



THE BIG BANG

'IT ALL STARTED WITH THE BIG BANG!'

[Big Bang Theory song](#)

THE BIG BANG THEORY



Time	10^{-43} sec.	10^{-32} sec.	10^{-6} sec.	3 min.	300,000 yrs.	1 billion yrs.	15 billion yrs.
Temperature		10^{27} °C	10^{13} °C	10^8 °C	$10,000$ °C	-200° C	-270° C

- 1** The cosmos goes through a superfast "inflation," expanding from the size of an atom to that of a grapefruit in a tiny fraction of a second
- 2** Post-inflation, the universe is a seething, hot soup of electrons, quarks and other particles
- 3** A rapidly cooling cosmos permits quarks to clump into protons and neutrons
- 4** Still too hot to form into atoms, charged electrons and protons prevent light from shining; the universe is a superhot fog
- 5** Electrons combine with protons and neutrons to form atoms, mostly hydrogen and helium. Light can finally shine
- 6** Gravity makes hydrogen and helium gas coalesce to form the giant clouds that will become galaxies; smaller clumps of gas collapse to form the first stars
- 7** As galaxies cluster together under gravity, the first stars die and spew heavy elements into space; these will eventually form into new stars and planets

NOTE: The numbers in cosmology are so great and the numbers in subatomic physics are so small that it is often necessary to express them in exponential form. Ten multiplied by itself, or 100, is written as 10^2 .

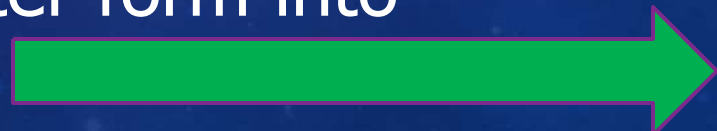
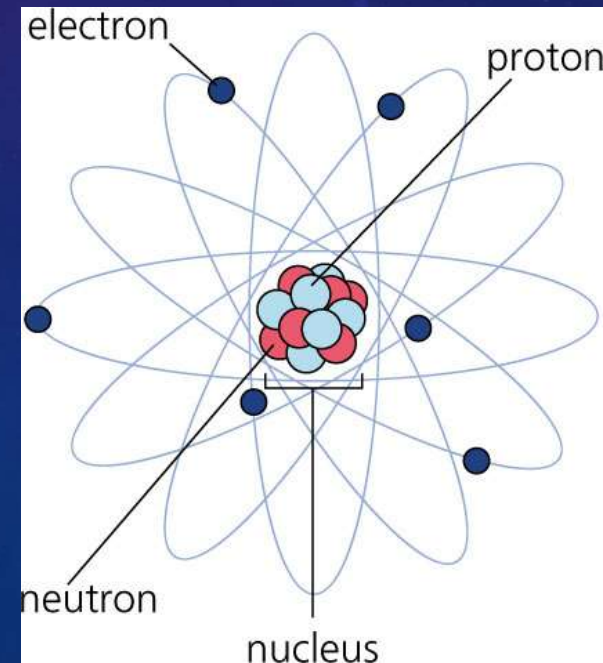
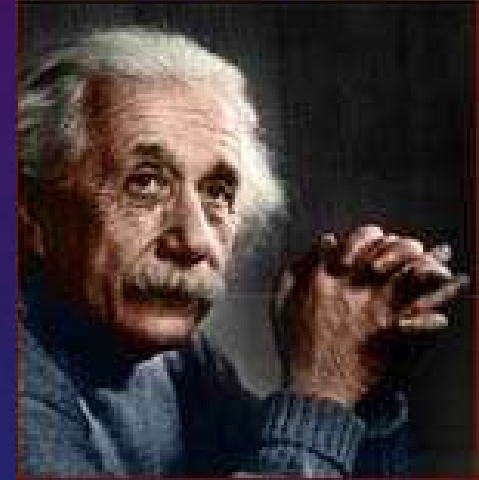
~ 3 MINUTES AFTER BIG

BANG

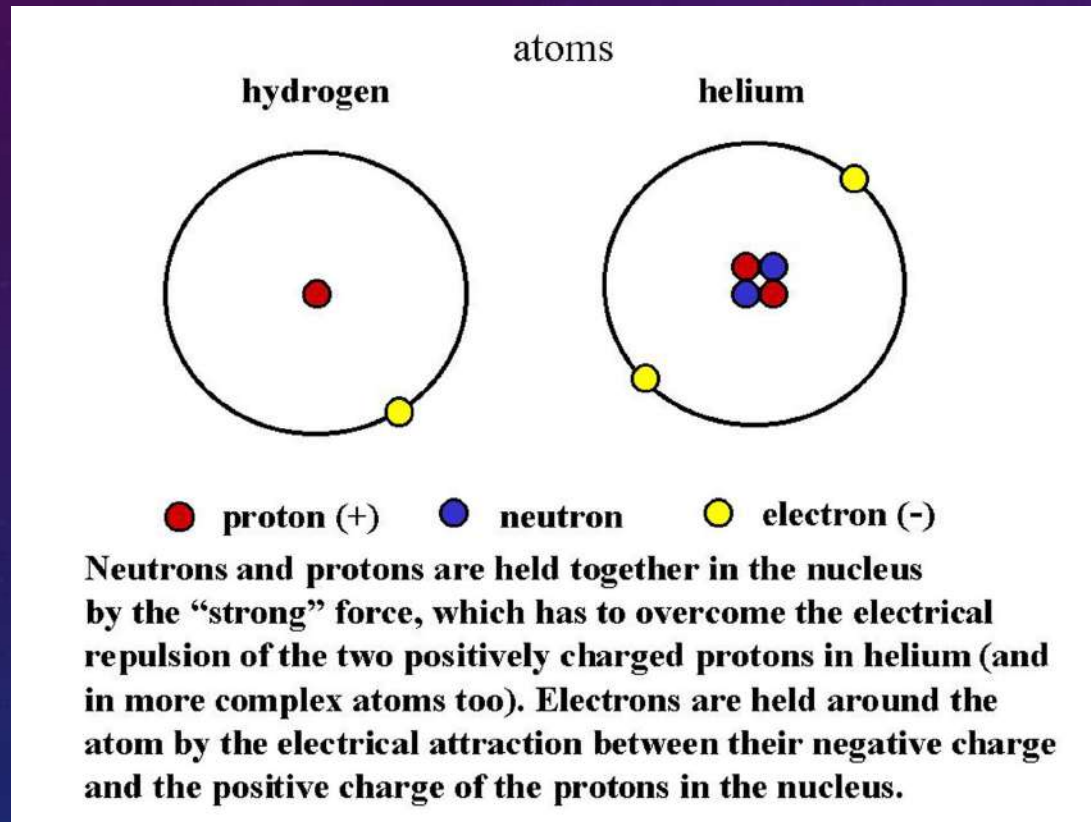
- The universe has grown from the size of an atom to larger than the size a grapefruit
- $E=mc^2$
- **energy froze into matter** according to Albert Einstein's equation.
- This basically says that like snowflakes freezing, **energy forms matter into clumps** that today we call protons, neutrons and electrons.
- These parts later form into atoms

NOBEL PRIZE WINNER:
ALBERT EINSTEIN

$$E = mc^2$$



~ SEVERAL HUNDRED THOUSAND YEARS AFTER BIG BANG



- **ATOMS form** (specifically **Hydrogen** and its isotopes with a small amount of **Helium**.)
- The **early Universe** was about **75% Hydrogen** and **25% Helium**. It is still almost the same today.

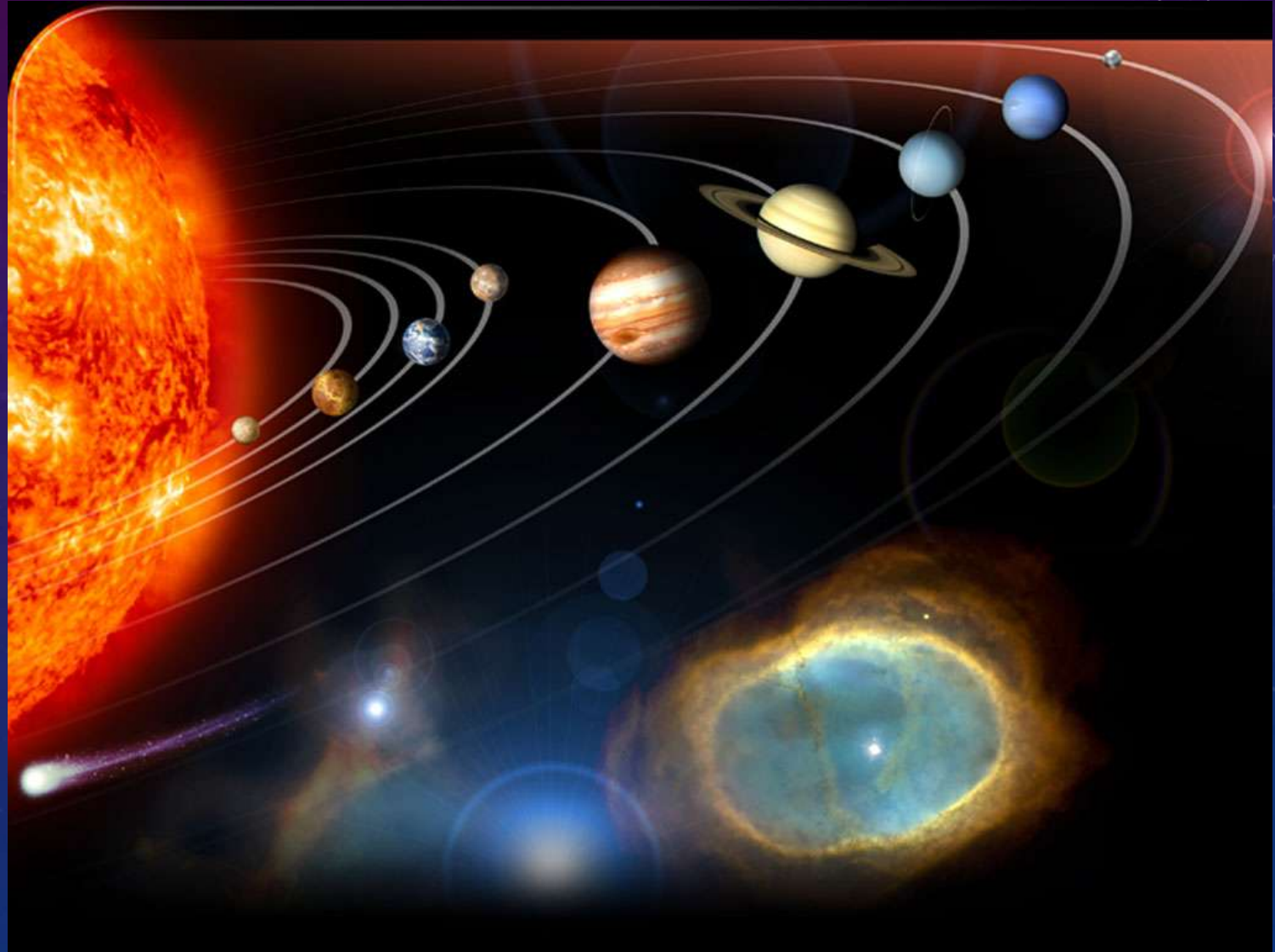
~200 TO 400 MILLION
YEARS AFTER BIG BANG



- 1st stars and galaxies form

~ 4.6 BILLION YEARS AGO

- Our Solar system forms



You are currently on a 4.5 billion
year old spaceship.

A self sufficient, organic, complex spaceship.

You are orbiting a power source that
is a million times larger than your ship.

There are 200 billion more power sources,
possibly with ships like yours, in your group.

There are 40 more groups in
your particular neighborhood.

Your neighborhood is moving at 2 million
miles per hour to an object that
is 150 million light years away.

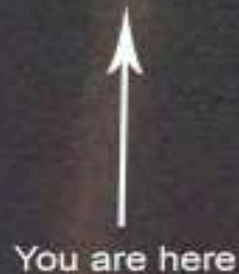
Welcome to life. It's more exciting
when you think on a larger scale.



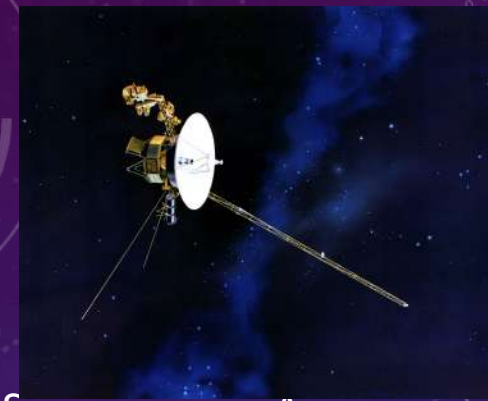
FOOD FOR
THOUGHT

"Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every "superstar," every "supreme leader," every saint and sinner in the history of our species lived there – on a mote of dust suspended in a sunbeam."

- Carl Sagan, 1934-1996



The Earth as imaged from the the Voyager 1 spacecraft, as it exited the solar system in 1990. Earth is nearly 4 billion miles away in this image.



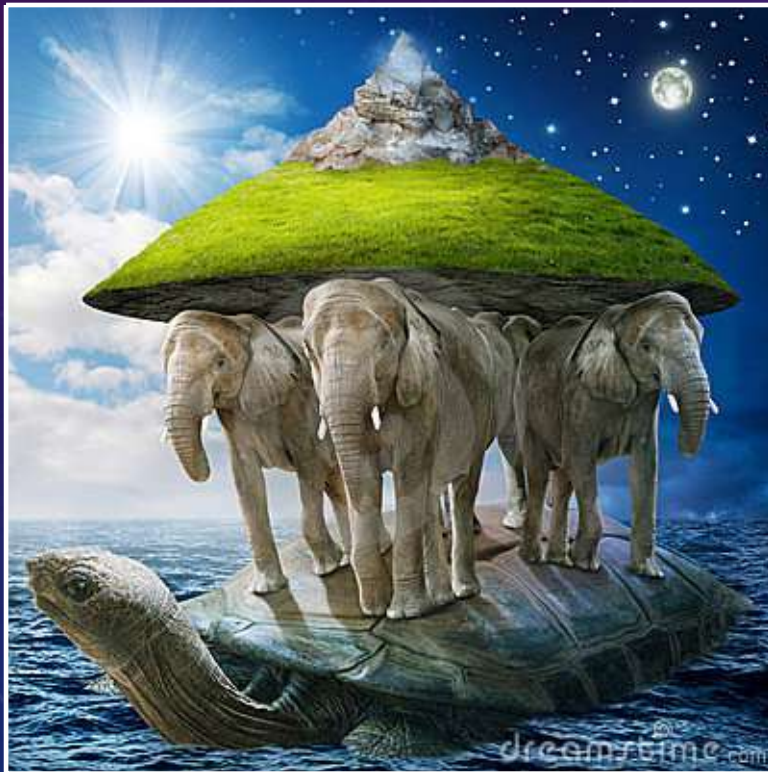
Carl Edward Sagan was an American astronomer, cosmologist and astrophysicist. Sagan assembled the first physical messages sent into space: the Pioneer plaque and the Voyager Golden Record, universal messages that could potentially be understood by any extra-terrestrial intelligence that might find them.



DIFFERENT THEORIES ON THE UNIVERSE

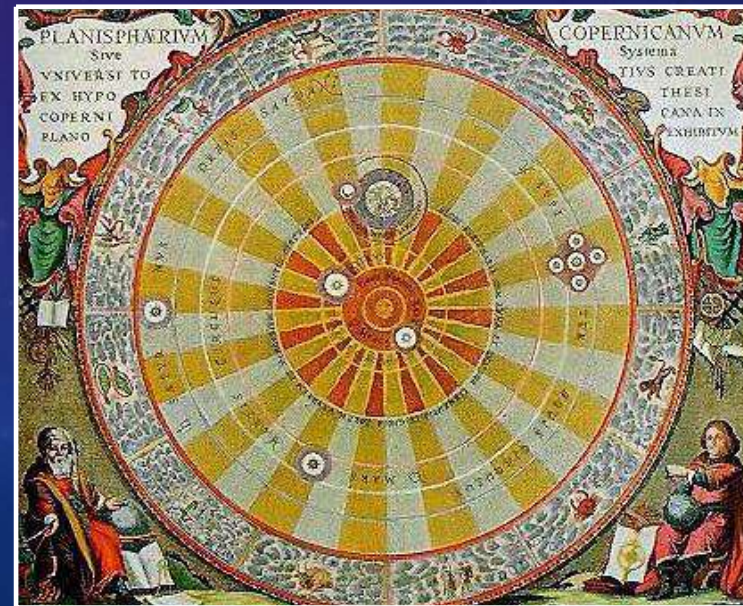
We have had many models that have represented the structure of the universe

Some ancient religions believed that the universe surrounded our Earth which sat upon the backs of elephants that rode a *cosmic turtle*!



Other, more mathematical models, placed the Earth and the Sun at the centre of the universe. It wasn't until 1915 when Albert Einstein's relativity theories marked the era of modern cosmology, proving that the Earth or the Sun was not at the universe's centre.

But even then we thought that the universe was contained within one galaxy, our own *Milky Way*.



DIFFERENT THEORIES ON THE UNIVERSE (COSMOLOGY)

Astronomy has seen 3 scientific revolutions in cosmology

2nd Century: Claudius Ptolemy (**Physics of Aristotle**)

- Model: Earth-centered Cosmology
- Big Idea: Different laws for Earth and the cosmos

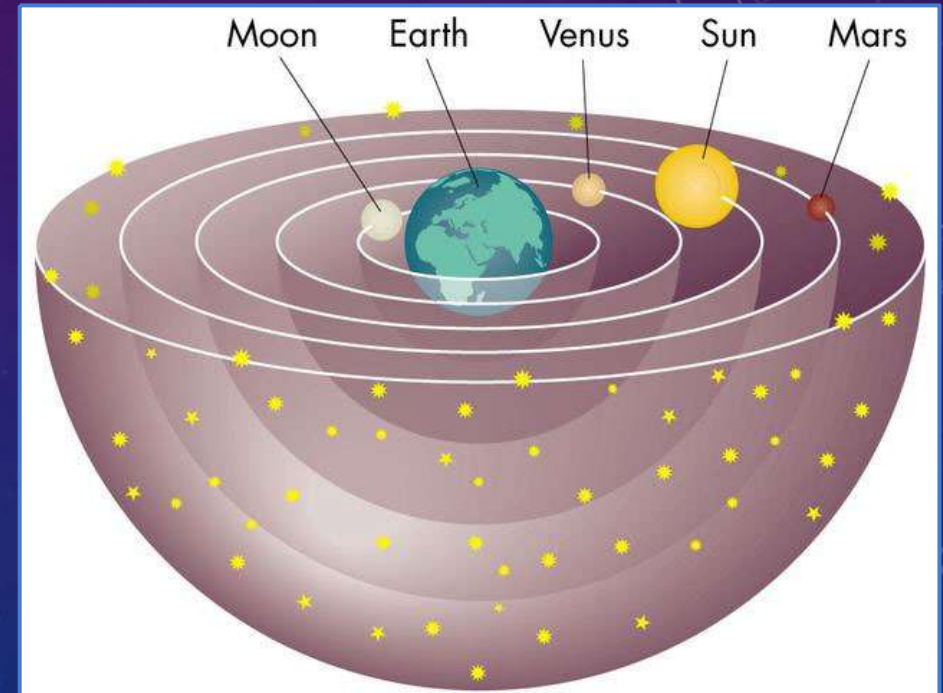
16th Century: Nicolaus Copernicus (**Physics of Newton**)

- Model: Sun-centered Cosmology
- Big Idea: Universal physics; same laws everywhere

20th Century: Edwin Hubble (**Physics of Einstein**)

- Model: Big Bang Cosmology
- Big Idea: Universe is changing, evolving

Earth-centered Cosmology: Claudius Ptolemy, 100-170 AD



...“the natural motion of the Earth ...is towards the center of the universe; that is the reason it is now lying at the center.”
Aristotle, On the Heavens

TESTING THE SUN CENTRED THEORY

As late as the turn of the 20th century, astronomers believed that the Sun was effectively at the center of the galaxy.

Prediction: Sun at centre of cosmos

Observation:

- Sun is *not* centre of universe (1918)
- Our galaxy is not the entire universe

CRISIS!!

Observations by Edwin Hubble and others proved that the Milky Way was just one galaxy of many (1923).



The Hubble Space Telescope is a space telescope that was launched into low Earth orbit in 1990 and remains in operation. With a 2.4-meter mirror, Hubble's four main instruments observe in the near ultraviolet, visible, and near infrared spectra. The telescope is named after the astronomer Edwin Hubble.

THE BIG BANG THEORY ORIGINS

During the early 1920s, an astronomer named Edwin Hubble was studying a number of 'fuzzy' cloud-like structures using a very large ground-based telescope. At the time, these objects were thought to be nebulae (clouds of dust and gas) within our galaxy.

He soon proved that these objects were galaxies like our own, each containing billions of stars. The world soon realised that the universe was much larger than originally thought.

Today, it has been estimated that we can see roughly 150 billion galaxies! This is likely to be grossly underestimated.





TESTING THE BIG BANG MODEL

Further study of the motions of the galaxies by Hubble revealed that they were racing away from us and each other: proof of an expanding universe (1929).

Prediction: The universe is expanding

Observation: Galaxies are moving apart from each other

The Big Bang Model is our currently held theory on the universe!

Many people believe that the Big Bang is “just a theory” with no evidence to support it. In science, the word “theory” means an idea that is well-established and supported by scientific evidence. Hubble’s observations of galaxies moving apart from each other is one of SEVERAL lines of evidence that supports the Big Bang model.

THE BIG BANG THEORY IS A THEORY ABOUT...

1. What the universe was like in the beginning
2. What's happening in the universe now

*Write these headings in your books.

The big bang theory doesn't just talk about the beginning of the universe, it also explains why the universe is the way it is today.



WHAT THE UNIVERSE WAS LIKE IN THE BEGINNING

- The Big Bang Theory suggests that about 14 billion years ago all the matter in the universe was contained in a hot, dense ball of radiation and sub-atomic particles. Prior to this there was no time or space as we know it!
- An explosion took place and the matter expanded. As it did so, small atoms began to form and then larger ones. So we can think of the Big Bang as not an explosion, but as an *expansion*! This expansion is still happening today.
- In the densest places, gravitational forces squeezed particles together and formed galaxies containing stars – about 200 million years after the Big Bang occurred



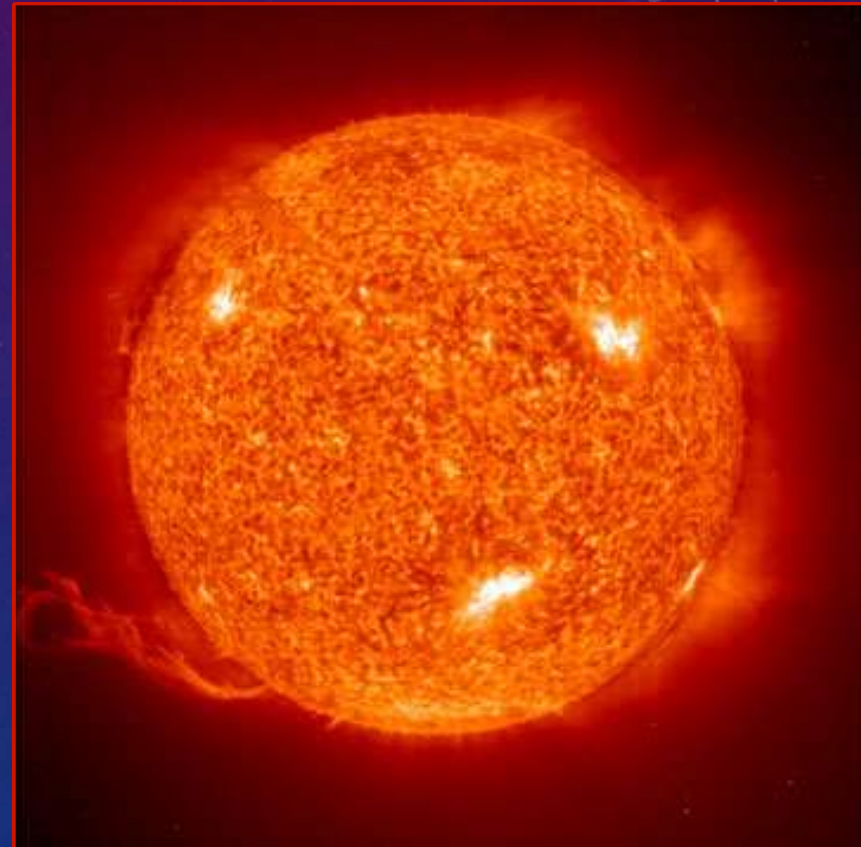
EVIDENCE FOR THE BIG BANG MODEL

The simplest of atoms, hydrogen, gets cooked into heavier elements at a high enough temperature and density (such as the cores of stars).

In the early hot and expanding universe, this fusion process only has time to cook hydrogen to helium (plus a little lithium) before the expansion and cooling shuts down the nuclear furnace.

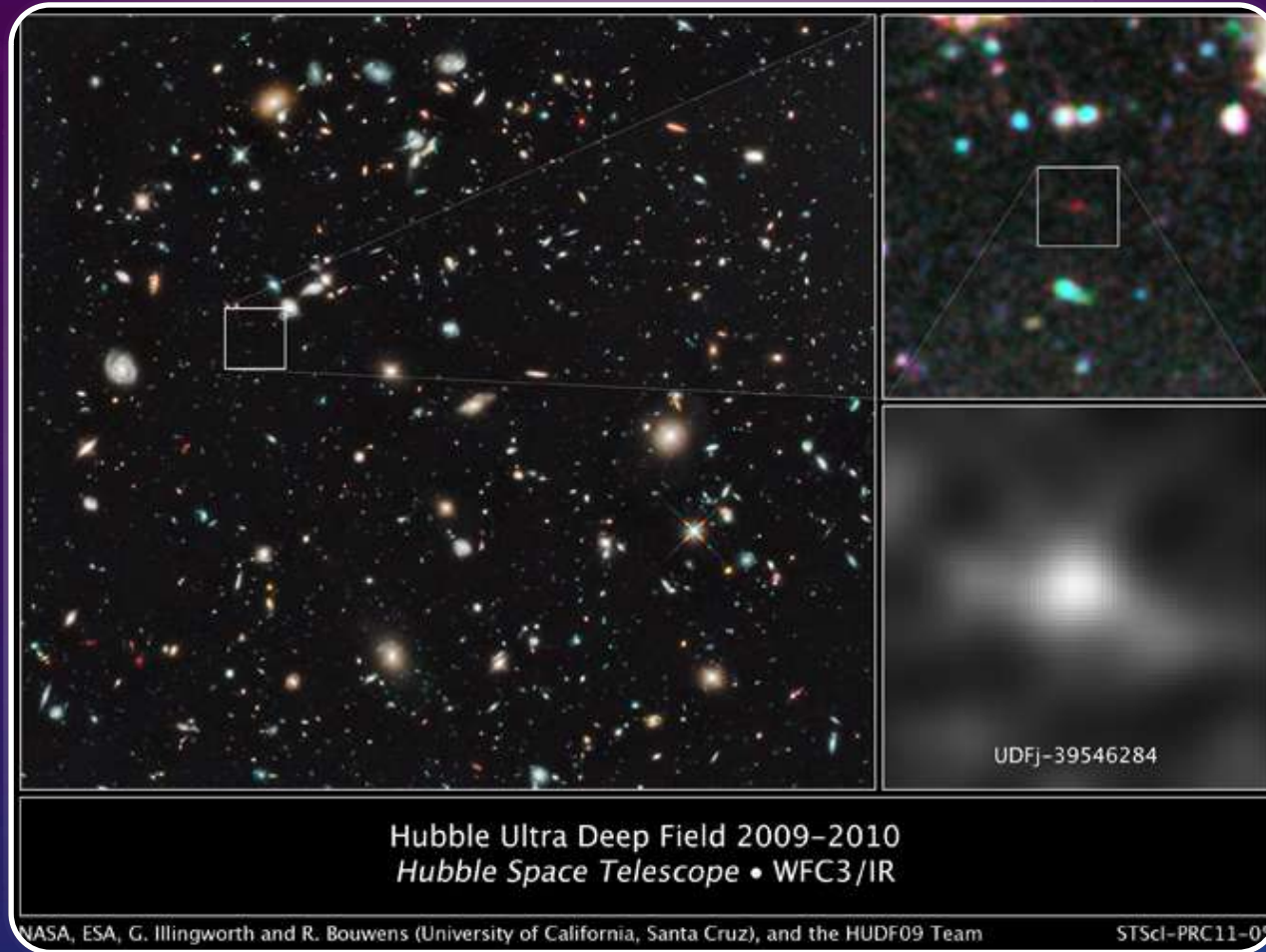
All elements above helium in the periodic table are created in the life cycles of stars. The universe is approximately 75% Hydrogen 25% Helium by mass, from the Big Bang. These were the first two elements formed as a result of the cooling.

The composition of objects in the universe is one of several lines of evidence that supports the Big Bang model.



Our sun: 74.5% Helium, 24.5% Hydrogen

EVIDENCE OF AN EXPANDING UNIVERSE



Since light travels at a finite speed, the light that we see is 'old'. For example, it takes just over 8 minutes for the light leaving the Sun's surface to reach Earth. Proxima Centauri (closest star to Earth) is 4.2 light years away. Therefore on any given night that we observe this star, the light we see is 4.2 years old.

The most distant object that we can see is a galaxy which is about 13.2 billion light years away!

If this galaxy's light has travelled for this long, the age of the universe must be at least 13.2 billion years old right?!

Not quite.....

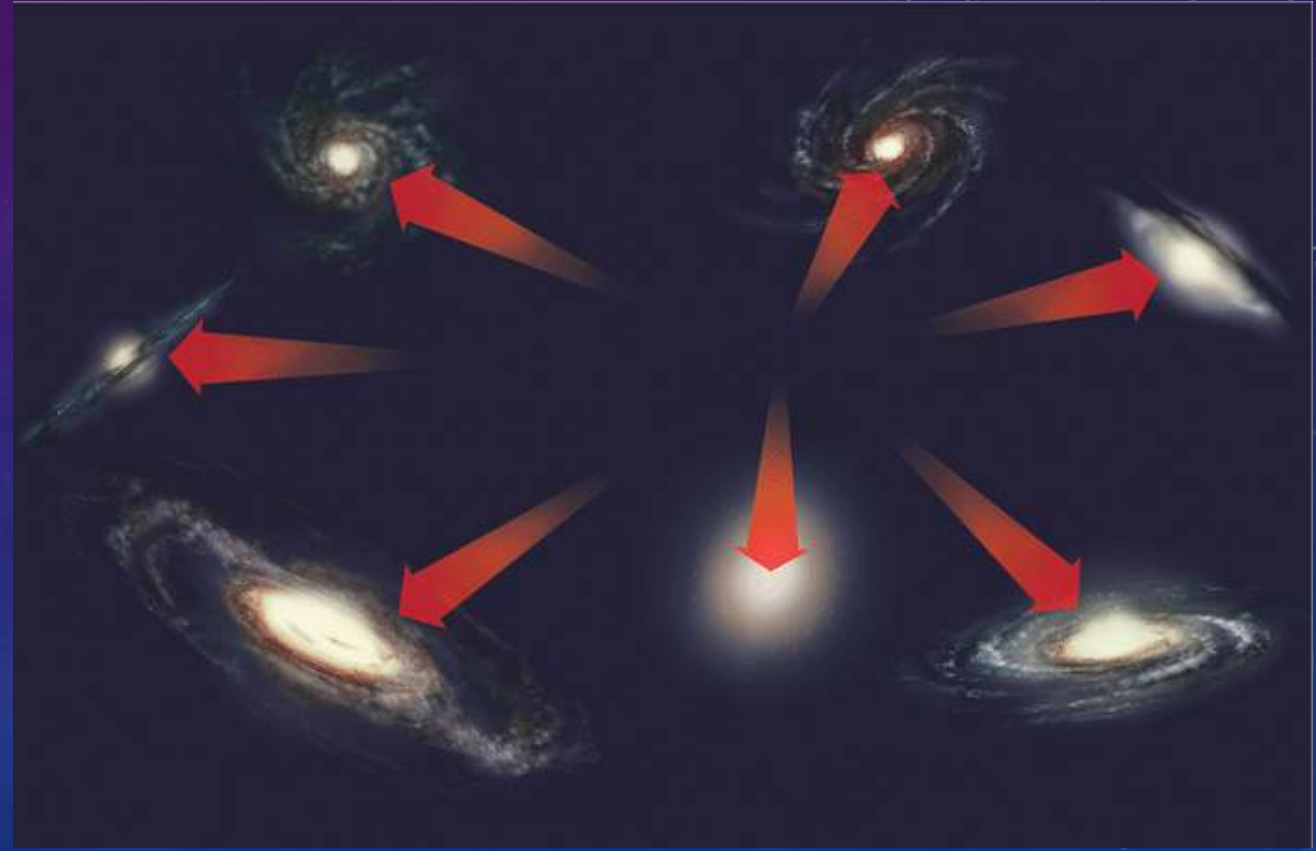
OUR EXPANDING UNIVERSE

When Hubble was making his observations, he noticed that almost all of the galaxies appeared to be moving away from our own (1929).

In fact, his findings suggested that the more distant the galaxy was, the faster it appeared to be moving away.

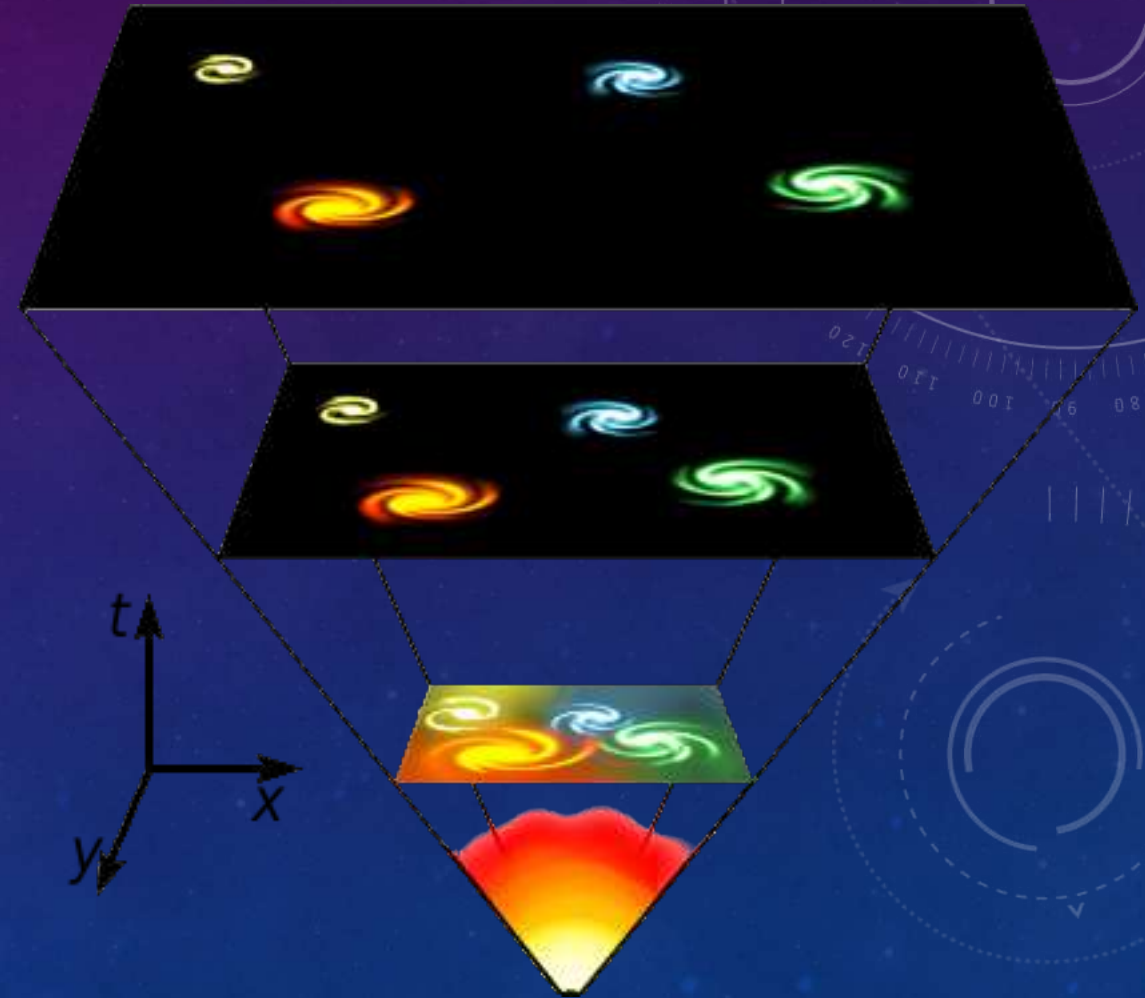
His discovery implied that all galaxies were moving away from each other and that the entire universe was expanding!

This is due to 'Redshift'



WHAT THE UNIVERSE WAS LIKE IN THE BEGINNING

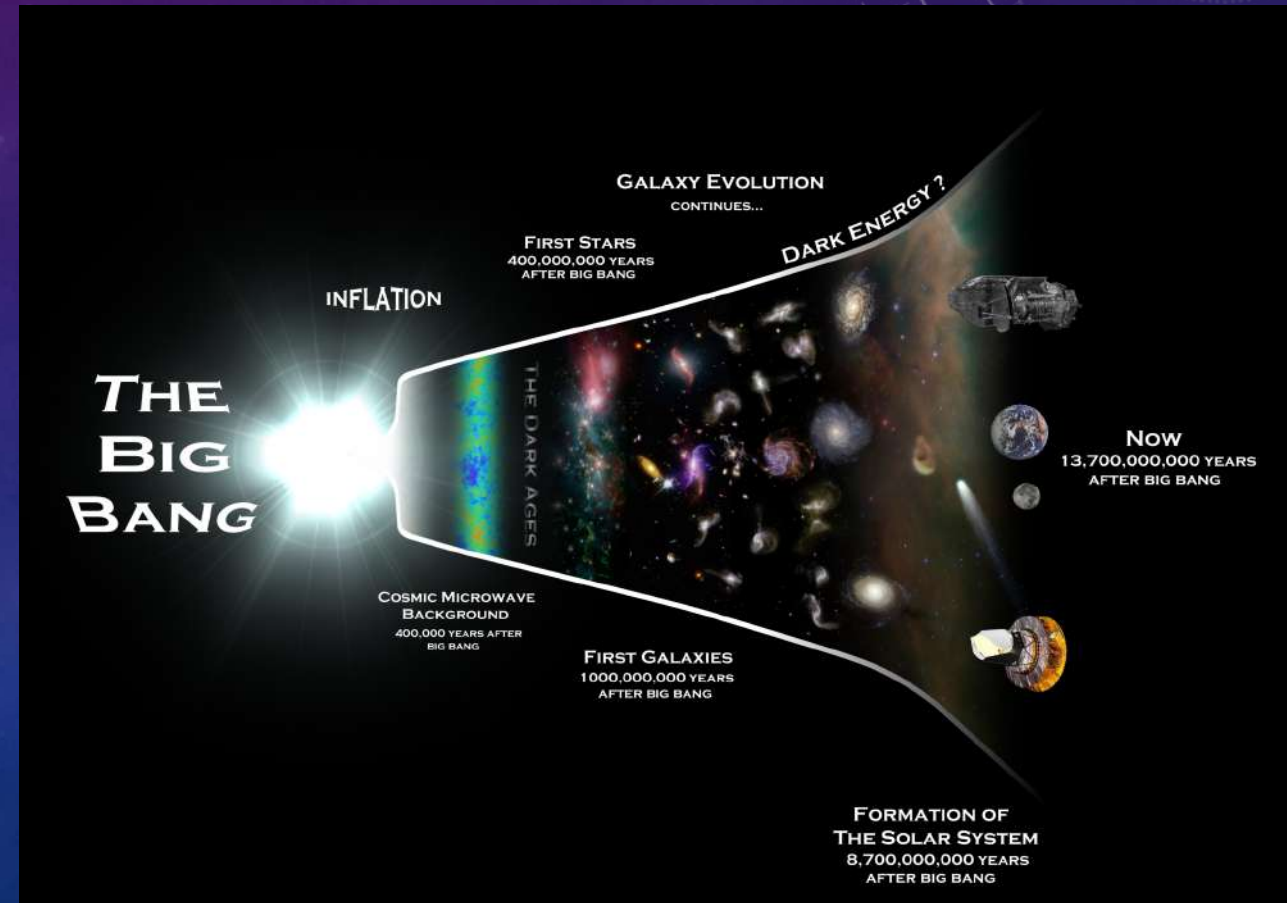
- About 14 billion years ago all the matter in the universe was contained in a hot, dense ball of radiation and sub-atomic particles. Relative to the size of a pin head!
- Big Bang is not an explosion, but an *expansion*! This expansion is still happening today.



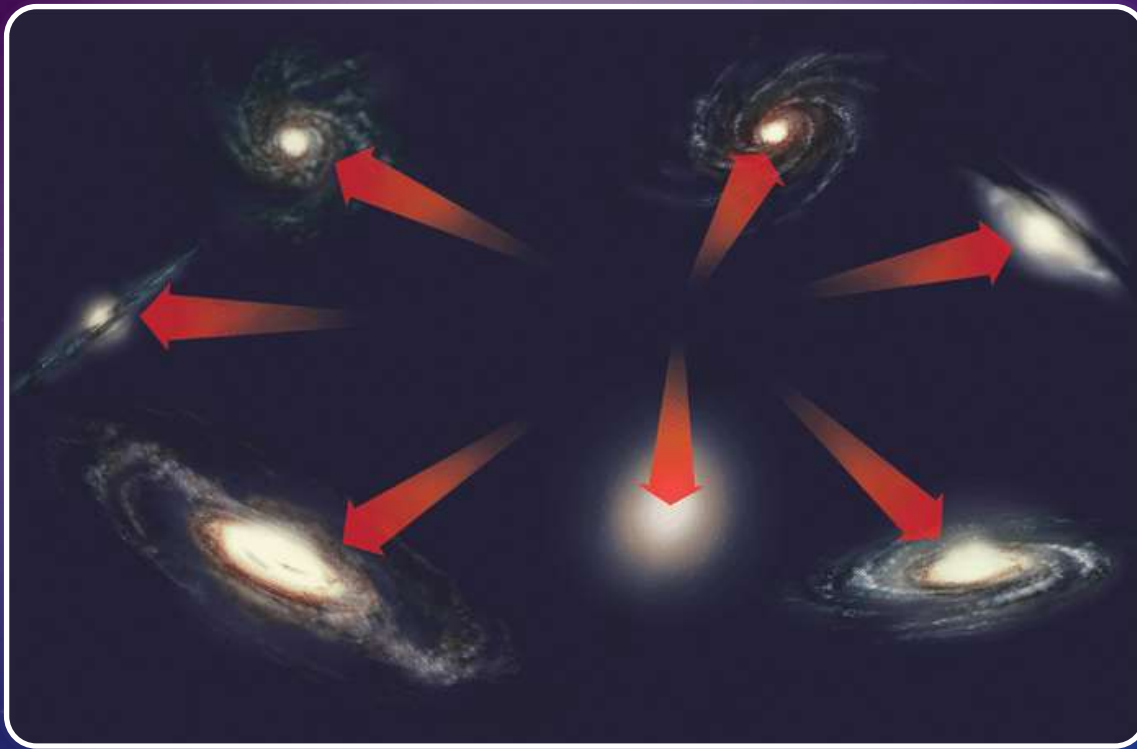
WHAT THE UNIVERSE WAS LIKE IN THE BEGINNING

- About 200 million years after the Big Bang occurred, gravitational forces compressed to form galaxies.
- Stars were born through nuclear fusion in stellar nebula's

[Video: What caused the Big Bang?](#)



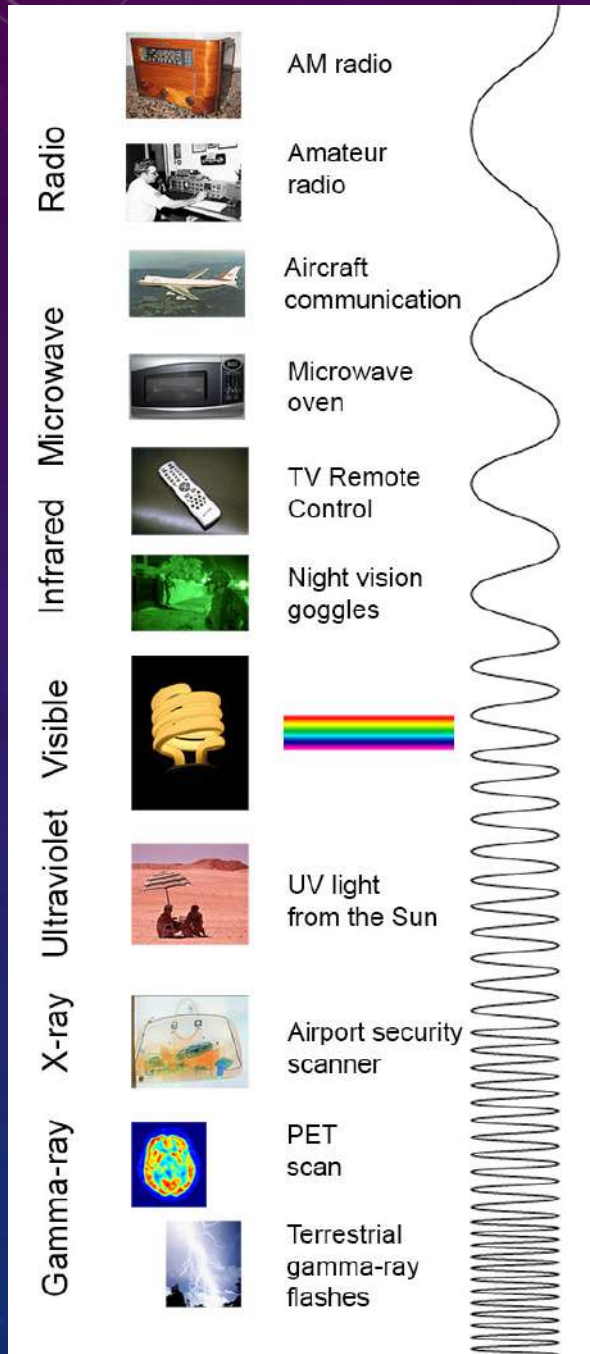
WHAT'S HAPPENING IN THE UNIVERSE NOW?



The universe is expanding!

- Since the Big Bang, **the size of the universe has been increasing rapidly.**
- The universe is billions of times larger now than it was early in history.
- Edwin Hubble first discovered that the galaxies were moving away from each other in 1929

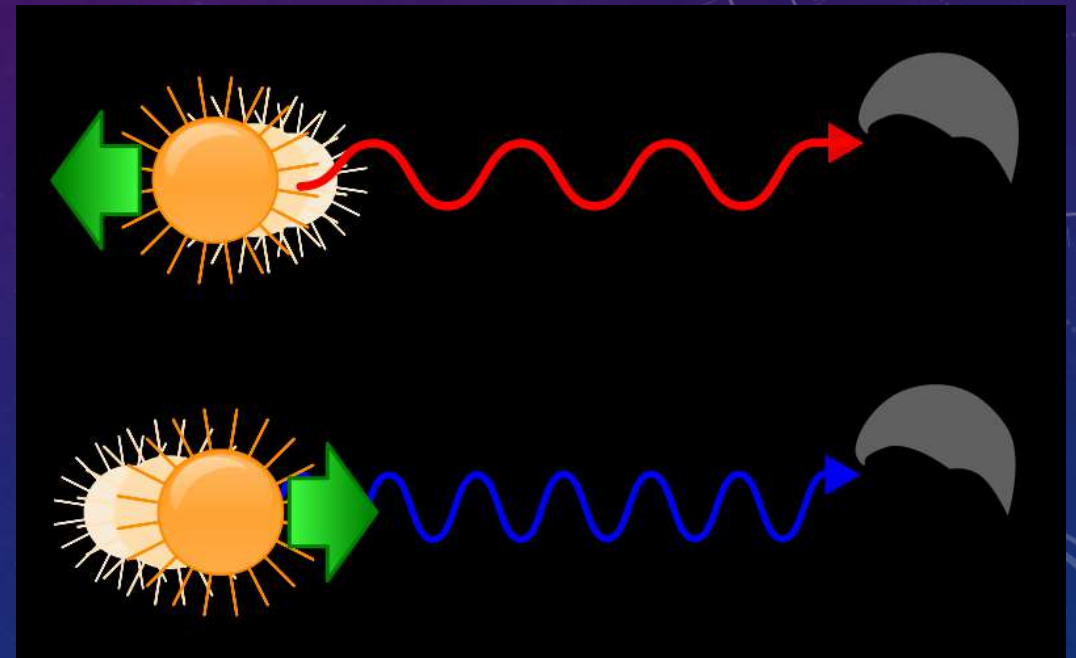
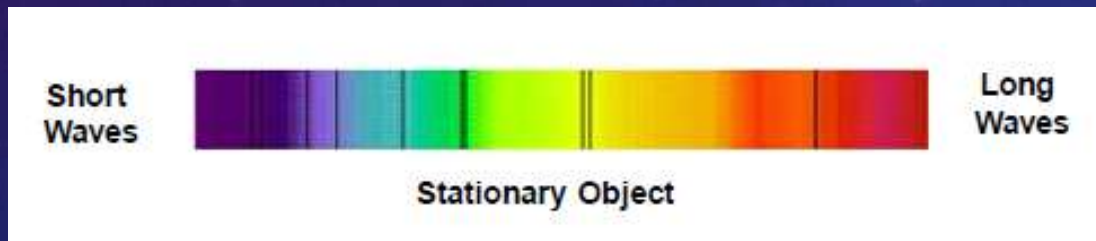
How did Hubble know this?



EVIDENCE THAT SUPPORTS BIG BANG THEORY

1. Redshift – occurs when celestial bodies are moving away from us. A shift towards the red end of the light spectrum.

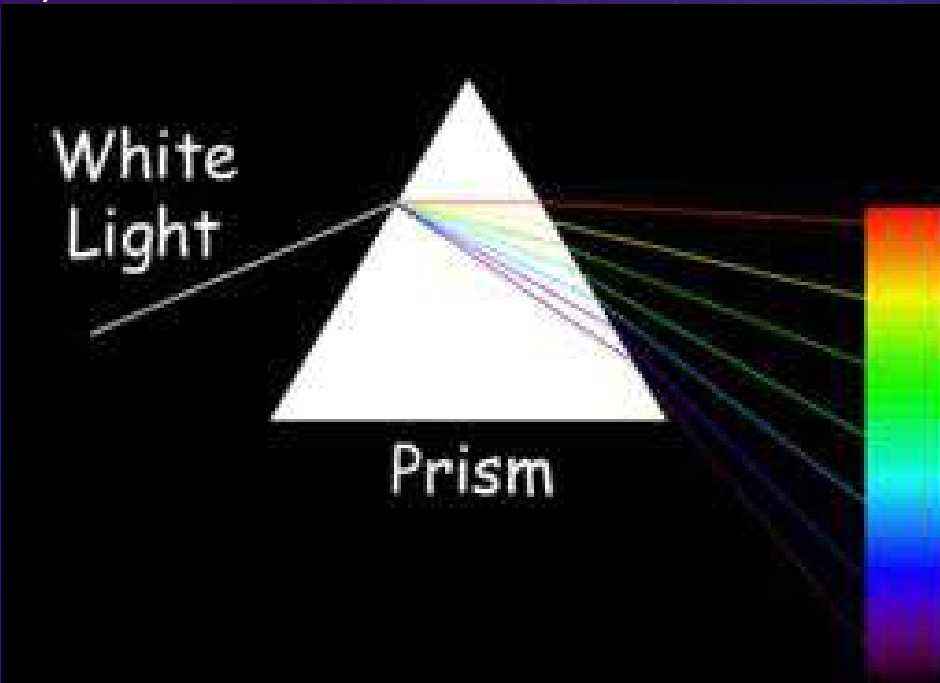
- Redshift is measured using telescopes such as Hubble telescope



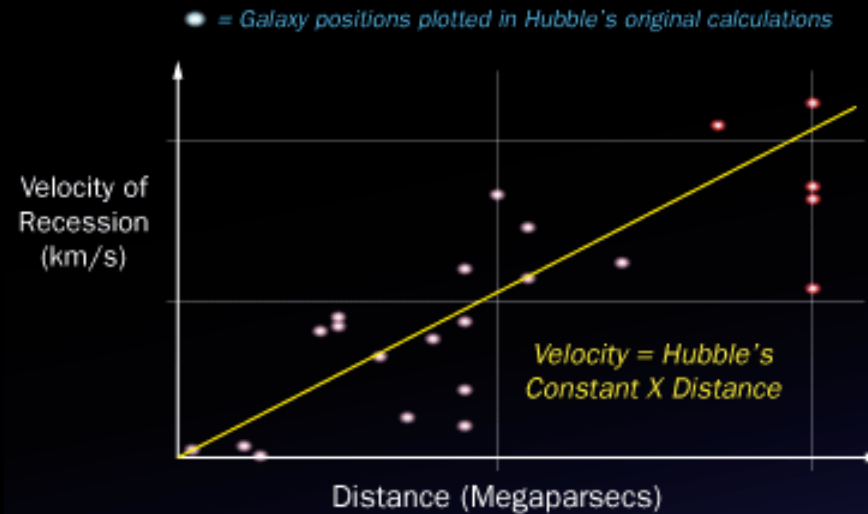
Objects that are moving toward you are blue
Objects that are moving away from you are **red**

UNIVERSAL EXPANSION AND HUBBLE'S LAW

- a) Hubble observed the majority of galaxies a
- b) The farther, the faster they move
- c) Red Shift



How Galaxies Work Hubble's Law ©2008 HowStuffWorks



Hubble's law states that the farther away a galaxy is, the faster it is moving away from us.

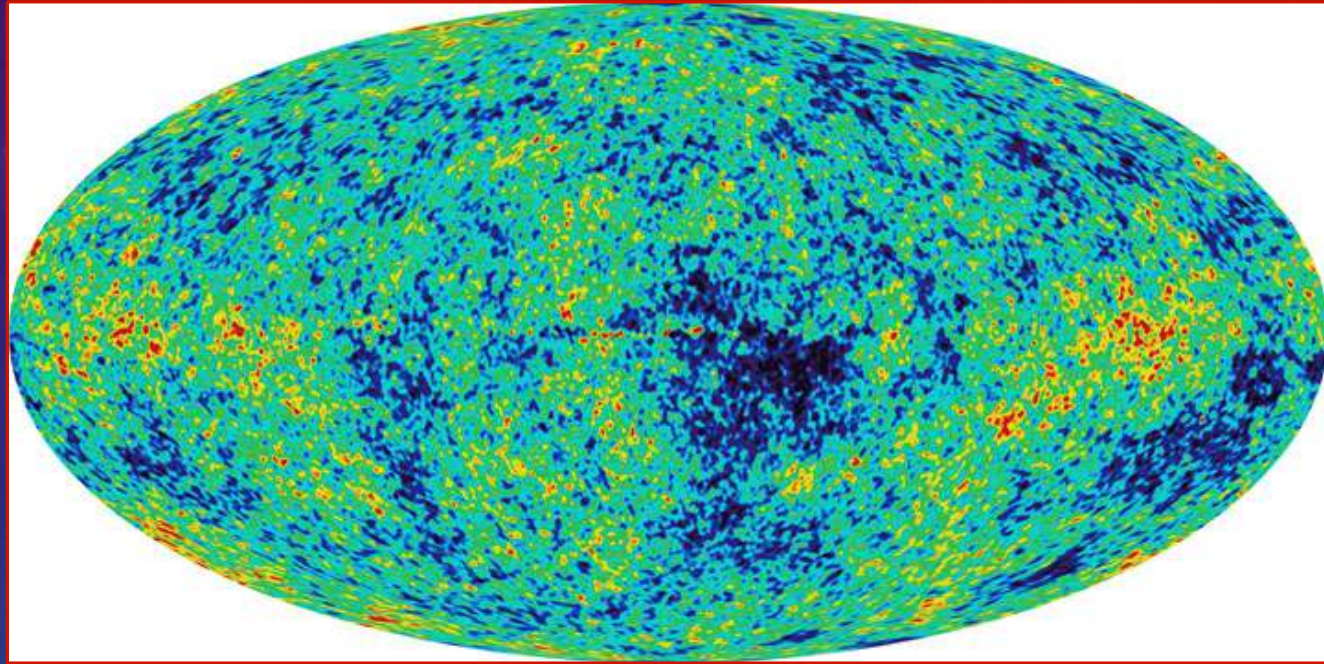
Redshift

The light emitted by a star changes as it moves away from the observer.



EVIDENCE THAT SUPPORTS BIG BANG THEORY

- 2. Cosmic background radiation - This glow comes from thermal energy left over from the big bang. The light from this time - 13.7 billion years ago, still bathes the cosmos.



The CMB is a snapshot of the oldest light in our Universe, imprinted on the sky when the Universe was just 380,000 years old.

WHY DO WE USE TELESCOPES?

- Telescopes are often attached to satellites in space to get clear images of Earth, Galaxies and Space.
- The images are not restricted by water vapour on Earth (which is found in our atmosphere), so its easier to see faraway plants and stars.

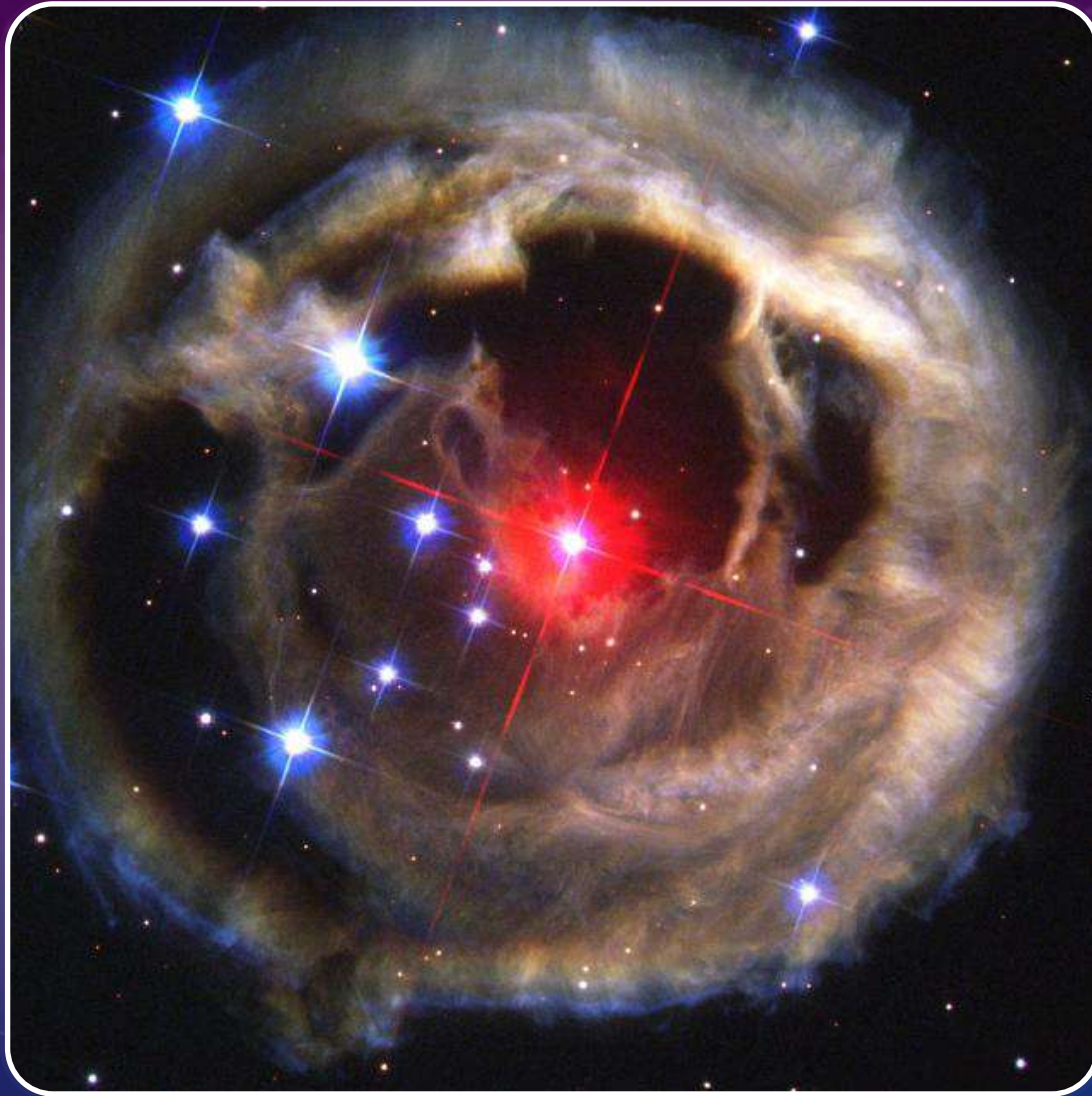
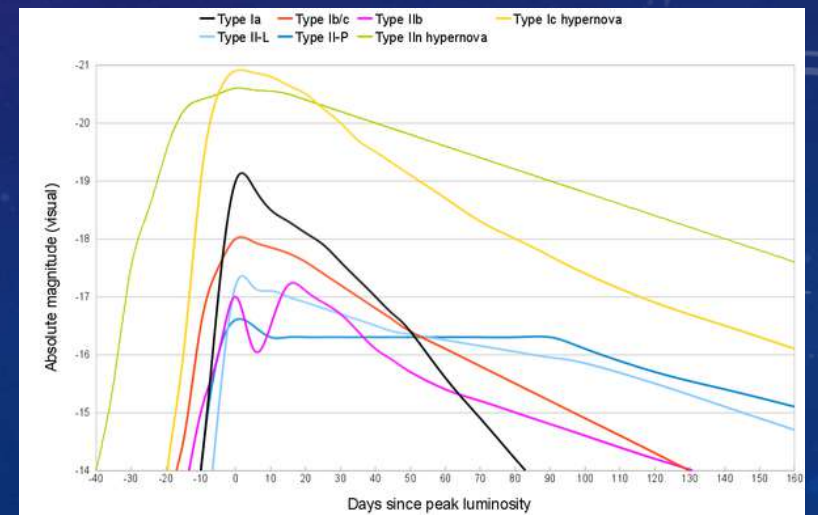


Photo from 2002 taken by Hubble Space telescope



DIFFERENT TECHNOLOGY USED IN TELESCOPES

Technology	Purpose	How it works
Spectral analysis	Determining the composition of a star (colour)	Breaks the light from an object into colours (e.g Redshift)
Infrared imaging	Observing new stars in a galaxy obscured by dust	Helps to observe through gas and dust particles
Light curve	A graph of light intensity of a celestial object over time	Shows minimum and maximum brightness due to the shape of the object



LETS PLAY BIG BANG HOT SEAT.....

When did the Big Bang theory first originate and with whom?

- a) 1989 by Edwin Hubble
- b) early 1500's by Galileo
- c) In the 1920's by Hubble
- d) 1800 by the cosmic turtle

BIG BANG HOT SEAT

What does red-shift support?

- a) That telescopes can detect red light
- b) That no light is emitted in the red end of the light spectrum
- c) That the universe is contracting
- d) That the universe is expanding

BIG BANG HOT SEAT

What is a singularity?

- a) No one knows
- b) something that is big and hot
- c) A zone of infinite pressure, and density that is infinitely small and hot.
- d) A zone of specific pressure and density

BIG BANG HOT SEAT

Our solar system was formed approximately _____ years ago

- a) 4.6 billion
- b) 4.6 million
- c) 13.7 million
- d) 13.7 billion

BIG BANG HOT SEAT

How big was the universe 13.7 billion years ago?

- a) Relative to the size of a pinhead
- b) smaller than an atom
- c) Size of a golf ball
- c) size of our sun

BIG BANG HOT SEAT

The big bang is thought of as an.....

- a) explosion
- b) expansion
- c) nuclear fusion
- d) exception

BIG BANG HOT SEAT

Galaxies were formed approximately years after the big bang

- a) 2 billion b) 2 million
- b) 20 billion d) 200 million

BIG BANG HOT SEAT

Since the Big Bang, the size of the universe has been

- a) Increasing slowly
- b) increasing rapidly
- c) Decreasing slowly
- d) decreasing rapidly

ANSWERS

- A
- D
- C
- A (big bang approximately 14 billion yrs ago)
- A
- B
- D
- B