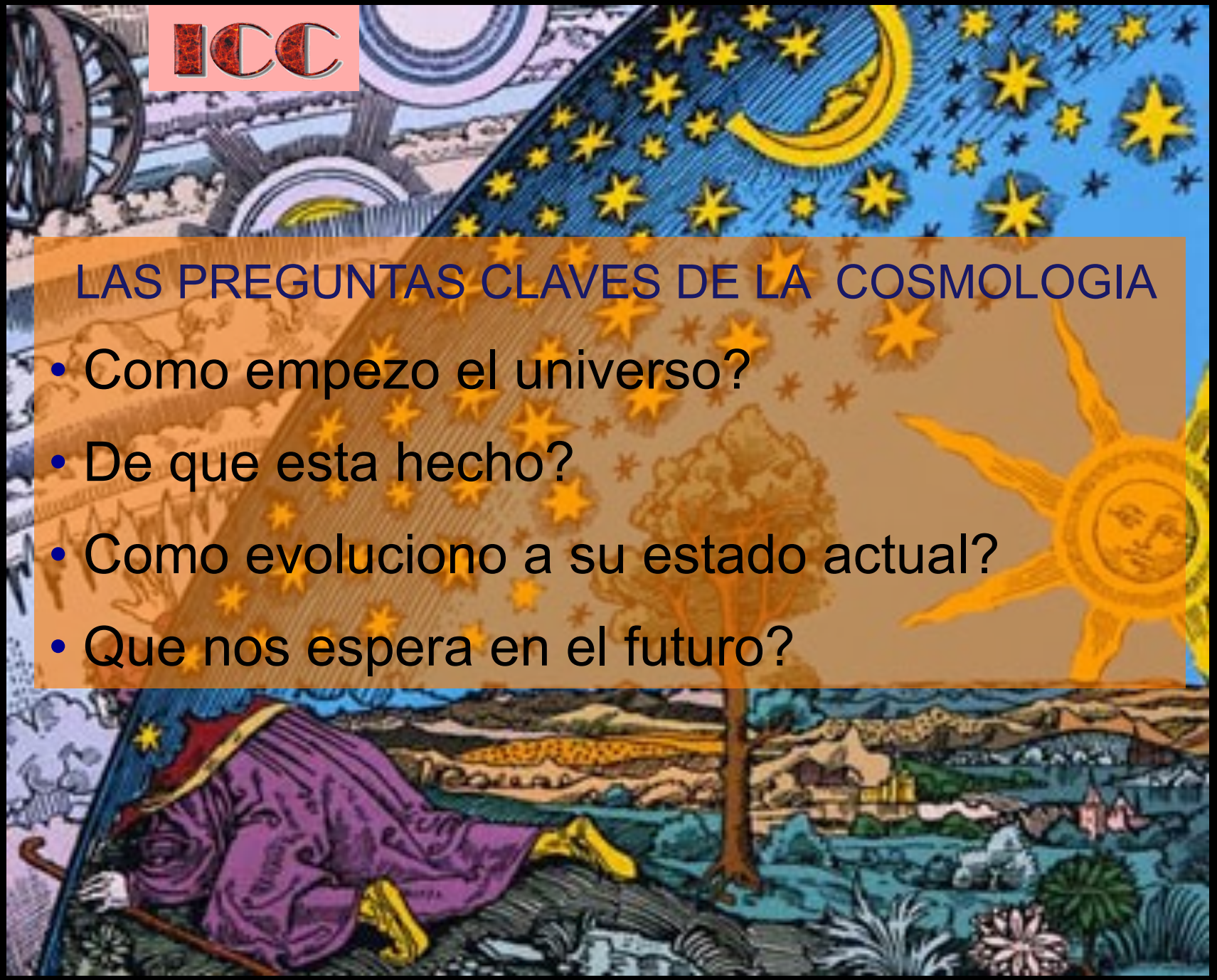
Todo de la nada:
la formacion de nuestro universo

Carlos S. Frenk
Institute for Computational Cosmology,
Durham



Flammarion 1888: tete des etoiles

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La ciencia del universo

La cosmologia moderna esta basada en:

Las leyes de la fisica: reglas generales sobre fenomenos naturales, derivadas empiricamente, y expresadas matematicamente e.g. ley de gravitacion de Newton, ley de los gases de Boyle, mecanica cuantica, relatividad

- Verificadas experimentalmente en la Tierra
- Universales (?)

La historia cosmica es una historia de nada

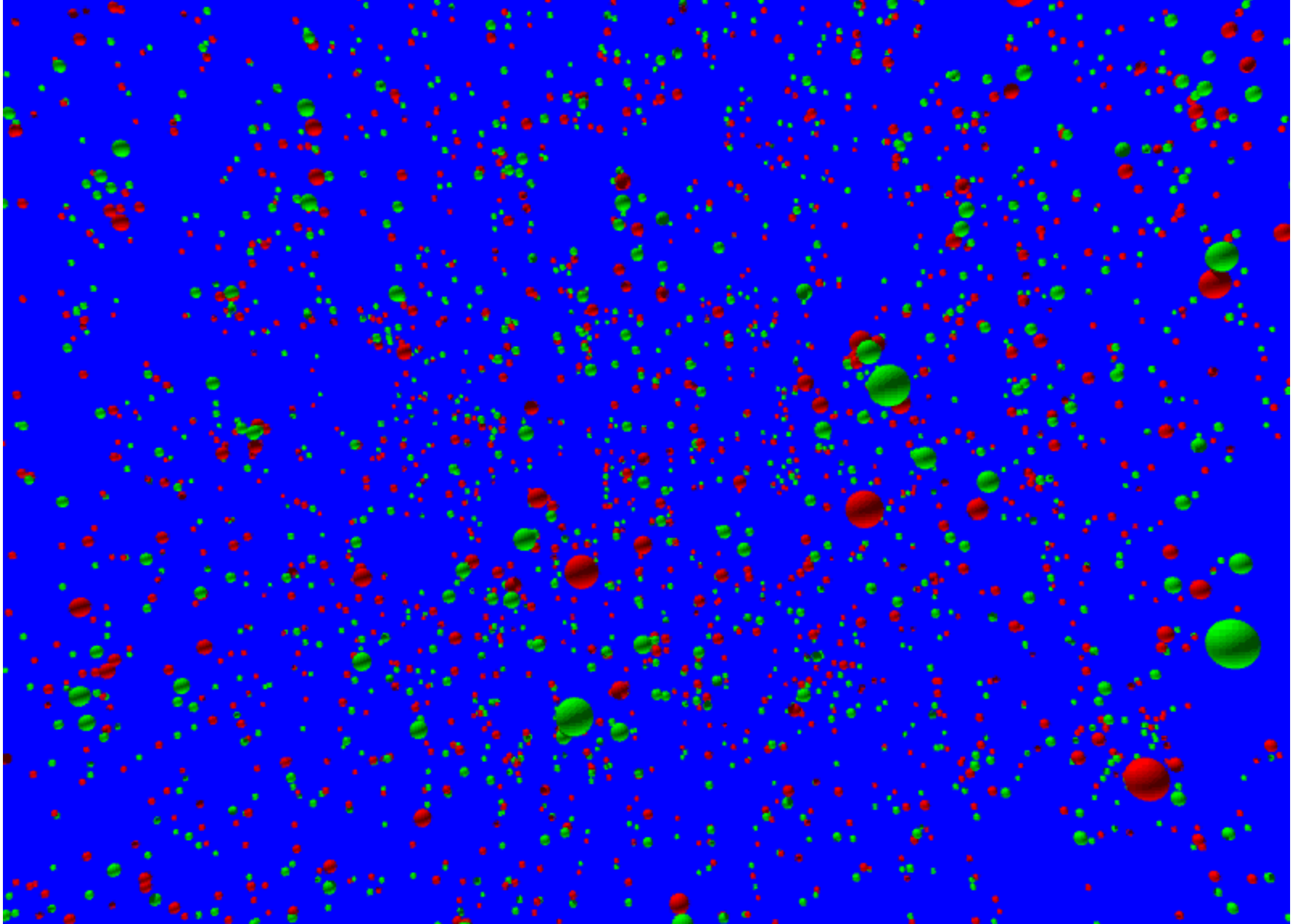
... o mas bien de como todo surgio de nada

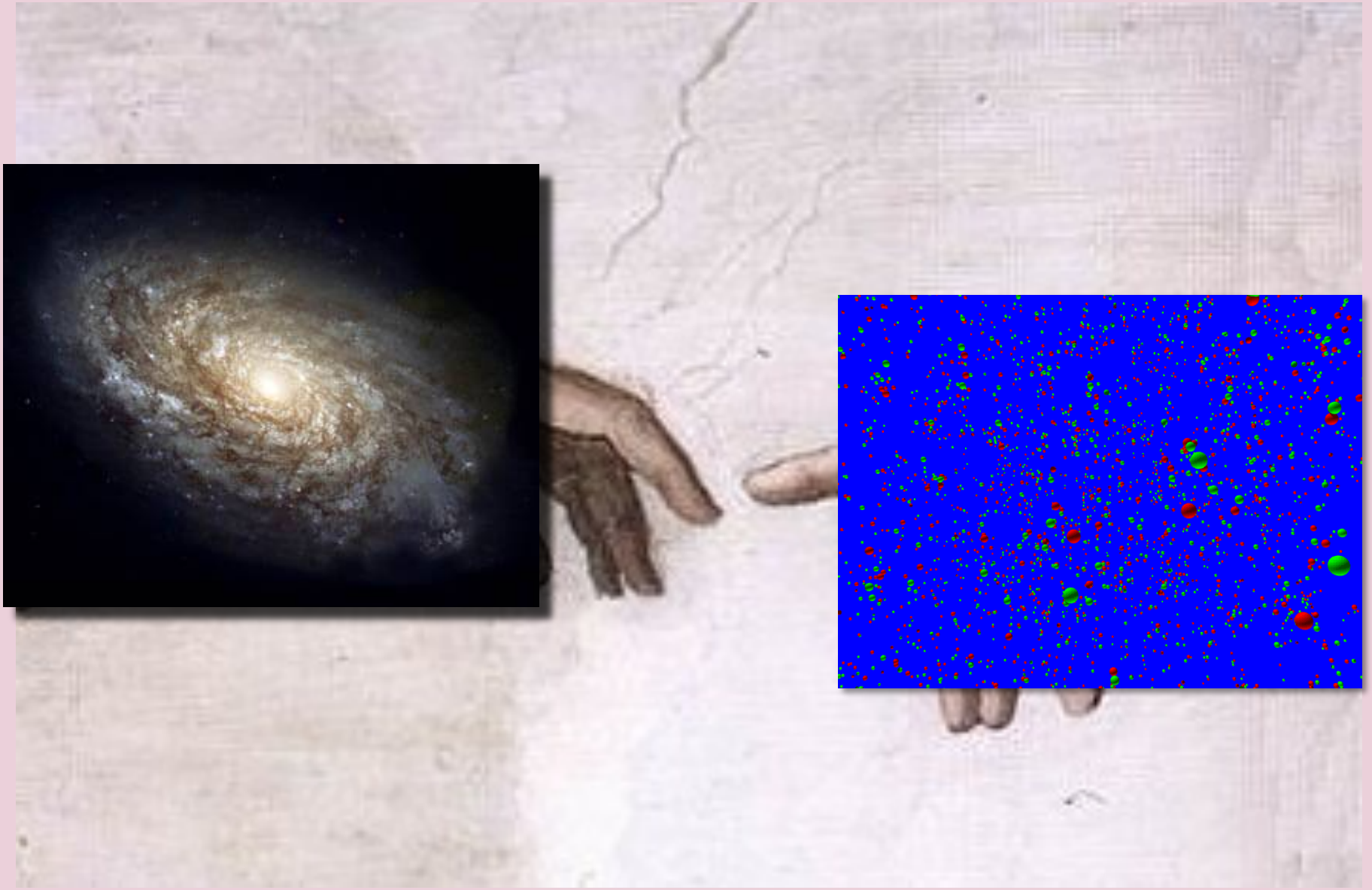
Nada?

En la fisica a la “nada” se le llama el “vacio”

… y el vacio esta lleno de energia

… la energia del vacio





Los bloques de construccion del universo

Galaxias: colecciones de hasta cien mil millones de estrellas

Virtual Voyage:
Milky Way to the Virgo Cluster

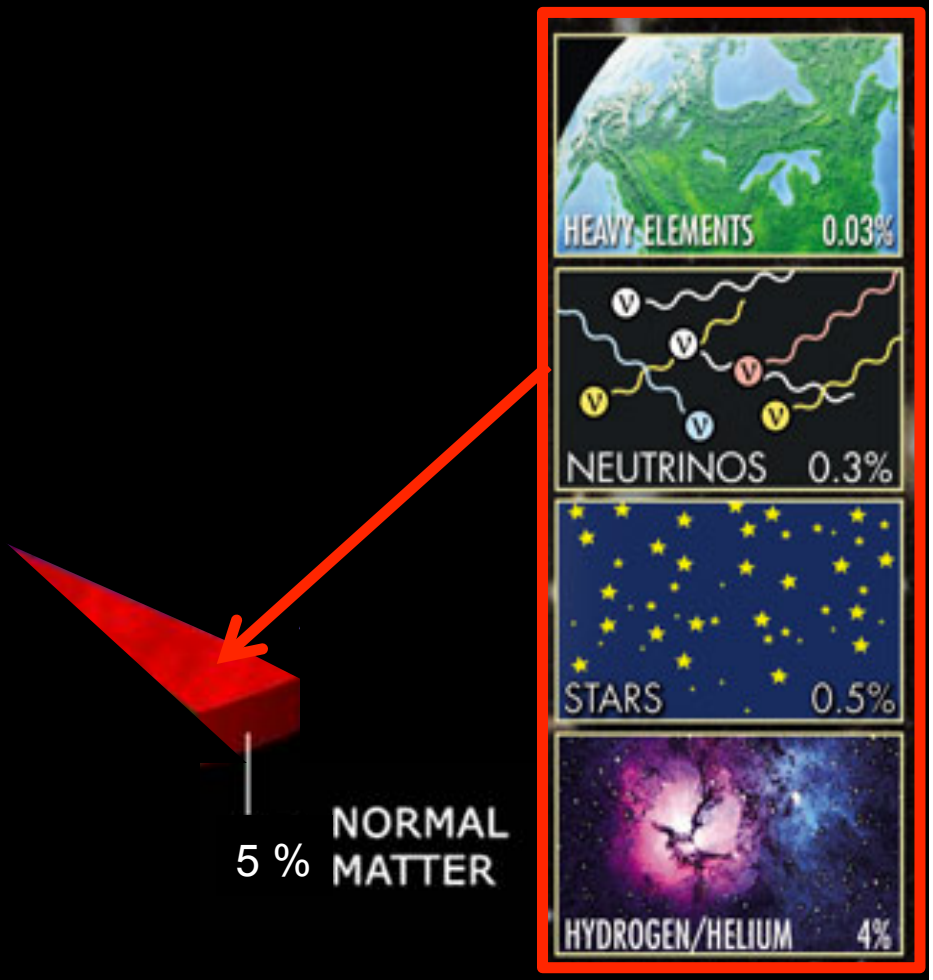
HDTV Visual Excerpt from "Runaway Universe"

Courtesy NOVA/WGBH, PBS

Tom Lucas Productions

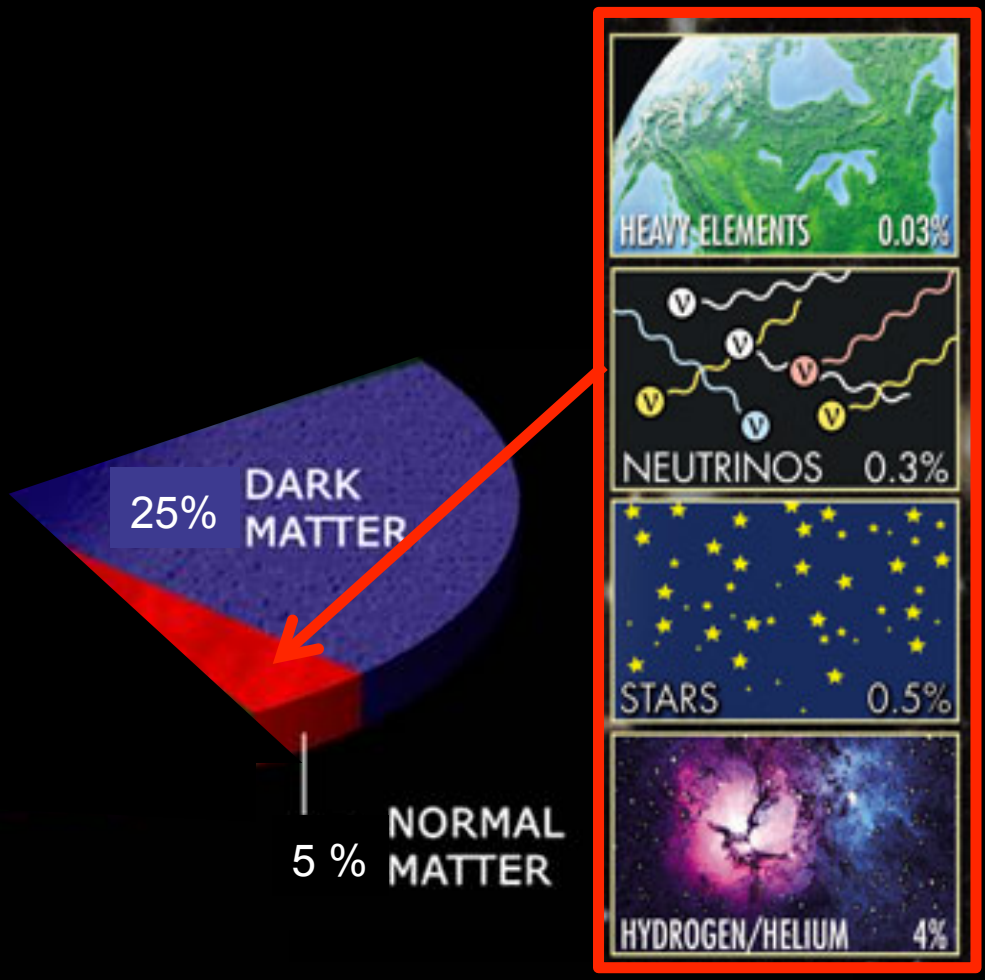
El contenido del universo

El contenido del universo



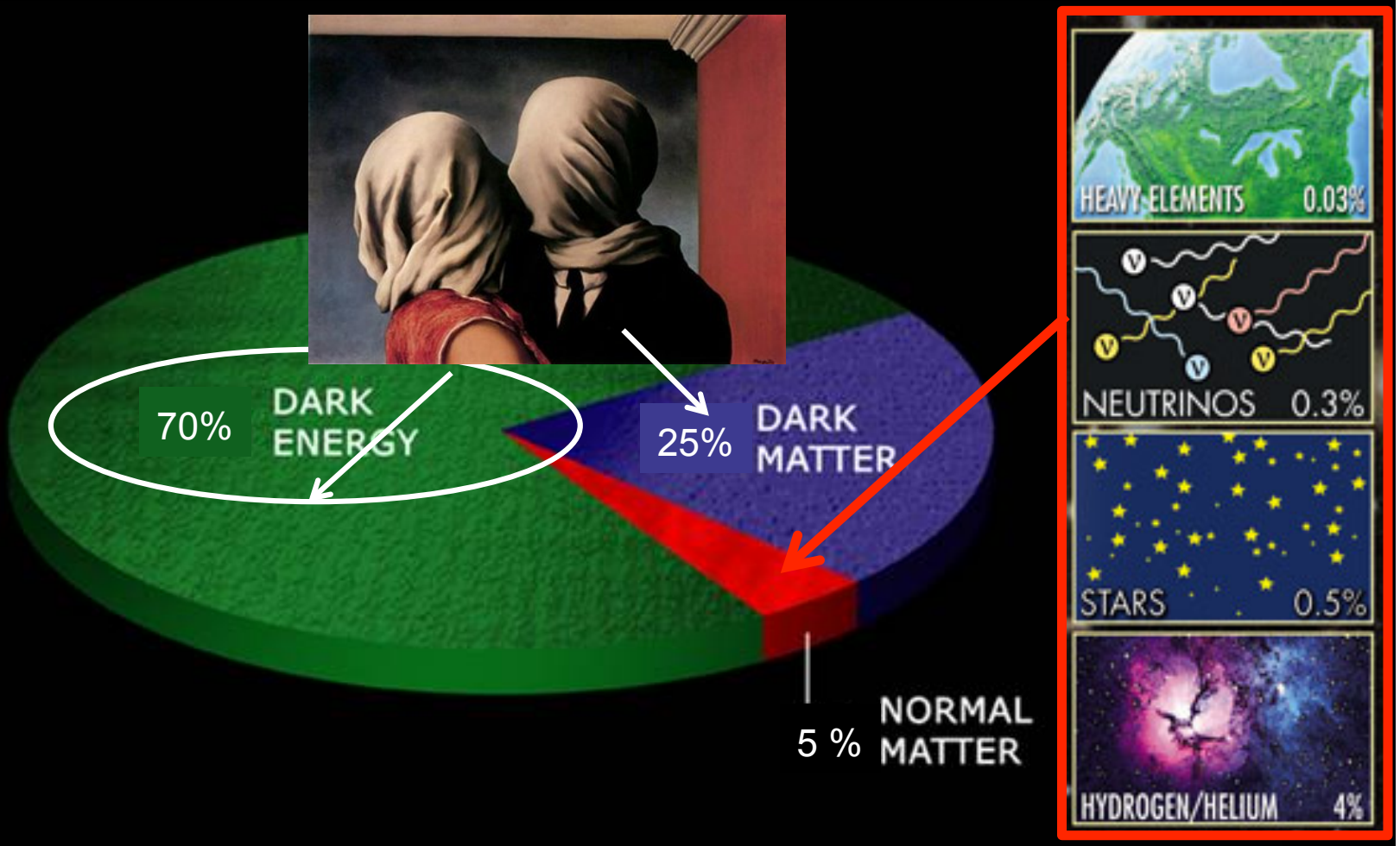
Normal matter ≡ matter made of ordinary atoms

El contenido del universo



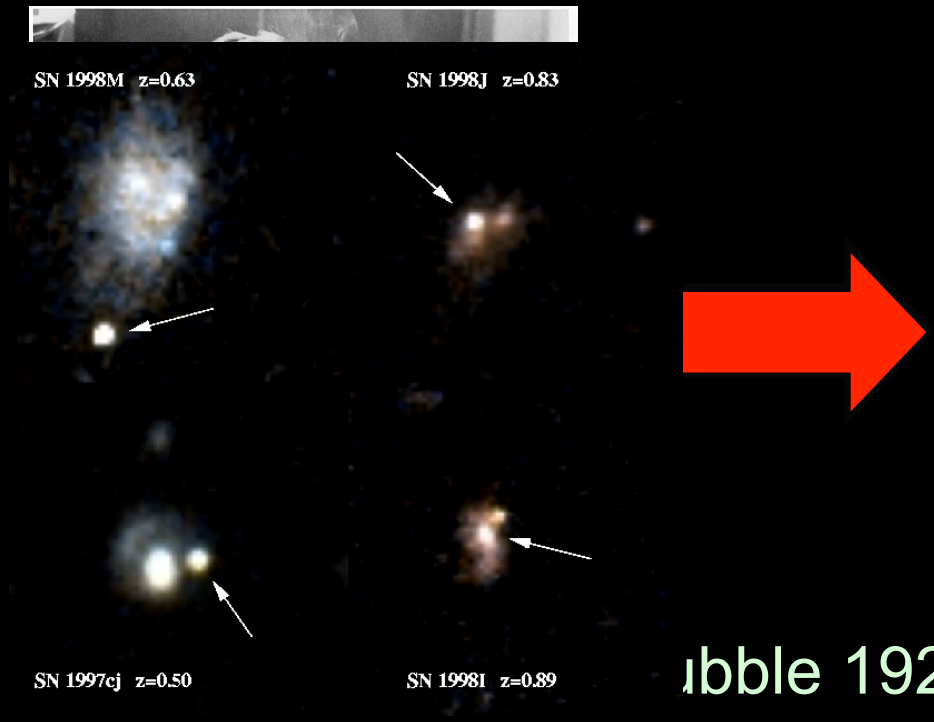
Dark matter ≡ matter that does not emit light at any wavelength

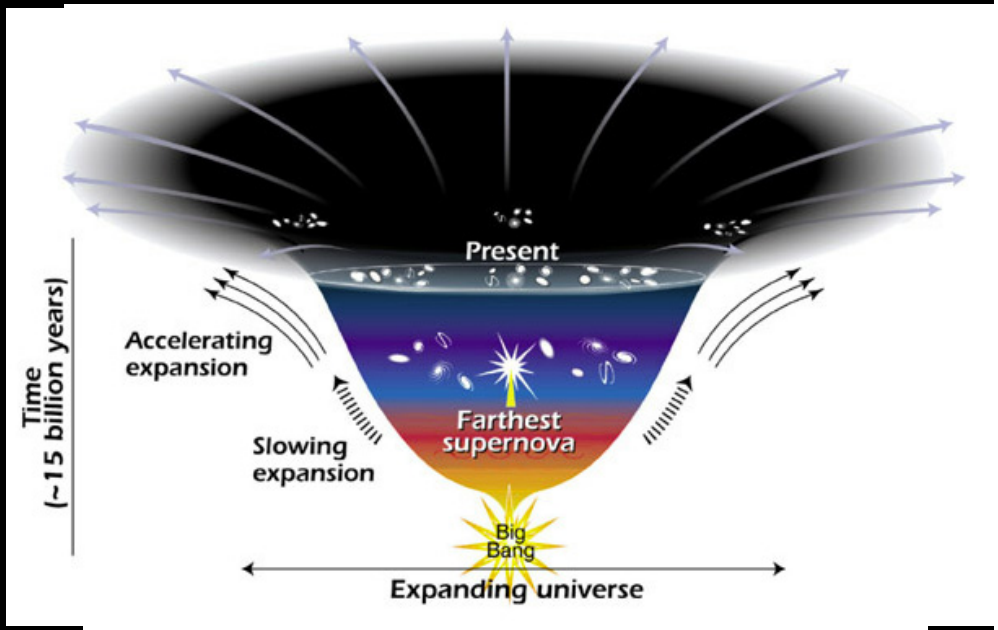
El contenido del universo



Dark energy ≡ mysterious form of energy which opposes gravity

La expansion cosmica





ıbble 1929:

La expansion esta acelerandose

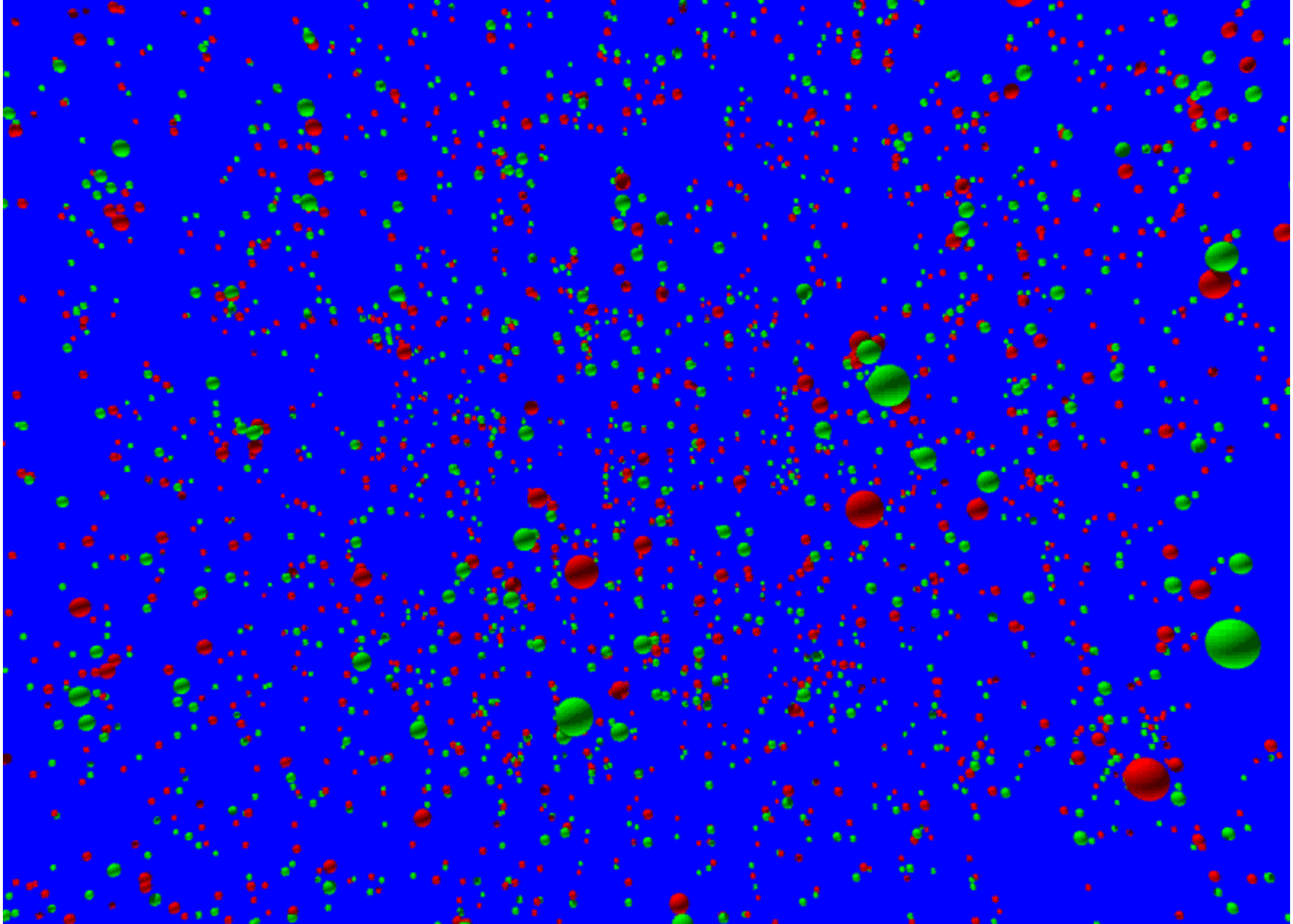
Premio Nobel de fisica 2011

➔Un universo lleno de energia obscura

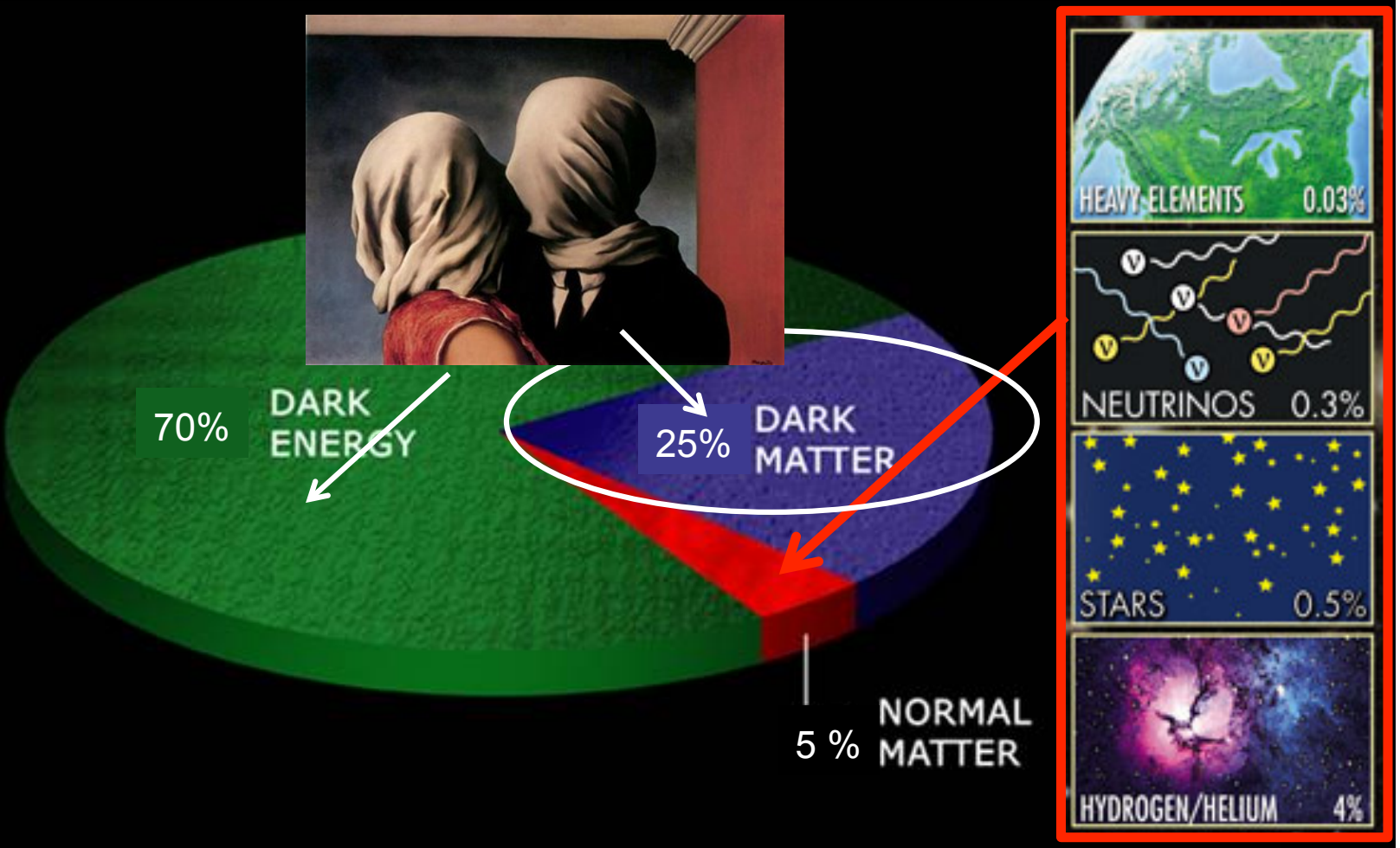
What is the cosmic dark energy?

A form of energy that produces a repulsive force, causing the universal expansion to accelerate

It is likely to be energy associated with empty space – the vacuum



El contenido del universo



Materia obscura: materia que no emite luz de ningun tipo

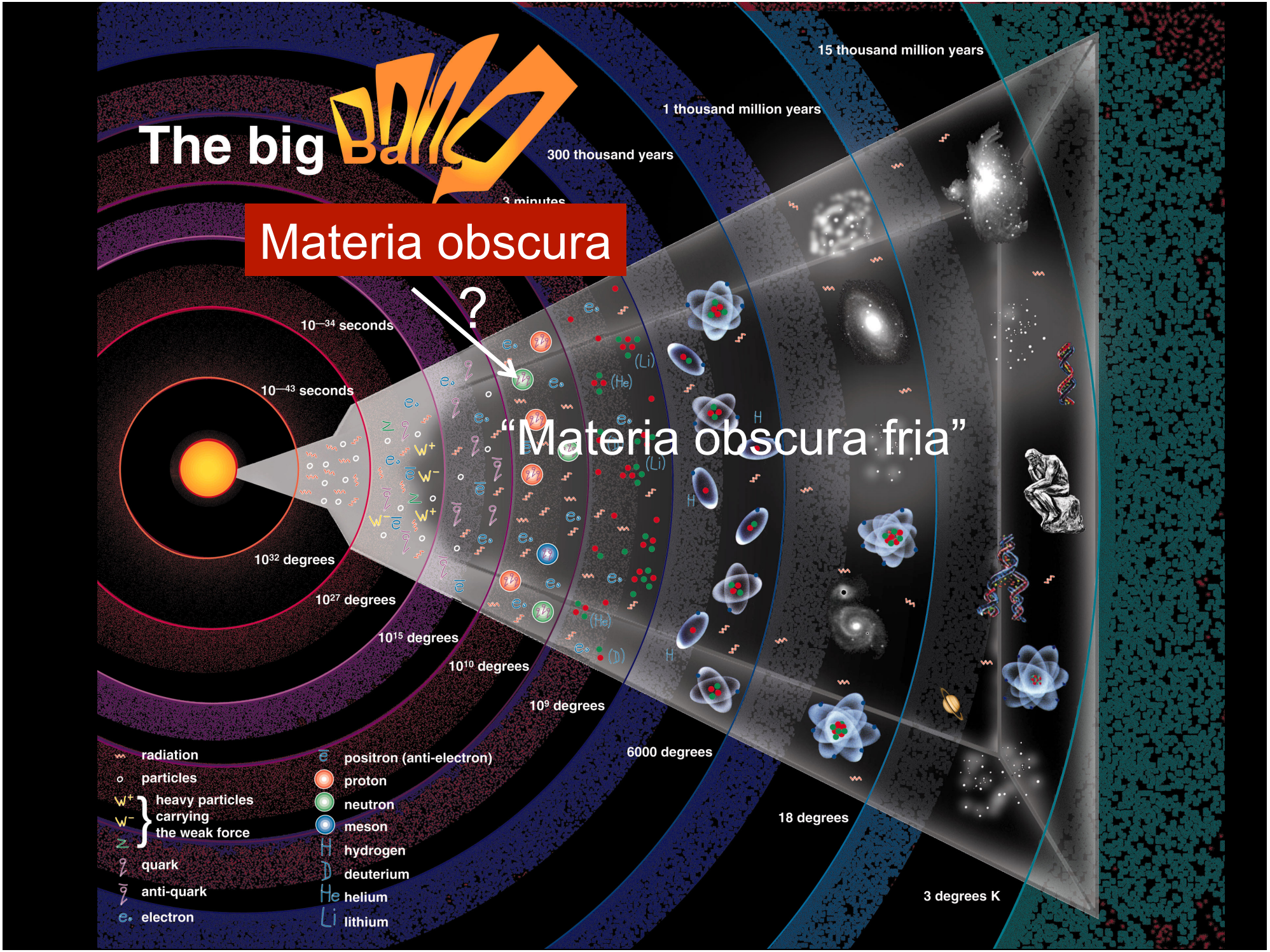
Stars rotate too fast to be held in place by gravity of visible mass

$$V^2 = \frac{GM}{r}$$

Clumps of dark matter: dark halos

→ dark matter keeps galaxy in place

Que es la materia obscura?


The big Bang
Materia obscura
?
"Materia obscura fria"
15 thousand million years
1 thousand million years
300 thousand years
3 minutes
10⁻³⁴ seconds
10⁻⁴³ seconds
10³² degrees
10²⁷ degrees
10¹⁵ degrees
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6000 degrees
18 degrees
3 degrees K
radiation
particles
heavy particles carrying the weak force
quark
anti-quark
electron
positron (anti-electron)
proton
neutron
meson
hydrogen
deuterium
helium
lithium

Que es la materia obscura?

Hipotes
particula
ordinaria

a
as
no

La busqueda de la materia obscura

Fisica experimental

ICC En busqueda de materia obscura

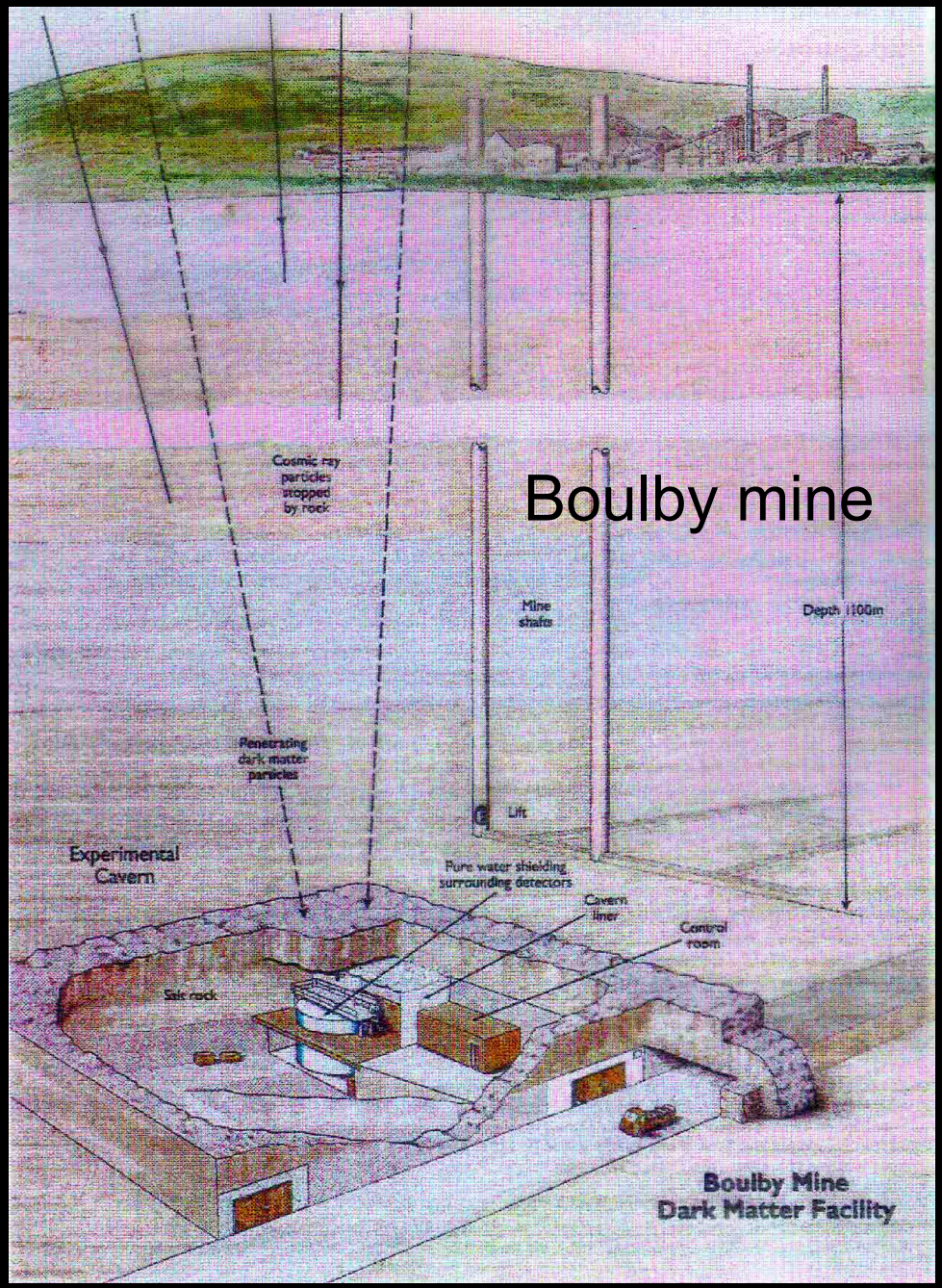
La busqueda de la materia obscura

ICC
University of Durham

Buscando materia obscura?

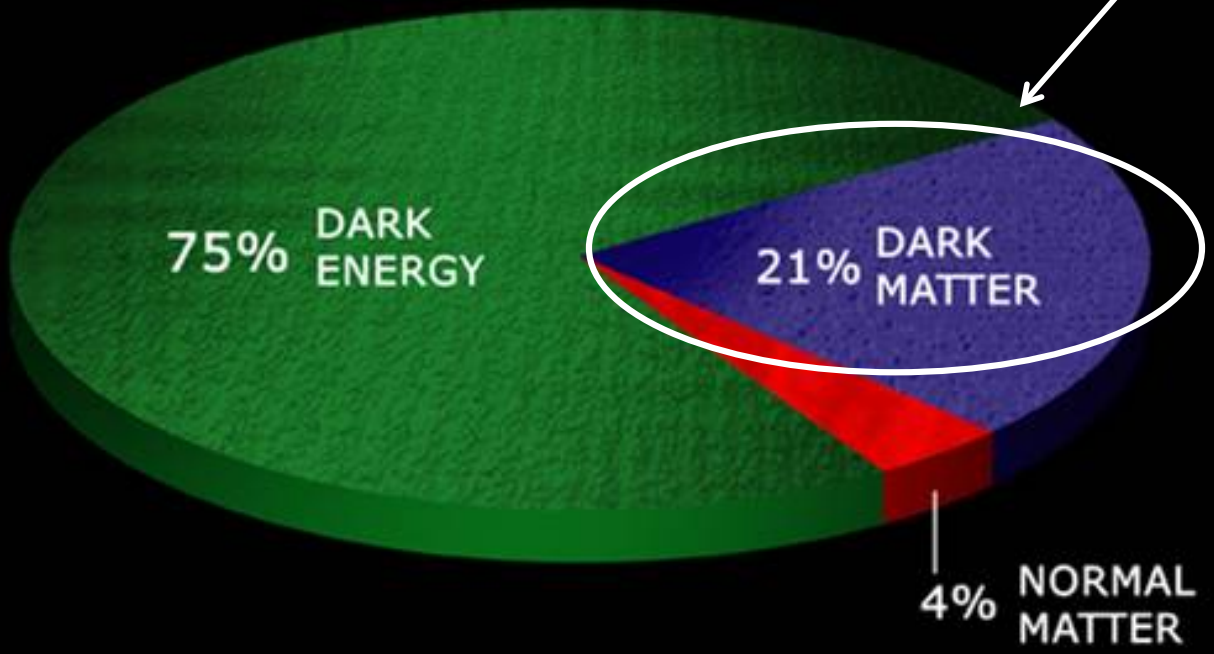
Looking for dark matter …
down the mine

(where cosmic rays can't penetrate)



El contenido del universo

porque es tan importante?



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La gravitacion de la materia obscura genera la estructura cosmica
De donde vienen las galaxias?

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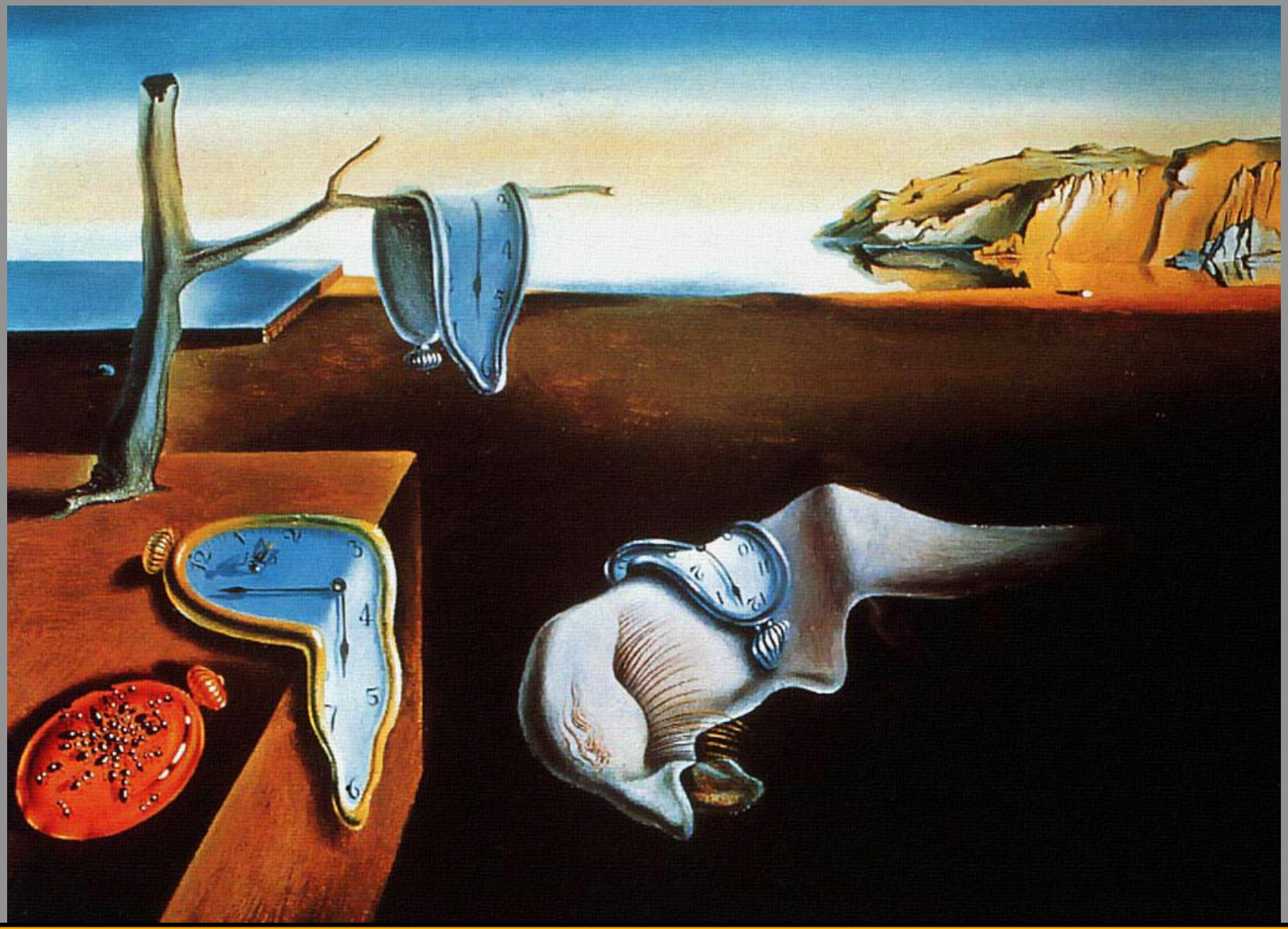
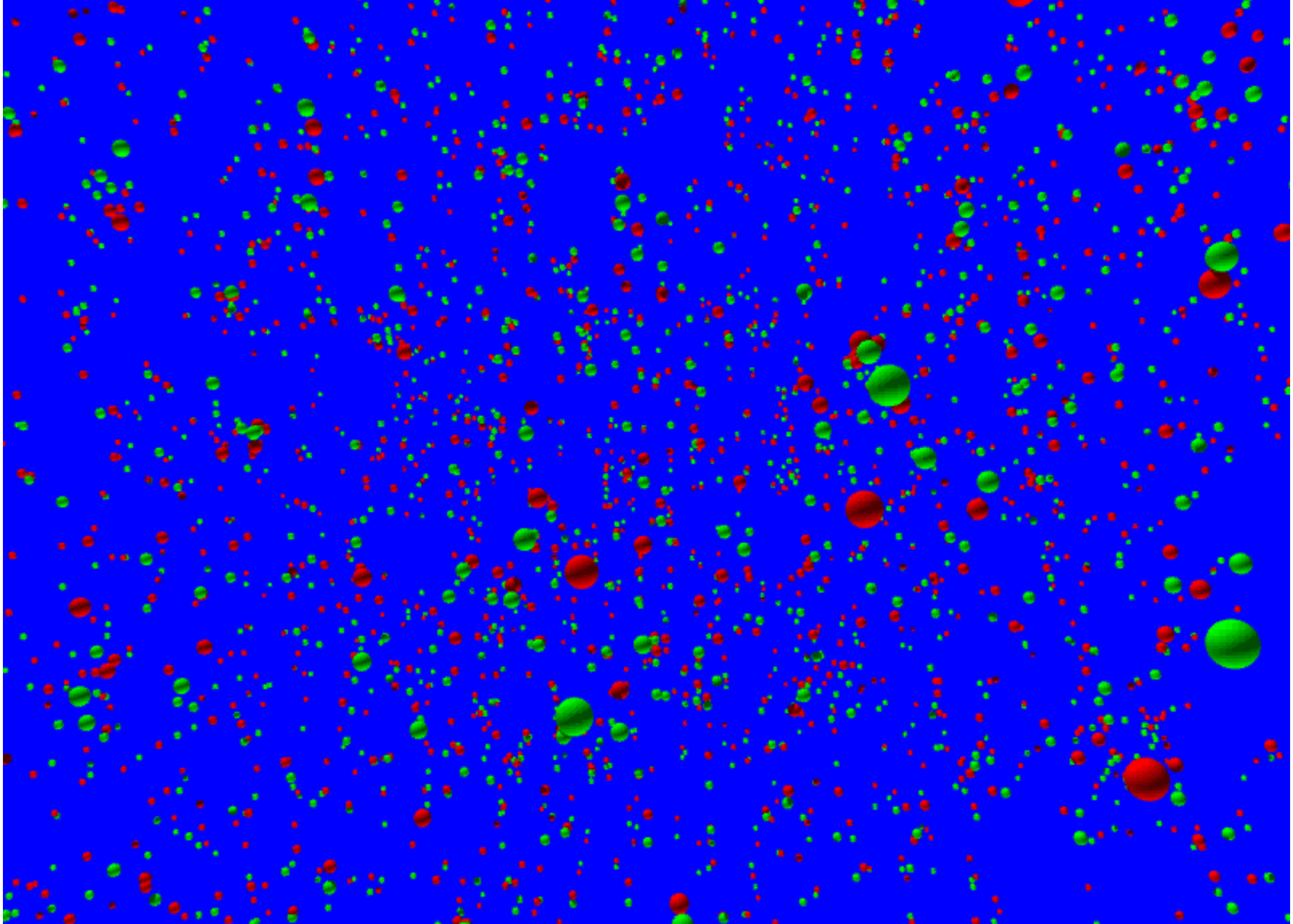
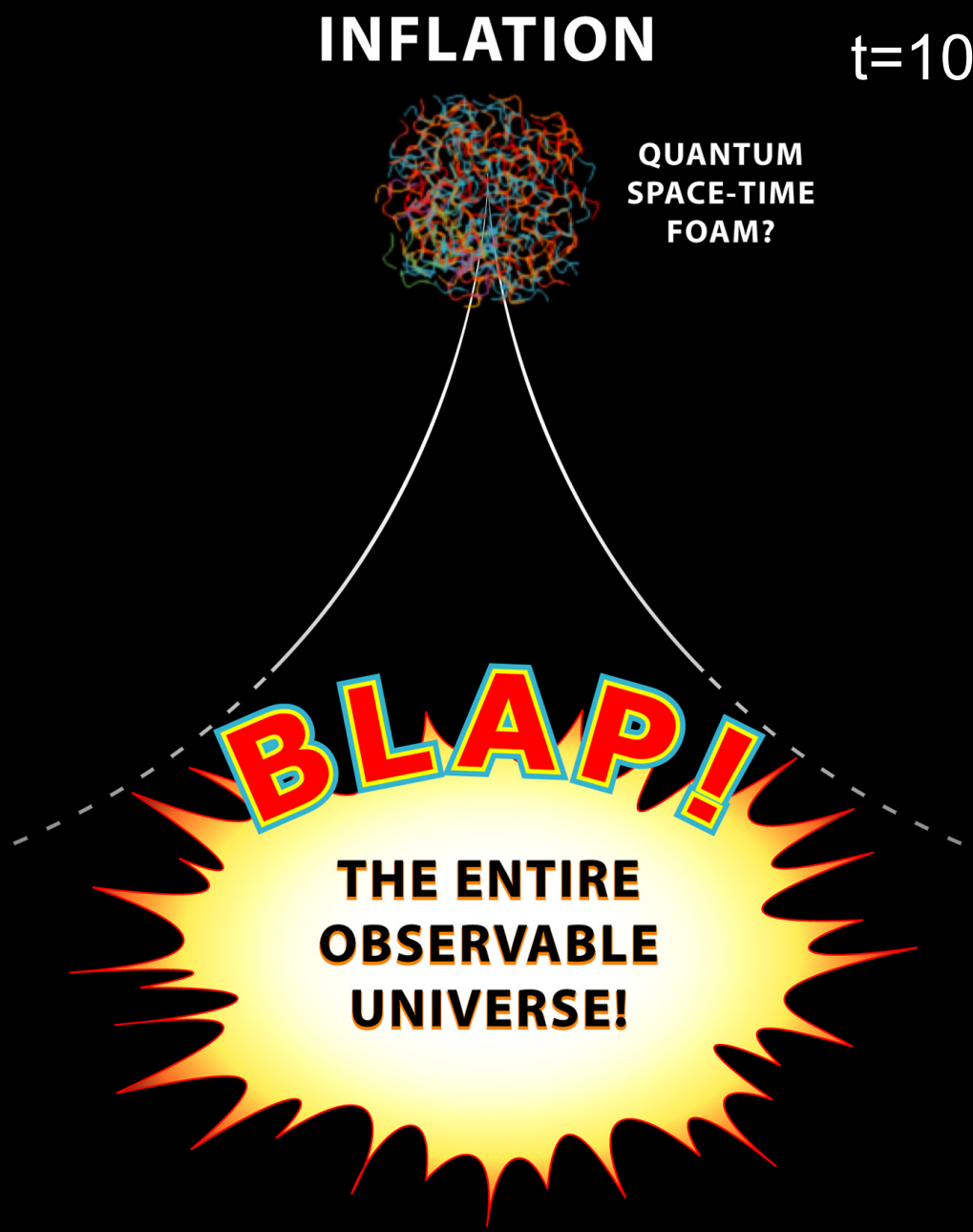
… el principio del tiempo (casi)

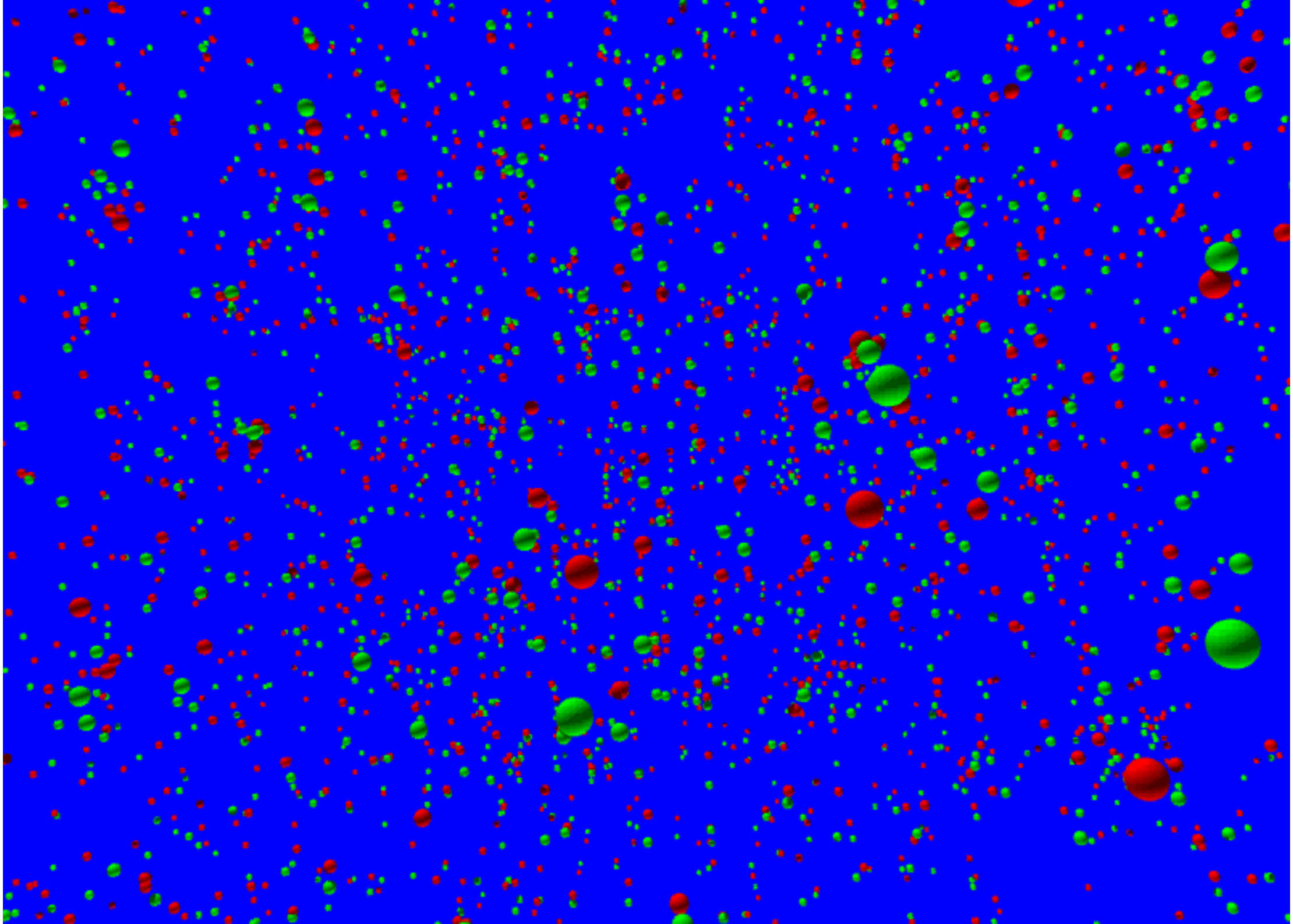


t=0.000000000000000000000000000001 segs



Las condiciones iniciales





Las condiciones iniciales

La teoria de la inflacion predice que pequñas fluctuaciones de masa - producidas por procesos cuanticos - aparecieron en el universo temprano

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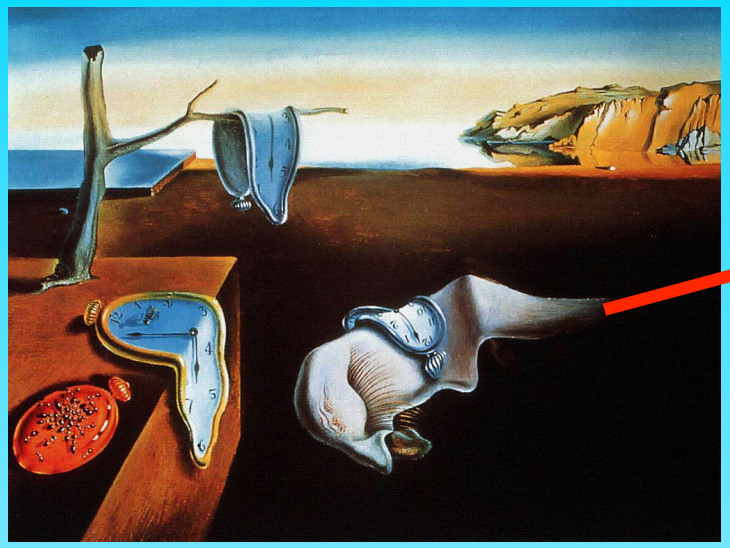
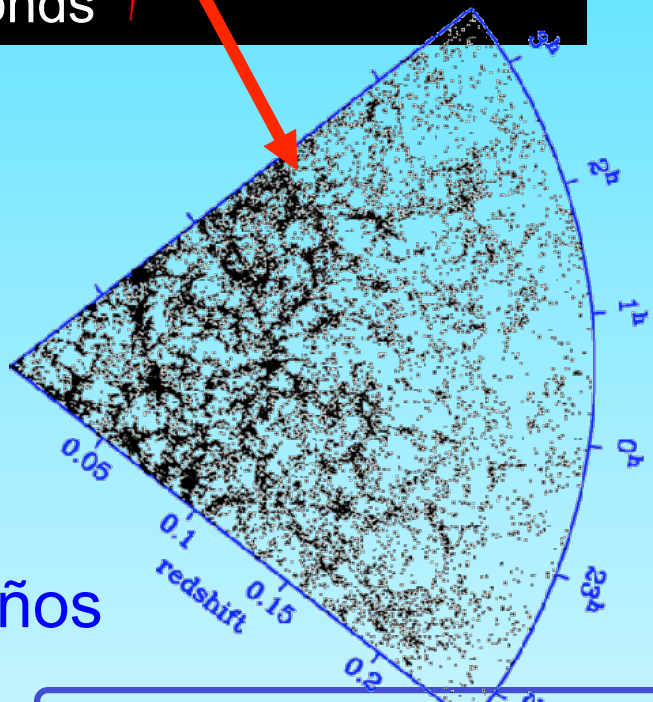
El crecimiento de estructura cosmica



De acuerdo a la teoria de la inflacion las galaxias surgieron de pequñas “fluctuatciones cuanticas”

t=14 mil milliones años



Institute for Computational Cosmology

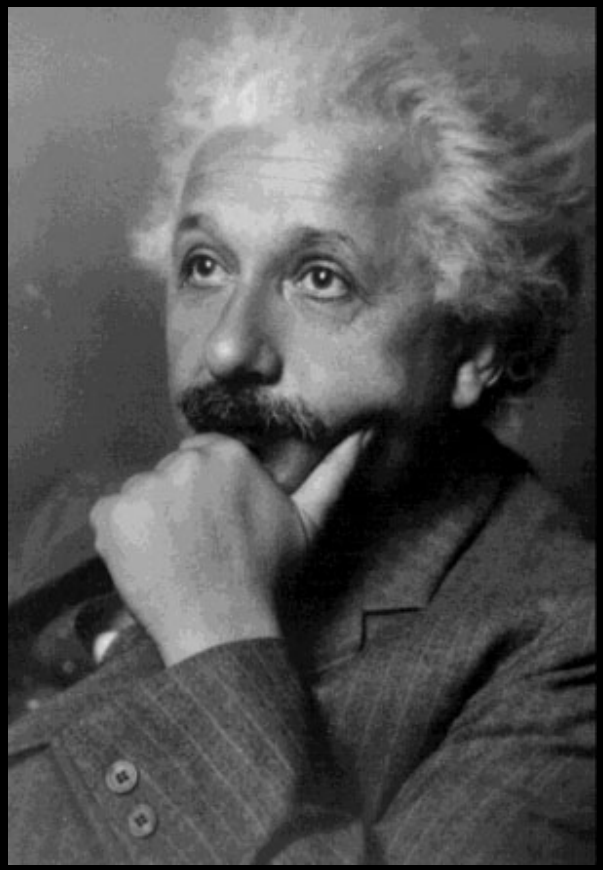

Las pequñas irregularidades cuanticas fueron amplificadas enormemente por la gravitacion de la materia obscura

Large Scale Structure

Computer simulation

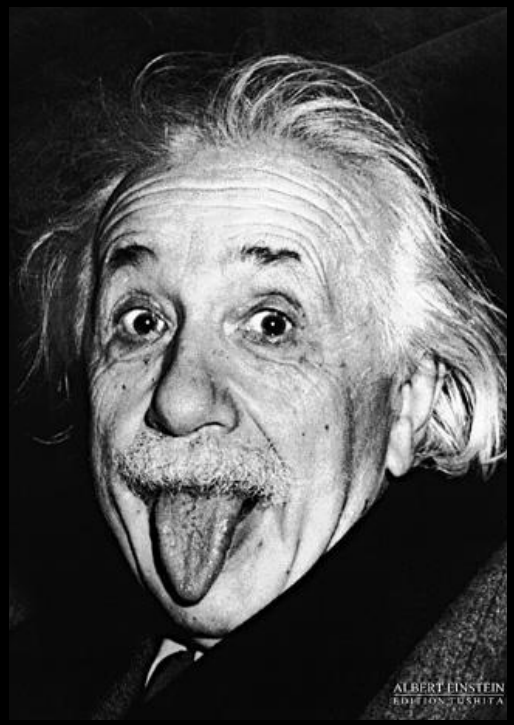
Small irregularities in the early universe grow under the action of gravity:

La fuerza gravitacional



?

La fuerza gravitacional



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- Verificadas experimentalmente en la Tierra
- Universales (?)

Para ser fisica, debe ser refutable!

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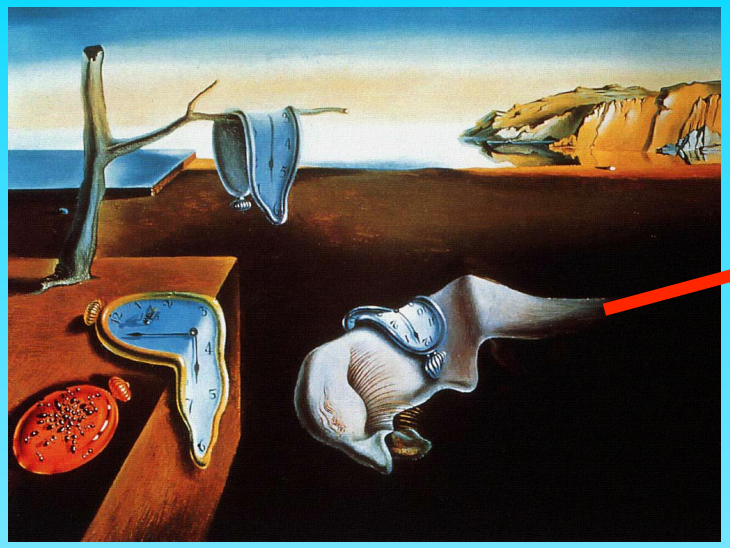
El crecimiento de estructura cosmica



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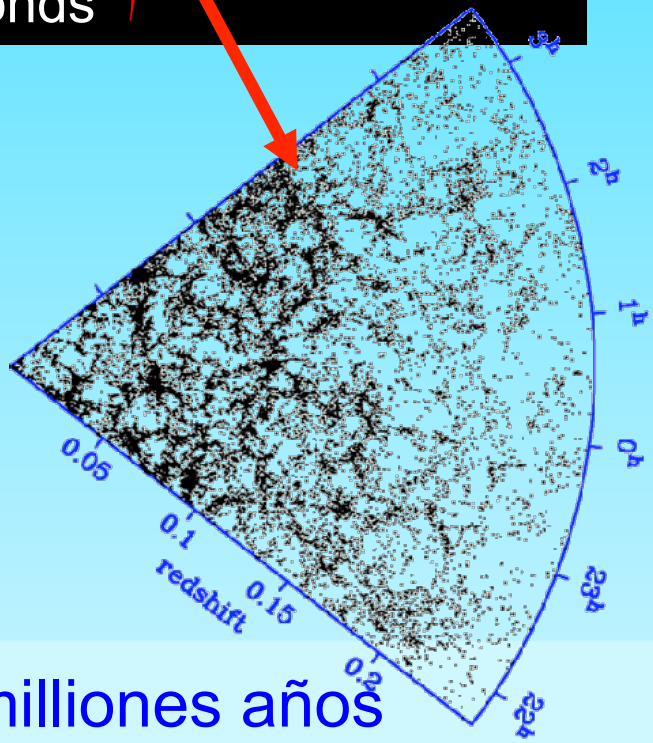

Como probamos esto?

t=14 mil milliones años

Necesitamos ver al pasado!

Es posible porque la luz viaja a velocidad finita (300,000 km/s)

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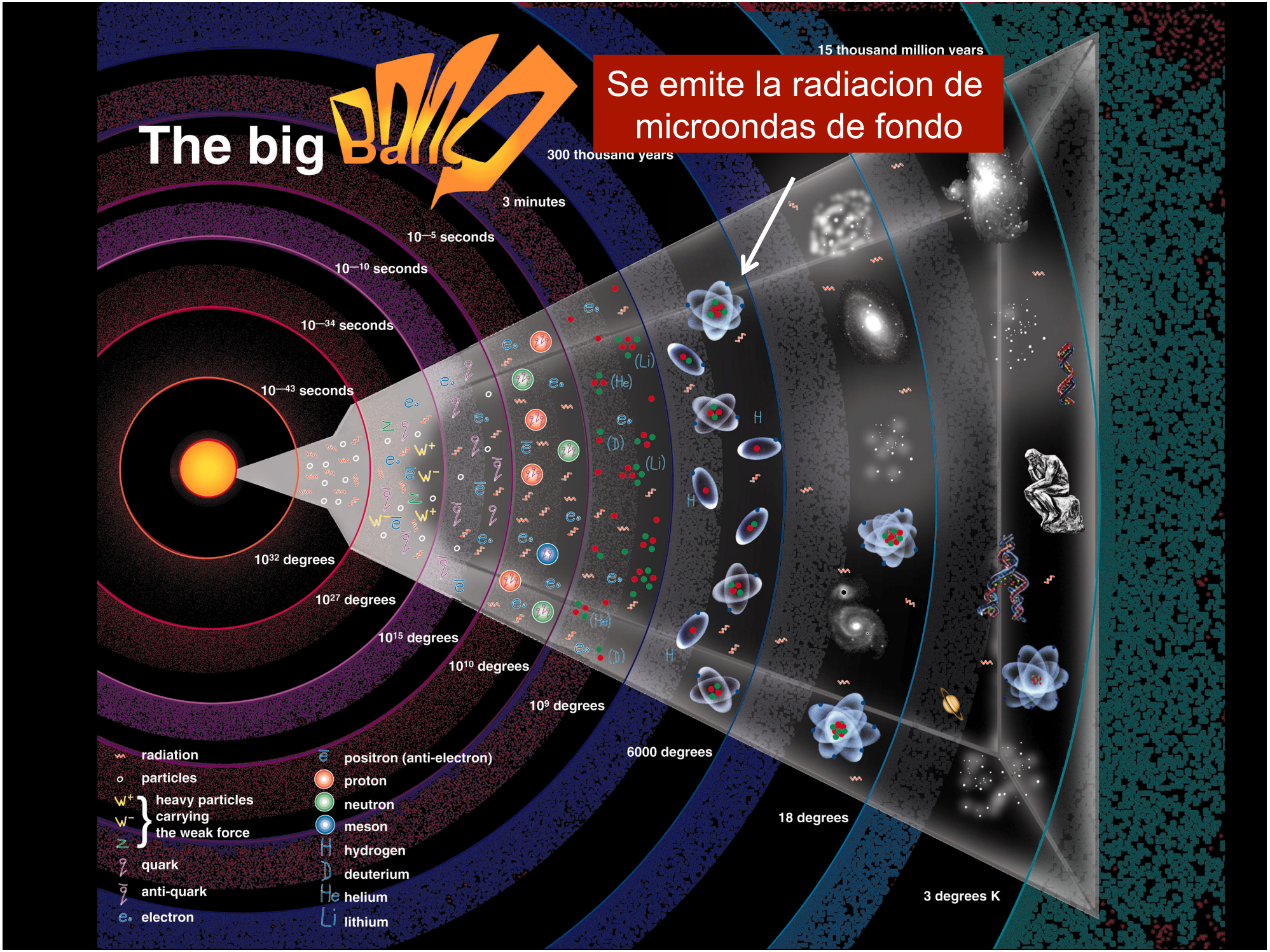
El universo temprano era muy caliente


The big Bang
Se emite la radiacion de microondas de fondo
15 thousand million years
300 thousand years
3 minutes
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10⁻¹⁰ seconds
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heavy particles carrying the weak force
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deuterium
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lithium

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El eco del Big Bang

Everywhere we look in the Universe we should feel the heat left over from the Big Bang.

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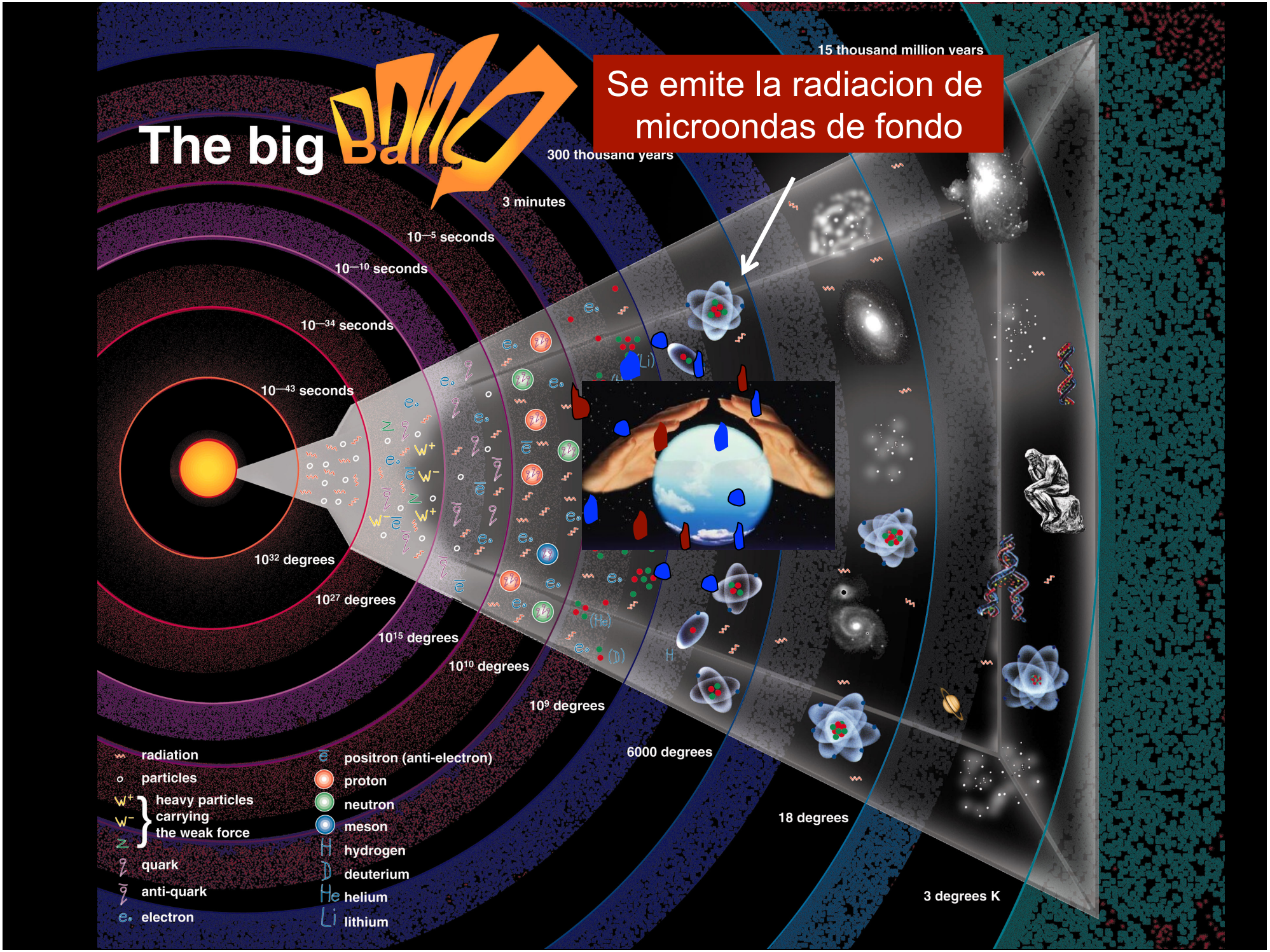
The echo of the Big Bang

In 1964, Arno Penzias & Bob Wilson were carrying out experiments using a microwave antenna for satellite communications.

As they pointed the antenna towards the sky, their receiver registered a faint ‘hiss’ coming from all directions that would not go away.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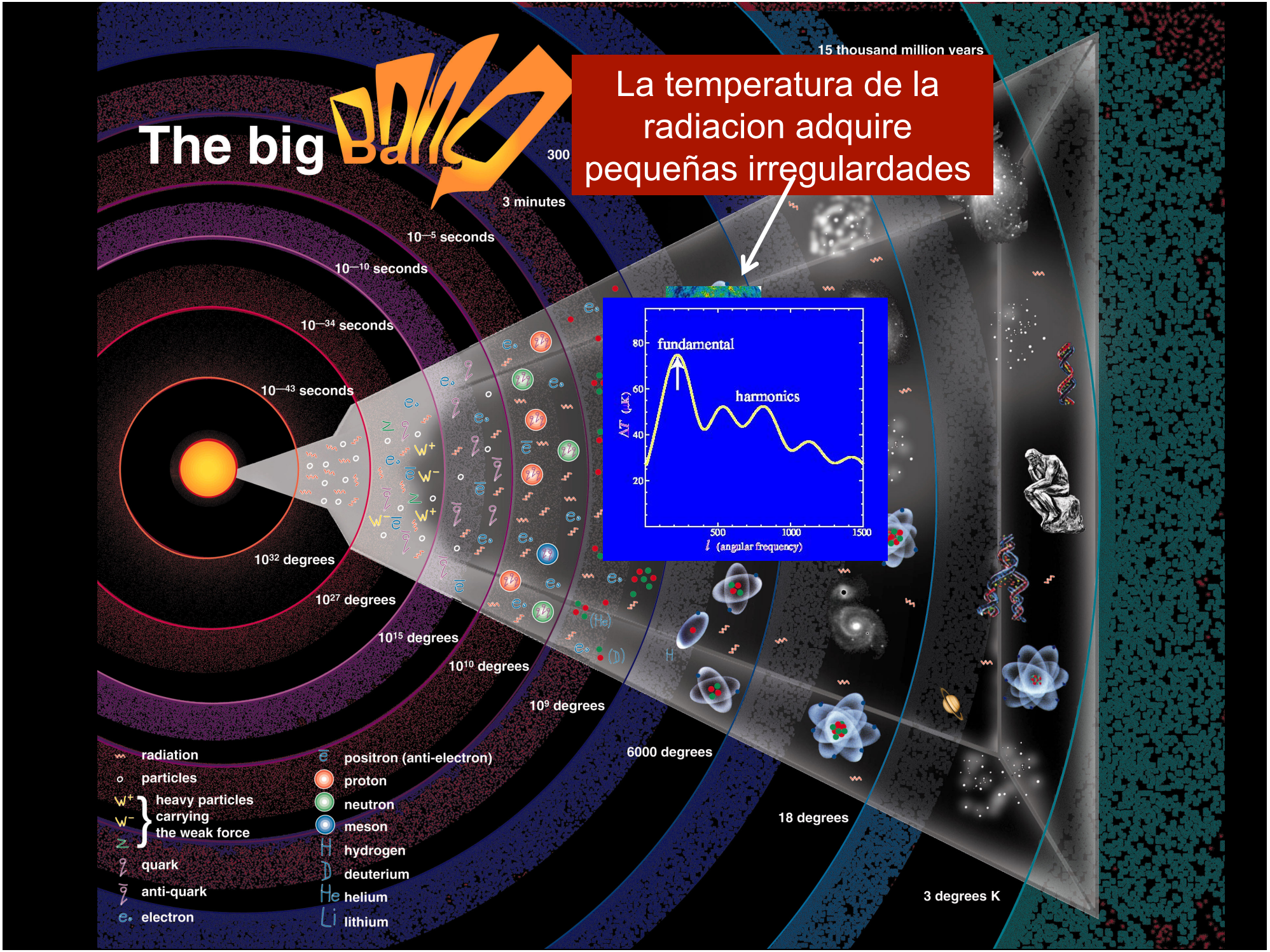
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10¹⁵ degrees
10¹⁰ degrees
10⁹ degrees
6000 degrees
18 degrees
3 degrees K
fundamental
harmonics
ΔT (μK)
80
60
40
20
500
1000
1500
l (angular frequency)
radiation
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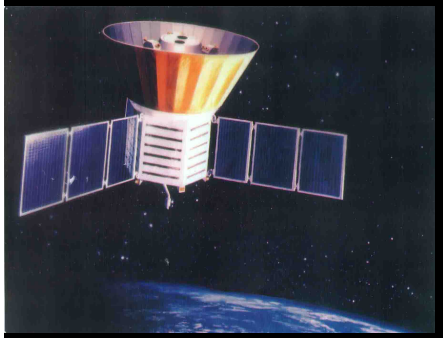
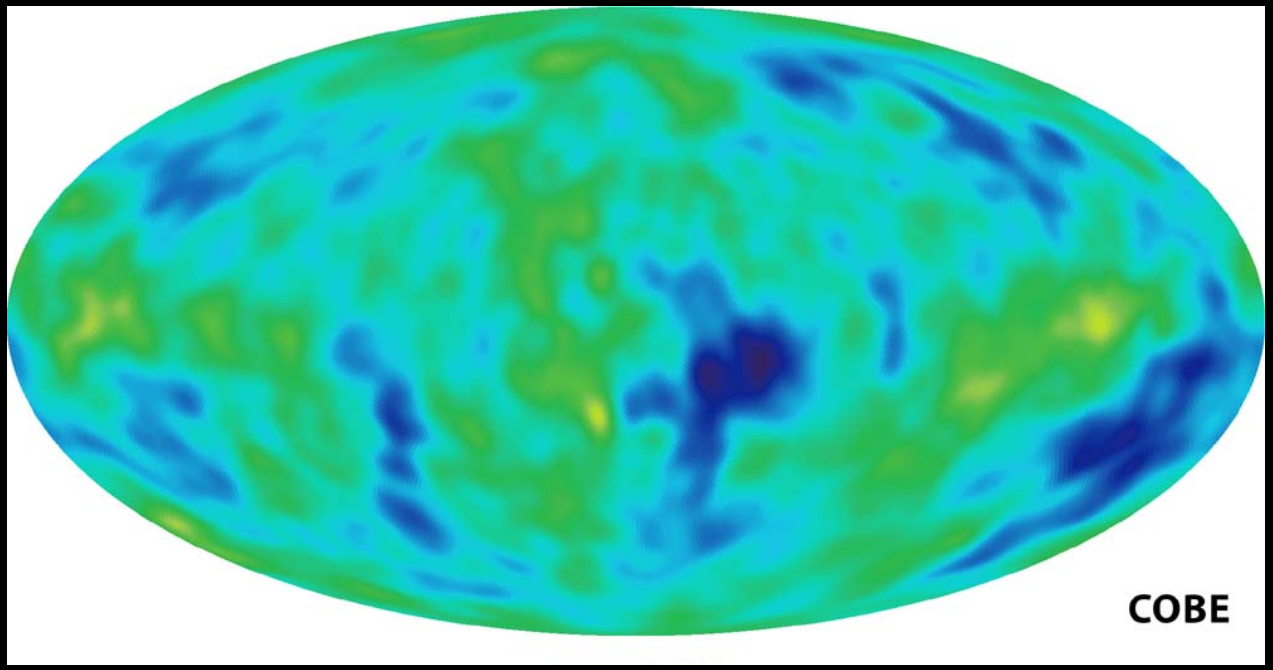
deuterium
helium
lithium

The CMB

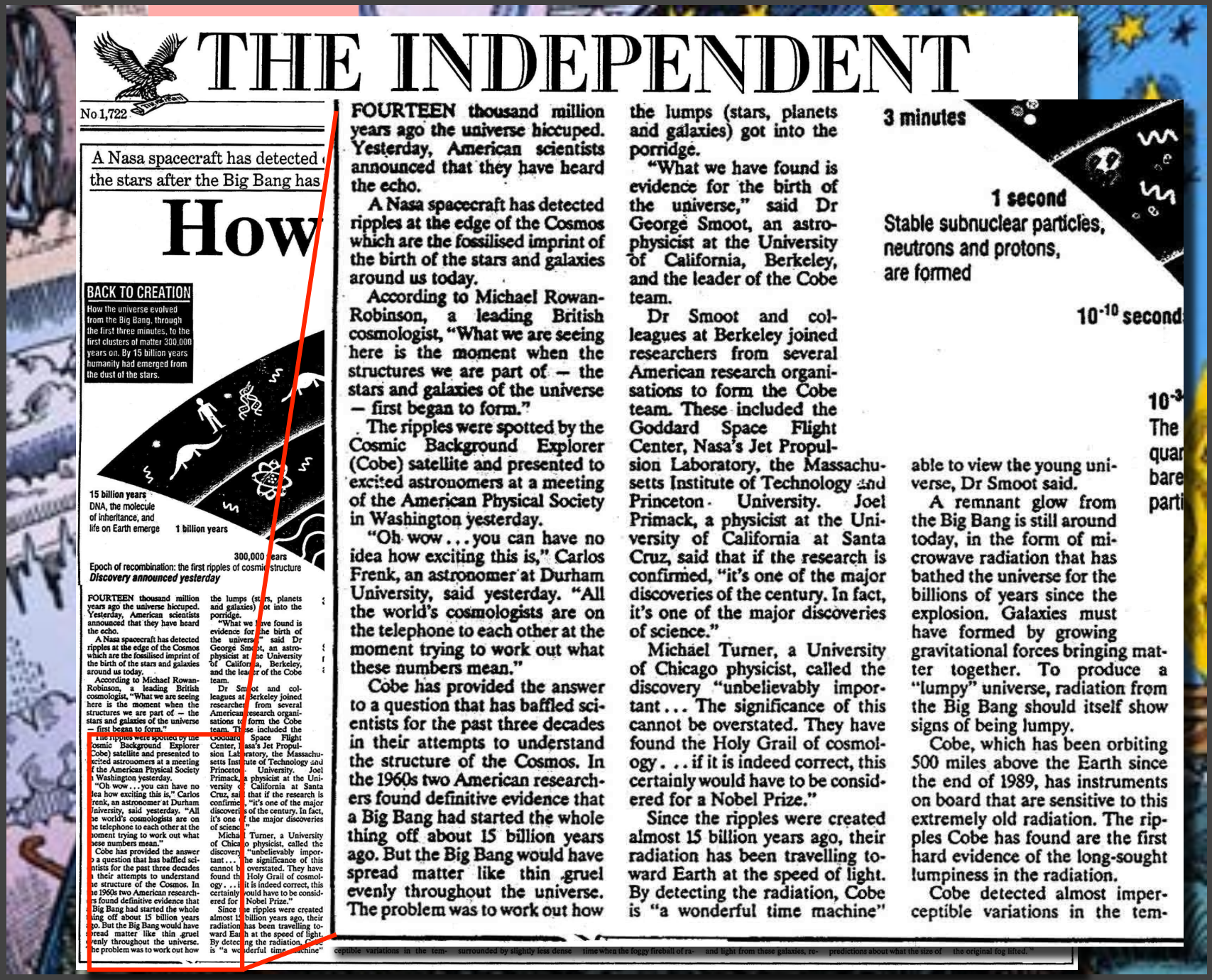
1992





The cosmic microwave background radiation (CMB) provides a window to the universe at $t \sim 3 \times 10^5$ yrs

In 1992 COBE discovered temperature fluctuations ($\Delta T/T \sim 10^{-5}$) consistent with inflation predictions



THE INDEPENDENT

No 1,722

A Nasa spacecraft has detected
the stars after the Big Bang has

How

BACK TO CREATION

How the universe evolved from the Big Bang, through the first three minutes, to the first clusters of matter 300,000 years on. By 15 billion years humanity had emerged from the dust of the stars.

15 billion years
DNA, the molecule of inheritance, and life on Earth emerge

1 billion years

300,000 years

Epoch of recombination: the first ripples of cosmic structure

Discovery announced yesterday

FOURTEEN thousand million years ago the universe hiccuped. Yesterday, American scientists announced that they have heard the echo.

A Nasa spacecraft has detected ripples at the edge of the Cosmos which are the fossilised imprint of the birth of the stars and galaxies around us today.

According to Michael Rowan-Robinson, a leading British cosmologist, "What we are seeing here is the moment when the structures we are part of — the stars and galaxies of the universe — first began to form."

The ripples were spotted by the Cosmic Background Explorer (Cobe) satellite and presented to excited astronomers at a meeting of the American Physical Society in Washington yesterday.

"Oh wow . . . you can have no idea how exciting this is," Carlos Frenk, an astronomer at Durham University, said yesterday. "All the world's cosmologists are on the telephone to each other at the moment trying to work out what these numbers mean."

Cobe has provided the answer to a question that has baffled scientists for the past three decades in their attempts to understand the structure of the Cosmos. In the 1960s two American researchers found definitive evidence that a Big Bang had started the whole thing off about 15 billion years ago. But the Big Bang would have spread matter like thin gruel evenly throughout the universe. The problem was to work out how the lumps (stars, planets and galaxies) got into the porridge.

"What we have found is evidence for the birth of the universe," said Dr George Smoot, an astrophysicist at the University of California, Berkeley, and the leader of the Cobe team.

Dr Smoot and colleagues at Berkeley joined researchers from several American research organisations to form the Cobe team. These included the Goddard Space Flight Center, Nasa's Jet Propulsion Laboratory, the Massachusetts Institute of Technology and Princeton University. Joel Primack, a physicist at the University of California at Santa Cruz, said that if the research is confirmed, "it's one of the major discoveries of the century. In fact, it's one of the major discoveries of science."

Michael Turner, a University of Chicago physicist, called the discovery "unbelievably important . . . The significance of this cannot be overstated. They have found the Holy Grail of cosmology . . . if it is indeed correct, this certainly would have to be considered for a Nobel Prize."

Since the ripples were created almost 15 billion years ago, their radiation has been travelling toward Earth at the speed of light. By detecting the radiation, Cobe is "a wonderful time machine" able to view the young universe, Dr Smoot said.

A remnant glow from the Big Bang is still around today, in the form of microwave radiation that has bathed the universe for the billions of years since the explosion. Galaxies must have formed by growing gravitational forces bringing matter together. To produce a "lumpy" universe, radiation from the Big Bang should itself show signs of being lumpy.

Cobe, which has been orbiting 500 miles above the Earth since the end of 1989, has instruments on board that are sensitive to this extremely old radiation. The ripples Cobe has found are the first hard evidence of the long-sought lumpiness in the radiation.

Cobe detected almost imperceptible variations in the tem- surrounded by slightly less dense time when the foggy fireball of ra- and light from these galaxies, re- predictions about what the size of the original fog lifted."

3 minutes

1 second
Stable subnuclear particles, neutrons and protons, are formed

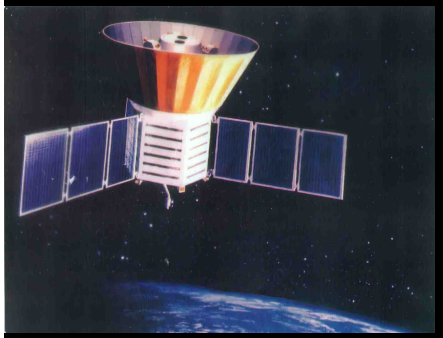
10^{-10} second

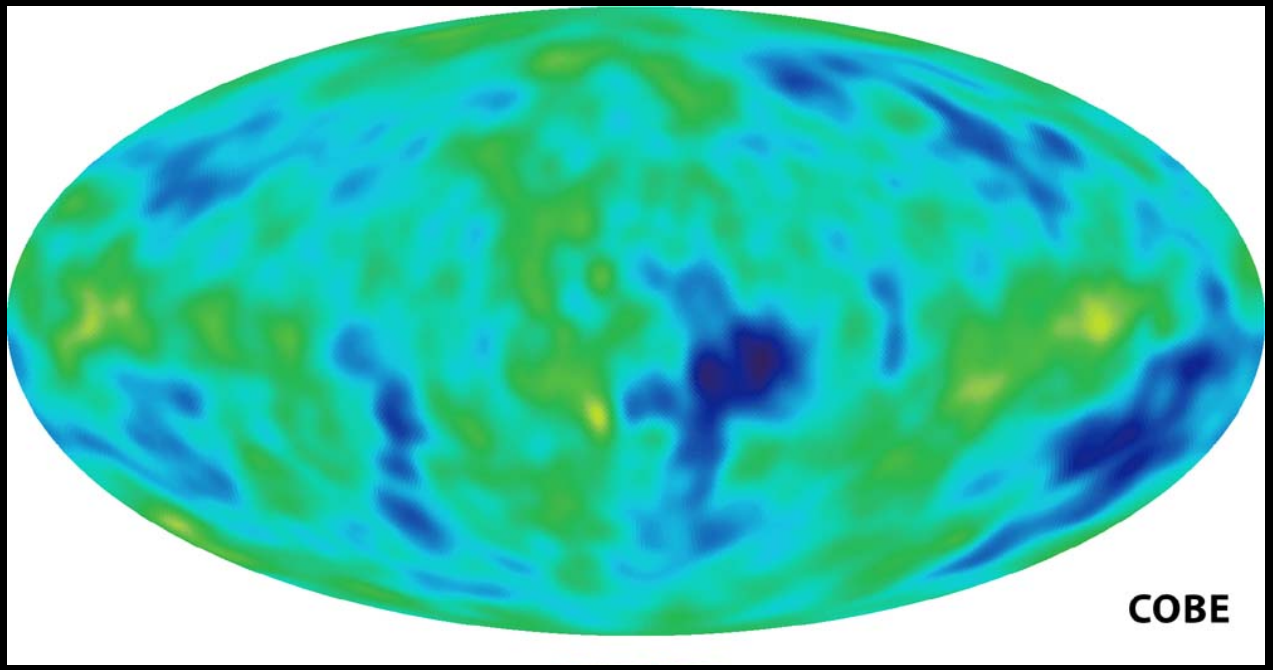
10^{-3}
The
quar
bare
parti

Flammarion 1888: tete des etoiles

The CMB

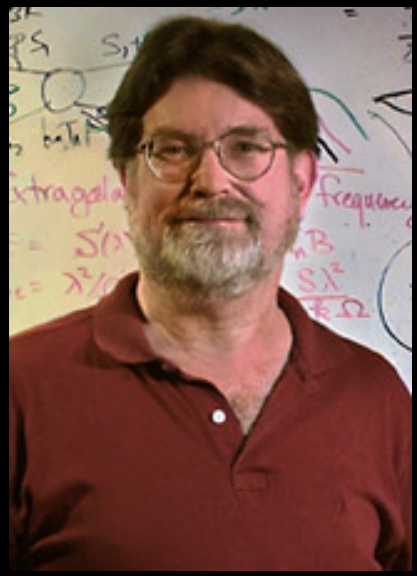
1992





George Smoot - Nobel Prize 2006

KUNGL. VETENSKAPSAKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES



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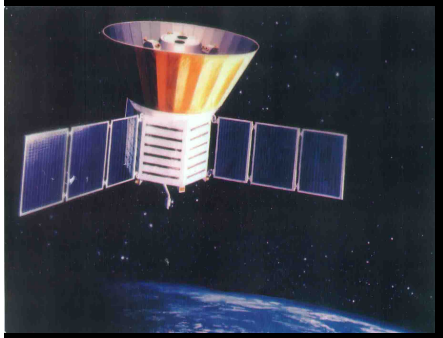
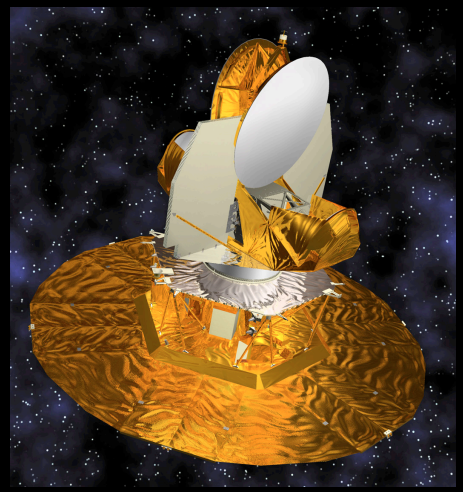
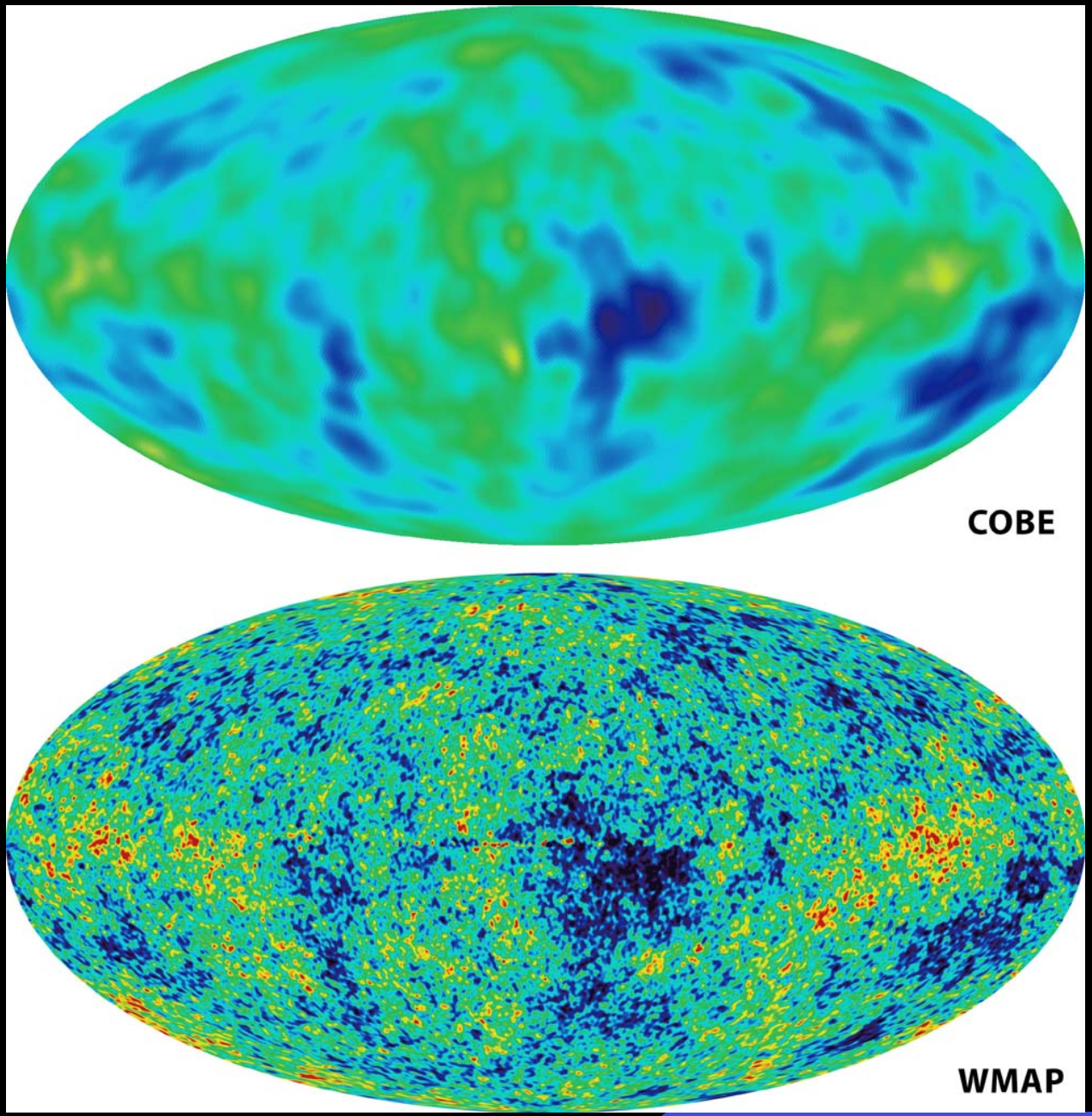


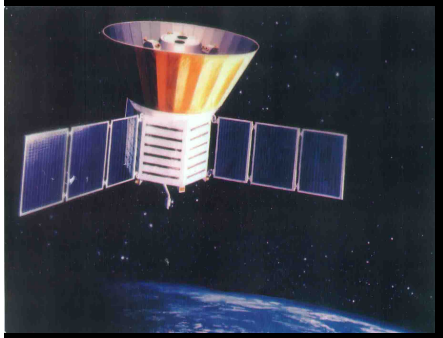
2003



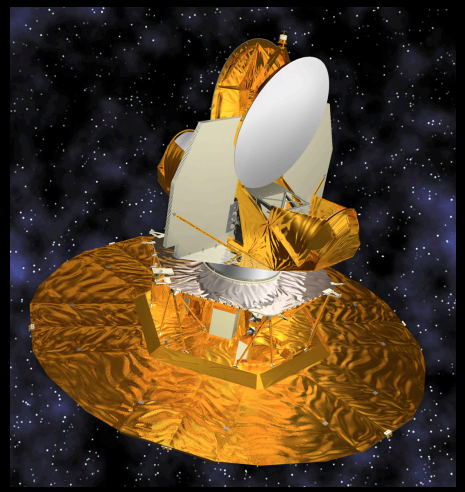


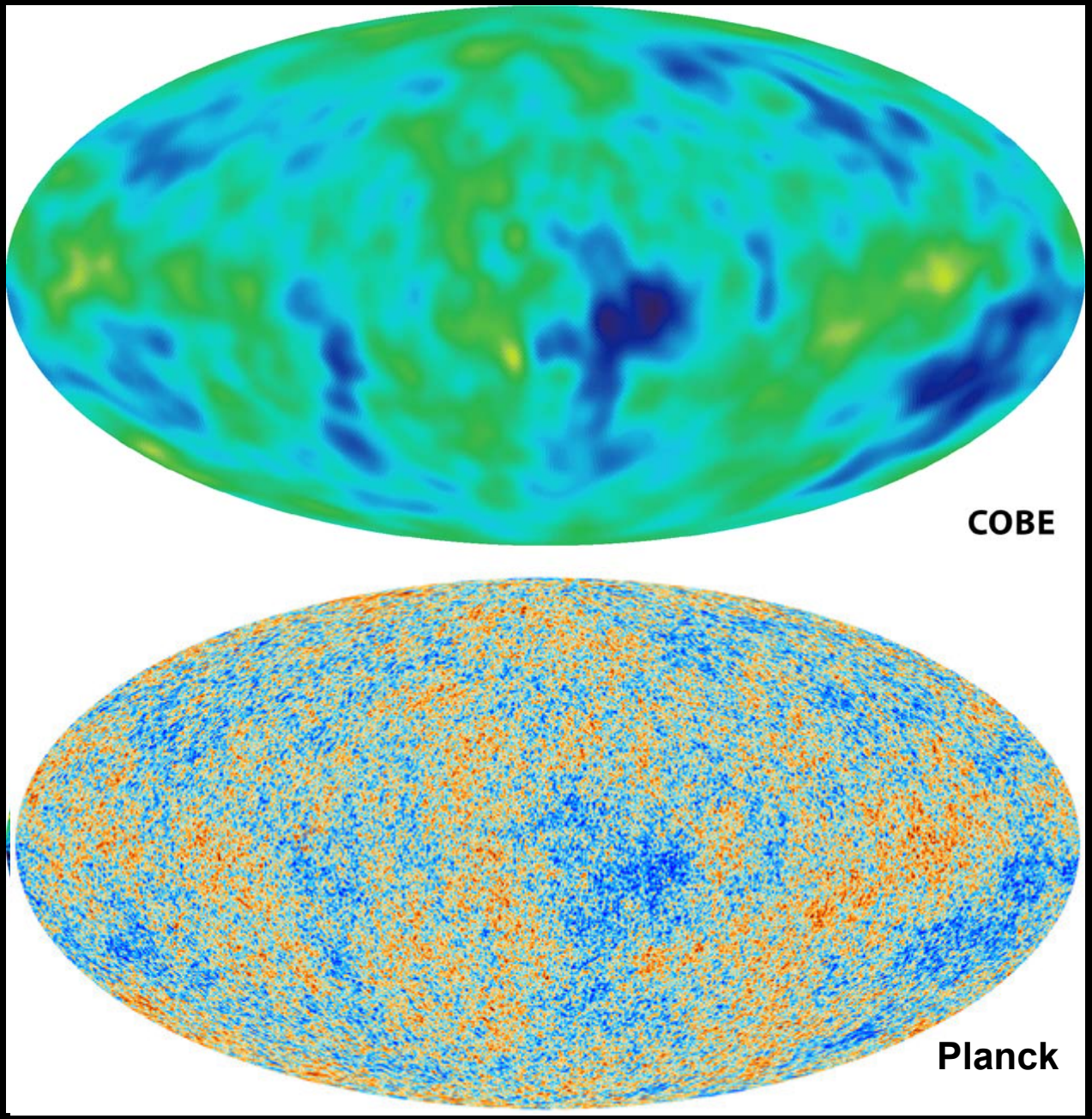
The CMB

1992

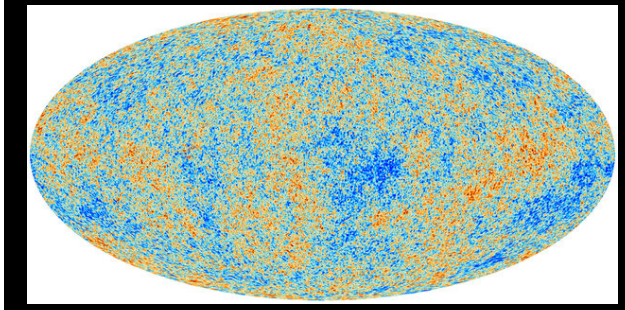


2012

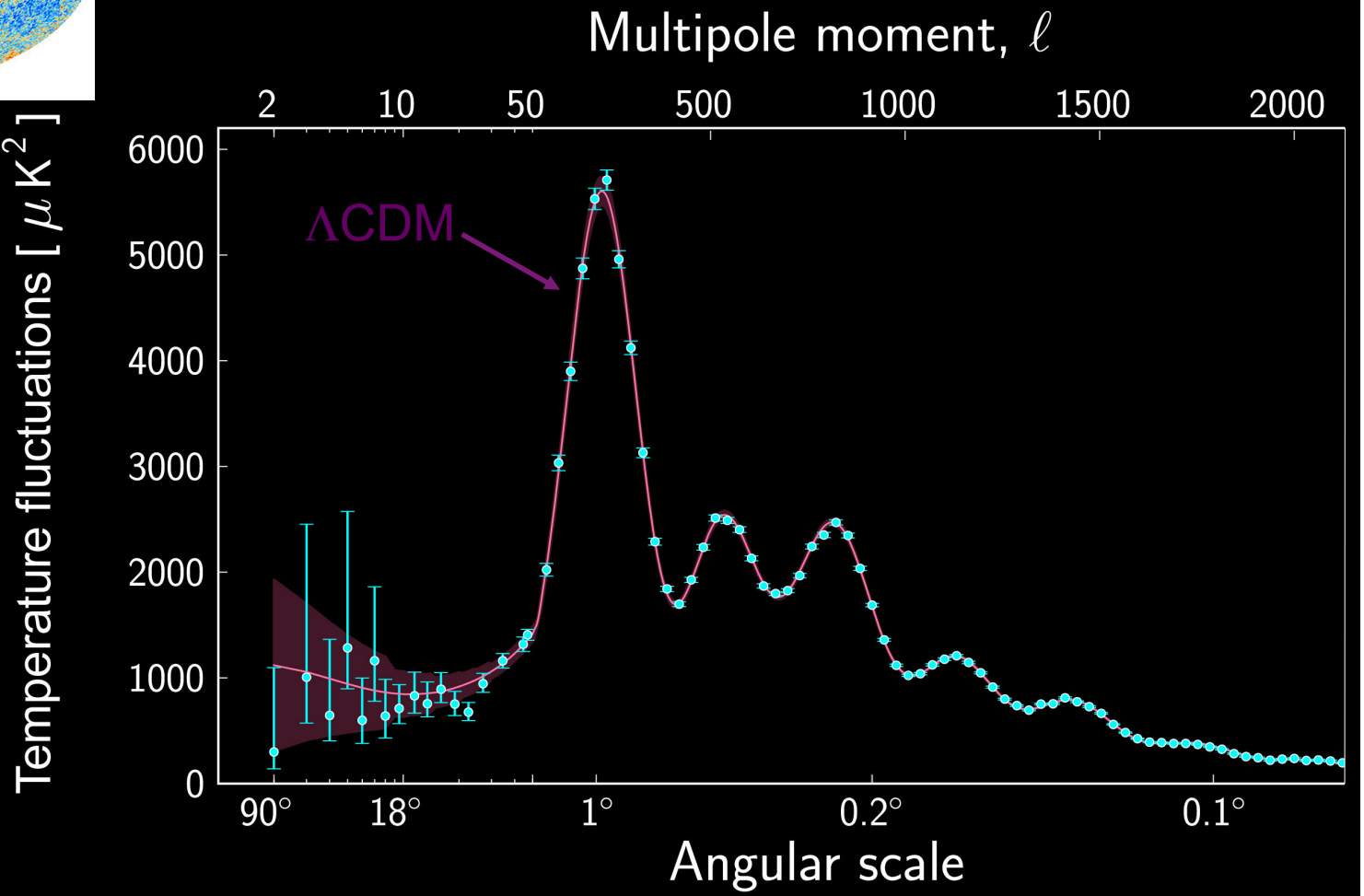




Planck: anisotropias en la temp. del CMB



Amplitud de la fluctuaciones z~1000

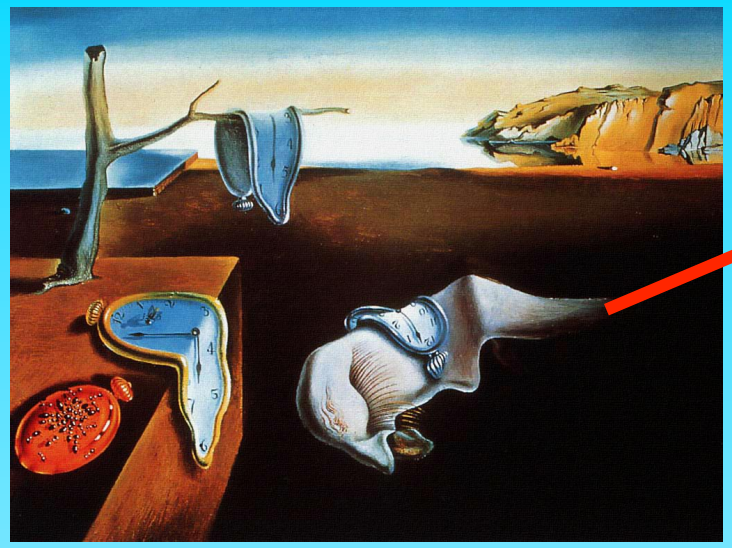


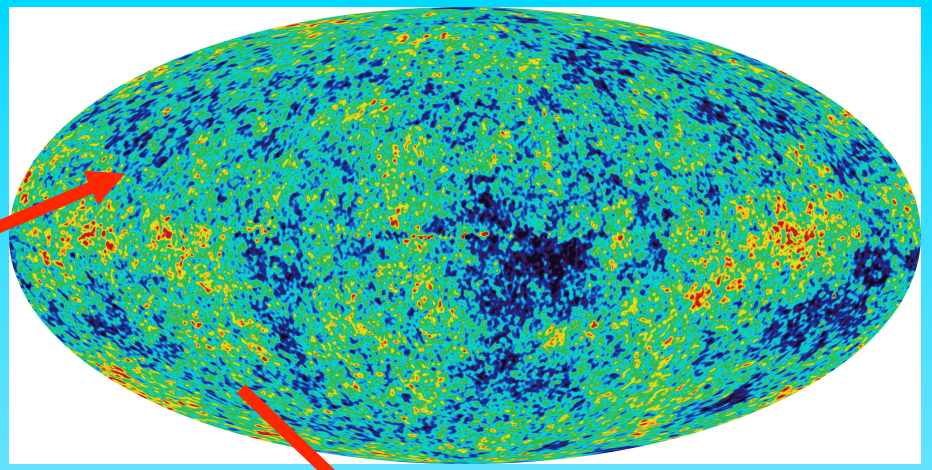
Los datos confirman las predicciones teoricas

Planck coll. 2013

University of Durham

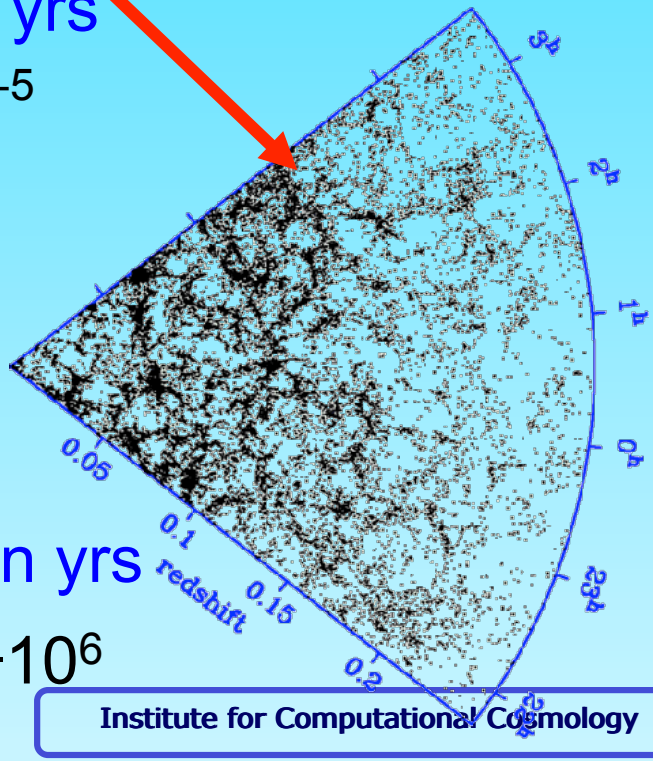
El crecimiento de estructura cosmica





t=380,000 yrs

$\delta\rho/\rho \sim 10^{-5}$



t=13.8 billion yrs

$\delta\rho/\rho \sim 1-10^{6}$

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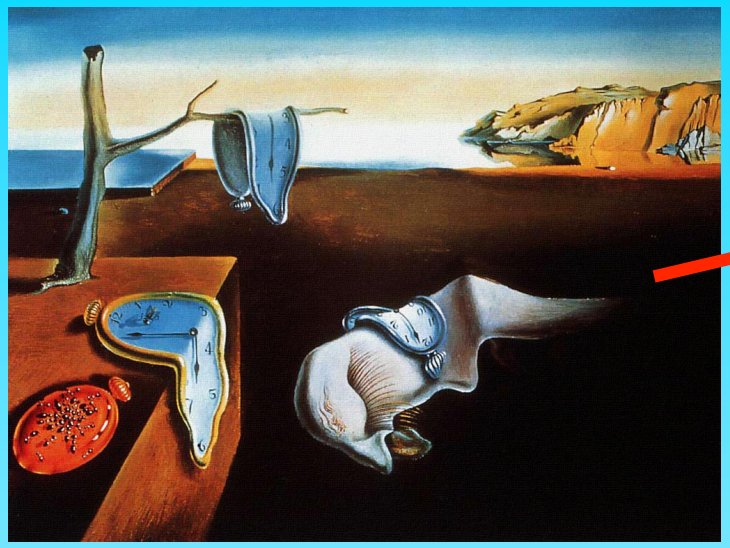
Tests del paradigma

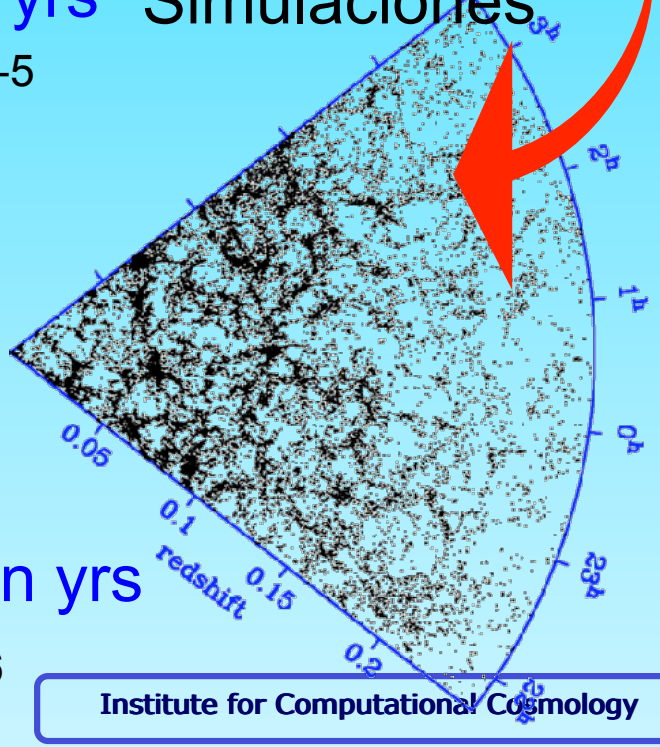


"Cosmology machine"

t=380,000 yrs Simulaciones

$\delta\rho/\rho \sim 10^{-5}$

Simulaciones en supercomputadoras usan leyes de la fisica para calcular come pequeñas perturbaciones primordiales dan lugar a las galaxias



t=13.8 billion yrs

$\delta\rho/\rho \sim 1\text{–}10^{6}$

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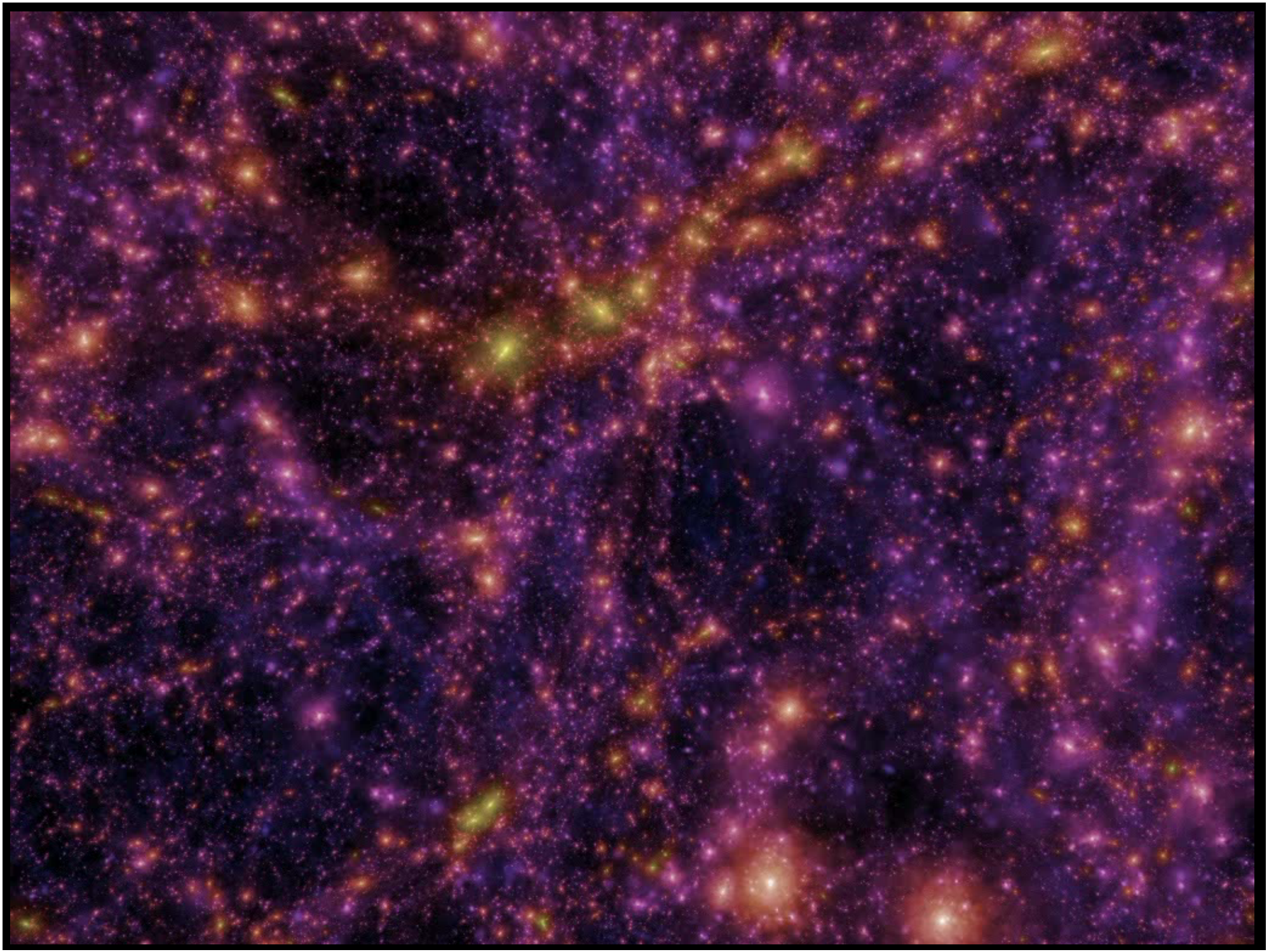
z = 48.4
T = 0.05 Gyr
500 kpc

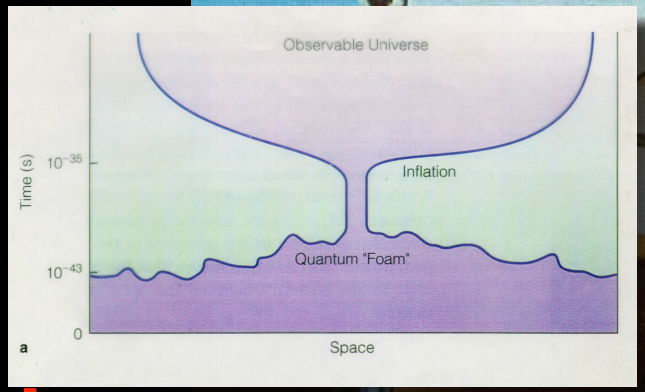


X-ray coronae in simulations of disc galaxy formation

Robert A. Crain, Ian G. McCarthy, Carlos S. Frenk, Tom Theuns & Joop Schaye

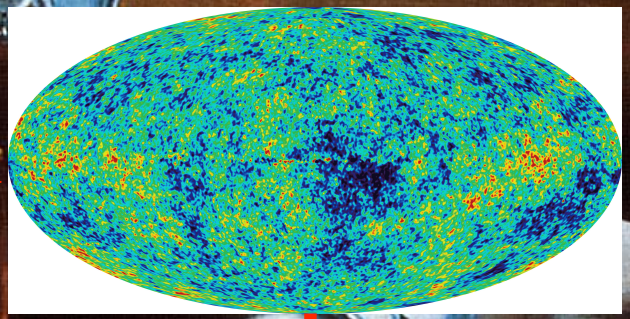
El origen de la estructura cosmica

Inflacion (t~10^{-35} s)



Pequeñas fluctuaciones cuanticas

CMB (t~$3x10^5$ yrs)

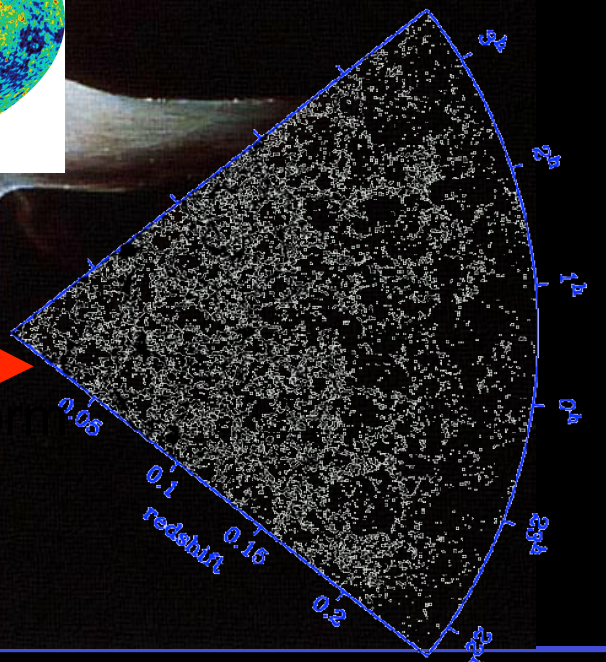


Galaxias (t~$13x10^9$yrs)

Materia obscura

Ripples seen as hot & cold spots in cosmic radiation

Galaxies form



Recent measurements of CMB temperature fluctuations and of the galaxy distribution confirm this paradigm.

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Es el final de la historia ?


Preguntas abiertas
Come empezo el universo?
Que es la energia obscura?
Que es la materia obscura?
art-wallpaper.org