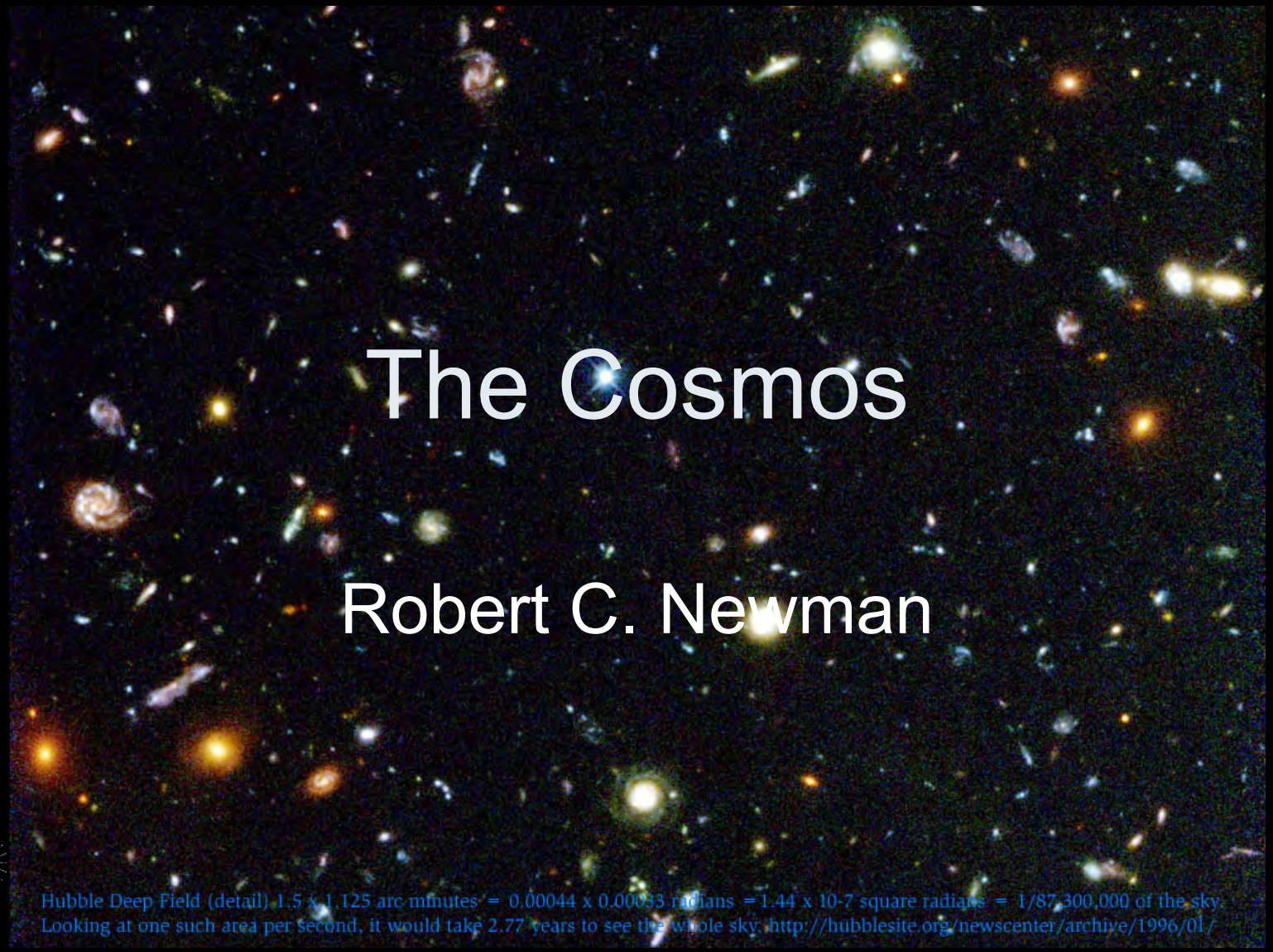
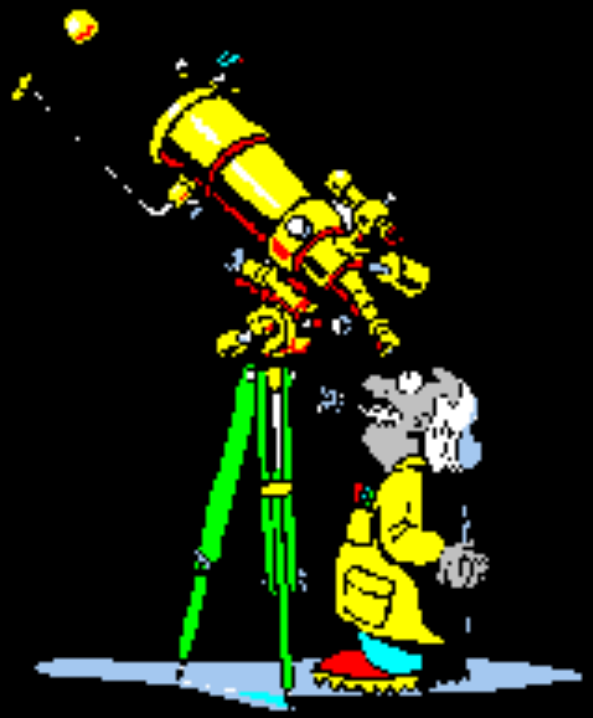


The Cosmos

- Carl Sagan said: "The cosmos is all that is, or ever was, or ever will be."
- If Christianity is true, Sagan is mistaken.
- But we can perhaps define the cosmos as "All that we humans can see from in here where we have been placed."
- Usually the terms 'cosmos' and 'universe' are used interchangeably.

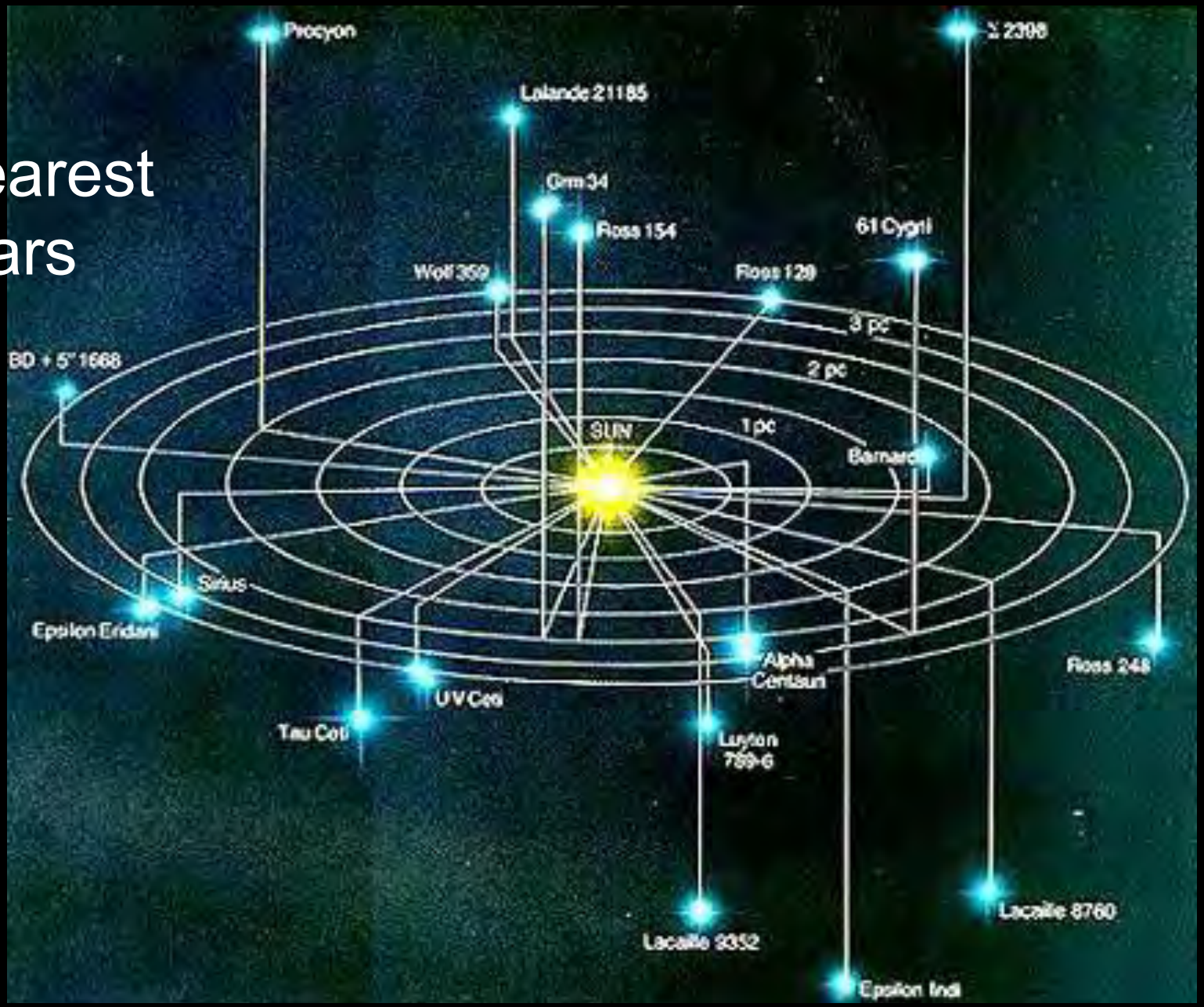
The Cosmos

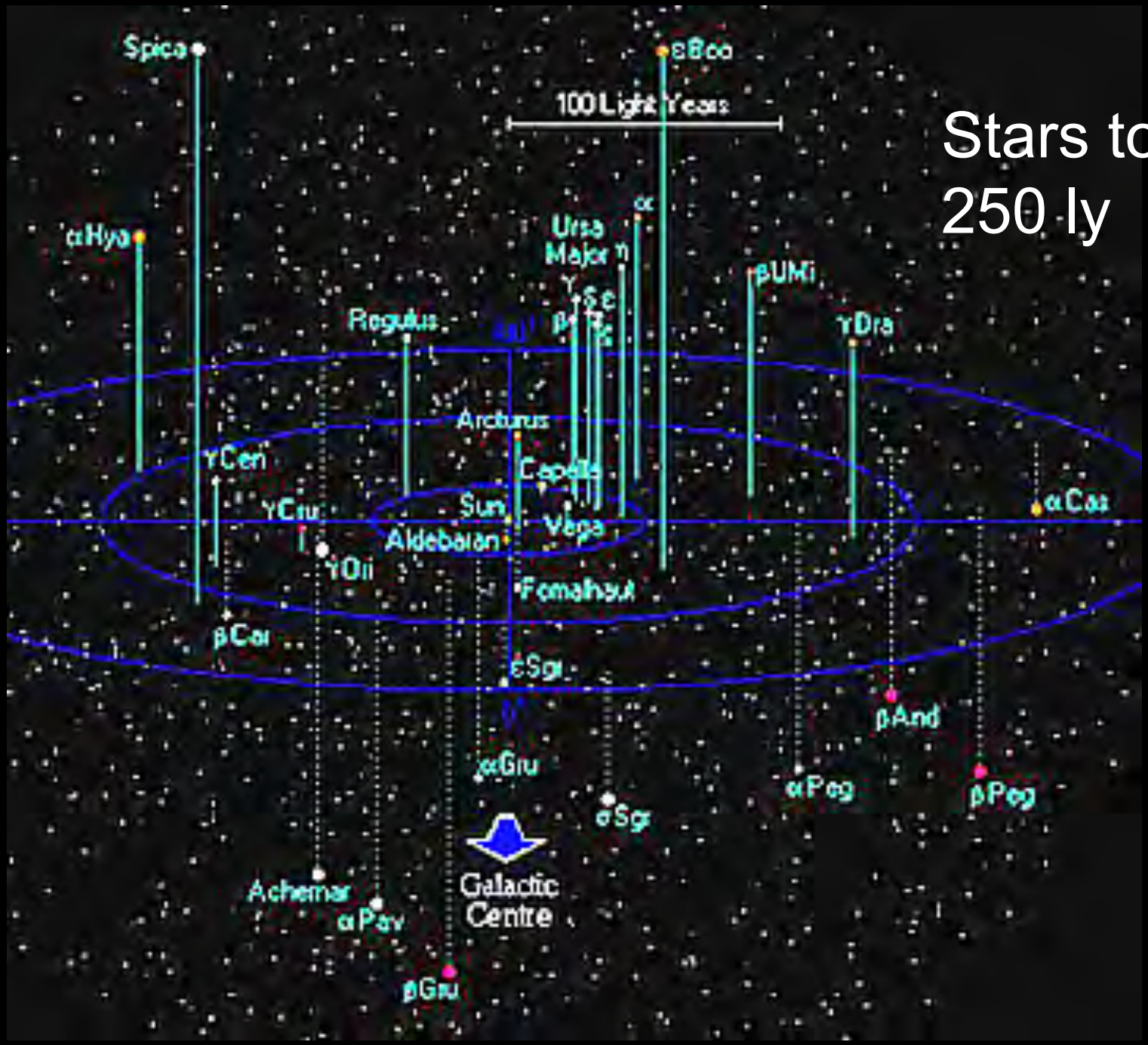
- So the topics we want to look at for this lecture are:
  - What can we see from in here?
  - How have our observations & our theorizing interacted?
- Let's take these topics in that order.



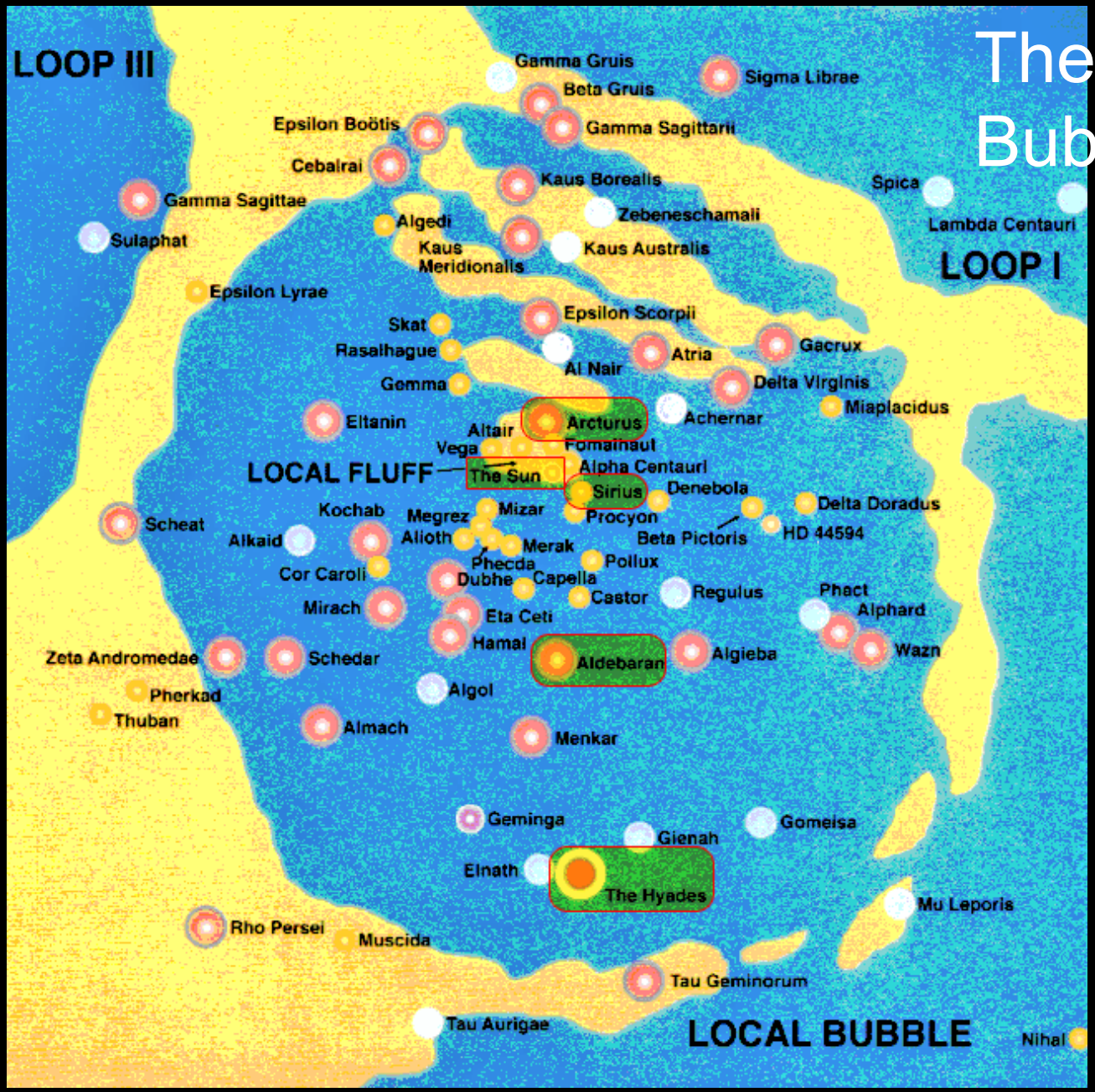

Looking Out…
Further & Further
Hubble Deep Field (detail) 1.5 x 1.125 arc minutes = 0.00044 x 0.00033 radians = 1.44 x 10-7 square radians = 1/87,300,000 of the sky.
Looking at one such area per second, it would take 2.77 years to see the whole sky. http://hubblesite.org/newscenter/archive/1996/01/

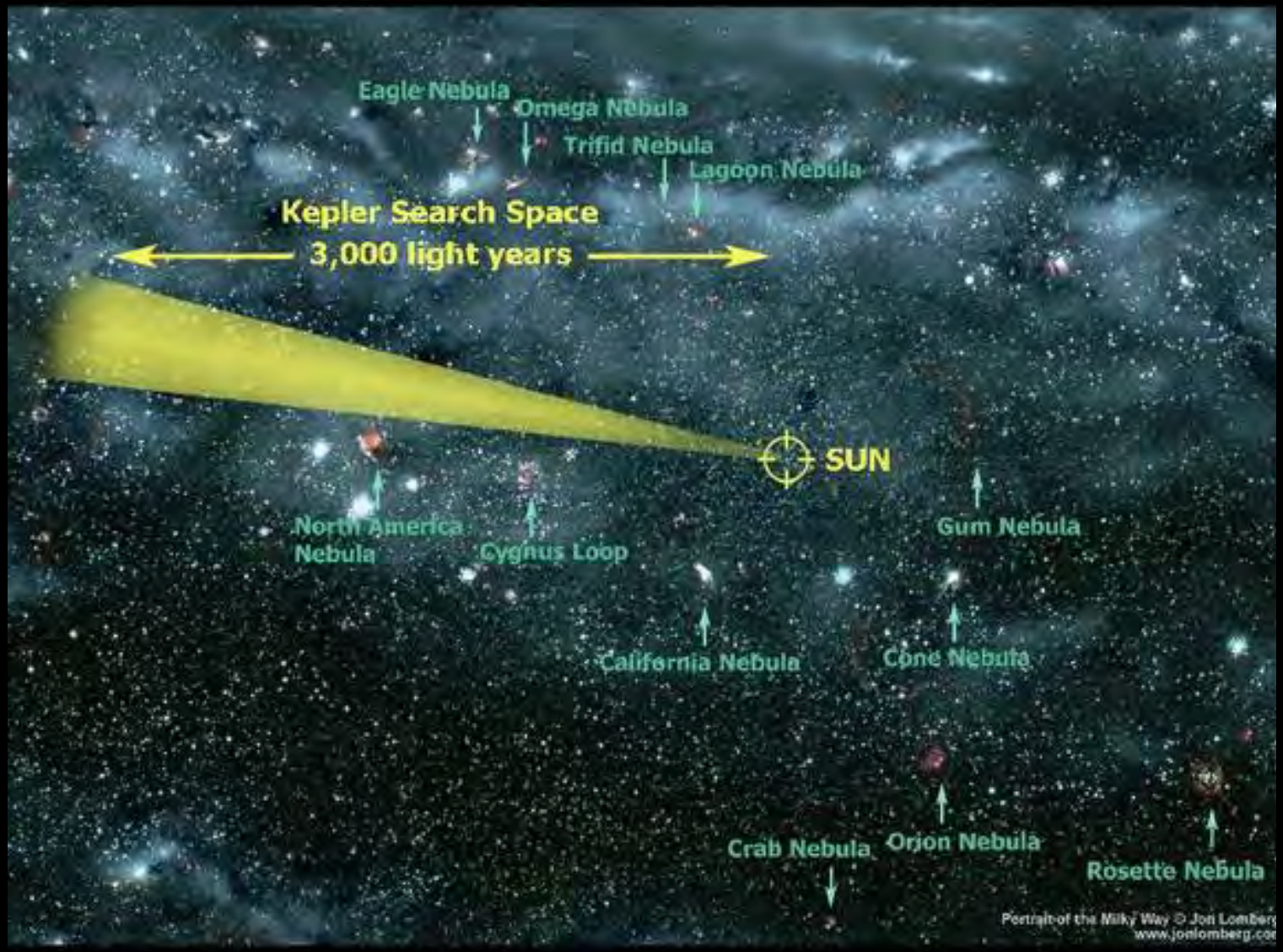
Nearest Stars



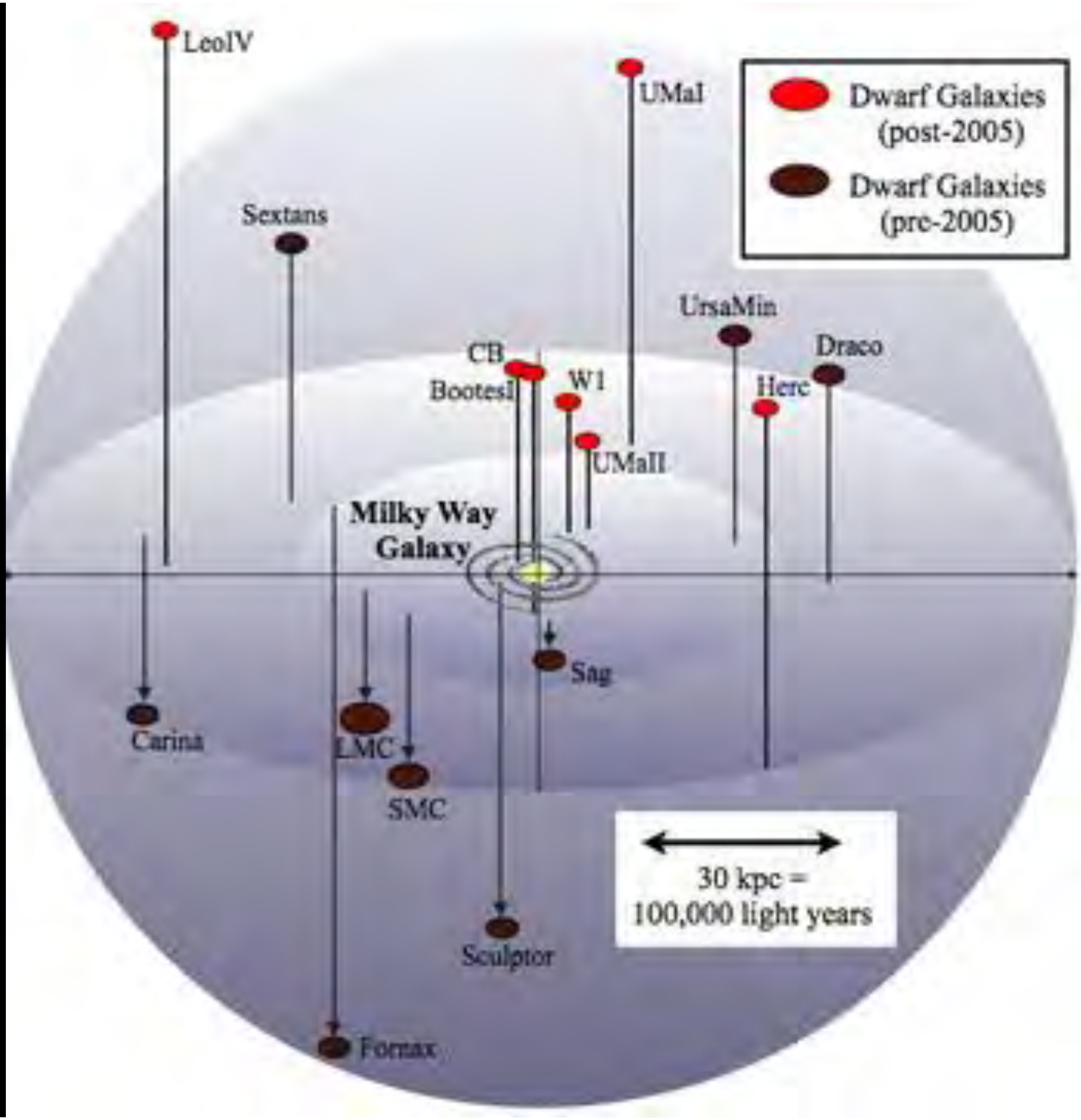


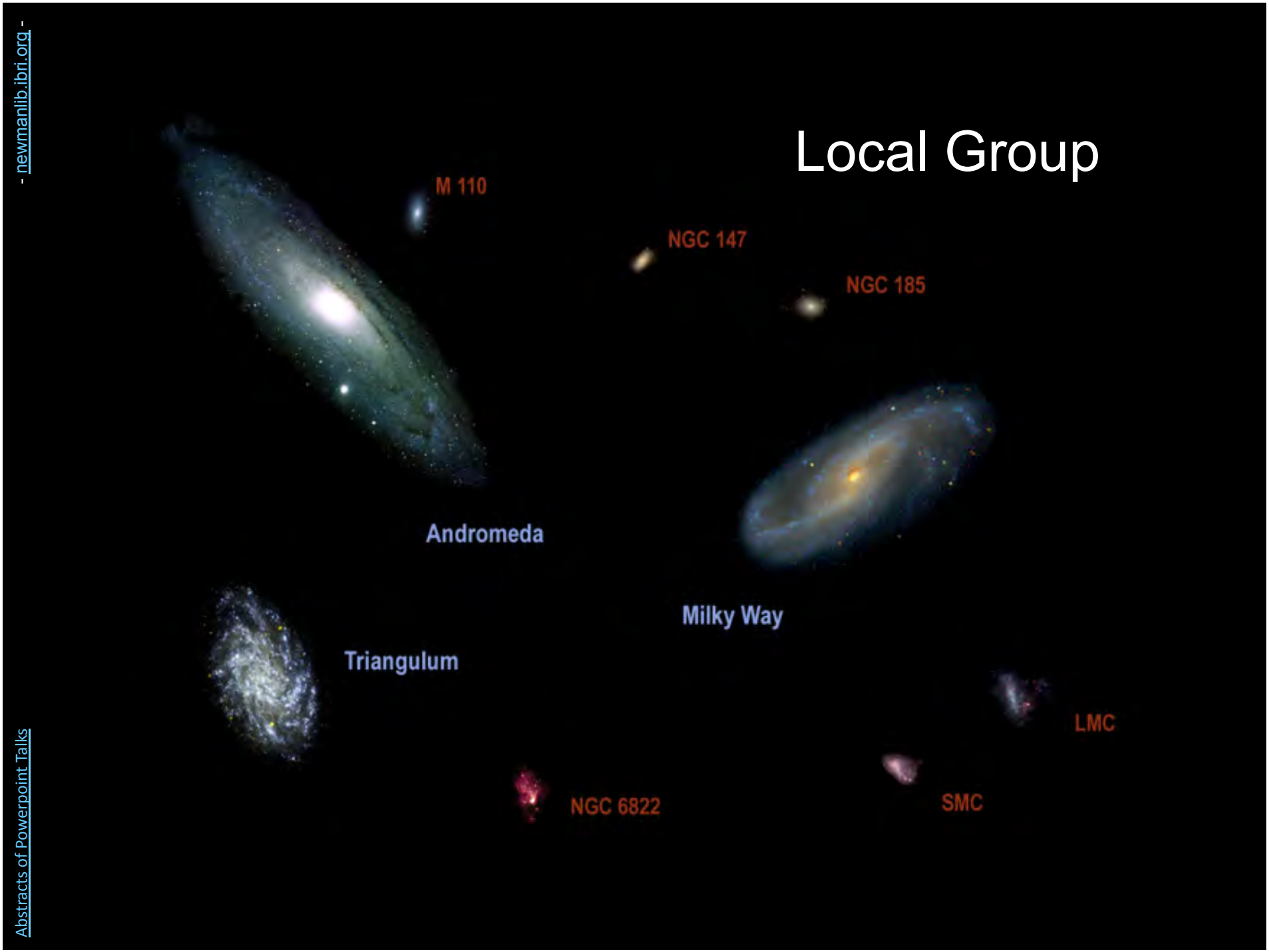
The Local Bubble

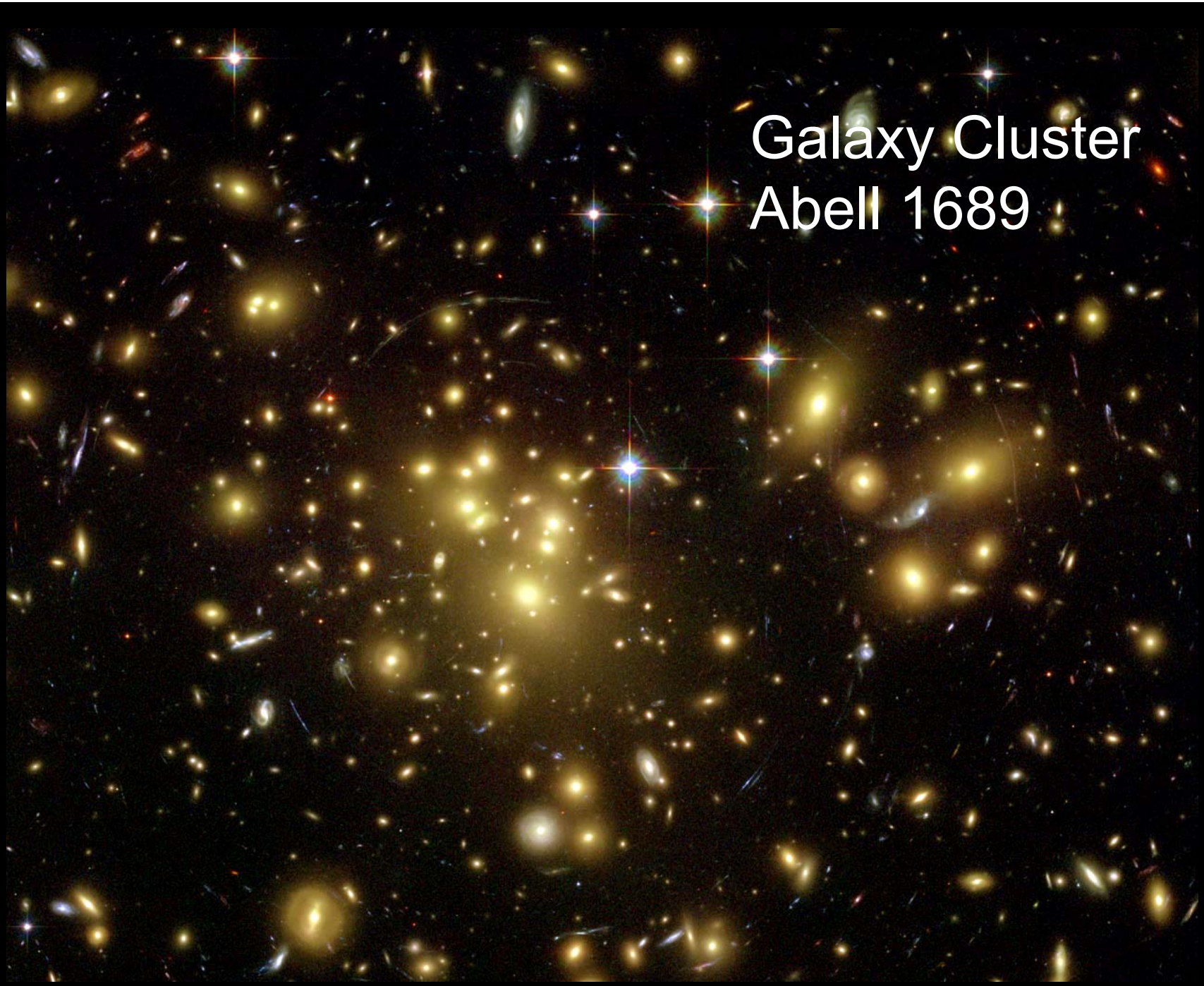


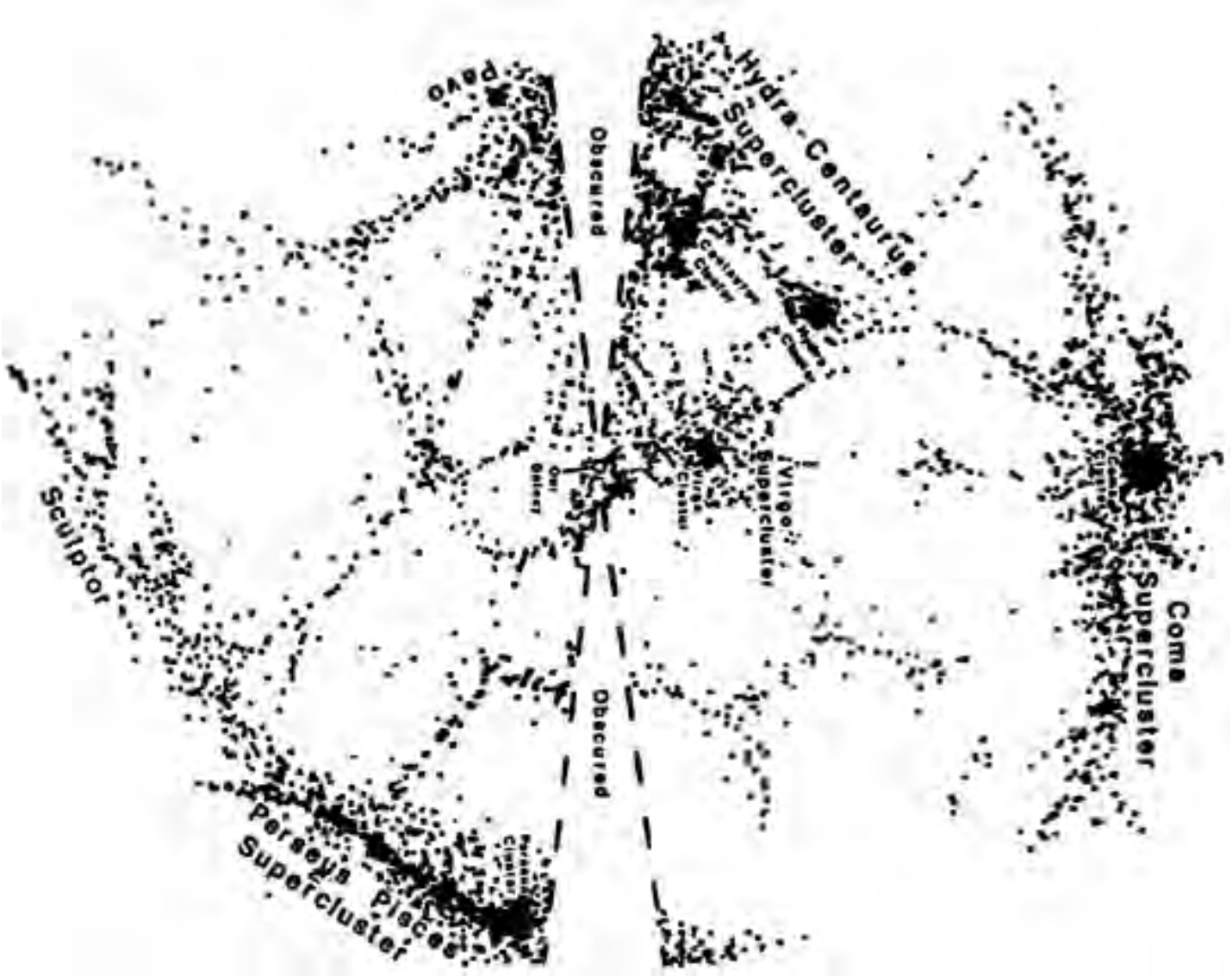


Our Galaxy

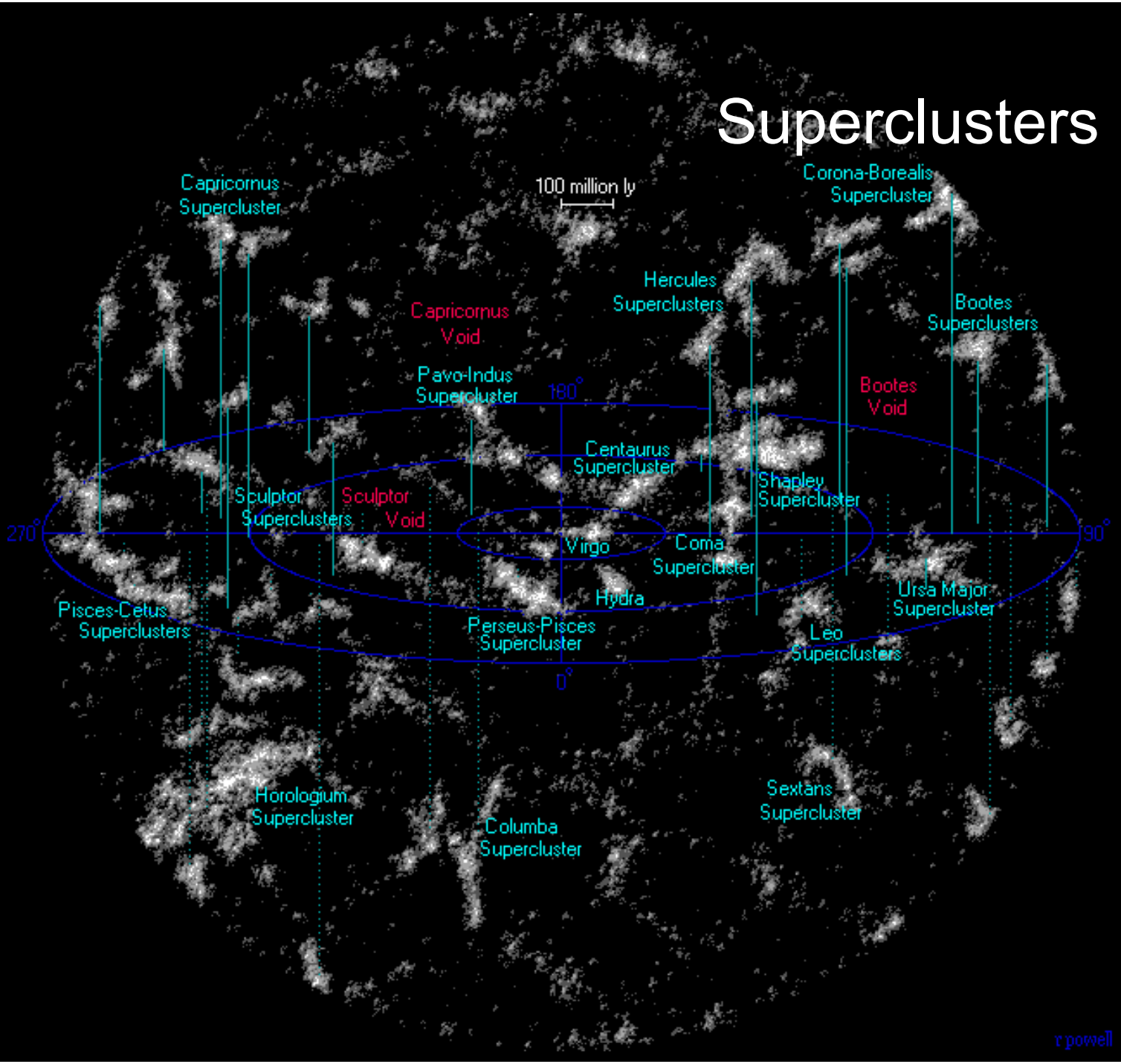



Local Group
M 110
NGC 147
NGC 185
Andromeda
Milky Way
Triangulum
LMC
SMC
NGC 6822



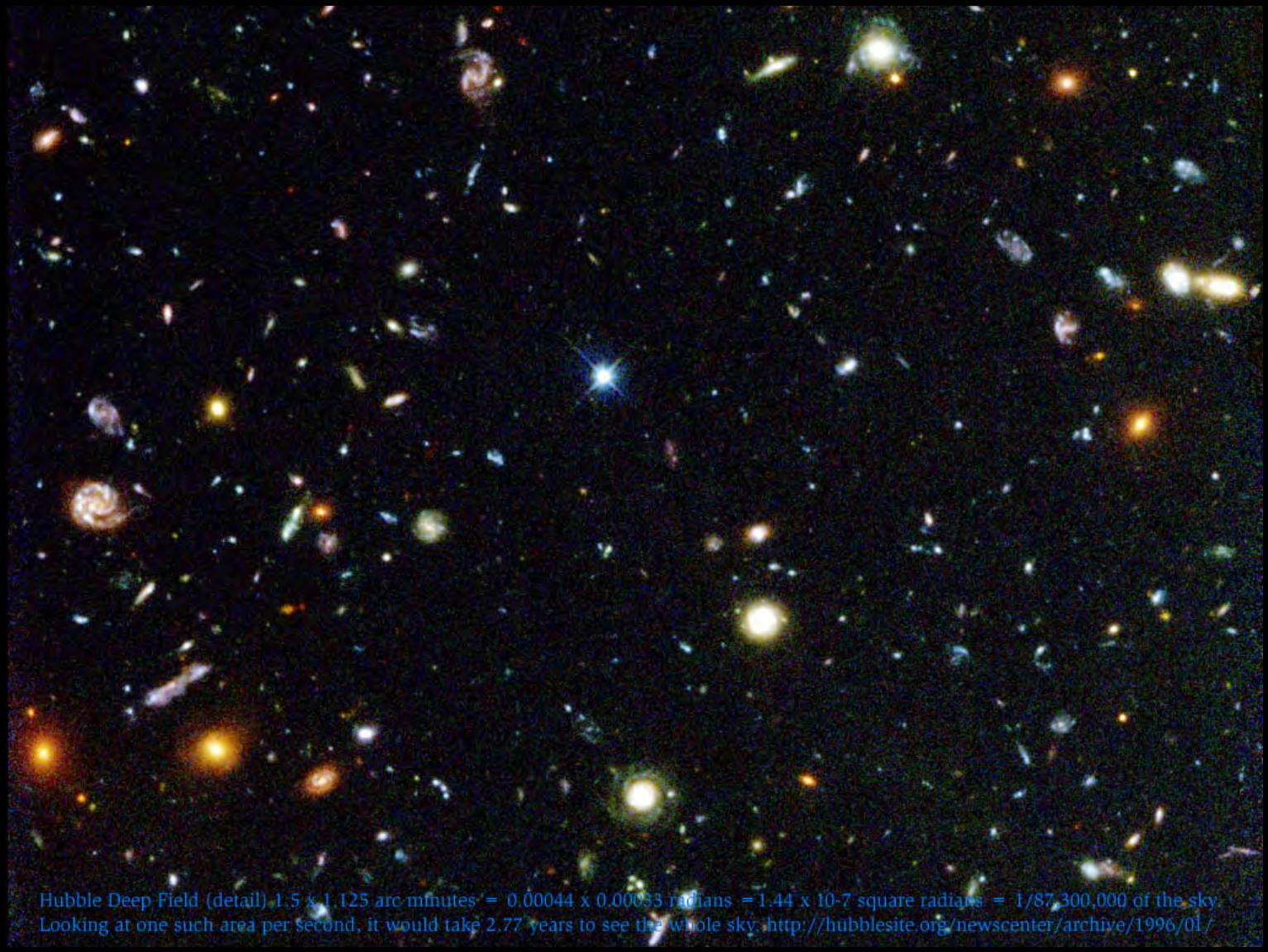

Pavo
Obscured
Hydra-Centaurus
Supercluster
Sculptor
Virgo
Supercluster
Coma
Supercluster
Obscured
Perseus
Supercluster
Pisces

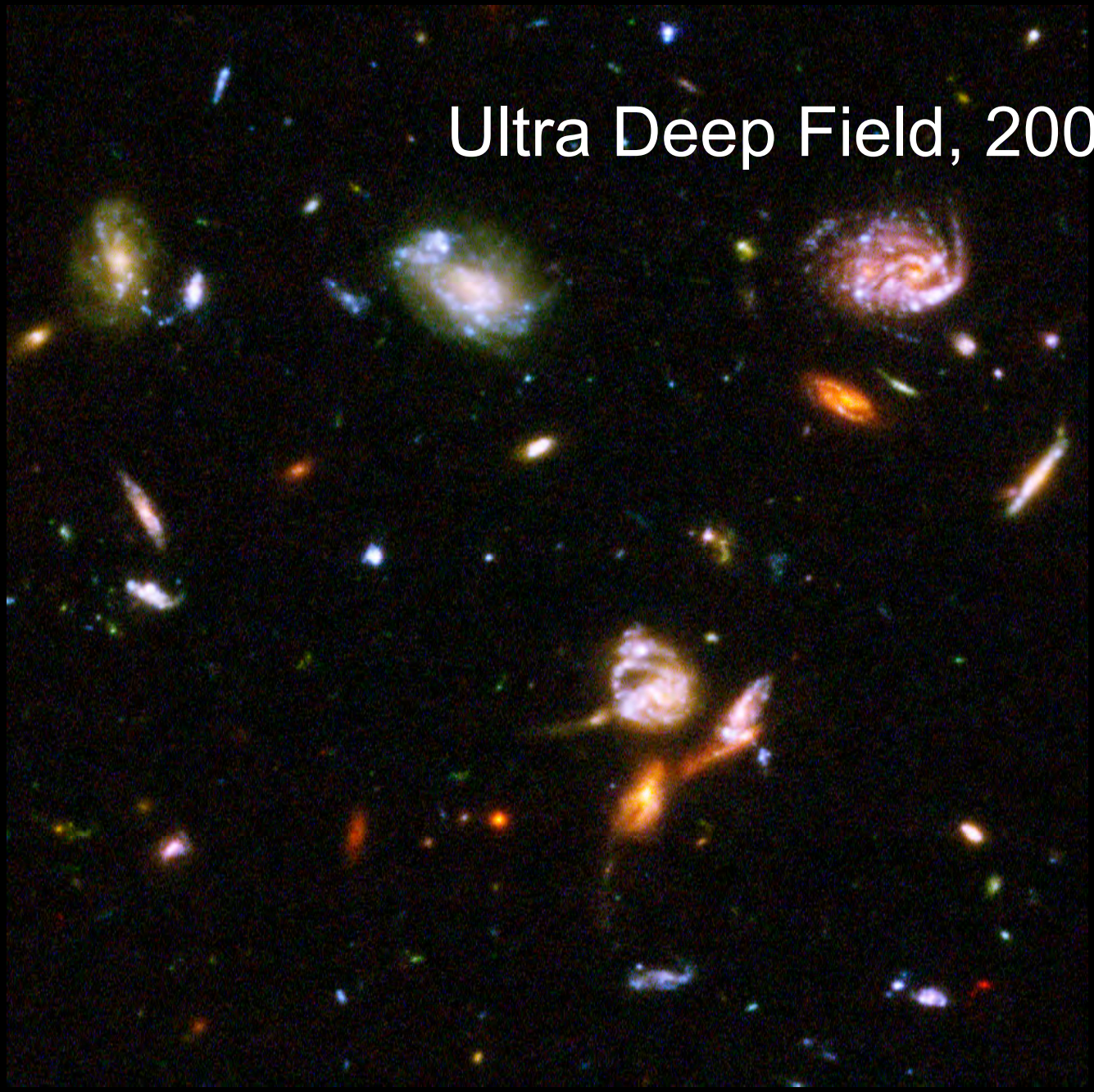
Superclusters



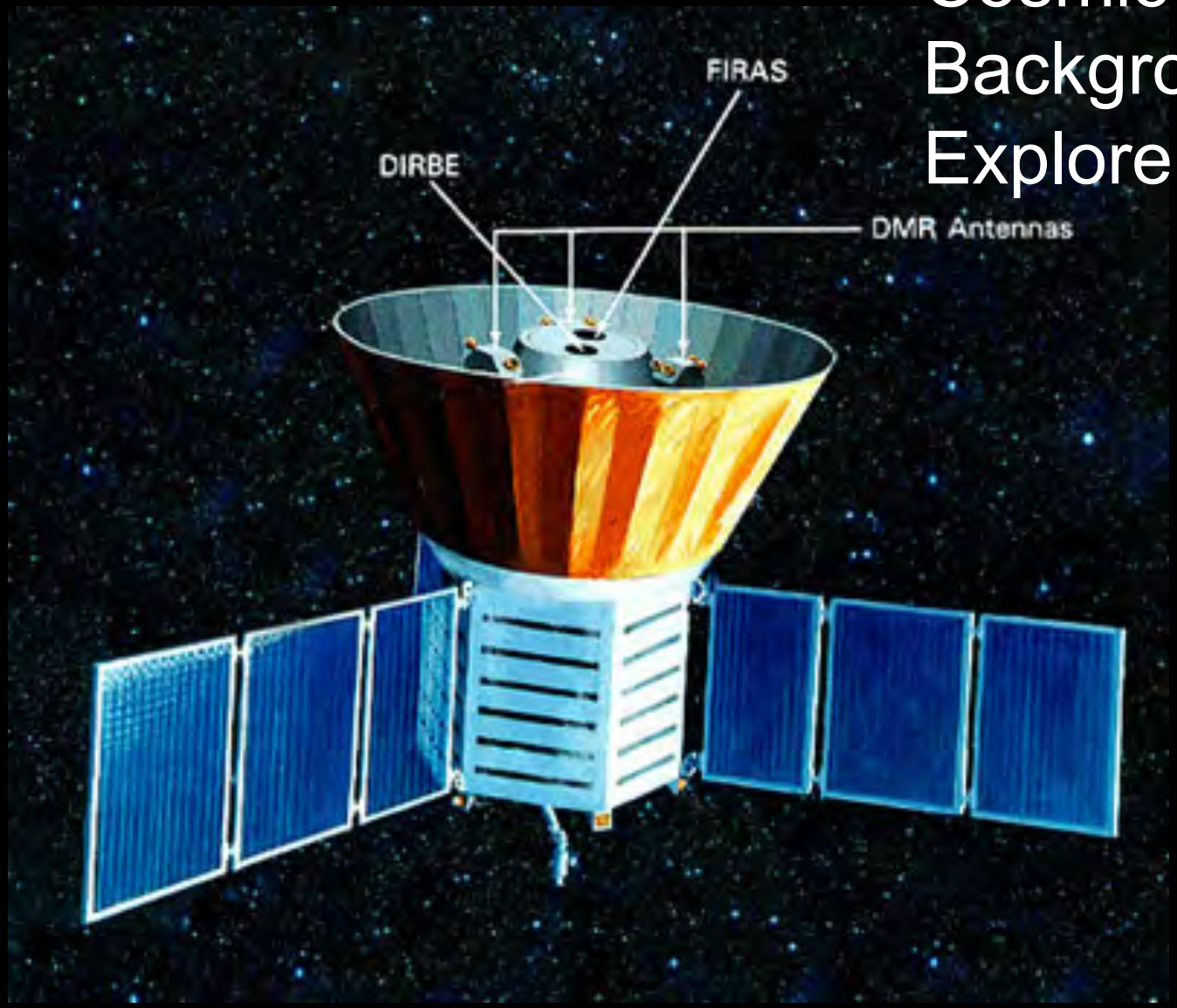
Hubble Space Telescope

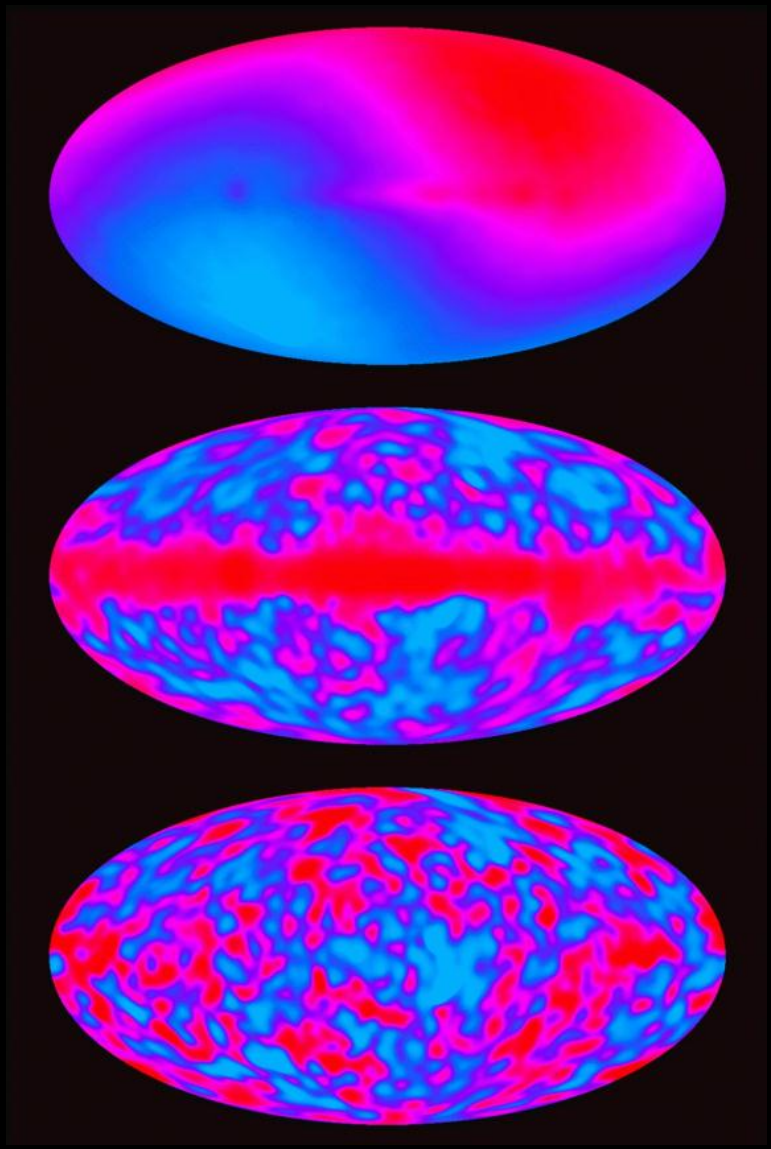
Hubble Deep Field, 1996




Ultra Deep Field, 2003/4

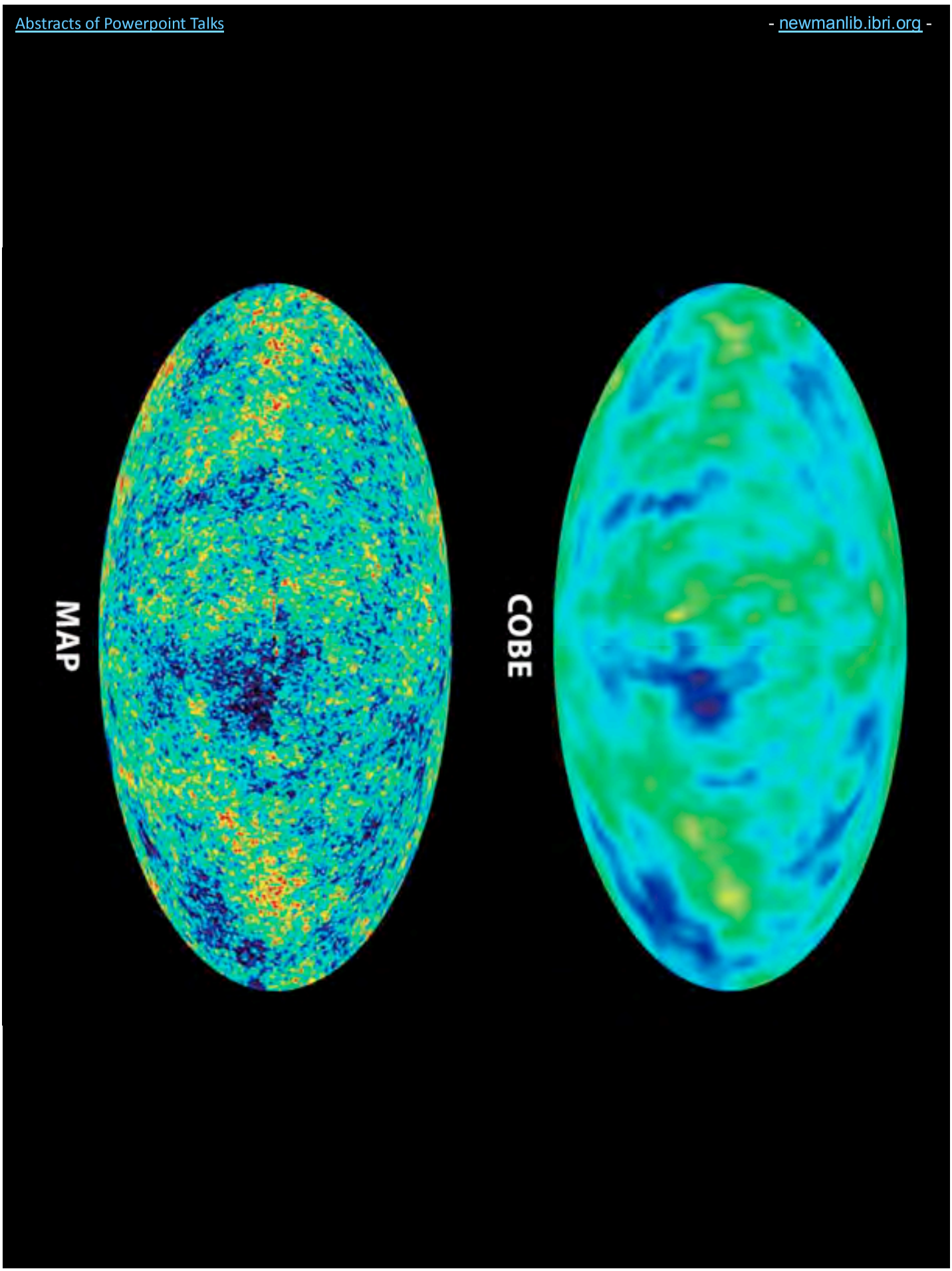
Cosmic Background Explorer





COBE Observations

Wilkinson Microwave Anisotropy Probe


MAP
COBE

Observation & Theory

- We have now given you a quick tour of observations.
- Here we will consider how these have interacted with theory.
- We give a sketch of cosmological theories.
- Then we note the triumph of the big-bang.
- Finally, we ask, "Where do we go from here?"

Cosmological Theories

- At the beginning of the 20th century, many astronomers thought that the universe had always existed, and that it was basically static.
- No one knew how stars burned, so they weren't sure how long they would last.
- Einstein's general theory of relativity began to change all that.

General Relativity

- When applied to the universe, Einstein saw that this predicted an expanding or contracting universe.
- Since no one thought that was the case, Einstein added a 'fudge factor' to make it static.
- But observations of galaxies in the 1910s and 20s by Slipher and Hubble showed the galaxies were moving apart.

The Big-Bang Theory

- In the late 1920s, George Lemaitre proposed what later came to be called the big-bang theory.
- He suggested that the universe was expanding from a very hot dense state, which he presumed to be creation.
- Many were unhappy with this, as they didn't like the concept of a creation.

Alternatives to Creation

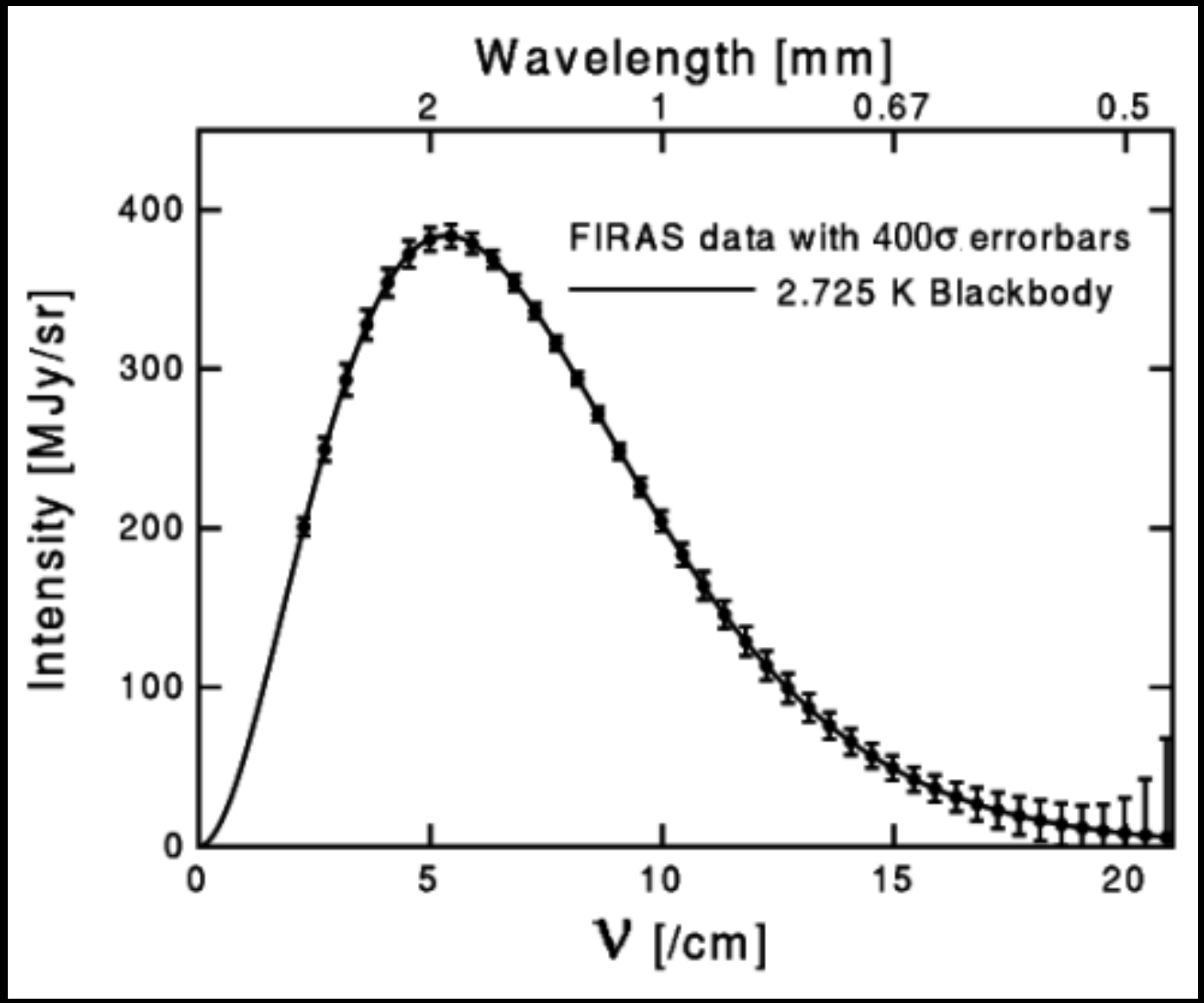
- Some modified the big-bang theory to avoid a creation, by having one or more 'bounces' in the history of the universe.
- Others proposed a steady-state theory, in which an infinite, eternal universe is continually expanding and adding more matter in such a way as to always look the same.

Observations & the Steady-State

- Attempts to count the number of galaxies in a given volume at increasing distances suggested the universe was more crowded earlier in its history.
- This became even more obvious when quasars were discovered in the 1960s and the same test was applied to them.
- The steady-state theory had predicted that the density of the universe was constant everywhere in time and this didn't seem to be the case.

The Cosmic Blackbody Radiation

- Also in the mid-1960s, Penzias and Wilson discovered that the sky was 'glowing' in all directions at microwave frequencies.
- This had been predicted years before as a consequence of big bang theories.
- In the following years, this radiation was carefully measured at various wavelengths and found to fit the predicted blackbody spectrum.



Triumph of the Big Bang

- This essentially eliminated the steady-state theories from competition, leaving the field to varieties of the big bang.
- Since then, the 'bouncing' varieties of the big bang have been eliminated as no way has been found to convert a collapsing universe into an expanding one.

Where Do We Go from Here?

- The simplest reading for the big bang would be a creation event at the bang.
- Scientists who don't believe in a God prefer to think of our universe as just a bubble formed in an infinite, eternal, static universe.
- So far, we have no clear evidence of more universes than our own.

Dark Matter

- It has been known for many years that there is not enough visible matter in the galaxies to hold them together.
- This led to the proposal of 'dark matter' (which we cannot see) as the source of the additional gravity.
- This has apparently been confirmed by the recent data from WMAP.

Dark Energy

- In the past few years, it has become apparent that (contrary to all expectations) our universe is expanding faster than it was earlier in its history.
- A quantity called 'dark energy' is proposed to explain this acceleration of our universe's expansion.