

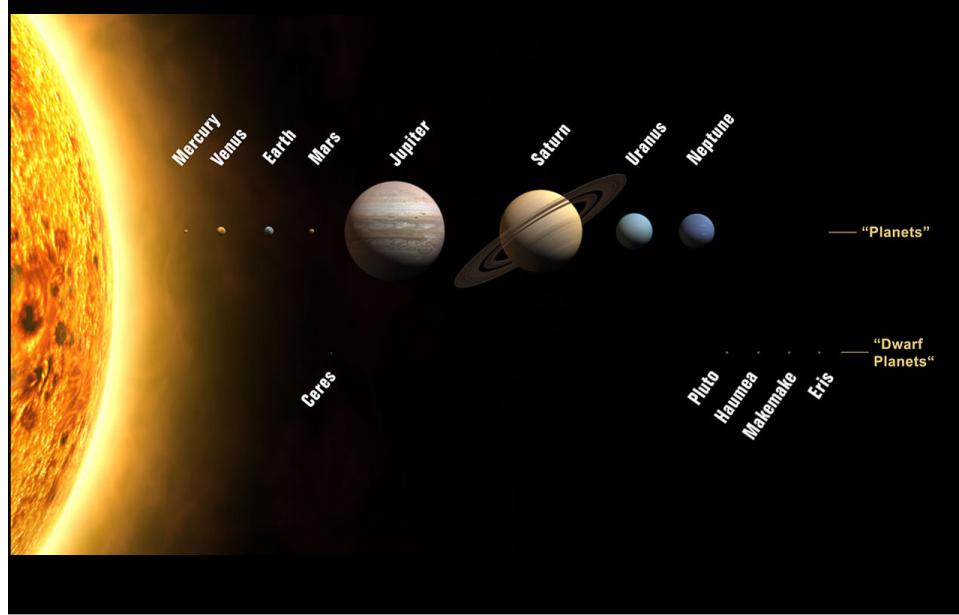
Lecture 2 – Part 2: Outline

Overview of the Universe

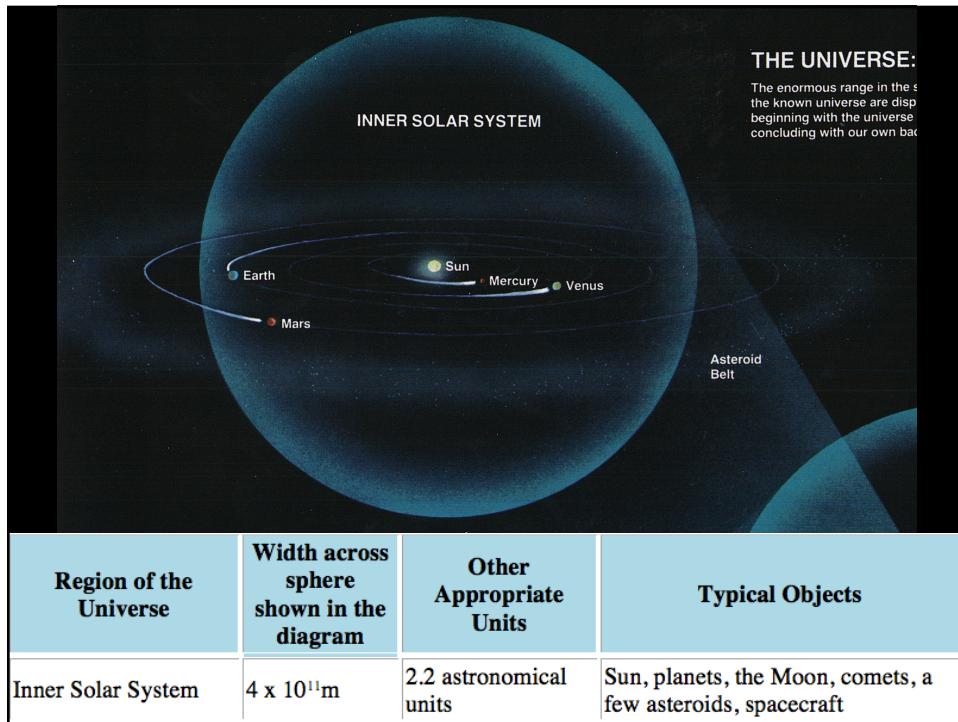
The Scale of the Universe

9

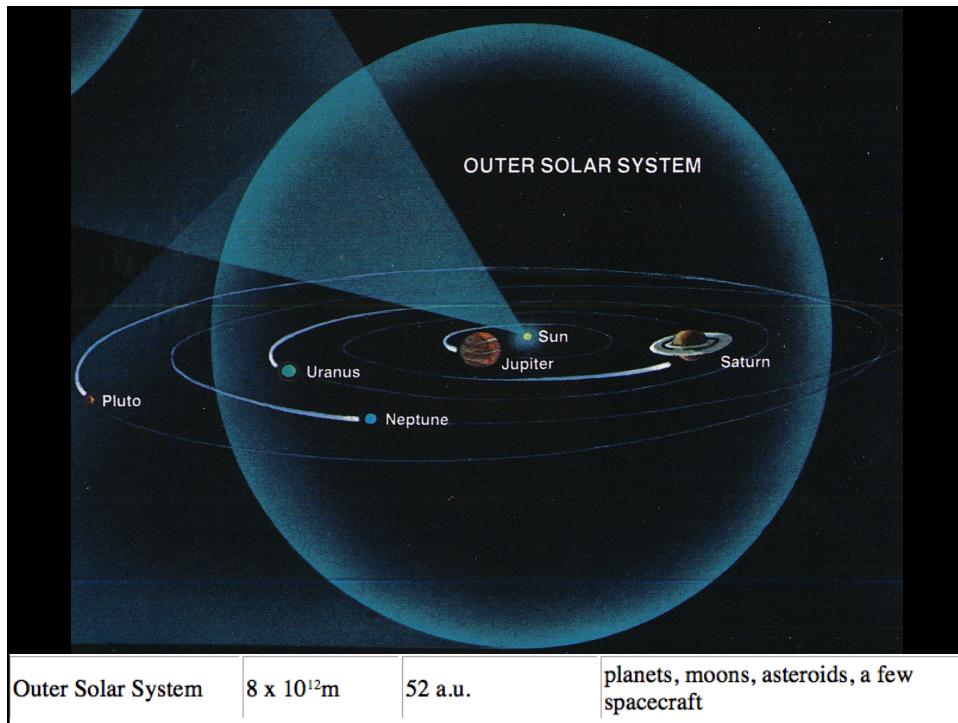
Largest Objects in the Solar system (drawn to scale)



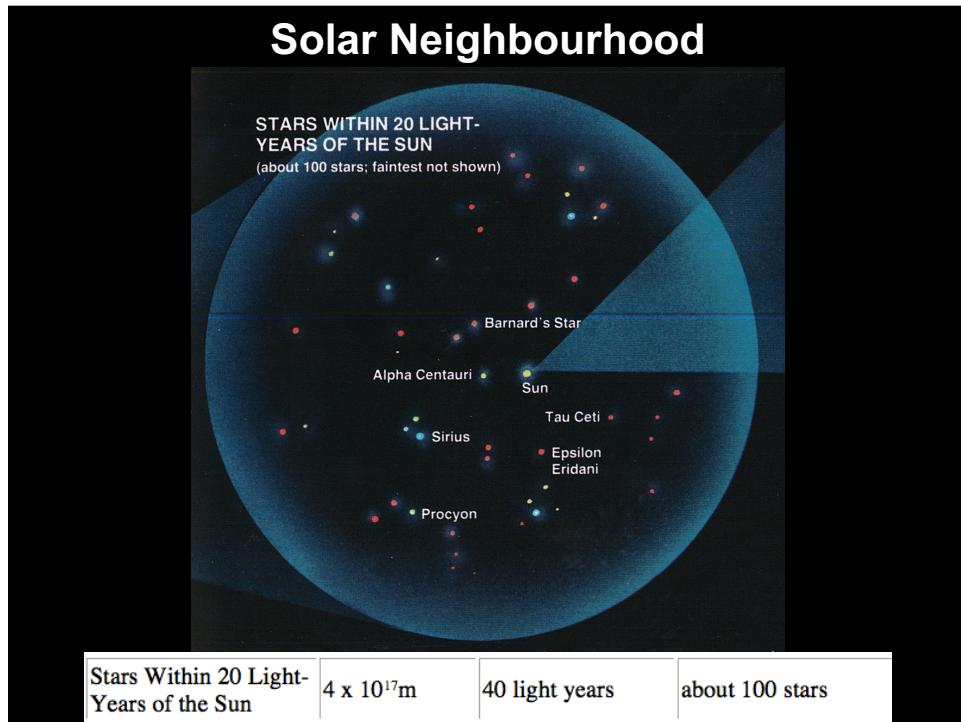
10



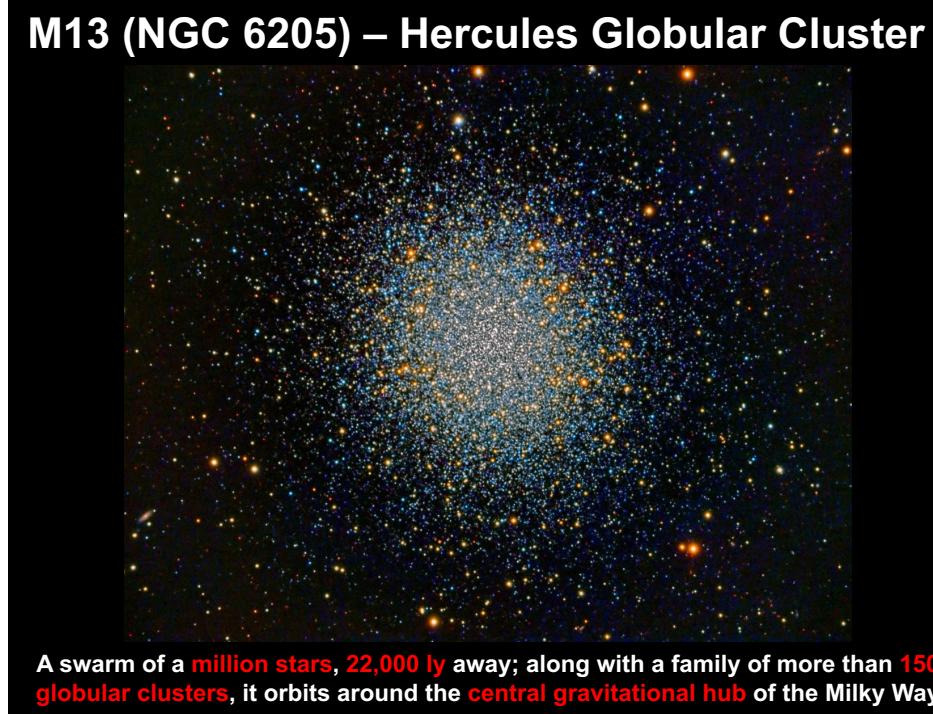
11



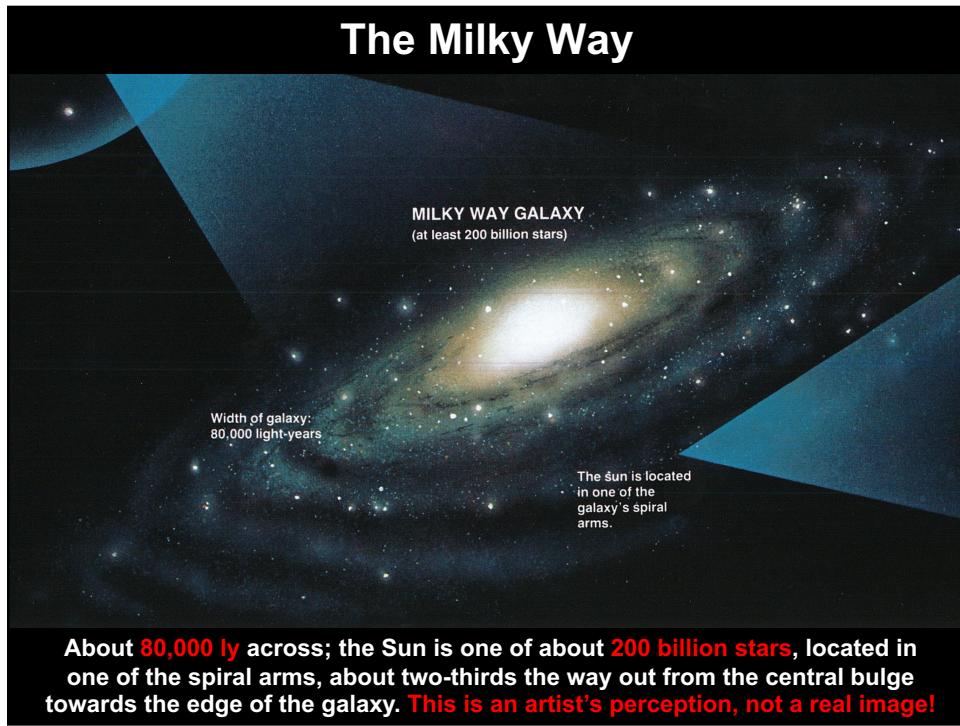
12



13



14



15



16

NGC 6118

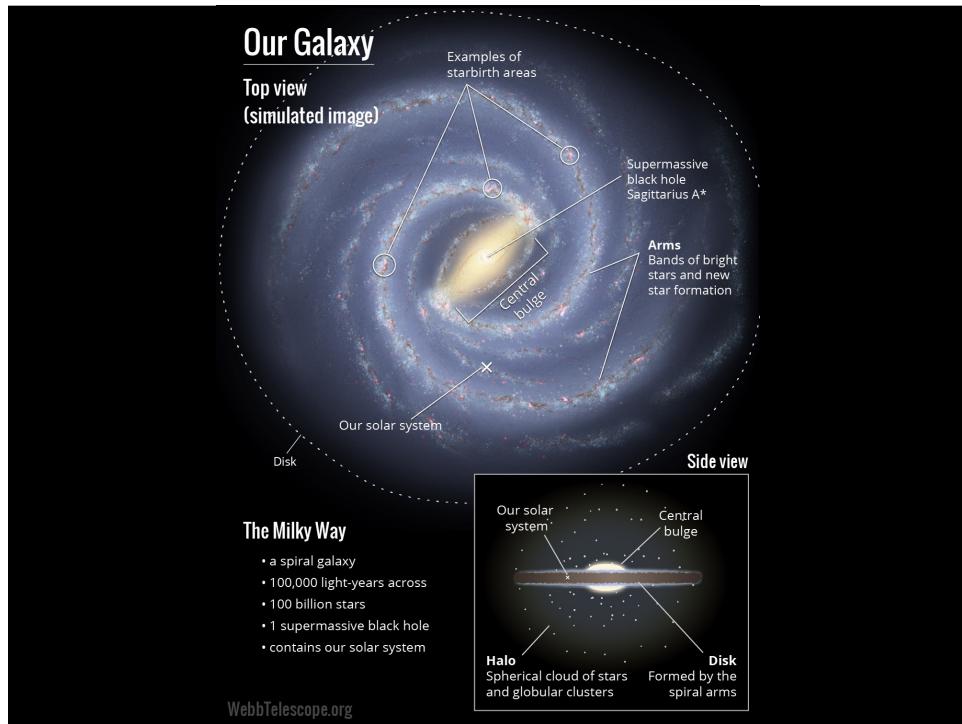
A spiral galaxy located **83 million ly** away; roughly, **110,000 ly across**; size about the **same** as our own galaxy, the Milky Way

17

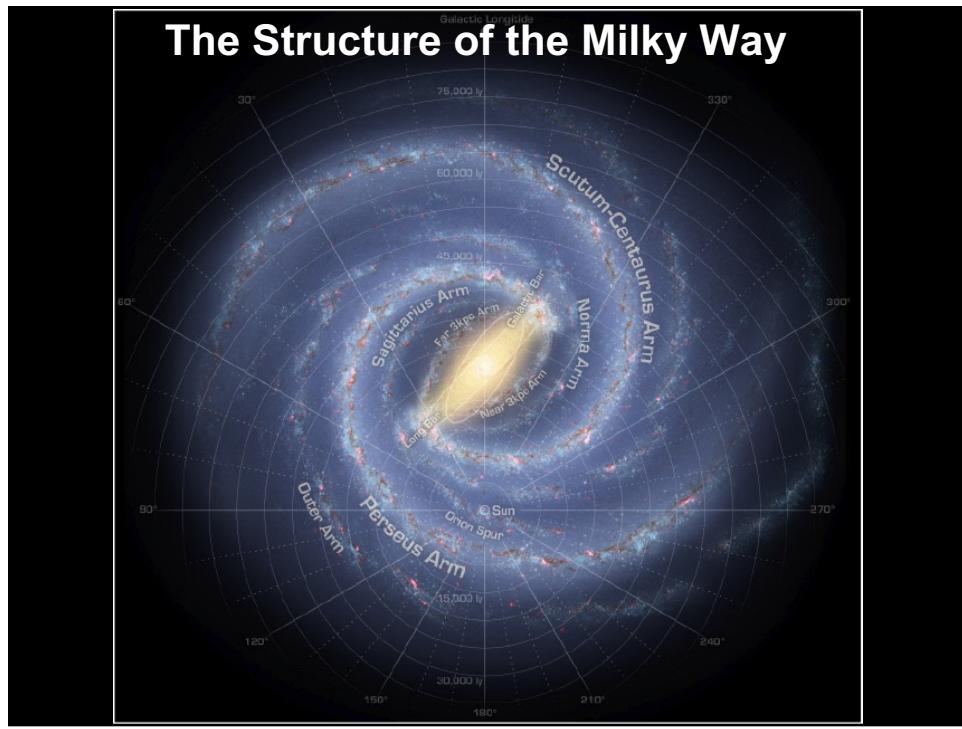
M101 – the Pinwheel Galaxy

This galaxy is a face-on spiral at a distance of **21 million light-years**. M101 is **almost twice** the diameter of the Milky Way, and it contains at least **1 trillion stars**.

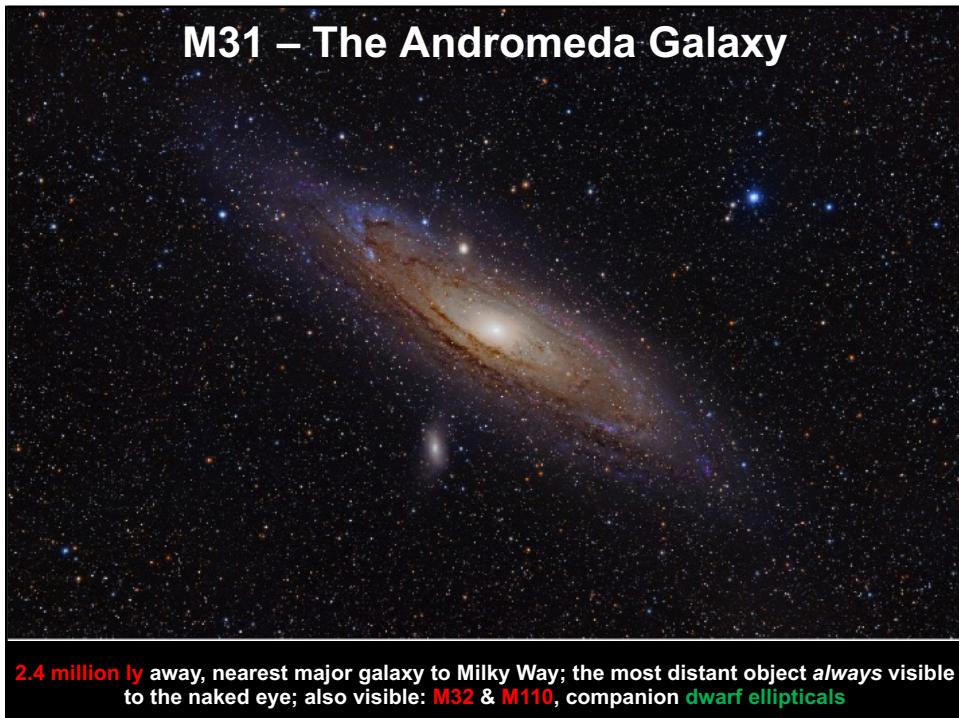
18



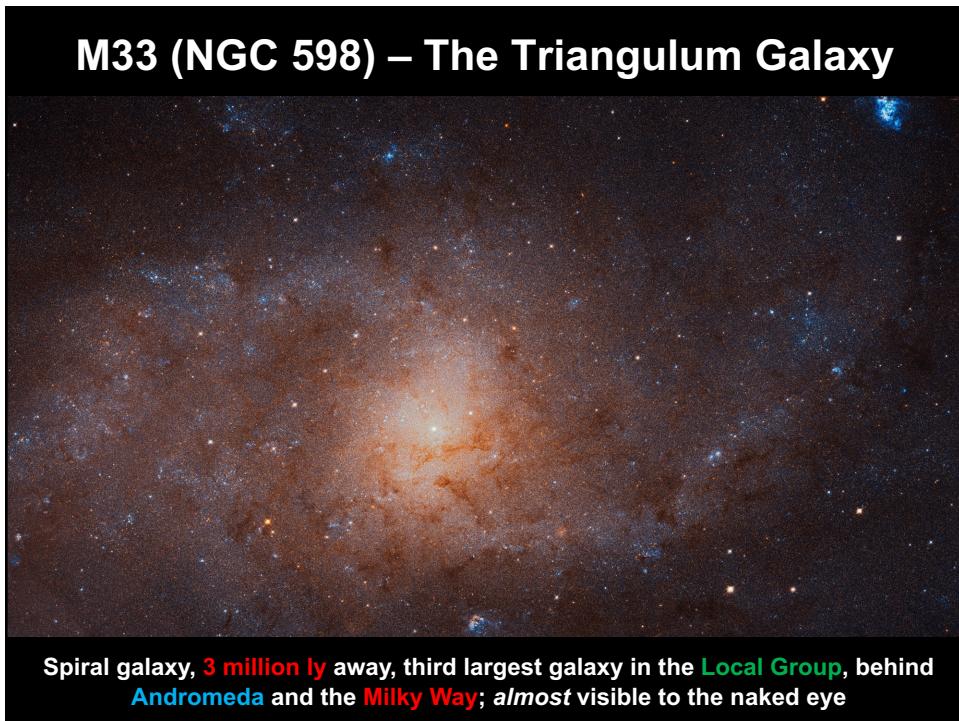
19



20



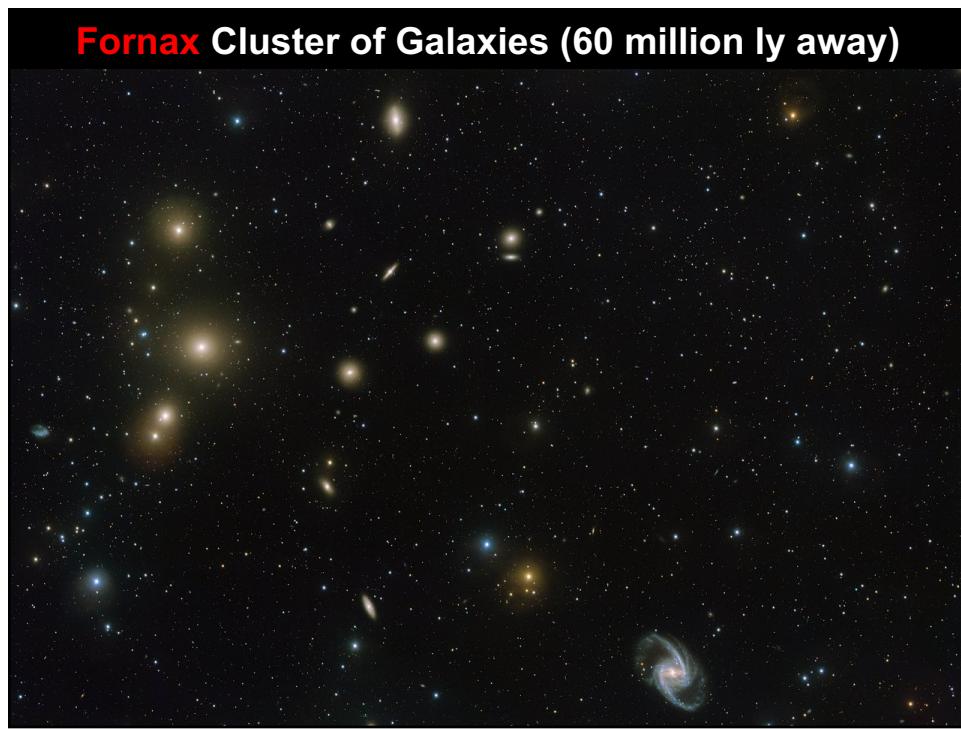
21



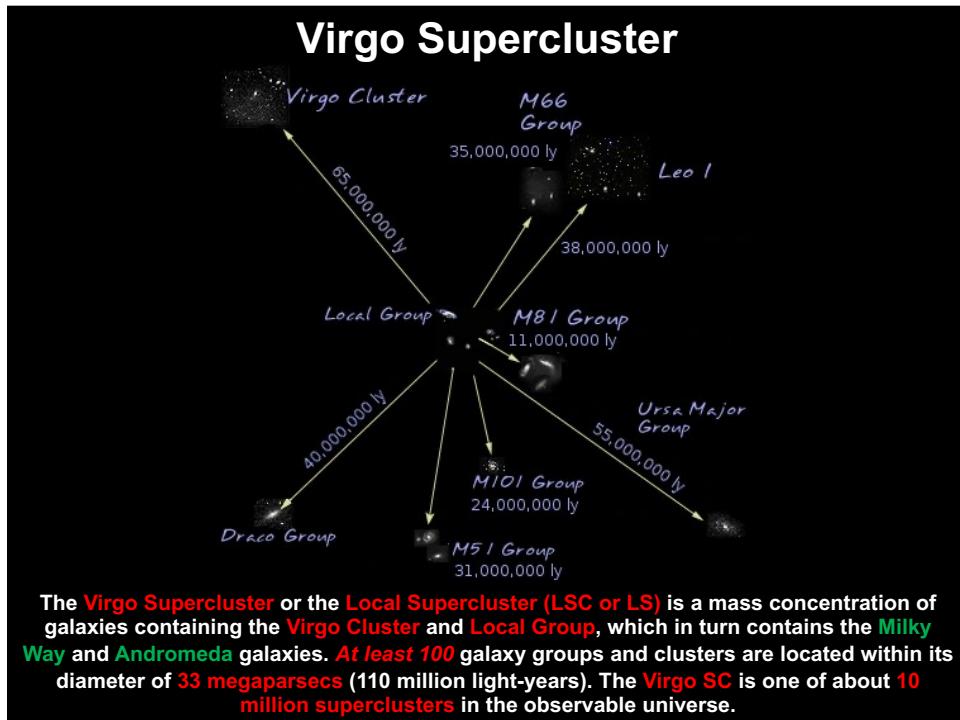
22



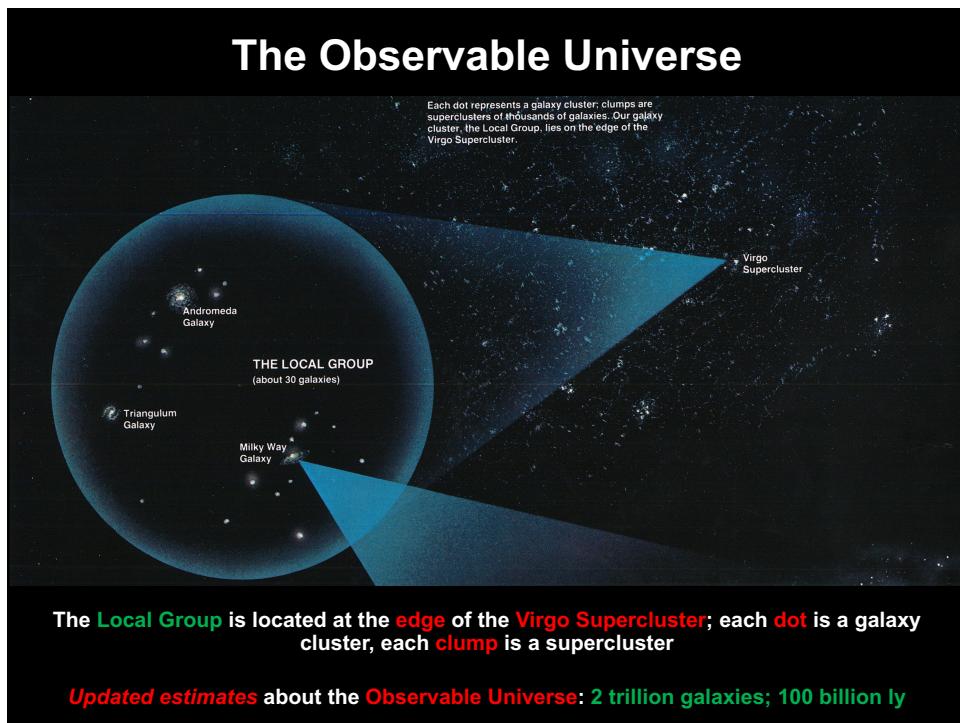
23



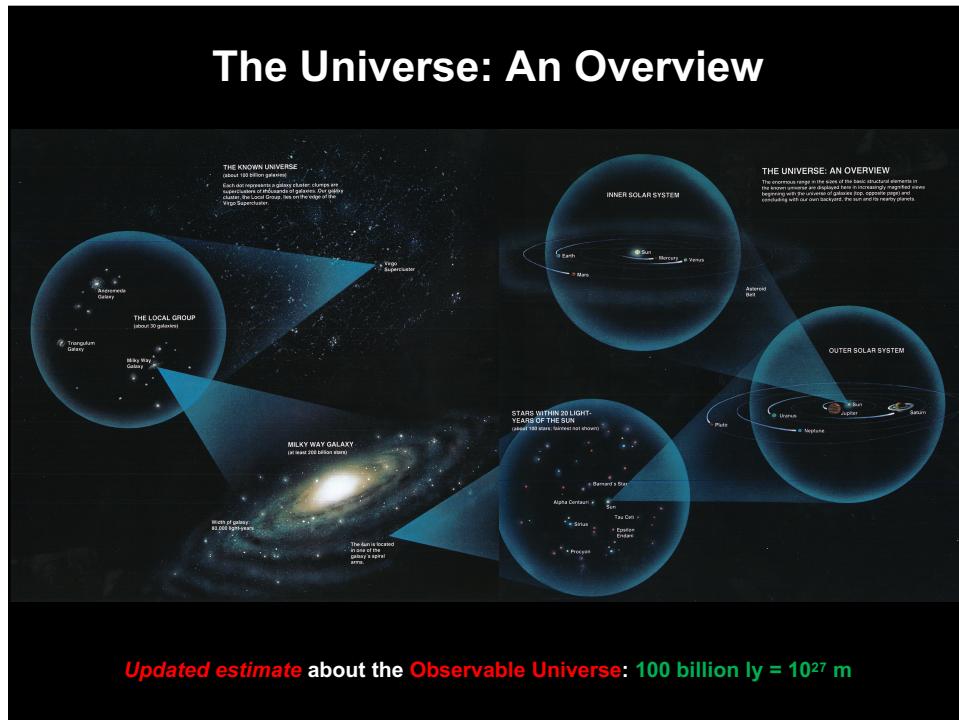
24



25



26



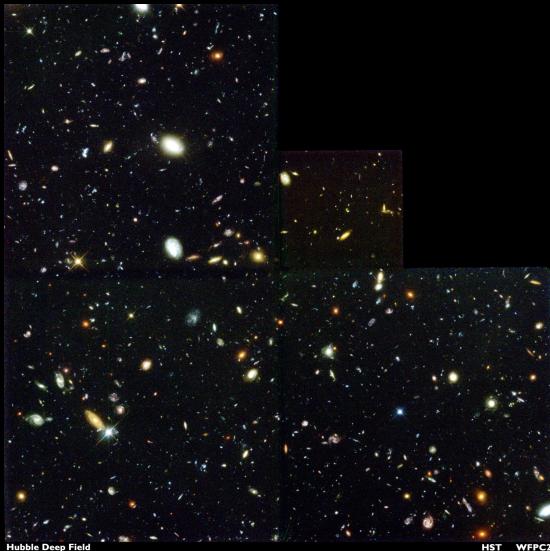
27

| The Scale of the Universe: Regions | | | |
|--|--|-------------------------|---|
| Region of the Universe | Width across sphere shown in the diagram | Other Appropriate Units | Typical Objects |
| Inner Solar System | $4 \times 10^{11} \text{ m}$ | 2.2 astronomical units | Sun, planets, the Moon, comets, a few asteroids, spacecraft |
| Outer Solar System | $8 \times 10^{12} \text{ m}$ | 52 a.u. | planets, moons, asteroids, a few spacecraft |
| Stars Within 20 Light-Years of the Sun | $4 \times 10^{17} \text{ m}$ | 40 light years | about 100 stars |
| Milky Way Galaxy | $7.6 \times 10^{20} \text{ m}$ | 80,000 light years | 300 billion of stars, star clusters, interstellar clouds, dark matter |
| The Local Group | $4 \times 10^{22} \text{ m}$ | 4 million light years | about 30 galaxies |

Updated estimate about the Observable Universe: $100 \text{ billion ly} = 10^{27} \text{ m}$

28

The Hubble Deep Field (HDF)



Hubble Deep Field
STScI-PRC-1 January 11, 1998 R. Williams and the HDF Team (STScI) and NASA

HST WFPC2

Hubble Deep Field image covers a speck of the sky only about the **width of a dime 75 feet away**. The field is a very small sample of the heavens but it is considered representative of the typical distribution of galaxies in space. In this small field, Hubble uncovered a bewildering assortment of **at least 1,500 galaxies** at various stages of evolution. The image was assembled from 342 separate exposures taken over ten consecutive days between December 18 and 28, 1995.

29

The Hubble Ultra Deep Field (HUDF)



A region of the observable Universe, **one-tenth the diameter of a full moon** viewed from Earth, smaller than a **1 mm²** piece of paper held 1 m away, and equal to roughly **one twenty-six-millionth of the total area of the sky**. Every object is a galaxy! The **yellow spiral** at the center is about **800 million ly** away; the faintest specks are about **12 billion ly** away.

30

The Hubble Extreme Deep Field (HXDF)



The **Hubble eXtreme Deep Field (HXDF)**, released on September 25, 2012, is an image of a portion of space in the center of the Hubble Ultra Deep Field image. Representing a total of two million seconds (about 23 days) of exposure time collected over 10 years, the image covers about 80% of the area of the **HUDF**, combining data from HUDF and HUDF Infrared (2009). This represents approximately one thirty-two millionth of the sky. Yet even in this tiny fraction of the sky, the long exposure reveals about 5500 galaxies, some of them so distant that we see them **when the Universe was less than 5% of its current age**.

31

The Scale of the Universe: Objects in Astronomy

| Object | Typical Size | Ratio of Size (compared to next smaller object) | Ratio of Size (compared to next larger object) |
|----------------|--------------------|--|---|
| Atom | 10^{-10}m | n/a | billionth of a billionth |
| Planet | 10^8m | billion billion times | hundredth |
| Star | 10^{10}m | 100 times | hundredth of a billionth |
| Galaxy | 10^{21}m | 100 billion times | hundredth |
| Galaxy cluster | 10^{23}m | 100 times | tenth |
| Supercluster | 10^{24}m | ten times | hundredth |

Updated estimate about the **Observable Universe**: $100 \text{ billion ly} = 10^{27} \text{ m}$

32