Norma G. SANCHEZ

Séance Daniel Chalonge Héctor de Vega

le 29 Novembre 2018

à la Maison de l'Argentine, CIUP, Paris 14e

Les Multivers, le dernier héritage de Stephen Hawking…

[Les développements scientifiques incorporent des nouveaux concepts et langage, ou attribuent des nouveaux contenus à des mots existants. Ce qui est perçu à un moment donné comme "difficile" ou non habituel, devient par la suite "standard" et incorporé à la pensée "habituel" par l'usage de ces mots dans les communications courantes....]

Avec le dernier article de Hawking paru en mai 2018 je mets en perspective et fais une intégration scientifique de divers domaines de recherche dans lesquels j'ai activement travaillé avec les théories physiques classiques et quantiques, la théorie des cordes, l'inflation, la fractalité de (et dans) l' Univers et des multivers que j' incorpore dans une nouvelle approche dans mes travaux en cours....

Le dernier travail de Stephen HAWKING

ou une mise en perspective scientifique à travers plusieurs mois de mai (de mai 1979 au mai 2018)

1. L'inflation . 2 L'inflation « éternelle »: l'évolution du concept et son contexte : 3. Les Multivers et leur contexte : 4: Fractalité, self-similarité, universalité, univers, multivers.

1. **Inflation: Gravitation semiclassique, non speculative.**
2. **Inflation « éternelle »?: Non, l'Inflation est Non éternelle.**
3. **Multivers: « Naturel » dans Cosmologie Quantique**

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A smooth exit from eternal inflation?

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Abstract: The usual theory of inflation breaks down in eternal inflation. We derive a dual description of eternal inflation in terms of a deformed Euclidean CFT located at the threshold of eternal inflation. The partition function gives the amplitude of different geometries of the threshold surface in the no-boundary state. Its local and global behavior in dual toy models shows that the amplitude is low for surfaces which are not nearly conformal to the round three-sphere and essentially zero for surfaces with negative curvature. Based on this we conjecture that the exit from eternal inflation does not produce an infinite fractal-like multiverse, but is finite and reasonably smooth.

Keywords: AdS-CFT Correspondence, Gauge-gravity correspondence, Models of Quantum Gravity, Spacetime Singularities

ArXiv ePrint: 1707.07702

JHEP04(2018)147

Quantum Multiverses, arXiv:1801.08631

James B. Hartle (Univ California Santa Barbara), Jan 2018

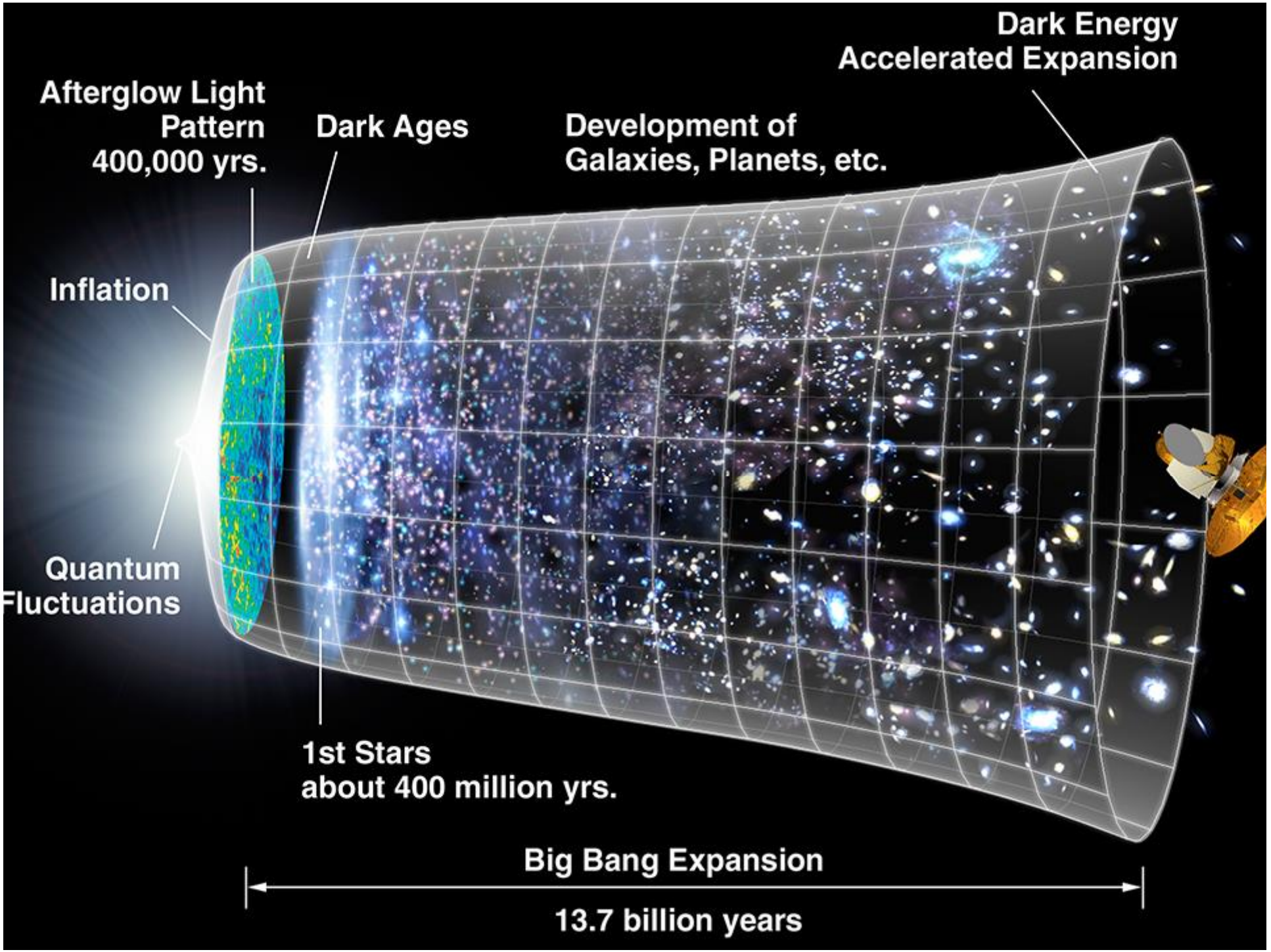
A quantum theory of the universe consists of a theory of its quantum dynamics and a theory of its quantum state
The theory predicts quantum multiverses

Quantum multiverses are not a choice or an assumption but are consequences of the theory

Quantum multiverses are generic for simple theories

We argue that the quantum multiverses of the universe are scientific, real, testable, falsifiable, and similar to those in other areas of science even if they are not directly observable on arbitrarily large scales.

Are quantum multiverses scientific? . Yes, in the author's opinion: As sketched above, in many areas of science one finds multiverses of the kind of an ensemble of possible situations only one of which is observed by us


Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
400,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Big Bang Expansion
13.7 billion years

From WMAP9 to Planck

Understanding the direction in which data are pointing:

- **Standard Model of the Universe**
- **Standard Single field Inflation**
- **NO RUNNING of the Primordial Spectral Index**
- **NO Primordial NON GAUSSIANITY**

Effective Theory of Inflation (ETI) confirmed by Planck

Quantity	ETI Prediction	Planck 2013
Spectral index $1 - n_s$	order $1/N = 0.02$	0.04
Running $dn_s/dlnk$	order $1/N^2 = 0.0004$	< 0.01
Non-Gaussianity f_{NL}	order $1/N = 0.02$	< 6
	ETI + WMAP+LSS	
tensor/scalar ratio r	r > 0.02	< 0.11 see BICEP
inflaton potential curvature $V''(0)$	$V''(0) < 0$	$V''(0) < 0$

ETI + WMAP+LSS means the MCMC analysis combining the ETI with WMAP and LSS data. Such analysis calls for an inflaton potential with negative curvature at horizon exit.The double well potential is favoured (new inflation).
D. Boyanovsky, C. Destri, H. J. de Vega, N. G. Sanchez, arXiv:0901.0549, IJMPA 24, 3669-3864 (2009).

Two key observable numbers :

associated to the primordial density and primordial gravitons :

PREDICTIONS

$$n_s = 0.9608 \,, \quad r \sim 0.04$$

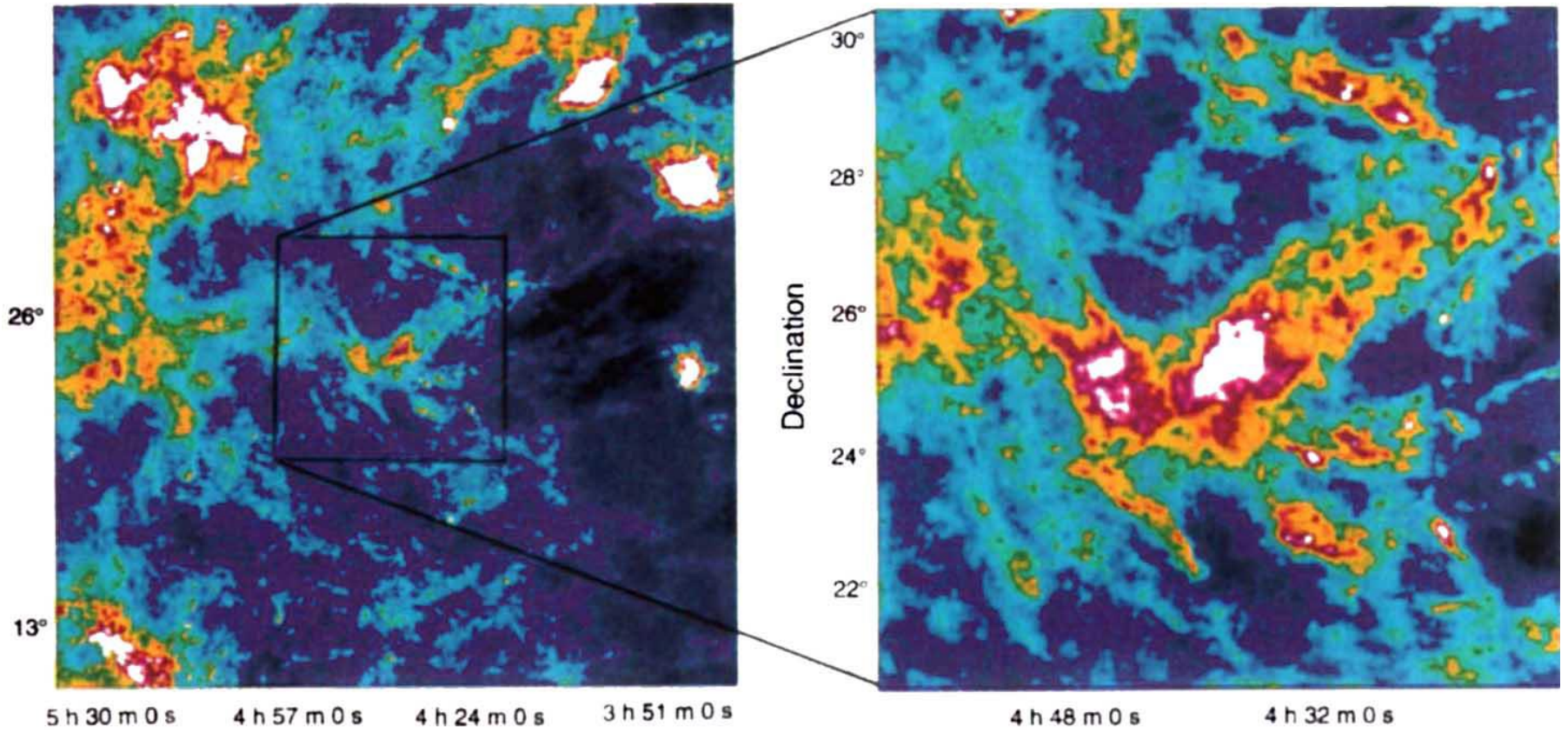
$$r > 0.021 \,, \; r < 0.07$$

DdS: Destri, de Vega, Sanchez & from WMAP data (PRD 2008)

PlanckBICEP2Keck 2015: $r < 0.08$

LETTERS TO NATURE

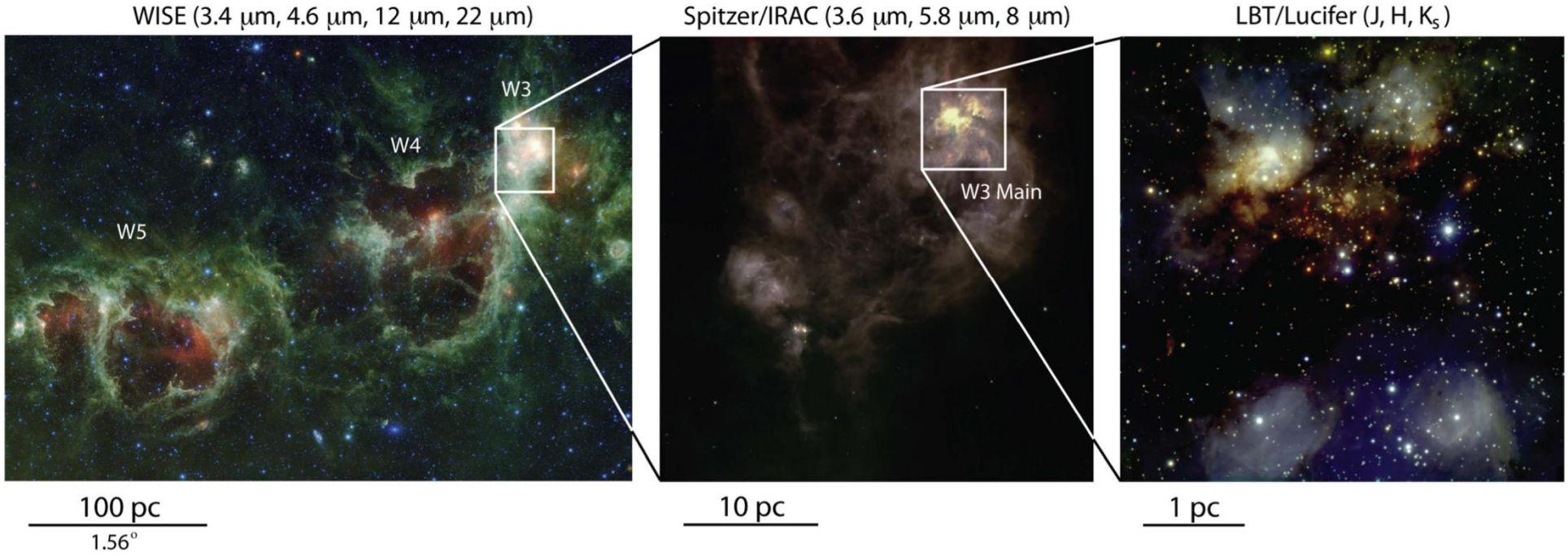
de Vega, Sanchez et al (1995)



This self-similar structure is confirmed by compilations of many different observations at widely different scales revealing the fractal structure of the ISM

HIERARCHICAL STRUCTURE OF ISM & STAR FORMATION

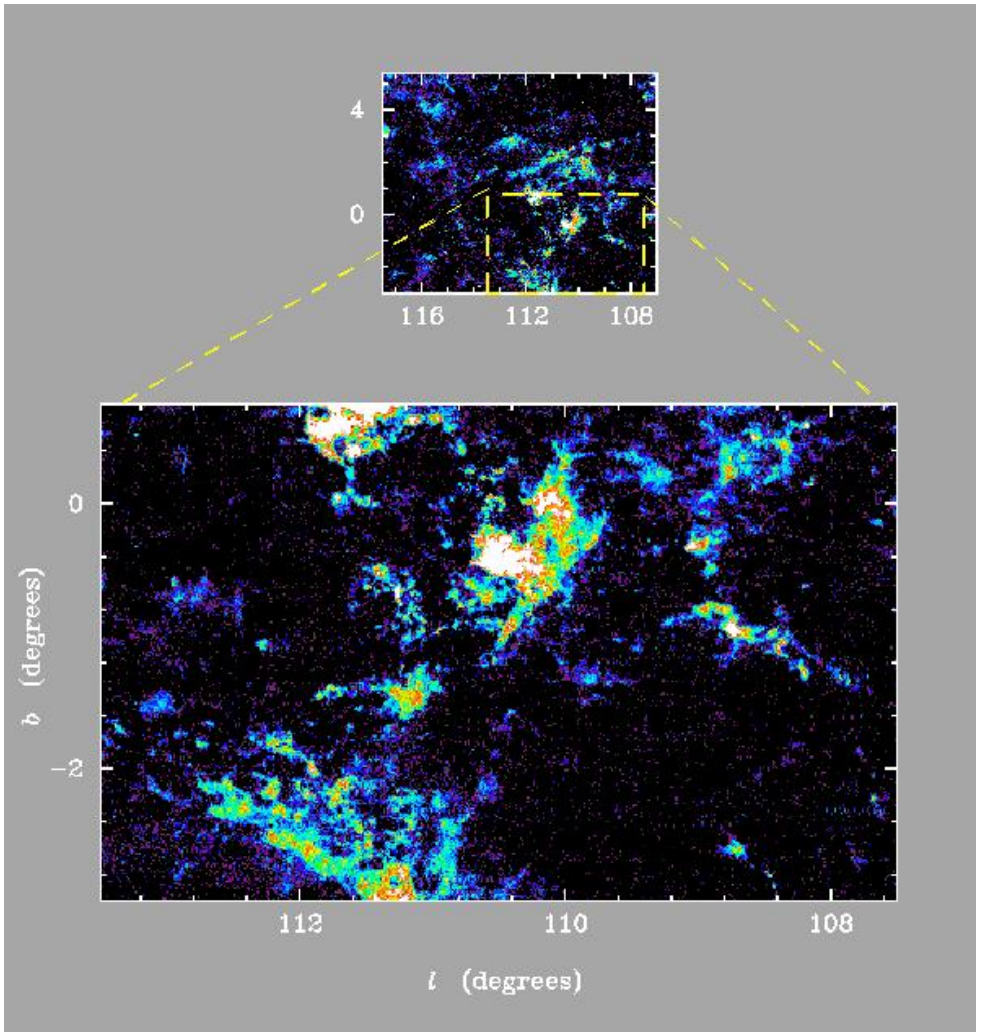
Publications of the Astronomical Society of the Pacific, July 2018, Gouliermis

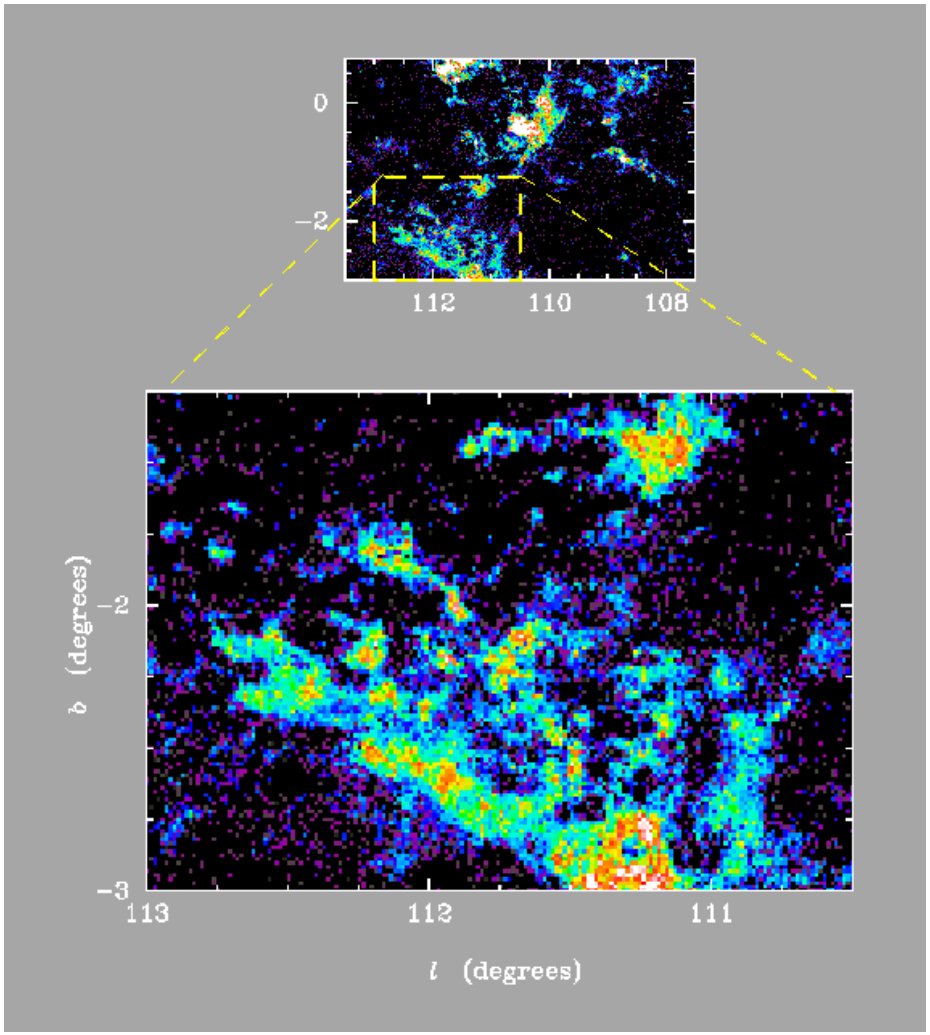


Hierarchy in the general area of the Galactic W3/W4/W5 cloud complex.
Left: the gaseous structures W4 and W5 (the heart and soul nebulae) in the NASA/WISE infrared image, covering at 100 pc scale the general region of the OB association Cas OB6.
Middle: the giant star-forming region W3, which is part of the W4 complex, at 10 pc scale in the NASA/Spitzer image. The star-burst of W3 Main, is the most active part of W3.
Right: the star-forming cluster of W3 Main is resolved in near-IR images from LBT/Luci at 1 pc scale.

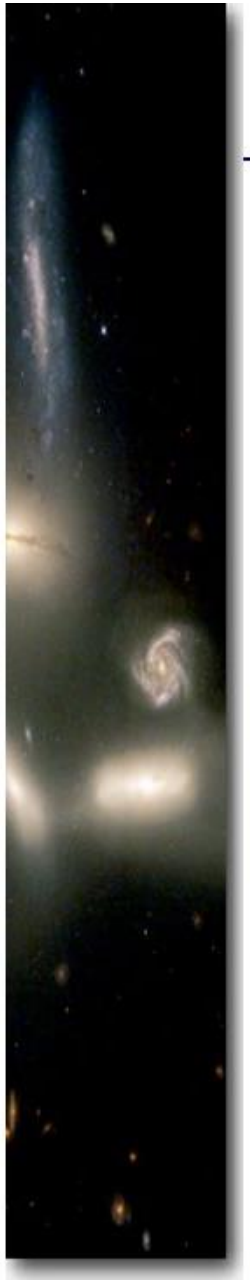
WISE image: NASA/JPL-Caltech/WISE Team. Spitzer

THE FRACTAL STRUCTURE OF THE ISM

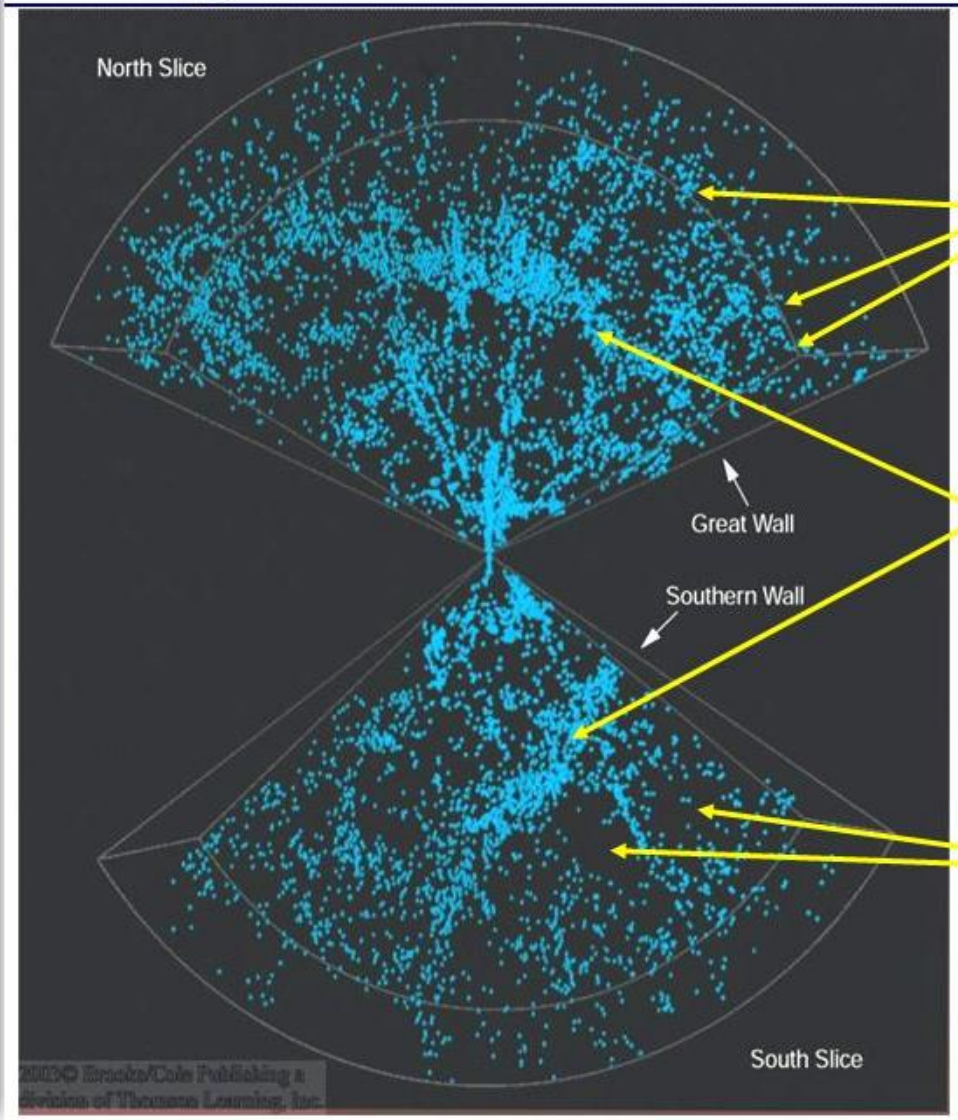




FRACTAL STRUCTURE IN LSS



Large Scale Structure



Superclusters = clusters of clusters of galaxies

Superclusters appear aligned along walls and filaments.

Vast regions of space are completely empty:

"voids"

The Cosmic Web

Large Scale Structure:

Like Soap Bubbles

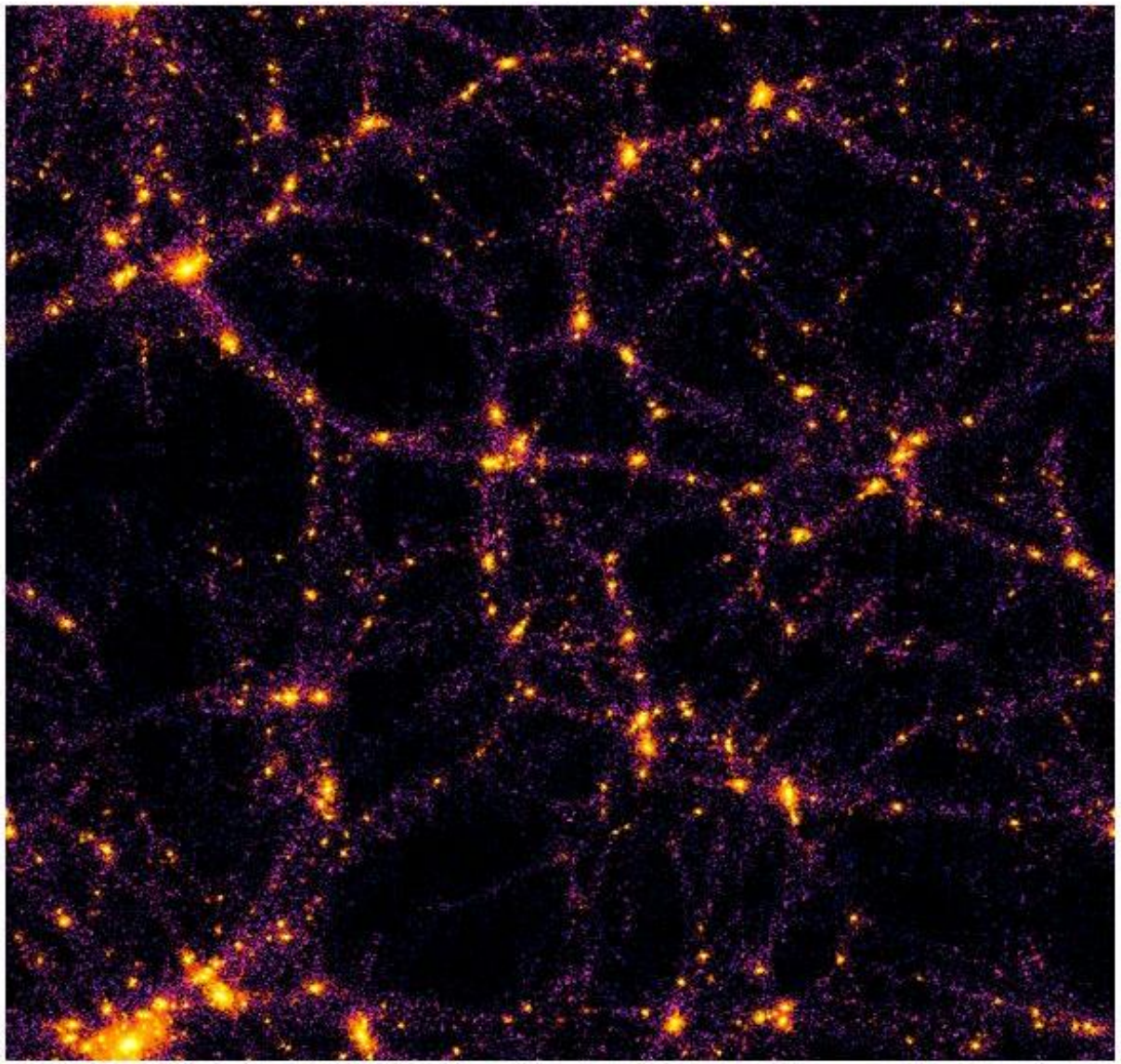
Empty **Voids**

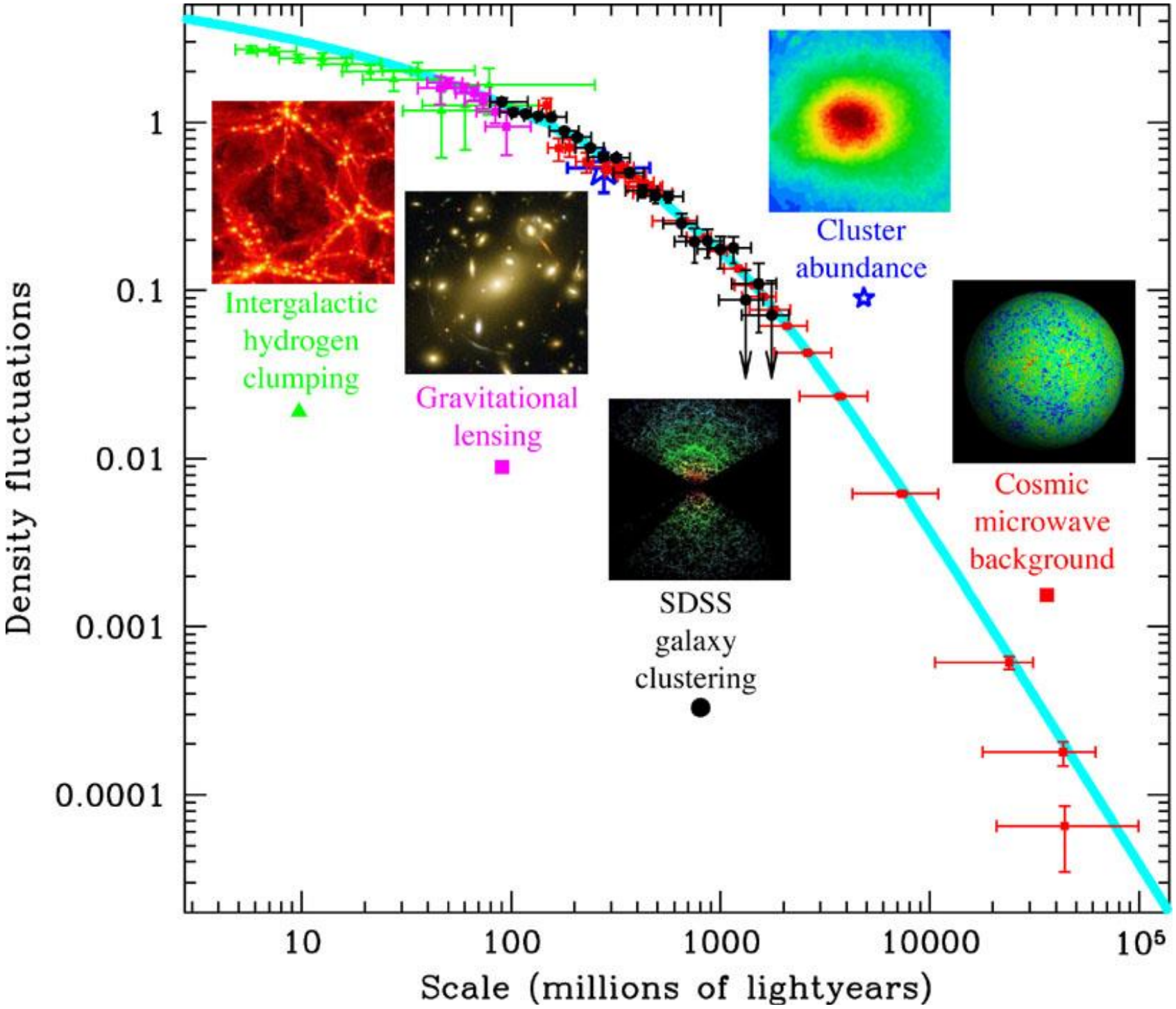
~50Mpc.

Galaxies are in
1. **Walls** between voids.

2. **Filaments** where walls intersect.

3. **Clusters** where filaments intersect.




Density fluctuations
1
0.1
0.01
0.001
0.0001
10
100
1000
10000
10⁵
Scale (millions of lightyears)
Intergalactic hydrogen clumping
Gravitational lensing
SDSS galaxy clustering
Cluster abundance
Cosmic microwave background

For a fractal medium, the mass depends on the size as

$$M(r) \propto r^{D}$$

D being the fractal (Haussdorf) dimension.

The conditional density behaves as

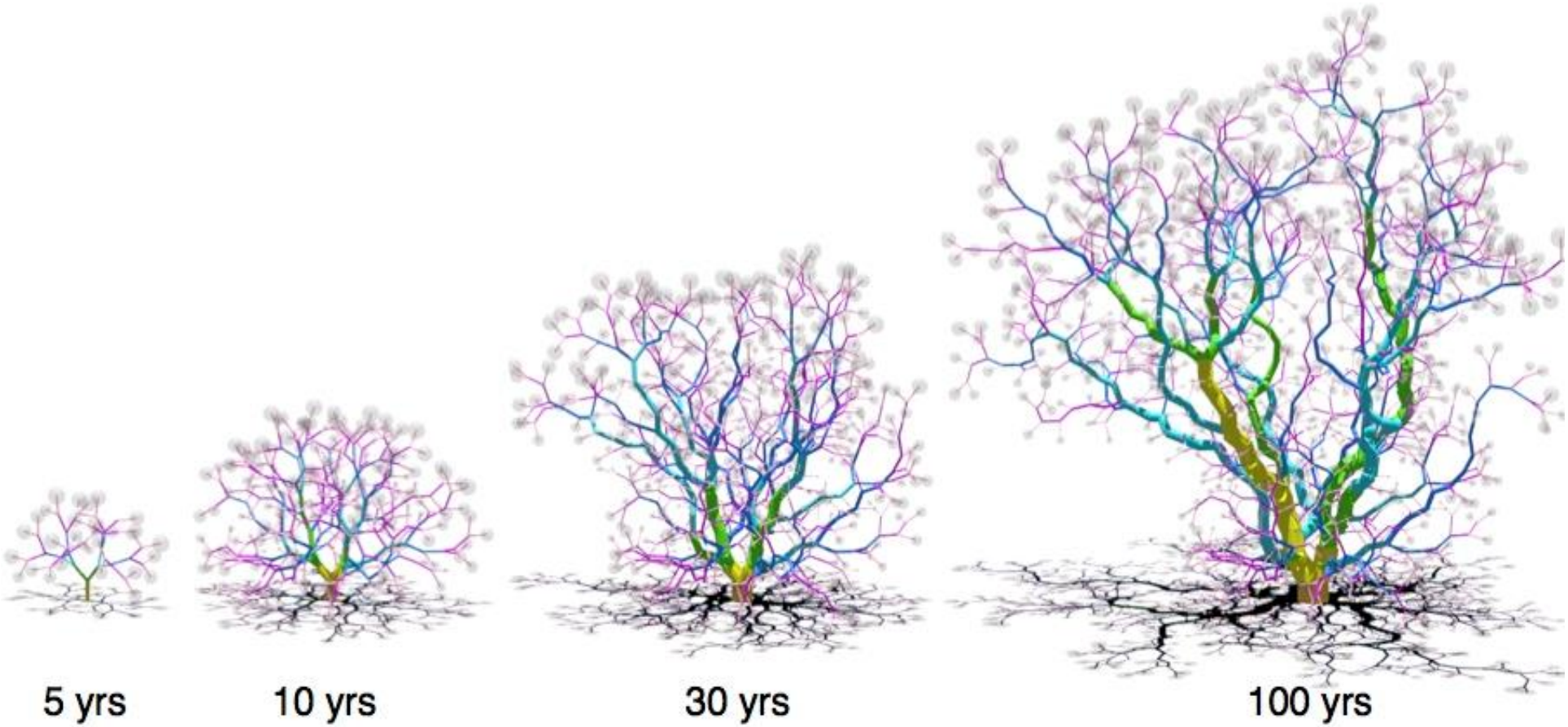
$$\Gamma(r) \propto r^{D-3}$$

This is exactly the statistical analysis used for the interstellar clouds, without adopting from the start any large-scale homogeneity assumption.

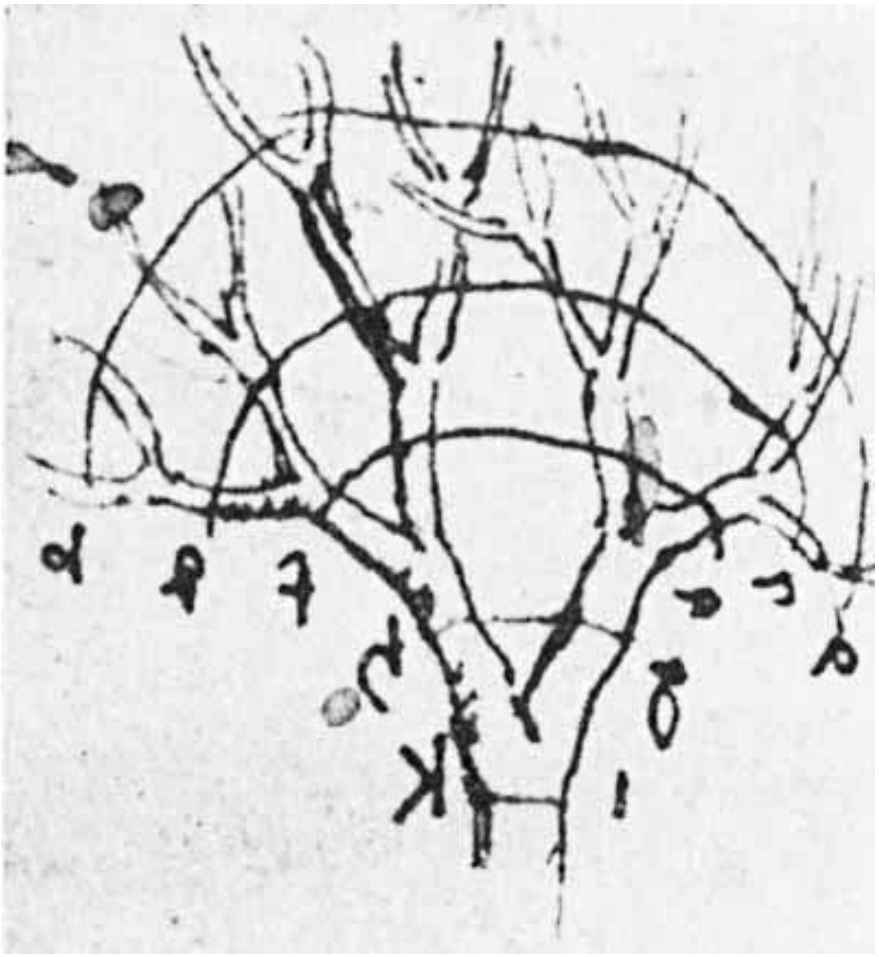
$$M = C R^{D}$$

C : constant , and D = 1.9 – 2.2

THE FRACTAL STRUCTURE OF TREES



THE LEONARDO DA VINCI FRACTAL TREE



Dessin extrait d'un des carnets de Léonard de Vinci illustrant sa découverte de la loi mathématique gouvernant les diamètres des branches d'un arbre.

If we find $\Omega \geq 1$, will it disprove inflation?

No!

At the present moment we have several models explaining homogeneity of closed and open universes, and all these models are based on inflation.

If we find $\Omega = 1$, will it prove inflation?

I Believe so, since ~99% of all inflationary models predict $\Omega = 1 \pm 10^{-4}$, and no other theories make this prediction

What is the meaning of stationarity of the universe?

We know that our universe is about 10^{10} years old!

Do we?

A typical distance from the root to the apple is 10^{10} years. However, most apples grow infinitely high...