Why are we here?
Origin of Universe and Ourselves

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Why are we here?
~100 Billions Stars in a Galaxy
Hubble Deep Field

~100 Billion Galaxies
Red shift up to $\sim 10$
Hubble’s Law: Expansion of the Universe

Big Bang!

14 Billion Light Years

Moving Away at Speed of Light

Horizon of Universe

Sun/Earth
Expansion of Universe

Size of Universe $\propto \sqrt{\text{Time}}$
Temperature of Universe

Temperature

Temperature = 1/Size

2.7°C

Beginning  Today  Size
Tevatron at Fermi Lab near Chicago (1980 – 2010)

6km Circumference
Unification of Four Forces

Grand Unification

Now
Unification of Four Forces

The diagram illustrates the relative strength of different forces as a function of temperature. The forces include:

- Strong force
- Electromagnetic force
- Weak force
- Electroweak force
- Gravity

The graph shows how these forces unite at a high temperature, marked as the Plank Epoch. The forces are represented on the y-axis, and the temperature on the x-axis.

Key points:

- **Strong force**: Initially strong, decreases in strength as temperature increases.
- **Electromagnetic force**: Strong at high temperatures, decreases and unifies with the weak force at lower temperatures.
- **Weak force**: Decreases in strength and unifies with the electroweak force.
- **Electroweak force**: Unifies with the weak force at a certain temperature.
- **Gravity**: Weak at high temperatures, becomes stronger as temperature decreases.

The diagram is labeled with the temperature ranges:

- **Now**: Low temperature range, showing gravity's dominance.
- **Big Bang**: High temperature range, illustrating the forces' unification at the Plank Epoch.

The graph is a visual representation of the theoretical aspects of particle physics, showing how different forces unify at extremely high temperatures before separating at lower temperatures.
Physicists’ View of Early Universe

Fiat lux

Let there be light
Structure of DNA

Molecule of DNA

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Symmetry Breaking

Time

0
1B years

Simple

Symmetry Break Down

Complex
Seven Phases of Cosmic Evolution

Spontaneous Symmetry Breaking

14 billion years ago

Origin of Particles
CERN and LHC in Geneva

27km Circumference
LHC Tunnel with Magnets
Particle detectors constructed at Westwood, now at LHC, CERN
First Event at LHC – Recreation of the Big Bang! (Nov 7, 2009)

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Seven Phases of Cosmic Evolution

Spontaneous Symmetry Breaking

14 billion years ago

Origin of Particles

Origin of Structure
Formation of Structure in the Universe

Dark Matter is required!

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XENON100 Detector

170 kg

(50 kg)
XENON100 Detector (2009)

Ethan Brown
(UCLA Student)
Seven Phases of Cosmic Evolution

Spontaneous Symmetry Breaking

14 billion years ago

Origin of Particles

Origin of Structure

Origin of Life

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Solar System (4.6 B years ago)
Organic Polymers (4.5B \rightarrow 4B \text{ years})

organic monomers from space

organic polymers

organic monomers

inorganic molecules from Earth

methane

water

carbon dioxide

hydrogen cyanide

an amino acid

a protein
How to observe the “Origin of Life”

- Exactly the same way as we look for the “Origin of Universe”

  ![Telescope ↔ Microscope](image)

- We must look for “Live Life”

- Take advantages of the state of art “Photon Detectors” in particle physics.
The H33D detector attaches to a standard fluorescence microscope. Laser illumination will permit to track multicolor qdot-labeled proteins in live cells virtually background-free.

Single Molecule Imaging

Nano Technology

Particle Physics Detector

Extracellular Medium

Cytoplasm

Nucleus

EGF

EGF-R

Shc

Grb2

Sos-1

Ras

Raf

QD

QD

QD

QD

QD

MEK

ERK

Elk-1

Particle Physics Detector

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Gold nano particle (40nm) attached to Transferrin Receptor (TfR) on Cancer Cell

Prof. Manuel Penichet (Oncology)
Seven Phases of Cosmic Evolution

Spontaneous Symmetry Breaking

14 billion years ago

Origin of Particles

Origin of Structure

Origin of Life

Origin of Consciousness

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Brain

100 Billions Neurons

Universe

100 Billions Galaxies
In vivo calcium imaging of neuronal activity

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In vivo calcium imaging of Barrel Cortex of Mouse

Barrel Cortex
Layer 2/3
150 µm deep

240 fps
Raw Data
(x3 faster than real)

Beam 1
(0 ns)
Beam 2
(+3 ns)
Beam 3
(+6 ns)
Beam 4
(+9 ns)

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In vivo calcium imaging of Barrel Cortex of Mouse

Barrel Cortex
Layer 2/3
150 µm deep

After averaging
(x3 faster than real)

58 neurons
(~100 billions neurons in our brain)

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Seven Phases of Cosmic Evolution

Spontaneous Symmetry Breaking

14 billion years ago

Origin of Particles
Origin of Structure
Origin of Life
Origin of Consciousness

PARTICULATE
GALACTIC
STELLAR
PLANETARY
CHEMICAL
BIOLOGICAL
CULTURAL
Why are we here?
There may be ~100 Billion Universes.
Four Major Science

Origin of Particles
Particle Physics

Origin of Universe
Cosmology

Origin of Life
Molecular Biology

Origin of Consciousness
Neurophysics