



Unveiling Fundamental Physics
from the Cosmic First Light:
from **COMPLEXITY**
to **SIMPLICITY**
to **COMPLEXITY**
to **SIMPLICITY**,
the Universe at Large

7⁺ numbers

3 densities: *ordinary* matter 4.4%

dark matter 26.8%

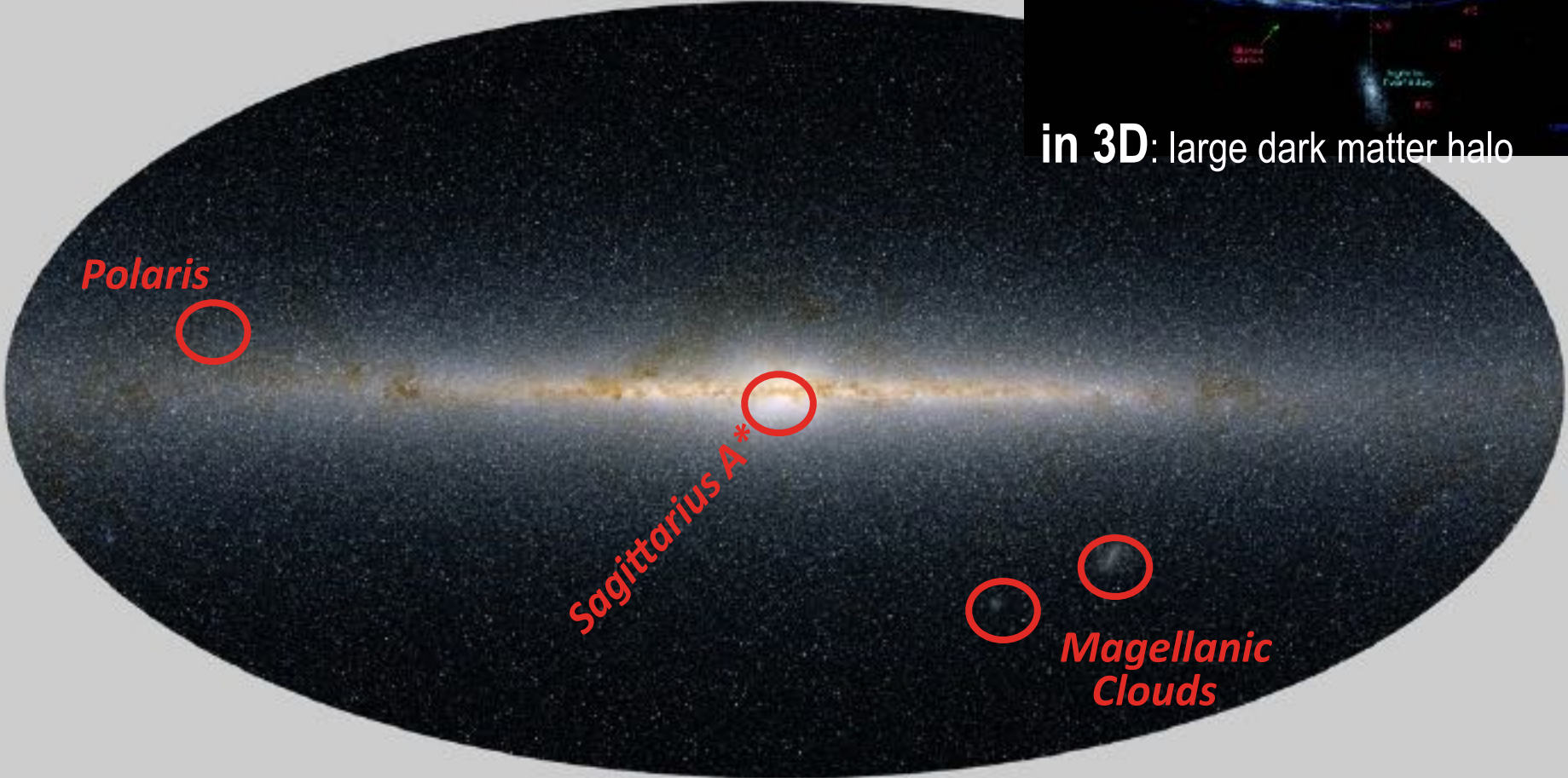
dark energy 68.8%

2 early-Universe inflation structure +1

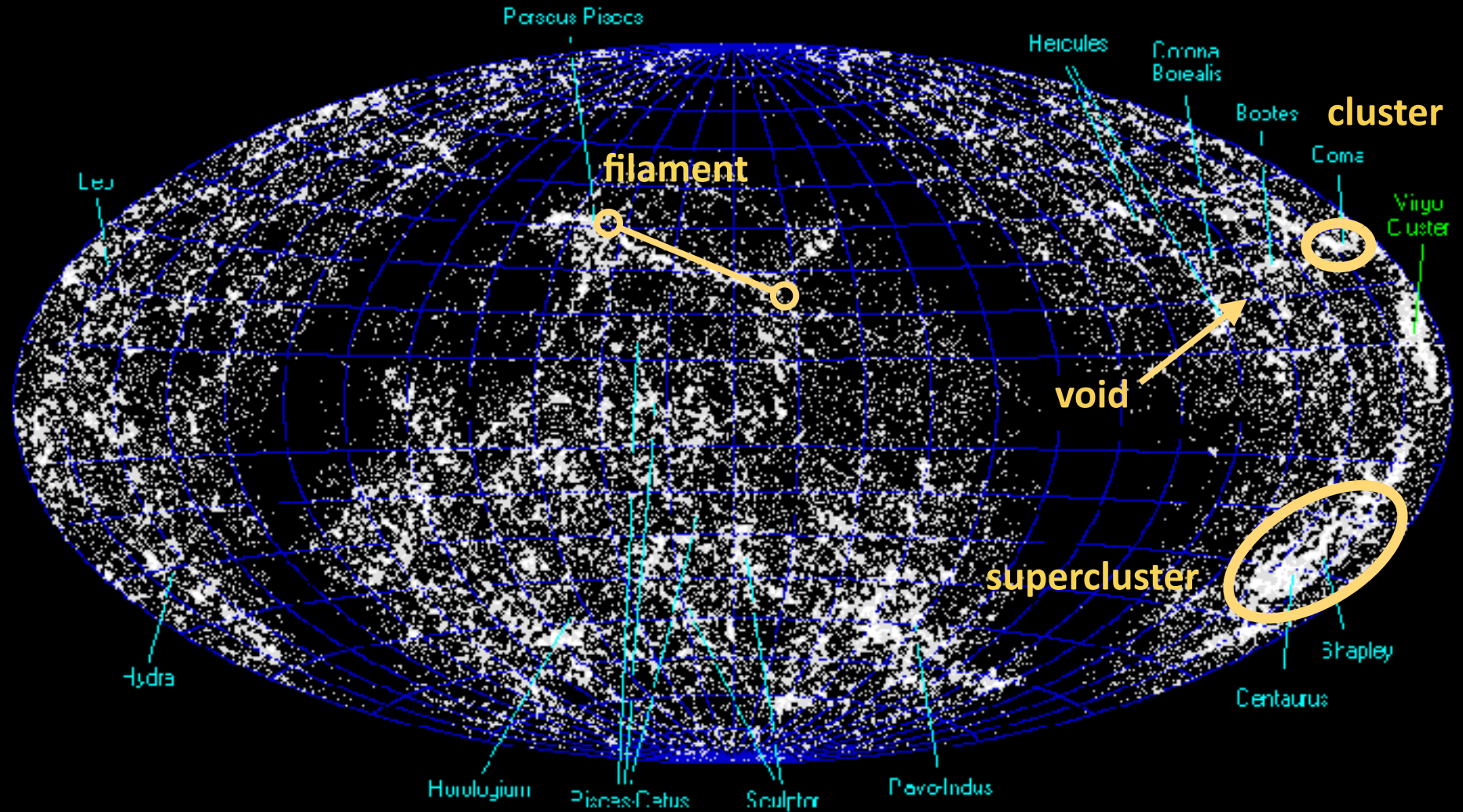


Milky Way in infra-red:

half a billion stars, a disk galaxy



Cosmic Web of 60,000 nearby galaxies:
exhibits “local” **COMPLEXITY** ~1 billion *light yrs*

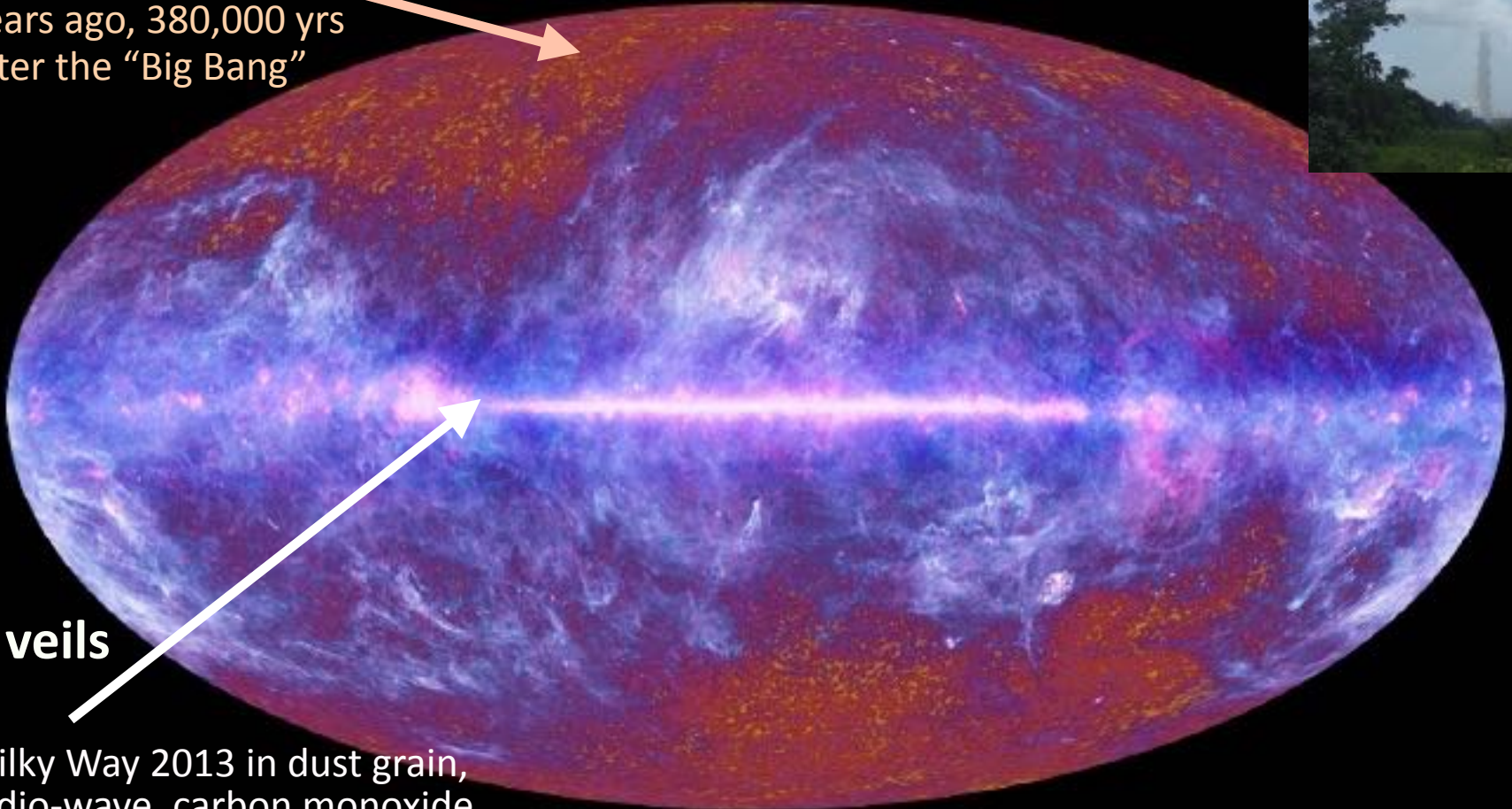


hard won observational emergence of the cosmic web of galaxies, clustered & interconnected



COMPLEXITY of here & now

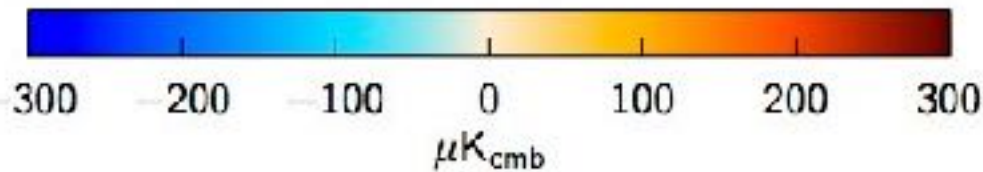
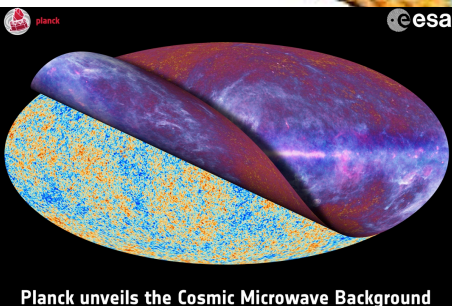
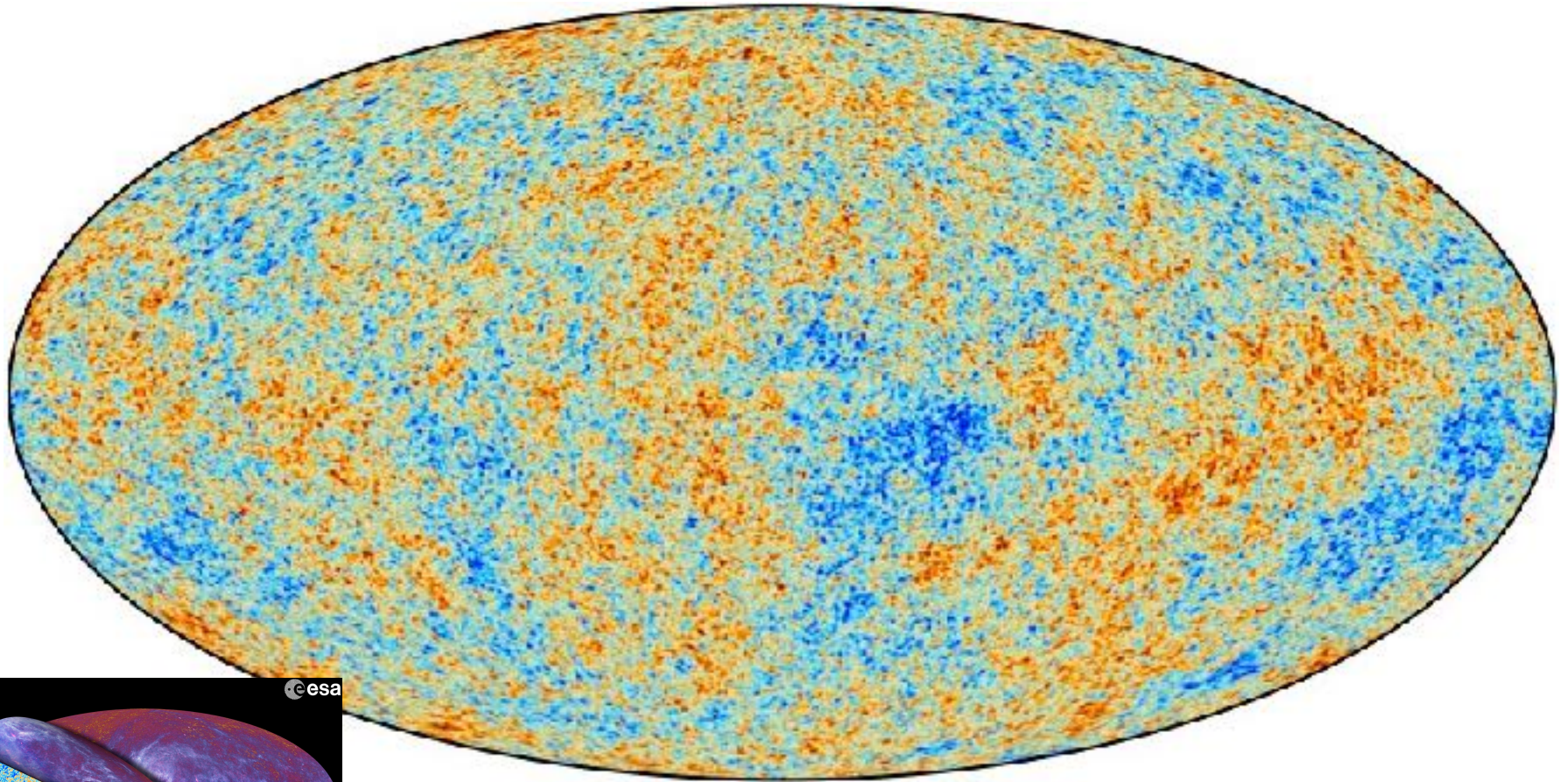
the primordial light,
released 13.8 billion
years ago, 380,000 yrs
after the "Big Bang"



7 veils

Milky Way 2013 in dust grain,
radio-wave, carbon monoxide
emissions; plus stellar, X-ray,
gamma ray, cosmic ray
emissions ...

Planck's primordial light unveiled
reveals **primordial sound waves**
=> the inharmonious '*music of the spheres*'
in 7+ numbers



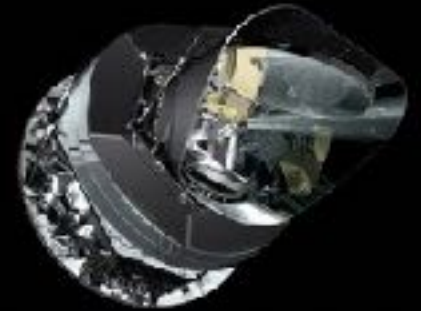
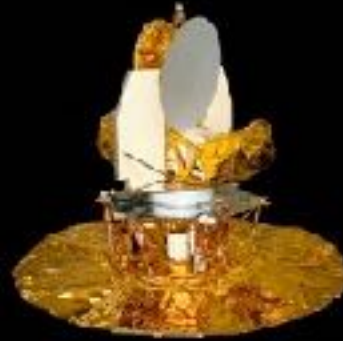
Planck unveils the Cosmic Microwave Background

Comparison of CMB Space Experiments: Increasing Resolution

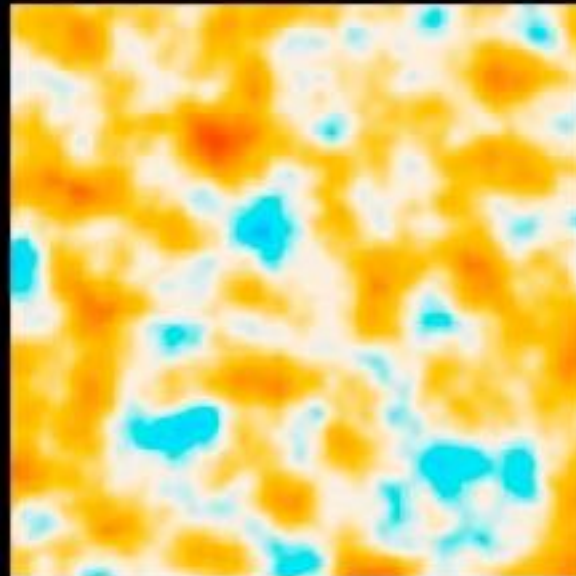
COBE 1989 launch

WMAP 2001 launch

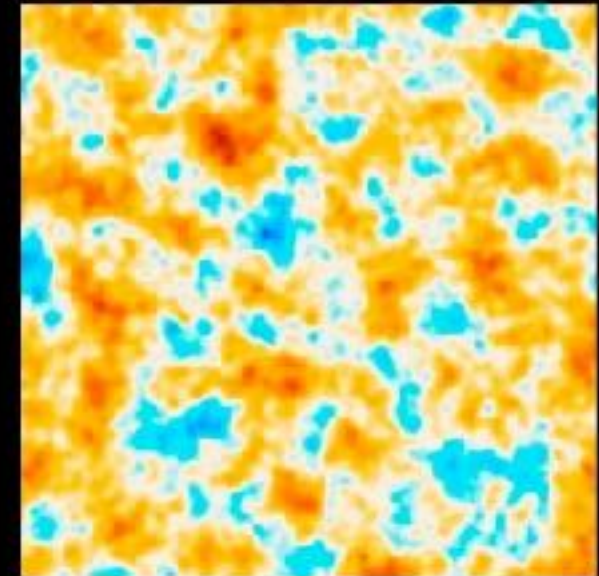
Planck 2009 launch



COBE



WMAP

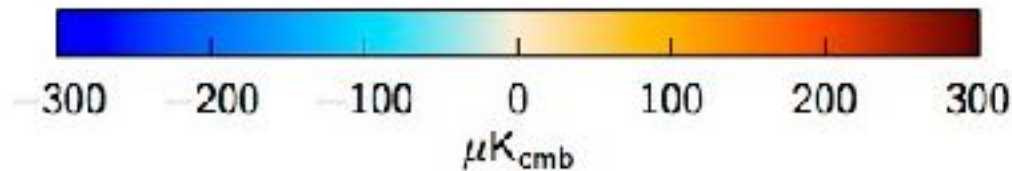
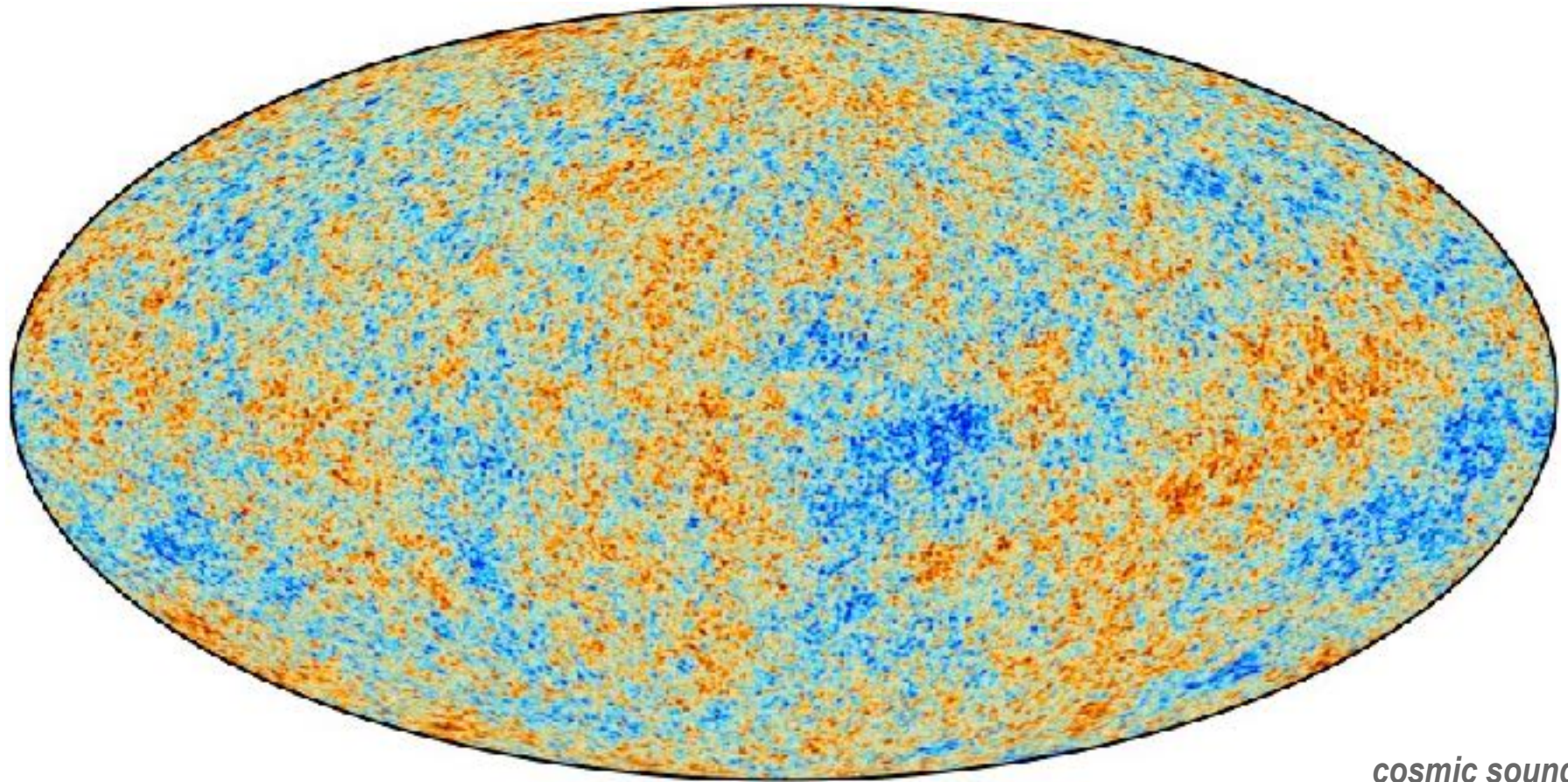


Planck

Temperature
changes in
micro-degrees

to even higher resolution with telescopes in Chile and the South Pole

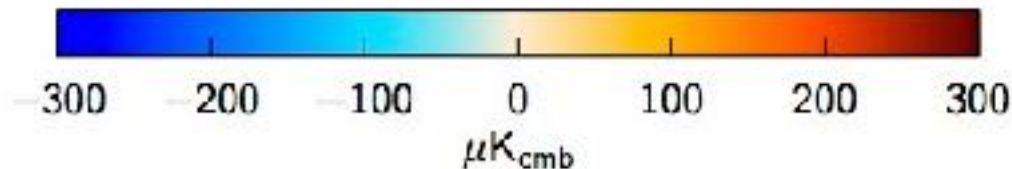
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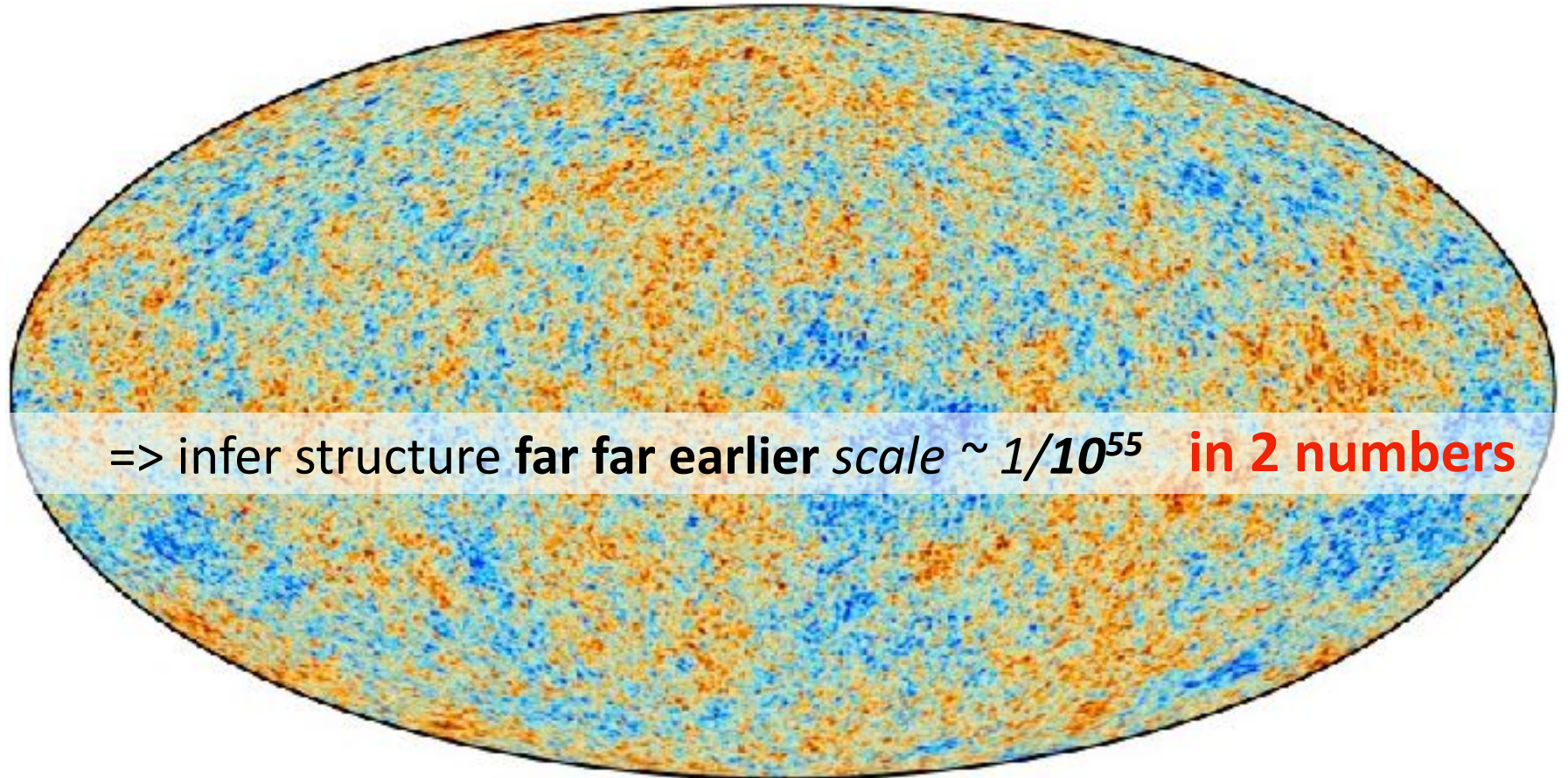
*cosmic sound
realization*

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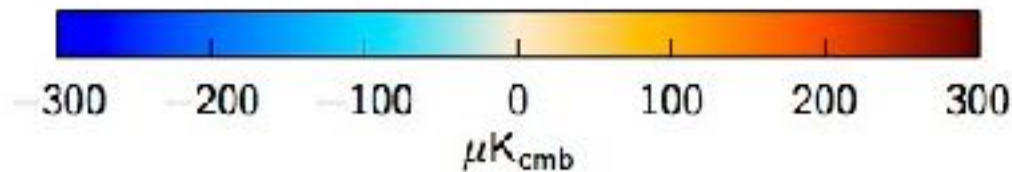
=> learn **matter / energy content & structure** at 380000 yr, *scale* ~1/1100
ordinary matter, dark matter, dark energy
in 3 numbers



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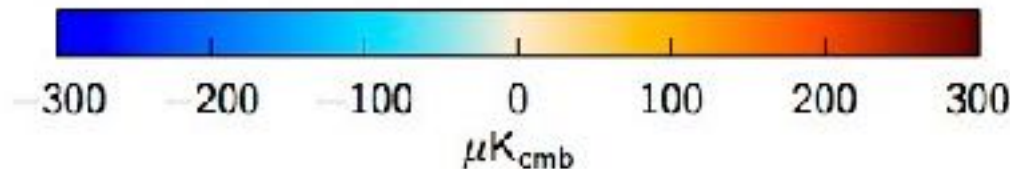


=> infer structure **far far earlier** *scale* $\sim 1/10^{55}$ **in 2 numbers**



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reveals **primordial sound waves**
=> the inharmonious '*music of the spheres*'
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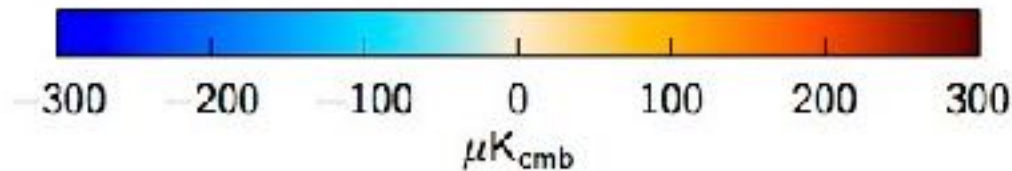
the ultra early Universe sounds like **classical music**
(all parts of the audible spectrum are used),
with slightly more bass than treble
sound is noise-like, as random as can be
Planck's most celebrated findings



Planck's primordial light unveiled
reveals **primordial sound waves**
=> the inharmonious '*music of the spheres*'
in 7+ numbers

=> infer structure **far far earlier** *scale* $\sim 1/10^{55}$ **in 2 numbers**
loudness, treble/bass

we search for a 3rd number, early Universe **gravity waves**



Simulation of the 7⁺ numbers

begets the **Cosmic Web** of clusters now & galaxies forming

SIMPLICITY to COMPLEXITY under Gravity

void

filament

cluster

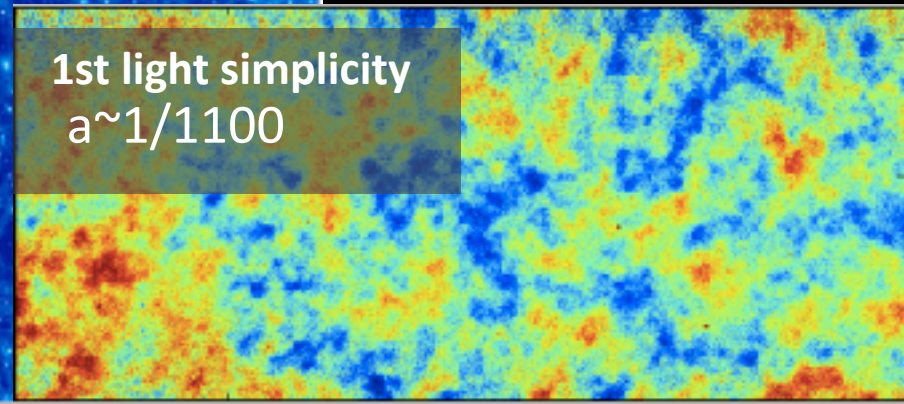
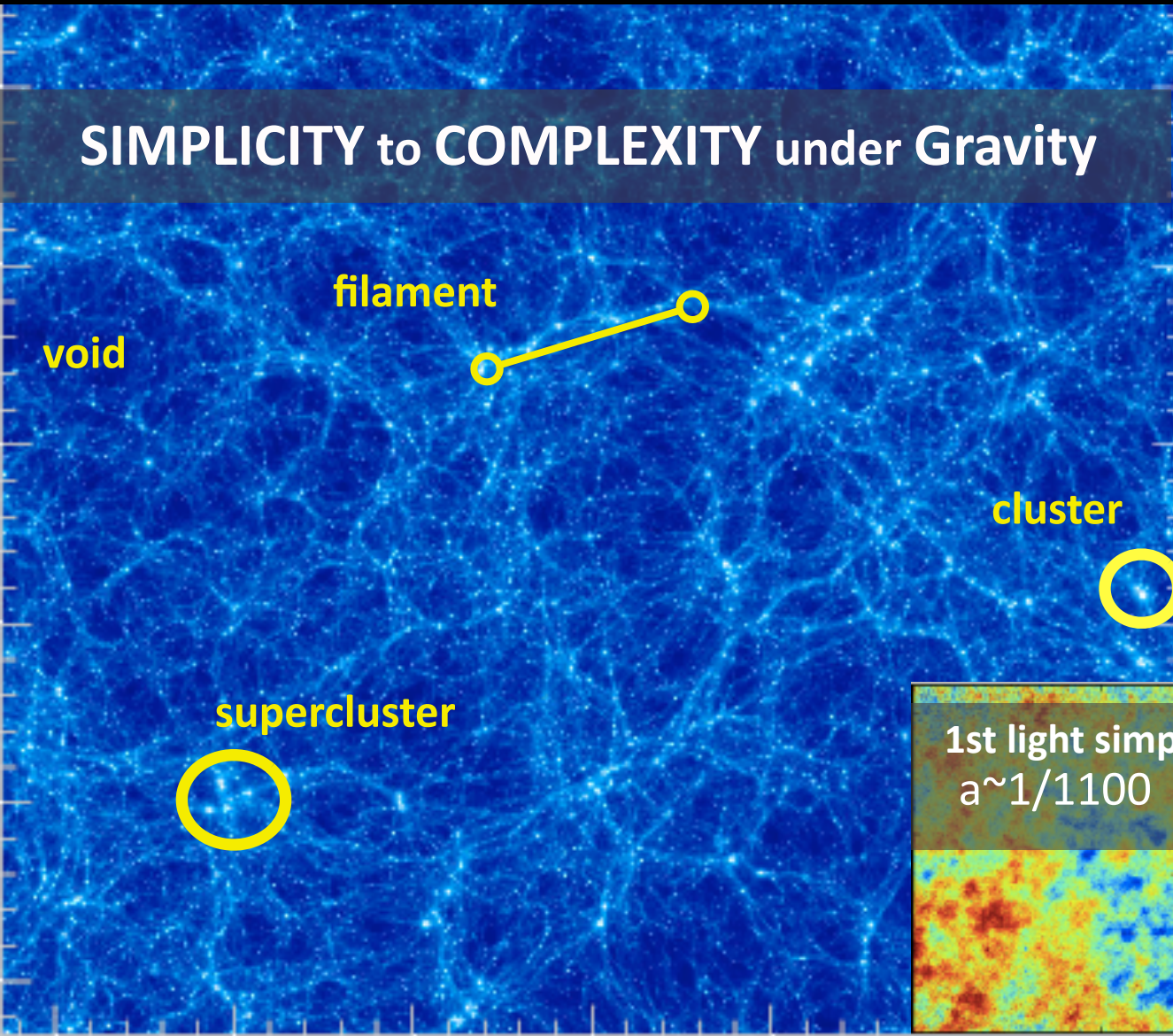
supercluster

~ **billion light years**

state of the art simulation

ordinary matter
dark matter
dark energy

1st light simplicity
 $a \sim 1/1100$



Let there be....

2 numbers +1
early **Dark Energy**

Inflation fluctuations
form: quantum jitter

let there be **Heat**
scale $\sim 10^{-29}$

Dark Matter
protons/Neutrons
form light nuclei
Helium forms

let there be **Light**
Cosmic background
radiation released from
matter
carries imprint of
fluctuations in matter which
grow to generate galaxies etc.

scale $\sim 1/1100$ 7 numbers +

COMPLEX ?

SIMPLE

NOW **CIFAR** formed
Pythagoras formed
writing $1/1.00000017$

Galaxies Cluster
Cosmic "web" of
vast filaments +
membranes

COMPLEX
Solar system
earth form

Life forms on earth
scale $\sim 1/1.4$
Dark Energy inflation

SIMPLE

Carbon/oxygen/etc
form

Galaxies form
scale $\sim 1/10$

