VIAGGI NEL PASSATO?

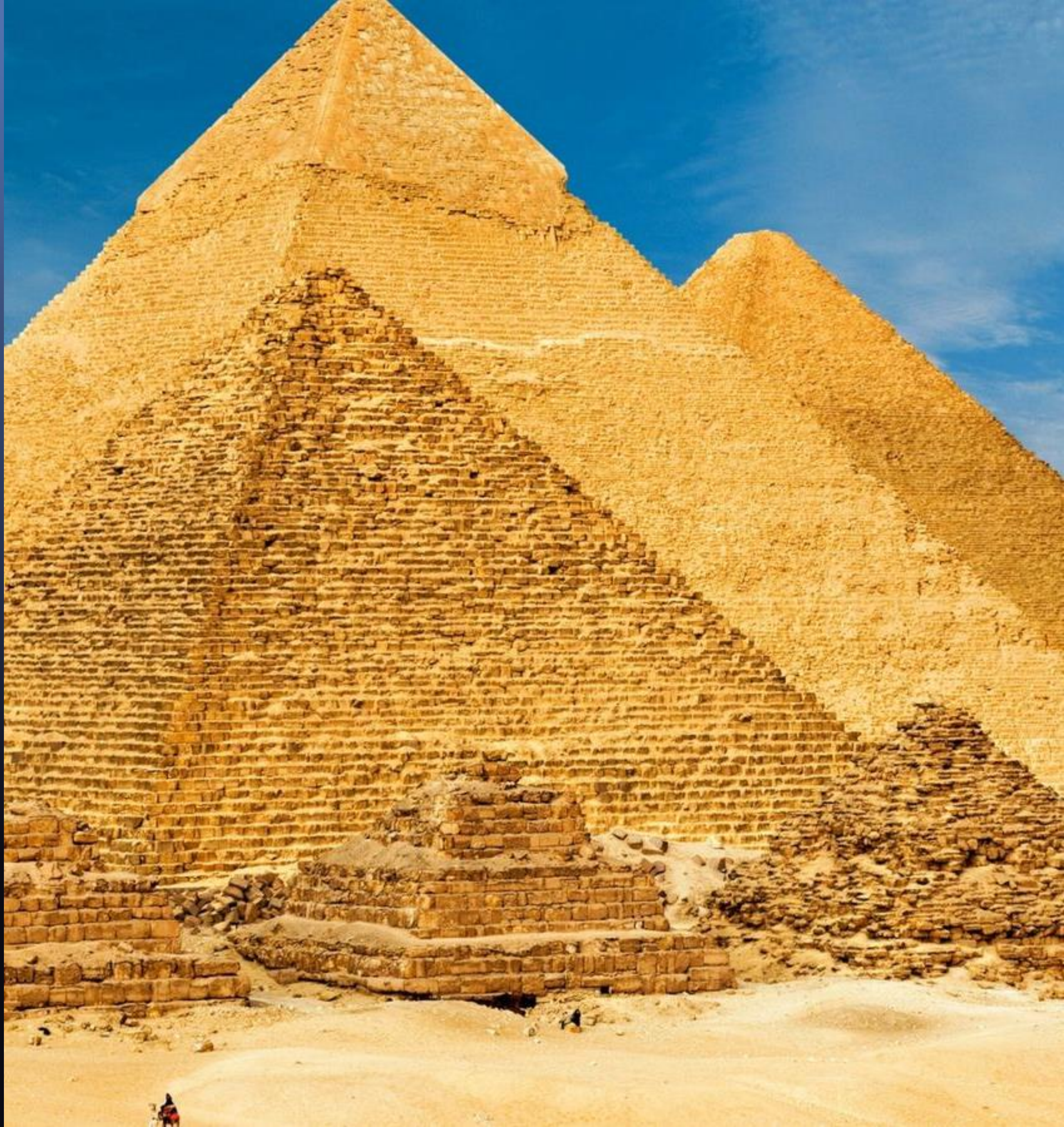
VEDERE LA NASCITA DELL'UNIVERSO

Art & Science ACROSS ITALY

INFN Istituto Nazionale di Fisica Nucleare

Vorreste vedervi cosi?

Oppure vedere gli Egizi che costruivano le Piramidi?



Oppure vedere un T-Rex dal vivo?

Non è possibile vedere il passato

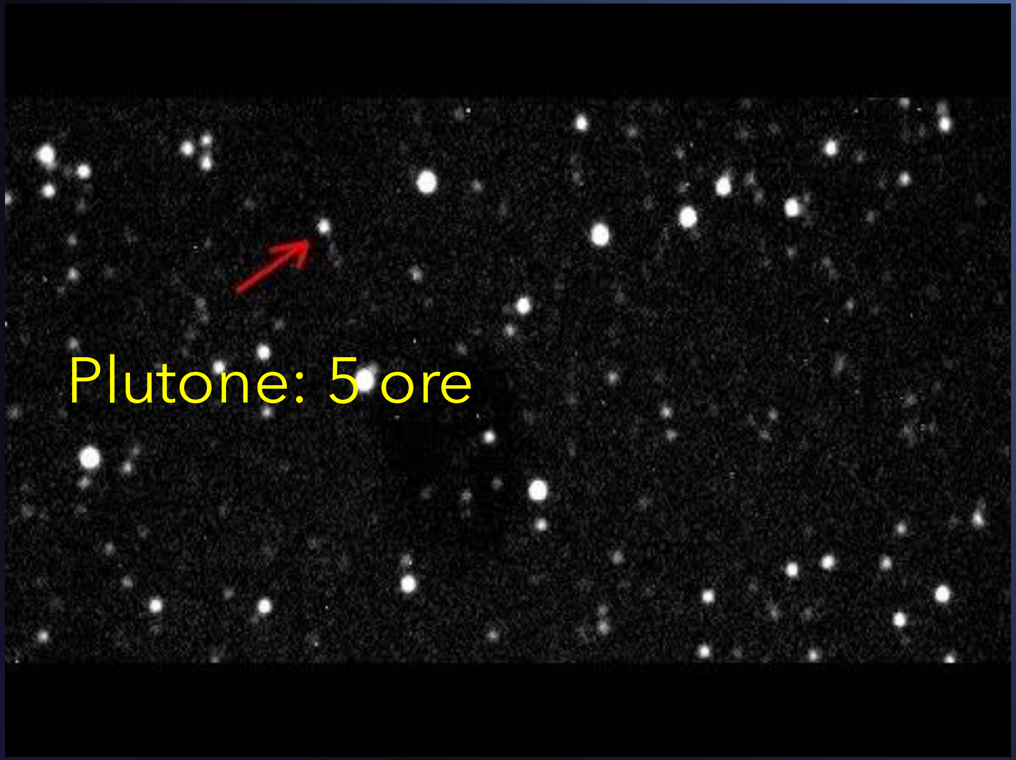
Ma ne siamo sicuri?

299 792 458 m/s

1 secondo

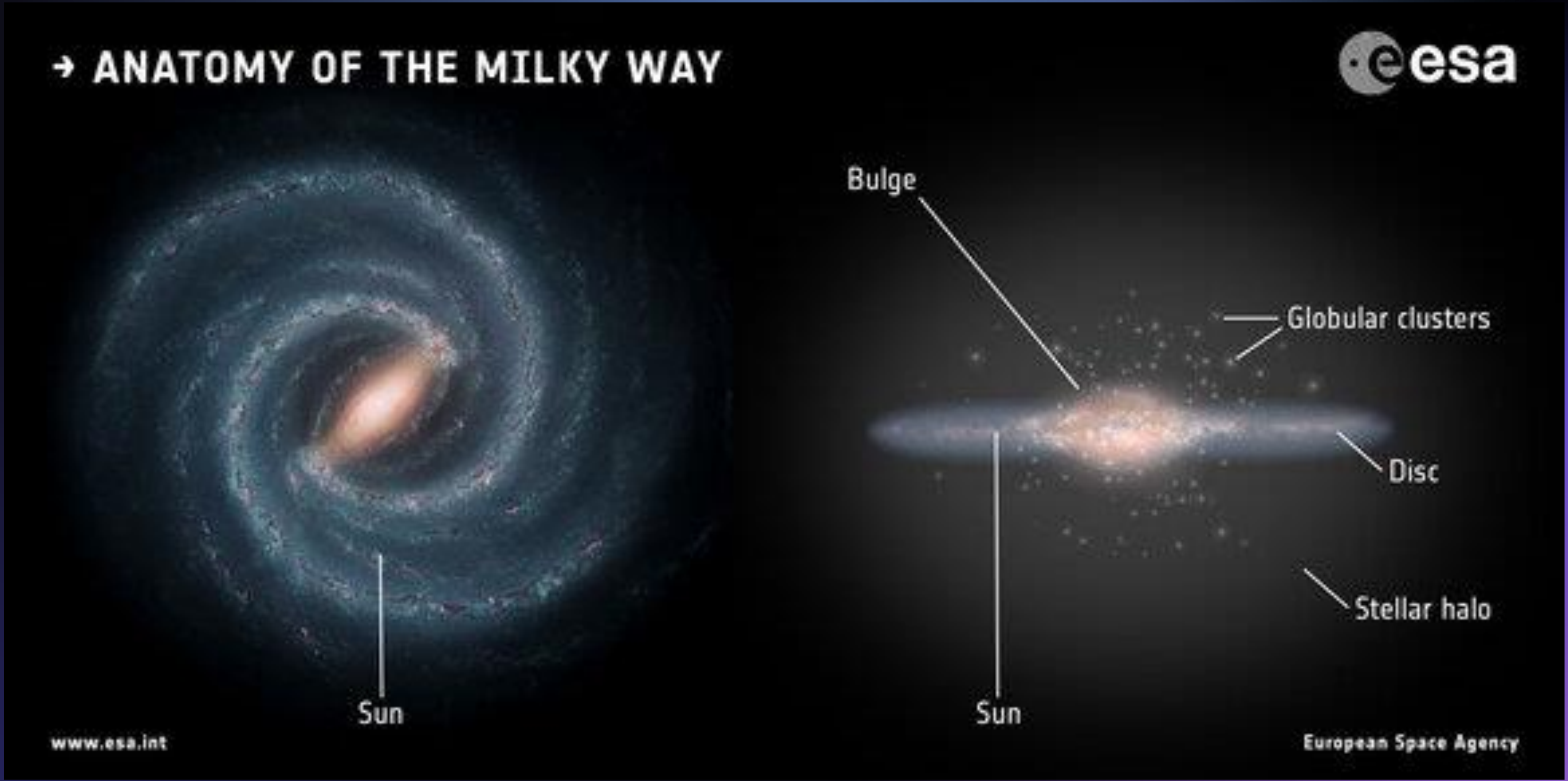
8 minuti

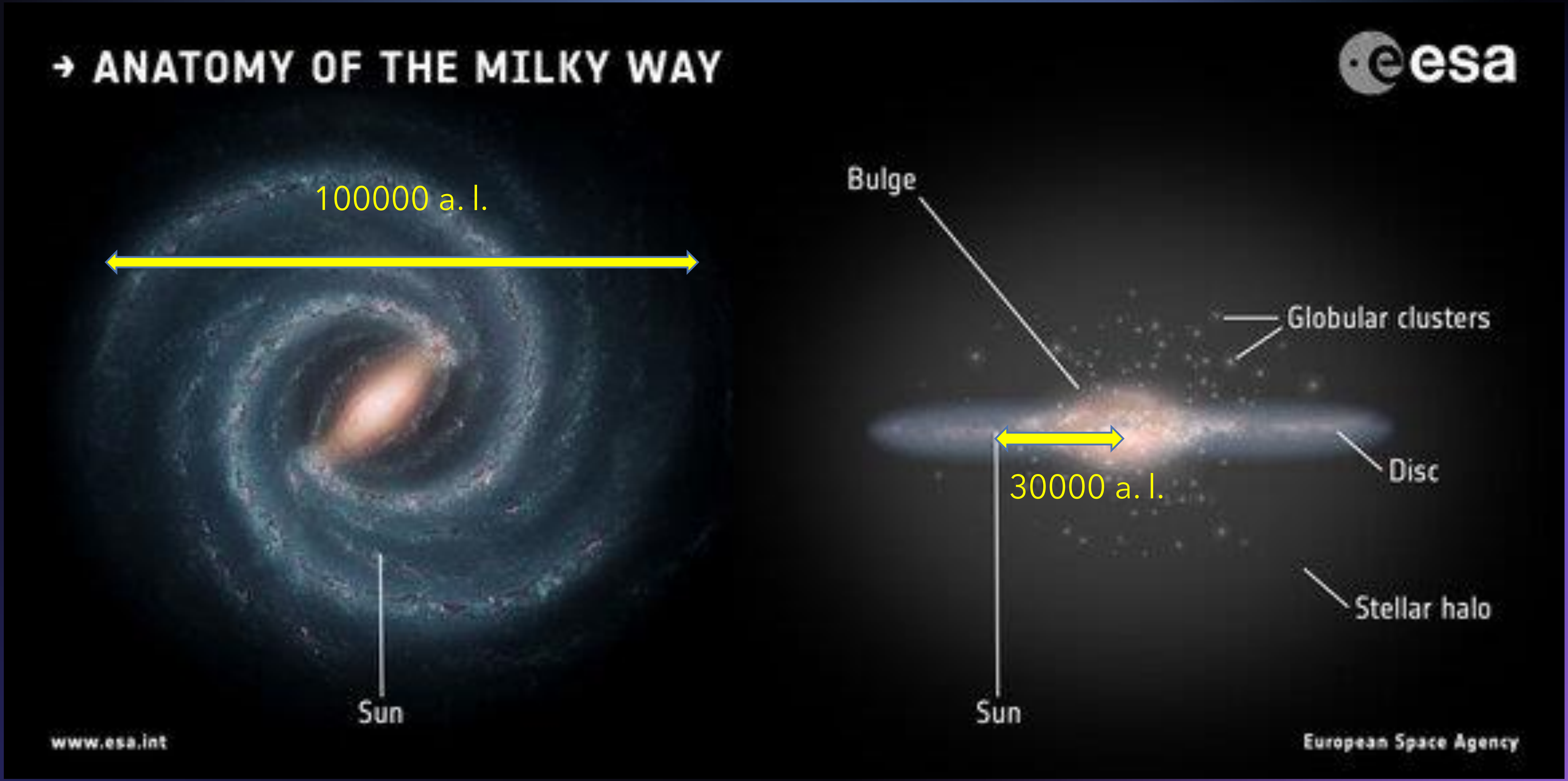

Alcuni anni, centinaia o migliaia di anni
Venus 4'
Mars 13'
Mercury 11'
Saturn 1 h 40 '
Moon 1''
30 milionesimi di secondo


Plutone: 5 ore

Voyager 1: 22 ore

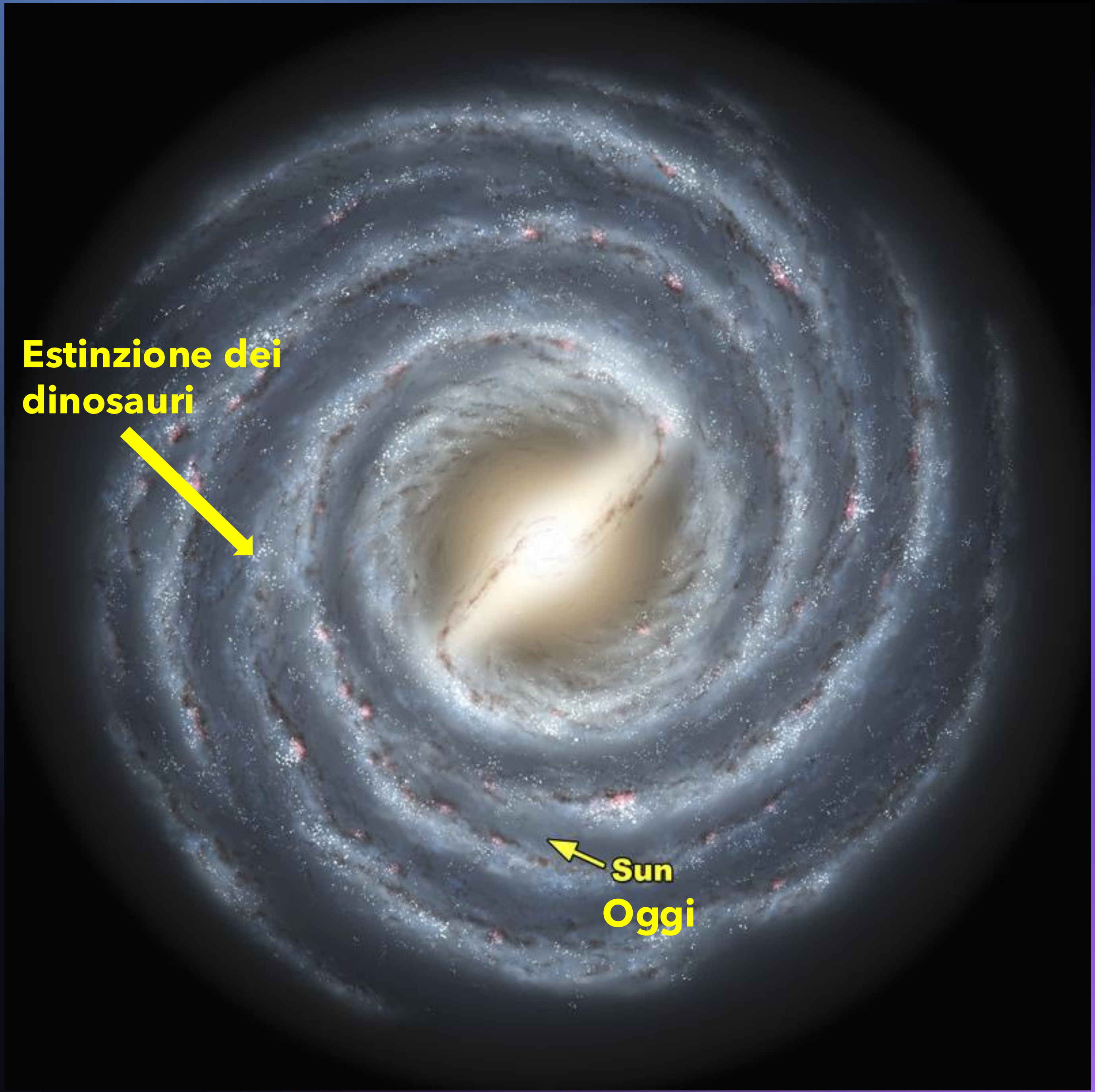
Proxima Centauri:
4.25 anni luce


→ ANATOMY OF THE MILKY WAY
esa
Bulge
Globular clusters
Disc
Stellar halo
Sun
Sun
www.esa.int
European Space Agency

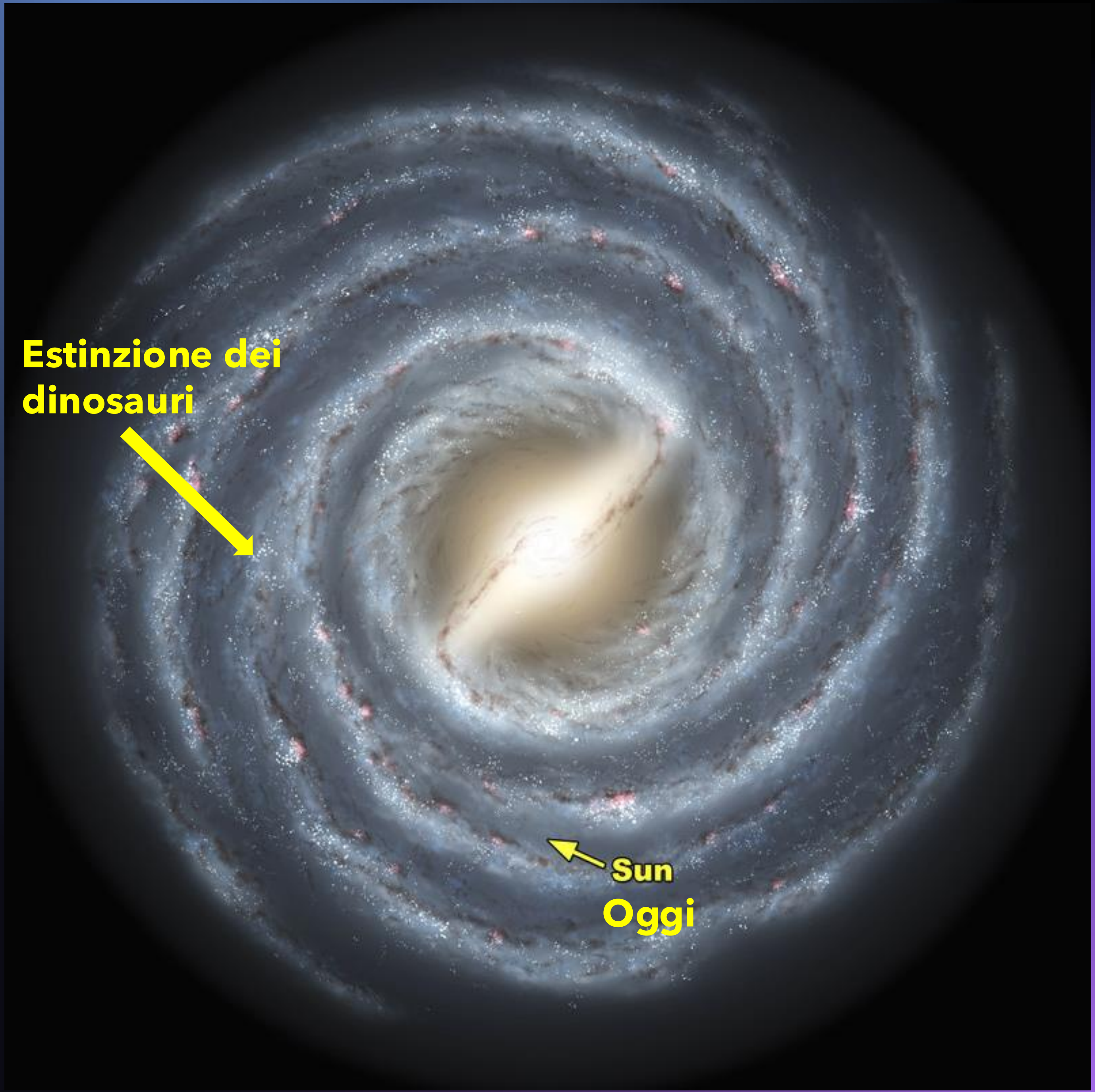


→ ANATOMY OF THE MILKY WAY
esa
100000 a. l.
Bulge
Globular clusters
Disc
30000 a. l.
Stellar halo
Sun
Sun
www.esa.int
European Space Agency

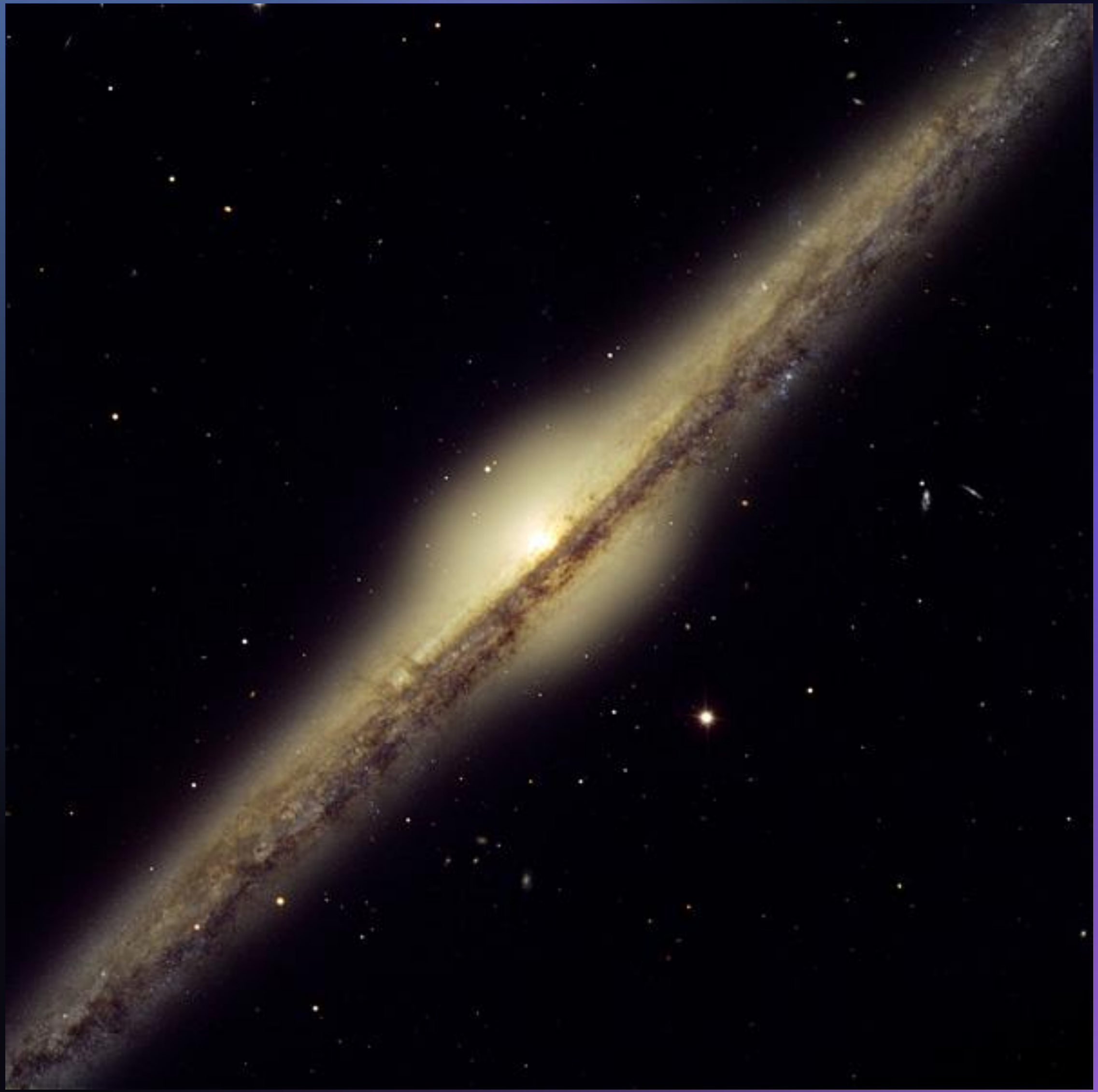
Un giro in 230 milioni di anni



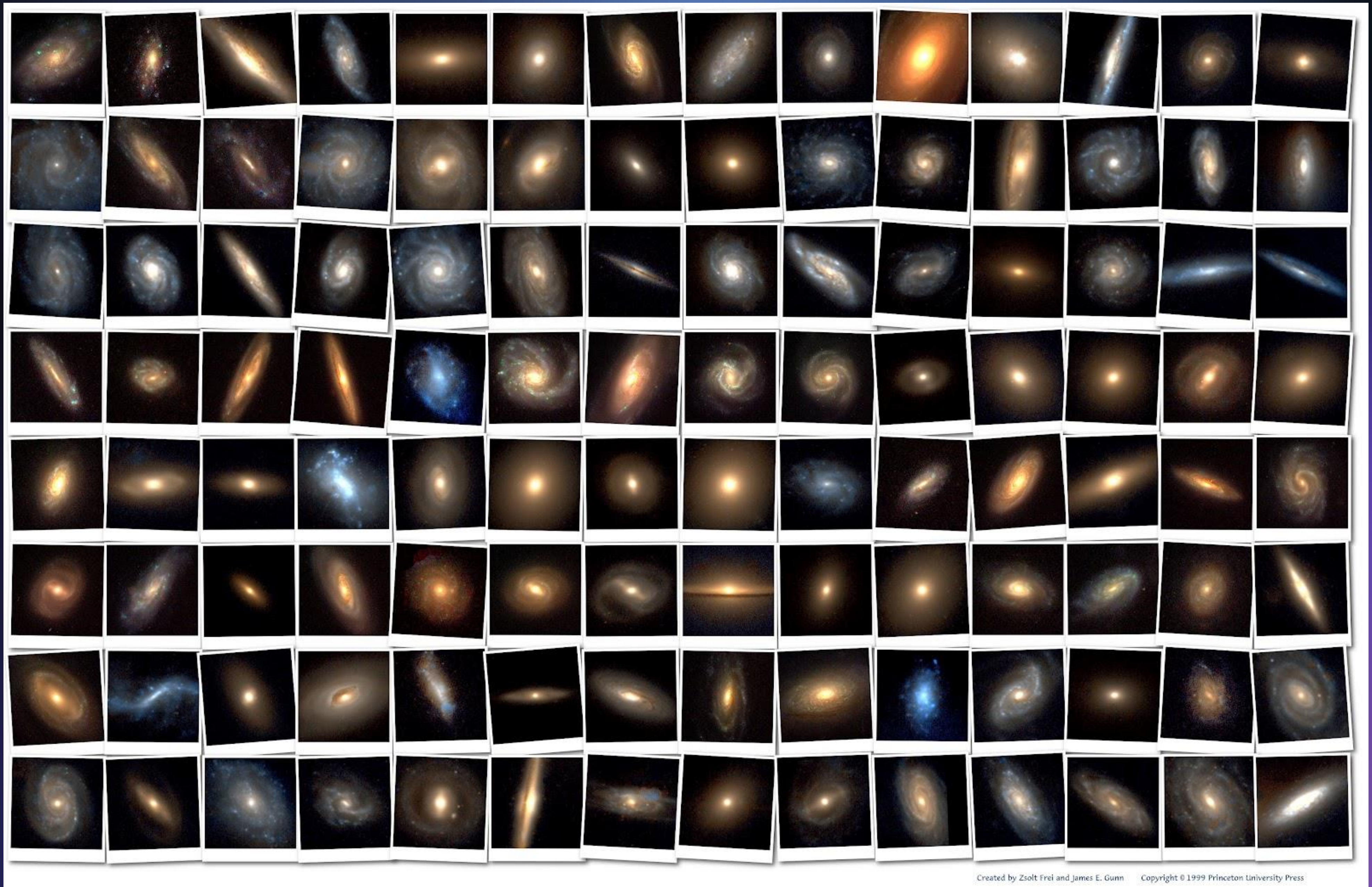
Velocità: 800 mila km/h



Galassie simili alla nostra, ma viste con inclinazioni diverse



2 milioni e 400 000 anni


Created by Zsolt Frei and James E. Gunn
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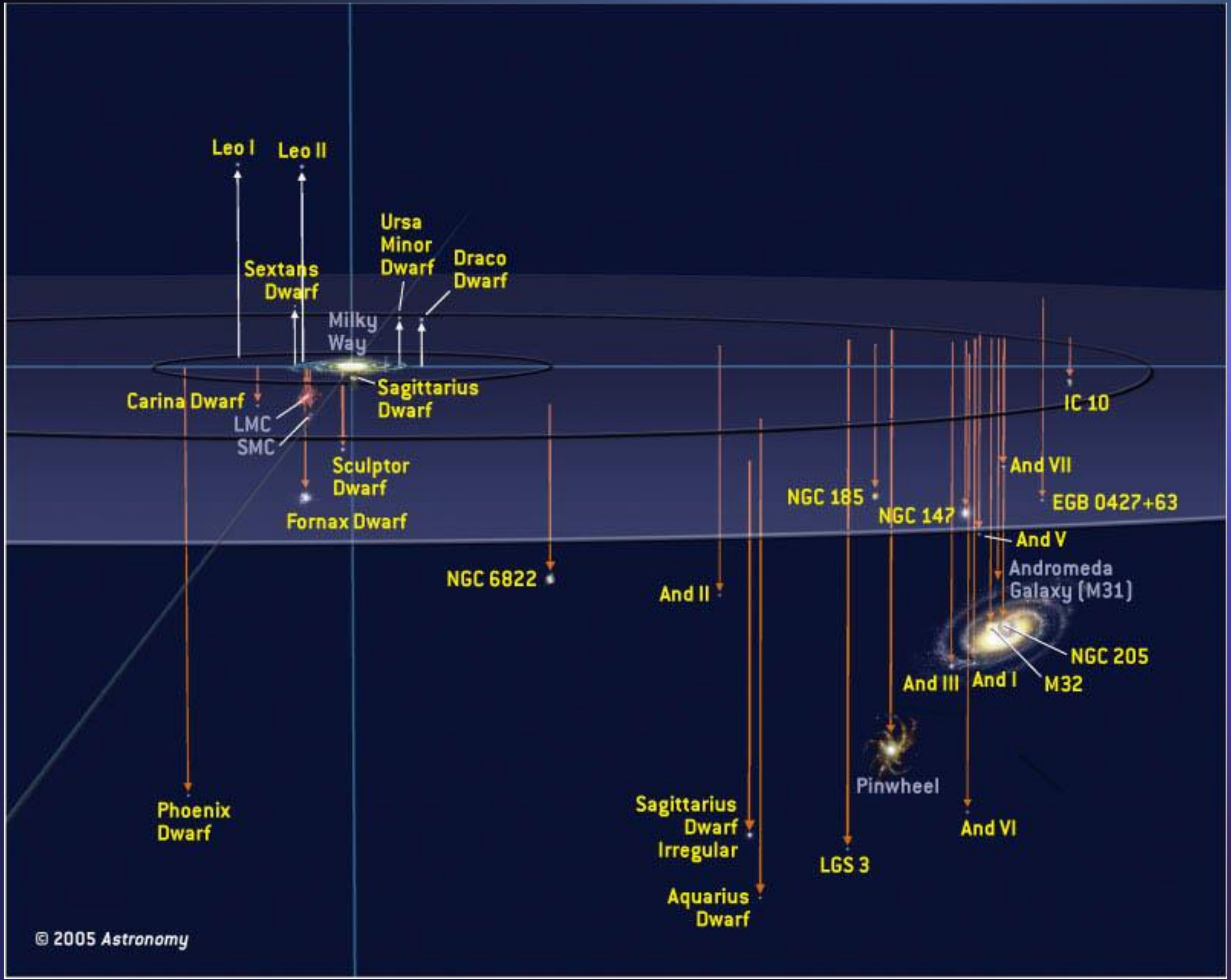


Il "gruppo locale" di galassie

Virgo Cluster

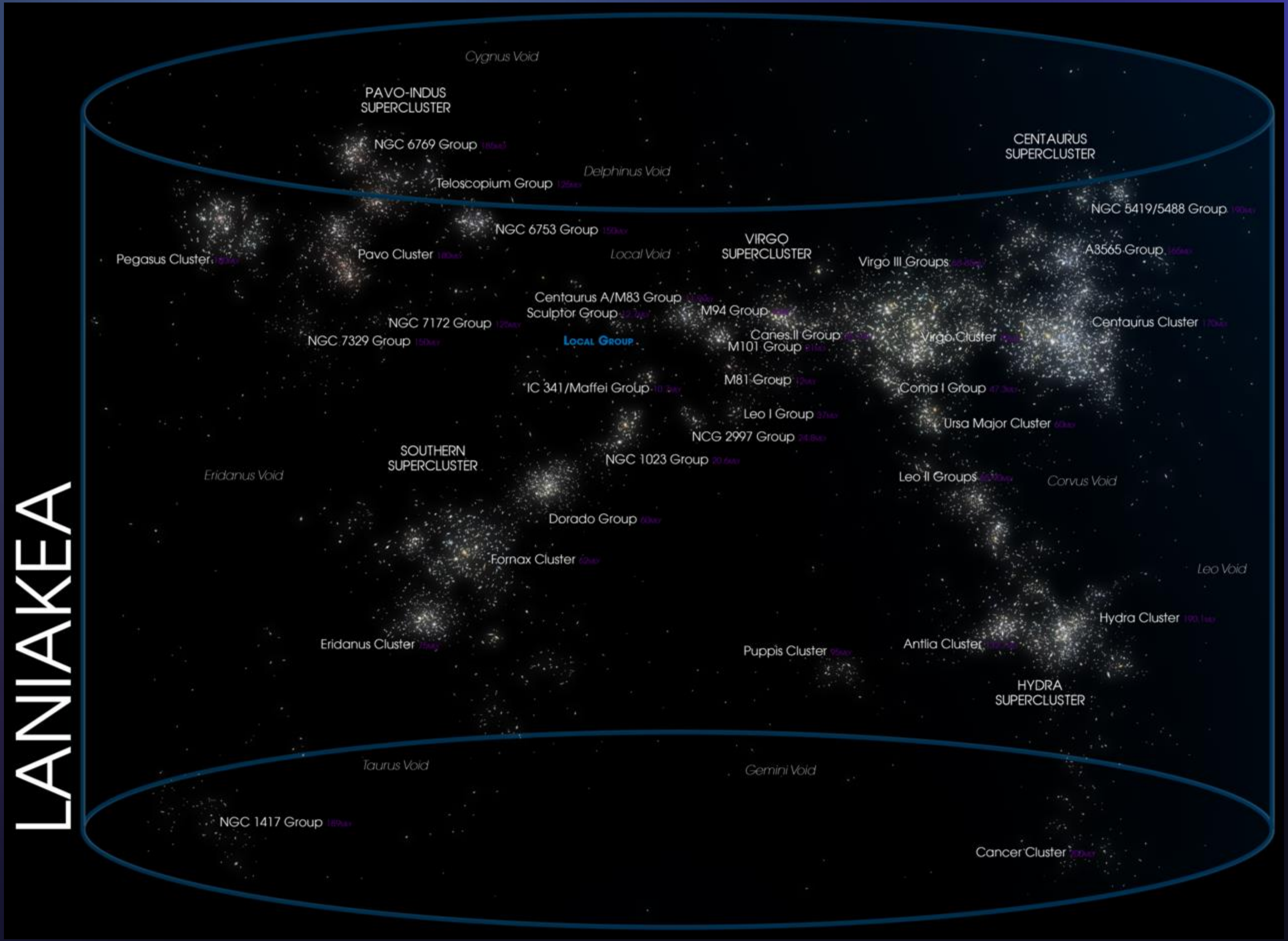
65 milioni di anni luce

Virgo Cluster

65 milioni di anni luce

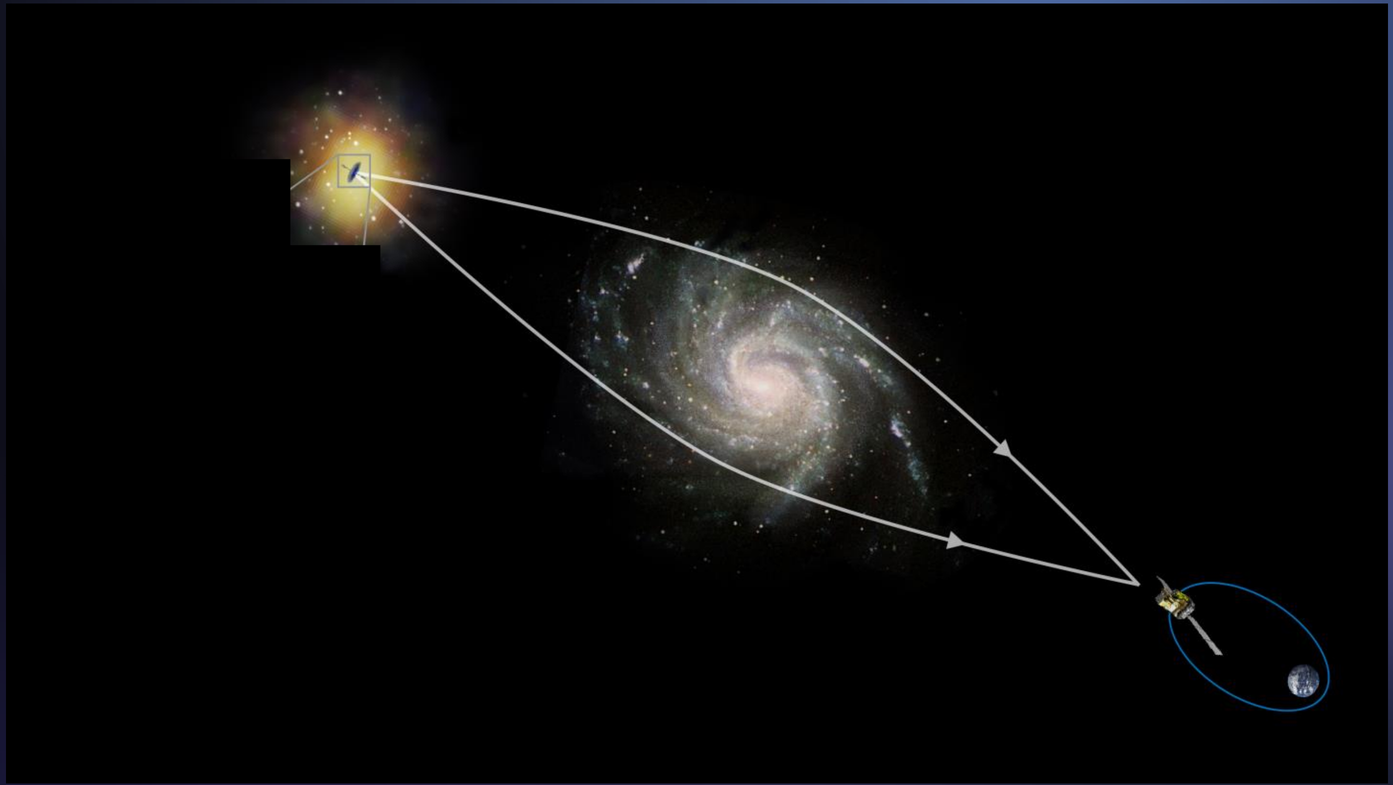
100mila galassie

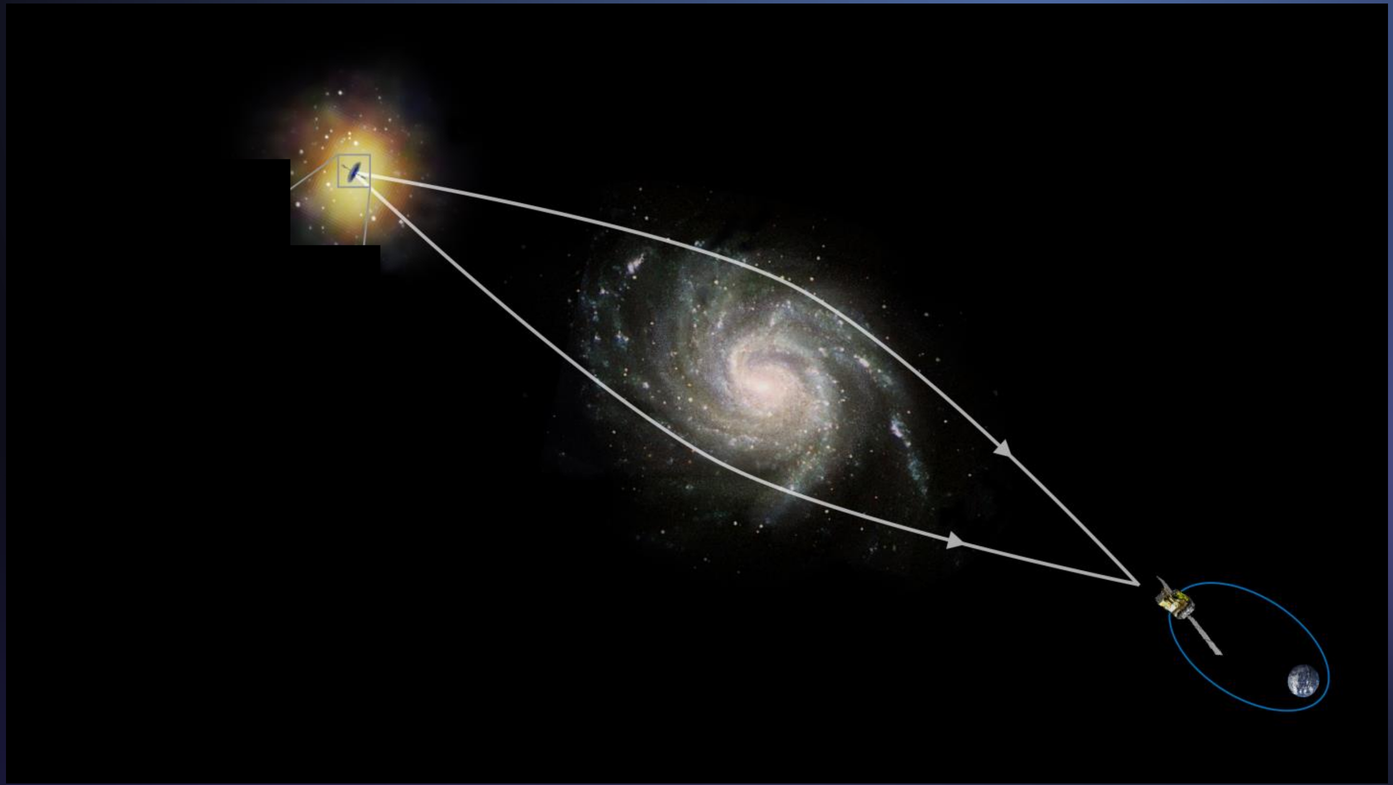
500 milioni di anni luce

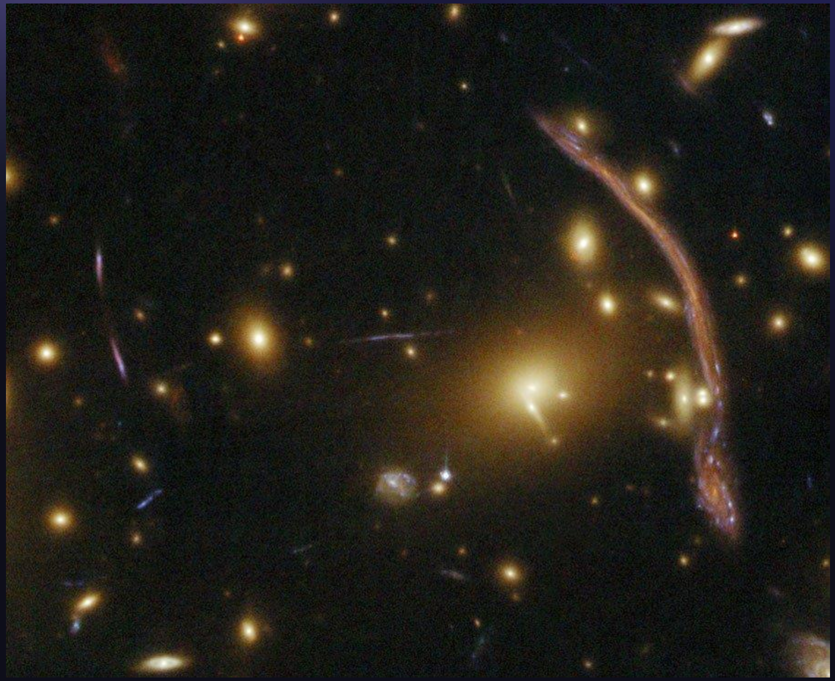


The Cheeshire Cat cluster

L'ammasso «Stregatto»
4.6 miliardi di a.l.

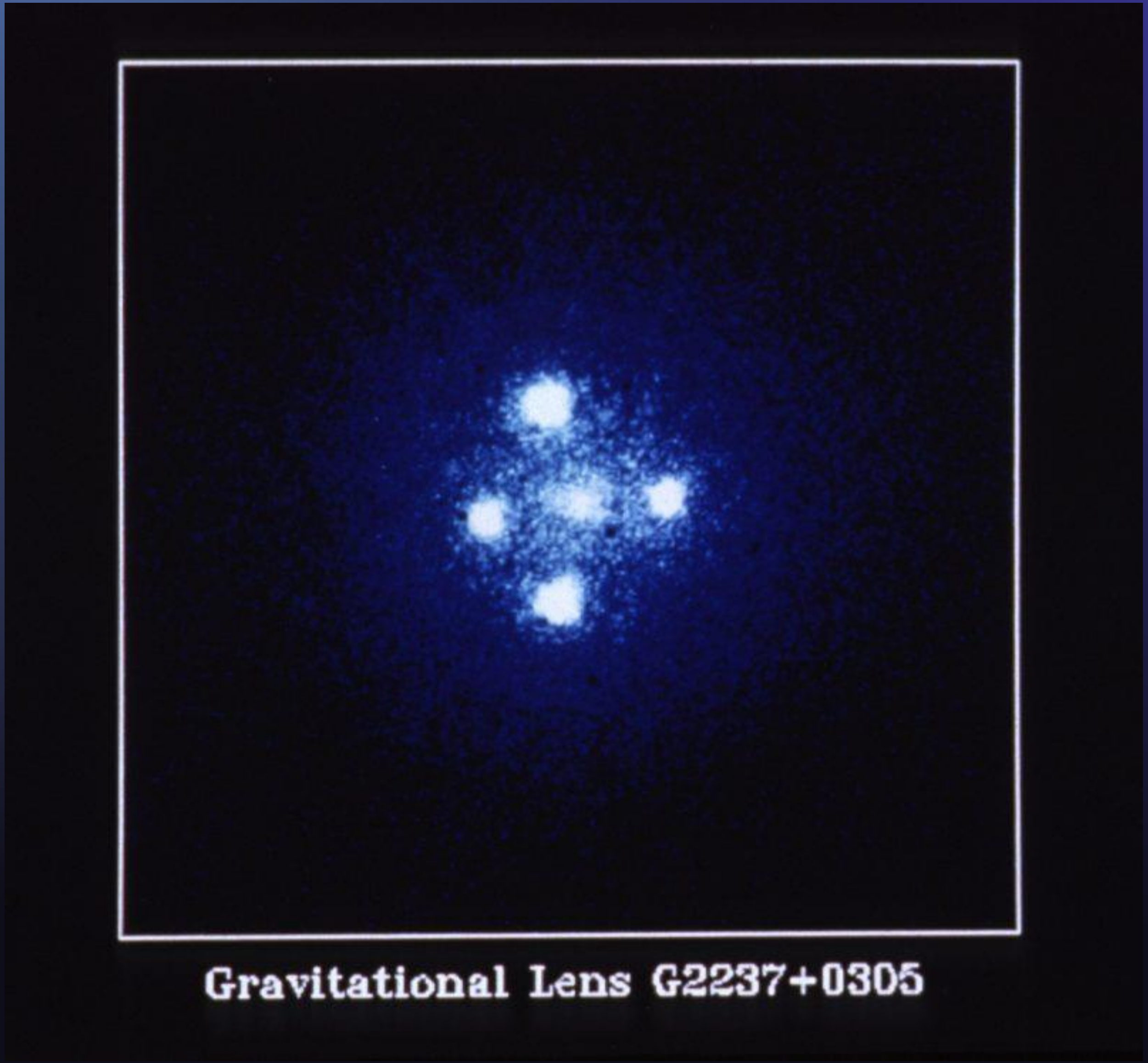






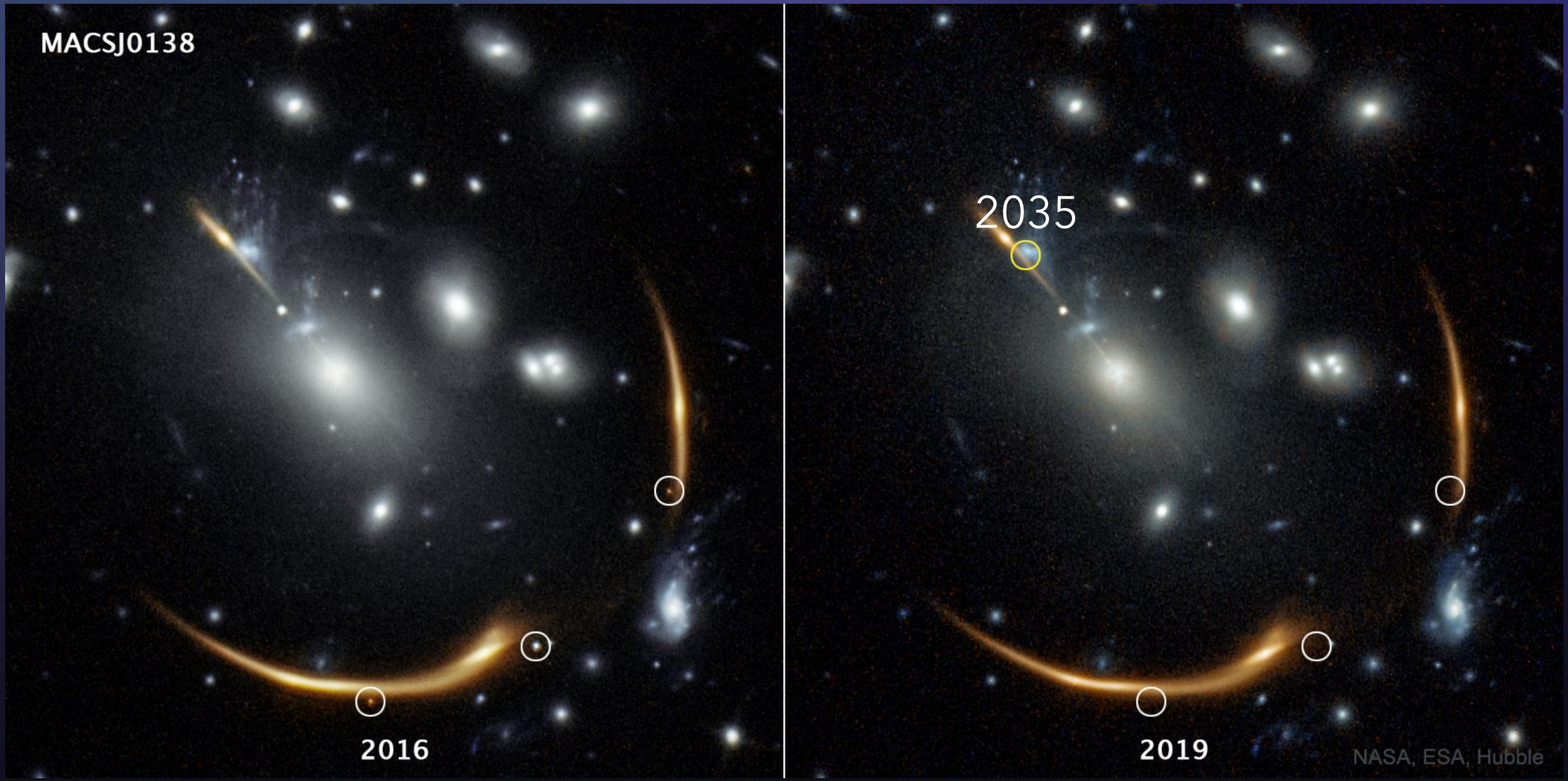
In mezzo c'è una galassia, distante 400milioni anni luce.

I 4 "bolli" luminosi sono 4 copie dello stesso oggetto (un quasar), distante 8 miliardi di anni luce.



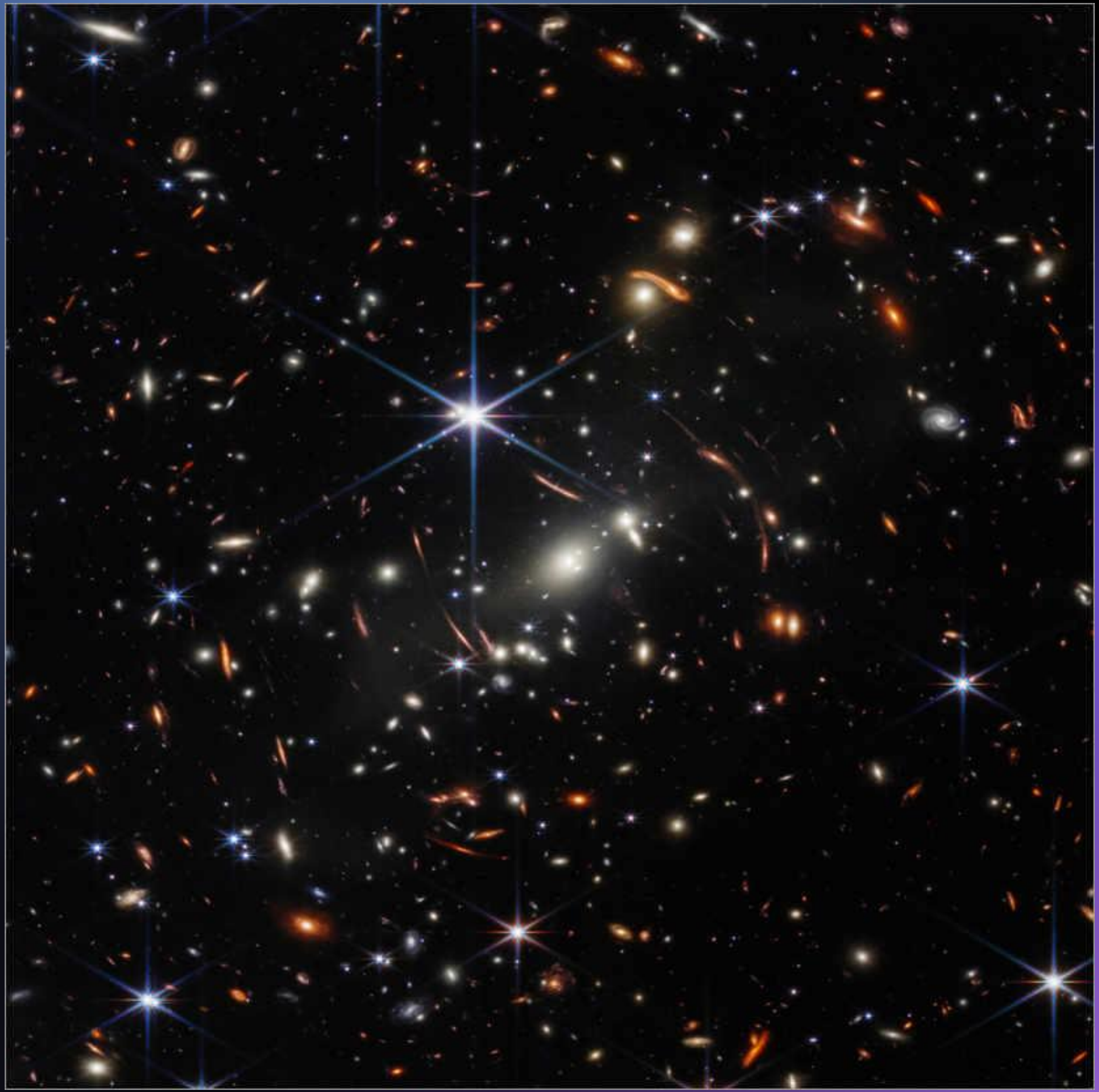
Supernova Requiem

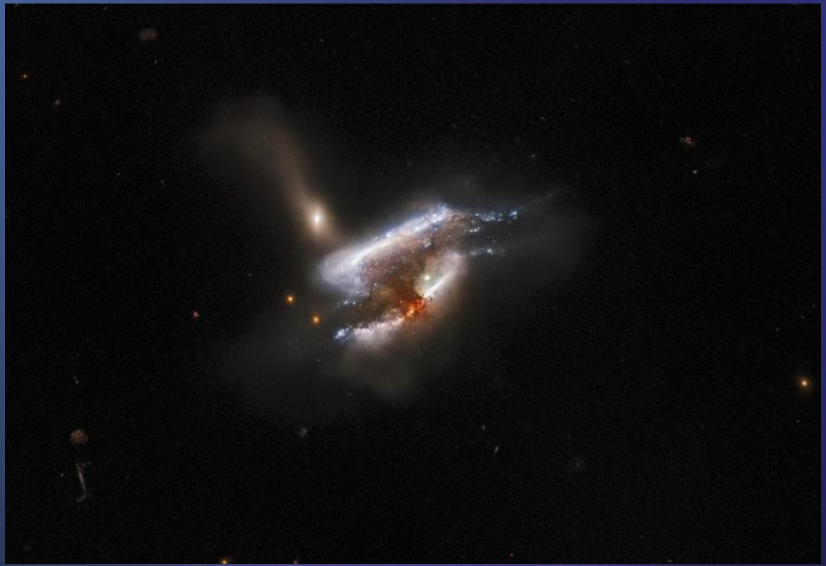
- Osservata nel 2016 in 3 punti diversi
- Previsione di prossima apparizione nel 2035
- Apparsa anche circa 50 anni fa, ma nessuno l'ha osservata per mancanza di adeguati strumenti tecnici.

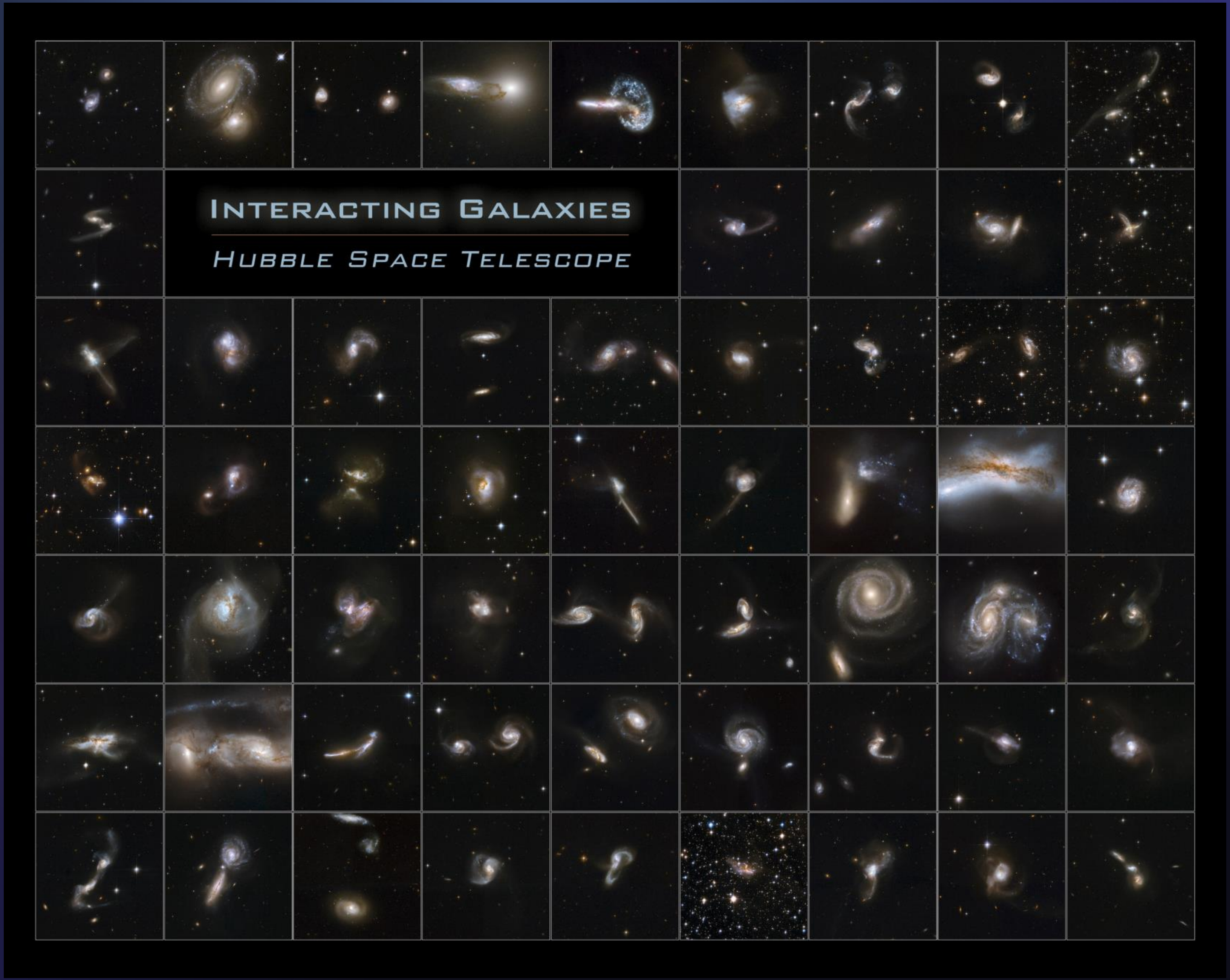


Ultra Deep Field

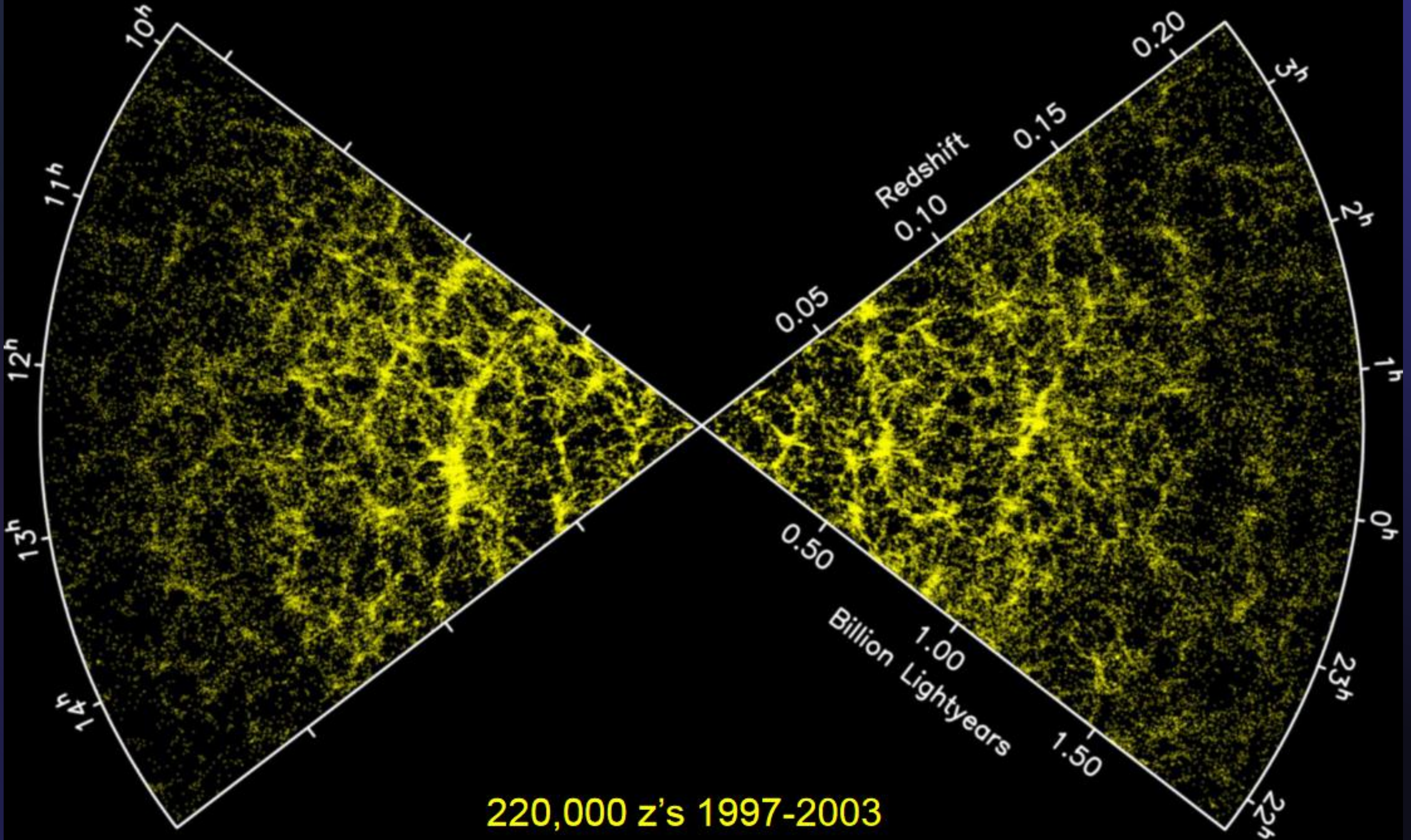
Le dimensioni di una pallina da ping pong vista a 100 metri di distanza





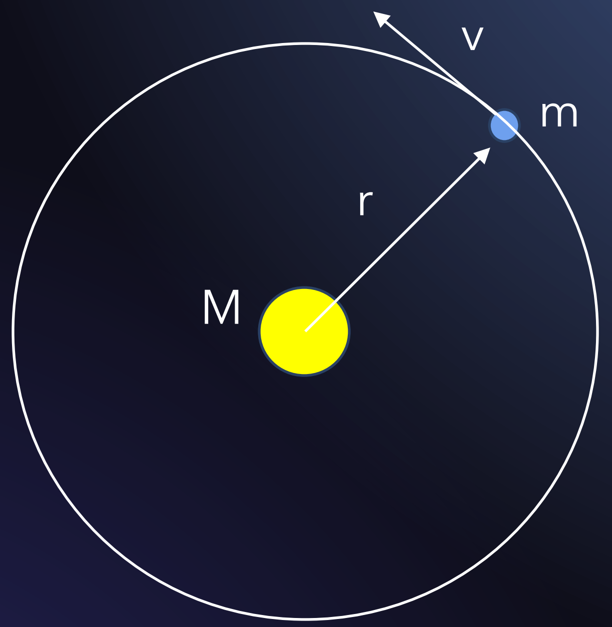
INTERACTING GALAXIES
HUBBLE SPACE TELESCOPE



220,000 z’s 1997-2003

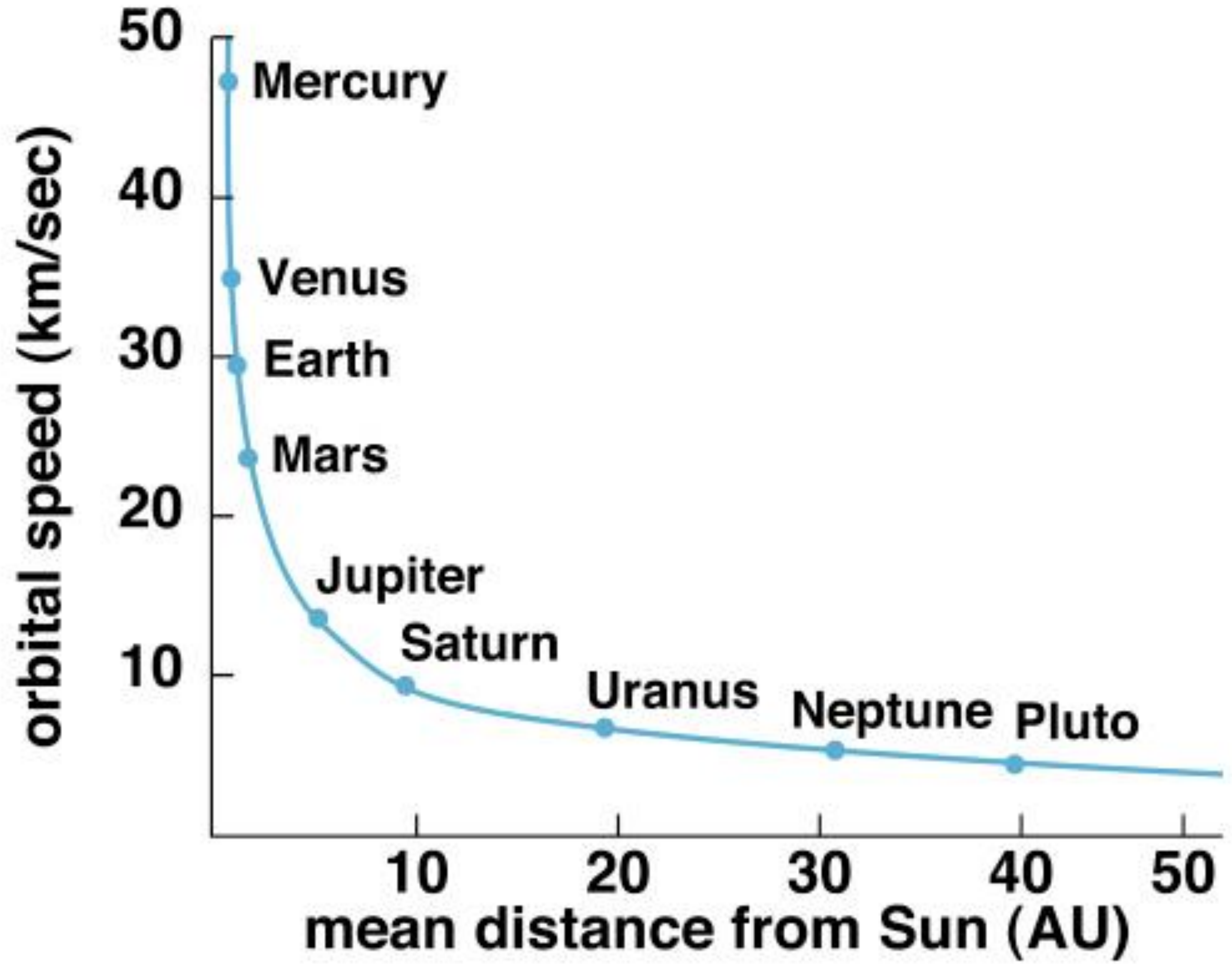
L'universo appare a grande scala come una **schiuma:** minuscole fluttuazioni primordiali della densità della materia sono state amplificate dalla gravità, portando a un universo strutturato in vuoti, filamenti e nodi.
Questo processo è guidato dalla materia oscura e verificato con simulazioni numeriche.

La Materia Oscura

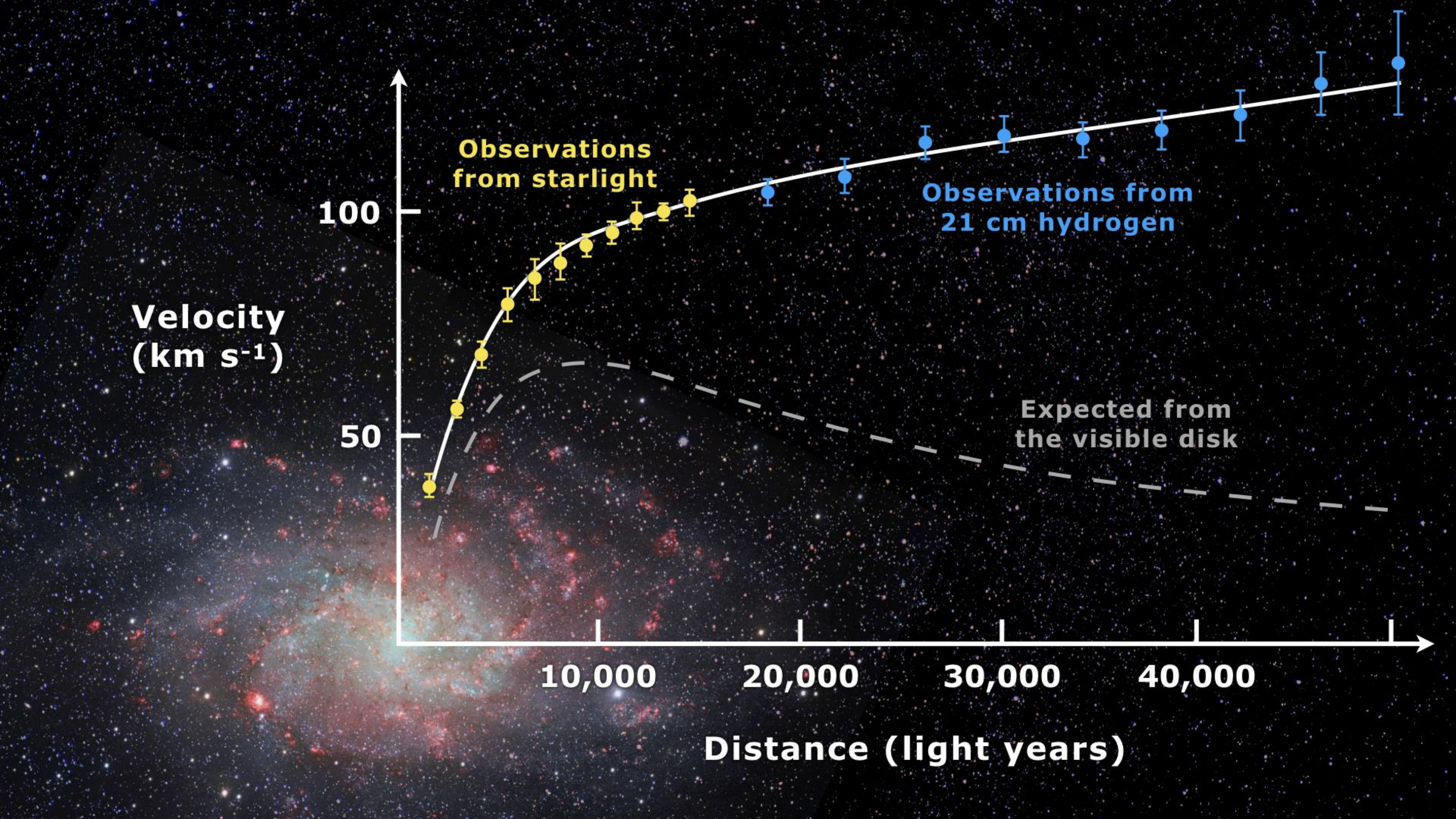


$$G \cdot \frac{m \cdot M}{r^2} = m \cdot \frac{v^2}{r}$$

$$v = \sqrt{G \cdot \frac{M}{r}}$$


50
40
30
20
10
orbital speed (km/sec)
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto
10
20
30
40
50
mean distance from Sun (AU)

(b)



Observations
from starlight
Observations from
21 cm hydrogen
Expected from
the visible disk
Velocity
(km s-1)
100
50
10,000
20,000
30,000
40,000
Distance (light years)

Caratteristiche che dovrebbe avere la Materia Oscura:

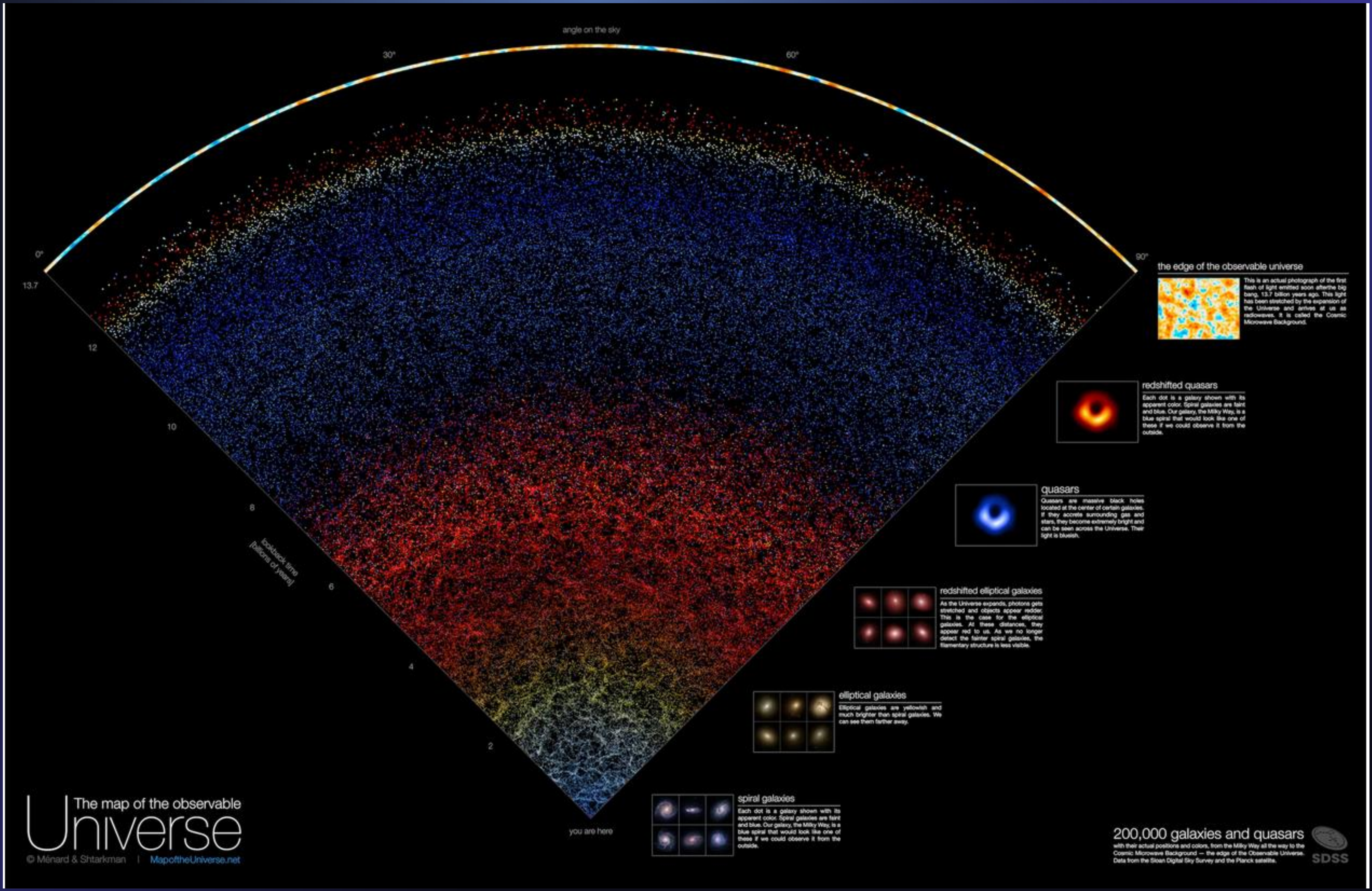
Deve interagire gravitazionalmente con la materia

Non interagisce con i campi elettromagnetici (non emette luce!).
È "oscura" nel senso che non emette, né riflette né assorbe le radiazioni elettromagnetiche

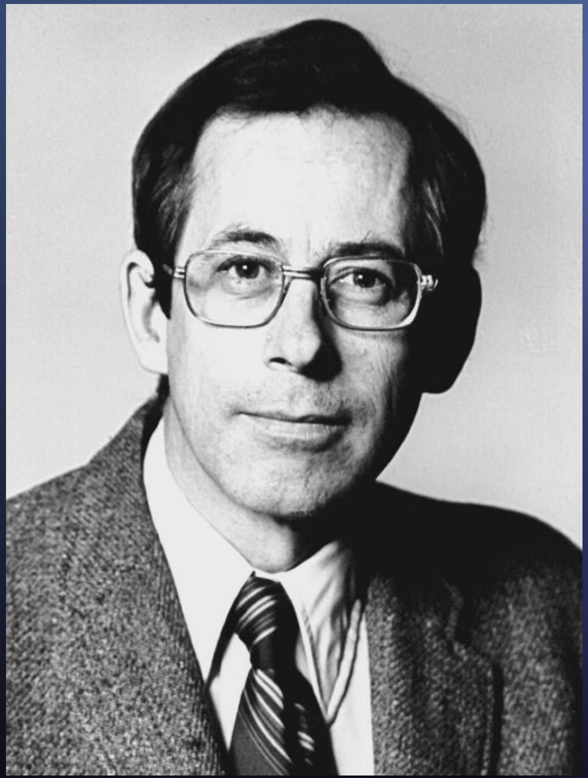
E' stabile (non decade in altre particelle)

E' «fredda»: le particelle erano non relativistiche («lente») al momento della formazione delle strutture dell'universo primordiale.
Ciò è necessario per permettere la formazione di strutture complesse come galassie e ammassi.

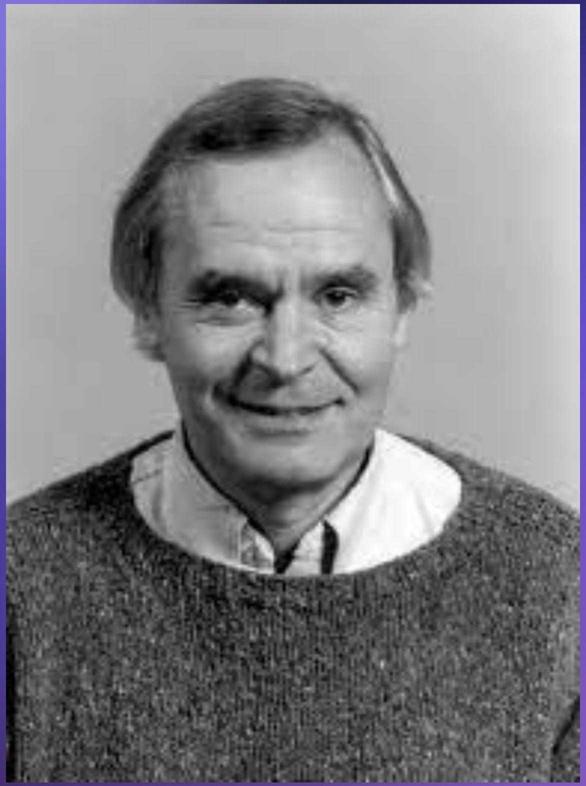
Tuttavia, finora, non conosciamo particelle candidate ad essere la materia oscura


angle on the sky
30°
60°
0°
90°
13.7
12
10
8
6
4
2
lookback time
(billions of years)
you are here
the edge of the observable universe
This is an actual photograph of the first flash of light emitted soon afterthe big bang, 13.7 billion years ago. This light has been stretched by the expansion of the Universe and arrives at us as radiowaves. It is called the Cosmic Microwave Background.
redshifted quasars
Each dot is a galaxy shown with its apparent color. Spiral galaxies are faint and blue. Our galaxy, the Milky Way, is a blue spiral that would look like one of these if we could observe it from the outside.
quasars
Quasars are massive black holes located at the center of certain galaxies. If they accrete surrounding gas and stars, they become extremely bright and can be seen across the Universe. Their light is blueish.
redshifted elliptical galaxies
As the Universe expands, photons gets stretched and objects appear redder. This is the case for the elliptical galaxies. At these distances, they appear red to us. As we no longer detect the fainter spiral galaxies, the filamentary structure is less visible.
elliptical galaxies
Elliptical galaxies are yellowish and much brighter than spiral galaxies. We can see them farther away.
spiral galaxies
Each dot is a galaxy shown with its apparent color. Spiral galaxies are faint and blue. Our galaxy, the Milky Way, is a blue spiral that would look like one of these if we could observe it from the outside.
The map of the observable
Universe
© Ménard & Shtarkman | MapoftheUniverse.net
200,000 galaxies and quasars
with their actual positions and colors, from the Milky Way all the way to the Cosmic Microwave Background — the edge of the Observable Universe. Data from the Sloan Digital Sky Survey and the Planck satellite.
SDSS

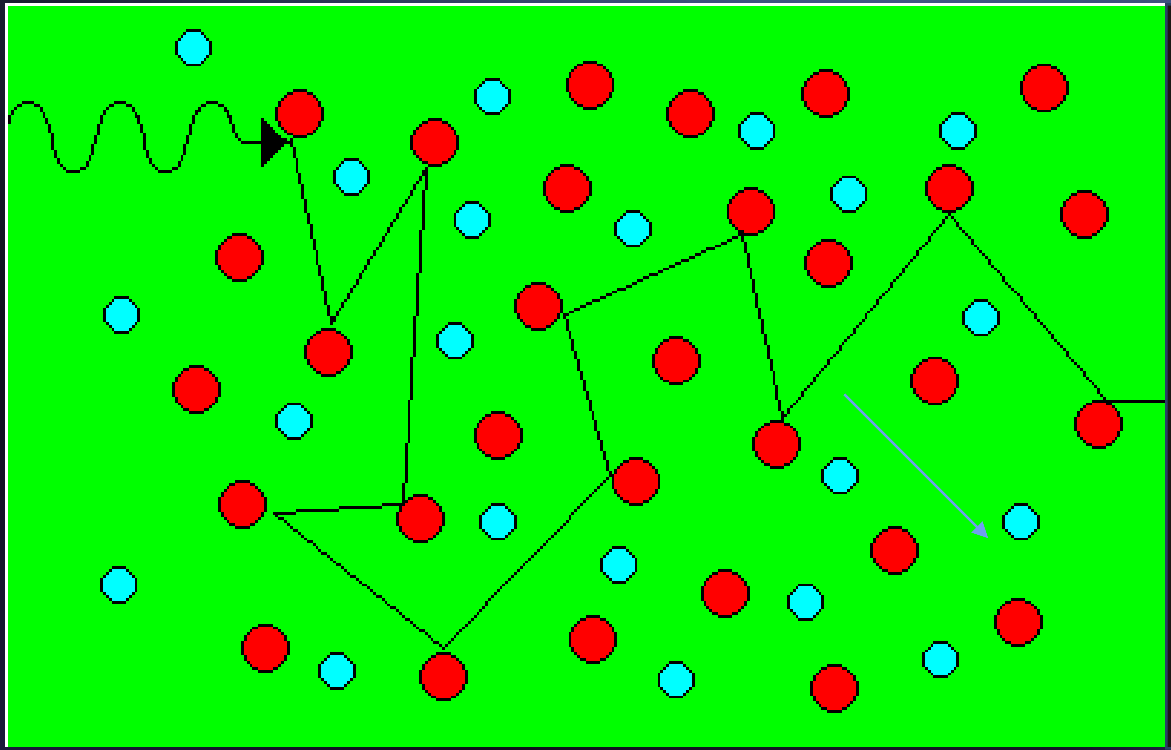
Robert Dicke



James Peebles



David Wilkinson

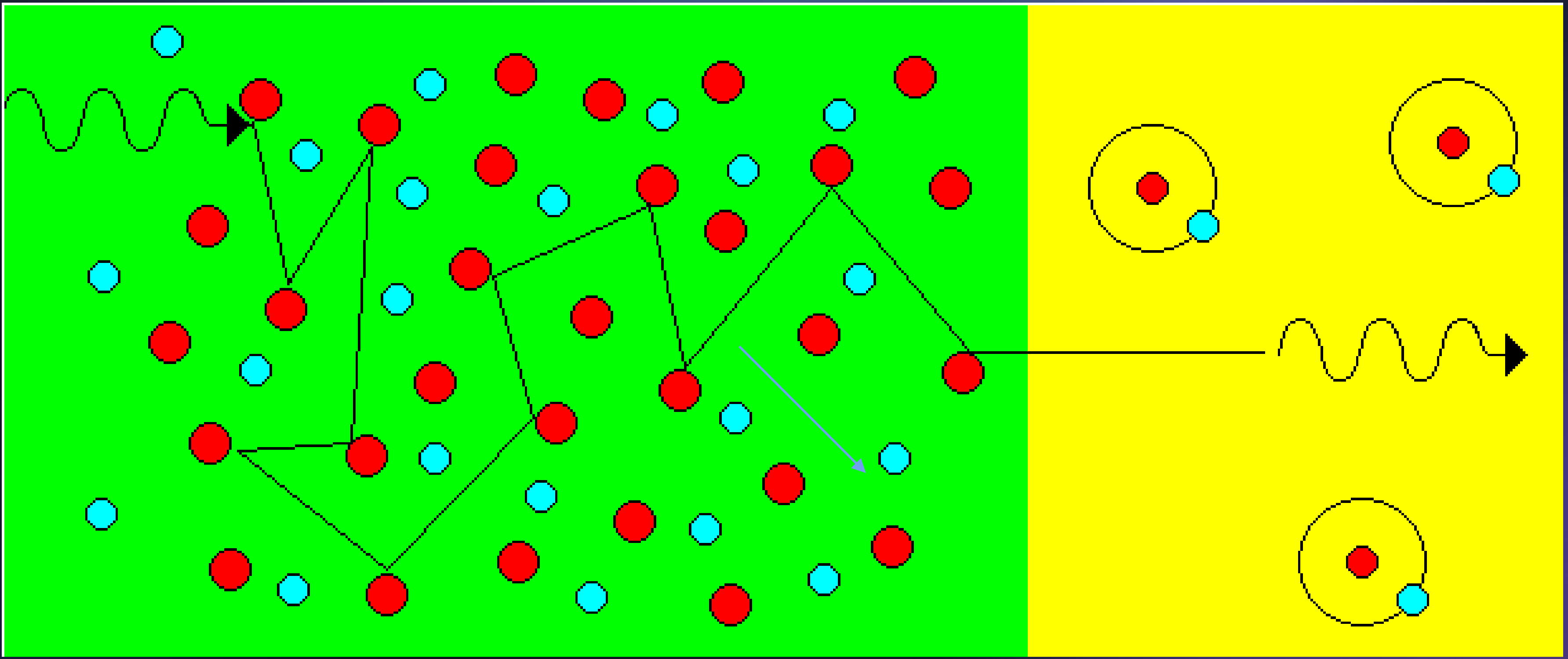


400 MILIONI DI FOTONI PER OGNI PROTONE

(O ELETTRONE)

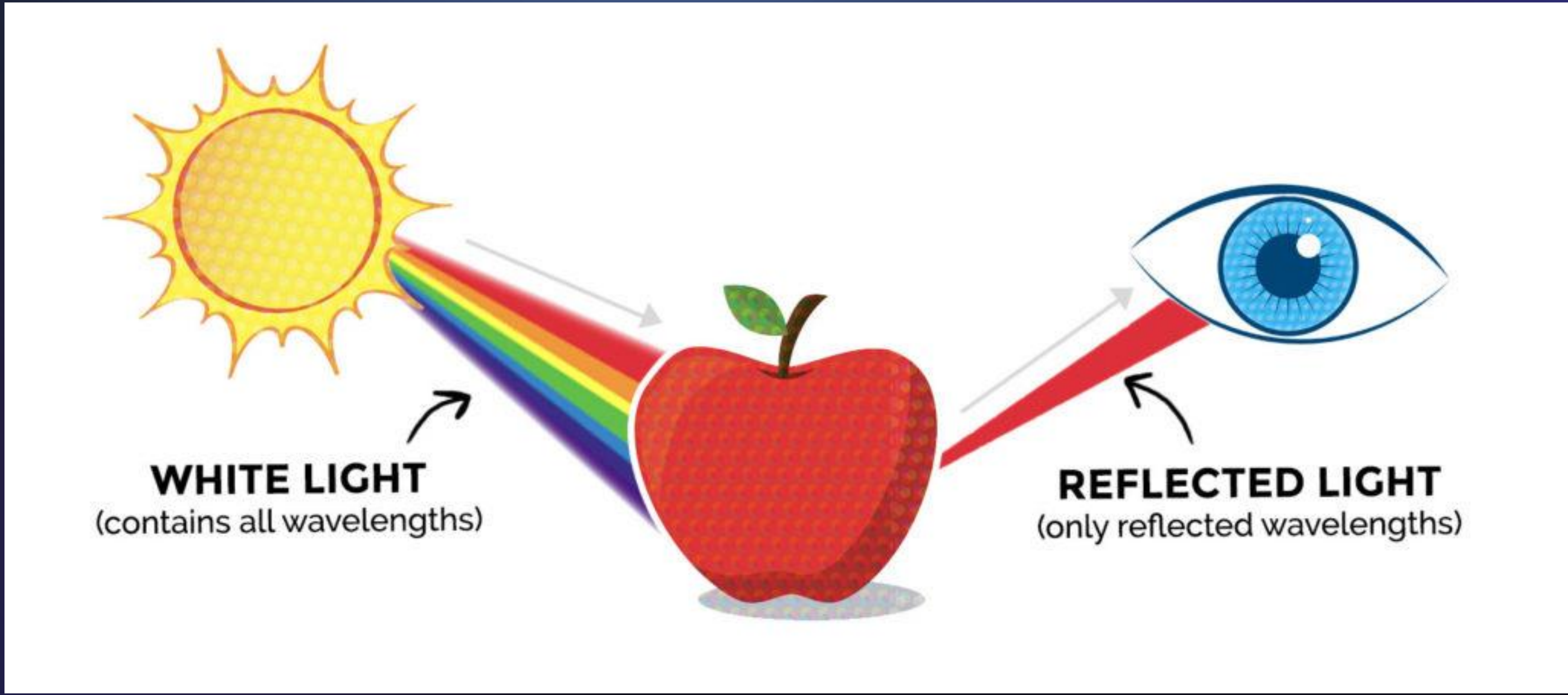
TEMPO

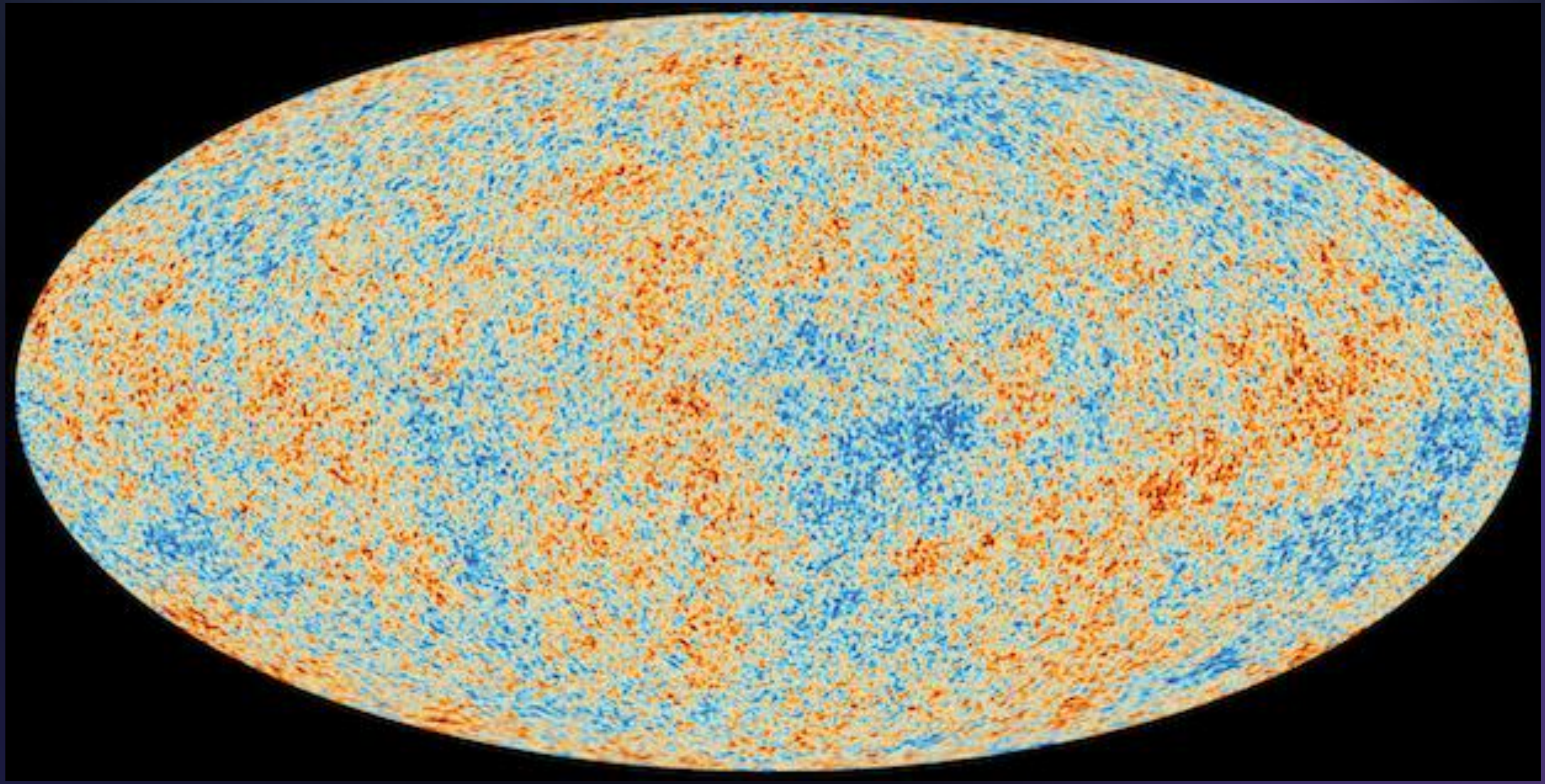
TEMPO



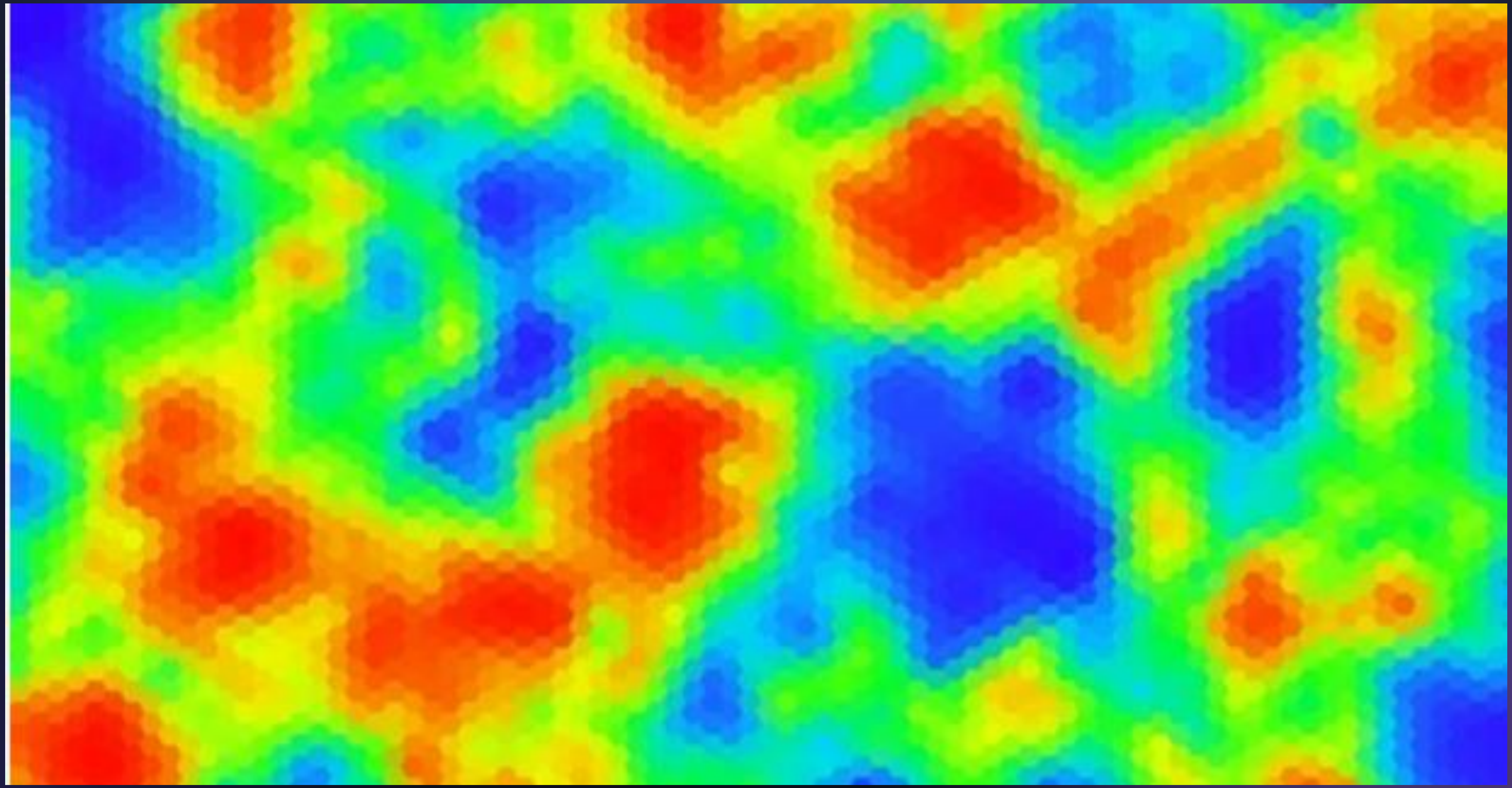
TEMPO

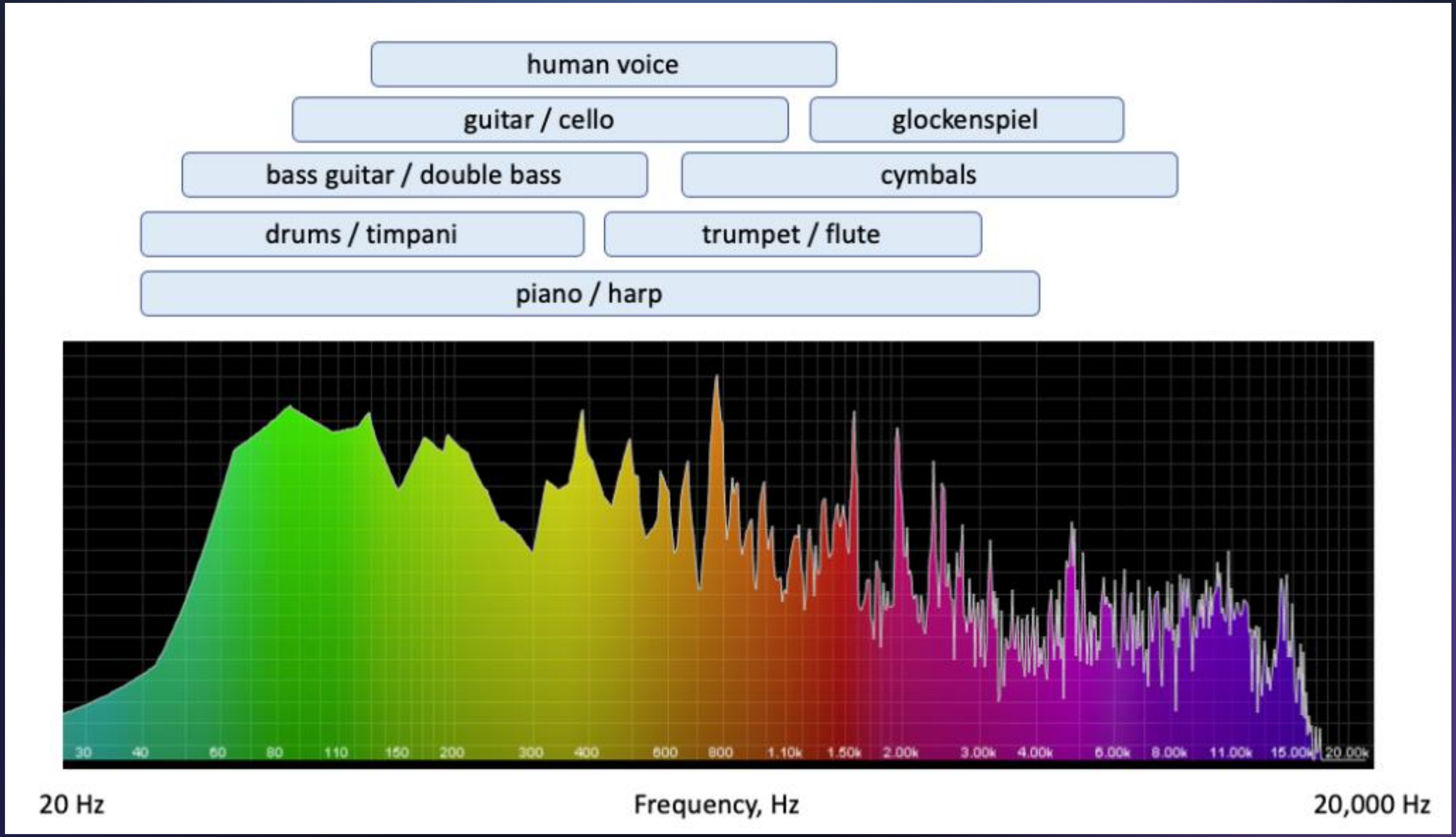
TEMPO

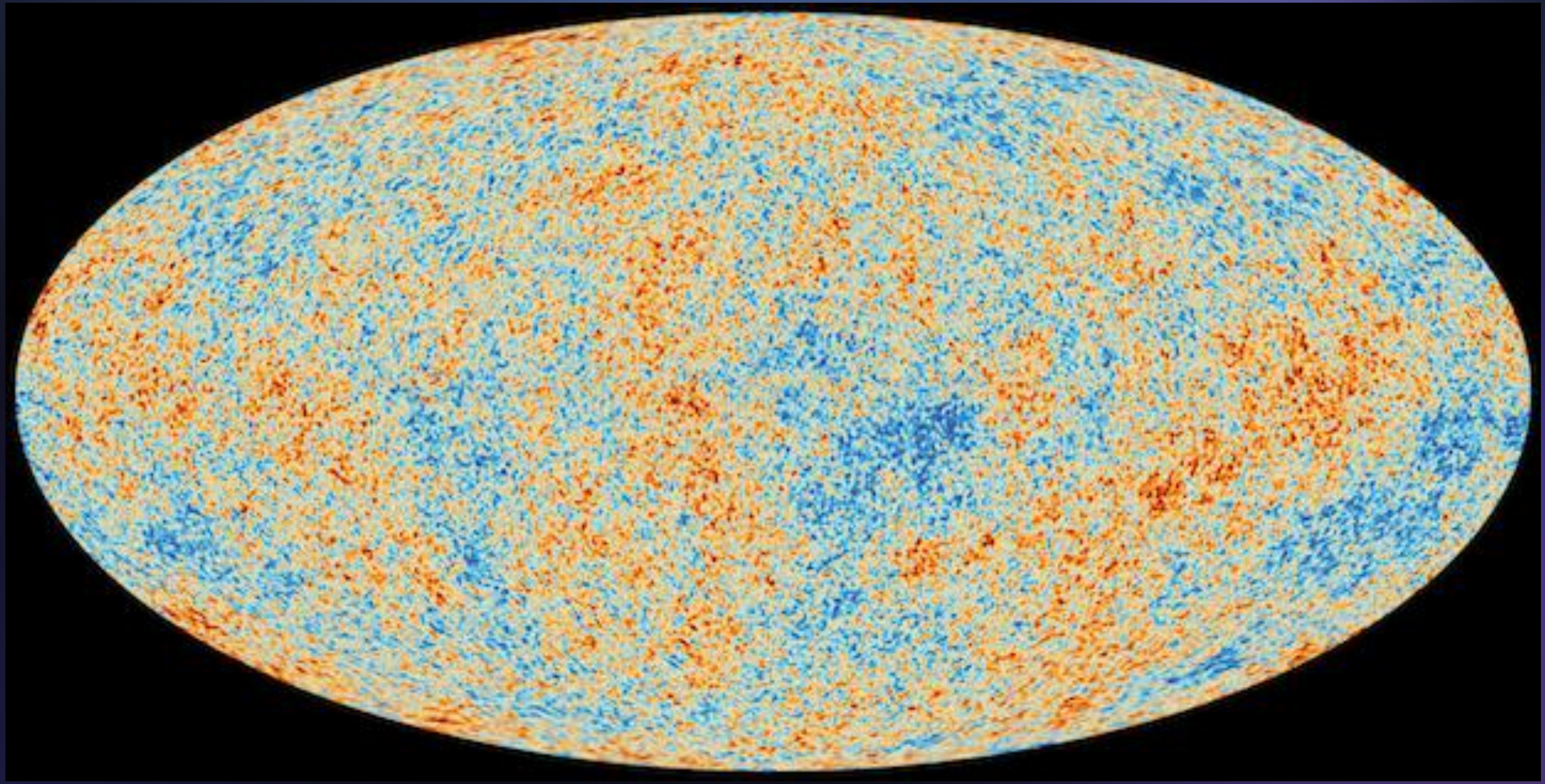

WHITE LIGHT
(contains all wavelengths)
REFLECTED LIGHT
(only reflected wavelengths)

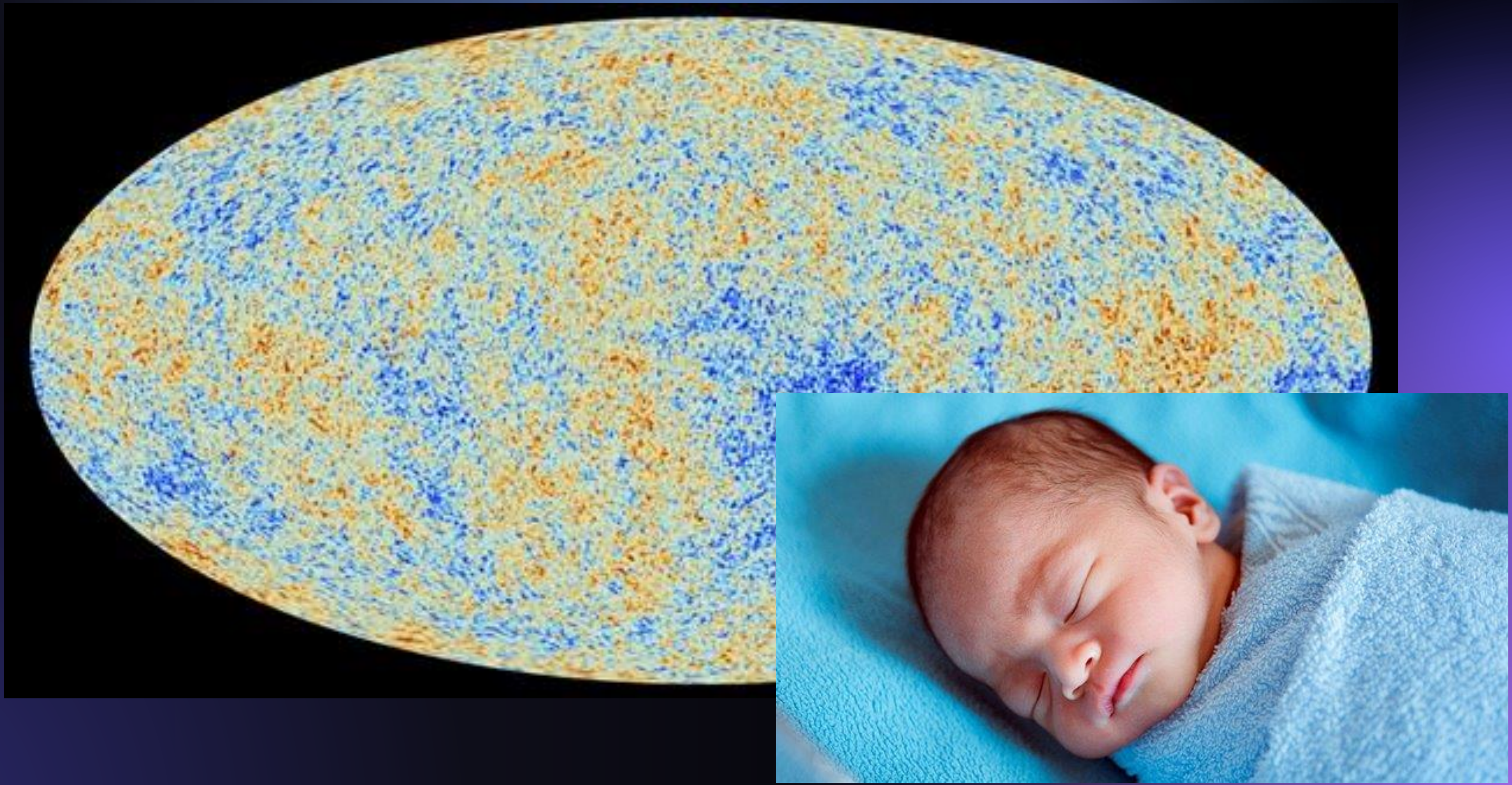


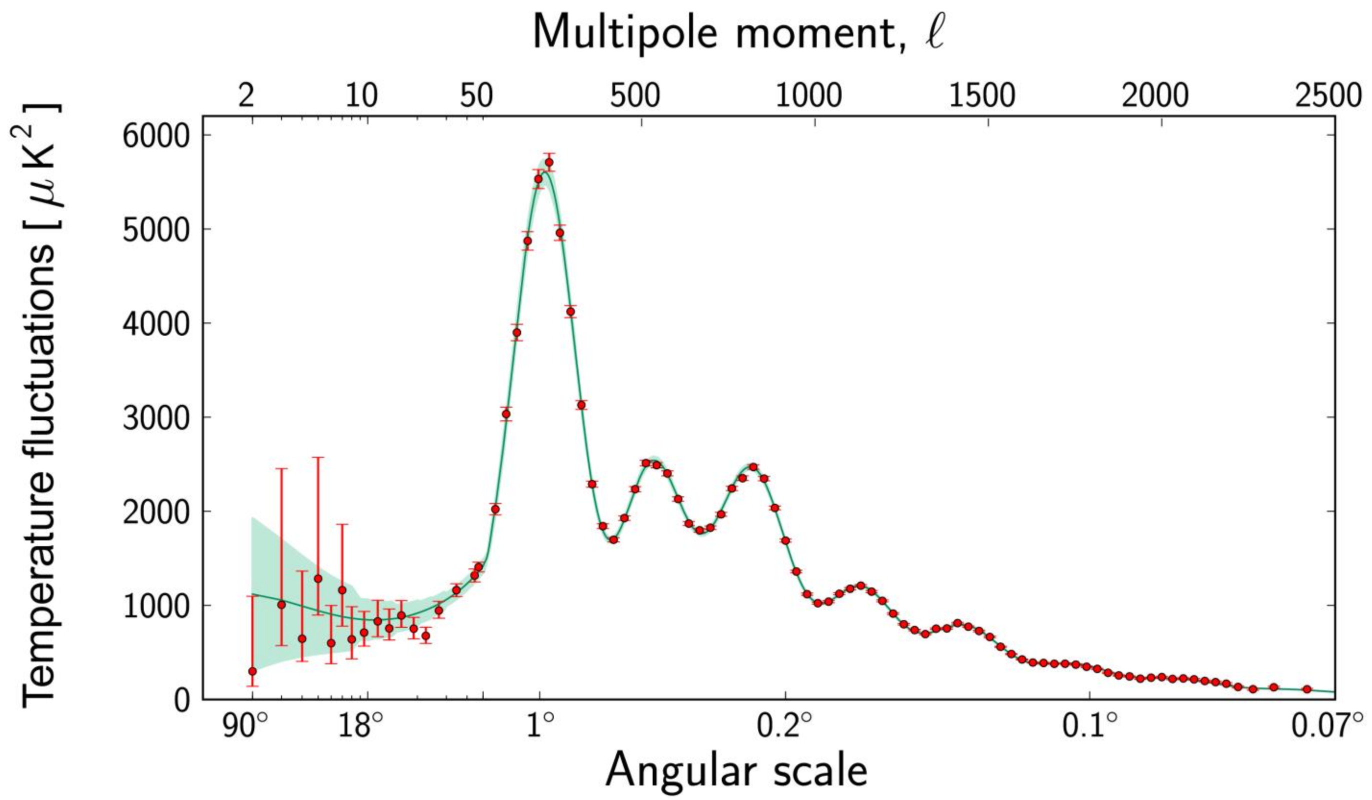

e=0.95
30.2°C
22.5°C
SELECT
ENTER
MENU




human voice
guitar / cello
glockenspiel
bass guitar / double bass
cymbals
drums / timpani
trumpet / flute
piano / harp
30
40
60
80
110
150
200
300
400
600
800
1.10k
1.50k
2.00k
3.00k
4.00k
6.00k
8.00k
11.00k
15.00k
20.00k
20 Hz
Frequency, Hz
20,000 Hz

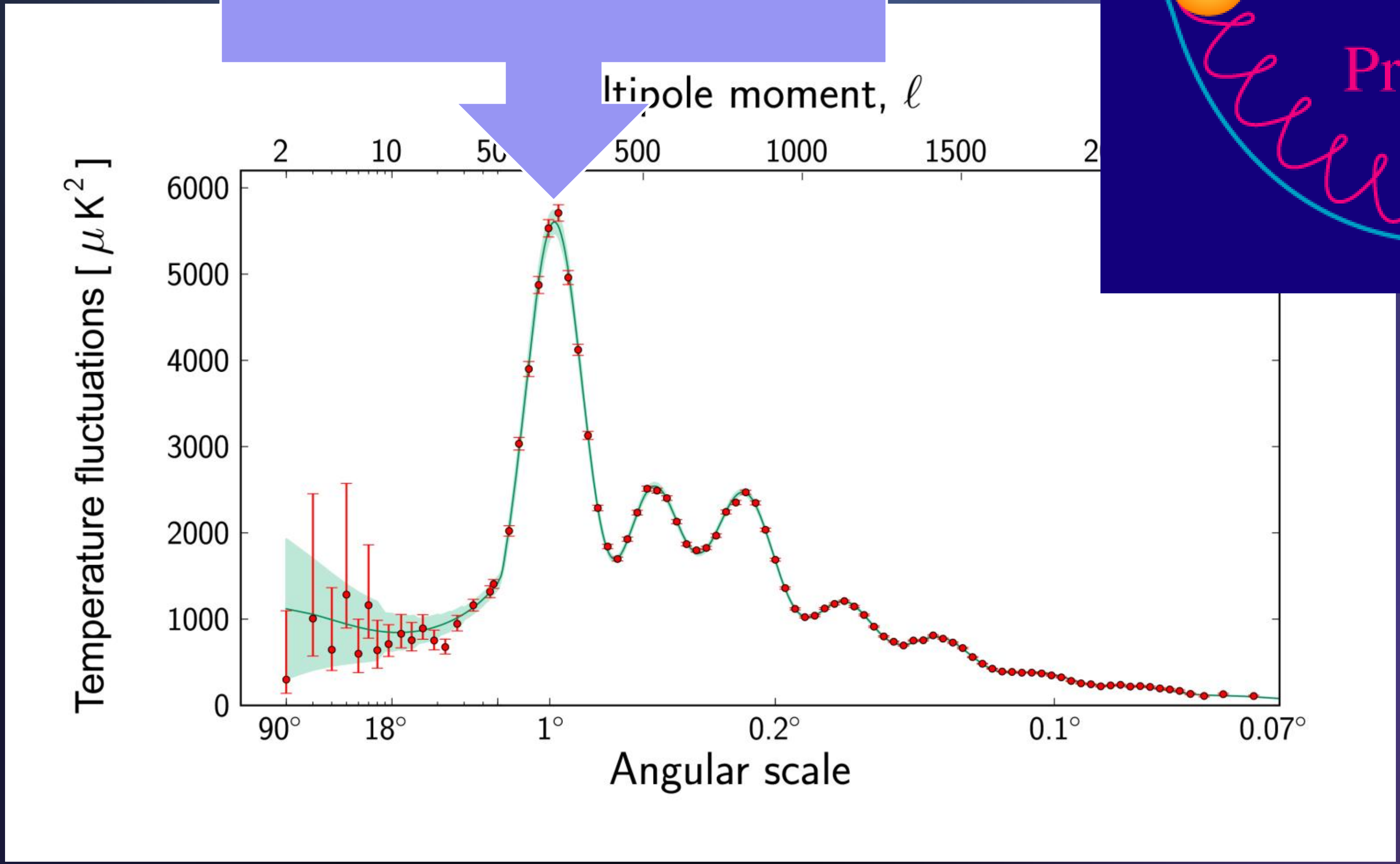


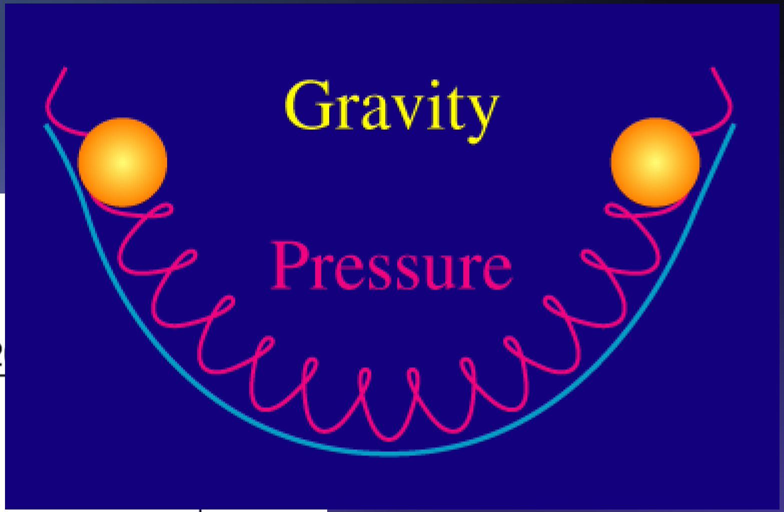




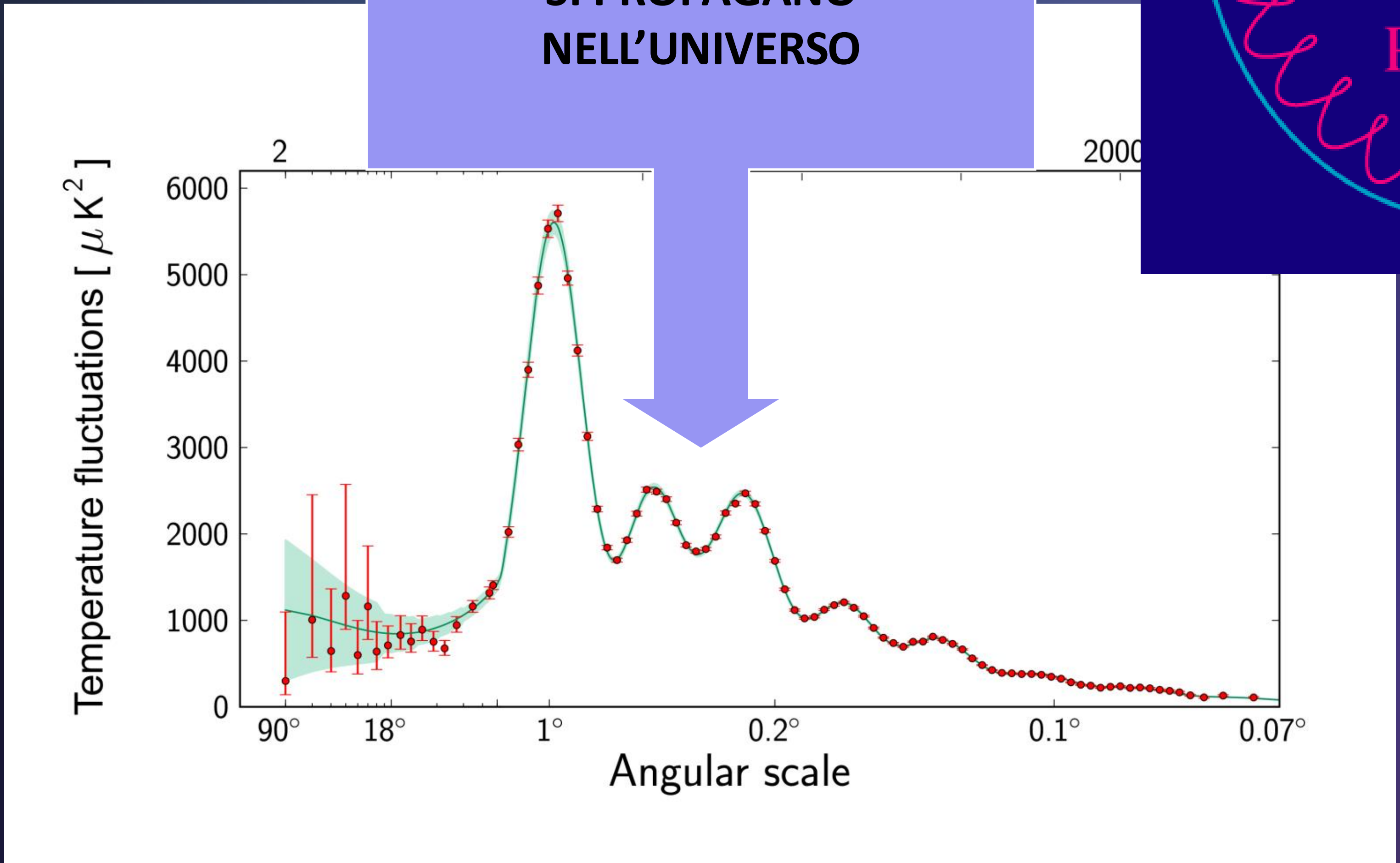
Multipole moment, ℓ
2
10
50
500
1000
1500
2000
2500
Temperature fluctuations [μK^2]
6000
5000
4000
3000
2000
1000
0
90°
18°
1°
0.2°
0.1°
0.07°
Angular scale

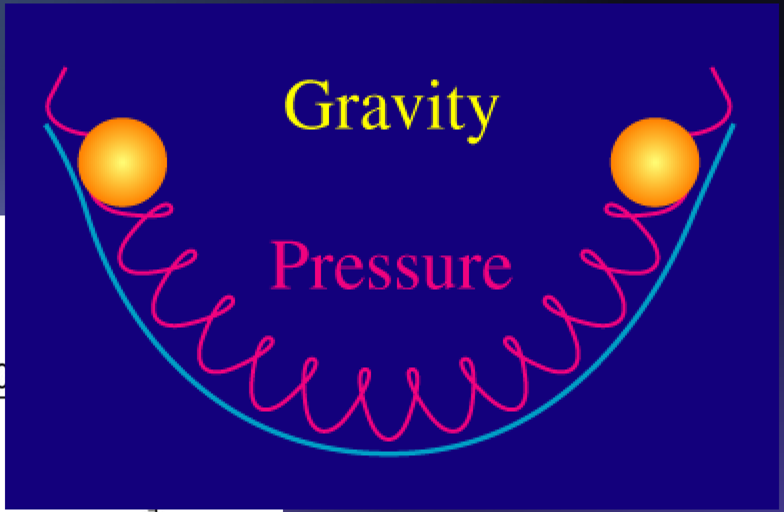
FLUTTUAZIONI DI DENSITA' DELL'UNIVERSO PRIMORDIALE

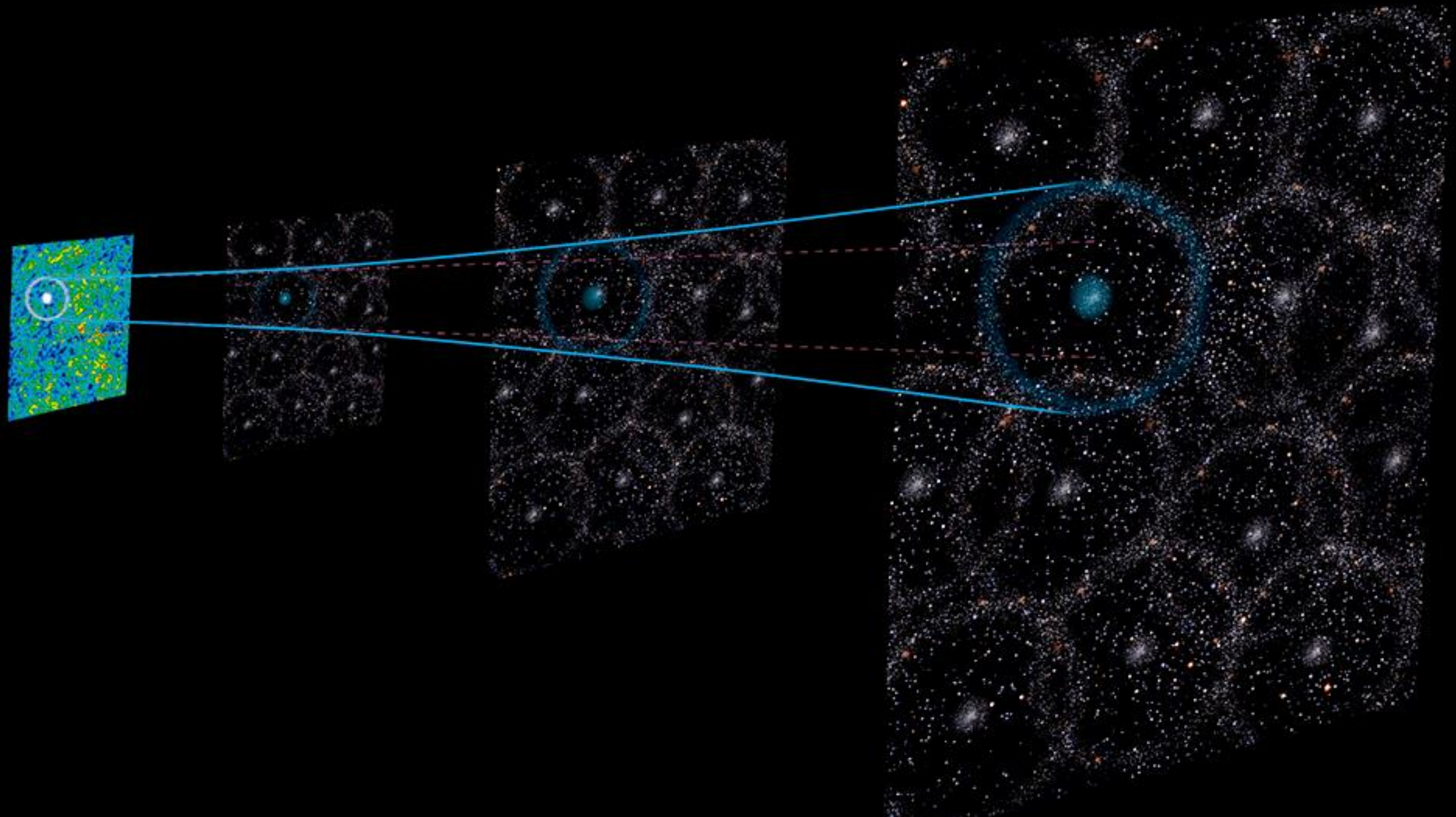


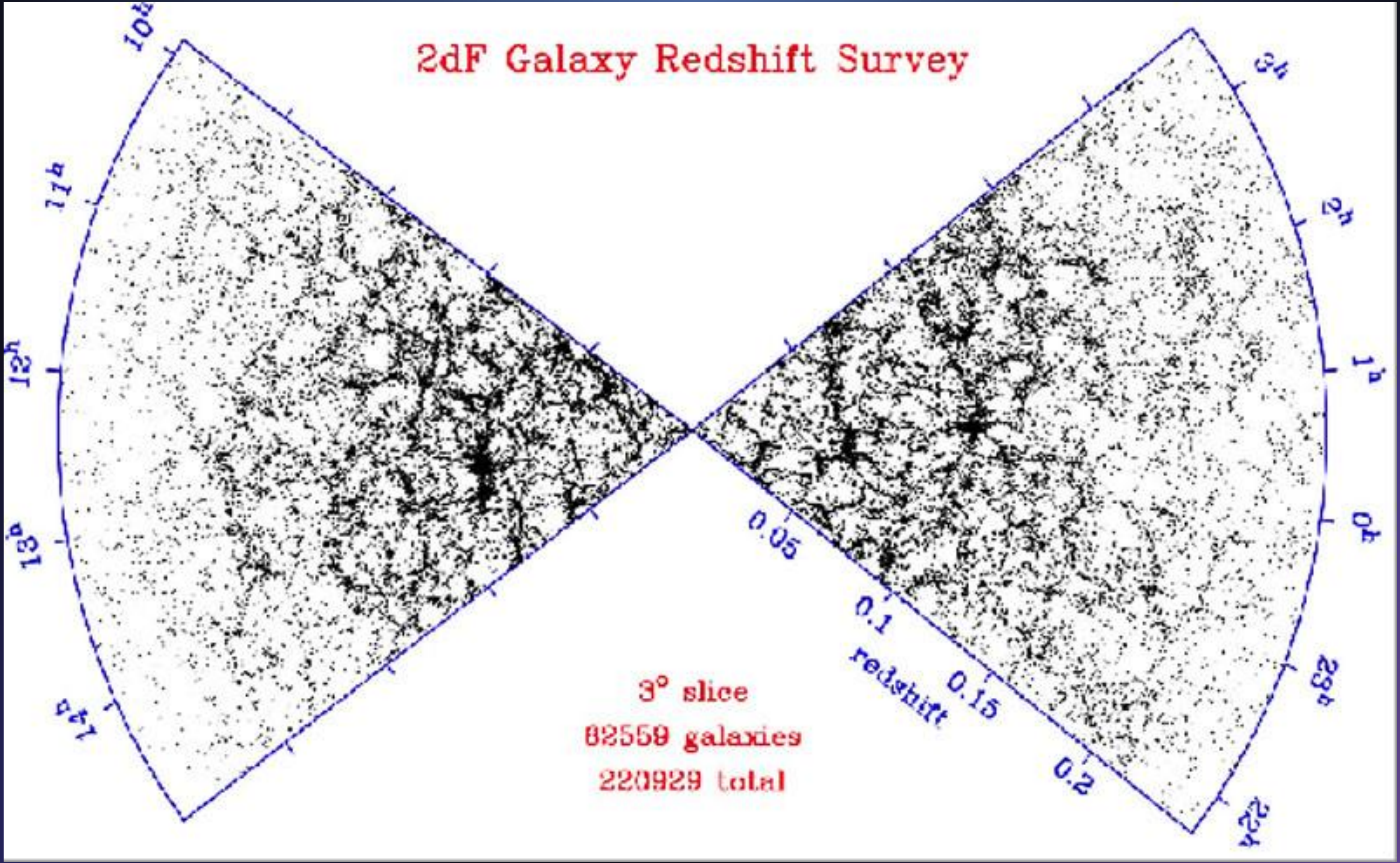


OSCILLAZIONI ACUSTICHE CHE SI PROPAGANO NELL'UNIVERSO

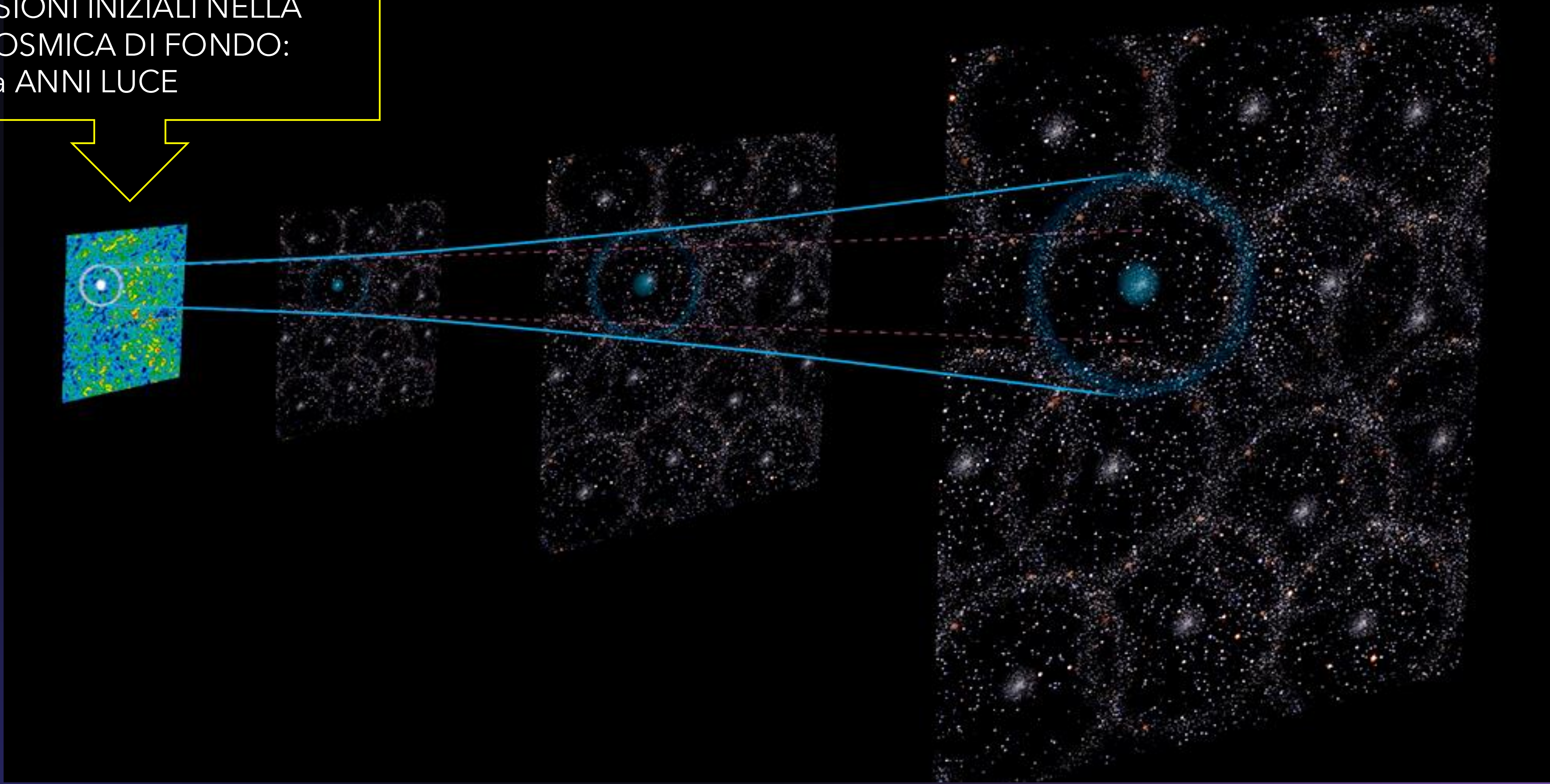


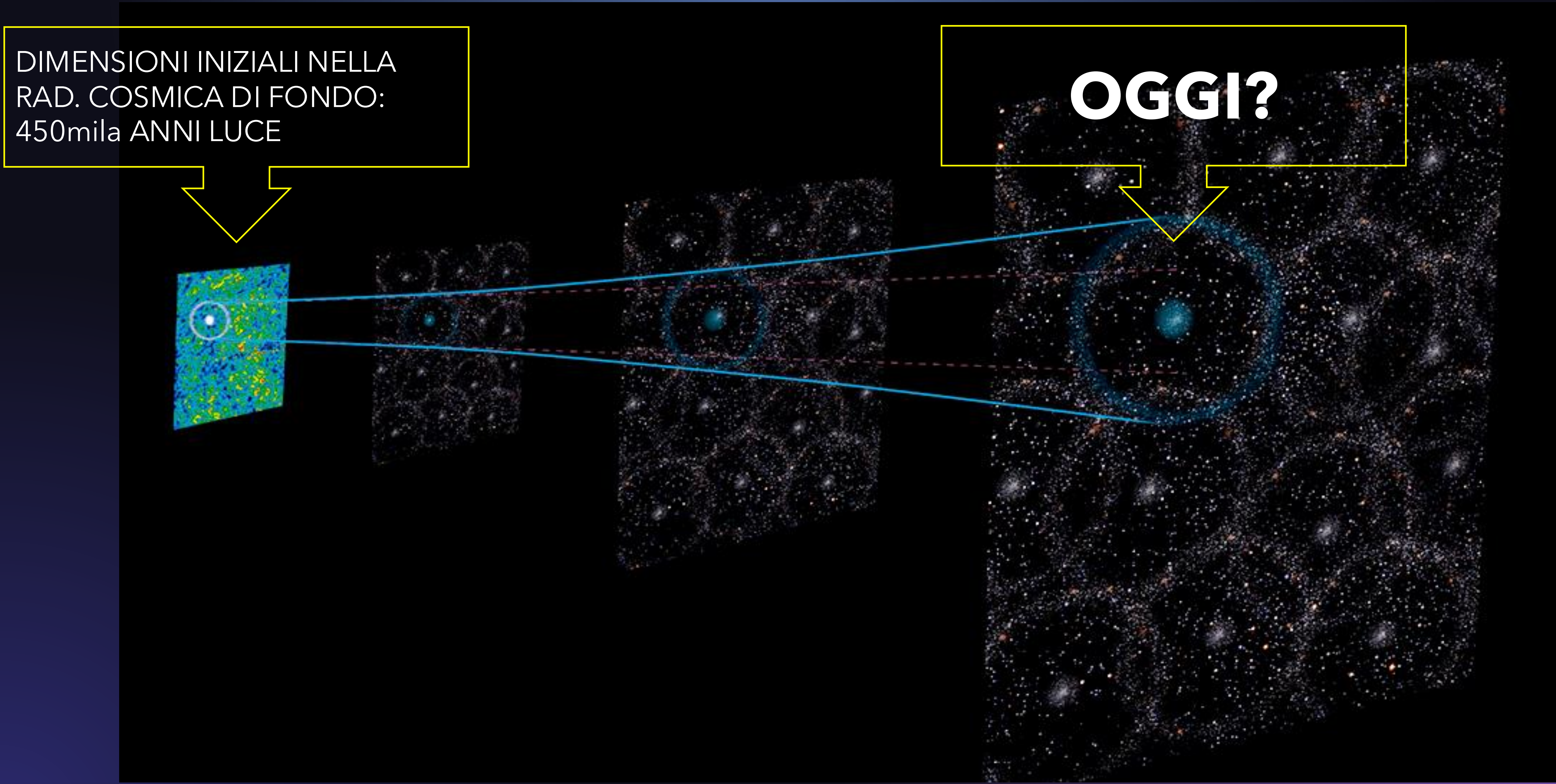


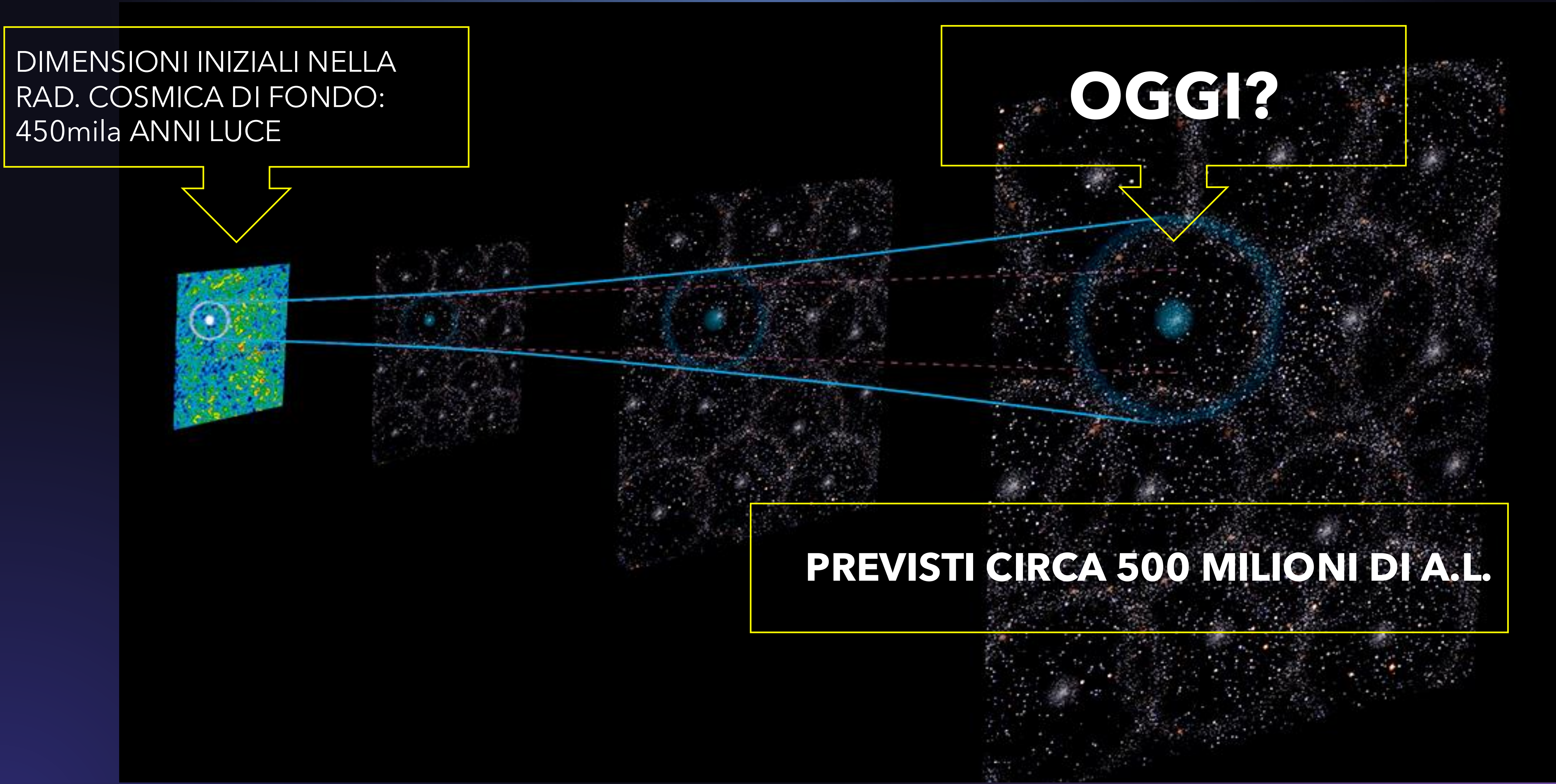



2dF Galaxy Redshift Survey
10h
11h
12h
13h
14h
3h
2h
1h
0h
23h
22h
0.05
0.1
0.15
0.2
redshift
3° slice
62559 galaxies
220929 total

DIMENSIONI INIZIALI NELLA
RAD. COSMICA DI FONDO:
450mila ANNI LUCE

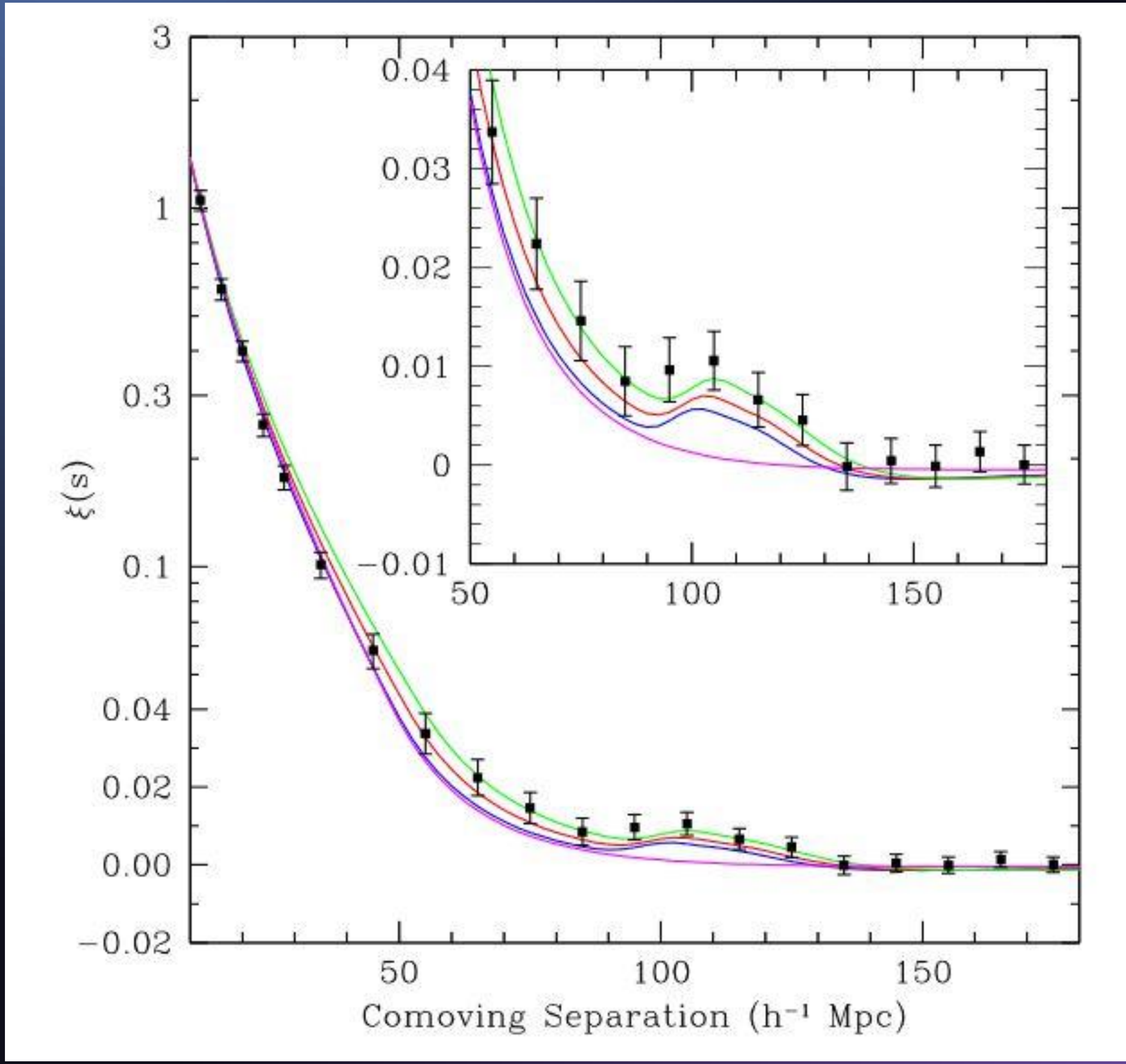



DIMENSIONI INIZIALI NELLA
RAD. COSMICA DI FONDO:
450mila ANNI LUCE
OGGI?

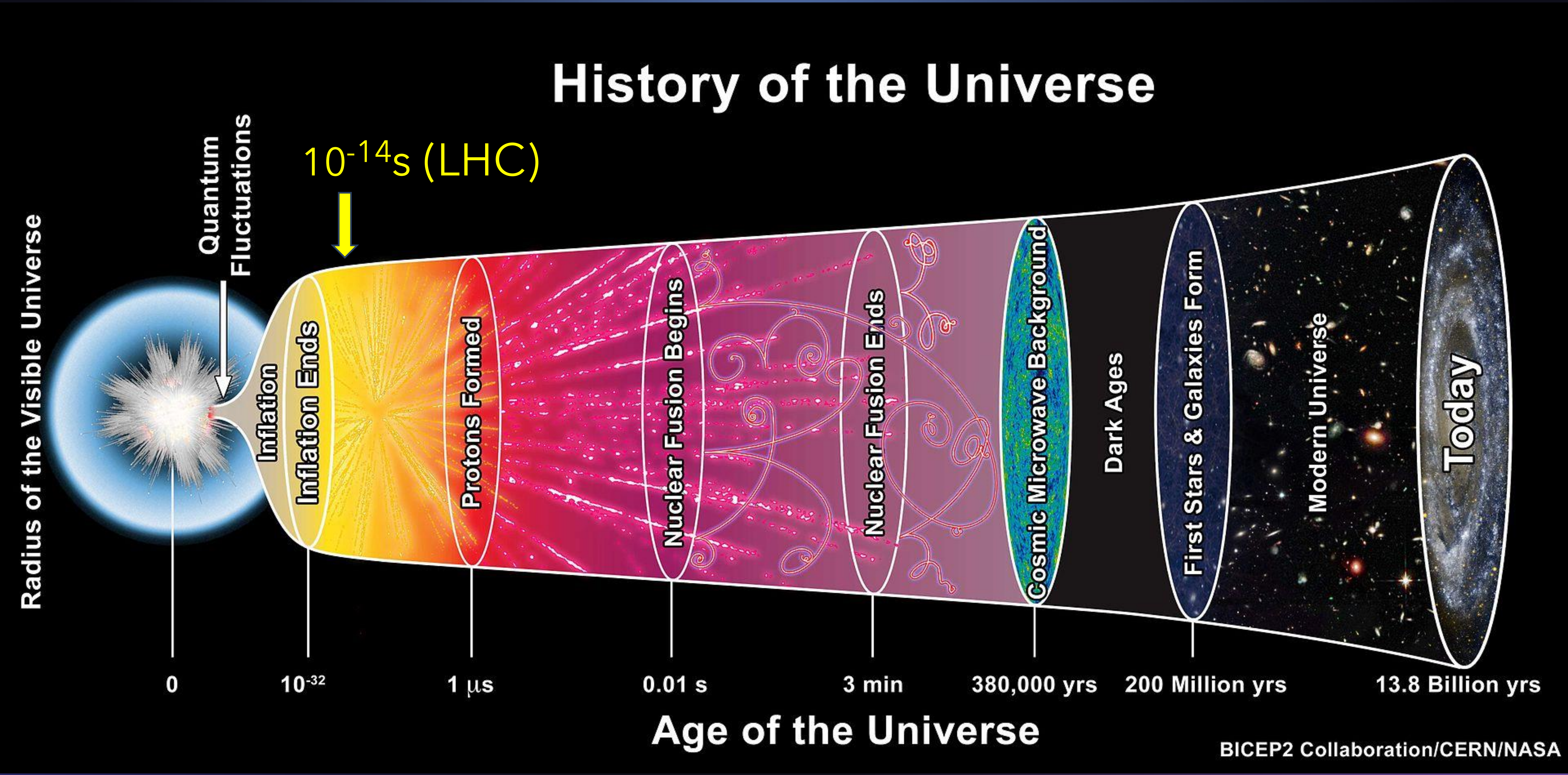

DIMENSIONI INIZIALI NELLA
RAD. COSMICA DI FONDO:
450mila ANNI LUCE
OGGI?
PREVISTI CIRCA 500 MILIONI DI A.L.

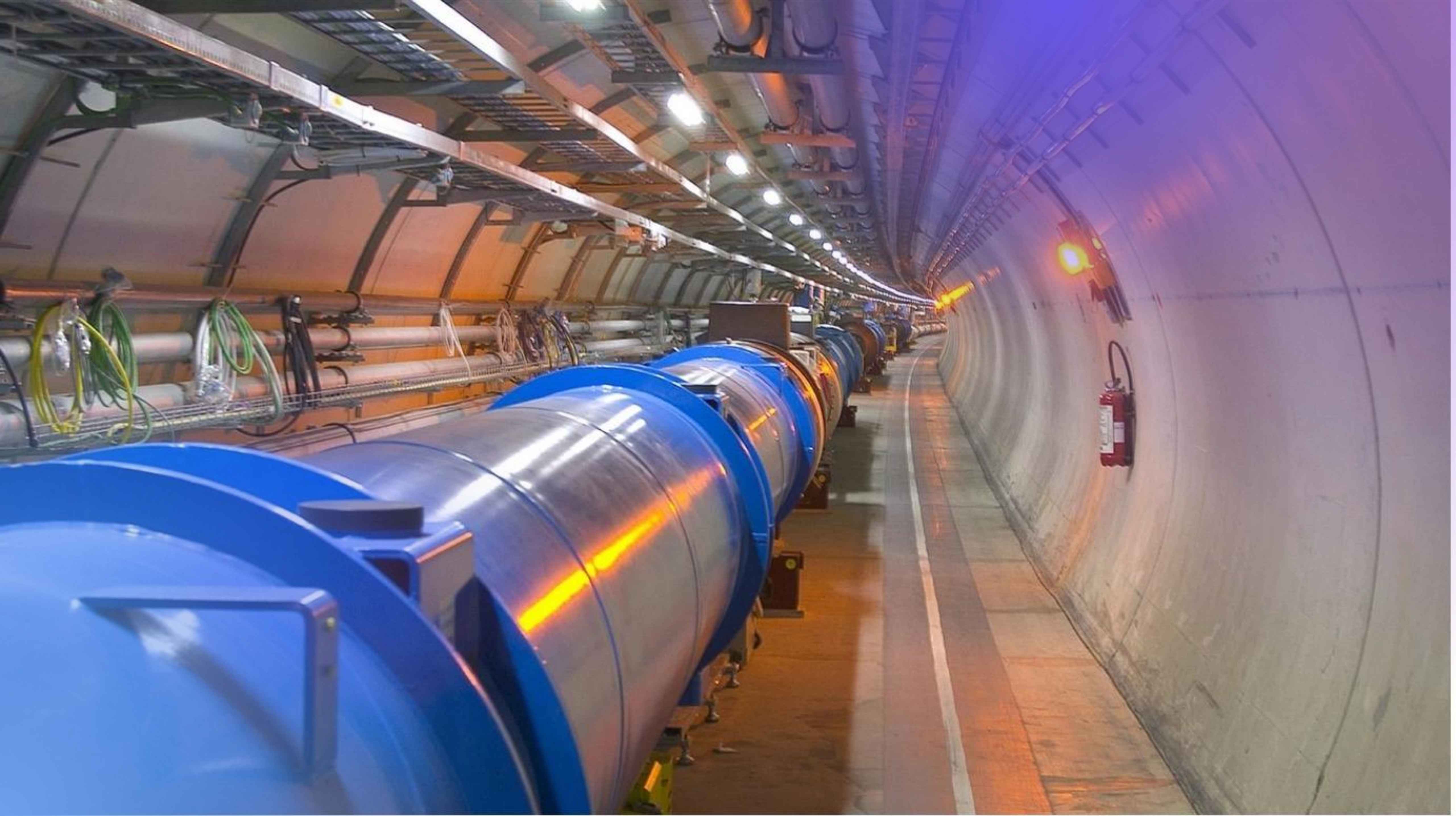
h ~ 0.7, 1 Mpc = 3.26 a.l.

RISULTATO: 490-515 a.l.

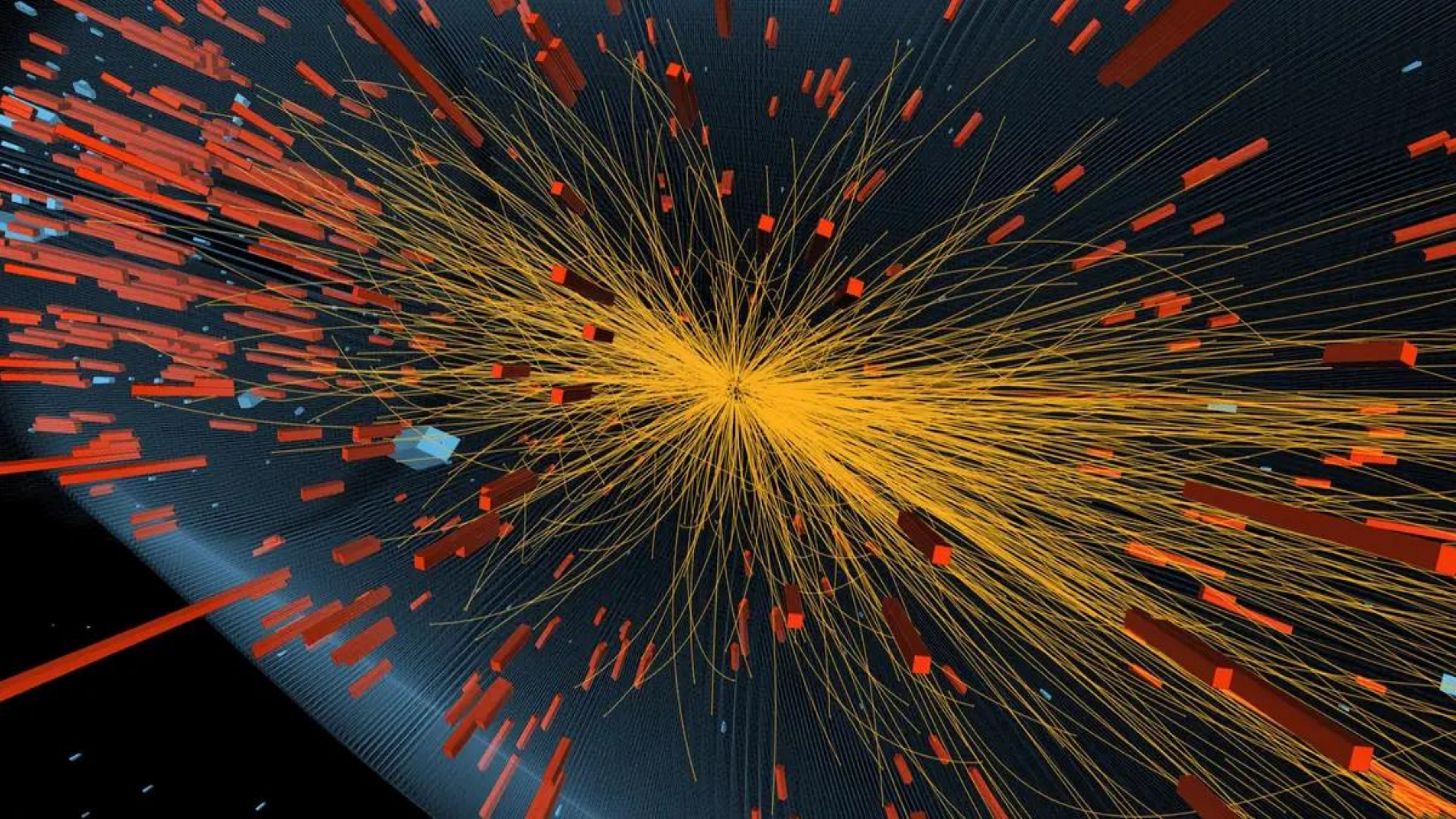


E ancora più indietro nel tempo?


History of the Universe
10^{-14}s (LHC)
Radius of the Visible Universe
Quantum Fluctuations
Inflation
Inflation Ends
Protons Formed
Nuclear Fusion Begins
Nuclear Fusion Ends
Cosmic Microwave Background
Dark Ages
First Stars & Galaxies Form
Modern Universe
Today
0
10^{-32}
1 μs
0.01 s
3 min
380,000 yrs
200 Million yrs
13.8 Billion yrs
Age of the Universe
BICEP2 Collaboration/CERN/NASA




LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
CMS
ALICE
LHC 27 km

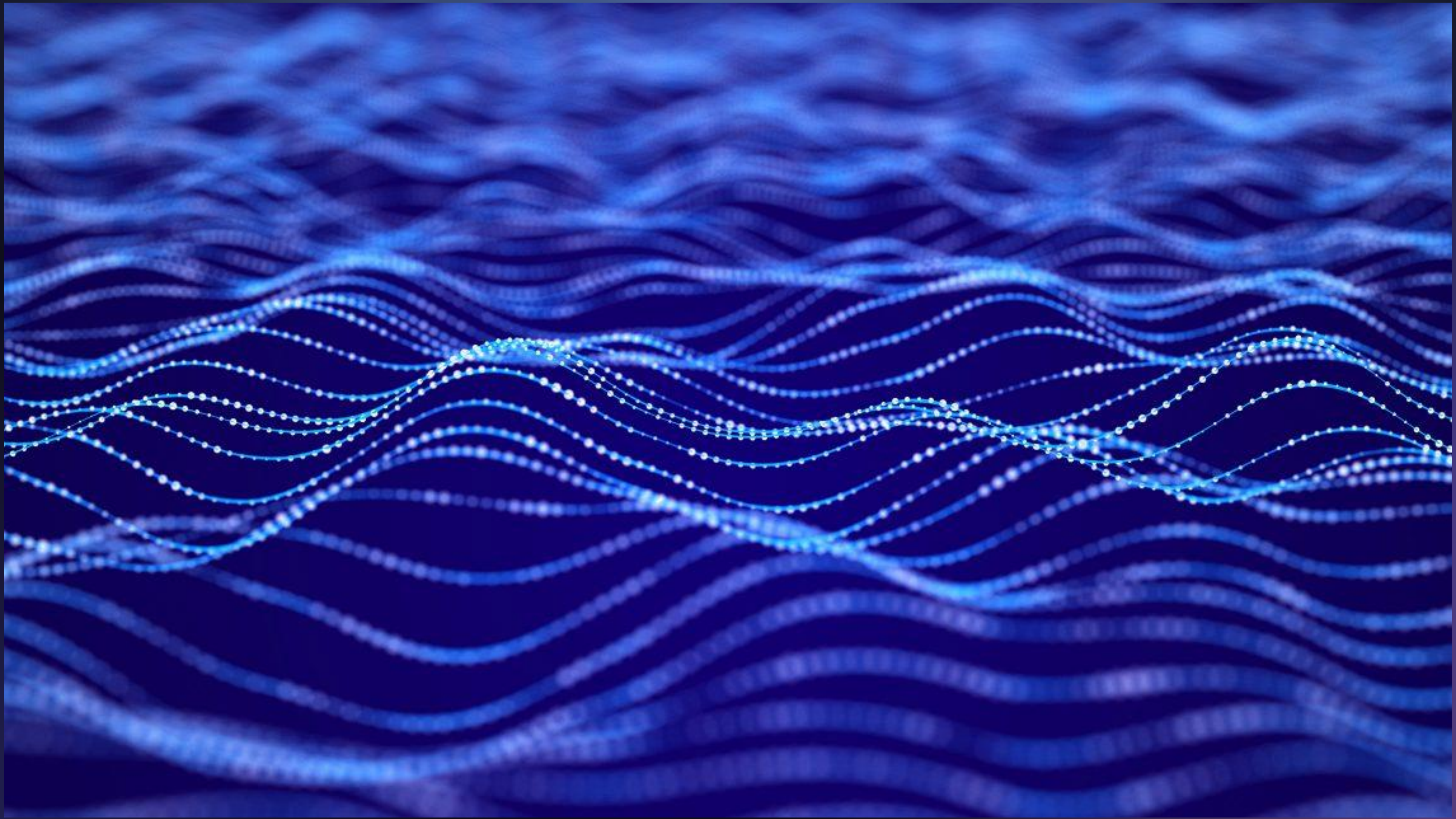


Indietro nel tempo, fino a 1 secondo dopo il Big Bang, i neutrini erano all'equilibrio termico con la materia

Espandendosi, l'Universo si raffredda. Circa 1 secondo dopo il Big Bang, queste interazioni divennero troppo rare rispetto all'espansione cosmica, e i neutrini **si** disaccoppiarono con il resto della materia, diventando liberi.

Osservare le caratteristiche di questo fondo di neutrini significherebbe vedere l'Universo come era 1 secondo dopo il Big Bang

E osservare come era l’Universo al momento del Big Bang?

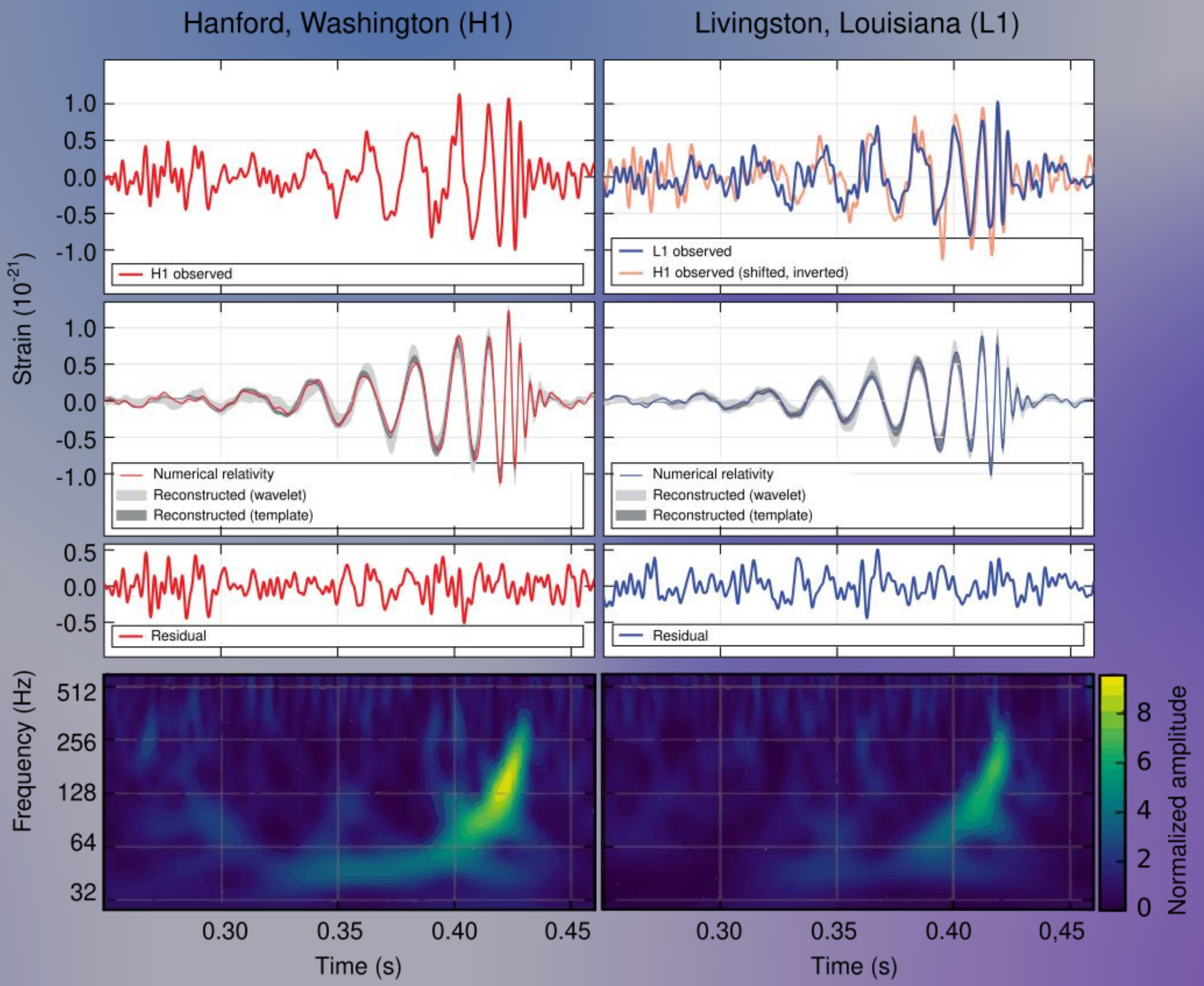


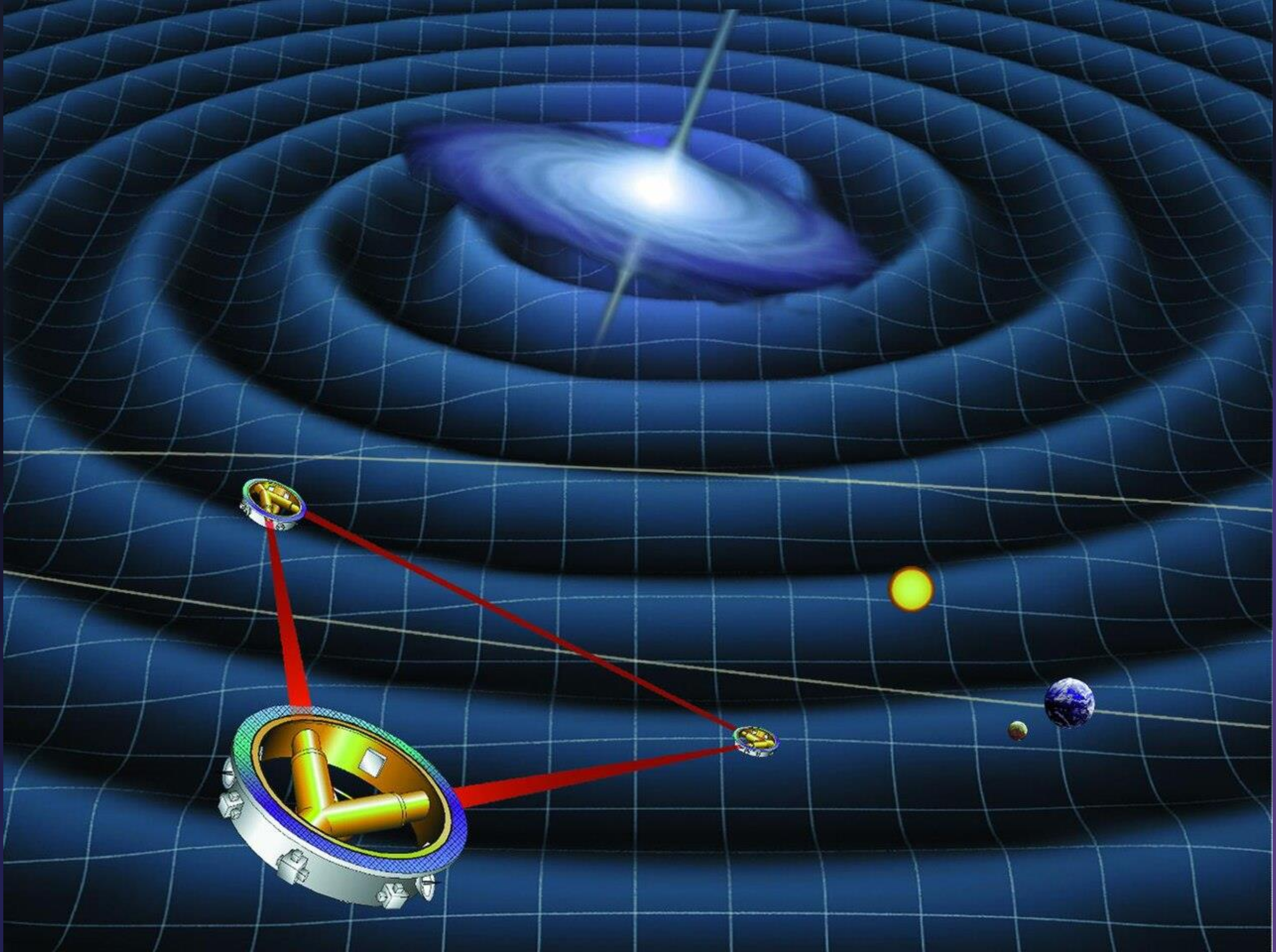
14 settembre 2015

Fusione di 2 buchi neri di massa 36 $M_\odot$ and 29 $M_\odot$ distanti 1.4 miliardi di a. l., che hanno generato un singolo buco nero di 62 $M_\odot$

3 masse solari sono state trasformate in onde gravitazionali.

Il processo è durato meno di 2 decimi di secondo, producendo 10^{49} W di potenza.





Una riflessione finale