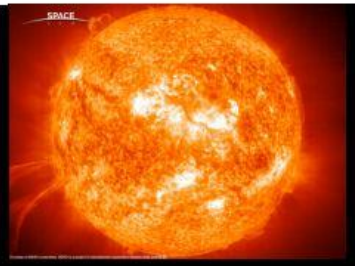
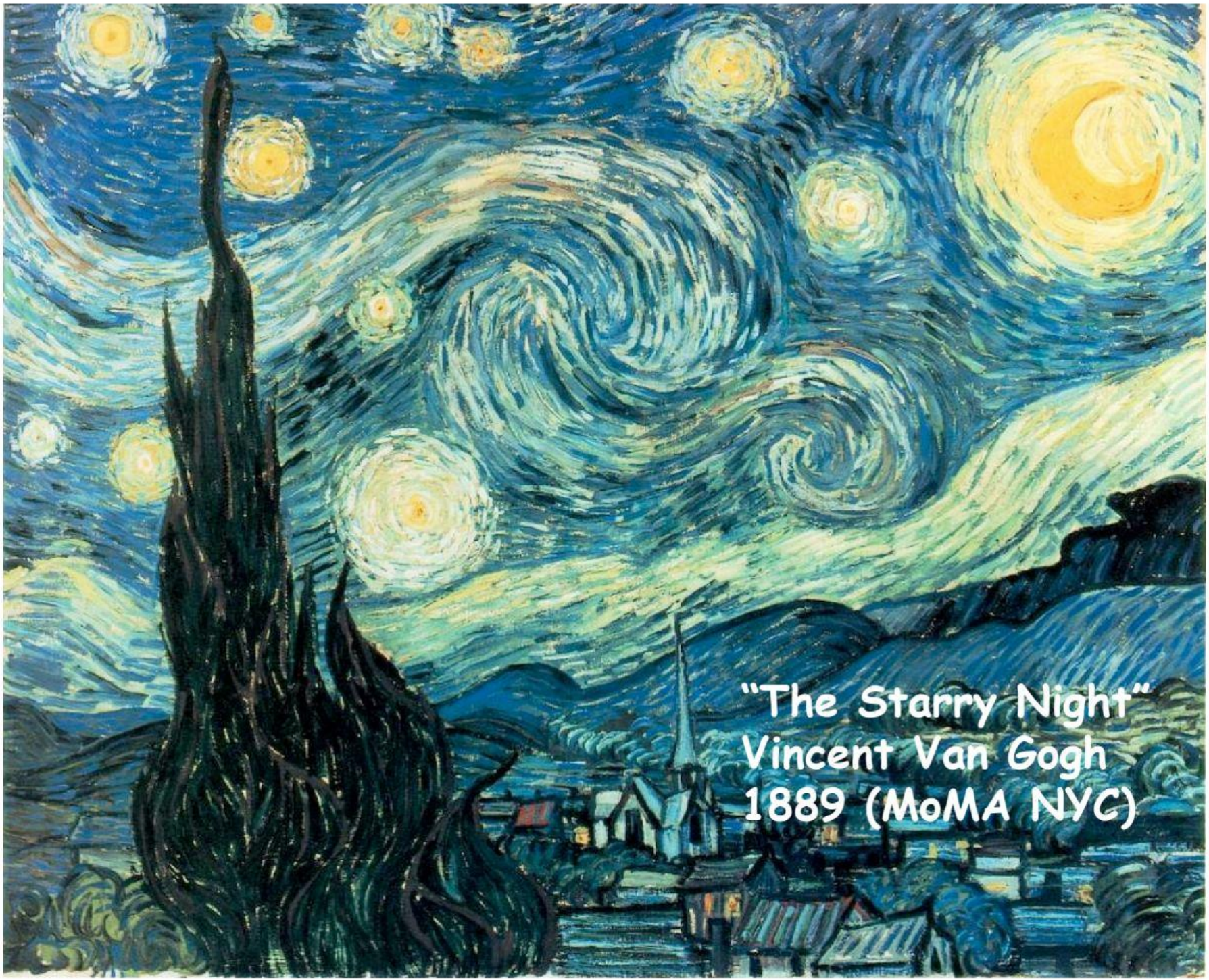


Great Explorers, The "Big Bang," Exploding Stars, and Other Fun Stuff

Bridgeview School
October 12, 2005

by
Jim Rohlf


"The Starry Night"
Vincent Van Gogh
1889 (MoMA NYC)

October 12, 1492

The "Santa Maria"

One month
to cross the
Atlantic Ocean

What did Columbus discover?

Columbus discovered that the earth was BIG.

How far away is the sun?

100 million miles ← hard to visualize

Easier: how long does it take to go there?

"Fall of Icarus"

Marc Chagall

1975

Centre Pompidou, Paris

How far away is the sun?

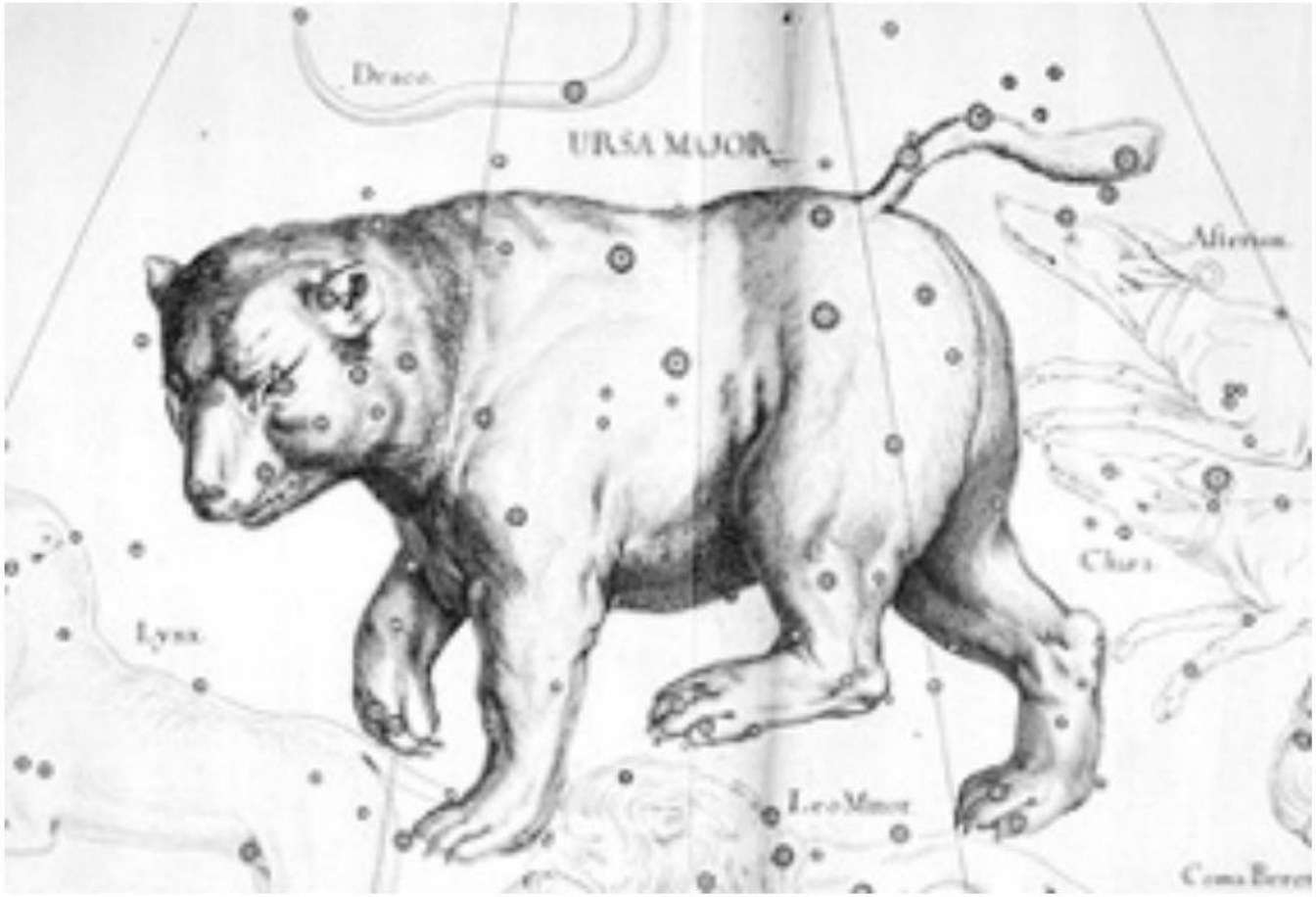
Real answer: It would take a whole year to go there by rocket ship.

Better answer: Light travels from the sun to you in 500 seconds (about 8 minutes). The sun is 8 light minutes away.

This means that we are seeing and feeling the sun not as it is right now but as it was eight minutes ago!
We are looking back in time by observing the sun!

We can see about 1000 or more stars at night… without a telescope

Constellation:
"Make believe" pattern of stars



Callisto

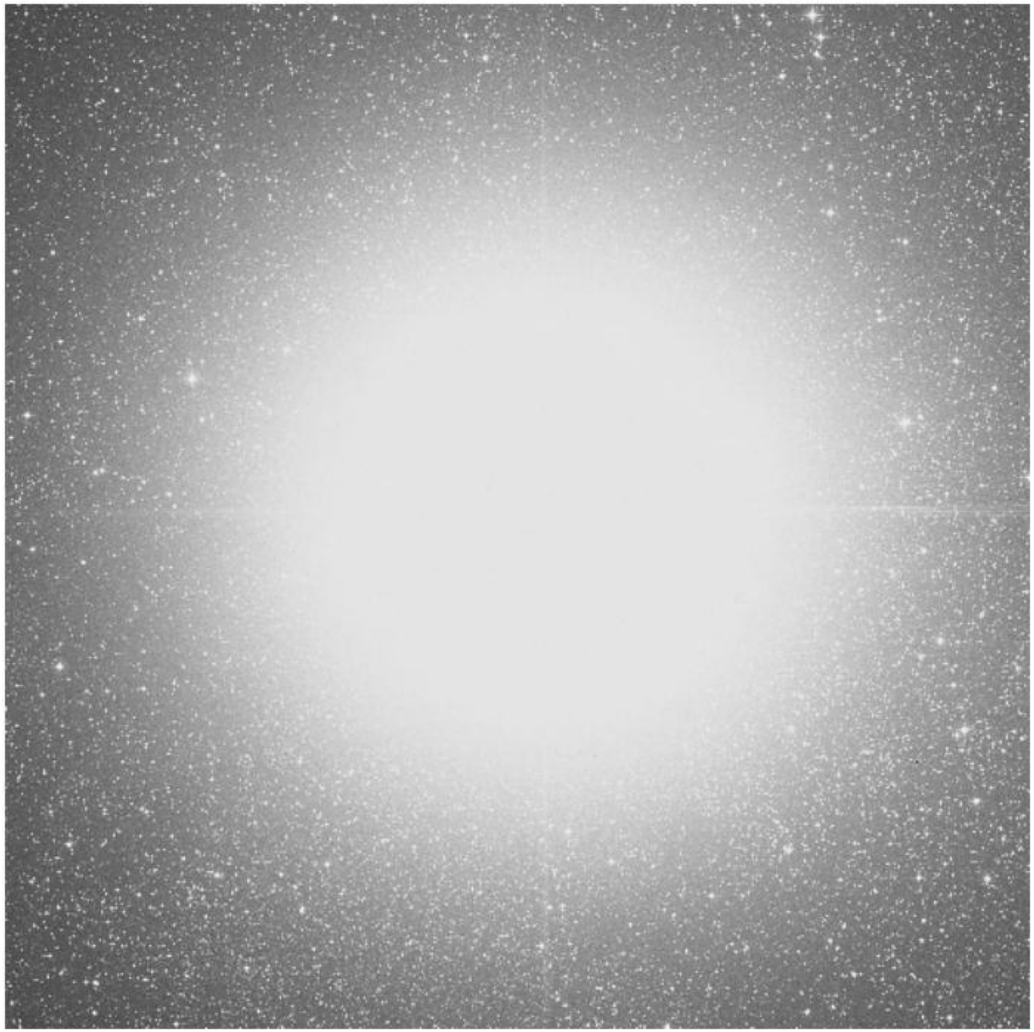
Turned into a bear that could not touch the ocean…

But they are fun and so are the myths…

What is the 2nd closest star?

Proxima (Alpha) Centauri: 4 "light years" away

Looking back 4 years in time!



Richard Feynman

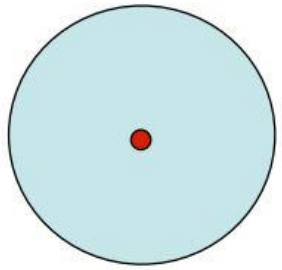
"If in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generations of creatures, what statement would contain the most information in the fewest words?"

Richard Feynman

"I believe it is the *atomic hypothesis* (or the atomic *fact*, or whatever you wish to call it) that *all things are made of atoms - little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another*. In that one sentence, you will see, there is an enormous amount of information about the world, if just a little imagination and thinking are applied."

The stars produce an enormous amount of light and heat (radiation).

The fuel for this is protons– the main ingredient of the sun and other stars.



Hydrogen atom:
A tiny nucleus, the proton, surrounded by an electron wave

The electrons are inside the star but it is too hot for the atoms to stay together (they melt!).

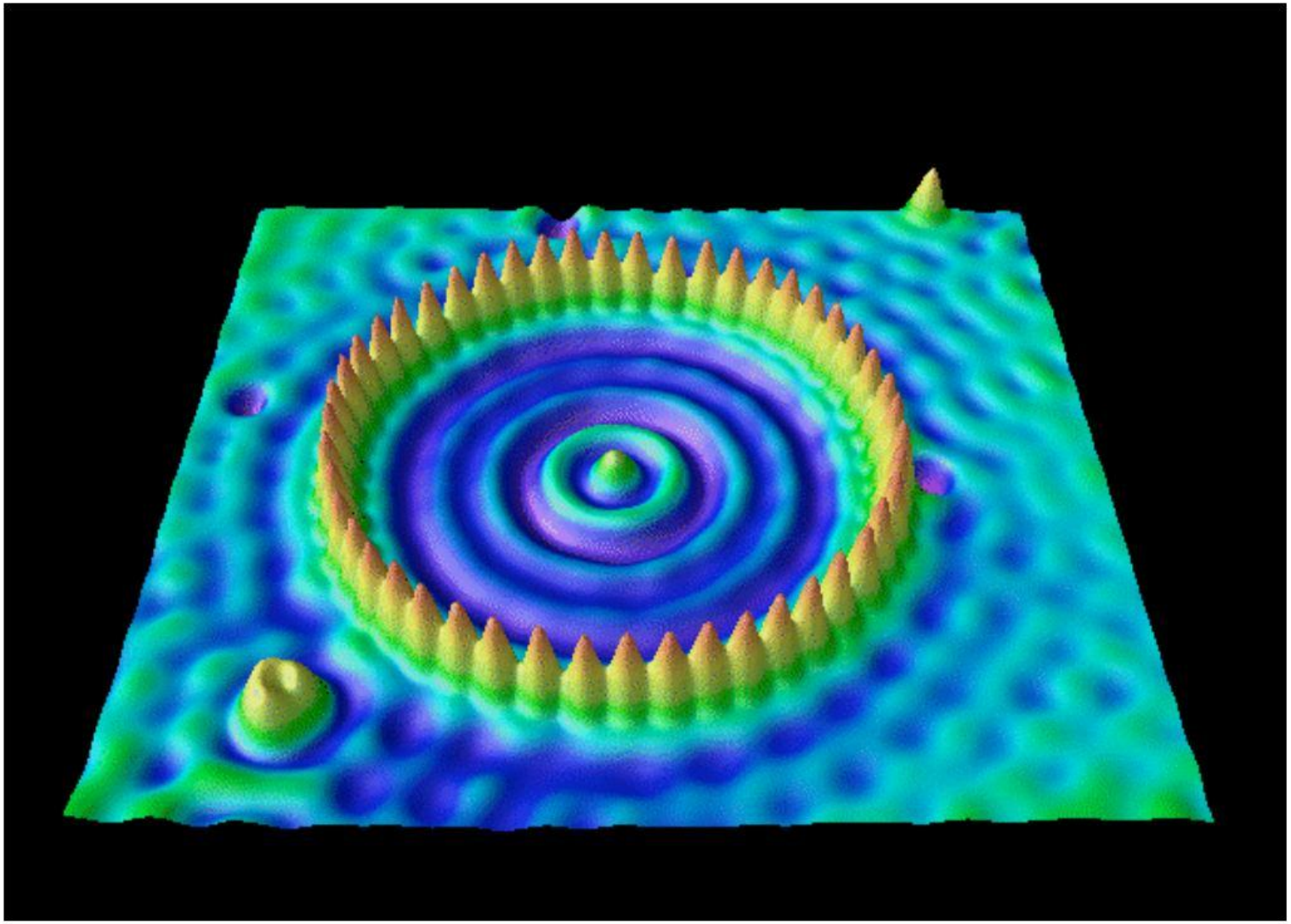
The sun is a "proton stove."

All atoms have about the same size (although different types have different weights).

The size of an atom is given by the size of the electron wave, which depends on its speed, which depends on how strong the pull is from the proton. This pull is called the electric force.

It turns out that the electric pull is almost unimaginably stronger than the pull of gravity. This causes atoms to be very tiny while the solar system is big.

Atomic electron waves



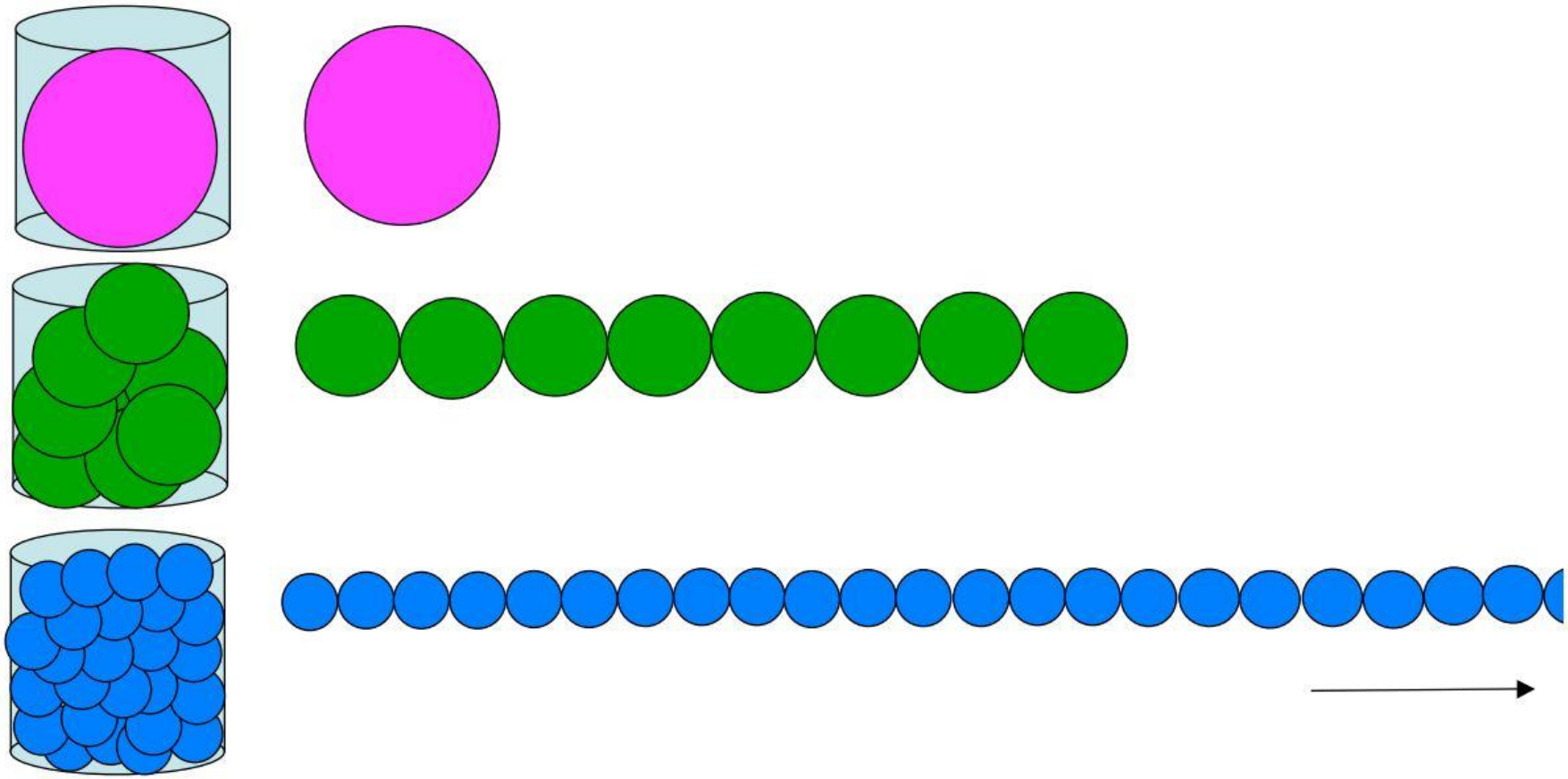
Picture made with a scanning tunneling microscope.

How many atoms in you?

There are many more atoms in you than grains of sand on Cape Cod.

If your atoms were as big as a grain of sand, and we spread them over all of Cape Cod, they would make a pile that was a mile high!

This is a lot of atoms!

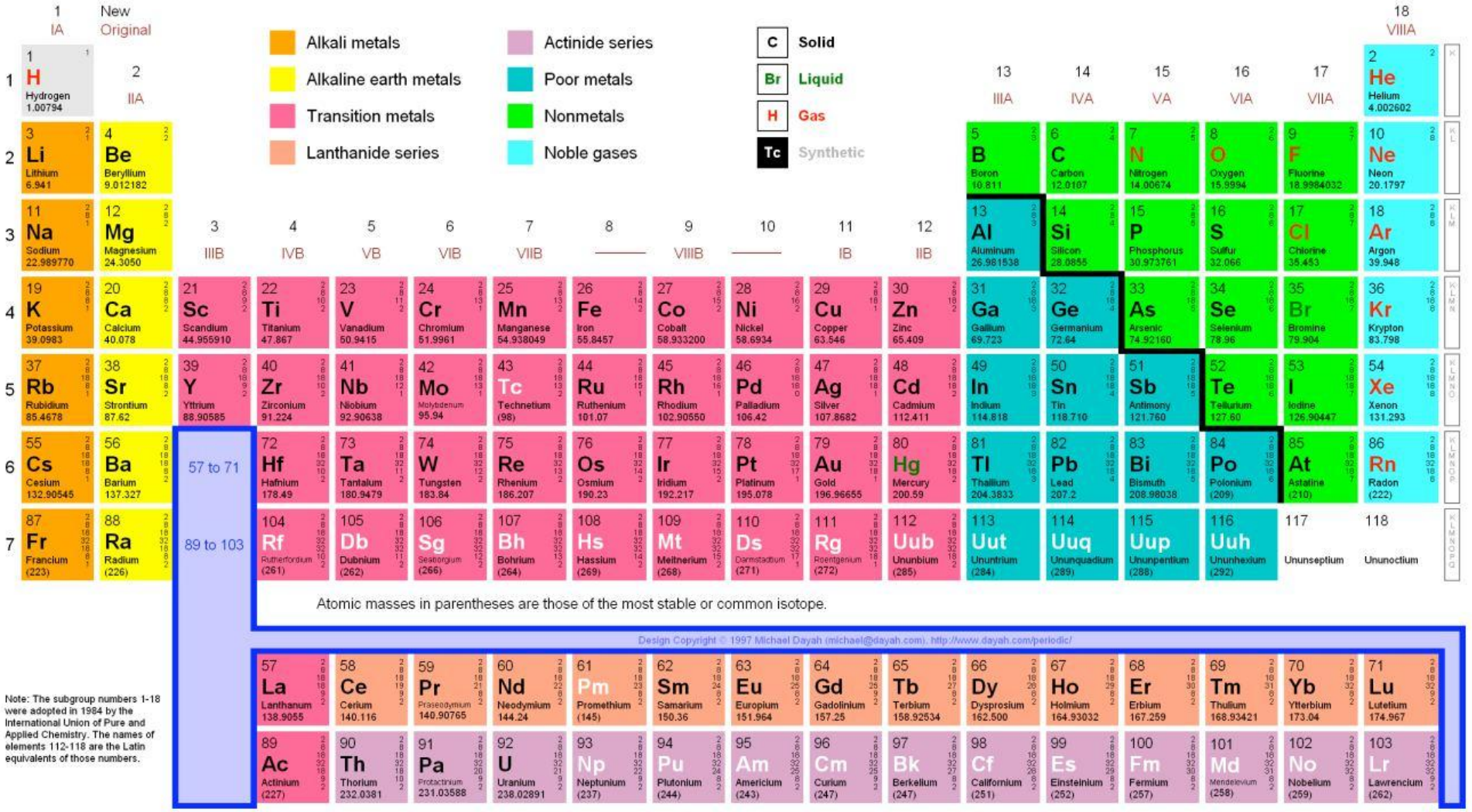


If you could take all the atoms in your body and line them up single file, they would strech all the way to the Andromeda Galaxy!

That's a lot of atoms.

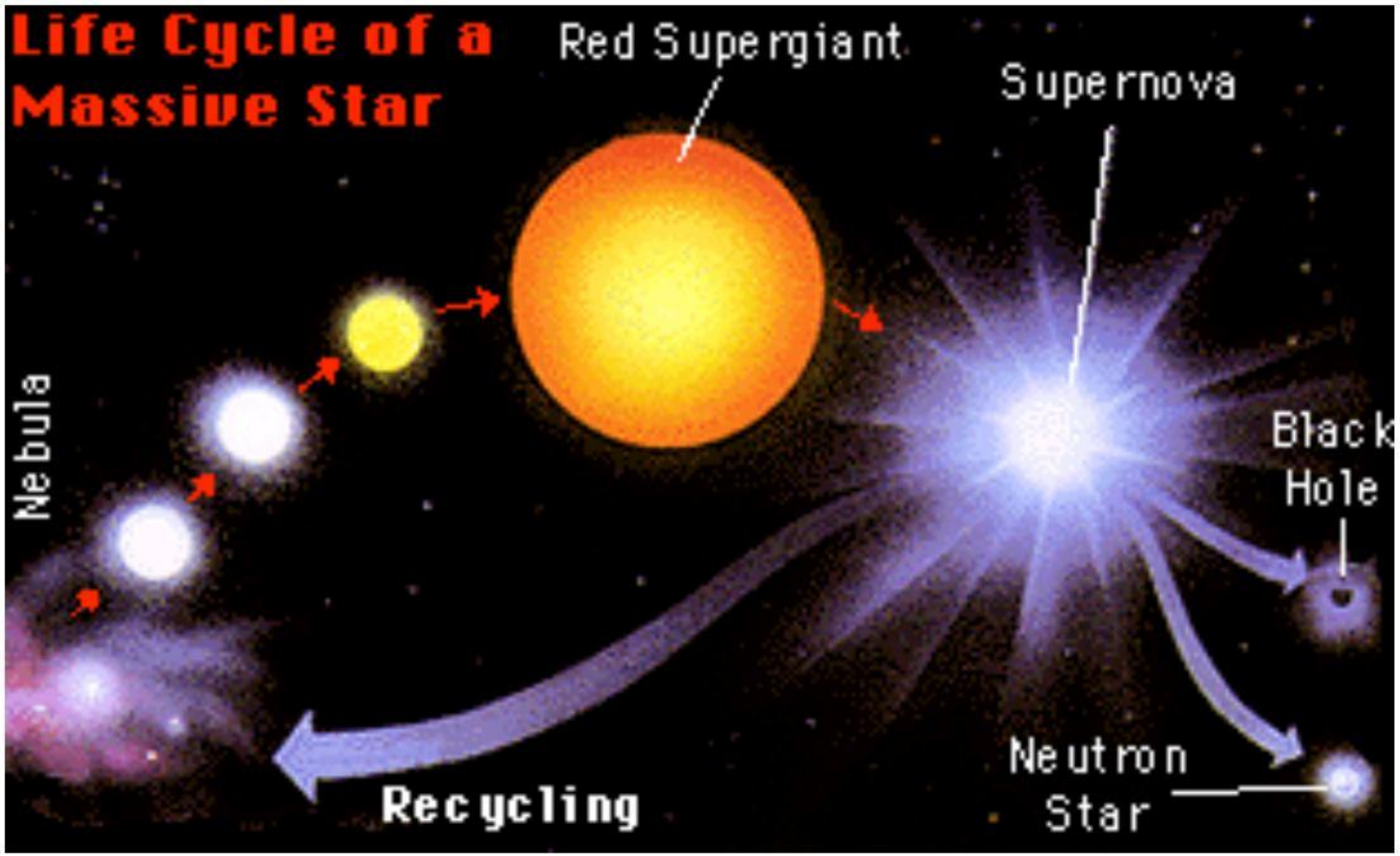
A star, we have seen is a proton burning stove. The protons to fuel the stove, as we shall see come from the "Big Bang." Inside the proton stove, something really exciting is cooking: the nuclei of heavier atoms (up to iron, number 26)!

Periodic Table of the Elements



Note: The subgroup numbers 1-18 were adopted in 1984 by the International Union of Pure and Applied Chemistry. The names of elements 112-118 are the Latin equivalents of those numbers.

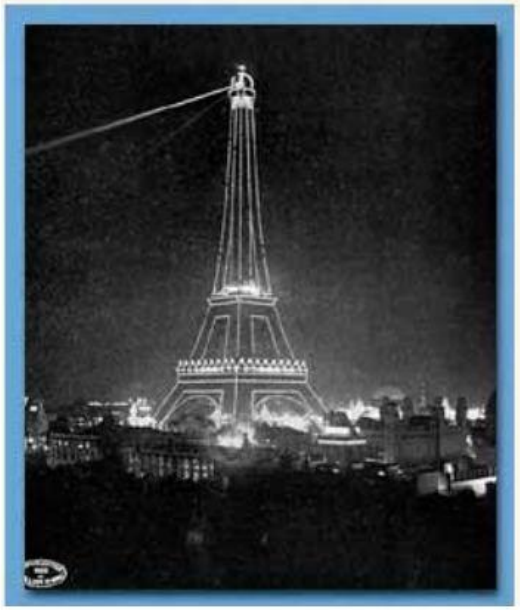
When a star runs out of protons, it has a gravitational collapse which can be followed by a HUGE explosion– a supernova!



The nuclei of atoms heavier than iron are produced in supernovae!

Marie Curie

It was an exciting time…



Paris lit by electricity in 1900

Discovered Radium and many atomic properties

Nearby supernova: Crab

July 4, 1054: seen on earth

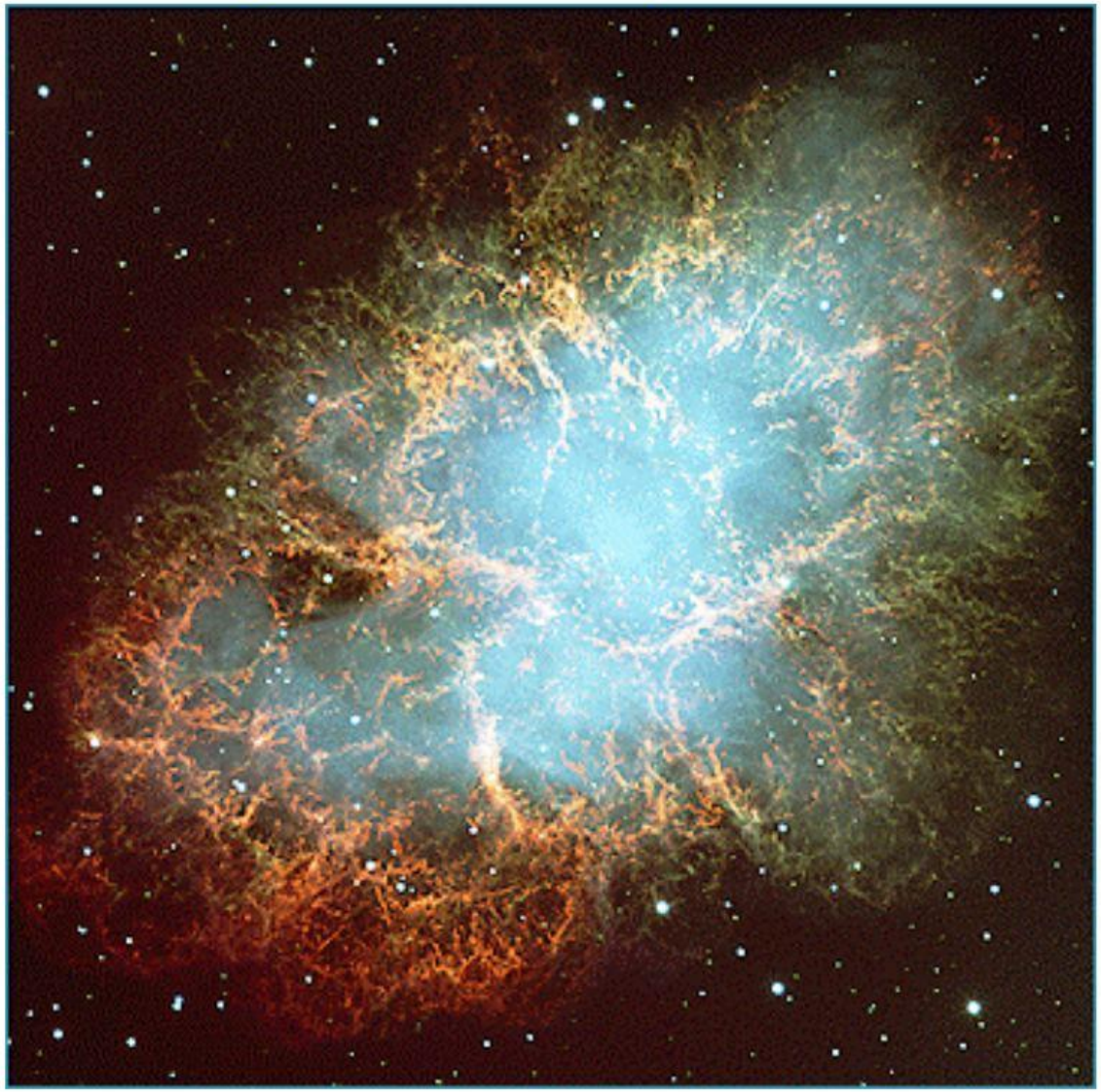
It took 6000 years for the light to reach the earth!

Chaco Canyon, New Mexico

What is left of the exploded star?

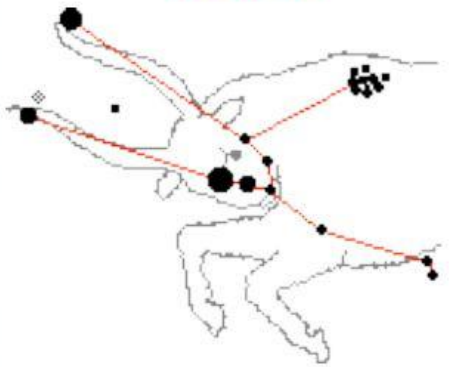
Stardust!

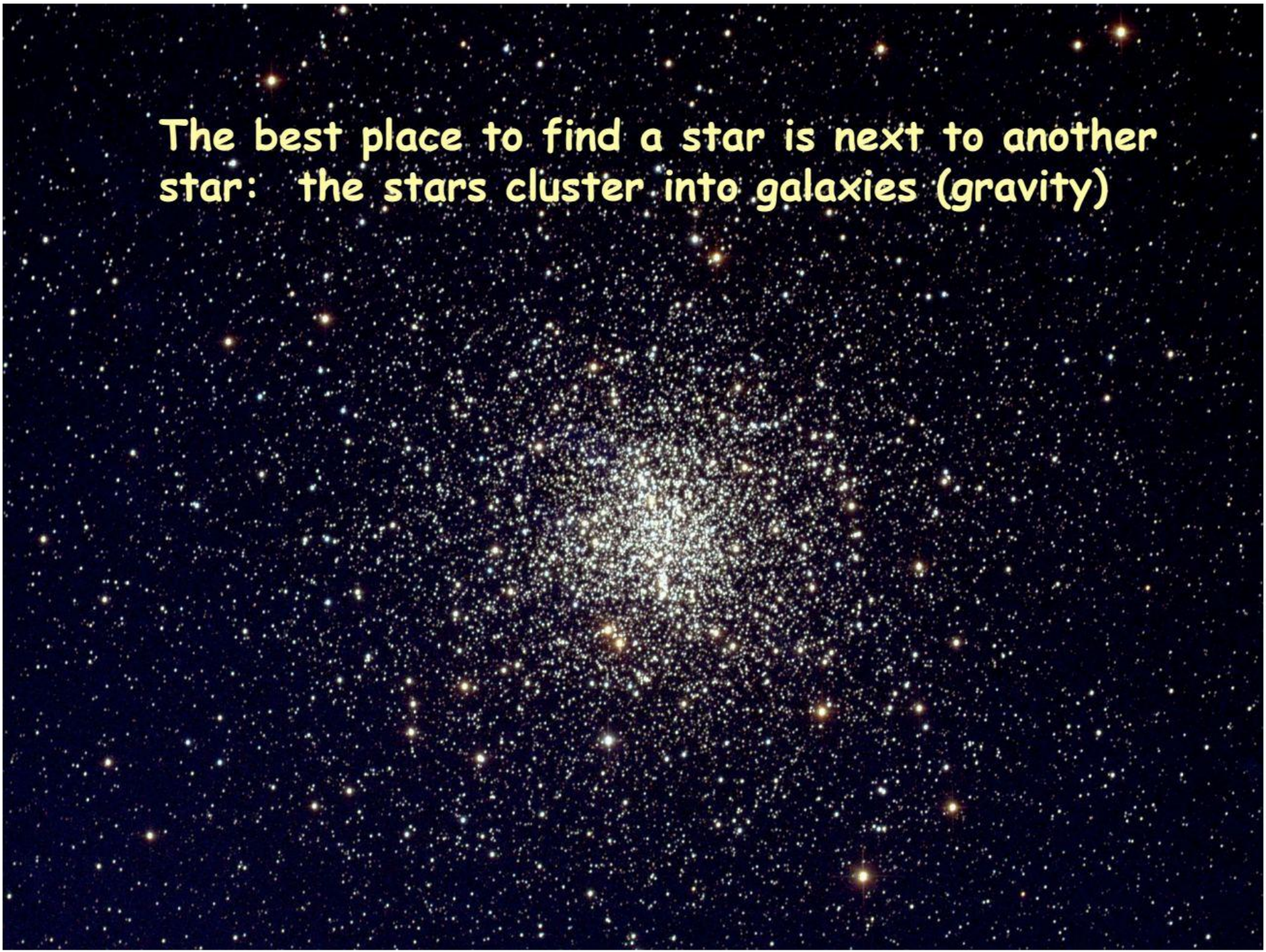
Looking back 6000 years in time!



Crab Nebula

Taurus



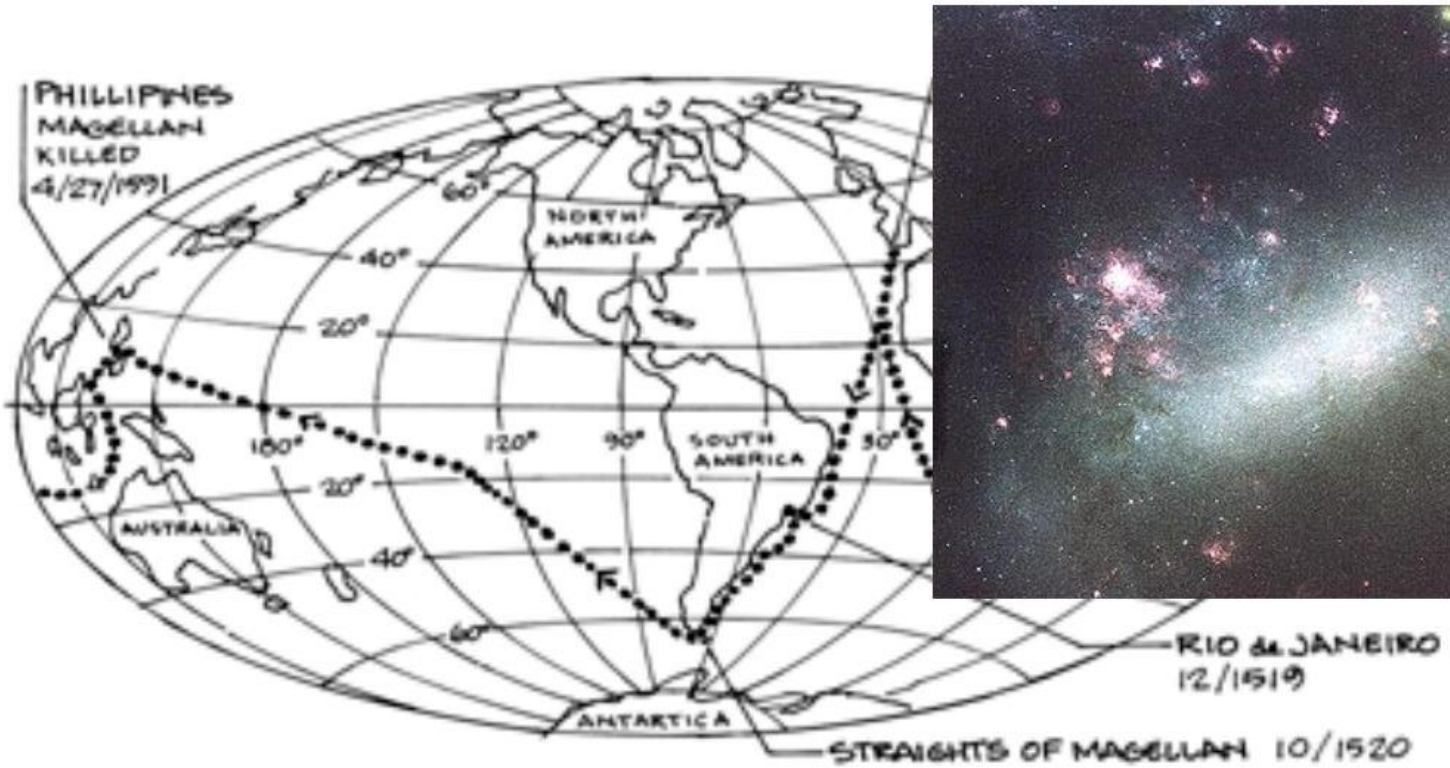

The best place to find a star is next to another star: the stars cluster into galaxies (gravity)


Our Galaxy: The Milky Way

There are about as many stars in our galaxy... as there are grains of fine sand in a large bucket!

(200 billion, more or less)

Ferdinand Magellan made a famous voyage to the Southern Hemisphere in 1519-21. He observed some stars in a nearby "dwarf" galaxy, now known as the **Large Magellanic Cloud**.



In 1987, the light from an exploding star in Large Magellanic Cloud reached the earth.

The star expoded 160,000 years ago!

Supernova 1987A

before supernova

during supernova

For about a month the star was as bright as the stars in the Big Dipper.

after supernova

Sanduleak-69 202, Large Magellanic Cloud

A modern day explorer: Edwin Hubble

(1889-1953)

Hubble discovered:

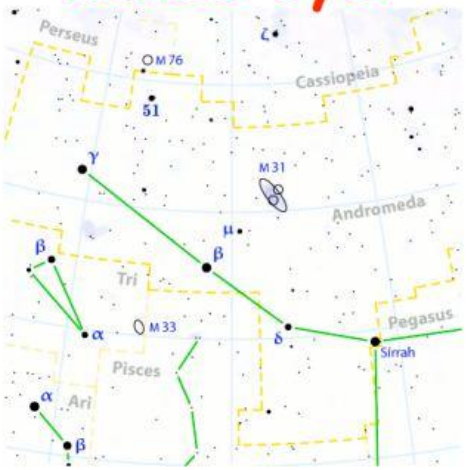
1) There are other galaxies besides ours.

2) The galaxies are moving away from each other.

Our neighboring galaxy: Andromeda (M31)

Looking back 3 million years!

Visible to naked eye!



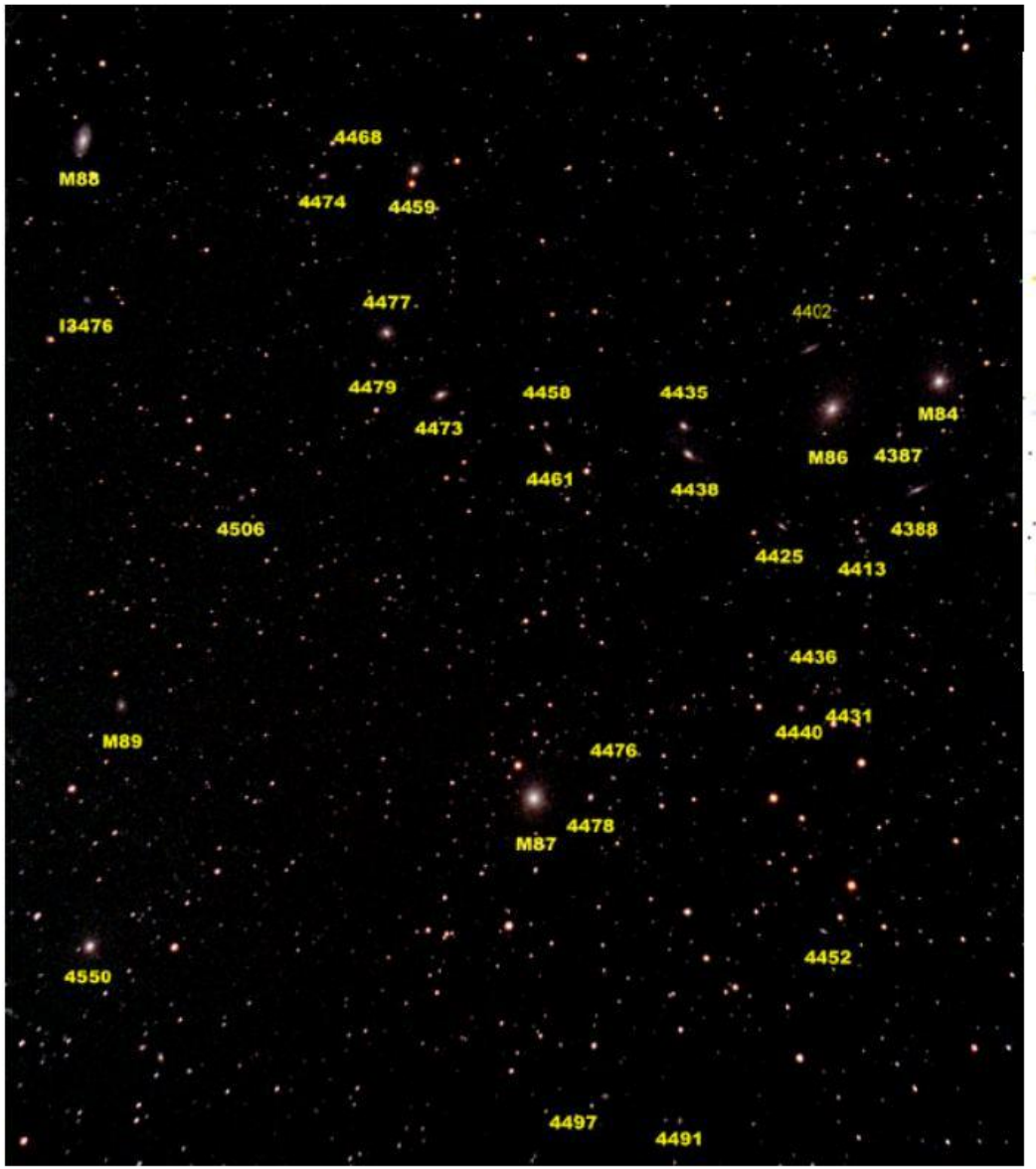
Gustave Doré

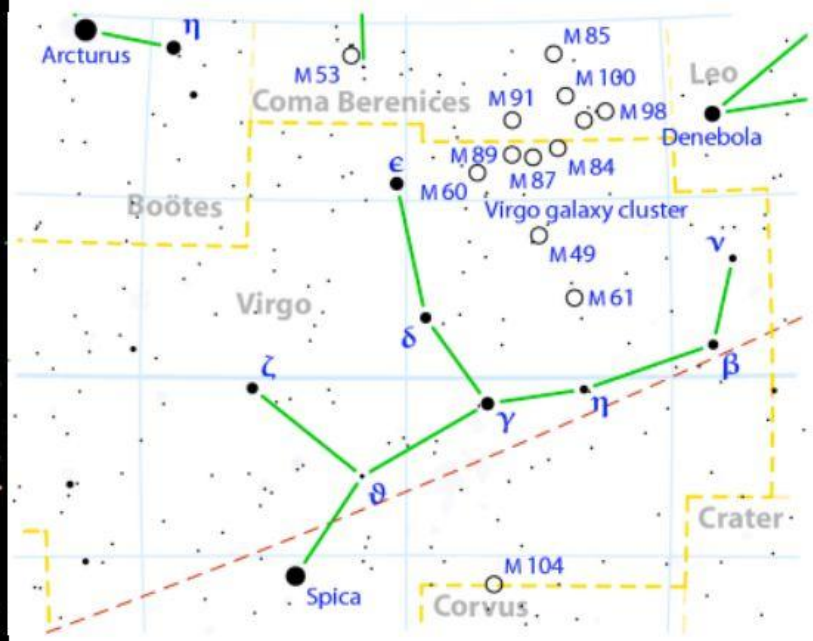
Cosmology


DUNKIN'
DONUTS
FLAVOR
OLOGY
COFFEE BLENDS & MYSTIC MATCHES
THIS BEVERAGE IS EXTREMELY HOT

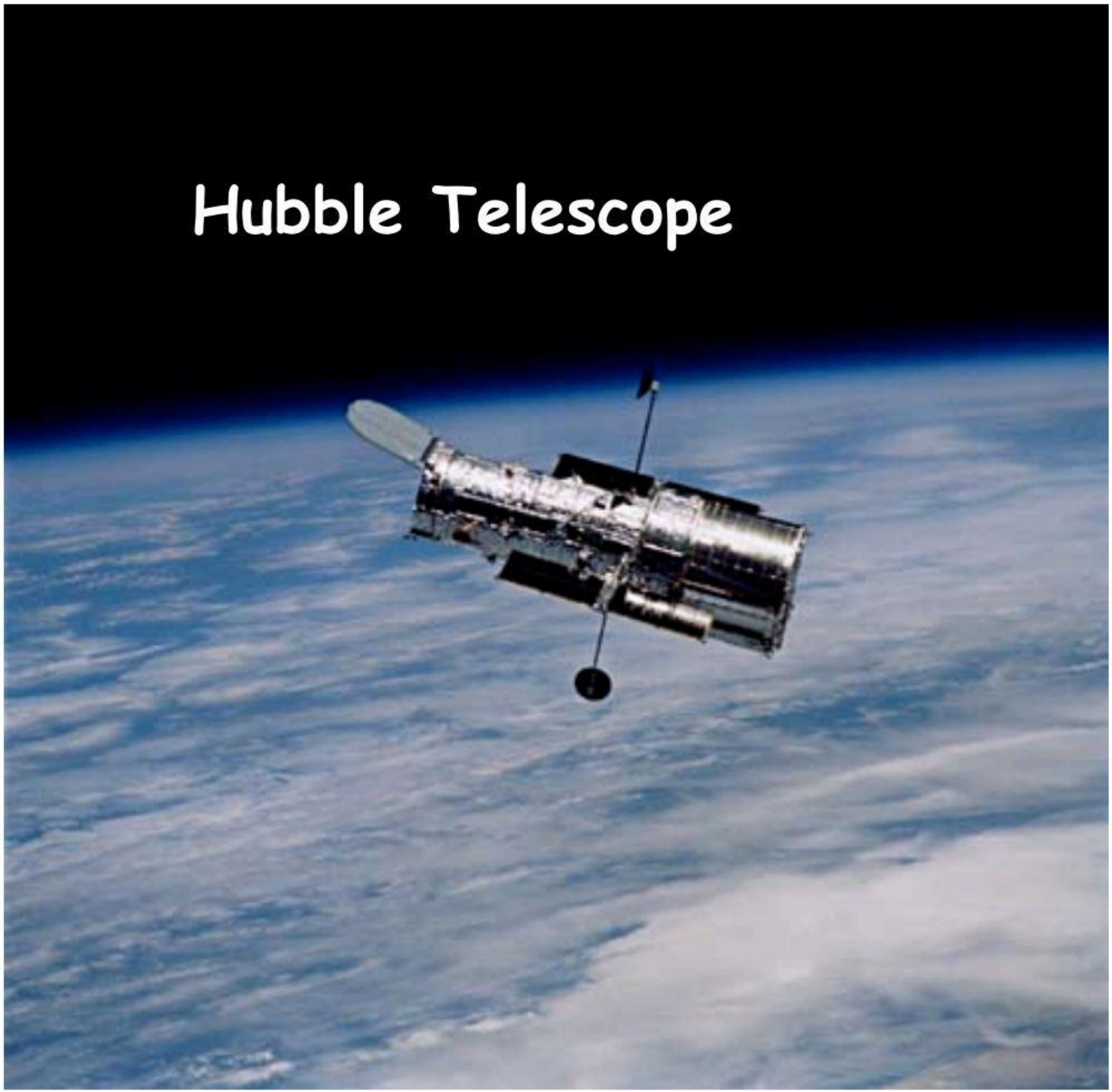
Our neighboring cluster of galaxies; Virgo

Looking back 50 million years!



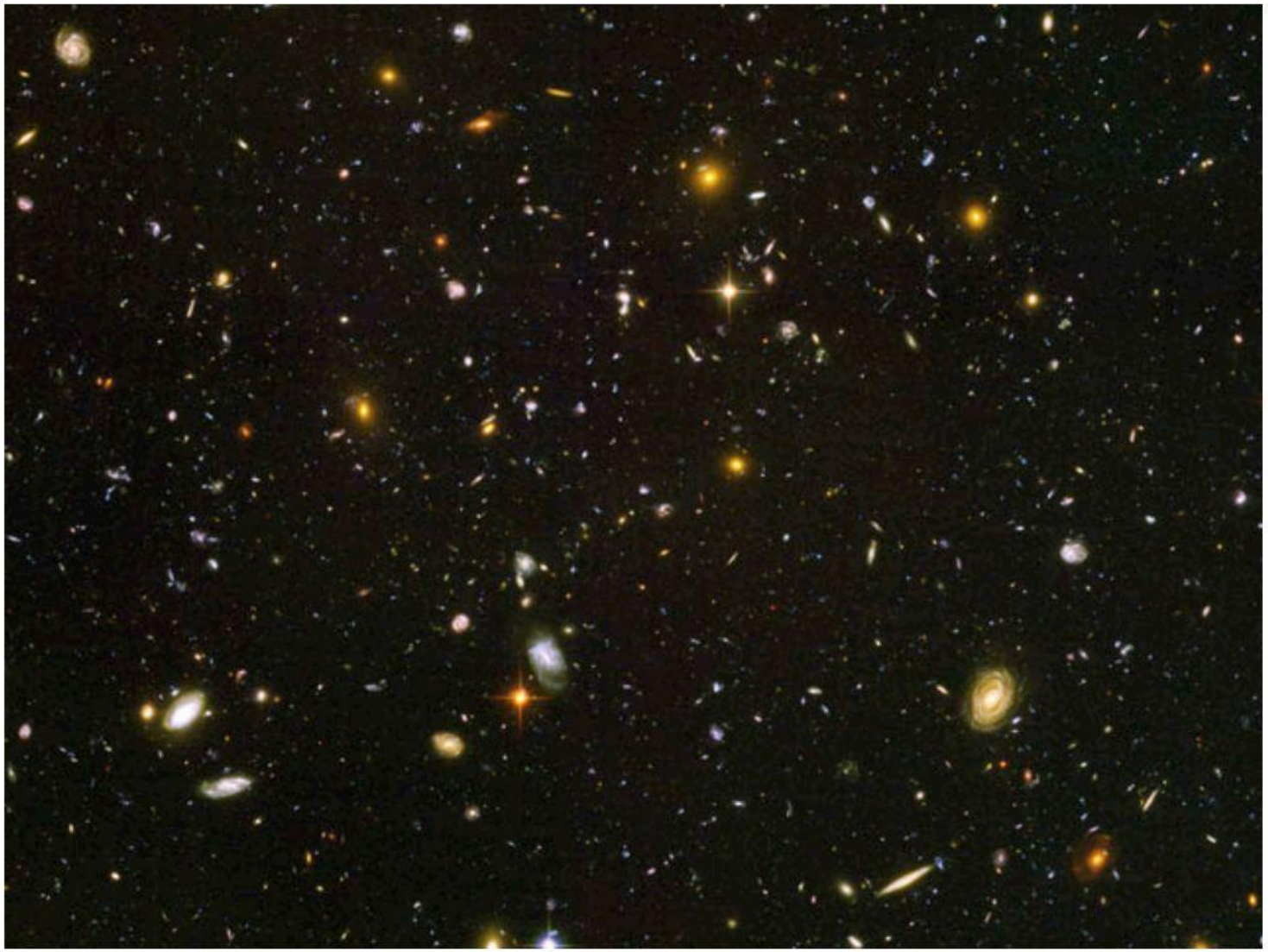


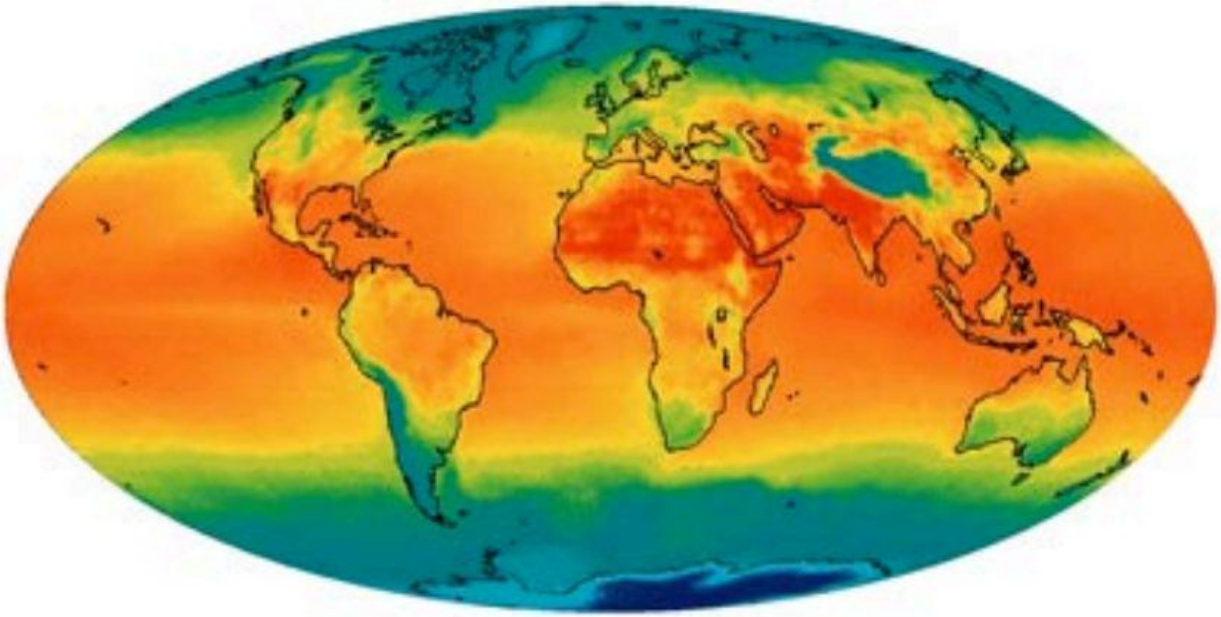
Hubble Telescope



View from Hubble telescope to the edge of the visible universe.

Looking back 10 billion years!





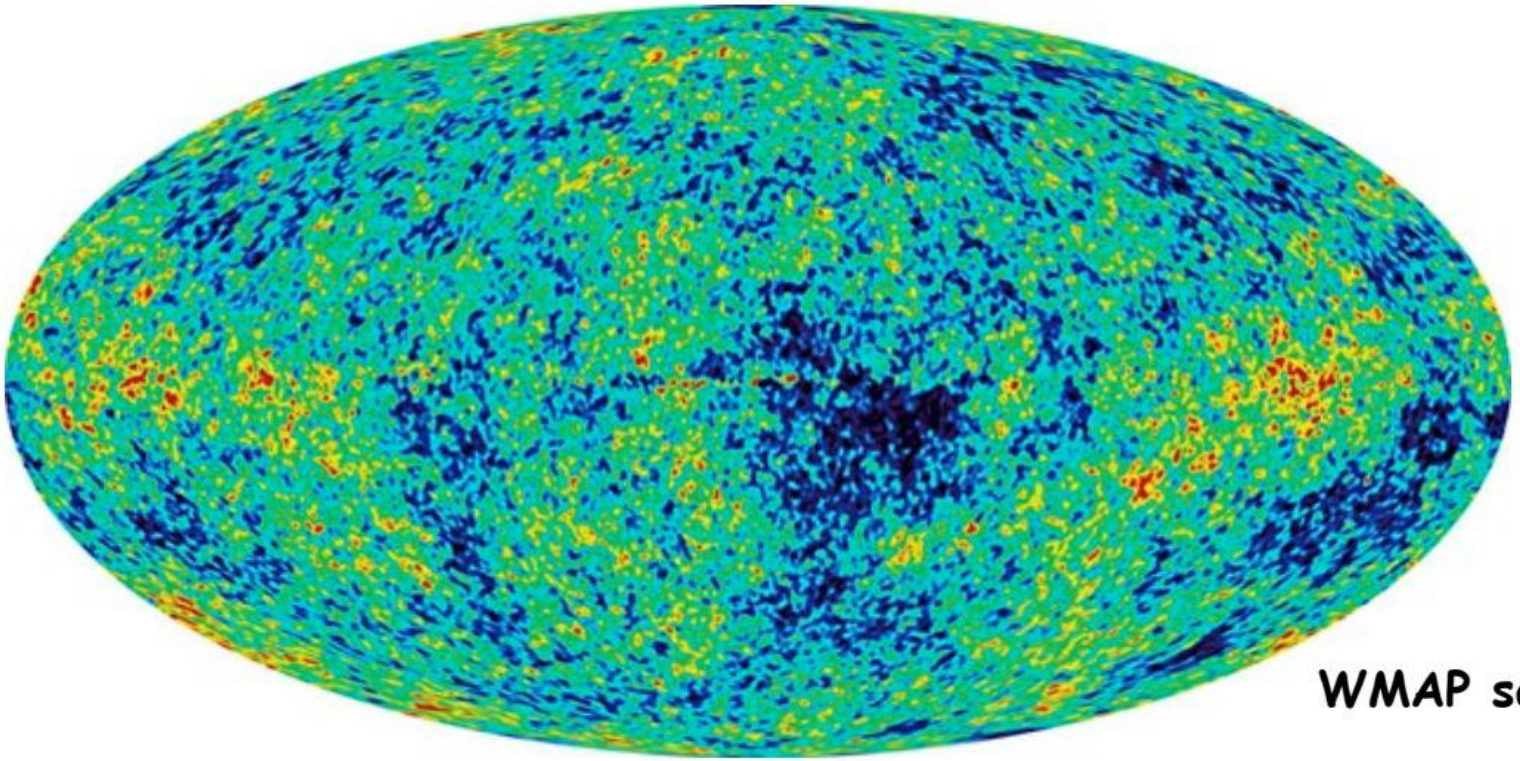
Earth Temperatures

-63° -13° 37°

Centigrade

June 1992

Baby picture of the universe with microwaves



WMAP satellite

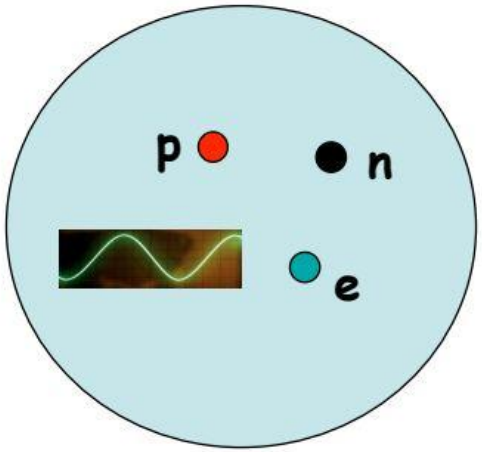
What do we know for sure?

The universe is expanding and cooling
(the galaxies are rushing away).

Physics of neutrons and protons
(how stars burn).

Physics of light and atoms
(can see microwaves from the first atoms).

Let's start our description where we start to know the physics… looking back as far in time as we can…



microsecond

The whole universe is only the size of the Sagamore bridge!

It is super HOT,
10 trillion degrees,
(10000000000000) !

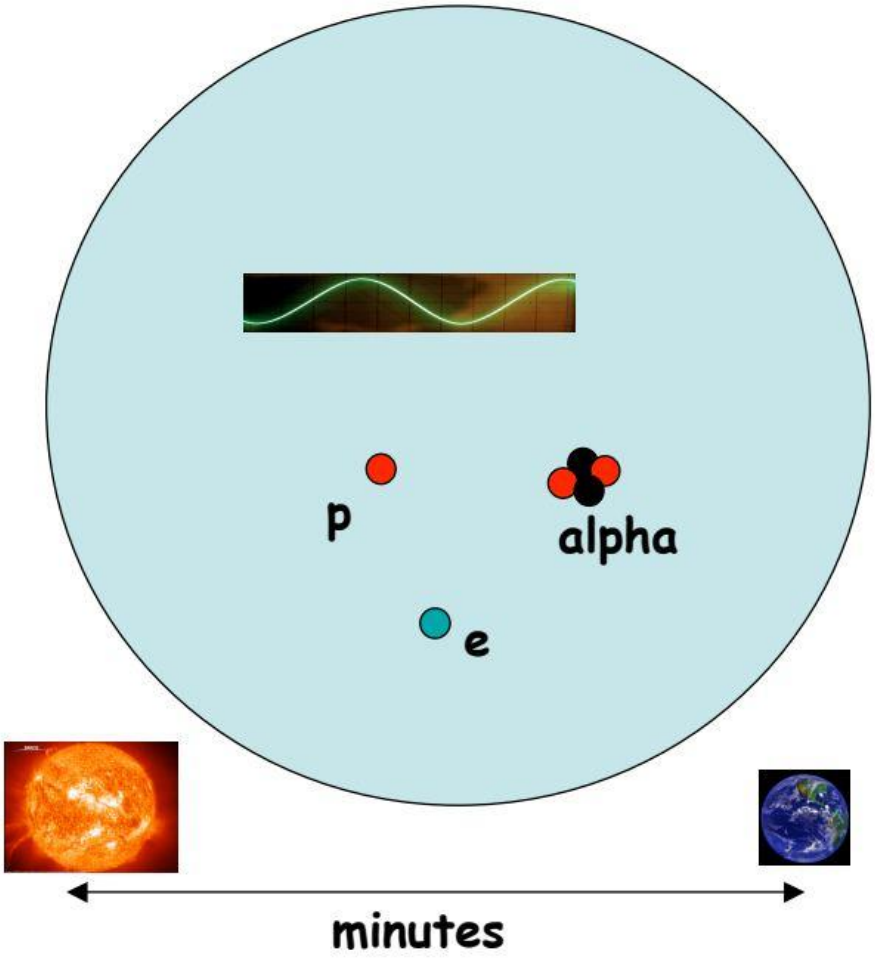
We have a hot "soup" of protons, neutrons, and electrons and radiation.

NO: stars, earth, people not even atoms!

Jackson Pollock, *Convergence*

(Buffalo, NY)

After a couple of minutes, the universe has greatly expanded and cooled….

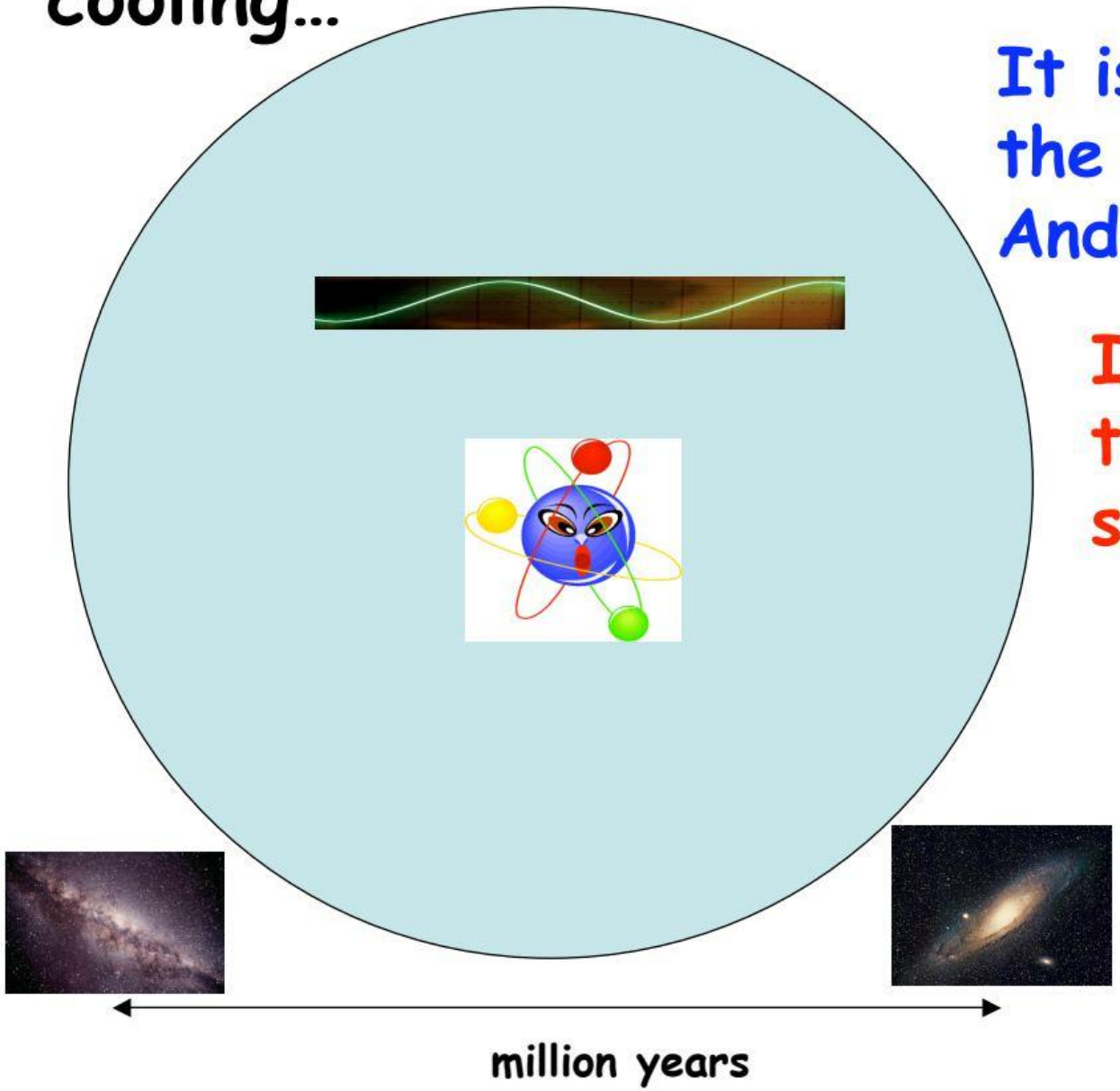


It is now as big as the distance to the sun!

It is still HOT, a billion Degrees, hotter than the inside of the sun.

It is just the right temperature to cook protons and neutrons into Helium nuclei (alpha particles)

After 400,000 years of expansion and cooling…



It is now as big as the distance to Andromeda!

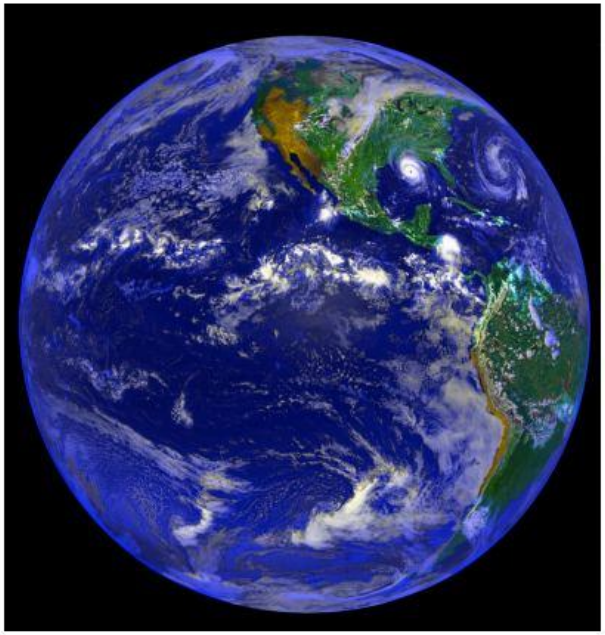
It is as hot, as the surface of a star ("white hot").

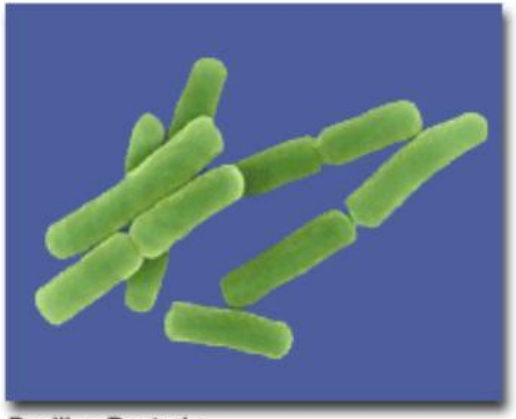
It is cool enough to make atoms of Hydrogen and Helium.

In the next billion years or so, the first stars were born by gravitational attraction of the atoms… and the stars were attracted to each other to form galaxies… and the galaxies were attracted to form clusters of galaxies…

One of these early galaxies was our own Milky Way…

Four billion years later, our own sun and earth were formed…



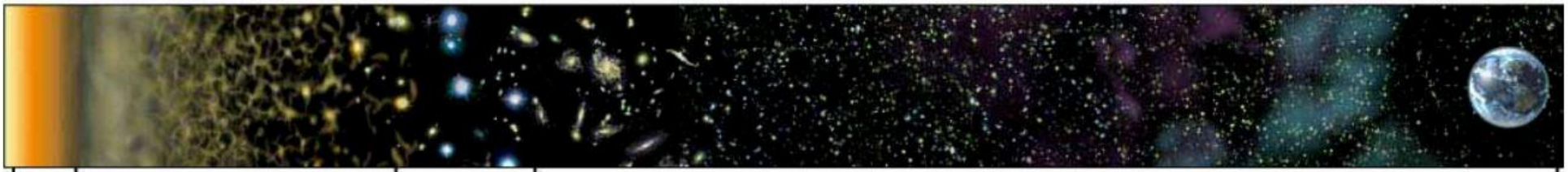


Bacillus Bacteria

and a billion years later the first cells appeared…

And a few billion years after that (200 million years ago), the first mammals appeared…

Time Since the Big Bang



0 | 379,000 years | 200 million years | 1 billion years | Present

First atoms

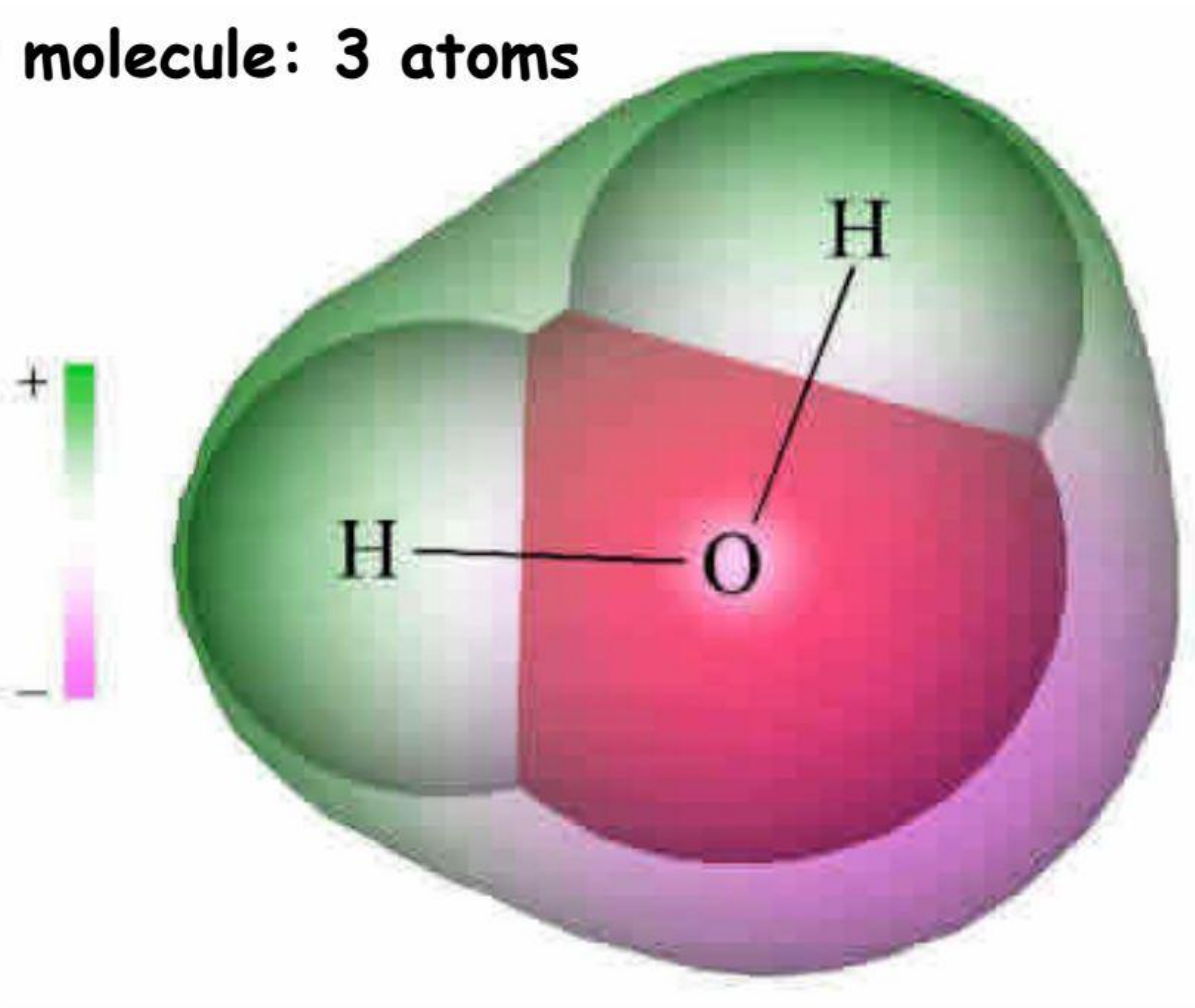
First stars

First galaxies

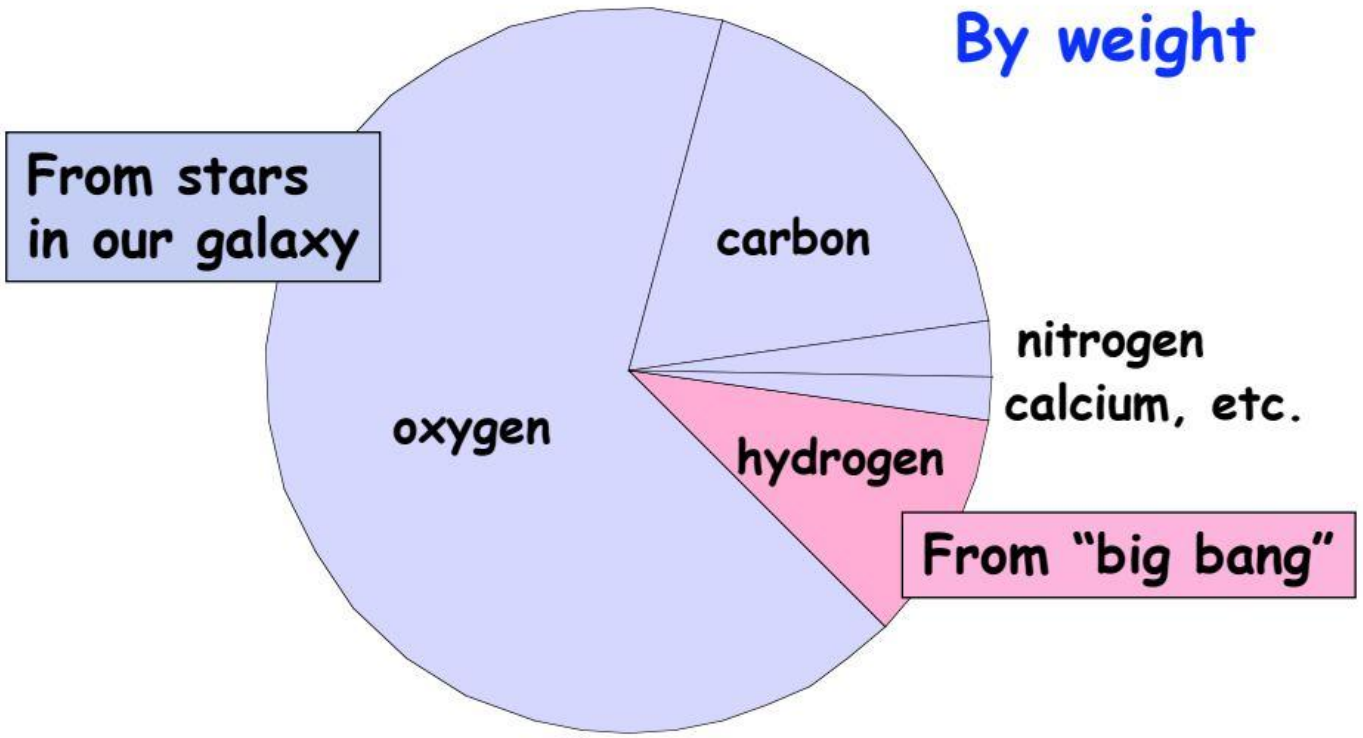
Now

You are mostly water

Water molecule: 3 atoms



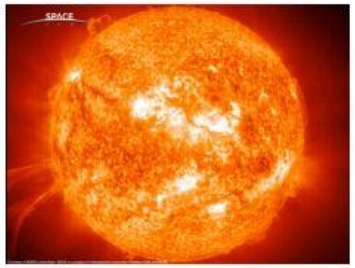
What are you made of and where did it came from?



You are 10% "big bang" hydrogen and 90% Milky Way stardust!

How old?

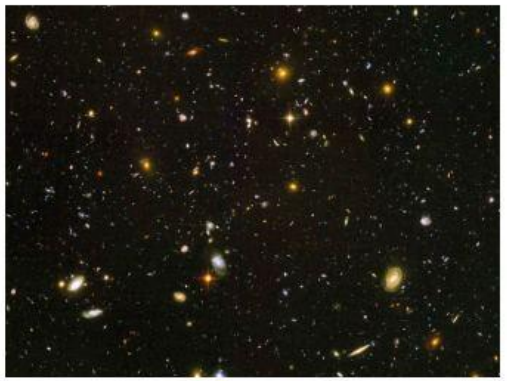
Sun 5 billion years



Earth 5 billion years

Milkey way 13 billion years

Universe? At least 13 billion years old, but beyond that we DO NOT KNOW because we do not yet know the physics

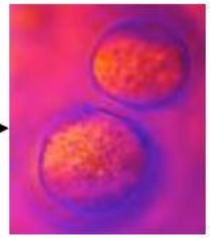


What if we want to understand even more about what happened and why?

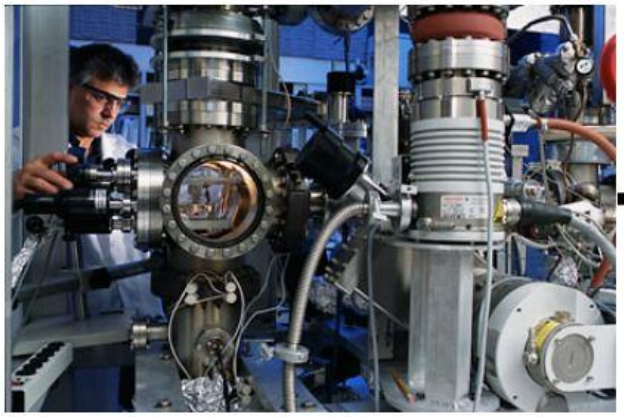
Further back in time the universe was very, very tiny (and hot)!

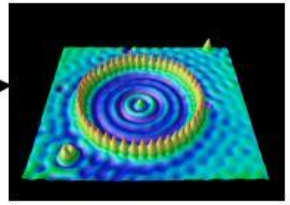
We need the world's best microscope!

Light wave microscope



Electron wave microscope

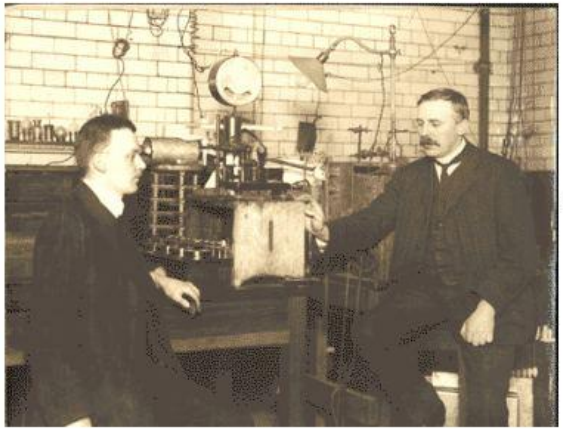




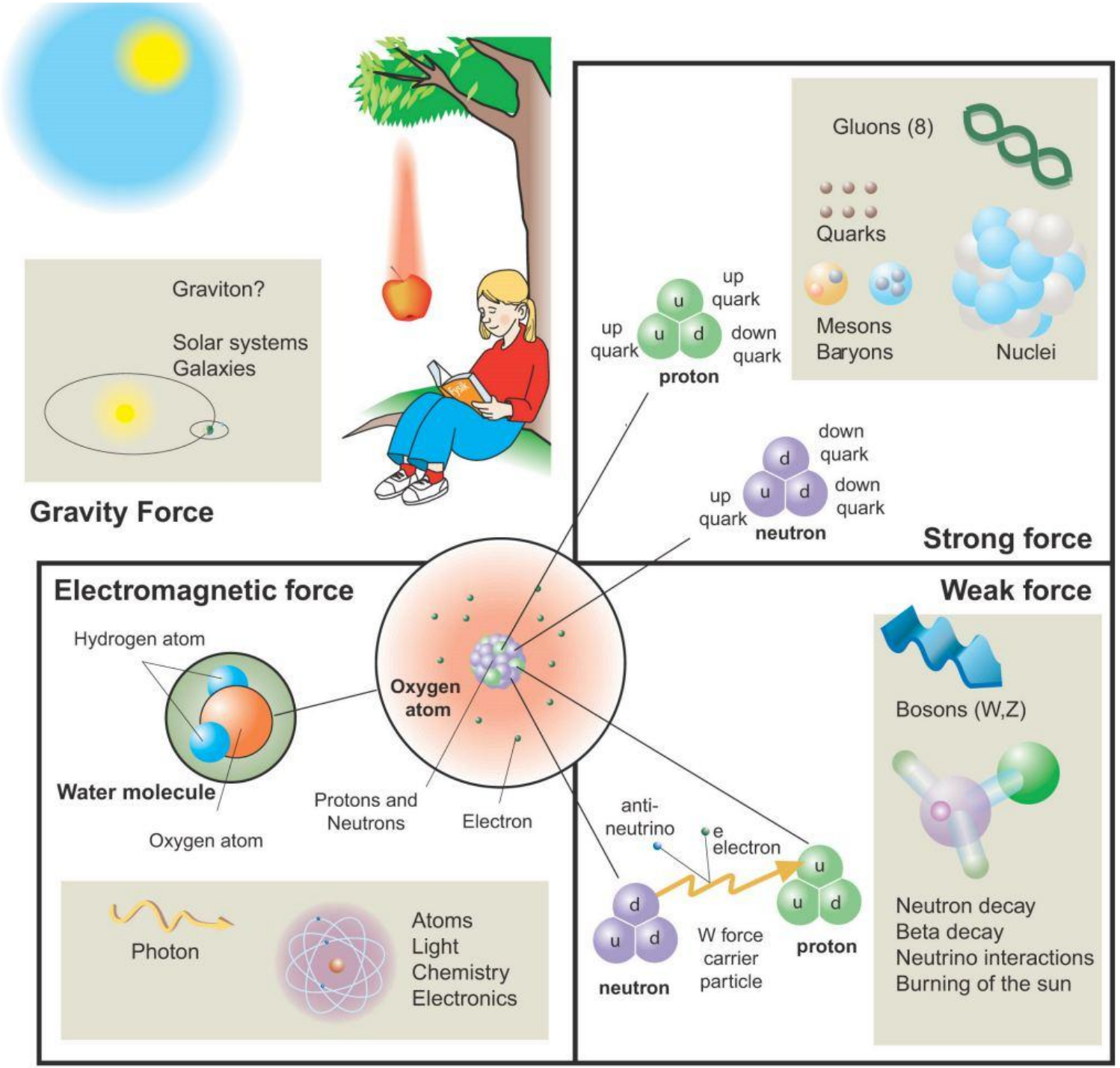
More powerful electron wave microscope

→ Quarks

Alpha wave microscope

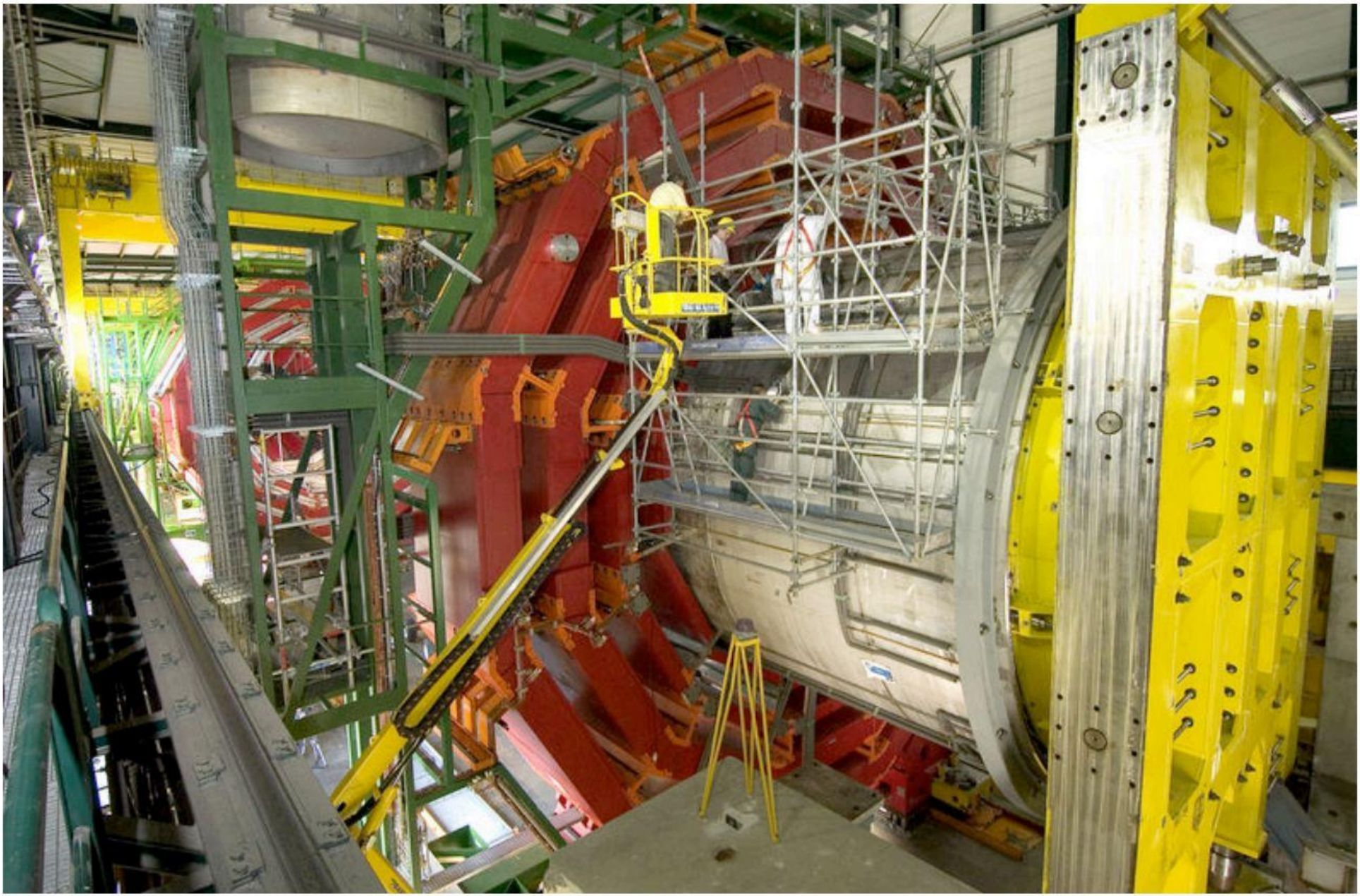


→ Atomic nucleus


Graviton?
Solar systems
Galaxies
Gravity Force
Gluons (8)
Quarks
Mesons
Baryons
Nuclei
up quark
up quark
down quark
proton
down quark
up quark
down quark
neutron
Strong force
Electromagnetic force
Hydrogen atom
Oxygen atom
Water molecule
Oxygen atom
Protons and Neutrons
Electron
Photon
Atoms
Light
Chemistry
Electronics
anti-neutrino
e electron
neutron
W force carrier particle
proton
Weak force
Bosons (W,Z)
Neutron decay
Beta decay
Neutrino interactions
Burning of the sun


GERMANY
Schaffhausen
Rhine
Bodensee
Basel
Winterthur
Zürich
Sankt Gallen
Zürichsee
LIECHTENSTEIN
AUSTRIA
FRANCE
Biel
Lucerne
Neuchâtel
BERN
Lake of Lucerne
J U R A
Fribourg
Lac de Neuchâtel
Rhine
Chur
Lausanne
A L P S
Lake Geneva
Lago Maggiore
ITALY
Geneva
Dufourspitze
Lugano
0 20 40 km
0 20 40 mi
6
8
10
47
46

Quark wave microscope



The universe is

Big!
Old!
Evolving!

Some links to explore…

European Space Agency
http://www.esa.int/esaKIDSen/index.html

Jet Propulsion Laboratory
http://www.jpl.nasa.gov

Windows to the Universe
http://www.windows.ucar.edu

Hubble Telescope
http://hubblesite.org

CERN
http://public.web.cern.ch