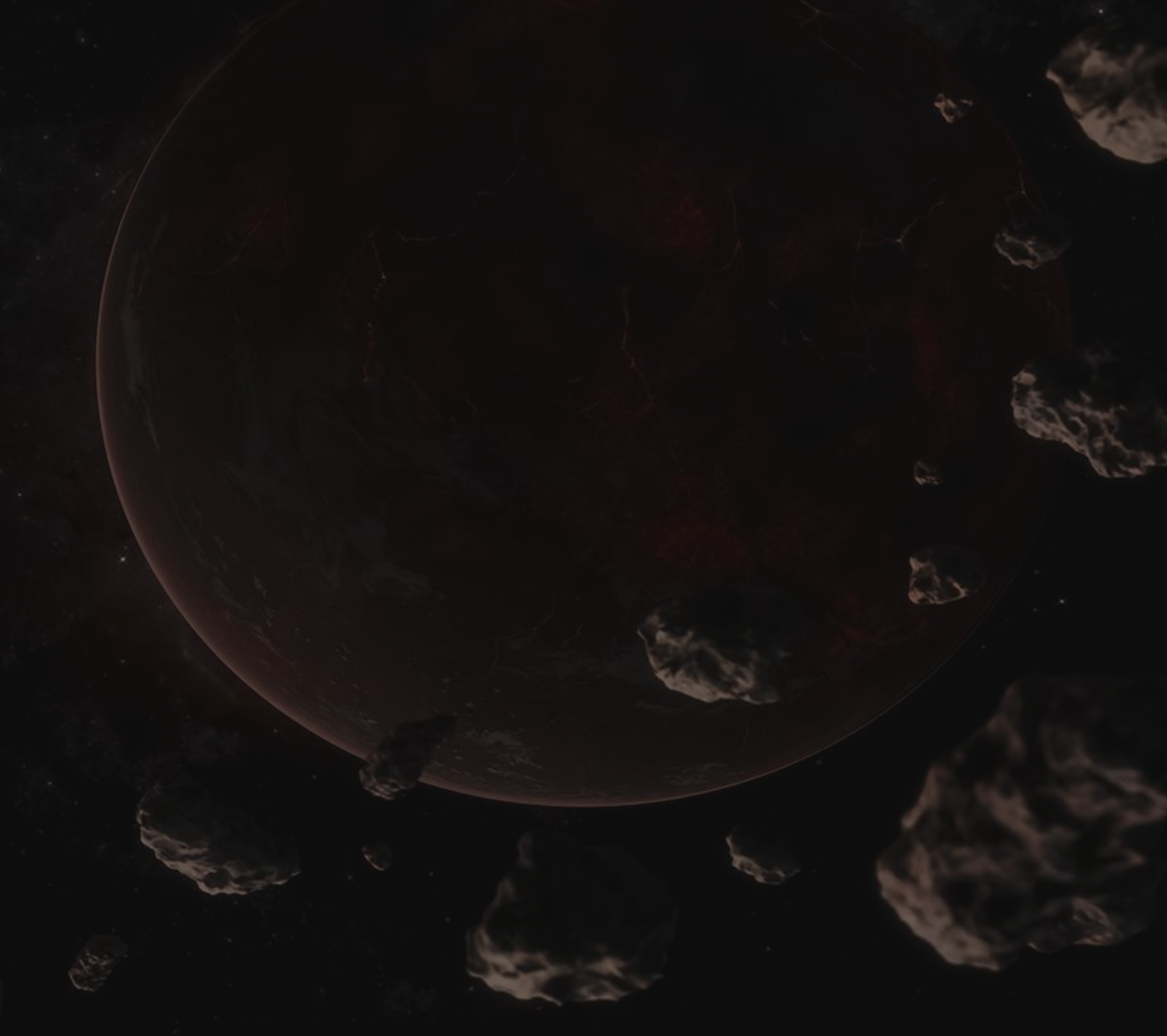


Figure 1: Strength reciprocal vs. energy graph not taking into account SUSY (left) and taking it (right)

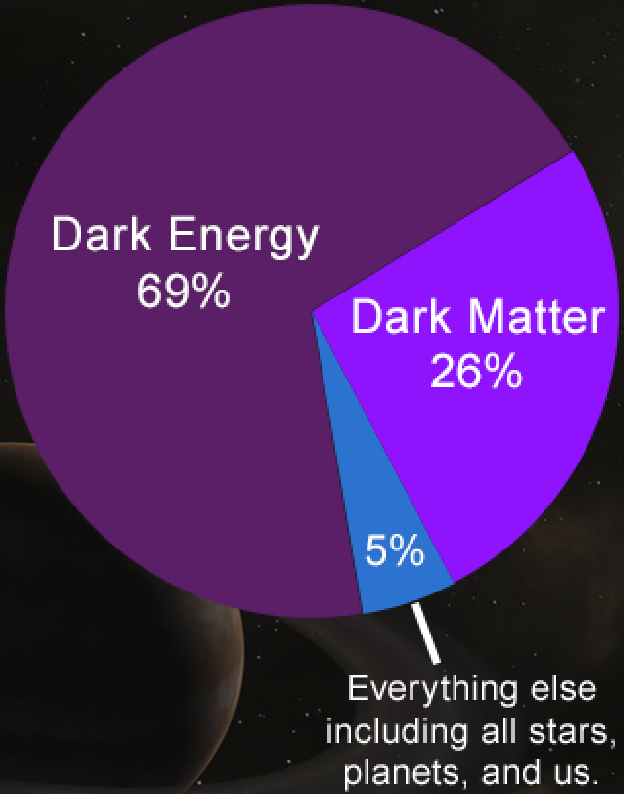
Source: *CERN, „Particle Physics Education CD-ROM," 1999.*

2

ΛCDM MODEL



What are these particles?



How do they work?

Figure 2: Content of the universe
Source: *https://chandra.harvard.edu/darkuniverse/*

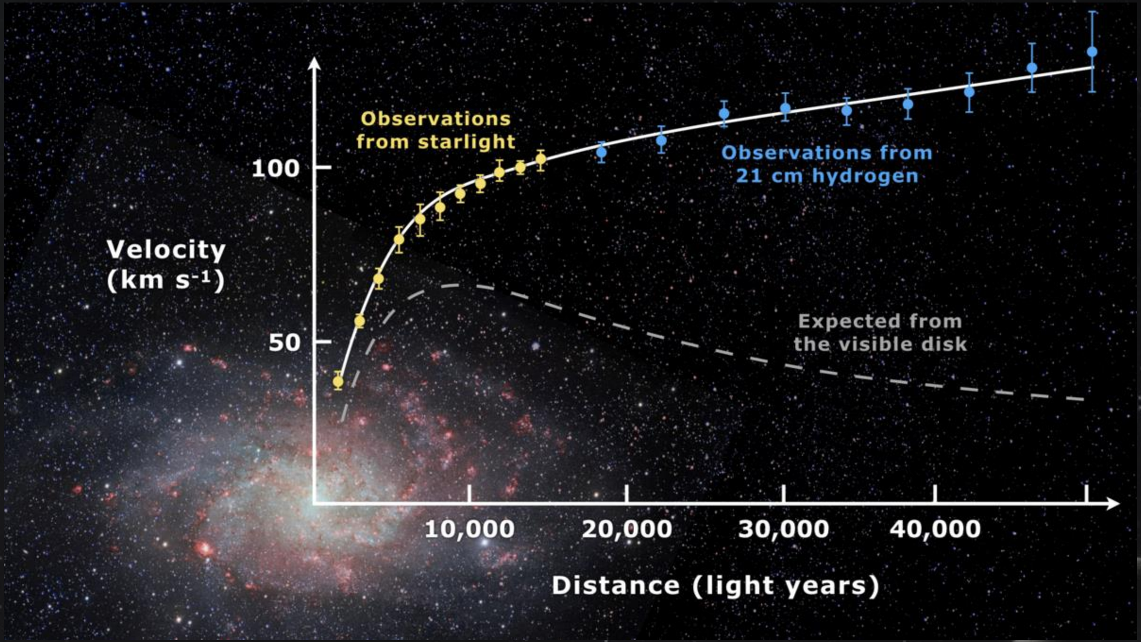


Figure 3: Observed vs expected galaxy velocities
Source:*https://commons.wikimedia.org/wiki/File:Rotation_curve_of_spiral_galaxy_Messier_33_(Triangulum).png*

Vera Rubin

Fritz Zwicki

DARK MATTER

Possible candidates

I. **WIMPs**

(Weakly interacting massive particle)

II. **Axions**

III. **Sterile Neutrinos**

The WIMPs

Heavy, electromagnetically neutral subatomic particle that is hypothesized to make up most dark matter and therefore some 22% of the universe

Characteristics:

- They don’t absorb/emit light
- They don’t interact strongly with other particles

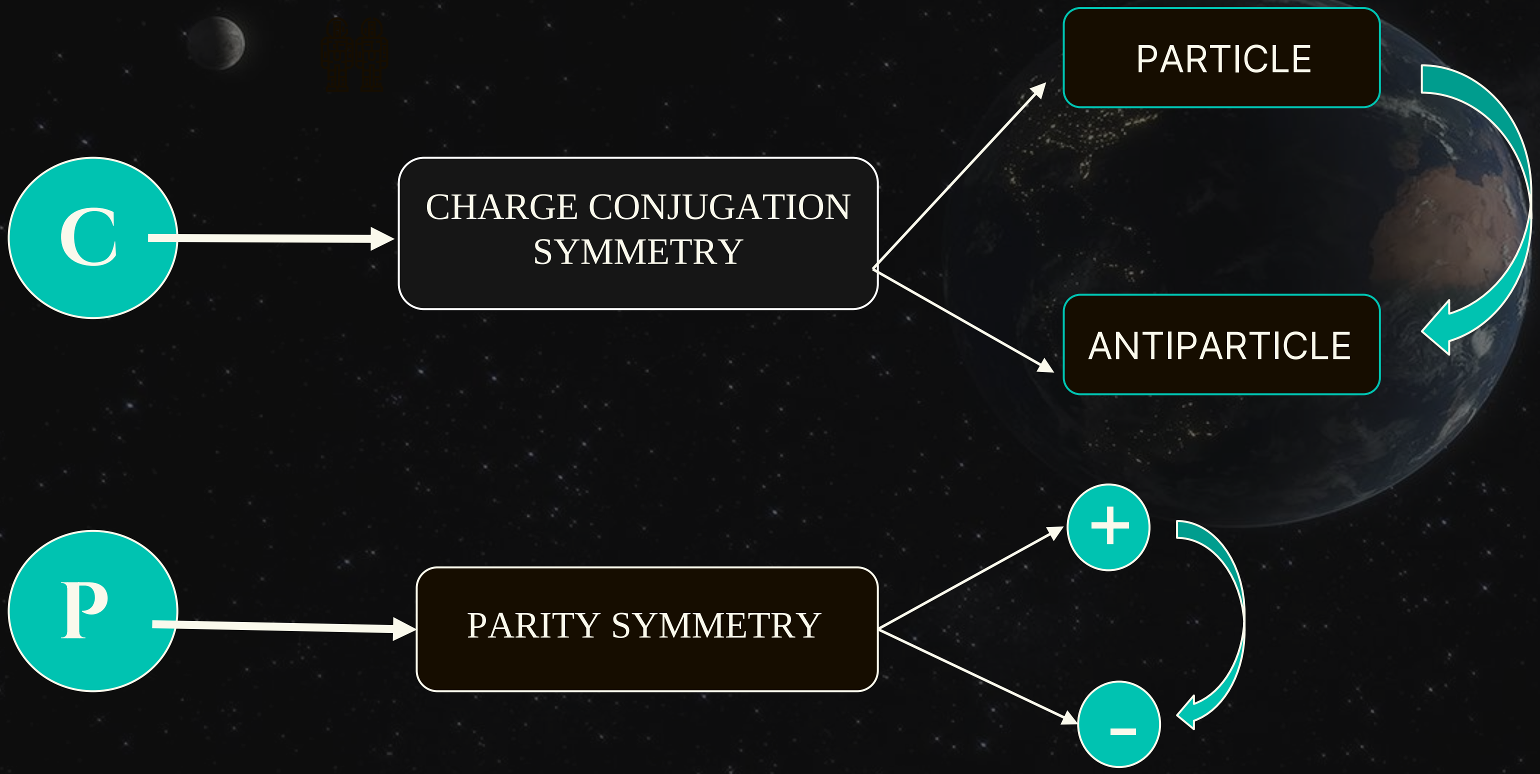
AXIONS

Axions are another well-motivated dark matter candidate. They were proposed to resolve the strong CP problem.

Characteristics:

- No electric charge
- Very small mass
- Very low interaction for strong and weak forces

CP Problem



Source:
Author's own graph

Sterile neutrinos

A special kind of neutrino that has been proposed to explain some unexpected experimental results, but they have not been definitively discovered. Scientists are looking hard for them in many different experiments.

Characteristics:

- No electric charge
- Very small mass
- Very low interaction for strong and weak forces


EXPANSION OF THE UNIVERSE
QUINTESSENCE

ΛCDM Model of Cosmology

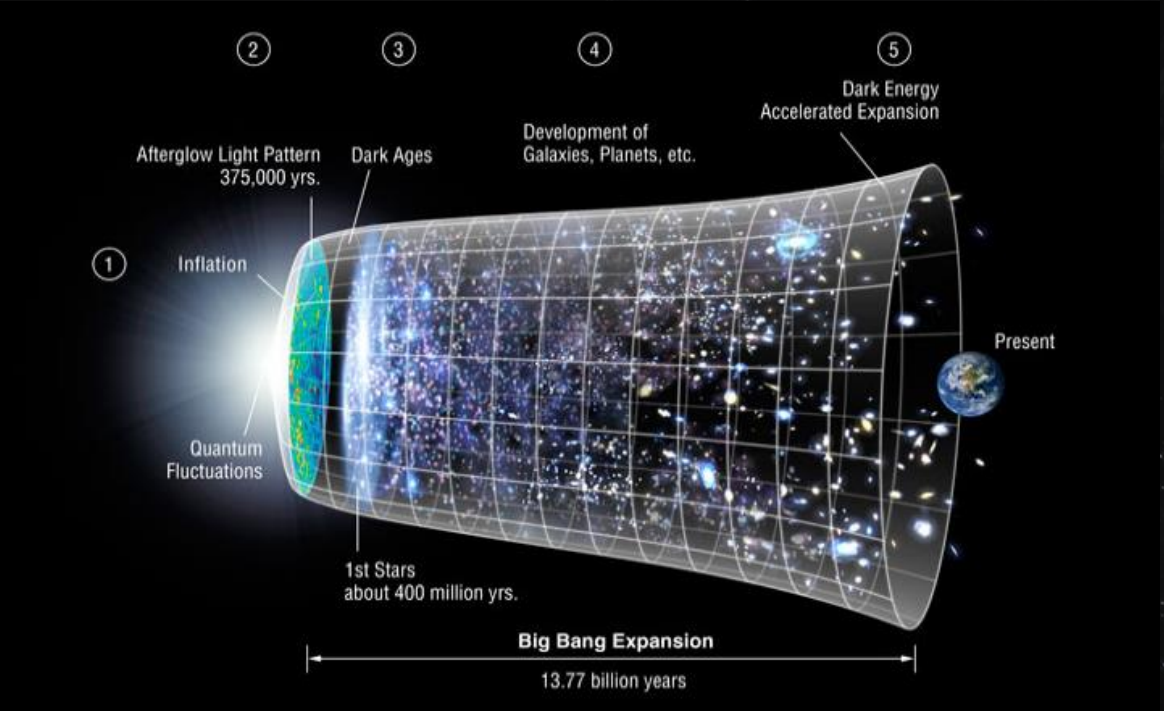


Figure 4: Big Bang Expansion
https://lambda.gsfc.nasa.gov/education/graphic_history/univ_evol.html

This model proposes specifically cold matter, such as:

1. Non - baryonic
2. Cold
3. Dissipationless
4. Collisionless

3

Cosmic microwave background

Matter Era – until today

Source:
Author's own graph

COSMIC MICROWAVE BACKGROUND

- Isotropic photon background with a blackbody spectrum (T=2.725 K)
- Before recombination: hot, dense plasma of particles (photons scattered off , Thomson scattering)
- Proves that photons/baryons **must** have existed in a highly interacting thermal state
- Small irregularities: Random *quantum fluctuations* before recombination

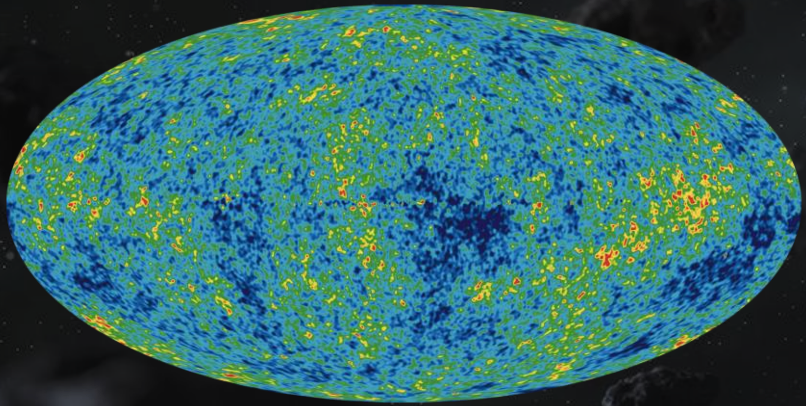


Figure 5: Cosmic Microwave Background (blue spots colder than red spots)
Source: *WMAP*

4

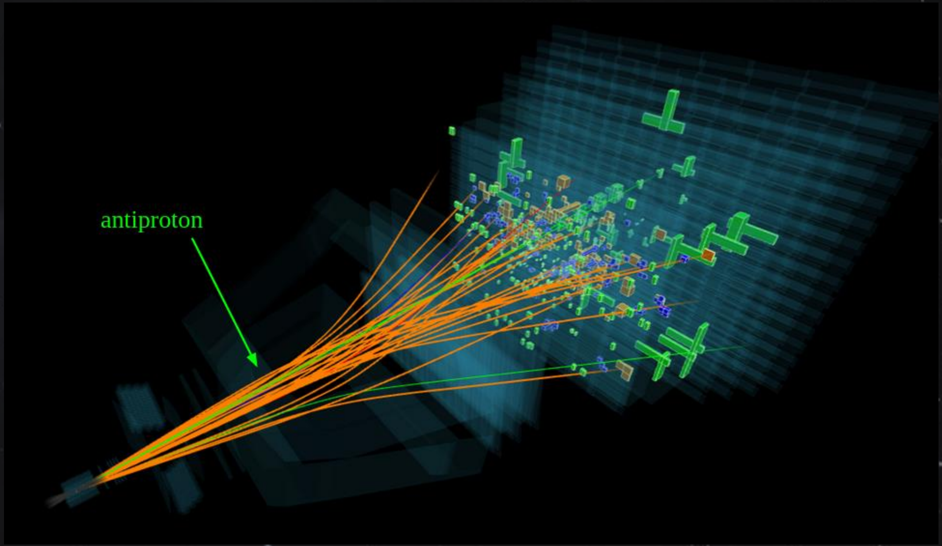
CERN EXPERIMENTS

I. LHCb / LHCf

II. ALICE

III. Others (ATLAS, CMS, ELENA/AD)

Large Hadron Collider beauty
Large Hadron Collider forward



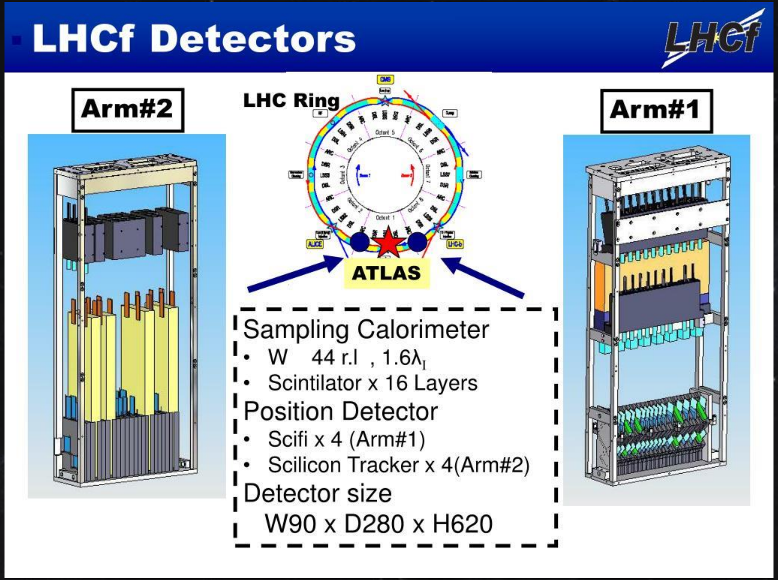
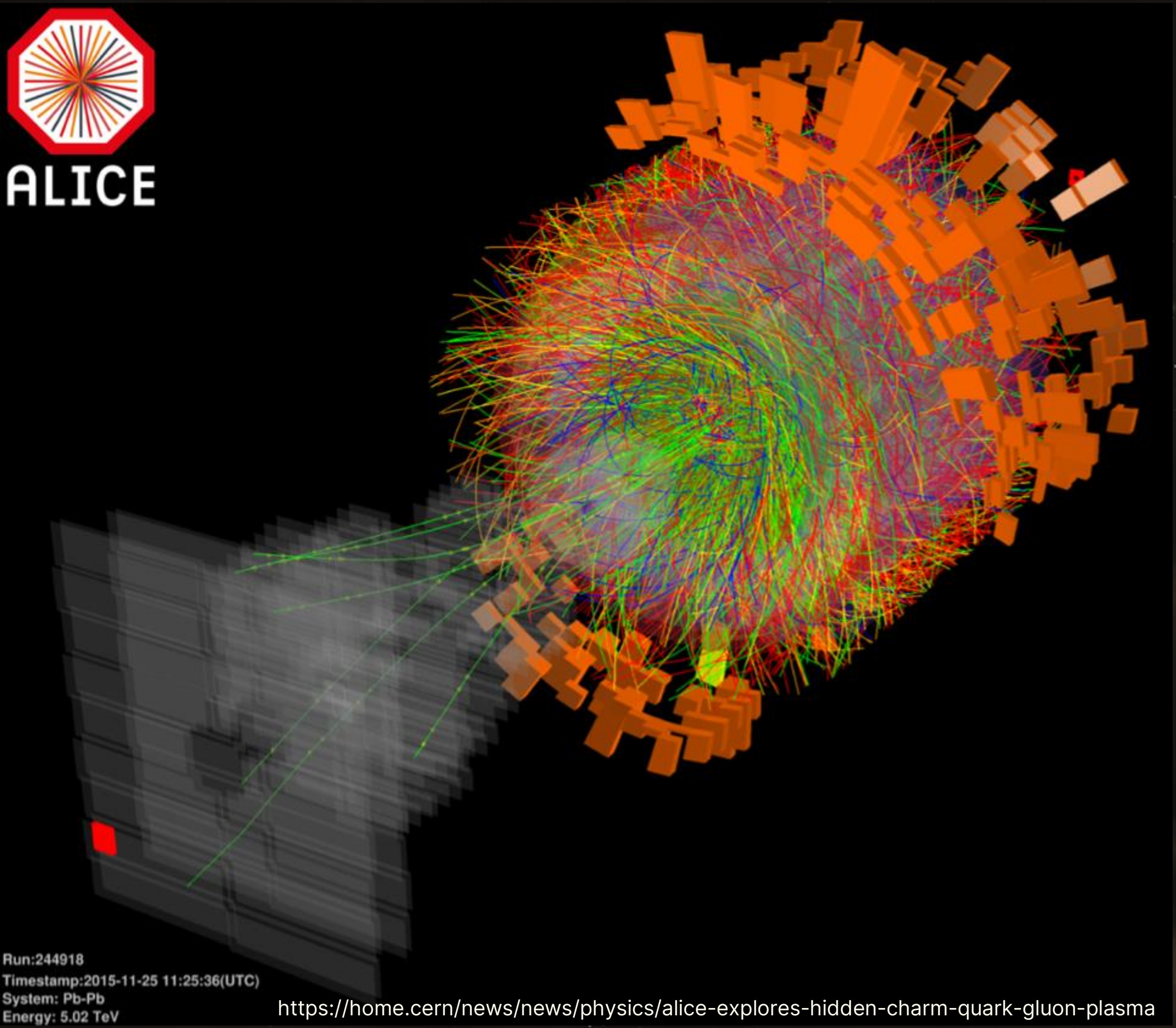


Figure 6: proton-proton collision at LHCb
https://home.web.cern.ch/news/news/physics/lhcb-reveals-secret-antimatter-creation-cosmic-collisions

Figure 7: LHCf Detectors
https://www.slideserve.com/varick/lhcf-detectors



https://home.cern/news/news/physics/alice-explores-hidden-charm-quark-gluon-plasma

What is the quark-gluon plasma state?

What happens at ALICE?

Resources

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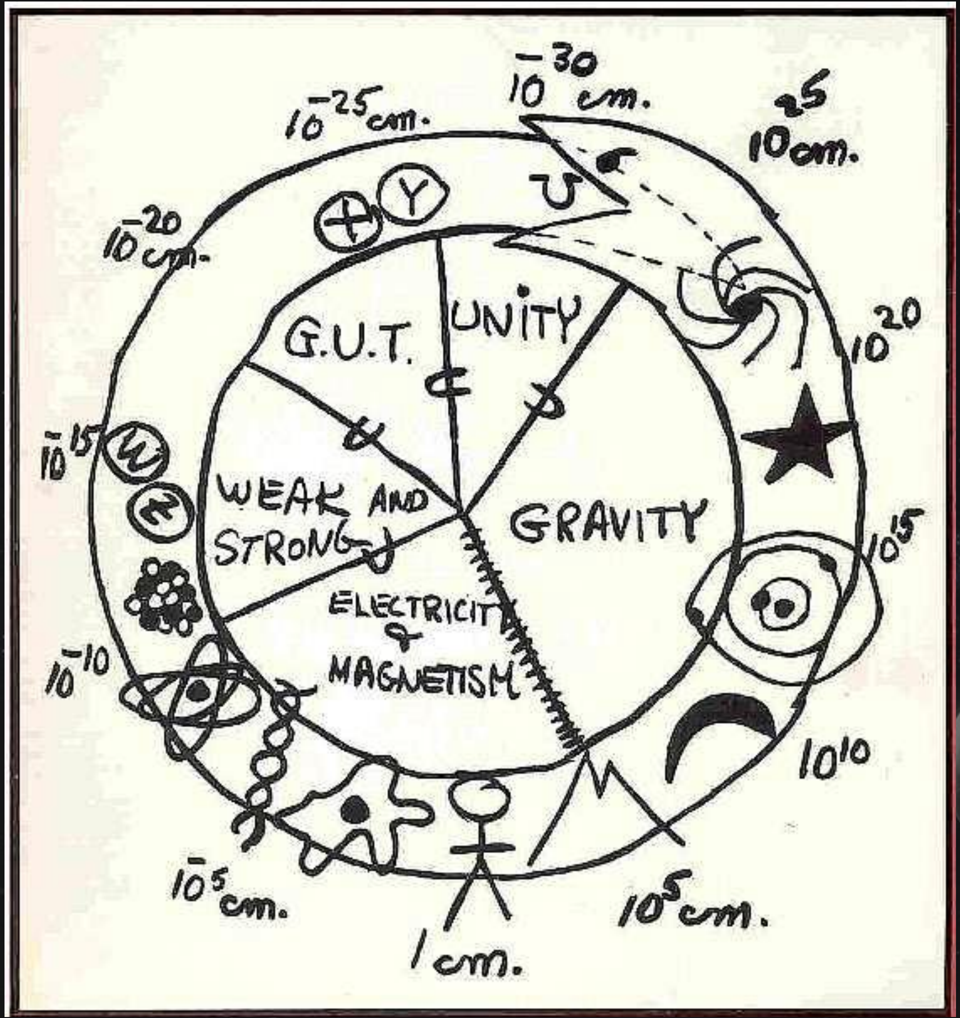
Special thanks for helping us to Dan Pruteanu AND Camelia Pirghie ♡



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G.U.T.
UNITY
WEAK AND STRONG
GRAVITY
ELECTRICITY & MAGNETISM
X
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