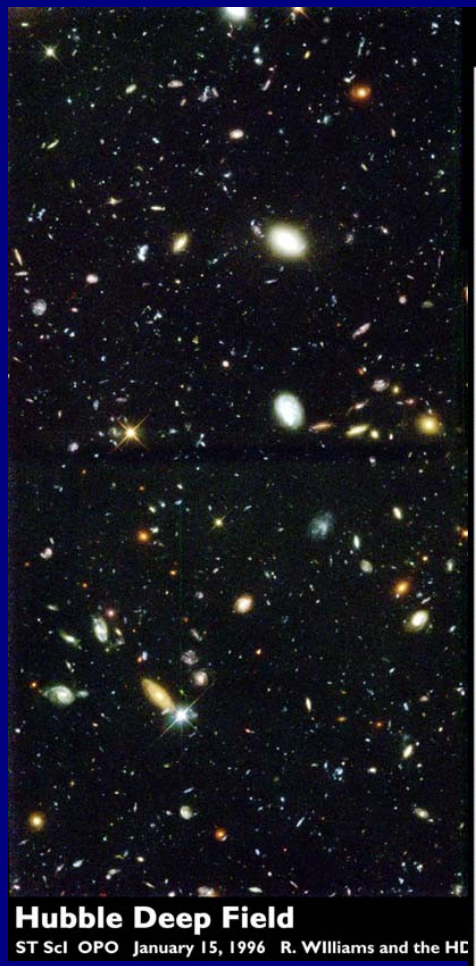
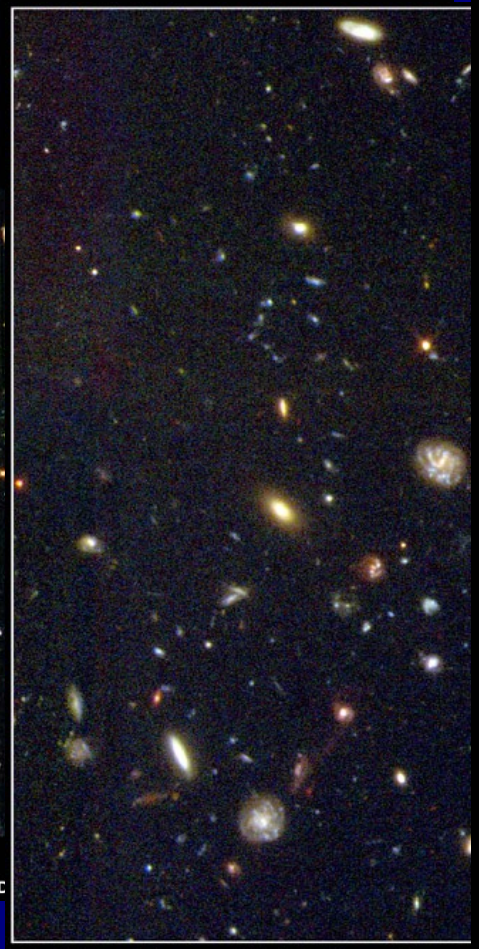
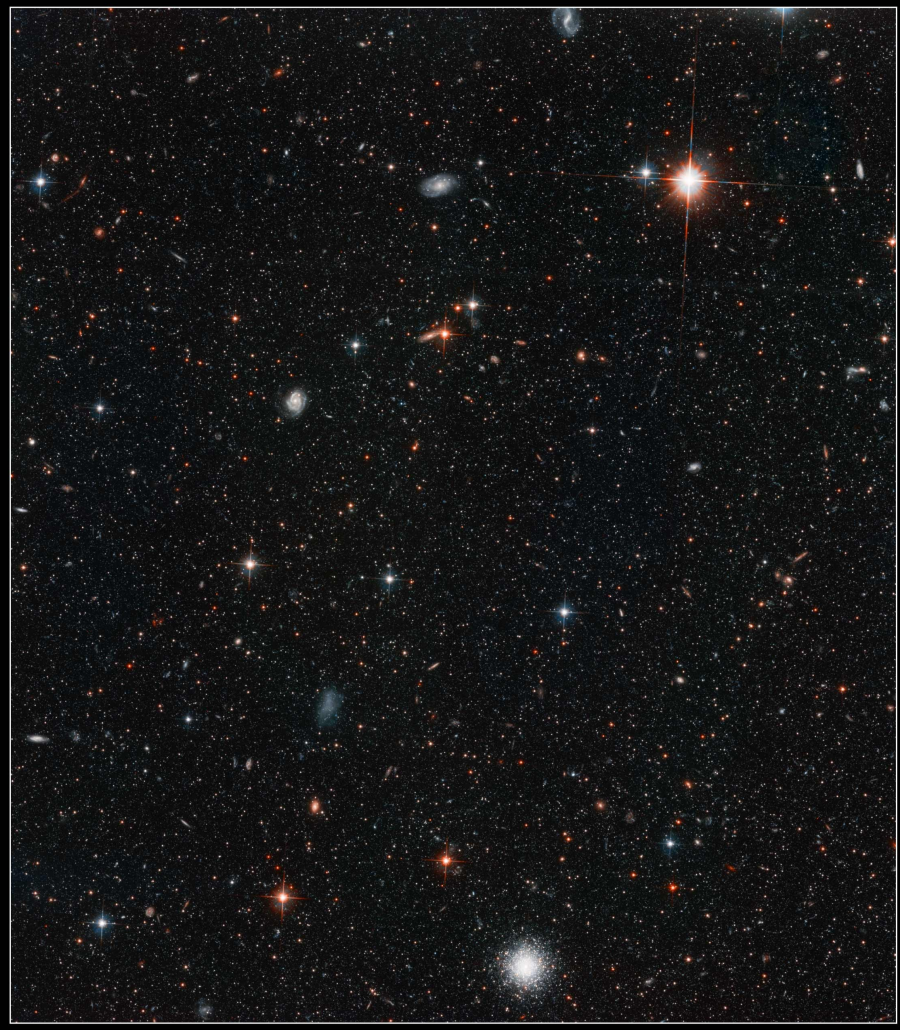
The Hubble Deep Fields



Hubble Deep Field
ST ScI OPO January 15, 1996 R. Williams and the HD



Hubble Deep Field South
PRC98-41a • STScI OPO • Novembe
The HDF-S Team • NASA



Andromeda Galaxy Halo • M31
Hubble Space Telescope • Advanced Camera for Surveys

NASA, ESA and T. Brown (STScI) • STScI-PRC03-15a

The Hubble Deep Fields

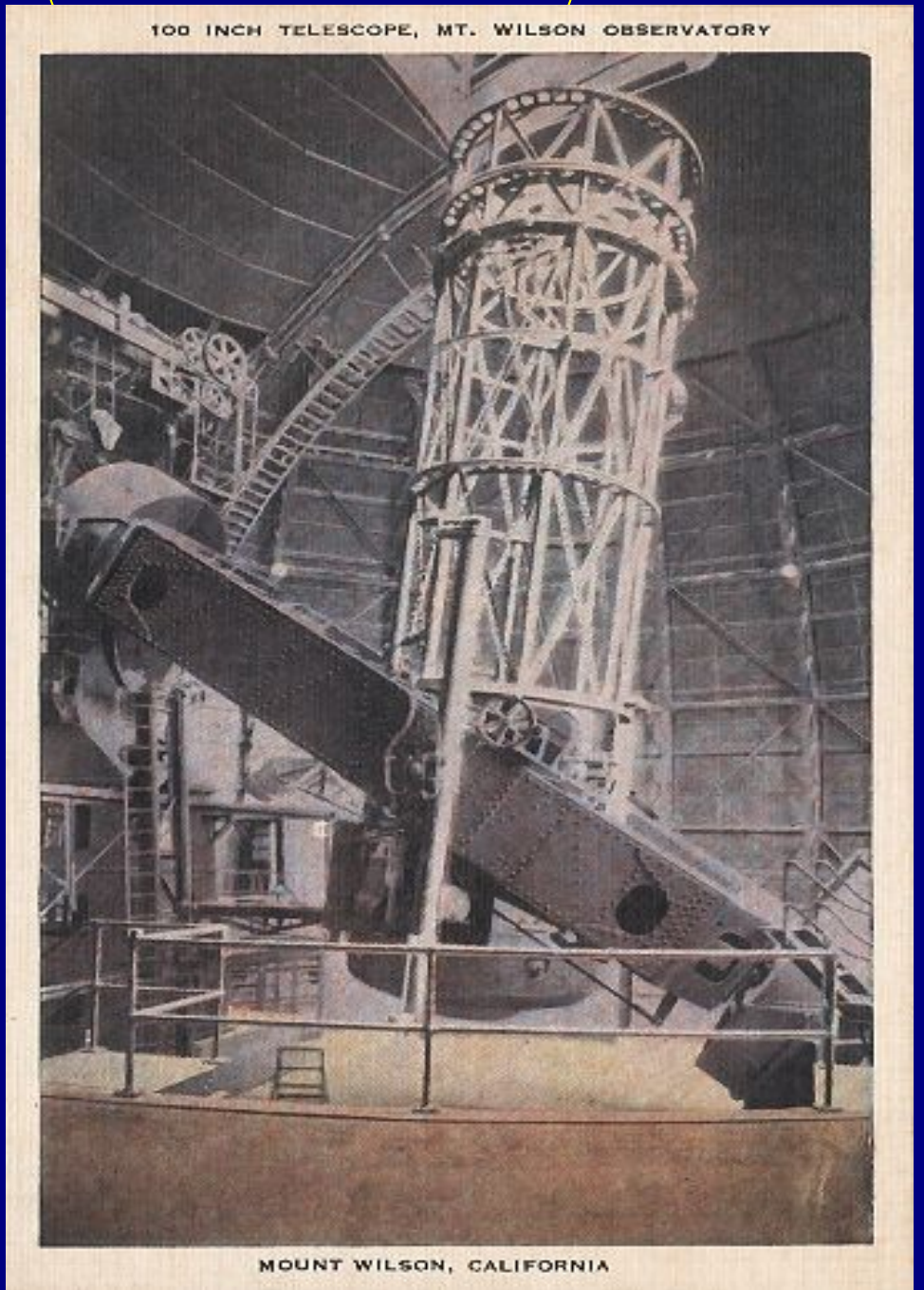
The Hubble Space Telescope stared for two weeks into deep space

- the objects seen are far, far away
- and we see them as they were a long time ago

Today we'll talk about
- Edwin P. Hubble
- the slow speed of light!
- the Big Bang, the expansion of the Universe
- the Hubble Space Telescope, the Hubble Deep Fields
- the lives of galaxies

Edwin P. Hubble (1889-1953)

- was good at sports & studied law, and later astronomy
- used the 100” Mt. Wilson telescope, the largest then available
- showed existence of stars in other galaxies
- in 1924 he measured the distance to Andromeda nebula (galaxy)
- showed in 1929 that the universe is expanding!
- Has a constant named after him, the Hubble Constant



The speed of light

First measured by Römer in 1676, Paris, France
- Used Io – a moon of Jupiter - as a clock
- eclipses were late when Earth was far from Jupiter
- light takes 22 min. to cross Earth's orbit diameter!

Now we have more accurate measurements: V=186,000 miles/sec
- light takes 16 min. to cross Earth's orbit diameter (Newton)

Time for light to travel from Sun to
Earth: 8 minutes, Pluto: 5 ½ hours
Proxima Centauri (nearest star): 4 years, 3 months
center of our Galaxy: 33,000 years, Andromeda galaxy 2 million yr
Farthest galaxy seen in Hubble Deep Fields: 10,000,000,000 years

For us, light seems very fast. [Thunder vs. lightning] But it is slow in the universe. We look further back in time when we look farther away!

The Big Bang

Edwin Hubble measured how fast other galaxies moved. Using Doppler effect and measured brightness, he found

- the further away they are, the faster they move away from us
- it's like looking at something after an explosion [marble experiment]
- the whole universe is expanding
- the Hubble Constant is the slope in the graph. Nowadays, the slope is about 8 times smaller [distances larger]
- he could "only" see 50 million light years away

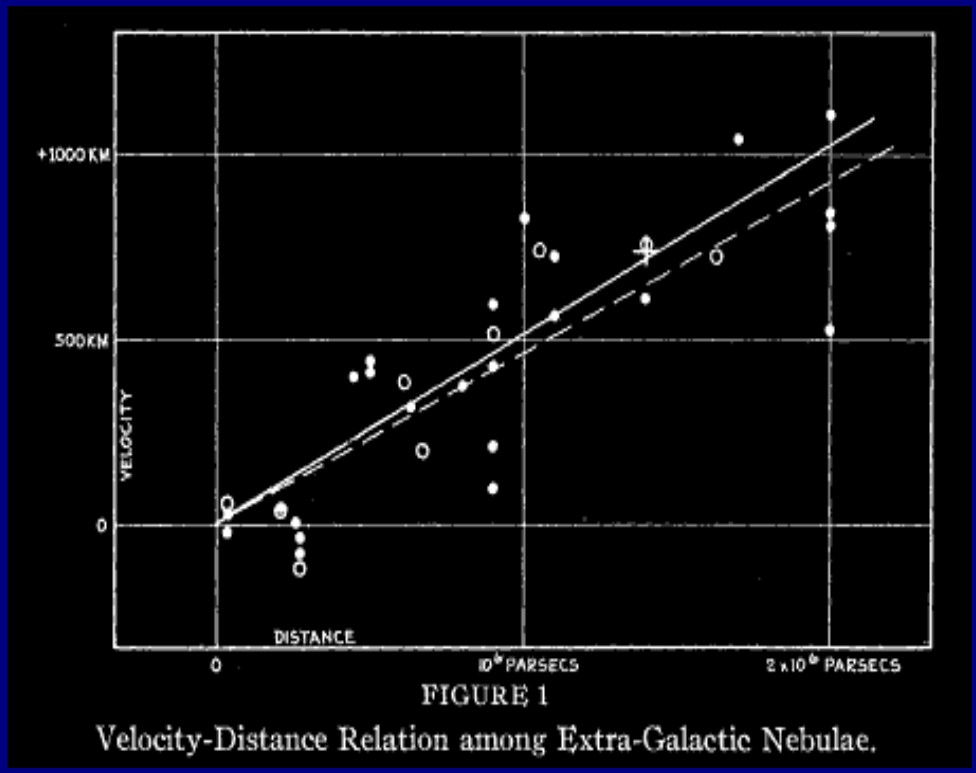
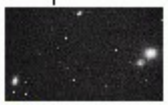


FIGURE 1
Velocity-Distance Relation among Extra-Galactic Nebulae.

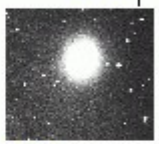
From the graph you can divide the distance by the slope to get the age of the universe. Hubble's distances were inaccurate, latest values show it's 9-15 billion years old (1 billion =1,000,000,000).

M110, E6pec



M59, E5

M49, E4



M32, cE2

M60, E2

M87, E1

M105, E1

M89, E0

M84, S0+

M86, S0+

M85, S0(s)+

M102/NGC 5866, S0_3

M104, Sa

M65, SABa

M81, Sab

M94, S(r)ab

M77, SABab

M90, SABab

M64, Sab

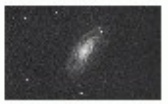
M96, SABab

M98, SABab

M31, Sb

M58, SABb

M91, SBb

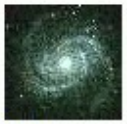


M88, Sb

M66, SABb

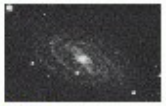
M95, SBb

M63, Sbc

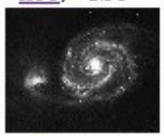


M100, SABbc

M61, SABbc



M109, SBbc



M51, Sbc

M106, SABbc

M74, Sc

M99, Sc

M83, SABc

M33, Scd

M101, SABcd

M108, SBcd

The Hubble Space Telescope

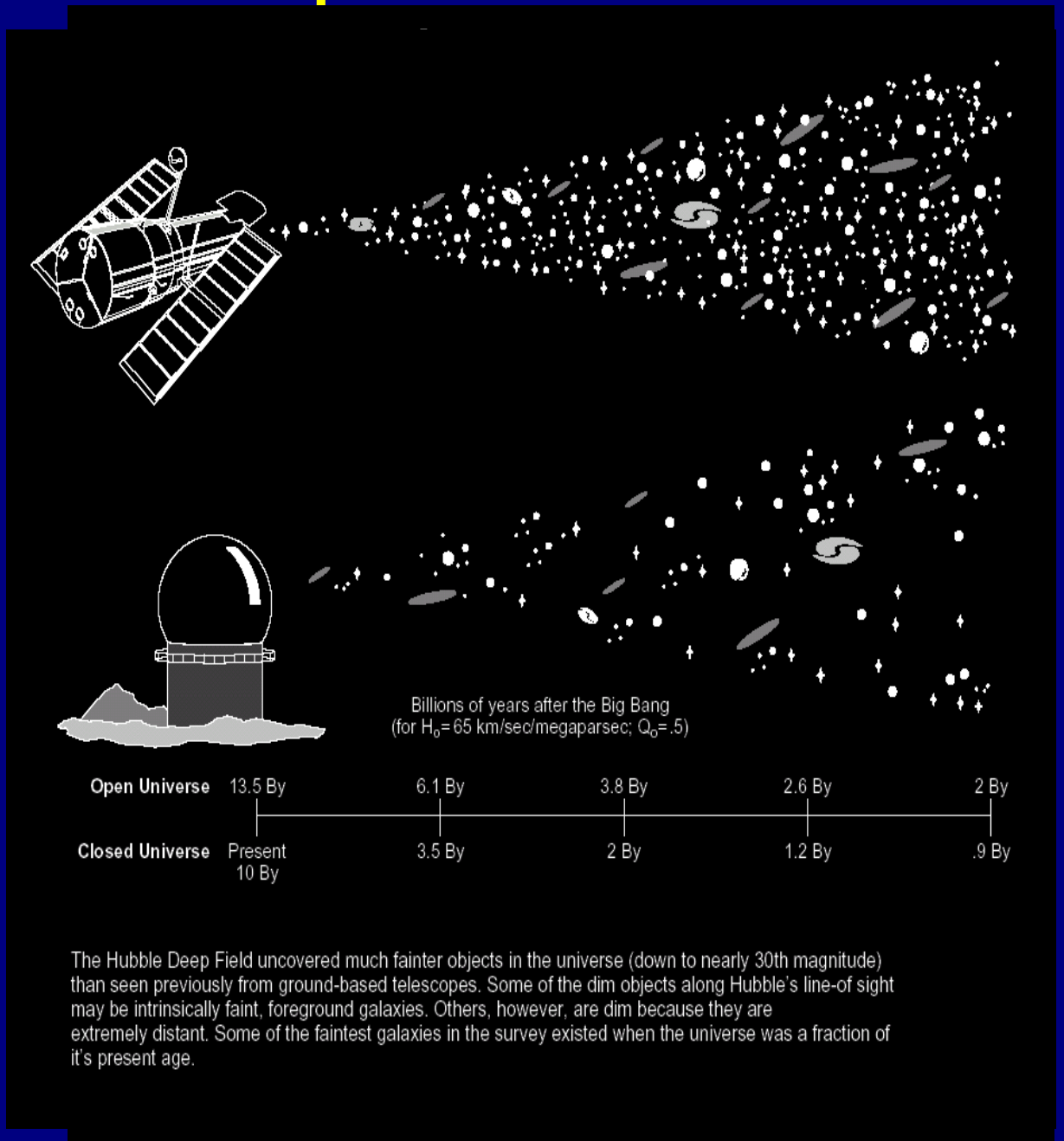
- Launched in 1990
- size of a school bus, 12 tons
- Mirror 94 ½", a bit smaller than the 100" telescope used by Edwin Hubble
- BUT it orbits 380 miles up to get above the atmosphere- a BIG advantage
- speed 5 miles/second
- must point at a dime 400 miles away

The Hubble Deep Fields

Hubble space telescope stared hard into space for 20 days...

It could see things 100 times dimmer than can be seen from the ground, so... it saw things 10 times farther away.

It could look back in time almost to the beginning of the universe (it was only 1/10 as old as it is now)



The Hubble Deep Field uncovered much fainter objects in the universe (down to nearly 30th magnitude) than seen previously from ground-based telescopes. Some of the dim objects along Hubble's line-of sight may be intrinsically faint, foreground galaxies. Others, however, are dim because they are extremely distant. Some of the faintest galaxies in the survey existed when the universe was a fraction of it's present age.

The Hubble Deep Field North

Near the "big dipper" where almost nothing could be seen from the ground, even with the biggest telescopes

Four billion times fainter than stars we can actually see

Full of new galaxies seen as they were when they were 10% as old as they are now!

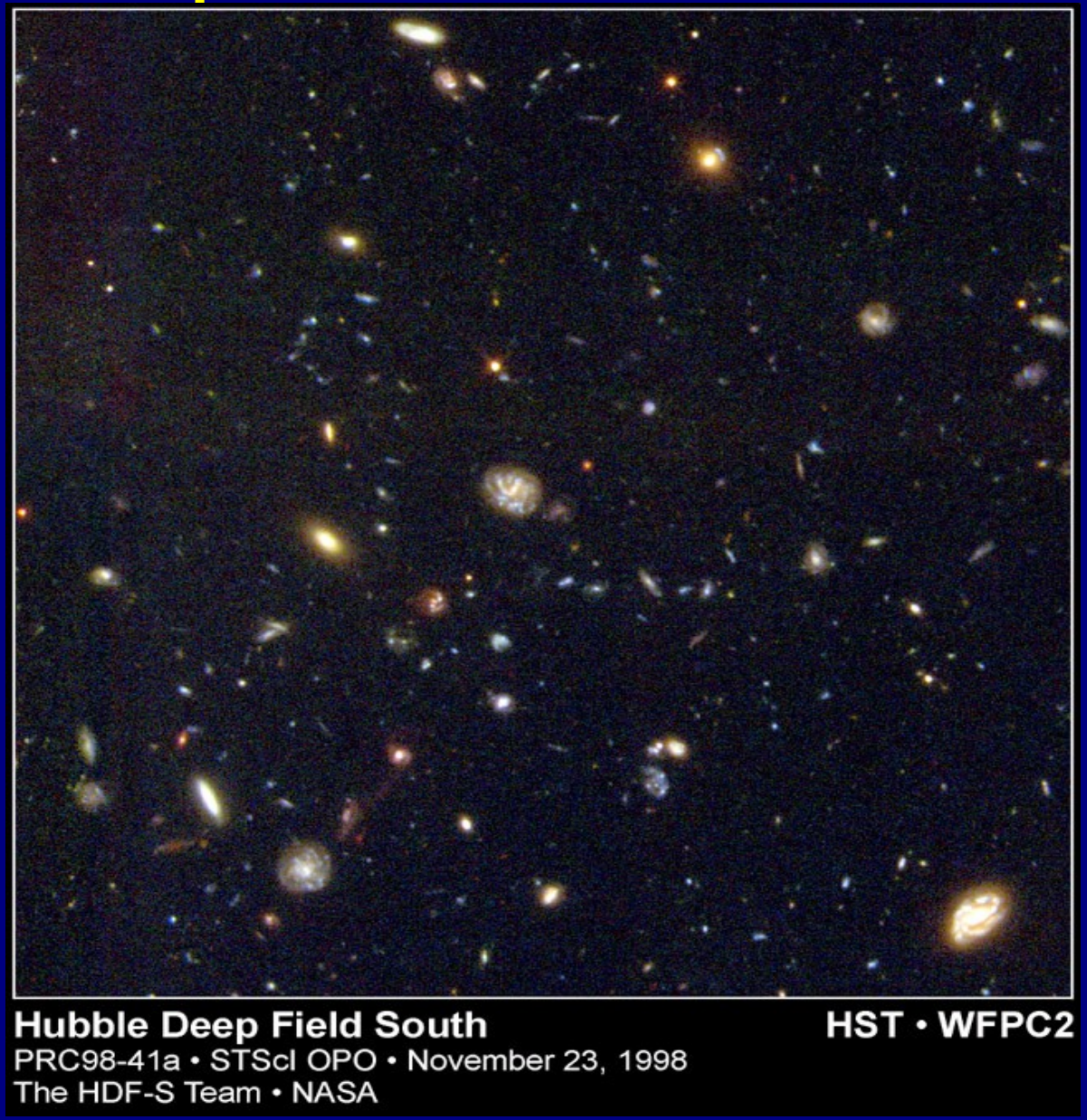
Farthest galaxy ever seen

The Hubble Deep Field South

Constellation of Tucana
(visible from Australia)

Stars were being born in "starbursts" 10 times faster than today, 5-15 billion years ago- galaxy evolution

Gravity acts like a lens

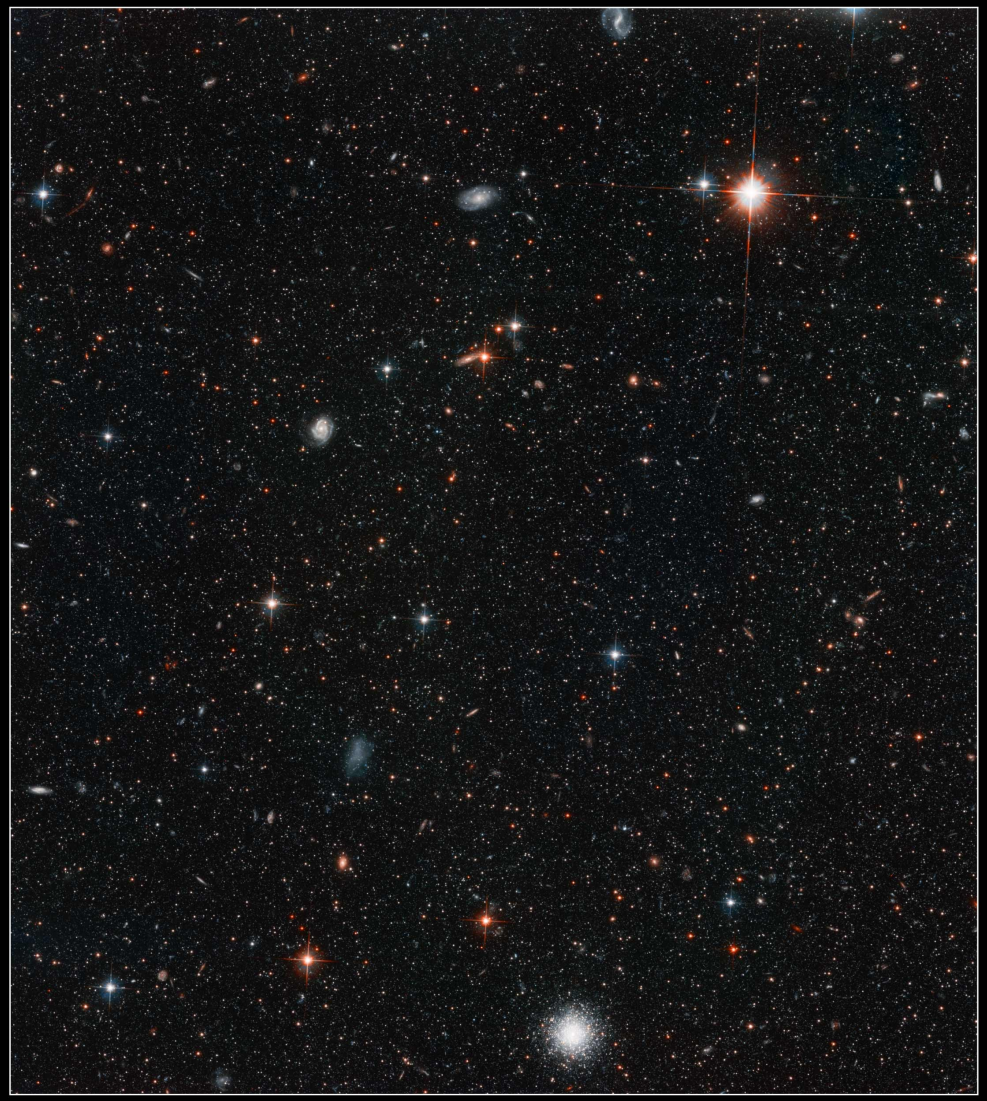


The Hubble Andromeda Deep Field

Stars/ clusters of the Andromeda galaxy (you can see it tonight, if clear)

faintest photograph ever taken in light you can see

There are lots more stars here because we are looking through a lot of our Galaxy (the "Milky Way").



Andromeda Galaxy Halo • M31
Hubble Space Telescope • Advanced Camera for Surveys

NASA, ESA and T. Brown (STScI) • STScI-PRC03-15a

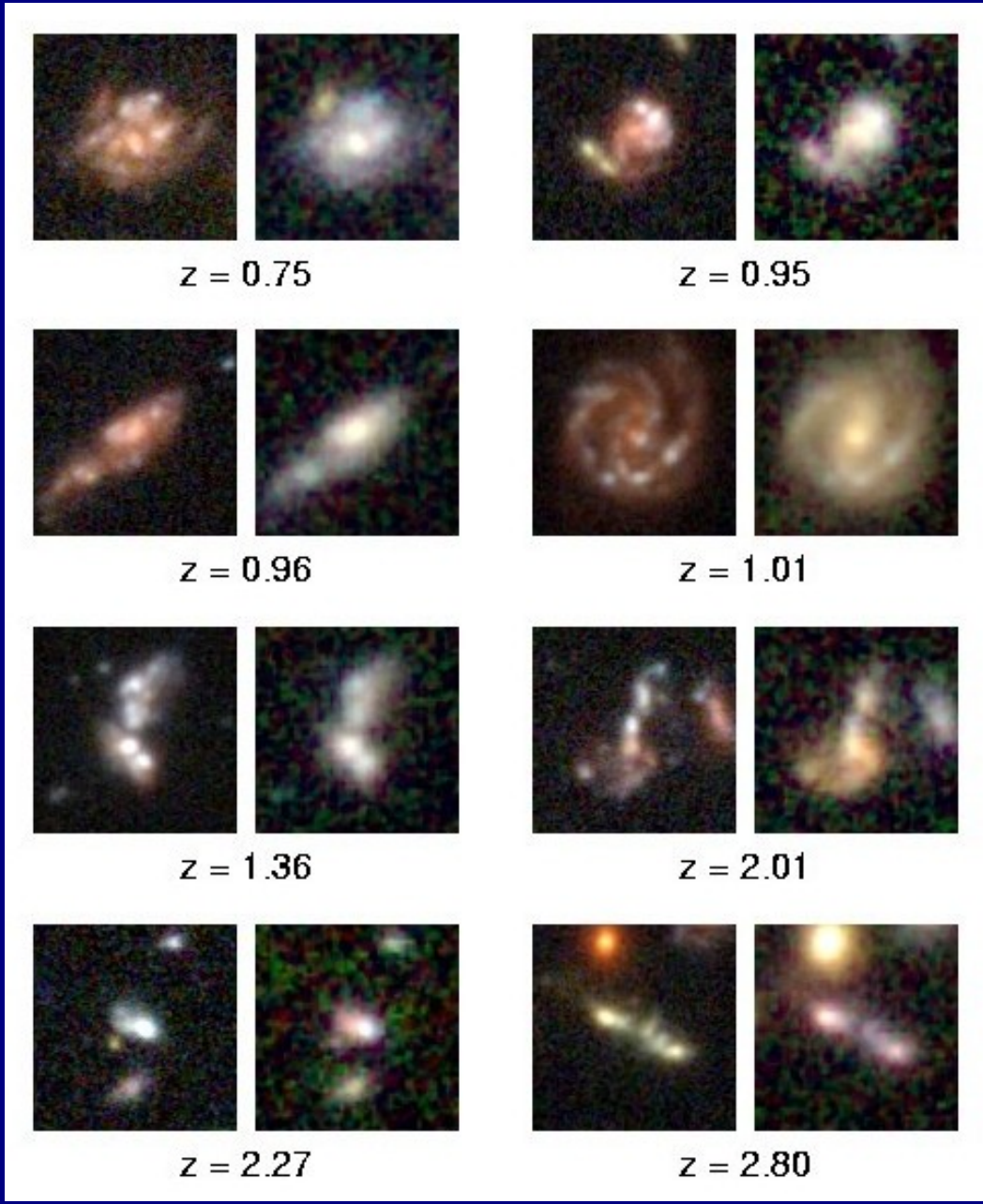
Galaxies change with time

The picture shows galaxies as our eyes might see them (left) and at infrared wavelengths (night spotting scopes).

The bigger values of z show younger galaxies. Oldest are top left, youngest bottom right.

Light has taken between 6 and 12 billion years to reach us, so we look that far back in time.

Then they were bursting with new, baby stars – 10 times more than are being born today



What have we learned?

The speed of light is not so fast after all

Edwin Hubble himself used a 100” telescope, and could look back in time “only” about 50 million years. He made many important discoveries

The Universe is huge, still expanding, after a Big Bang 9-15 billion years ago

The Hubble Space Telescope -also a 100” telescope -- can look back in time to about 1 billion years after the big bang, because there is no atmosphere to mess up the pictures

The data show us how the universe is populated by stars, galaxies, and how they have evolved in time, to less than 10% of the age of the Universe. It's like looking at a 7 year-old compared with a 70 year-old

You can be an astronomer too! You need to be good at Math and Science!