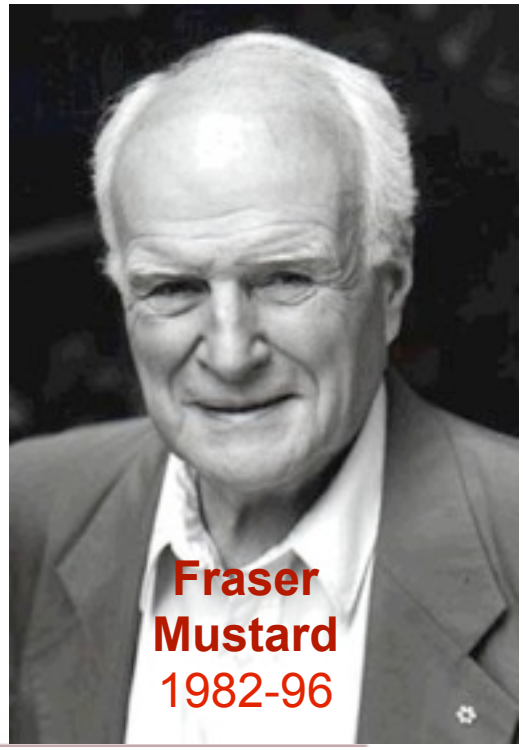
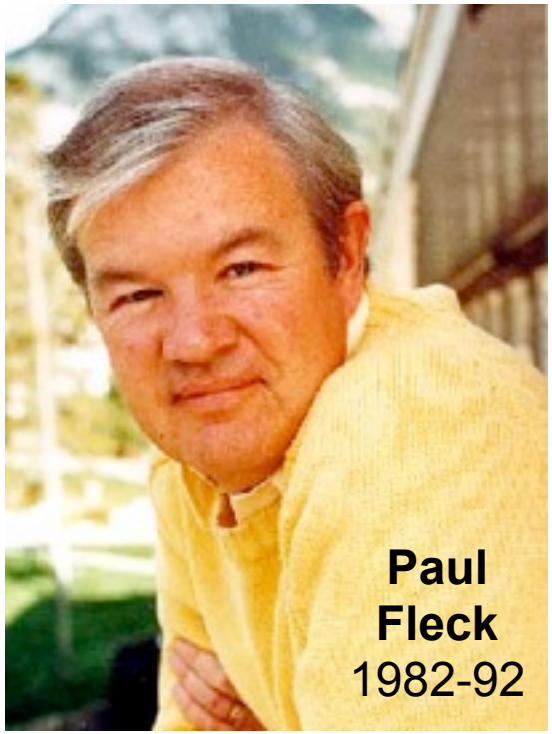
CIFAR Cosmology & Gravity Program at the Banff Centre

1985, 1987, 1991, 1992, 1993, 1997, 2000, 2001, 2004, 2006, 2013a,b

85 Growth of Cosmic Fluctuations and Microwave Background Anisotropies, 87 Large Scale Cosmic Structure and .. Galaxy Formation, ..
COBE, Clusters, ***Cosmic Web***, New Horizons in String Cosmology @BIRS, Cosmological Parameters, ***Planck***, Early Universe Physics, ***Inflation***, ...

Banff Centre partners artists with big ***U&I*** thinkers *2013 Calgary Herald*





CIFAR CANADIAN INSTITUTE for ADVANCED RESEARCH

CITA ICAT Canadian Institute for Theoretical Astrophysics / L'institut canadien d'astrophysique theorique

www.cita.utoronto.ca/~**bond**/bondtalks/bond_banff13_cifar_07_20f.pdf

the BOUNDed flow of information
the BOUNDless thought of man

“To me every hour of the light and dark is a miracle. Every cubic inch of space is a miracle.”

– Walt Whitman

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In every **teaspoon** of air ~5 cubic cm

Ordinary Matter ~amu /nm^3 **4.8%**

cosmic ***radiation*** **412 /cm^3 0.005%**

cosmic ***neutrinos*** ~*cosmic* ***photons*** >0.47%

cosmic ***gravity waves*** << *cosmic* ***photons***

- ***Dark Matter*** ~amu /m^3 **26.0 ± 1%**

compressed in MilkyWay ~0.1 amu /cm^3 ;

for LHC@CERN-type relics ~ 1 every 10 cm

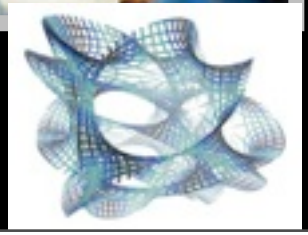
- ***Dark Energy*** ~vacuum potential

~ 3 amu /m^3 **69.2 ± 1.0%**

- ***Higgs@CERN*** *vacuum* **origin of mass**
- ***vacuum fluctuations*** **virtual particles**

the origin of all the cosmic structure we see

the BOUNDed flow of information
the BOUNDless thought of man



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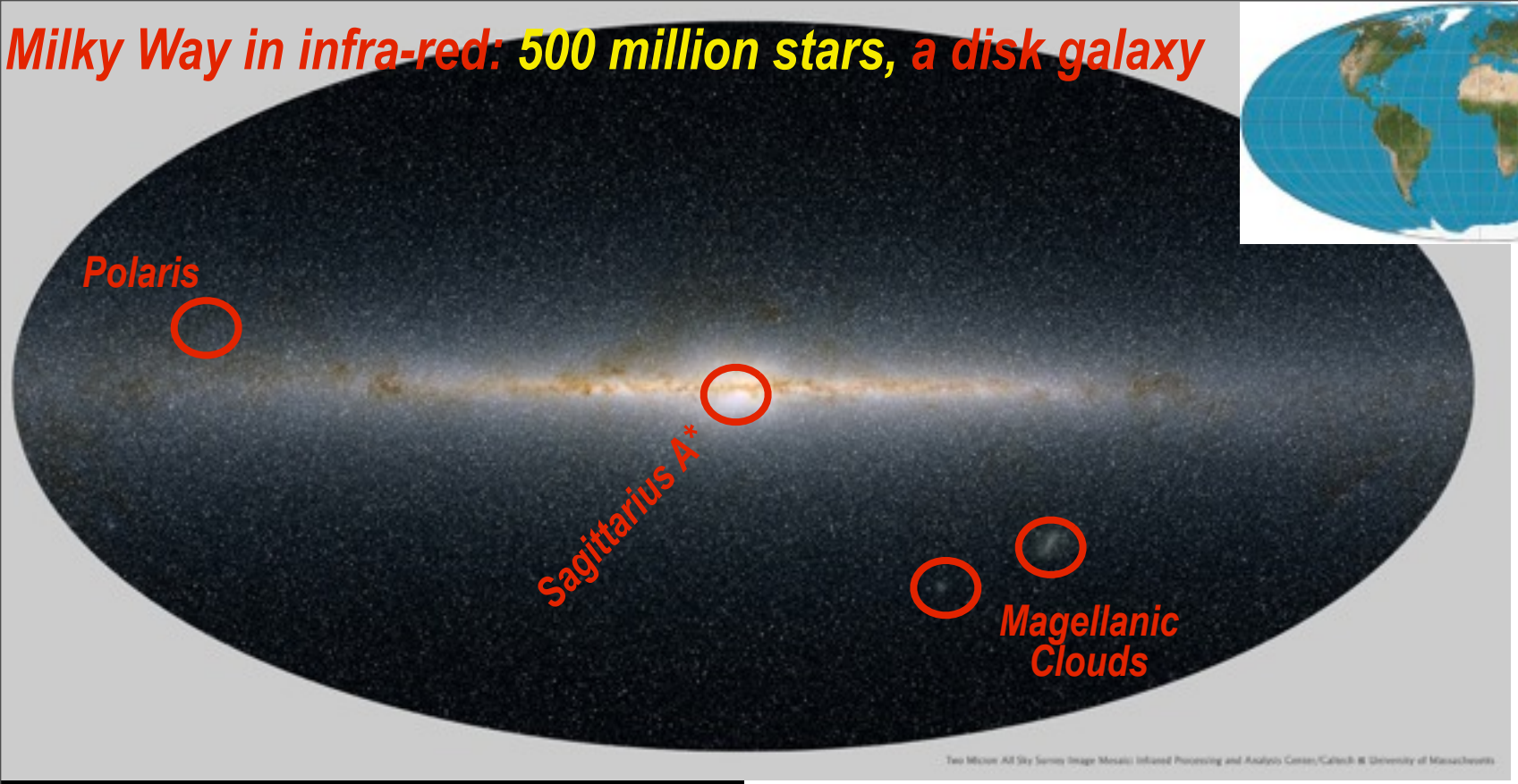
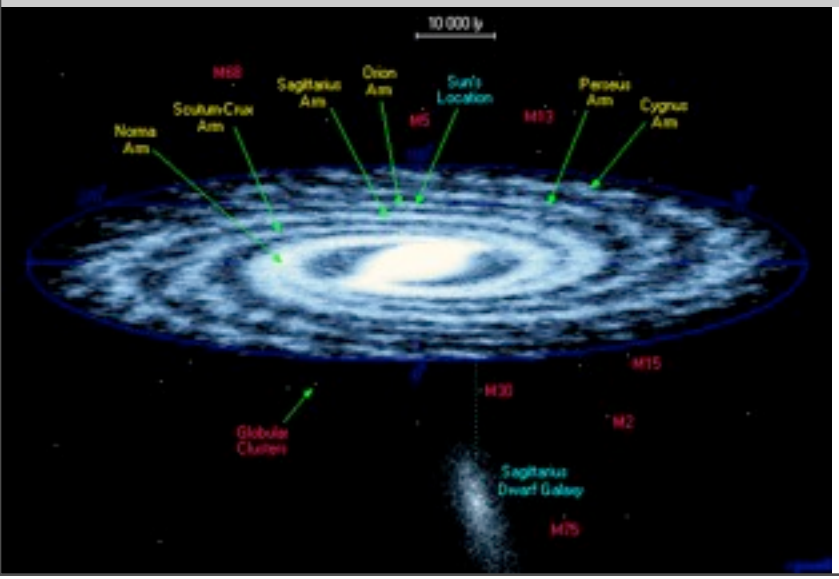
the origin of all the cosmic structure we see

strings + extra dimensions **here&now?, 6?**

Milky Way in infra-red: 500 million stars, a disk galaxy





large halo of Dark Matter

1970s/80s around galaxies;

1930s around clusters of galaxies

mass in **Dark Matter** $= 5.36 \pm 0.12\ X$

mass in **Ordinary Matter** *(stars+gas)*

on average in the Universe

complexity of here & now

the primordial light,
released 13.8 billion years ago,
380000 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 ...

The Planck one-year all-sky survey

esa

the primordial light unveiled

March 21, 2013

Google Planck Satellite 2013 results: yields 926,000 links

Government of Canada / Gouvernement du Canada

Canadian Space Agency

Home > Audiences > Media > News releases > 201
> Canadian astronomers reveal surprising new portr

Canadian astronomers reveal surp

Planck space mission sheds light on t

Longueuil, Quebec, March 21, 2013 – Th
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and that th

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U of T News

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Plancking at U of T: space

CITA–ICAT

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PLANCK Light

The New York Times

Space & Cosmos

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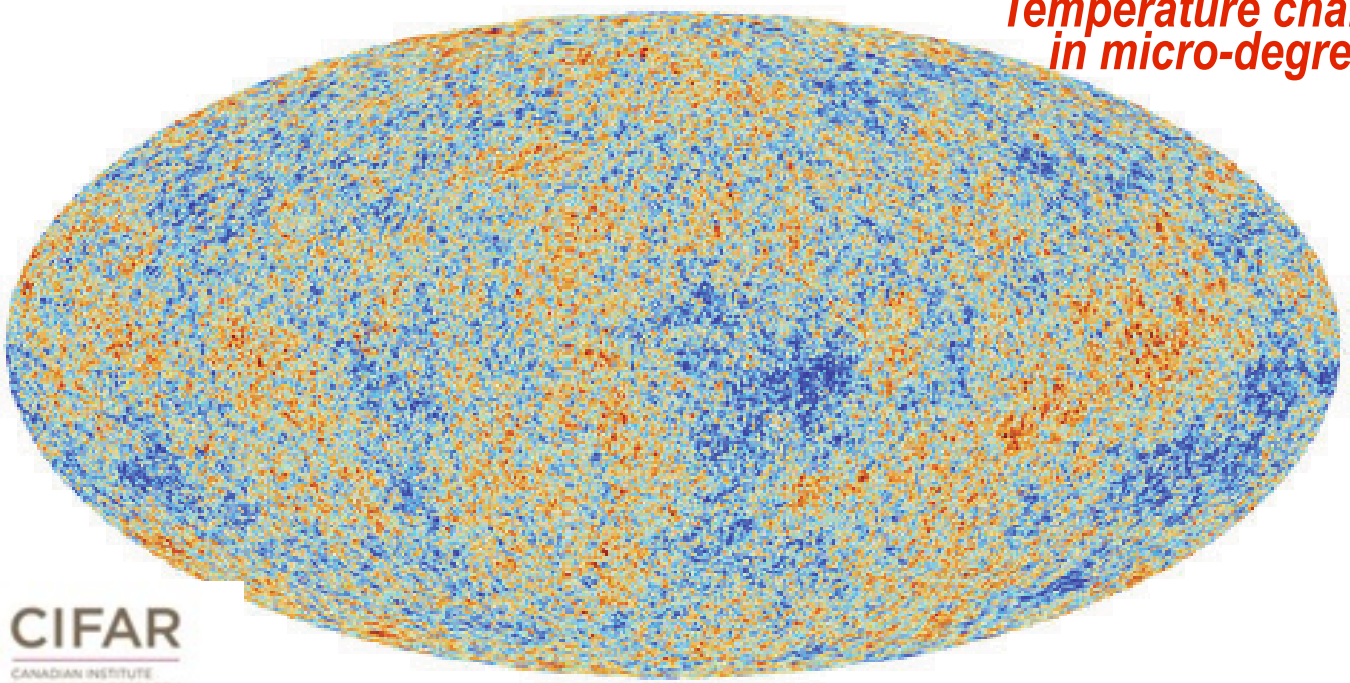
ENVIRONMENT | SPACE & COSMOS

Universe as an Infant: Fatter Than Expected and Kind of Lumpy

Temperature changes in micro-degrees



European Space Agency; Planck Collaboration

A view of the cosmic microwave background collected by the European Space Agency's Planck satellite. The heat map of the cosmos was imprinted on the sky when the universe was just 380,000 years old.

By DENNIS OVERBYE
Published: March 21, 2013 | 345 Comments

Astronomers released the latest and most exquisite baby picture yet of the universe on Thursday, one that showed it to be 80 million to 100 million years older and a little fatter than previously thought.

FACEBOOK

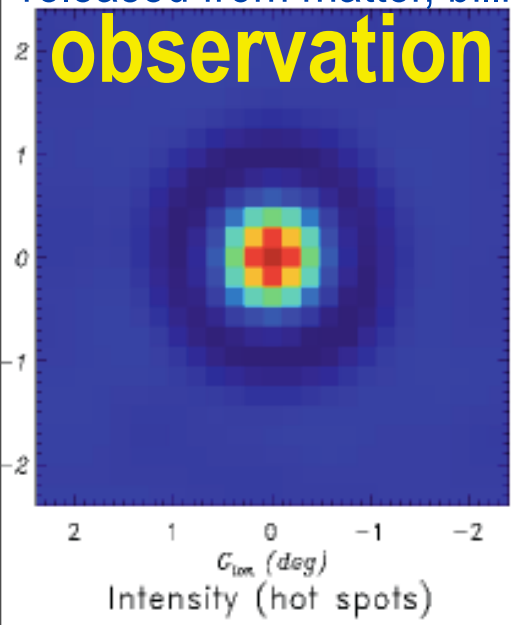
TWITTER

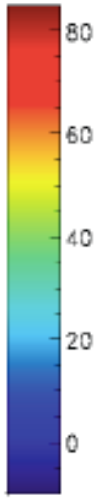
scale a: now = 1 = e^0 when we **observe** the **1st light**

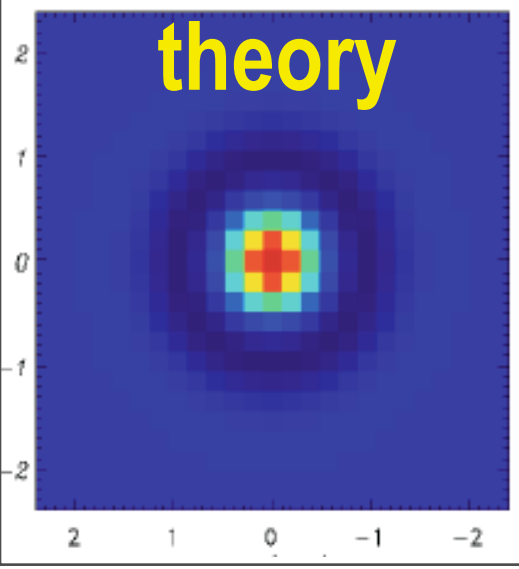
then = e^{-7} = 1/1100 when it was released from matter, billion X denser

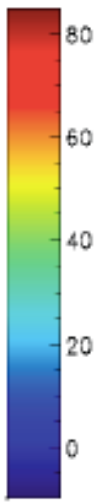
reveals ***primordial sound waves*** *in matter* ***13.8 billion years ago,*** *when the* **1st light** *was released from matter 380000 yr after the* **1st heat & light** *were created in the Big Bang*

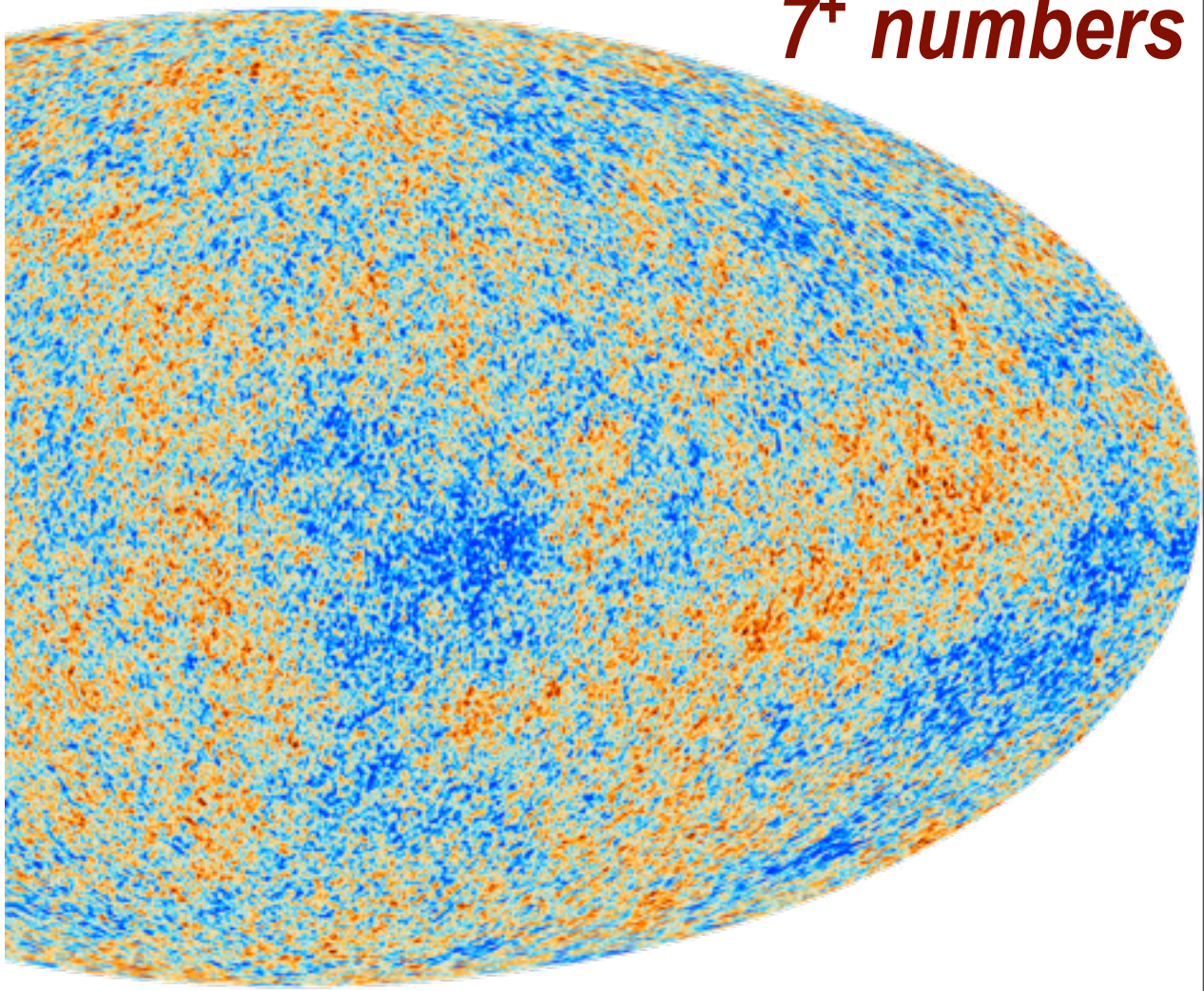
7+ numbers









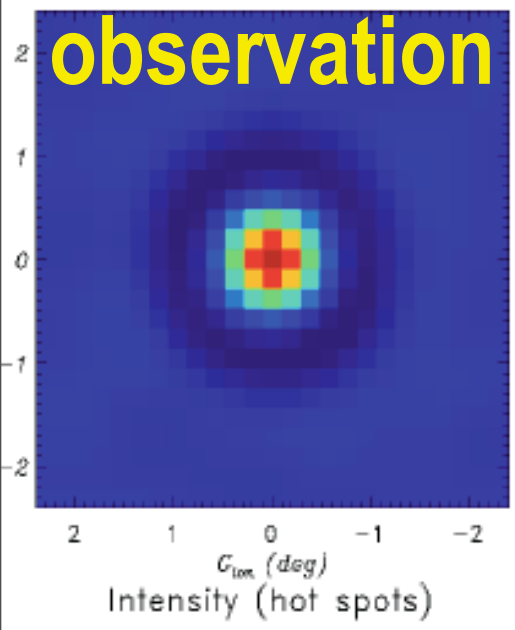


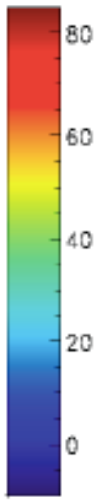
SIMPLICITY

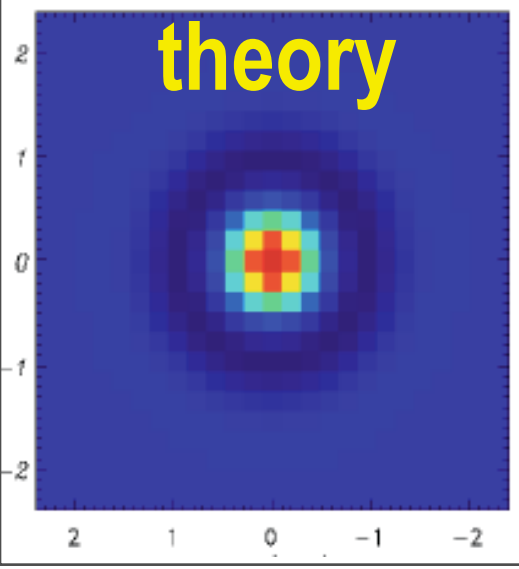
at a~e^{-7}

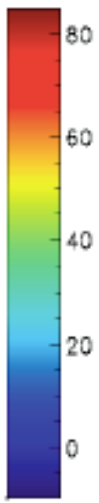
reveals primordial sound waves in matter

=> learn **contents & structure** *at* a~e^{-7} *380000 yr*









7^{+} numbers

WHAT IS U MADE OF?

Dark Energy 69.2 ± 1.0%

Dark Matter 26.0 ± 1%

Ordinary Matter: 4.8%

Cosmic Radiation: 0.005%

Cosmic Neutrinos > 0.47%

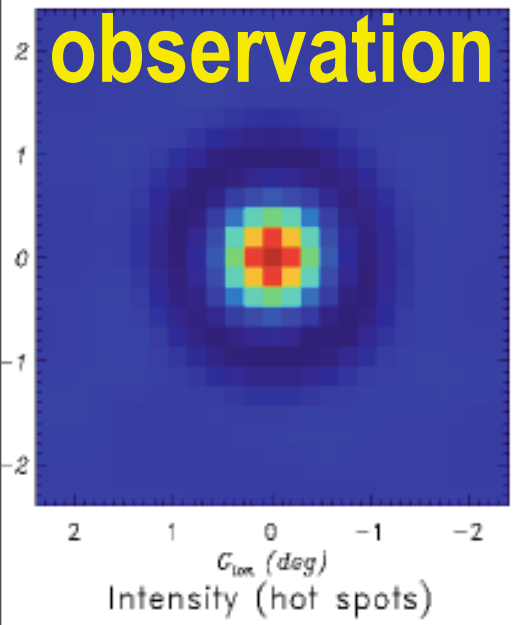
light from 13.8 billion years ago

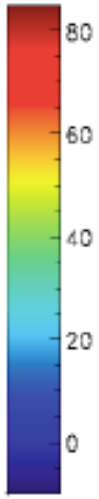
SIMPLICITY

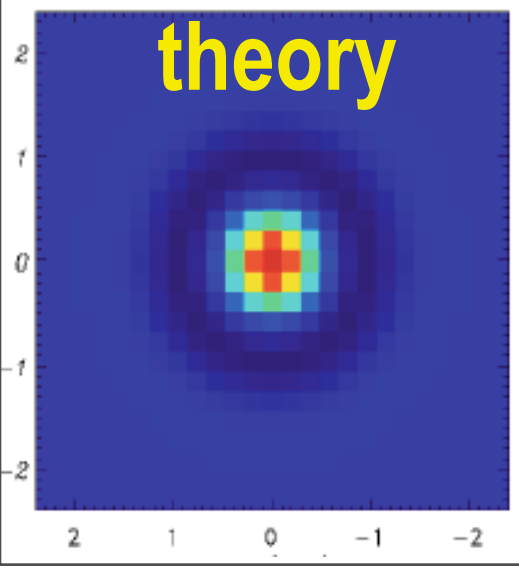
at a~e^{-7}~1/1100 =>
at a~e^{-67+60}

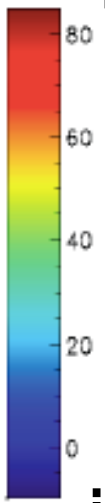
reveals ***primordial sound waves*** *in matter*

=> *infer* ***structure*** *far far earlier* a~e^{-67+60} ~1/10^{30+25}









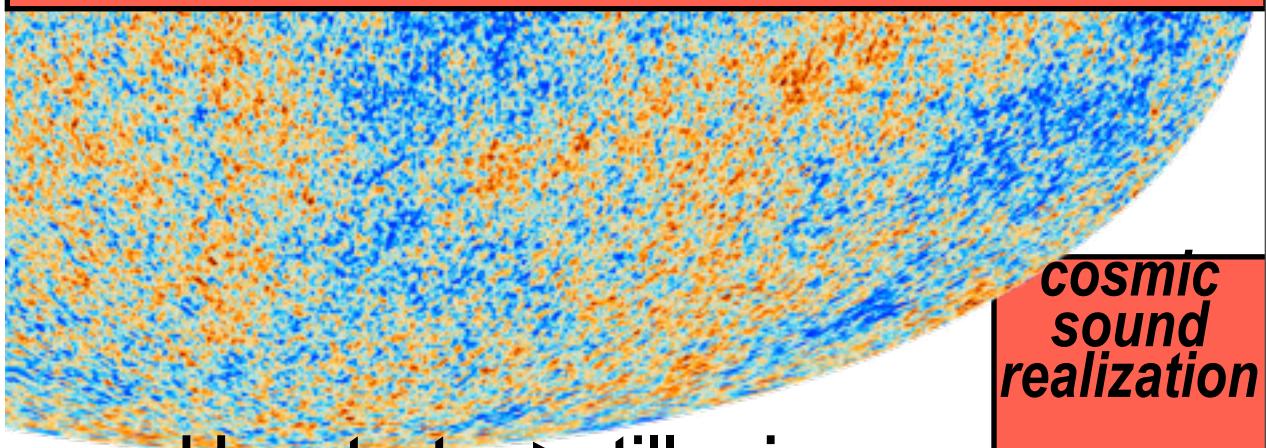
7^{+} numbers

***Early Universe* STRUCTURE**

"red" noise: 2 numbers at a~e^{-67+55}

almost like classical music *(all parts of the audible spectrum are used)*, with *slightly* more bass than treble

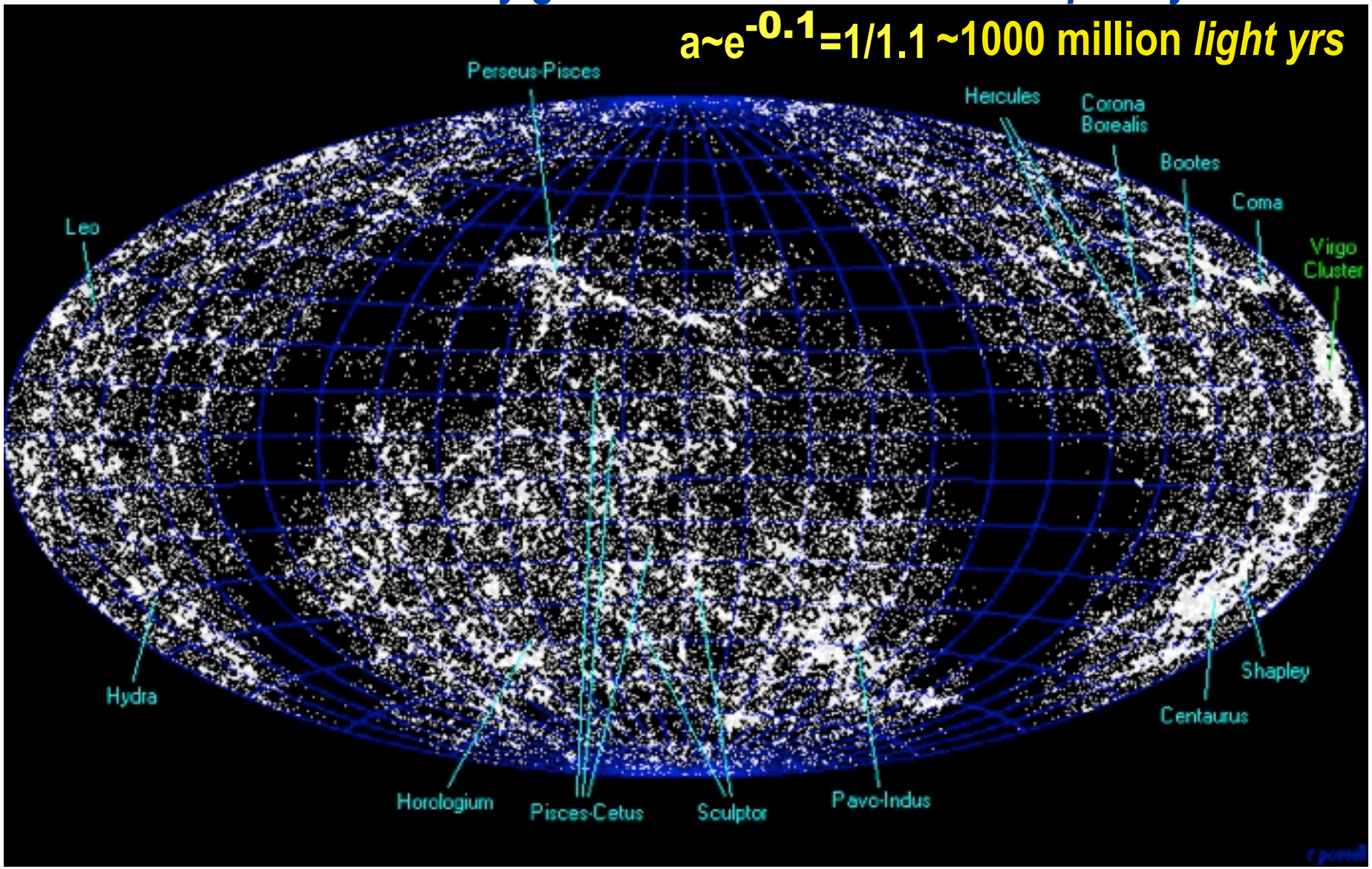
Planck's most celebrated finding



cosmic sound realization

add contents => still noise
inharmonious *'music of the spheres'*

cosmic web of 60000 nearby galaxies: *exhibits "local" complexity*



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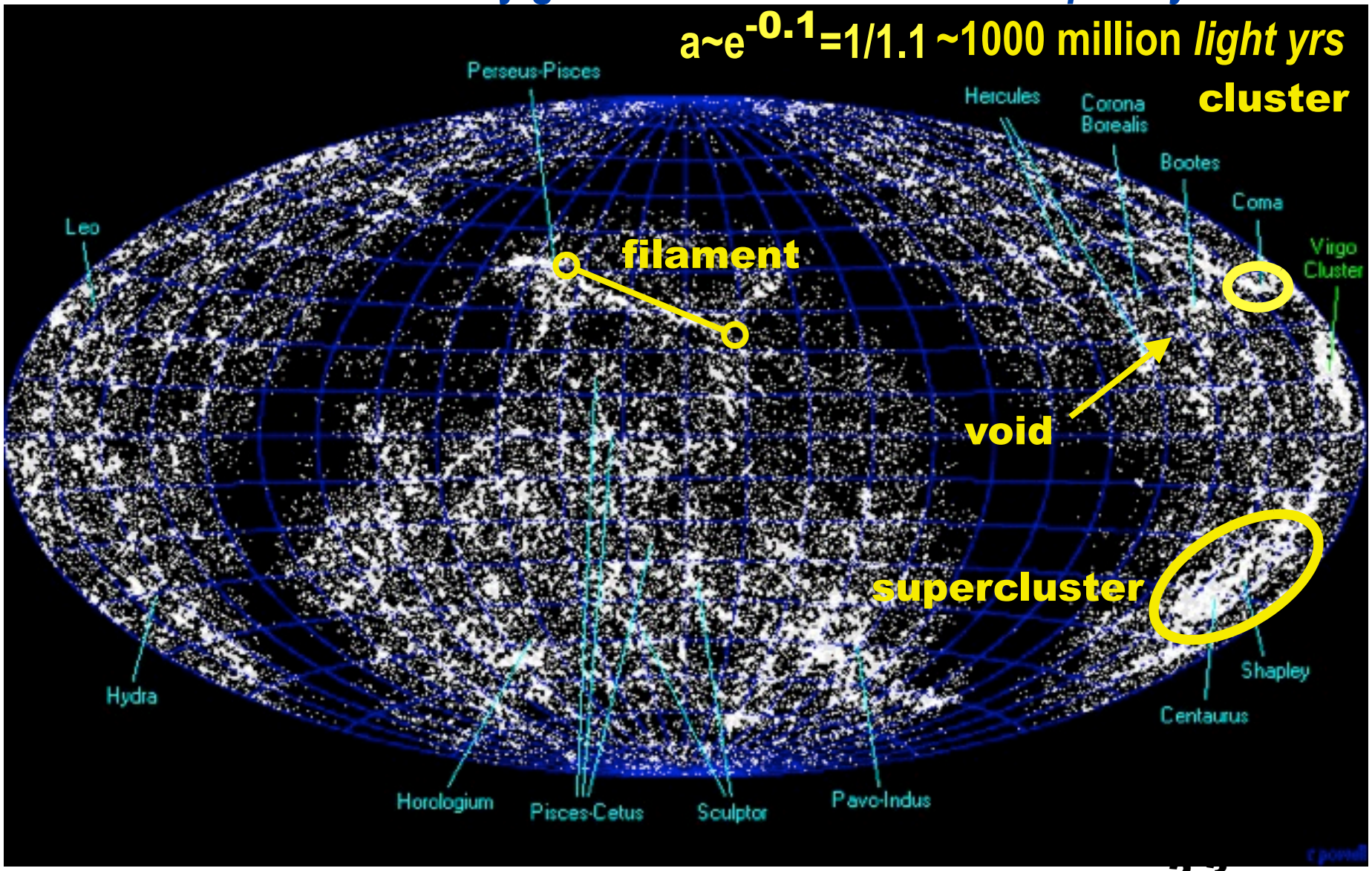


we observe galaxies out to a time when the universe was $a=e^{-2.3}=1/10$ *smaller in overall scale, average density 1000X larger*

no galaxies formed when the universe was smaller than $a=e^{-3}=1/20$

Simulation of the 7^{+} number fields begets the Cosmic Web

of clusters now a~1 & galaxies "then" a~1/5

1300 Million light years

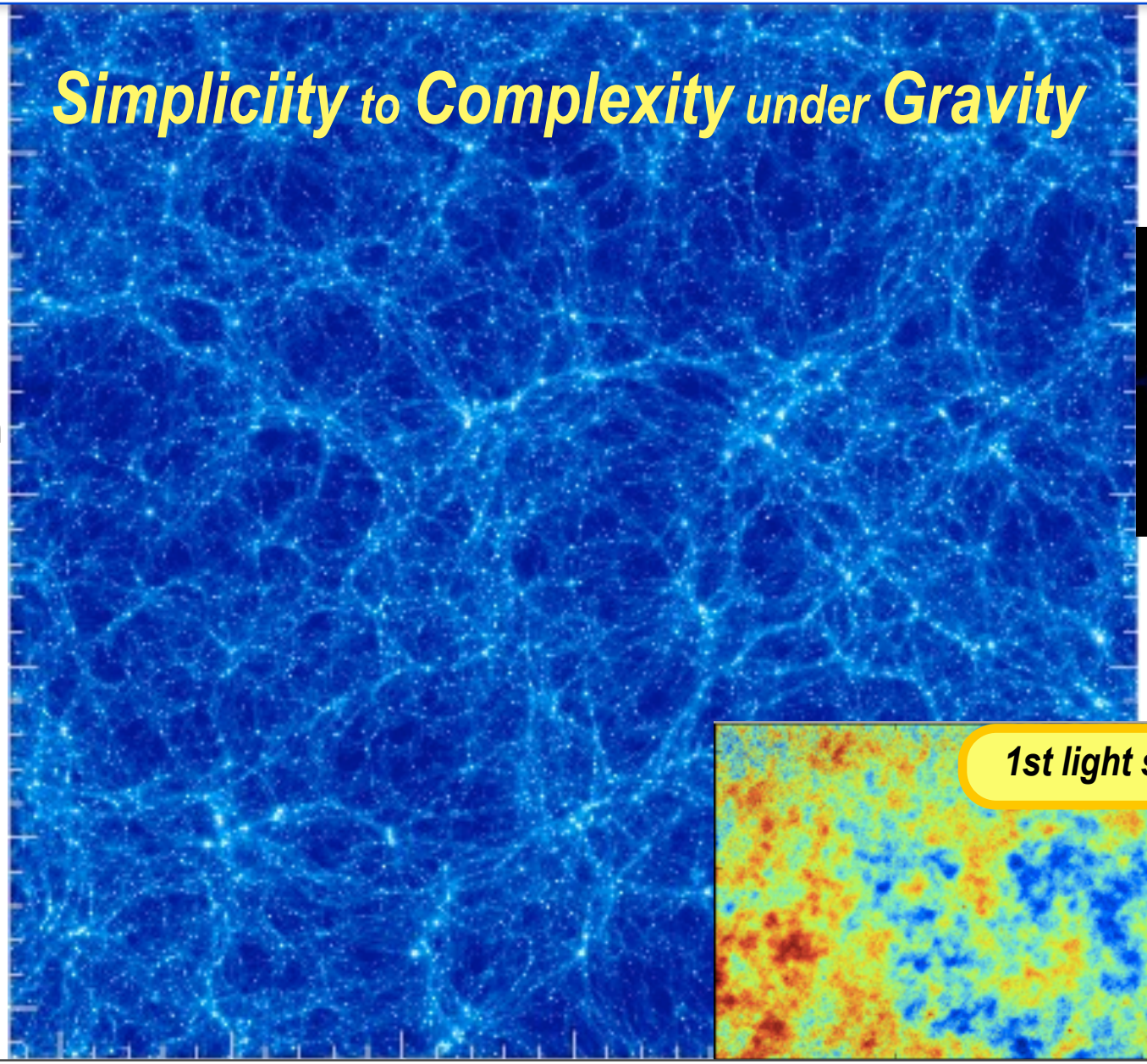
state of the art simulation of

gas density

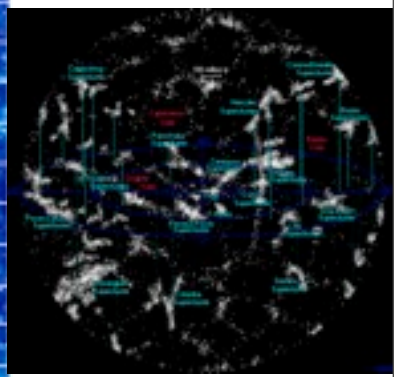
& dark matter

& dark energy

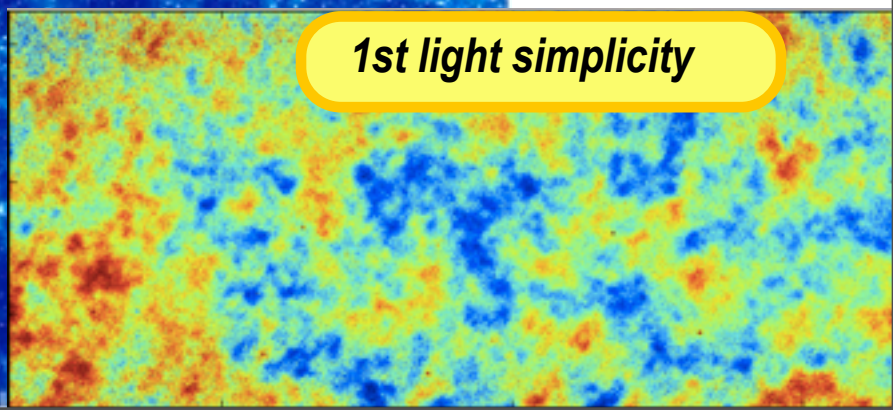
512^3



$a=e^{0}=1$ now



$a\sim e^{-7}\sim 1/1100$



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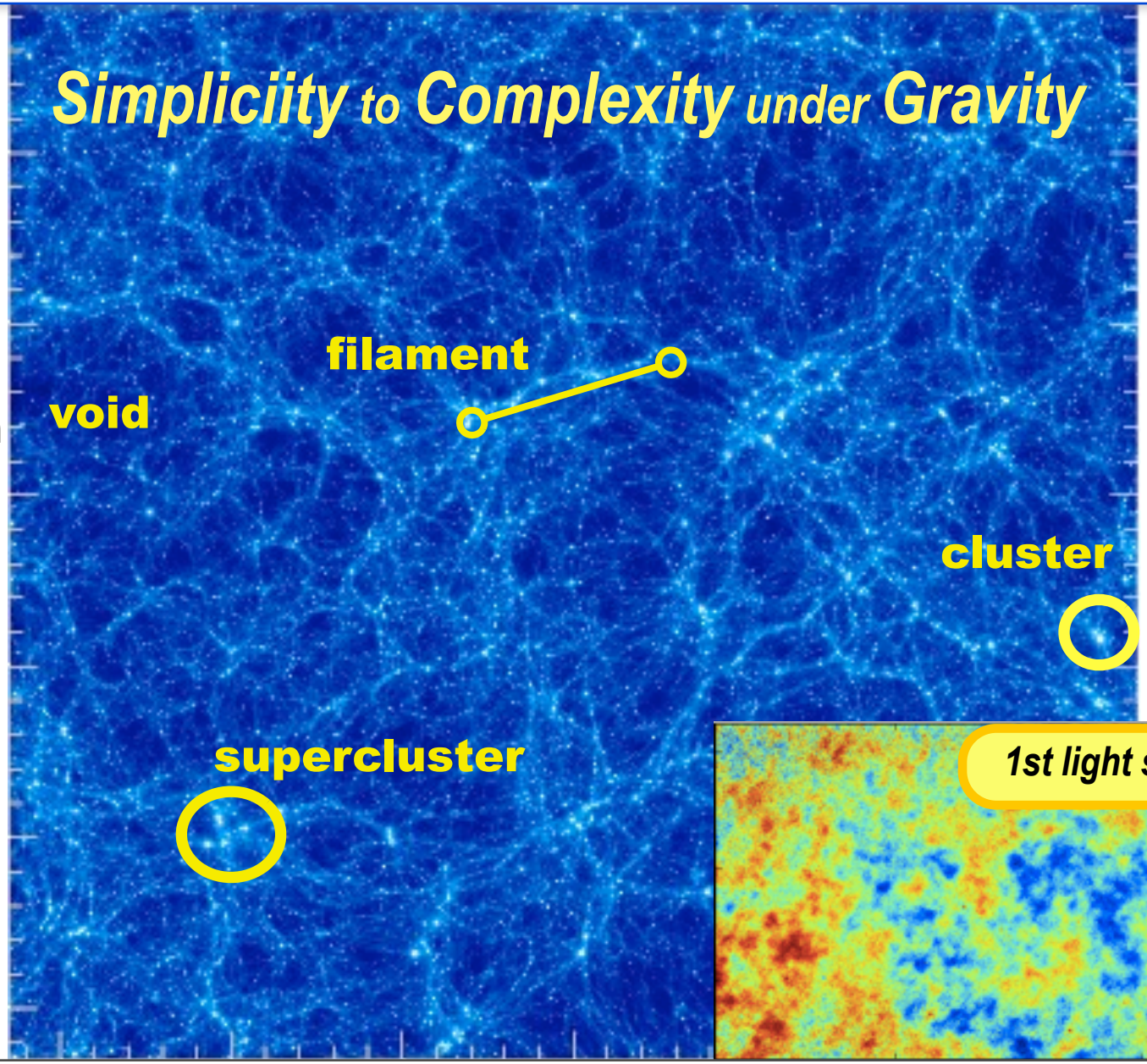

$a=e^{0}=1$ now

simulates gas from 1 to $a\sim e^{-0.1}\sim 1/1.1$

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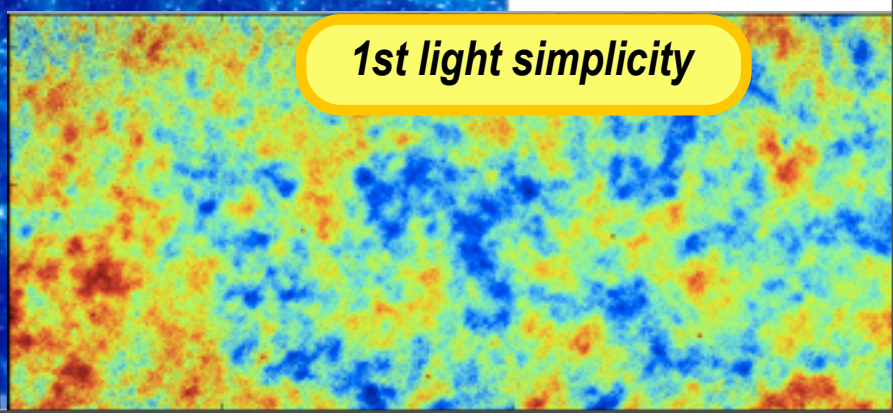

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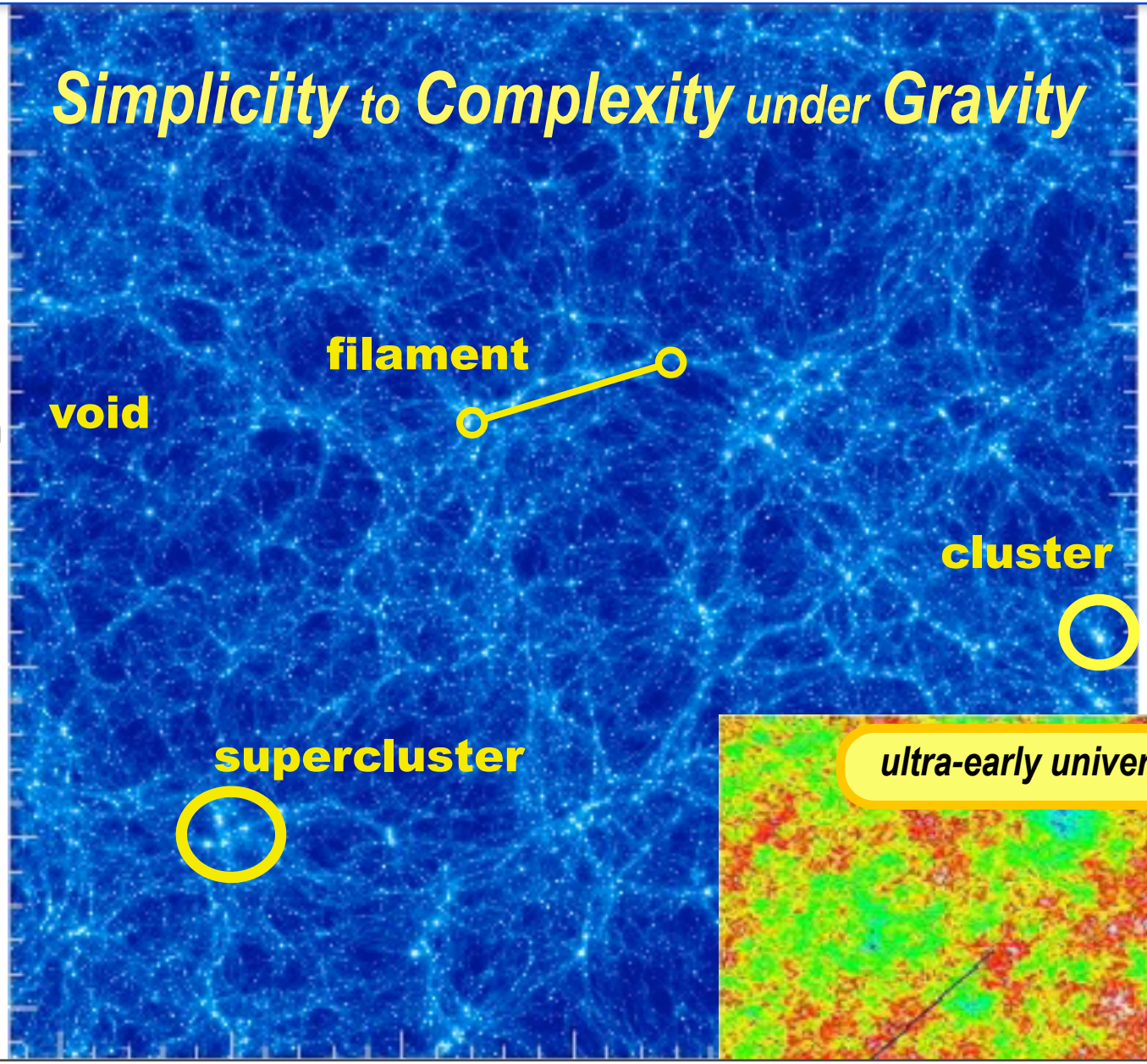

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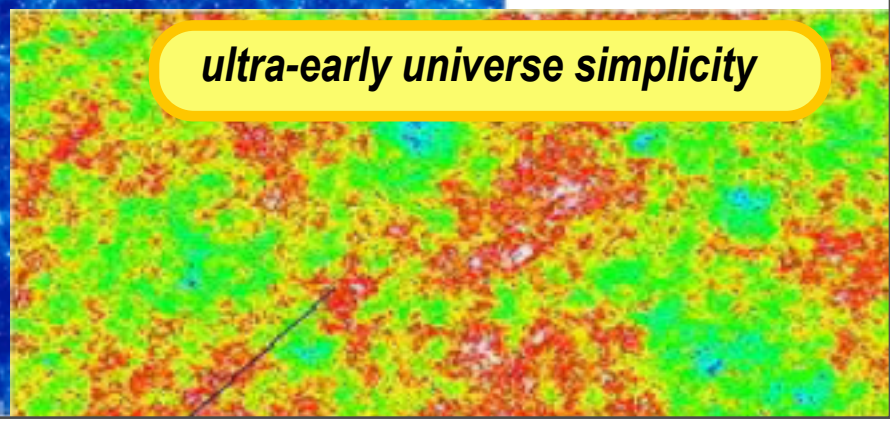
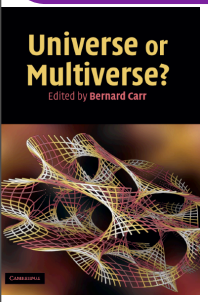
$a\sim e^{-67+60}$

$\sim 1/10^{30+25}$



UltraUltraUltraLargeScaleStructure beyond our Horizon via *early* dark energy+quantum+gravity

Horizons: the ultimate-speed constraint on light & information



UisIT

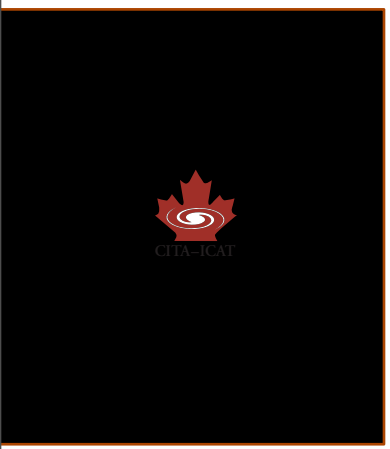
we simulate the unknown and the unknowable from the known, the power of MATHematical reasoning coupled with the ARTisanship of experimenting

O dark dark dark. They all go into the dark,
The vacant interstellar spaces, the vacant into the vacant
... So the darkness shall be the light
TS Eliot

we learn of IT from the ***bits*** we capture in our *little* **G**iga*ntic* BIT

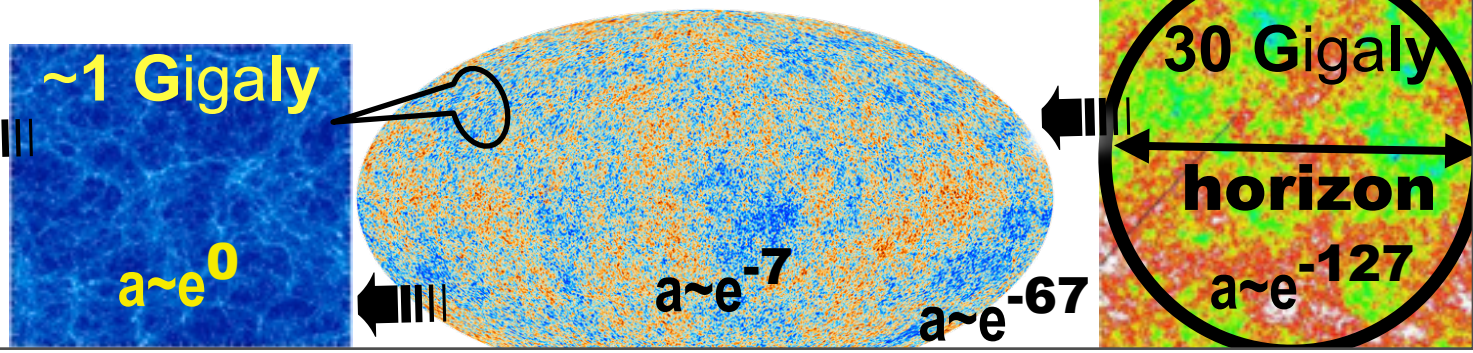
U is a very**very**very**very***BIG* IT

our little BIT is just a part of IT



END

a future DE-Void



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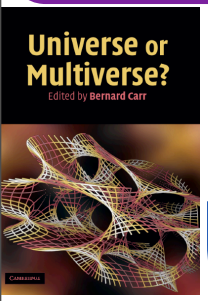

U=IT

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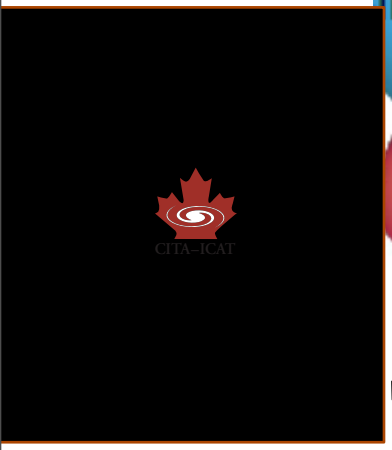

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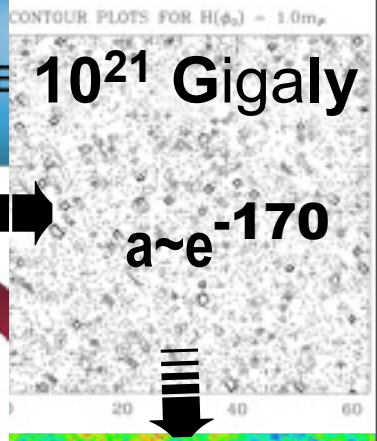

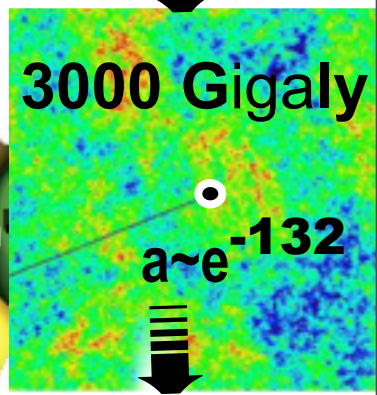

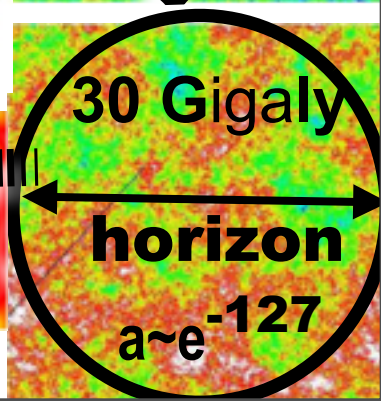

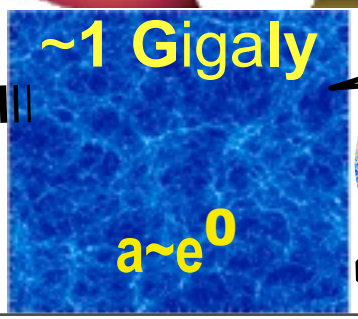

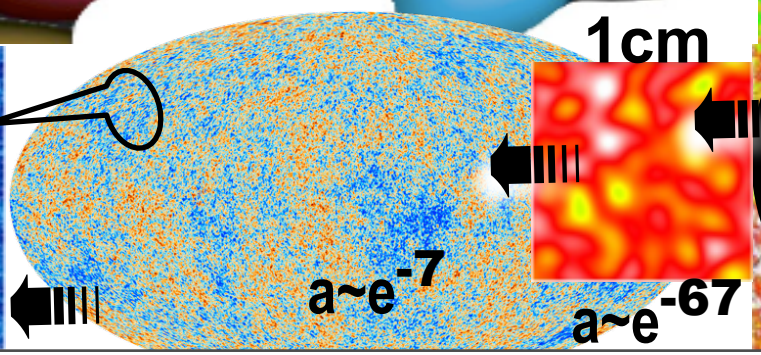

We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time

– T. S. Eliot

Let there be vacuum potential early Dark Energy to $e^{-170?}$

Let there be the cosmic web quantum jitter e^{-127} to e^{-67}

Let there be Heat: matter & radiation forms $a \sim e^{-67}$

Let there be Dark Matter, light nuclei $a \sim e^{-21}$ to e^{-35}

Let there be Light: 1st light released, 1st atoms $a \sim e^{-7}$

Let there be 1st stars $a \sim e^{-3}$

1st heavy nuclei (O, C, Fe,..)

galaxies form $e^{-1.2}$ to $e^{-2.2}$

Let there be earth $a \sim e^{-0.34}$

1st writing $a \sim e^{-0.0000004}$

Let there be here & now $a \sim e^{0}$

Let there be late Dark Energy to e^{+}

we think most of the Volume of the Universe has not Banged

Our little Big Bang

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will our BIT of U re-Bang? no ..maybe

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And the end of all our exploring
Will be to arrive where we started
And know the place for the first time

– T. S. Eliot

will our BIT of U re-Bang? no ..maybe