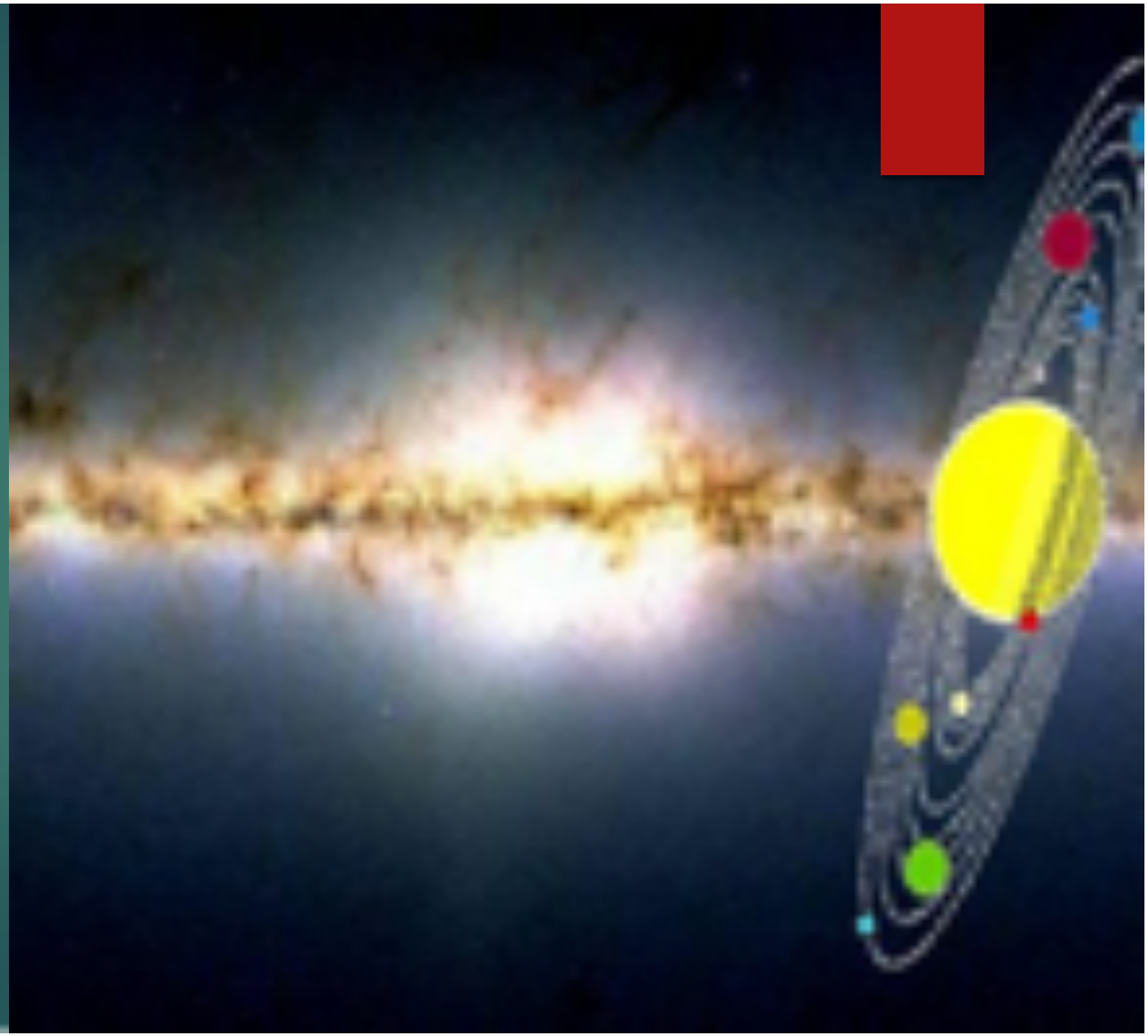
From The Steady State To The Big Bang

THE DISCOVERY OF THE MODERN UNIVERSE

Our Solar System in the Milky Way



Our Solar System is moving towards the star Vega within the Milky Way Galaxy.

We are moving at a speed of about 500,000 miles per hour!

It takes 230 million years to go around the galaxy once.

This just in – the Milky Way Galaxy is twisted!

There are not enough stars to keep the galaxy together. Instead, there is apparently a large sphere of something in which the galaxy is embedded.

We can see the gravitational effects of this "something", but we don't know what it is. It appears to be hanging around in large amounts throughout the universe, and is necessary for galaxies to form.

We call it, for lack of a better term, Dark Matter.

A Map of our "Local Group" of Galaxies

There are about 50 galaxies total.

This is a "gravitationally bound" group – all the galaxies are held together by the group's gravity.

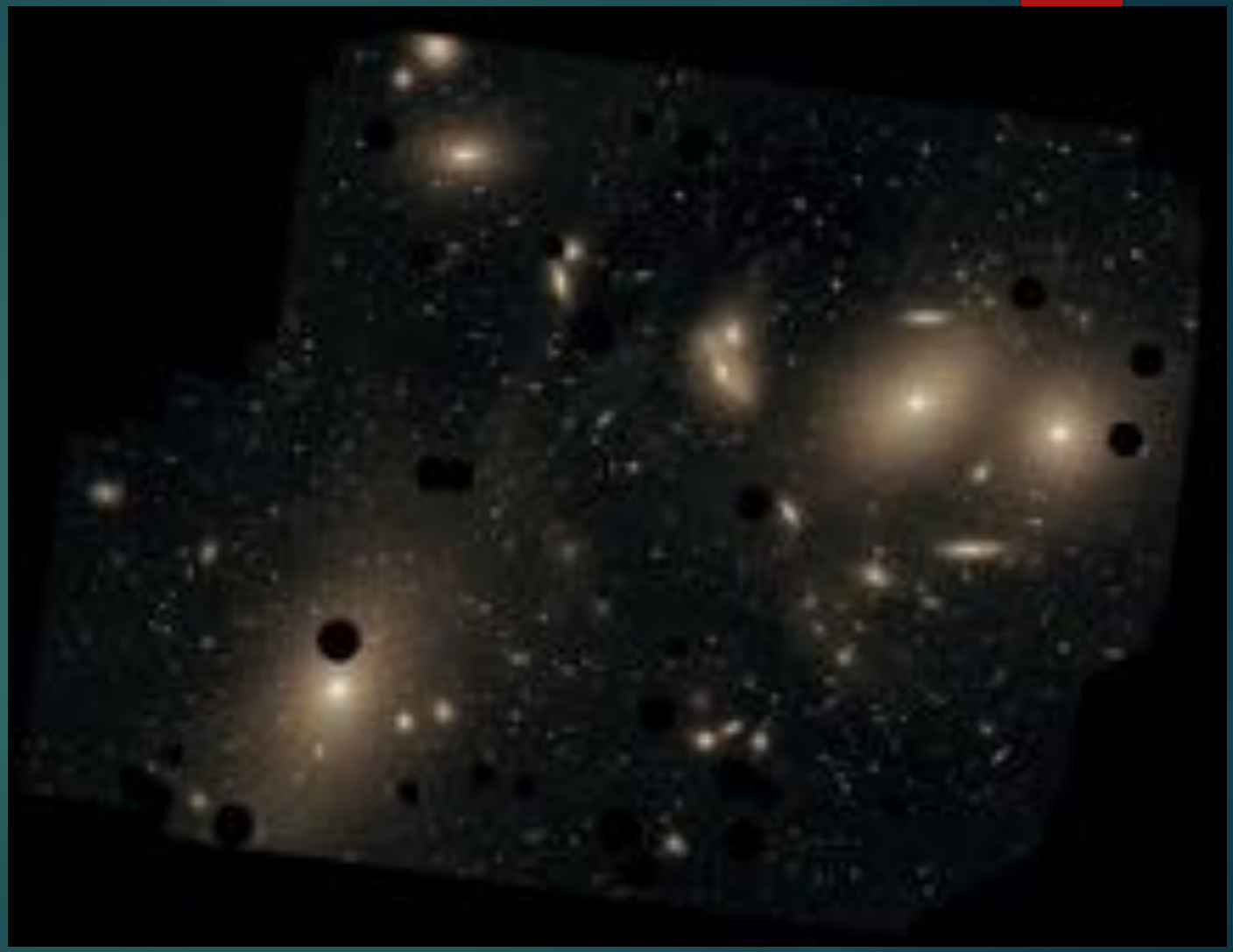
Picture of the Triangulum Galaxy, the third largest galaxy in our local group.

It is about 3 million light years away – very close to a megaparsec!

The Virgo Cluster of Galaxies – a cluster of about 2000 galaxies.

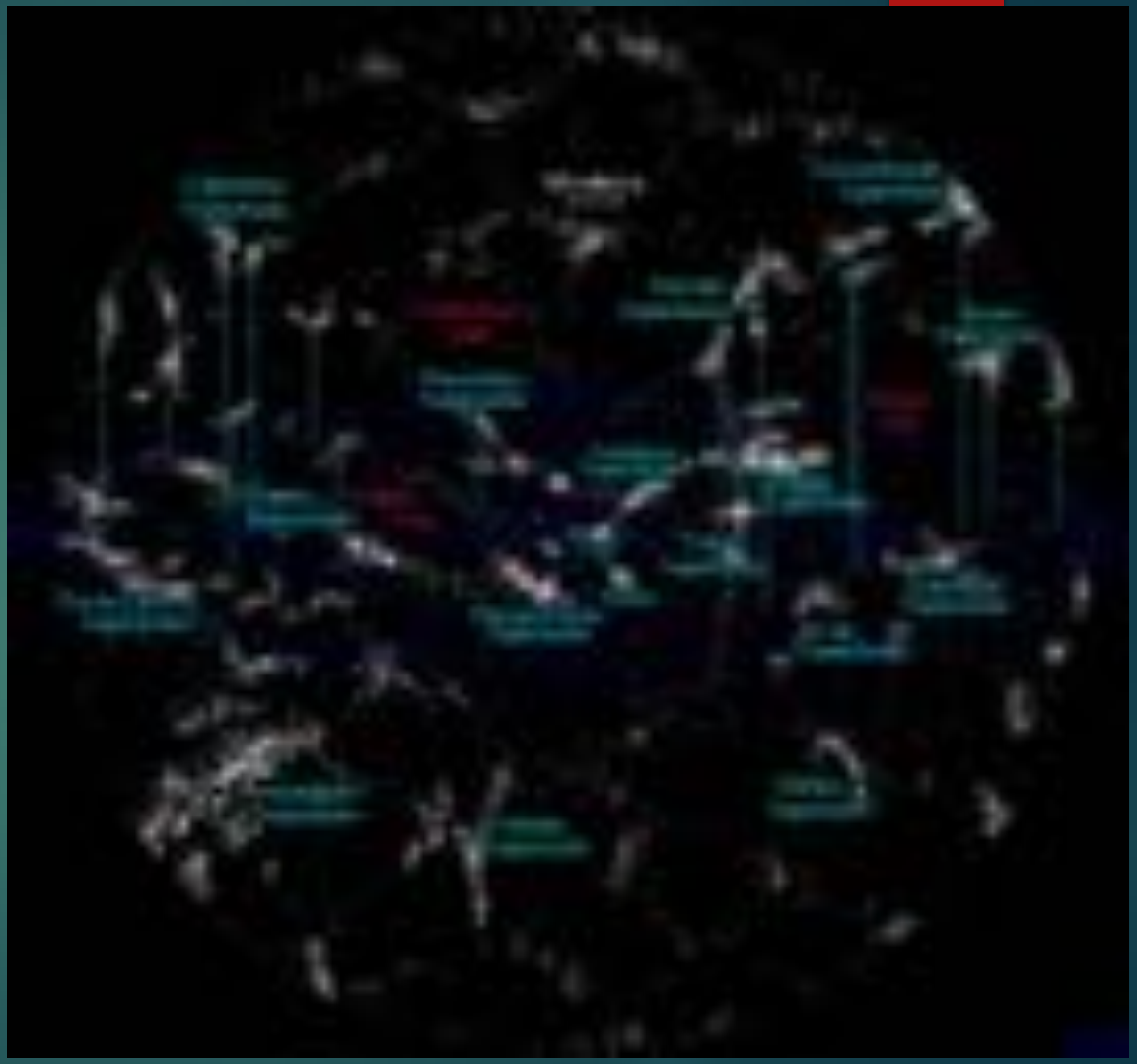
This is a collection of various groups of galaxies whose center is about 59 million light years from us.

There is a very thin but very hot gas in between the galaxies.



Map of the "nearby" superclusters of galaxies.

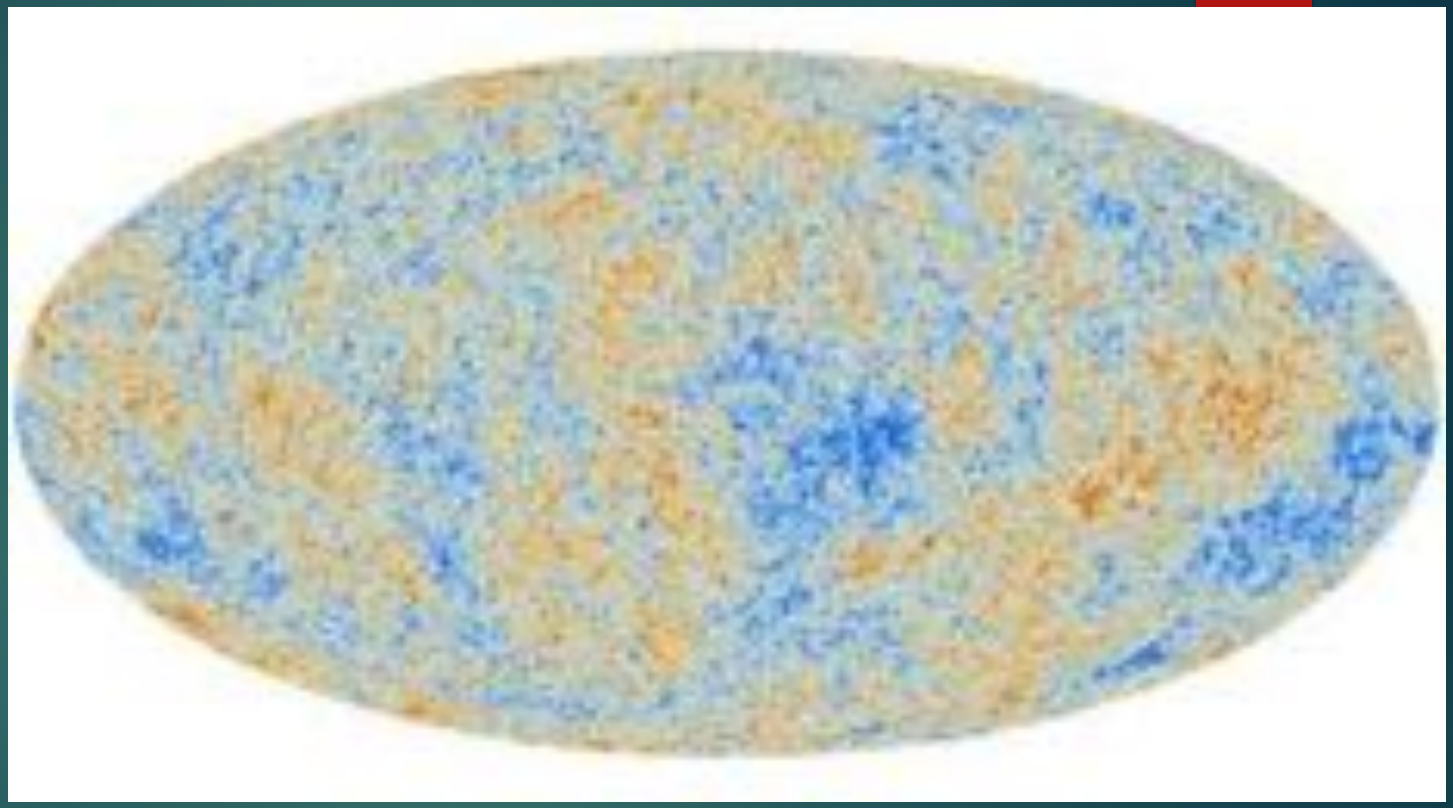
Superclusters are the largest gravitationally bound objects in the universe.



Globular Clusters – Perhaps the oldest stars in the Universe

Penzias and Wilson and the radio telescope that found the Cosmic Backgroun d Radiation

Map of the Cosmic Background Radiation



The Cosmic Background Radiation comes from about 380,000 years after the beginning of the universe.

How do we know what happened before that?

- Logical Deductions from what we do know (we know what we ended up with, so what processes could get us there?
- Particle Accelerators re-create conditions of the early universe, all the way to the first second.

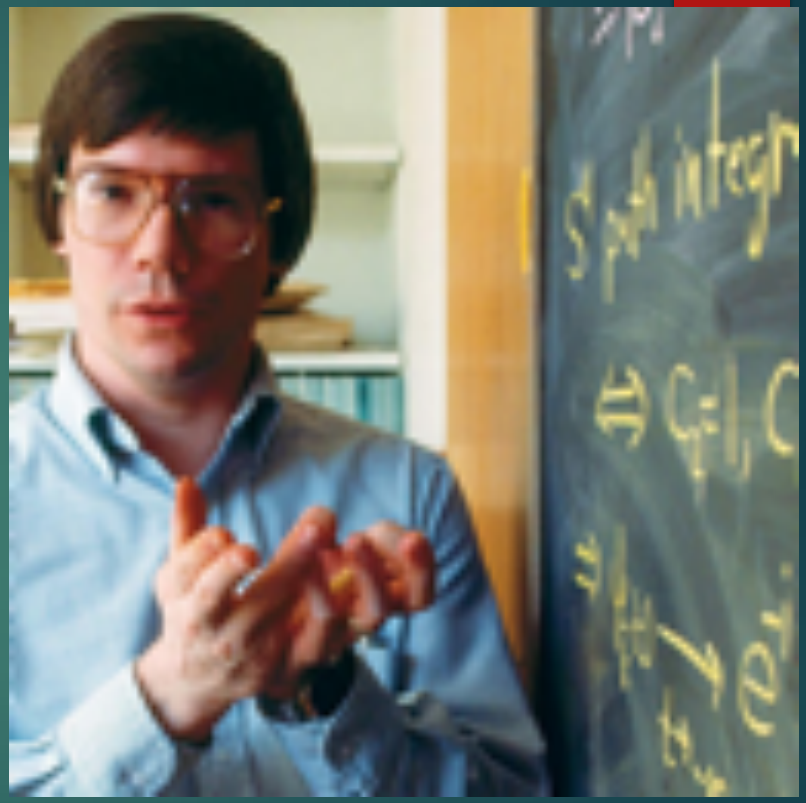
It's quite a detective work!

At t=0, Physics doesn't work. Everything ends up being divided by zero. We have no idea what the universe was like at the moment of creation.

In the first second, the universe is astonishingly small – much smaller than a subatomic particle. It is made of profoundly intense radiation and is at a temperature of 10^{30} degrees.

The Fundamental Forces of Physics begin to appear in the first second.

When the strong nuclear force kicks in, it creates an astonishing expansion of the universe. The universe is about 20 light years across after 1 second. This is called "inflation", and was first proposed by Alan Guth in 1979. By the end of 1 second the temperature has dropped to 10,000,000 degrees.



Alan Guth

For a long time, as the universe cools, light turns into particles which are blasted back into light again. Eventually the universe cools and the most fundamental particles begin to form and remain, and eventually the first atoms begin to form – mostly hydrogen but some helium, and a trace of other elements.

Can light turn into matter? We have pictures!

A Bubble Chamber picture of a gamma ray turning into an electron-positron pair.

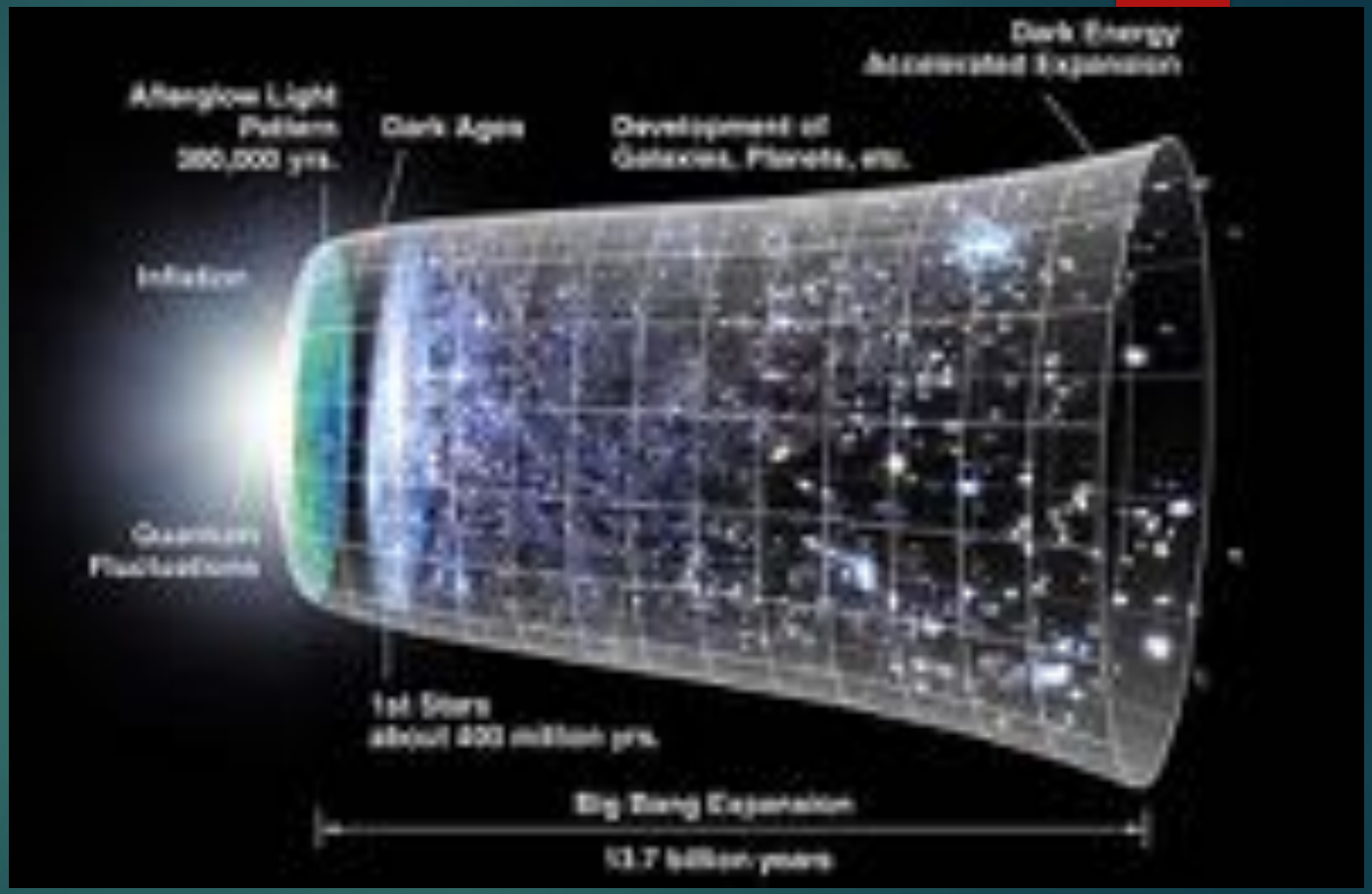
In other words, this is a picture of light turning into matter.

This raises a new puzzle. When light turns into matter, it creates a particle and an antiparticle. Both, every time. If a particle touches its antiparticle, they blow each other up and everything turns back into light again.

Our observable universe seems to be made entirely of particles. So where did all the antiparticles go?

Solve this one and win a Nobel Prize.

An overview of the development of the Universe



Let's begin our conclusion with one more mystery. In 1997 careful measurements began to show that space is actually beginning to expand more rapidly than it used to. This all seems to have begun about 4 billion years ago.

There is no known process for the expansion of space. Expanding all of space would use a prodigious amount of energy. Since we don't detect it, and we don't know what it is, we call it Dark Energy.

- It is now believed that ordinary matter is about 4% of the Universe.
- 23% of the universe is Dark Matter.
- 73% of the Universe is Dark Energy.

This means we don't know what 96% of the universe is.

Because space is expanding as time goes by, something that began sending light our way billions of years ago is now much farther away than it was.

So, the "observable" universe is 13.8 billion years old, and the oldest objects are now 46 billion light years away from us.

This is a picture of the oldest known galaxy, 13.4 billion years old. It is now 32 billion light years away.

By NASA, ESA, P. Oesch (Yale University), G. Brammer (STScI), P. van Dokkum (Yale University), and G. Illingworth (University of California, Santa Cruz)

Hubble Space Telescope

Launched April 1990

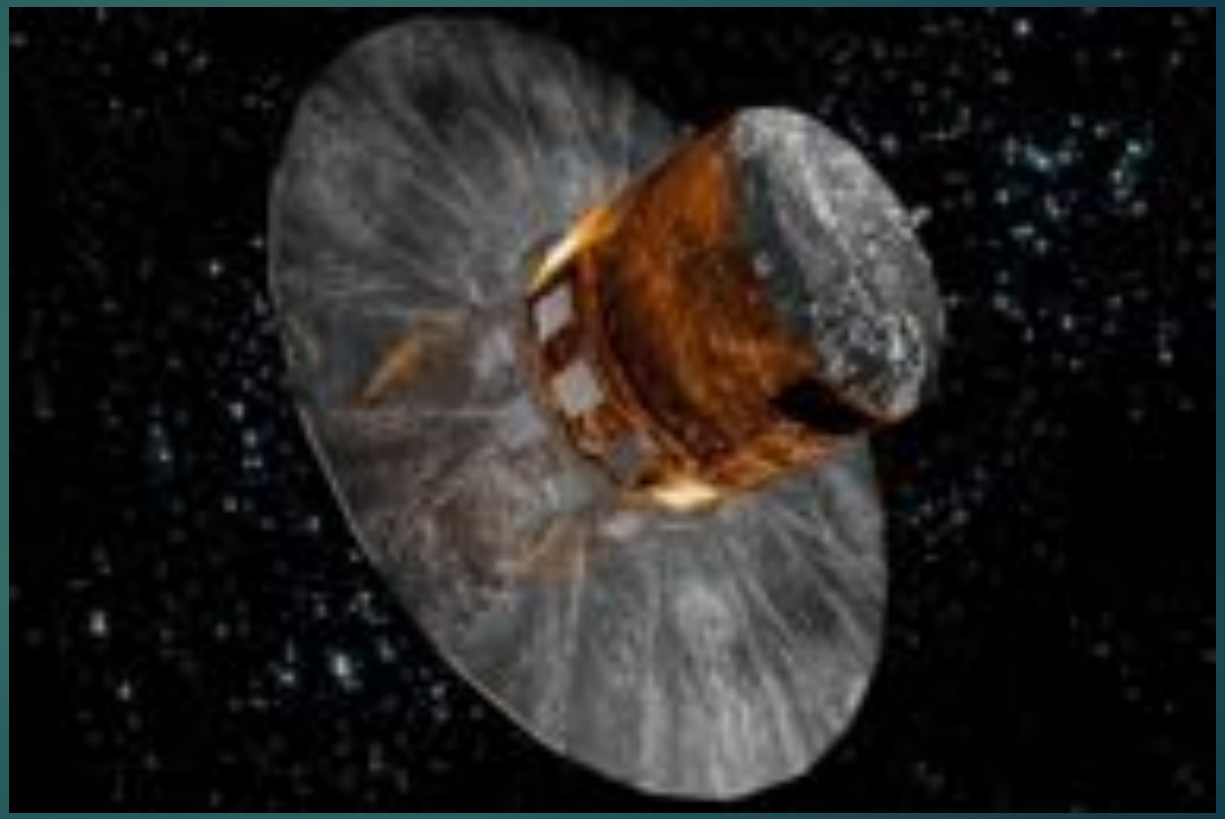
Chandra X-Ray Telescope

Launched July 1999

By NASA/CXC/NGST - http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11185 (image link), Public Domain

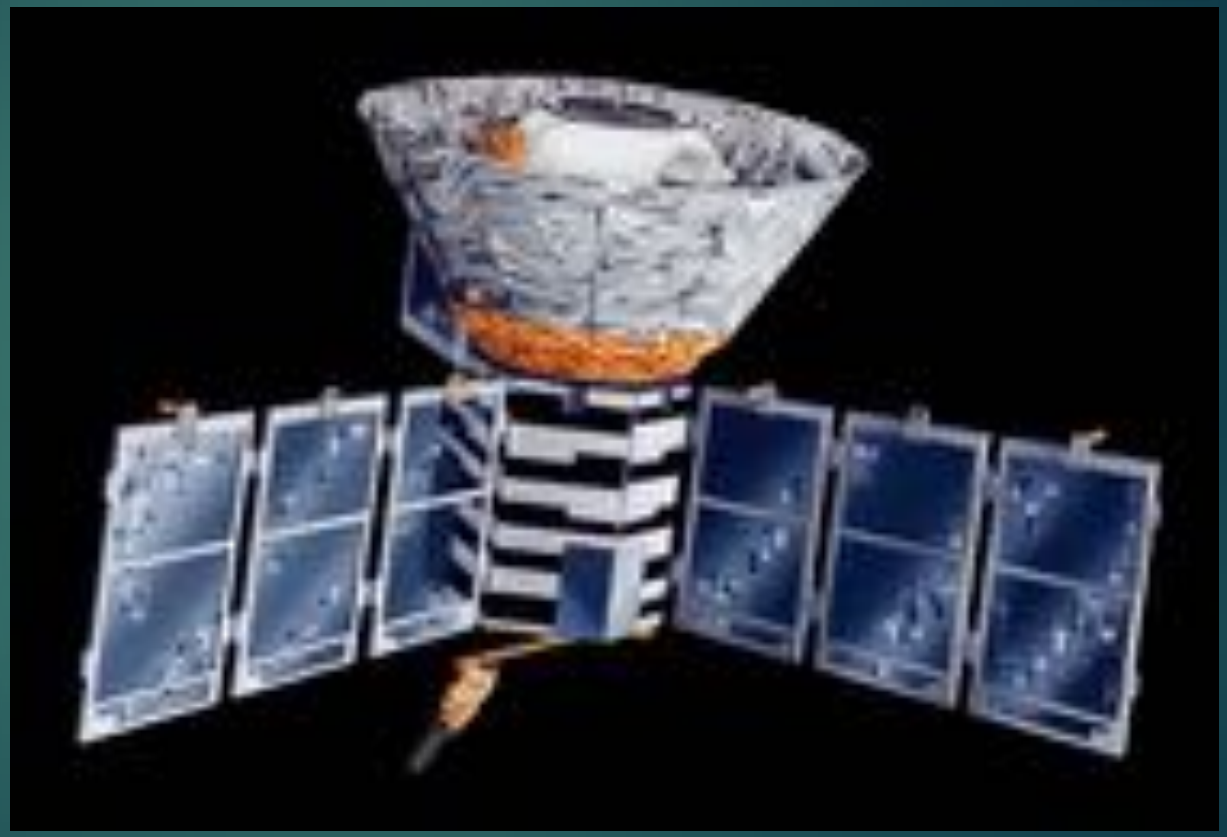
Gaia
Space
Telescope

Launched
December
2013



COBE Telescope

Launched November 1989, Terminated December 1993



Stephen Hawking

Thanks so much!

My email is medodge@comcast.net

Hope to see you again soon!

Mark Dodge