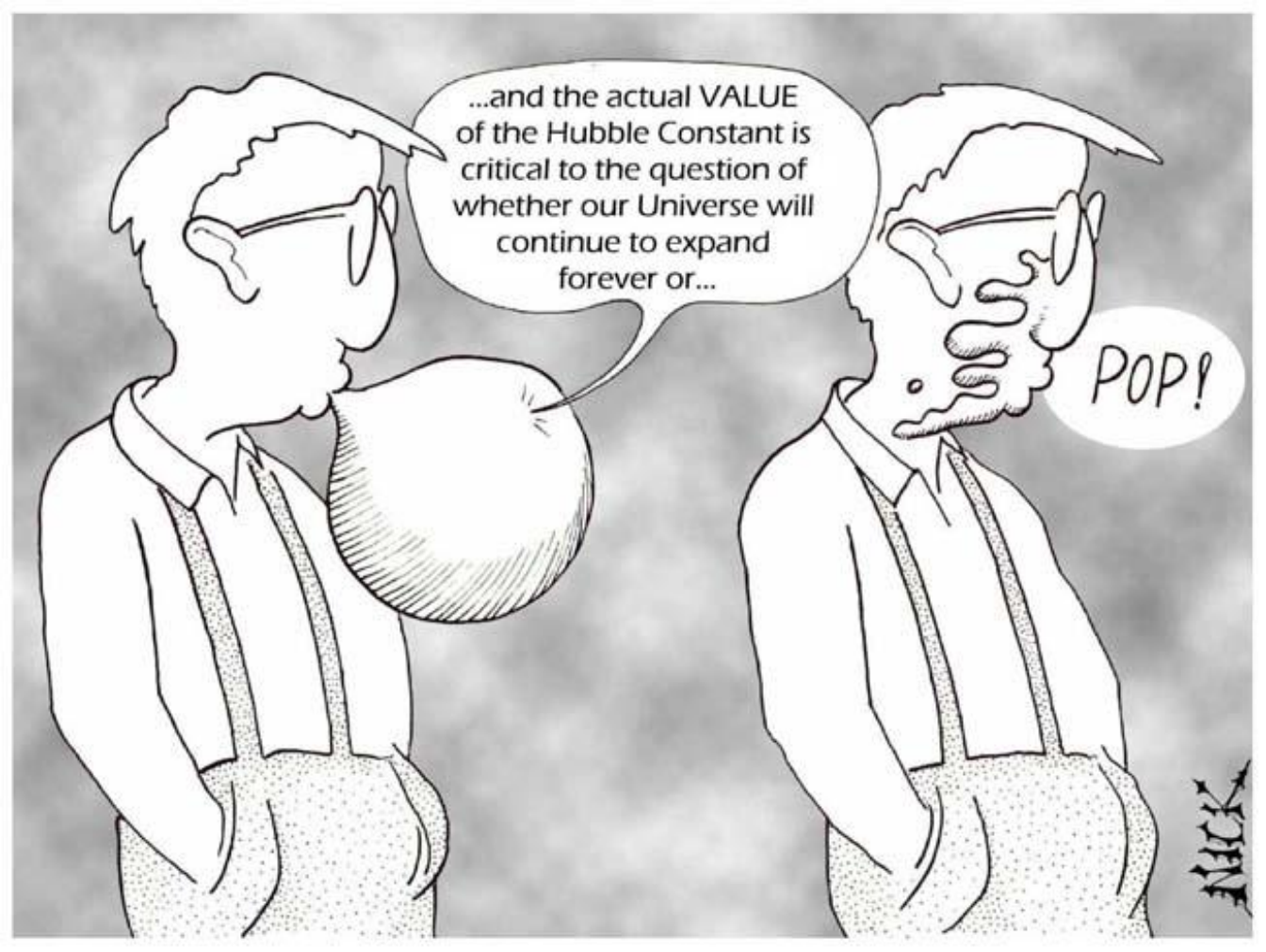
The History and the Fate of the Universe



Overview

A. The Expanding Universe
   1. Einstein's Theory of Gravity.
   2. Einstein's Repulsive force.
   3. Hubble's observation.
   4. Implications of Hubble's observation.

Overview

B. The History of the Universe-
Big Bang to Present Day.

1. Before 10^{-43} seconds.
2. Why does the early Universe have no particles?
3. What is the Quark Soup
4. Why is the universe 25% helium?
5. Why were the Dark Ages “dark”?
6. What is the CMB?
7. What information do we get from it?

Overview

C. Dark Matter
   1. What is the evidence?
   2. What are three possible explanations?
   3. What's the most plausible (currently)

D. The History of the Universe
   Present Day to The End
   1. What is "shape" of the current universe?
   2. What are the possible "fates" of the universe?
   3. What determines the Fate of the Universe?

Einstein's Big Idea

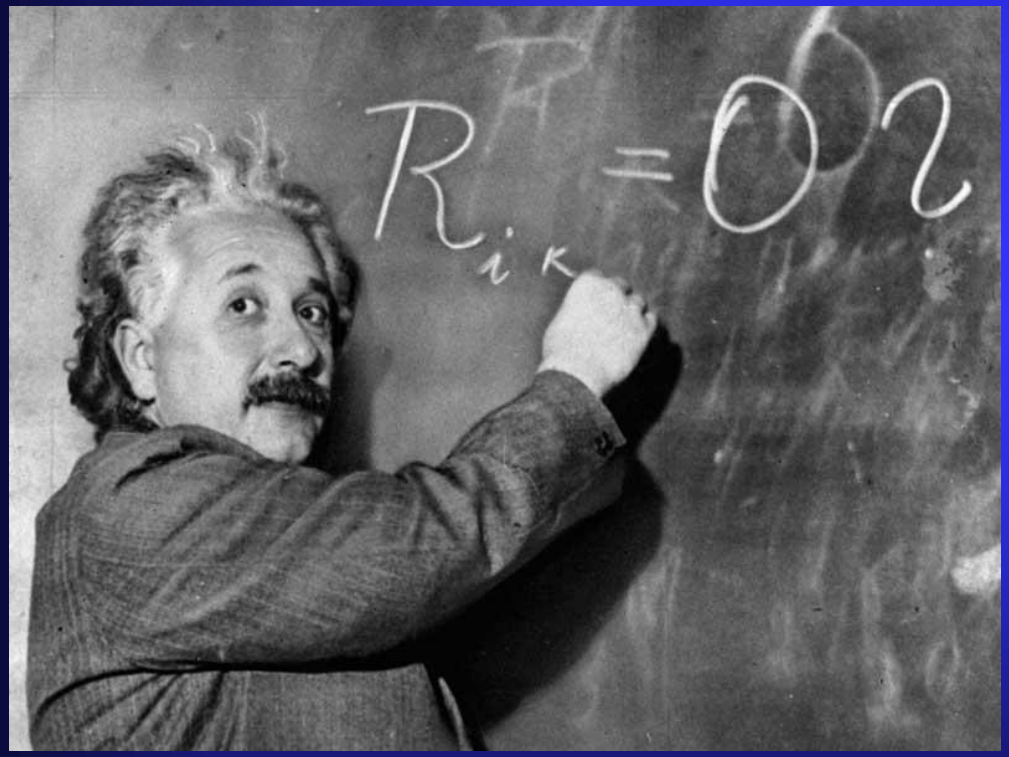
Bendy Stretchy Space

Objects in space always follow “straight” lines.

But the Space is Curved

The Repulsive Force

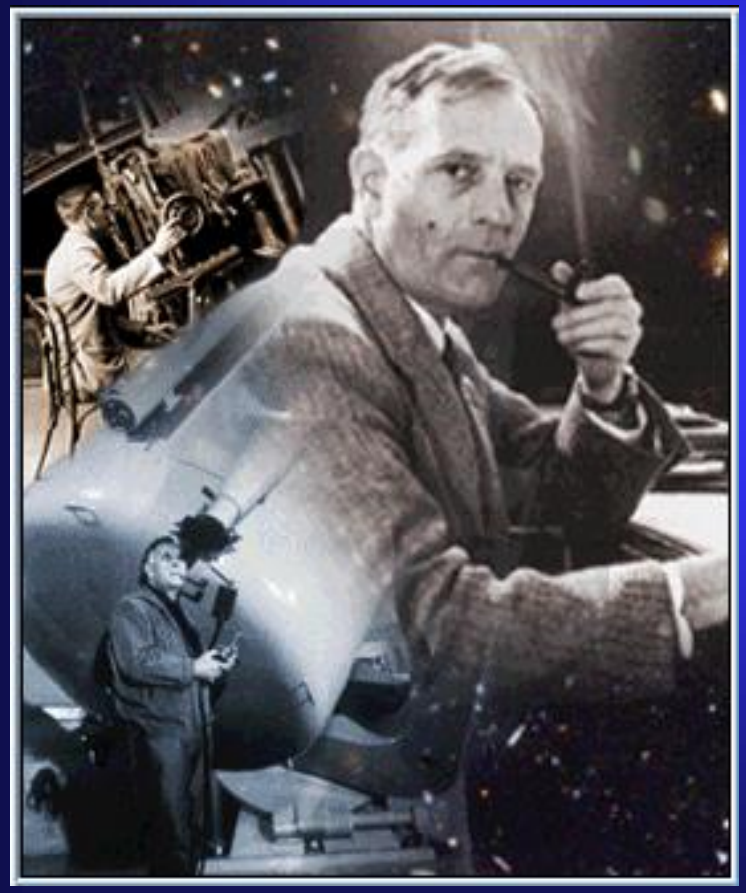
The Universe is static, you see.

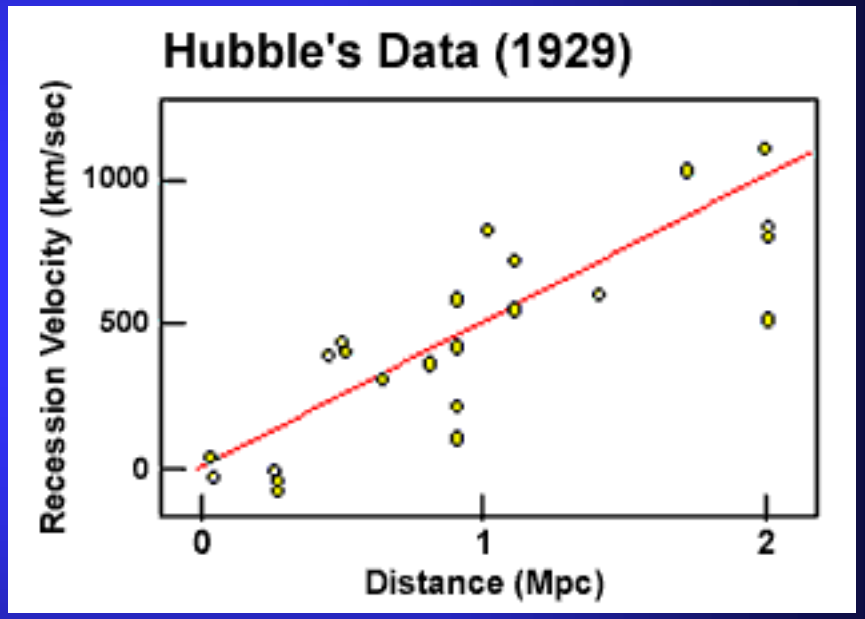


A repulsive force is introduced to halt gravitational collapse

Galactic Red Shift

Everything is moving away!

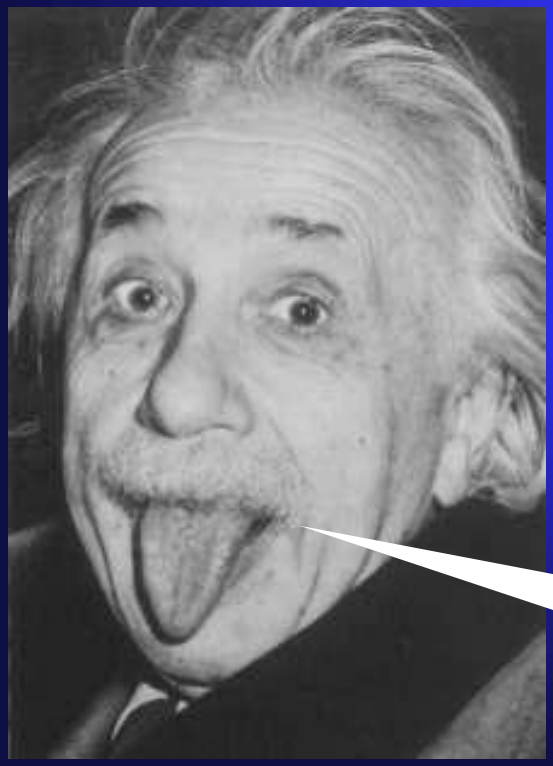


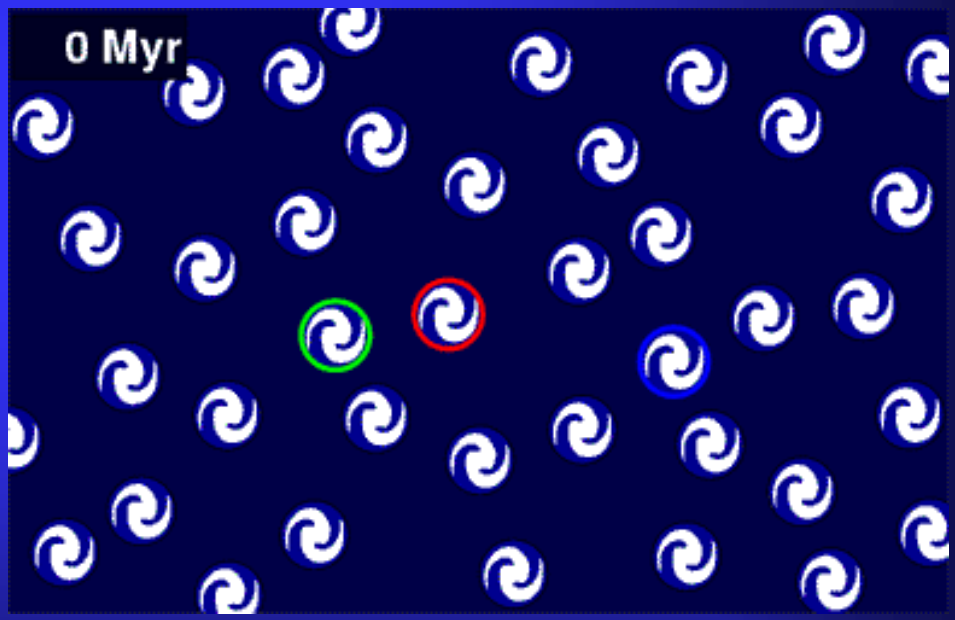


$$V = H_o D$$

The Universe is Expanding

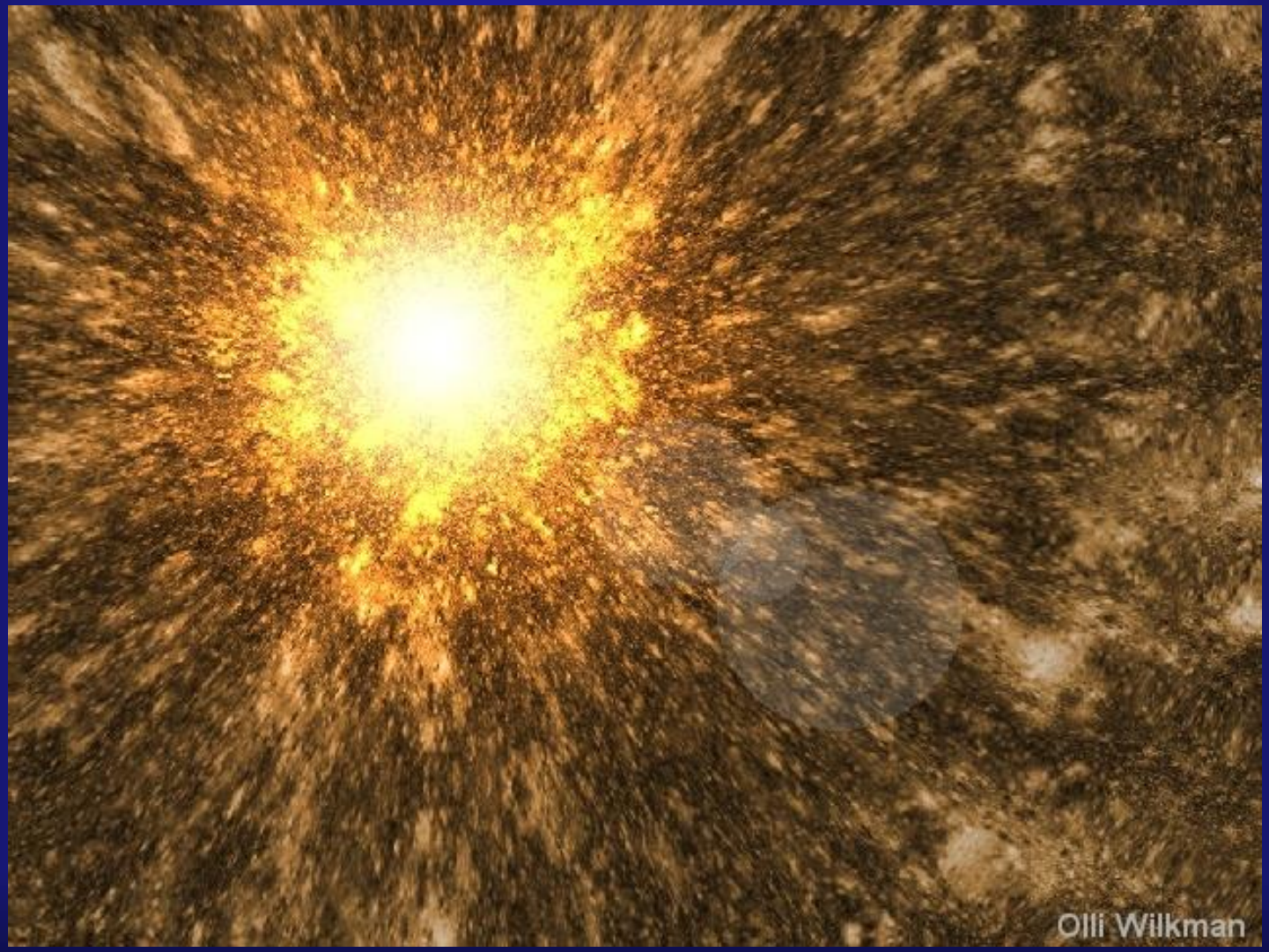
The space between galaxies must be increasing





Oops!

Happy Birthday!



A4

Bang!

The moment of creation

It makes no sense to ask what happened before the Big Bang
There is no before

It makes no sense to ask what is outside the Universe
There is no outside

Space and Time came into existence at the Big Bang

The Observable Universe

Discuss and explain your answer

Are the Galaxies in the observable universe the ONLY galaxies in the universe?

A4

The Observable Universe

Which is correct?
Discuss and explain.

Galaxy X will likley sees lots of Galaxies in one direction and very few in the other.

Galaxy X will likely see lots of Galaxies in every direction.

A4

The Age of the Universe

Everything is moving apart.

If we run the clock backwards… we everything is moving together.

So, if we know the expansion rate, we know the age of the universe!

A5

When we observe the observable edge of the Universe, we see:

A) How that spot really appears today
B) How that spot looked at the moment of the Big Bang
C) How that spot looked a long time ago, but not at the time of the Big Bang.
D) How that spot will appear at some future time.

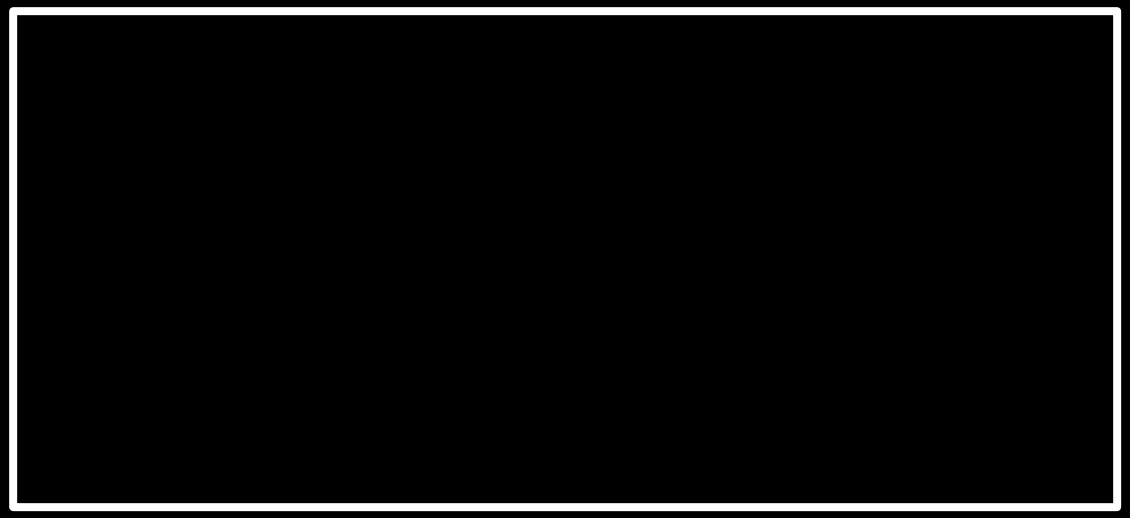
Scientists who live at the observable edge of the Universe observing their local environment would see:

A) How that spot really appears today
B) How that spot looked at the moment of the Big Bang
C) How that spot looked a long time ago, but not at the time of the Big Bang.
D) How that spot will appear at some future time.

Scientists who live at the observable edge of the Universe observing OUR spot in the universe would see:

A) How that spot really appears today
B) How that spot looked at the moment of the Big Bang
C) How that spot looked a long time ago, but not at the time of the Big Bang.
D) How that spot will appear at some future time.

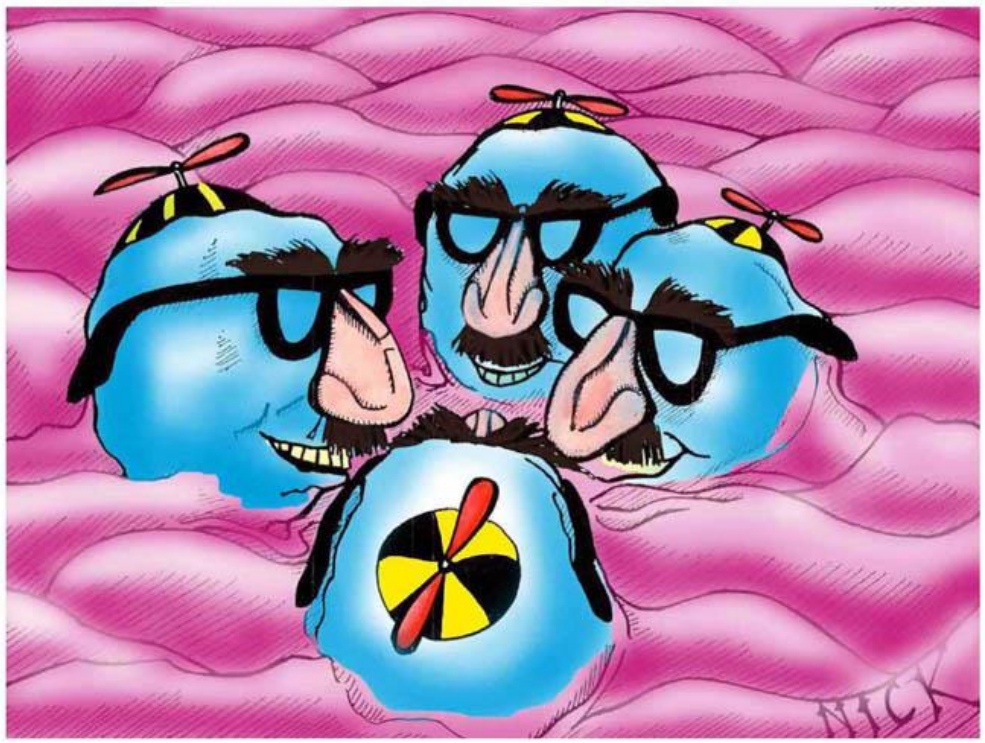
Everything that we know before 10^{-43} seconds.



B1

Quantum Fluctuations

The very early universe is ruled by quantum effects

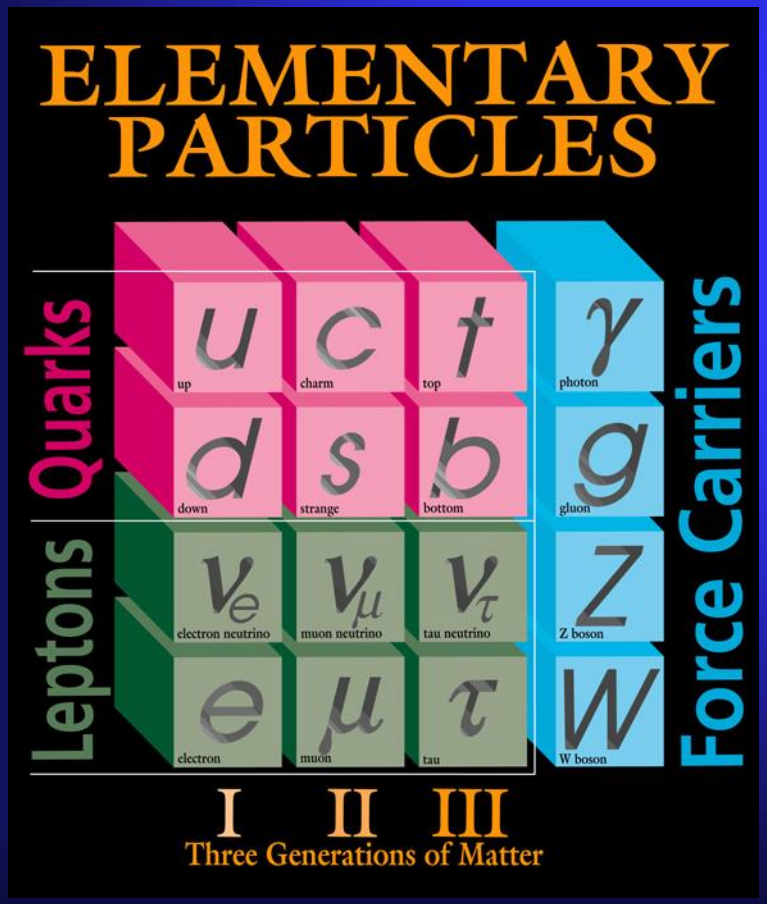


At a resolution of 10^{-24} metres, isolated clumps of Strange Matter pop briefly out of the quantum foam to debate the possible existence of Particle Physicists.

B2

Particles at Last

The energy density drops so that particles can form



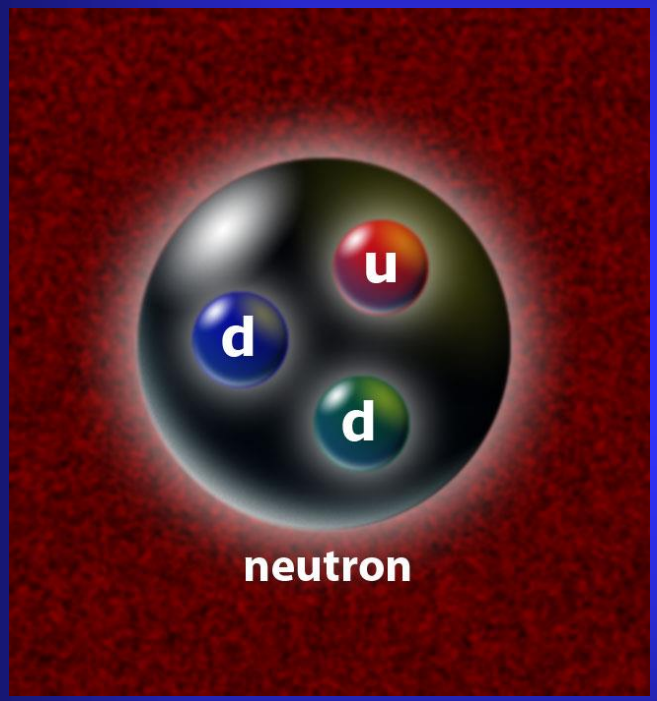
The era of particle physics begins at 10^{-10} seconds

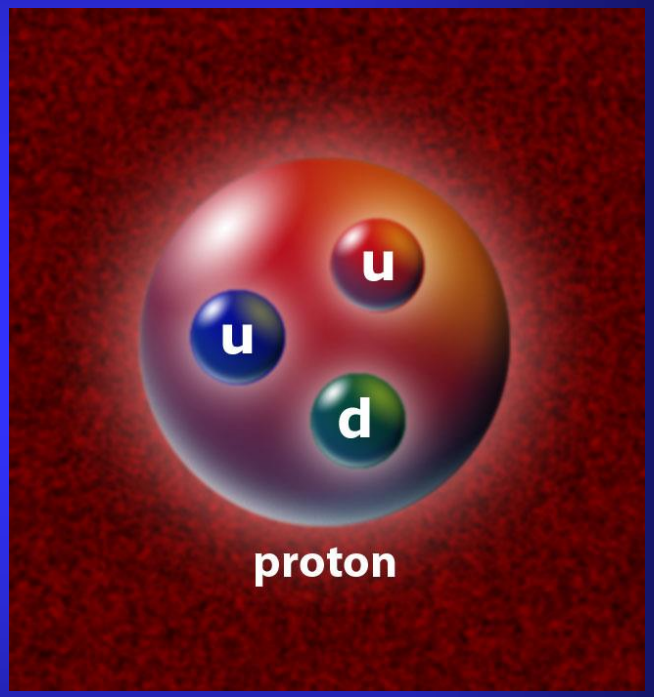
This is the **quark soup** era

B3

Nucleosynthesis

The Universe is about 1 second old





Quarks combine to form protons and neutrons

B4

Nucleosynthesis

How would the ratio of Hydrogen to Helium change if the expansion rate were faster?

How would the ratio of Hydrogen to Helium change if the expansion rate were slower?

Distance

After Nucleosynthesis, the Universe was "dark" because

A) Fusion stopped so no light was being produced
B) The universe was too dense to produce light
C) There was plenty of light, it just couldn't get very far

B5

The Dark Ages

The Universe is opaque for a long time.

Densities are too high for photons to go very far

B5

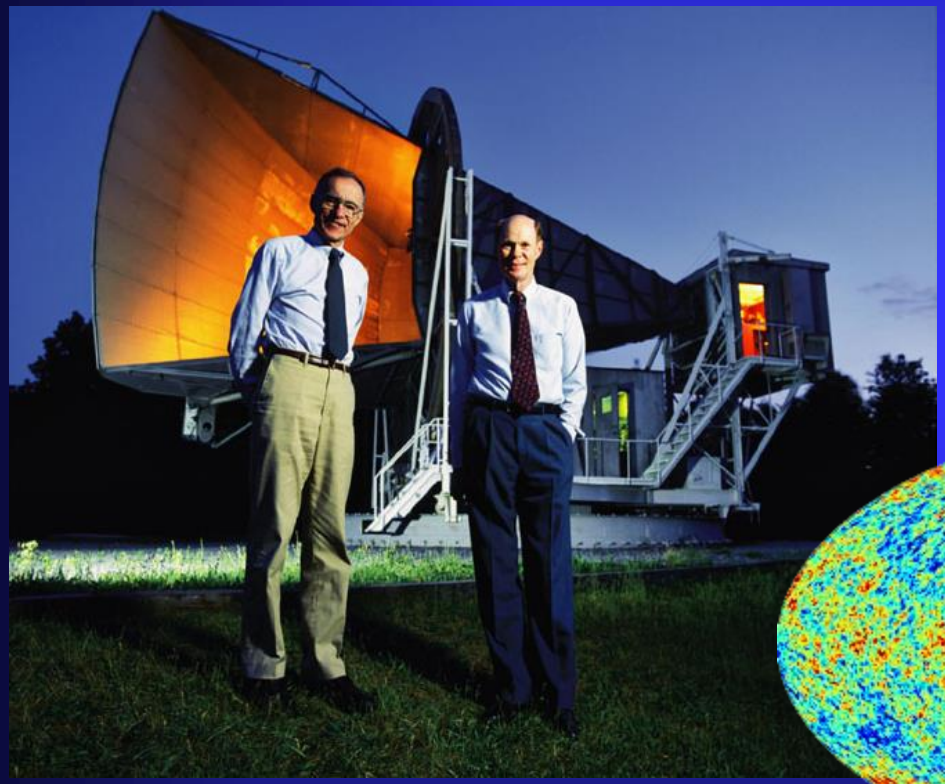
The Fog Lifts

After 380,000 years, the photons are free

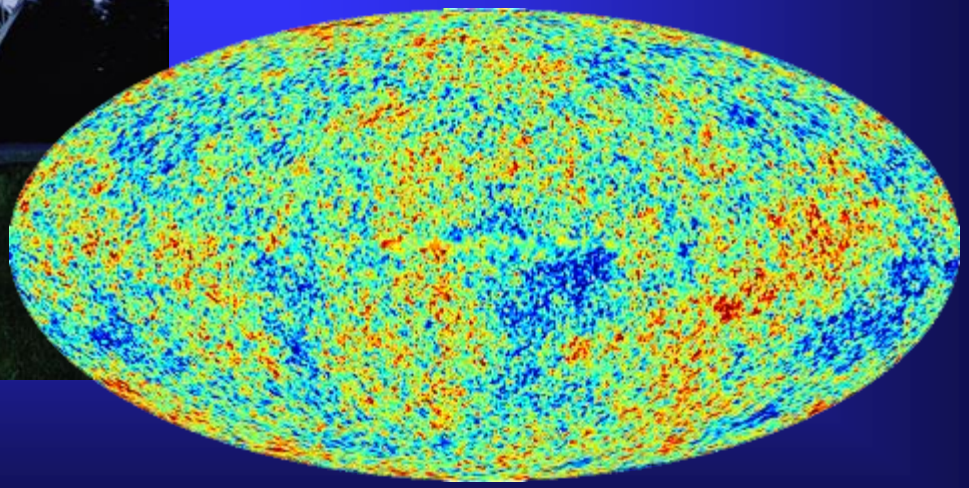
B6

Evidence

Where are the first free photons?

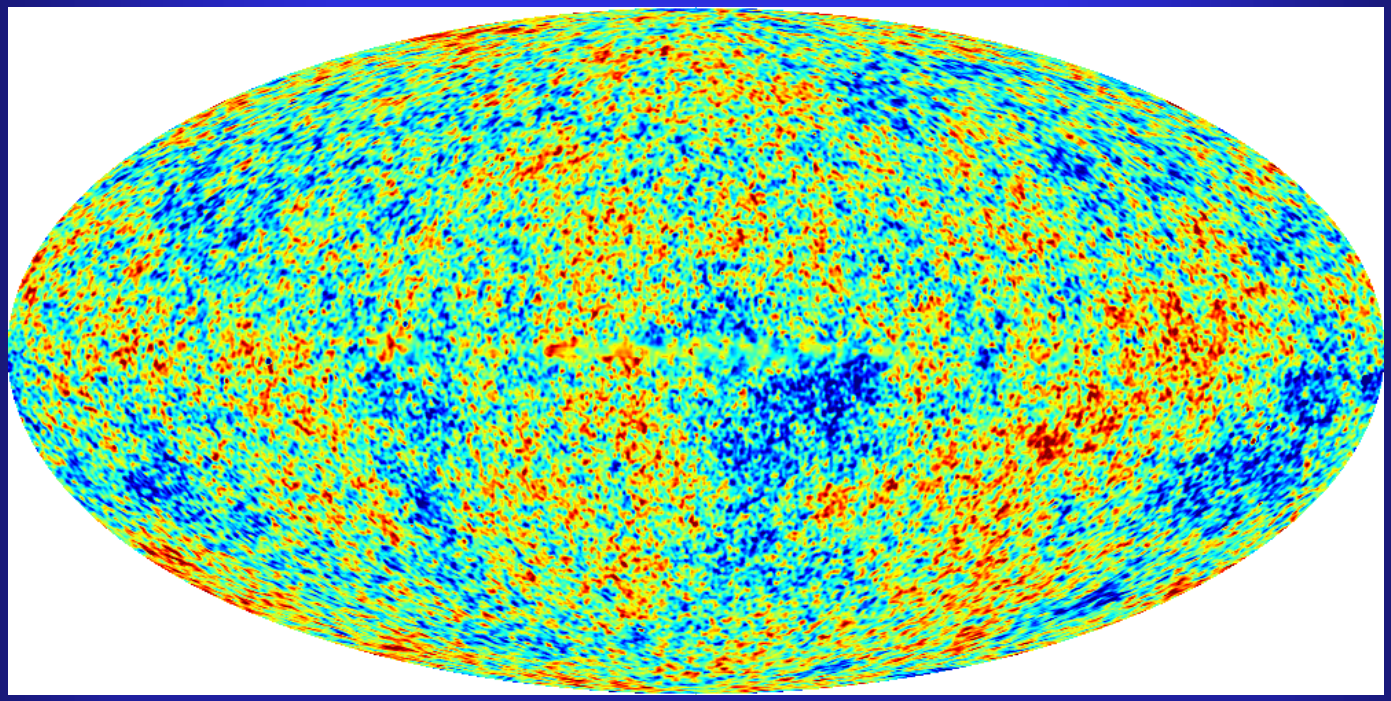


Cosmic
Microwave
Background



The Seeds of Structure

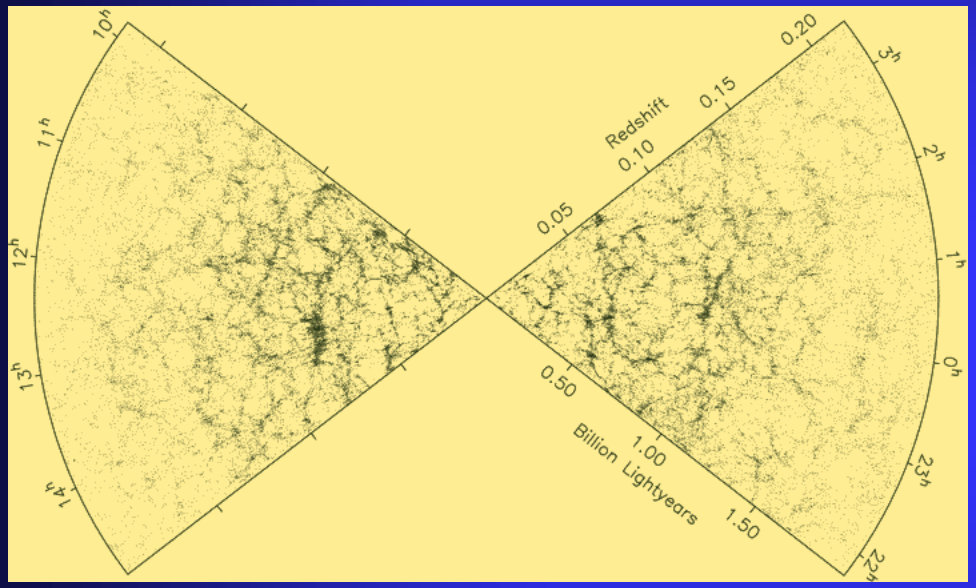
A period of rapid inflation magnified the early quantum fluctuations

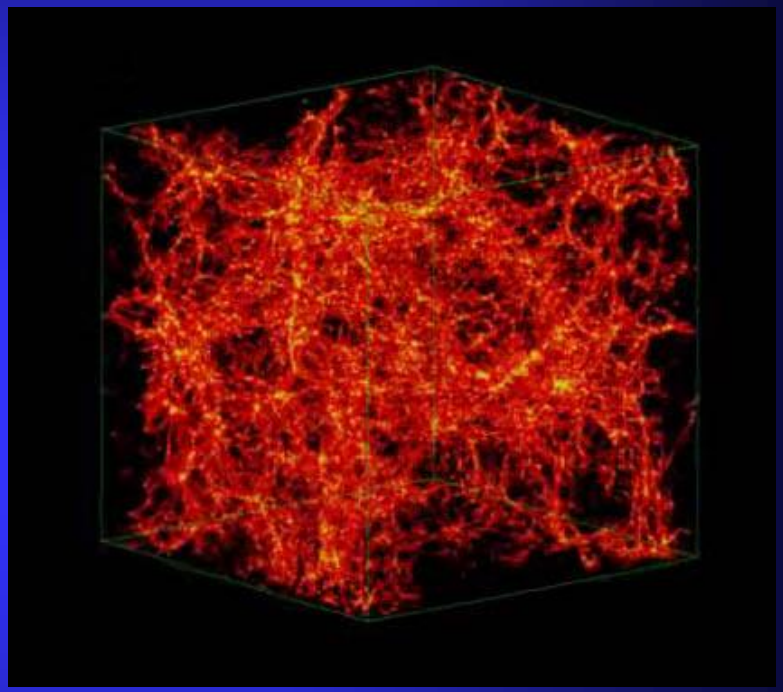


On large scales, the Universe is quite uniform

B7

How to Build a Universe





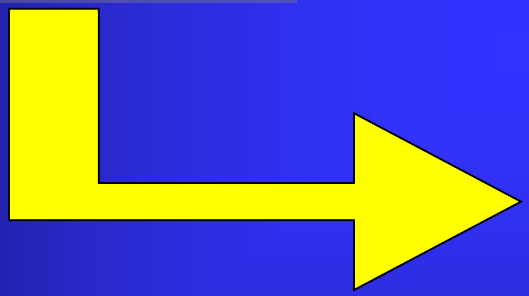
The original over densities eventually grew into galaxies

B7

Dark Matter

Kepler

$$p^2 = a^3$$



Newton

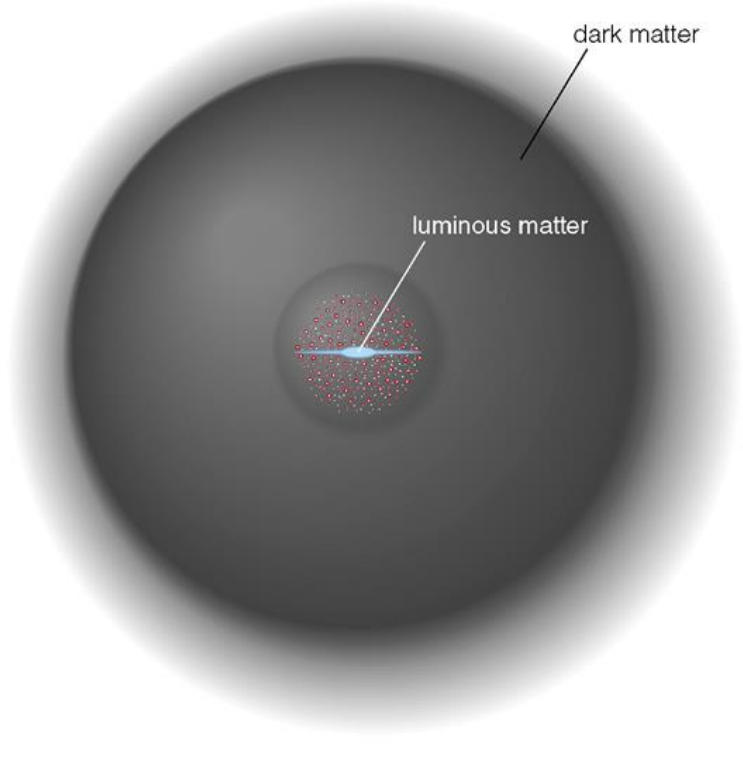
$$p^2 = \frac{4\pi^2}{G(M_1 + M_2)} a^3$$

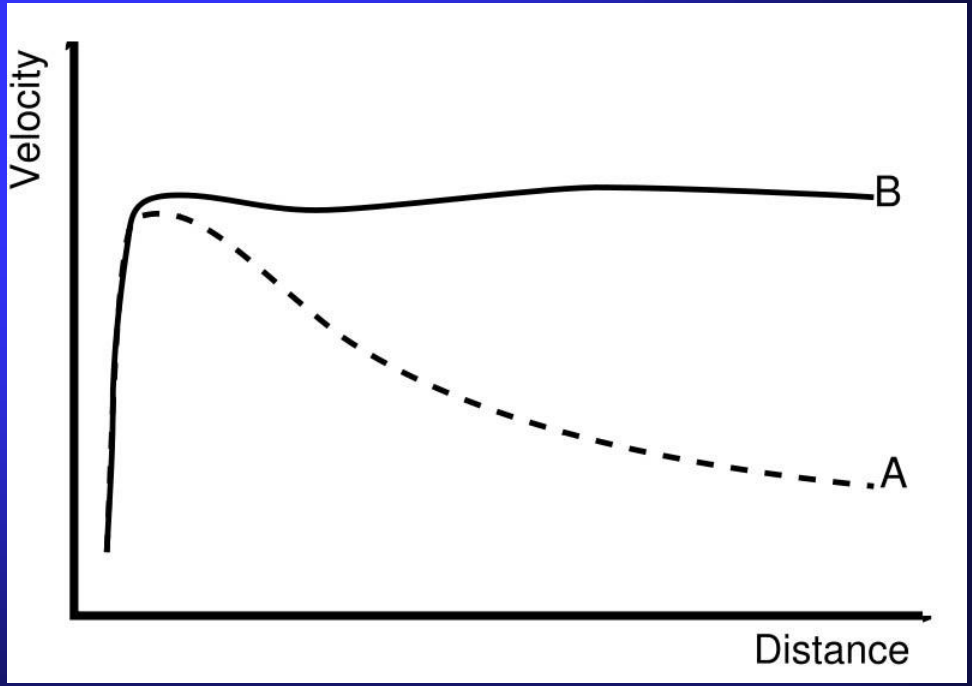
Orbital period depends on *BOTH* masses

C1

Galactic Rotation Curve

We can't see all of the Milky Way's mass





C1

Kepler's Second Law

Kepler

$$p^2 = a^3$$

Newton

$$p^2 = \frac{4\pi^2}{G(M_1 + M_{enc})} a^3$$

Orbital period depends on the ENCLOSED mass

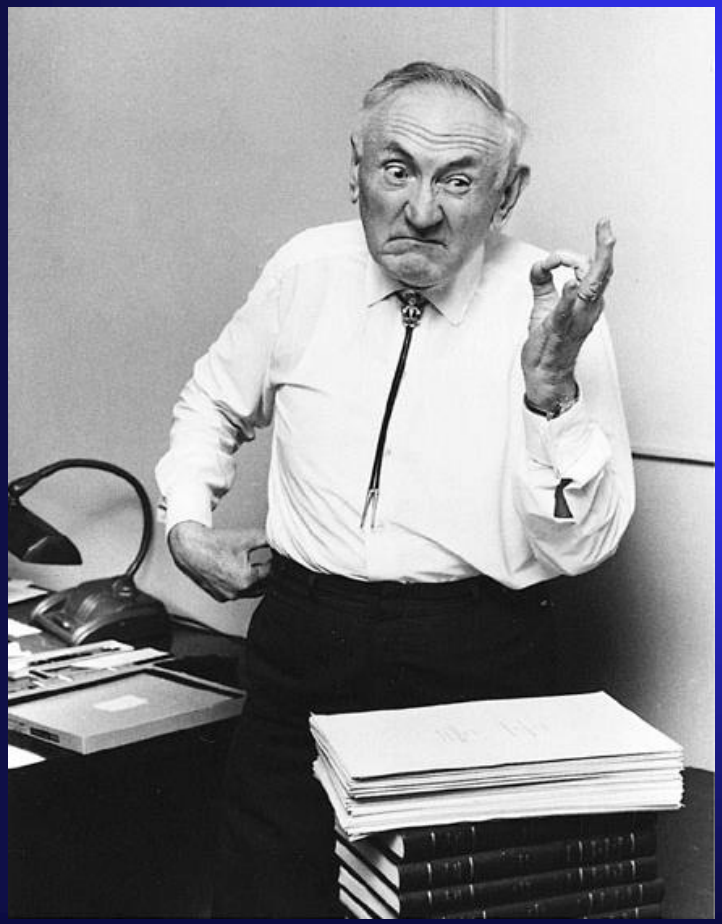
If the Sun were 2 solar masses instead of 1 solar mass

A) Our orbital period would be lower
B) Our orbital velocity would be higher
C) Our orbital velocity would be the same
D) Our orbital velocity would be lower

C5

Galaxy Clusters

Orbital velocities in clusters of galaxies are strange too



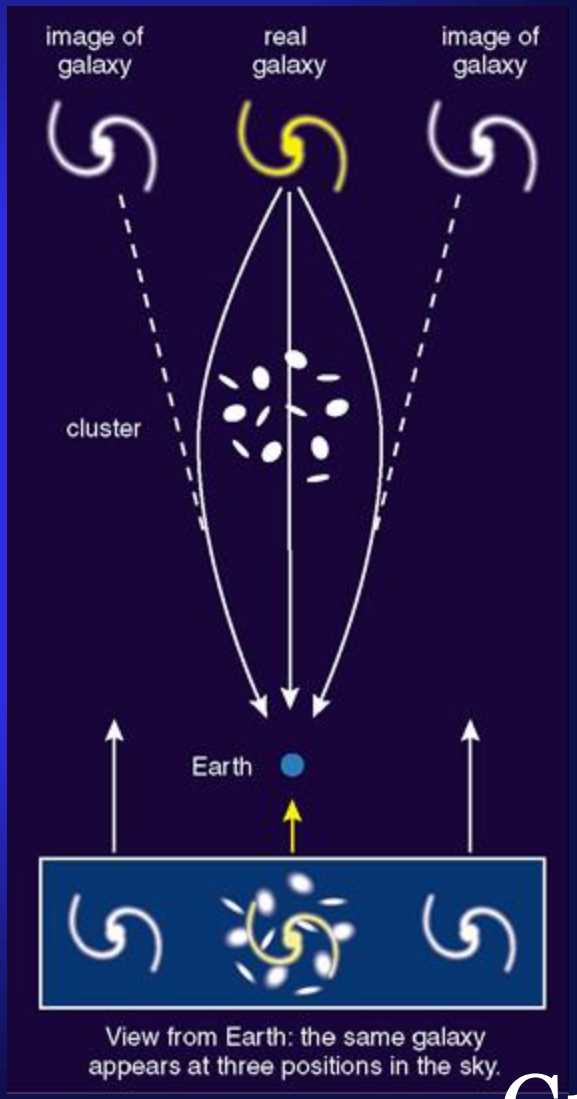
We can ‘weigh’ the cluster by measuring velocities of the galaxies

Once again, there isn’t enough mass.

C1

Gravitational Lensing

Abel Cluster



C1

What is it?

Could it be ordinary matter?

MACHO's
Massive Compact
Halo Objects

Surveys detect a few,
but not enough

C2

WIMP's

Or is it extraordinary matter?

Weakly
Interacting
Massive
Particles

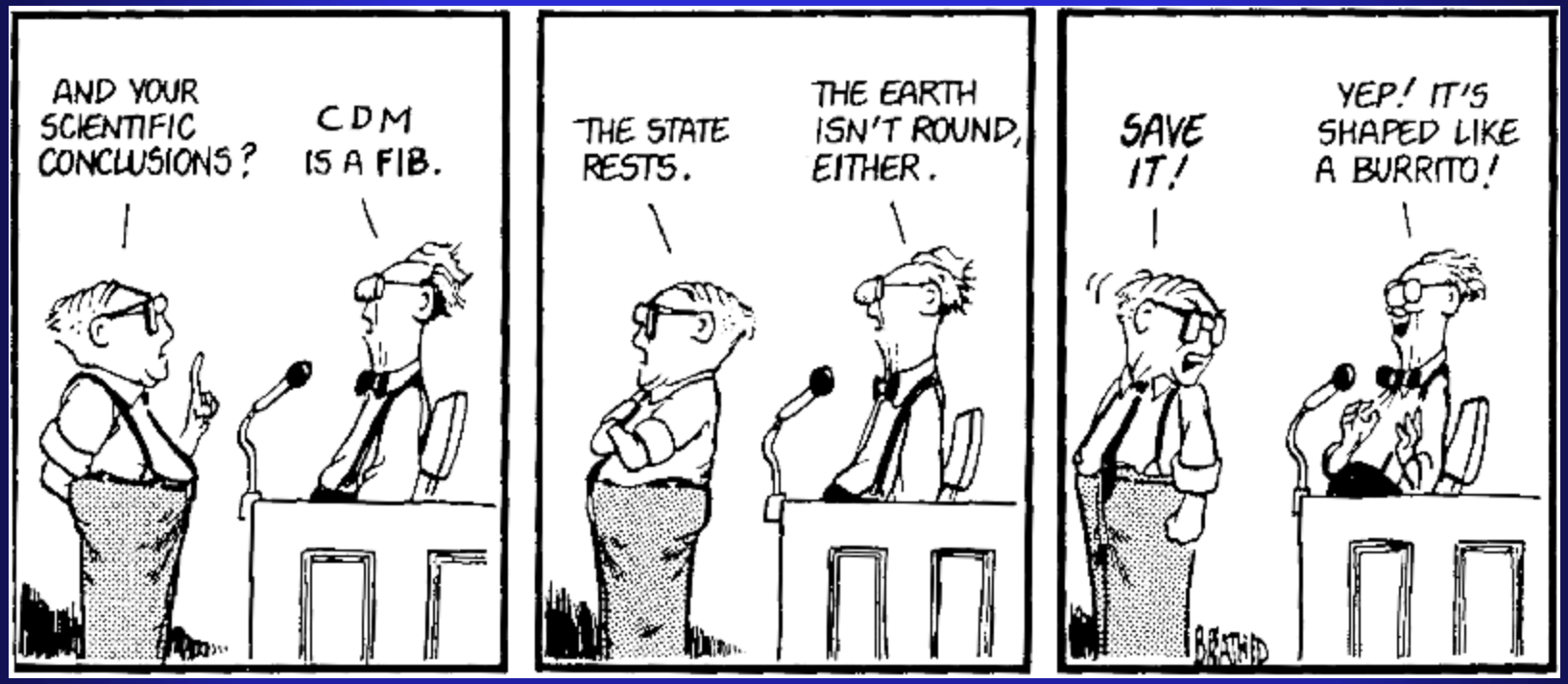
They Interact gravitationally only

CMD = Cold Dark Matter

C2

MoND

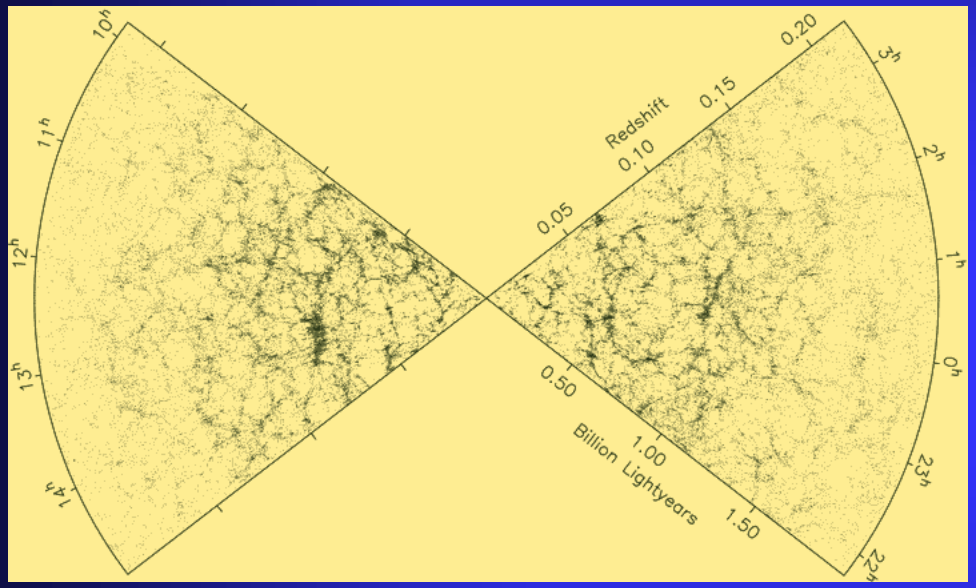
Modified Newtonian Dynamics

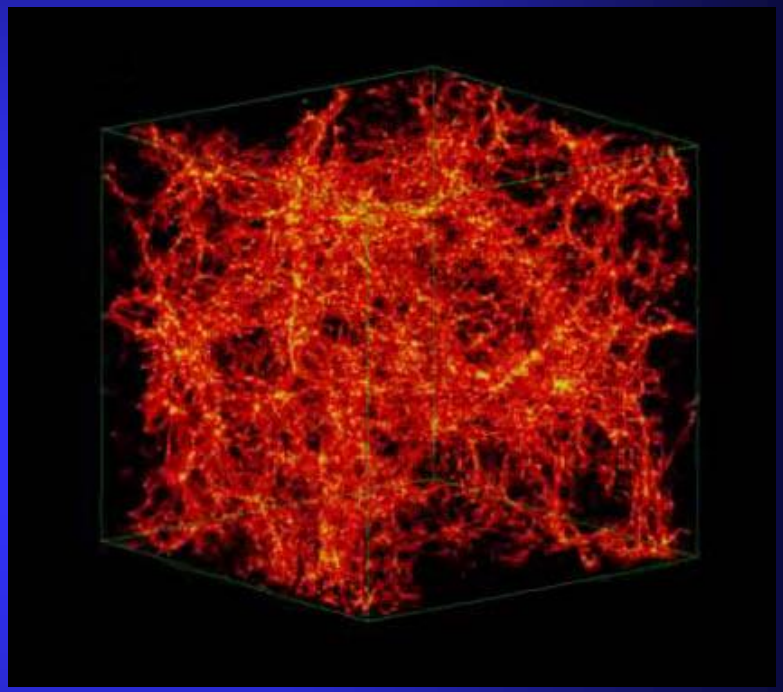


It hasn't come close to working yet

C2

How to Build a Universe



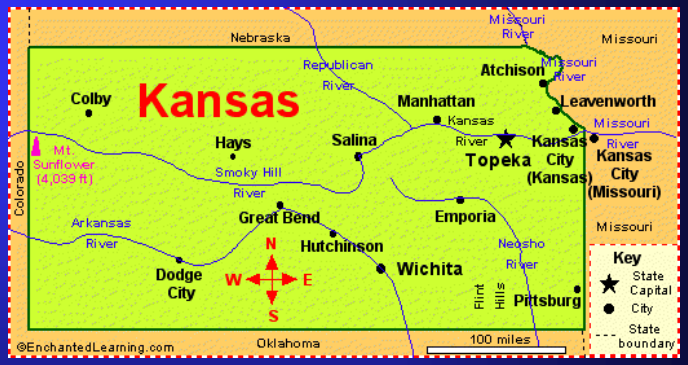


The original over densities eventually grew into galaxies

C3

What Shape is the Universe?

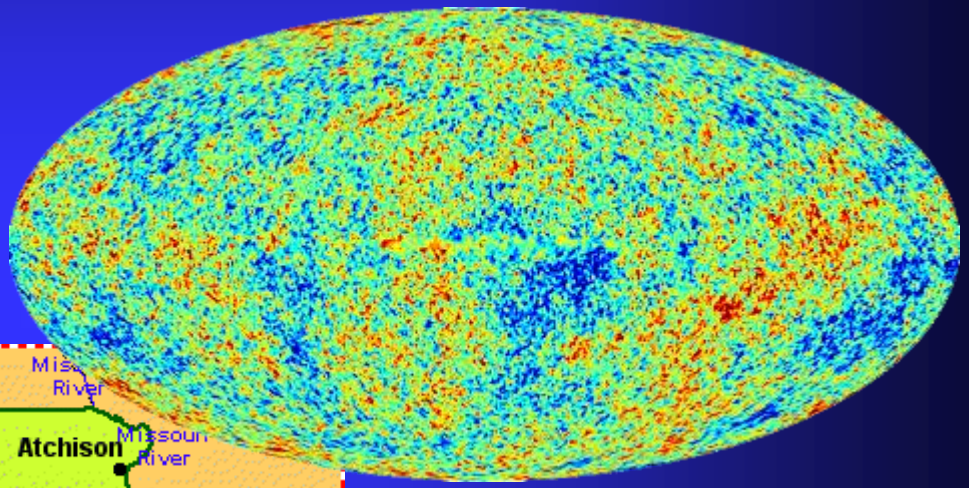
Since gravity warps space… what is the overall shape of the Universe?



D1

Looks Pretty Flat

At least overall.



D1

The Fate of the Universe

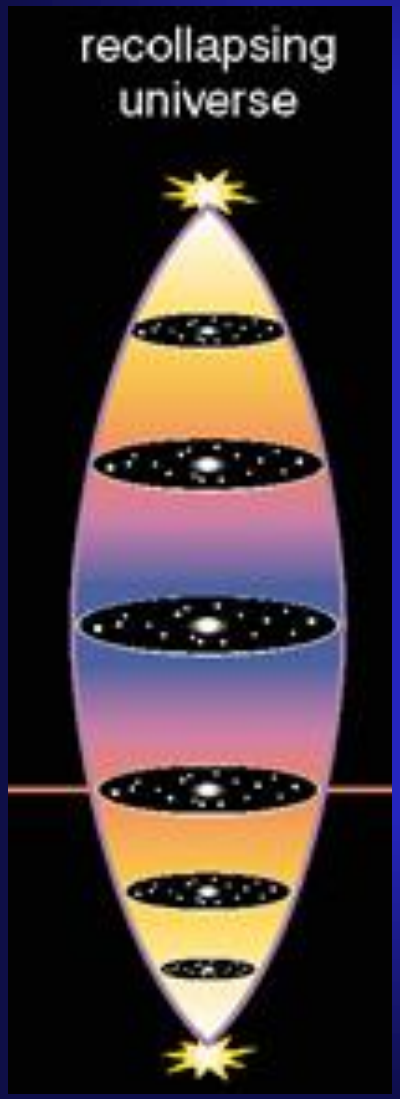
An escape velocity question on a grand scale

It the Universe has Critical Density it will re-collapse

If it doesn't, it won't

D3

The Big Crunch

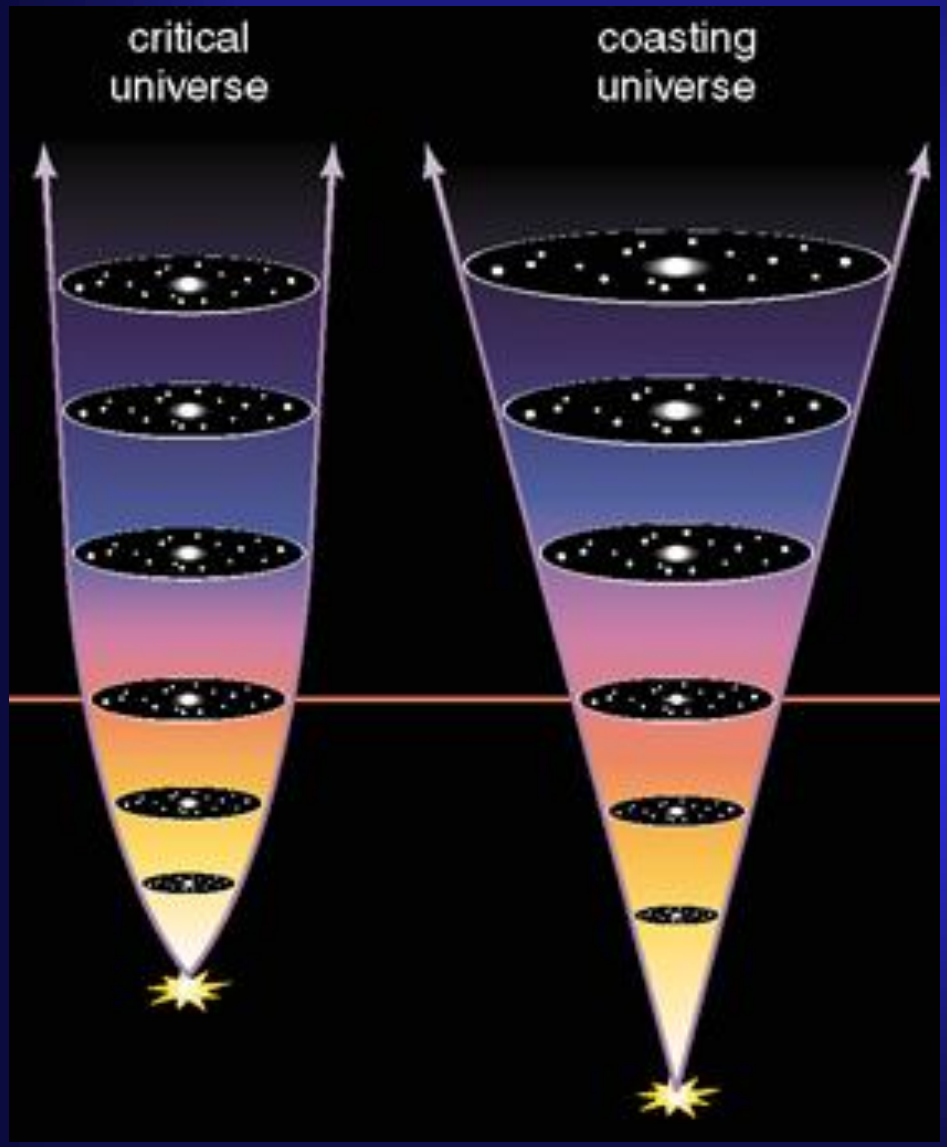


The density of the Universe is greater than critical density and the Universe re-collapses

Perhaps there is another Big Bang and the whole thing just keeps happening over and over

D2

Heat Death



The density of the Universe is at or below critical density

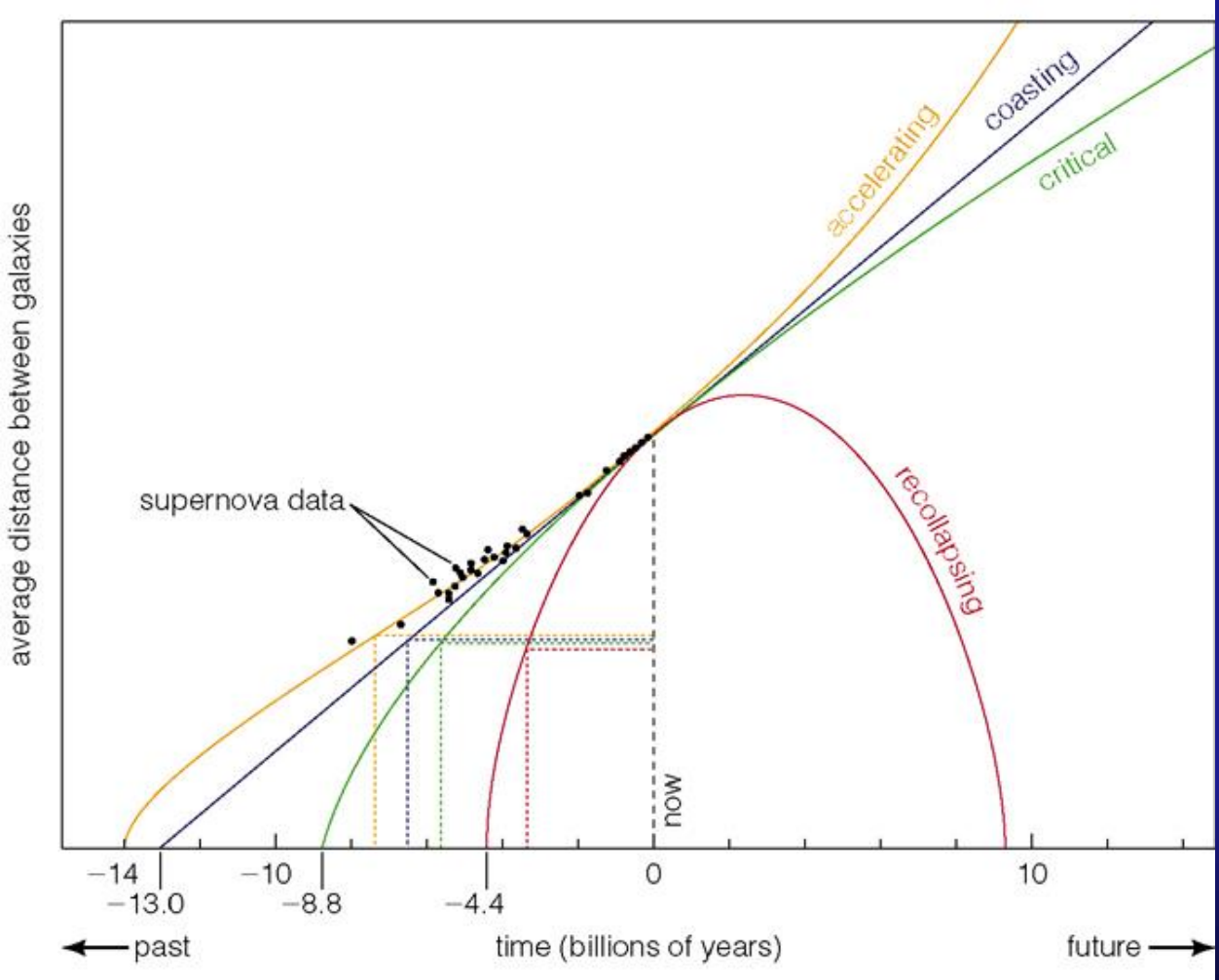
It will expand forever

Eventually all of the stars will burn out

D2

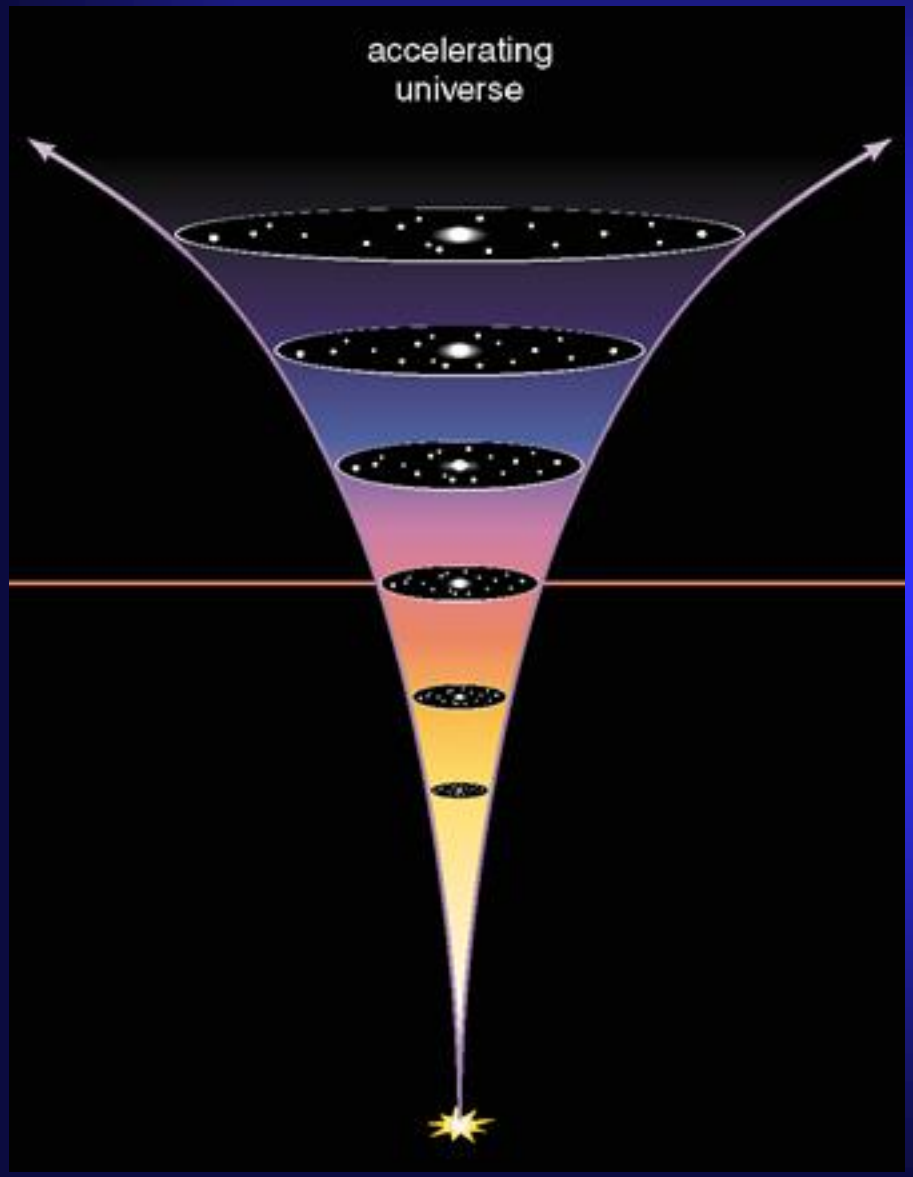
Some Things Never Die

The expansion appears to be accelerating



D3

The Big Rip



Eventually the expansion will be so fast that gravity won't hold it together

Eventually NOTHING will hold it together!

D2

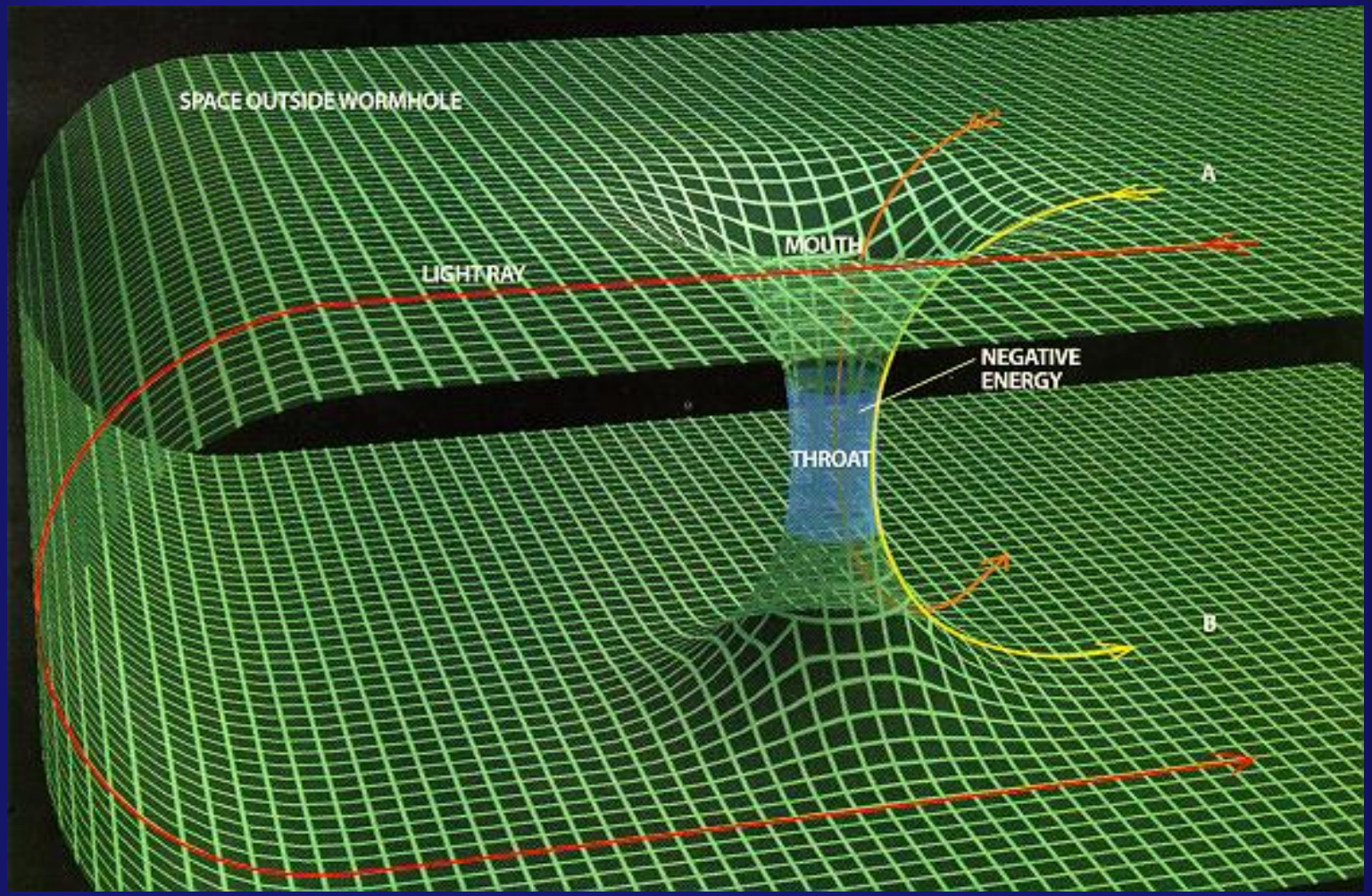
The End?

Current models
30 percent matter
70 percent dark energy

The super nova data remains controversial

Remember the Ether!

Wormholes



Connecting Distant Points

Black, White, Worm…

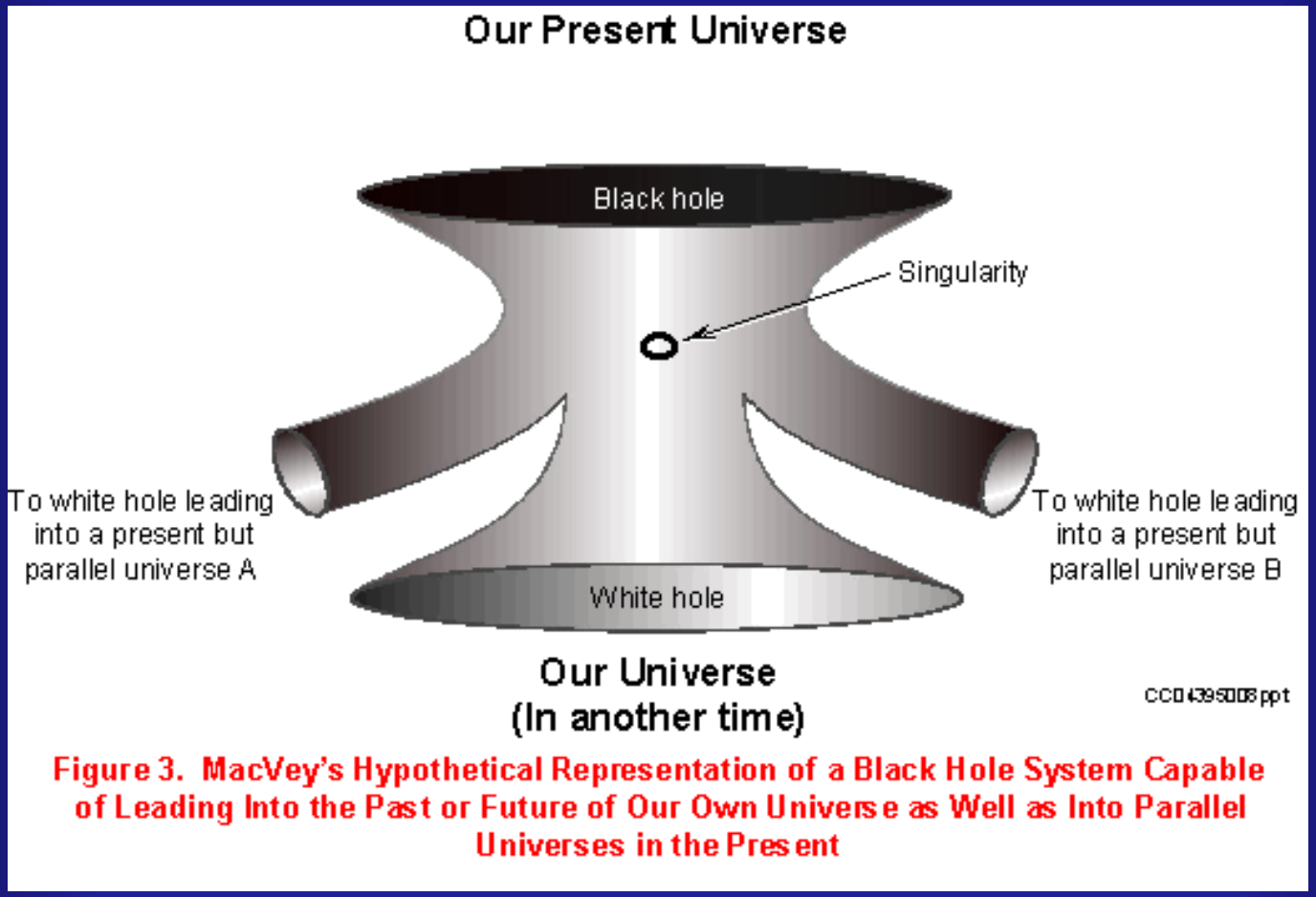
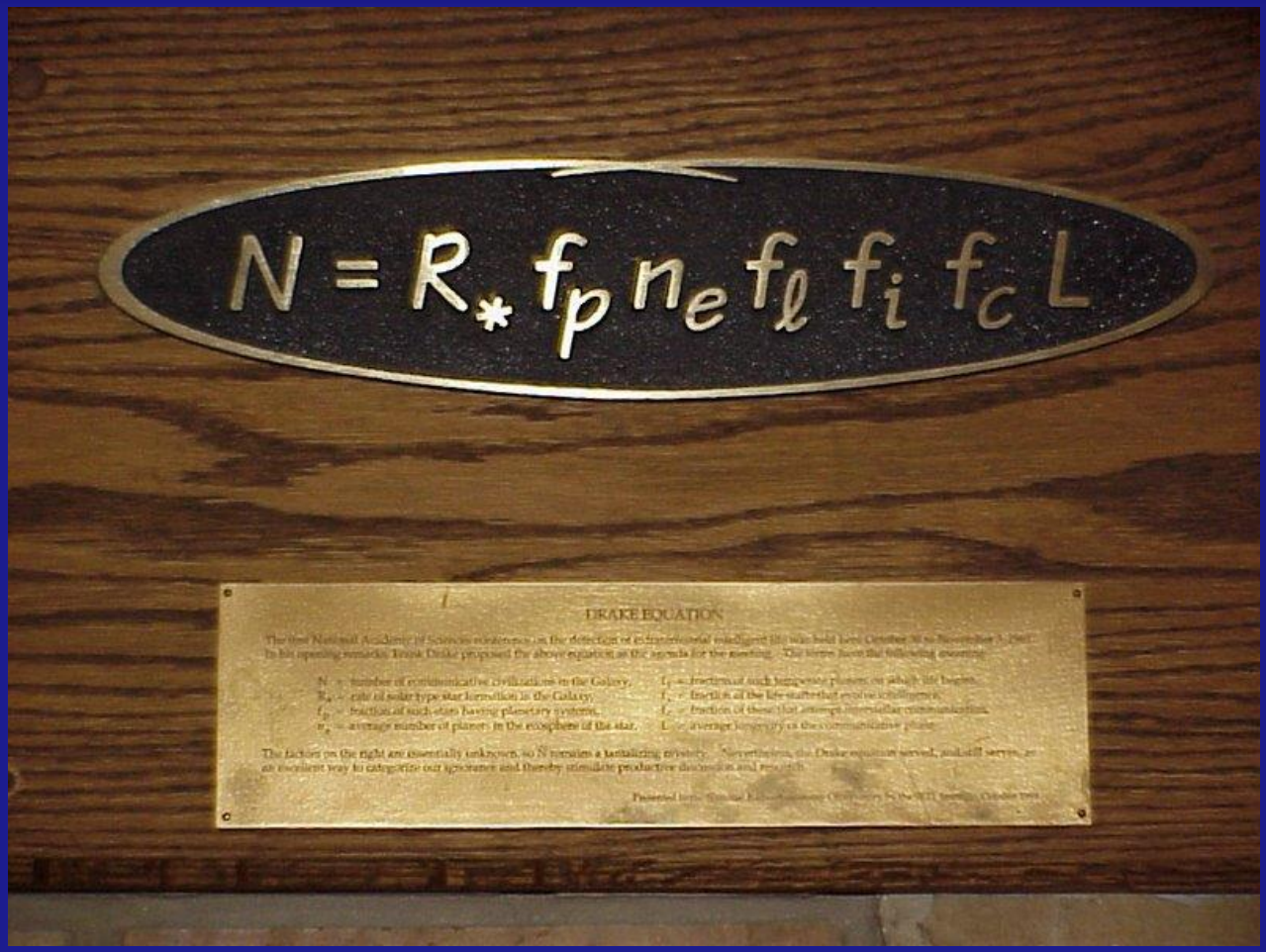


Figure 3. MacVey's Hypothetical Representation of a Black Hole System Capable of Leading Into the Past or Future of Our Own Universe as Well as Into Parallel Universes in the Present

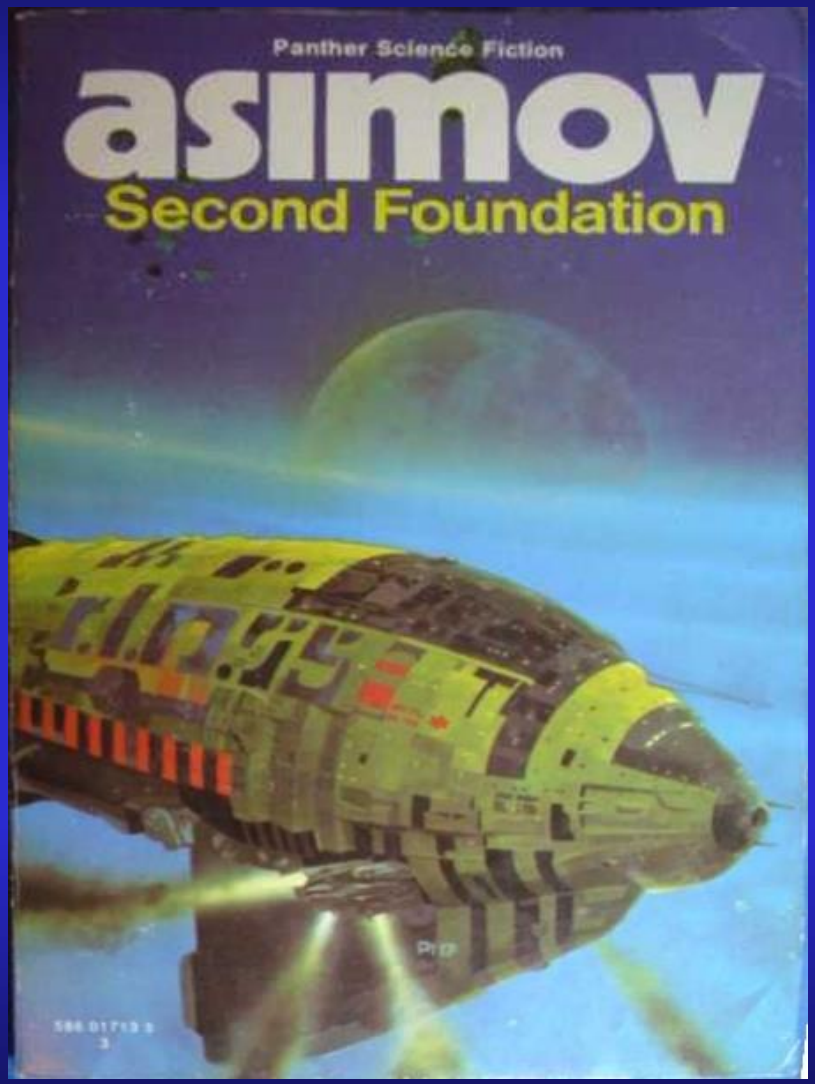
Connecting Distant Points
In space AND time

Life?



According to Drake, N = 10,000

Galactic Colonization!



How long would it take to colonize the galaxy?

Where are they?

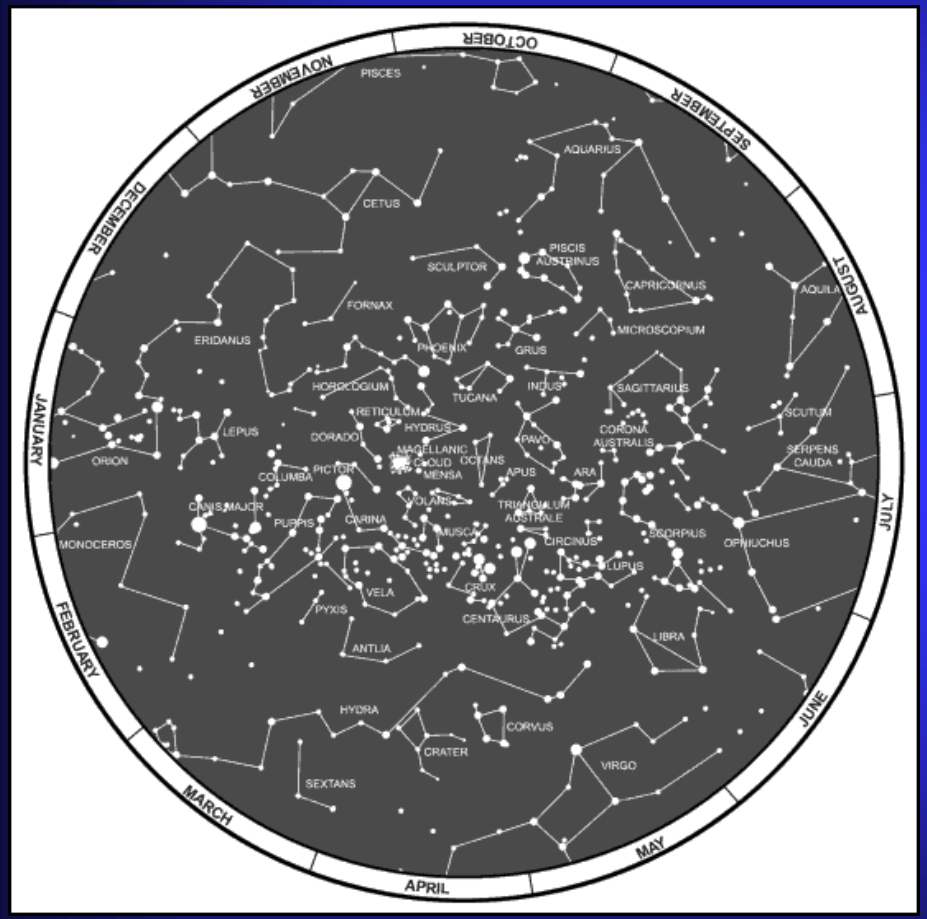
They're Here!

They've come and gone… Not interested

How long does it take to develop intelligence?

How long do intelligent civilizations persist?

Constellations



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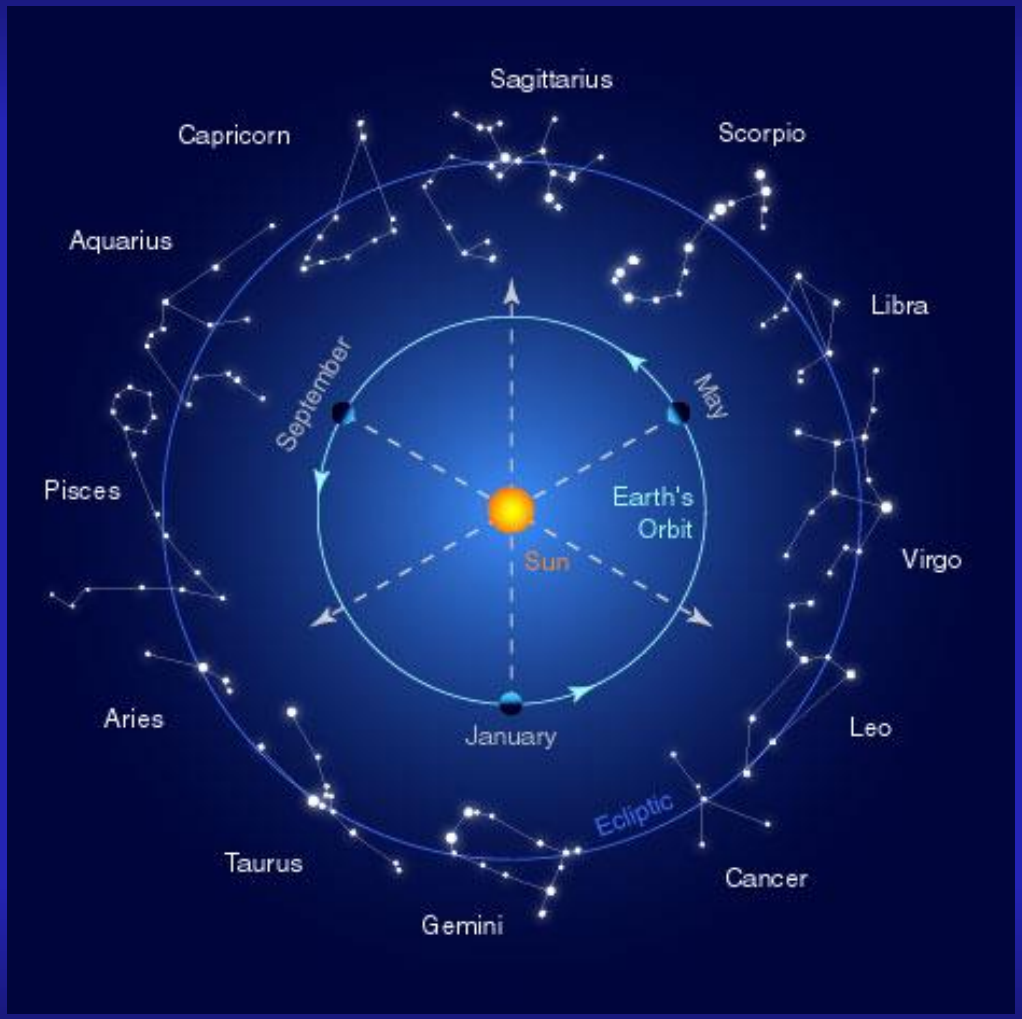
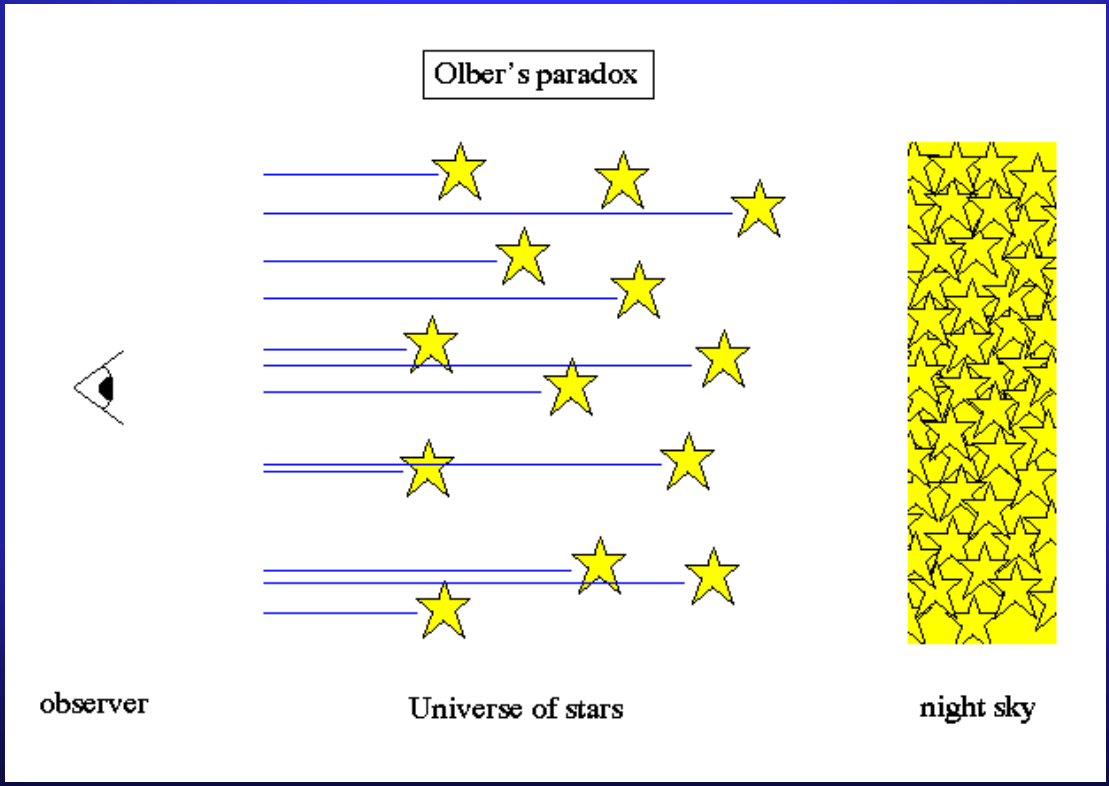
Astrology



A testable hypothesis?

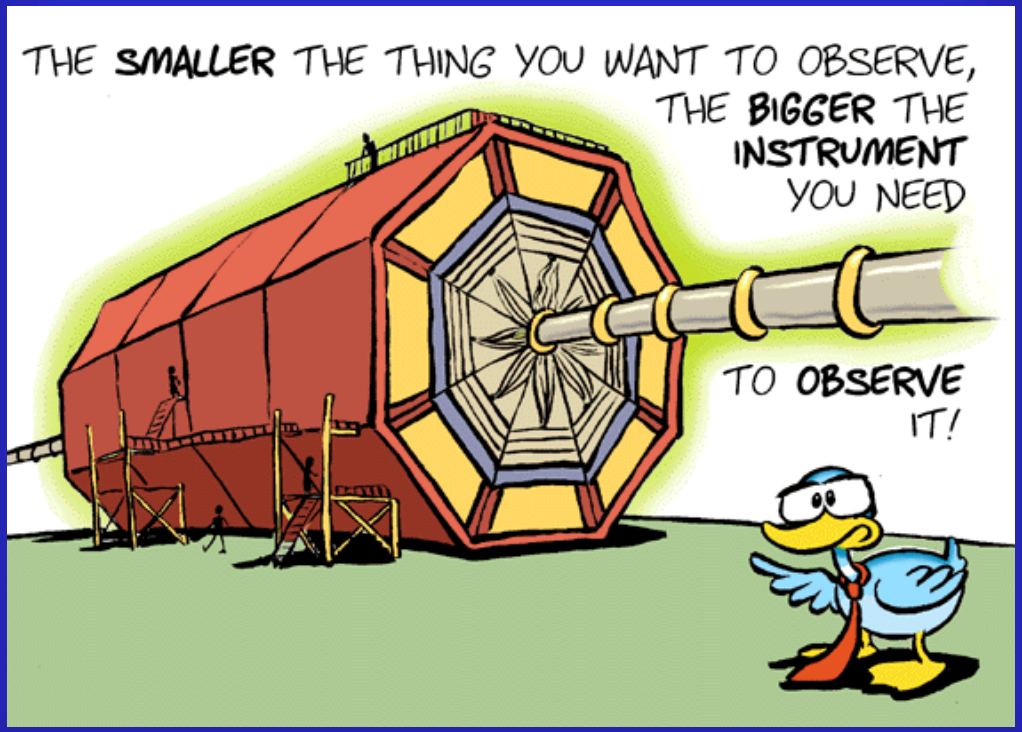
Olber's Paradox

The Universe is definitely much different today than it was in the past



A Brief History

At first, there was no matter



We use particle accelerators to study the very beginning