

# Galaxies

Harken Observatory  
Pewaukee Public Library

First presented Saturday, November 4, 2006 by Scott Berg

Created by Scott Berg

A similar version was shown at the Milwaukee Astronomical Society on October 20, 2006

# Galaxies

- What is a galaxy?
- Size and Distance
- Famous Galaxies & Galaxy Types
- Home – The Milky Way
- Galactic Maps & Distances
- Hubble Ultra Deep Field Photo
- Harken Observatory

Harken Observatory  
Pewaukee Public Library

2

## What is a galaxy?

- A galaxy is a large collection of stars, planets, comets, meteors, dust and gas held together by gravity and that can be recognized as a distinct entity.
- Galaxies come in many shapes and sizes.
- Galaxies are usually far apart with (almost) nothing in the space between them, BUT galaxies are always in motion and sometimes collide.

Harken Observatory  
Pewaukee Public Library

3

# Galaxies

- What is a galaxy?
- Size and Distance
- Famous Galaxies & Galaxy Types
- Home – The Milky Way
- Galactic Maps & Distances
- Hubble Ultra Deep Field Photo
- Harken Observatory

Harken Observatory  
Pewaukee Public Library

4

## Size and Distance

- To understand the size and distance associated with galaxies, we need some measurements.
- Feet and miles become cumbersome to use:
  - 6 foot person is  $6/5280 = 0.001136$  miles
  - 100 miles is  $100*5280*12 = 6,336,000$  inches
- Astronomers made up their own unique measure for length.

# Light and Distance

- Light is the fastest thing in the universe. That was one of Einstein's big insights.

- 186,282 miles/second =  $1.86282 \times 10^5$  mps

- 669,600,000 miles/hour =  $6.696 \times 10^8$  mph

- 299,792 kilometers/second =  $2.99792 \times 10^5$  kps

- 1,079,252,706 km/sec =  $1.07925 \times 10^9$  kph

- Astronomers measure distance using time.

- Q: "How far to grandma's?" A: "About an hour."

Harken Observatory  
Pewaukee Public Library

# Light Year

- How far does light travel in one year?
- 5,878,612,843,200 miles = 1 **light year**

$$186,282 \frac{\text{miles}}{\text{second}} \times 60 \frac{\text{sec}}{\text{min}} \times 60 \frac{\text{min}}{\text{hour}} \times 24 \frac{\text{hours}}{\text{day}} \times 365.25 \frac{\text{days}}{\text{year}} = 5.878 \times 10^{12} \frac{\text{miles}}{\text{year}}$$

- In practice, the definition is often looser. e.g. drop the "282", forget leap day, ... After all, what's a million miles among trillions?

# Galaxies

- What is a galaxy?
- Size and Distance
- Famous Galaxies & Galaxy Types
- Home – The Milky Way
- Galactic Maps & Distances
- Hubble Ultra Deep Field Photo
- Harken Observatory

Harken Observatory  
Pewaukee Public Library

8



Messier discovered on October 13, 1773 and named M51

M51 aka NGC 5194 (type Sbc – spiral, between b and c)

Smaller galaxy is NGC 5195 (type SB0-a – spiral with bar, tight arms)

This galaxy was the first one where the spiral structure was discovered, in spring 1845 by Lord Rosse, who made a [very careful and accurate painting](#). Therefore, M51 is sometimes referenced as Rosse's Galaxy or Lord Rosse's "Question Mark" - he is cited with this name (see, e.g., [NED](#)).



<http://www.seds.org/messier/xtra/ngc/n7331.html>

Discovered by William Herschel in 1784.

NGC 7331 is one of the brighter galaxies which is not included in Messier's catalog. It exposes a fine spiral structure despite its small inclination from the edge-on position. Several companions and background galaxies are visible even in our photo.

Our image is a CCD image by Robert Stephens of the Riverside Astronomical Society.

NGC 7331 was among the earliest recognized spiral galaxies, and listed by Lord Rosse in his list of 14 "spiral or curvilinear nebulae" discovered before 1850.

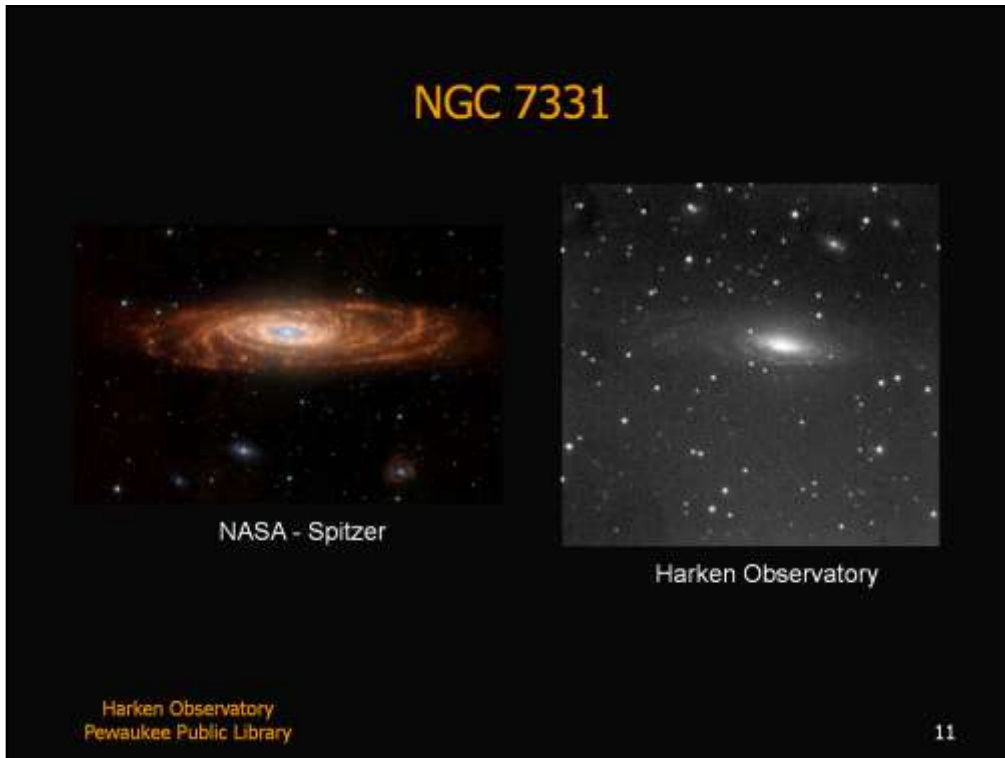
One supernova has been discovered in NGC 7331 so far: SN 1959D, discovered by Milton Humason at 32"W and 13"N of the galaxy's nucleus. This supernova became as bright as 13.4 mag (see IAUC 1682 and PASP 105, 1250).

NGC 7331 is contained in the SAC 110 Best NGC List. In the RASC's Finest N.G.C. Objects Objects list. Caldwell 30 in Patrick Moore's list.

\*\*\*\*\*

<http://www.noao.edu/outreach/aop/observers/n7331.html>

NGC 7331 is one of 18 galaxies chosen by the HST Extragalactic Distance Scale Key Project to calibrate secondary distance estimators, using HST to obtain an accurate distance via Cepheid variables, with the ultimate goal of using these to measure  $H_0$ , a cosmological parameter) to an external accuracy of 10%. It was determined this galaxy is 49 million light years away (and perhaps 30,000 light years across). In this image you will see some of the nearby neighbors being both spiral and elliptical galaxies. Nearby by this field (not shown) is another famous group of galaxies known as [Stephan's Quintet](#).



<http://www.seds.org/messier/xtra/ngc/n7331.html>

Discovered by William Herschel in 1784.

NGC 7331 is one of the brighter galaxies which is not included in Messier's catalog. It exposes a fine spiral structure despite its small inclination from the edge-on position. Several companions and background galaxies are visible even in our photo.

Our image is a CCD image by Robert Stephens of the Riverside Astronomical Society.

NGC 7331 was among the earliest recognized spiral galaxies, and listed by Lord Rosse in his list of 14 "spiral or curvilinear nebulae" discovered before 1850.

One supernova has been discovered in NGC 7331 so far: SN 1959D, discovered by Milton Humason at 32"W and 13"N of the galaxy's nucleus. This supernova became as bright as 13.4 mag (see IAUC 1682 and PASP 105, 1250).

NGC 7331 is contained in the SAC 110 Best NGC List. In the RASC's Finest N.G.C. Objects Objects list. Caldwell 30 in Patrick Moore's list.

\*\*\*\*\*

<http://www.noao.edu/outreach/aop/observers/n7331.html>

NGC 7331 is one of 18 galaxies chosen by the HST Extragalactic Distance Scale Key Project to calibrate secondary distance estimators, using HST to obtain an accurate distance via Cepheid variables, with the ultimate goal of using these to measure  $H_0$ , a cosmological parameter to an external accuracy of 10%. It was determined this galaxy is 49 million light years away (and perhaps 30,000 light years across). In this image you will see some of the nearby neighbors being both spiral and elliptical galaxies. Nearby by this field (not shown) is another famous group of galaxies known as [Stephan's Quintet](#).



<http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/28/image/a>  
**The Majestic Sombrero Galaxy (M104)**

STScI-PRC2003-28

NASA's Hubble Space Telescope has trained its razor-sharp eye on one of the universe's most stately and photogenic galaxies, the Sombrero galaxy, Messier 104 (M104). The galaxy's hallmark is a brilliant white, bulbous core encircled by the thick dust lanes comprising the spiral structure of the galaxy. As seen from Earth, the galaxy is tilted nearly edge-on. We view it from just six degrees north of its equatorial plane. This brilliant galaxy was named the Sombrero because of its resemblance to the broad rim and high-topped Mexican hat.

At a relatively bright magnitude of +8, M104 is just beyond the limit of naked-eye visibility and is easily seen through small telescopes. The Sombrero lies at the southern edge of the rich Virgo cluster of galaxies and is one of the most massive objects in that group, equivalent to 800 billion suns. The galaxy is 50,000 light-years across and is located 28 million light-years from Earth.

Hubble easily resolves M104's rich system of globular clusters, estimated to be nearly 2,000 in number — 10 times as many as orbit our Milky Way galaxy. The ages of the clusters are similar to the clusters in the Milky Way, ranging from 10-13 billion years old. Embedded in the bright core of M104 is a smaller disk, which is tilted relative to the large disk. X-ray emission suggests that there is material falling into the compact core, where a 1-billion-solar-mass black hole resides.

In the 19th century, some astronomers speculated that M104 was simply an edge-on disk of luminous gas surrounding a young star, which is prototypical of the genesis of our solar system. But in 1912, astronomer V. M. Slipher discovered that the hat-like object appeared to be rushing away from us at 700 miles per second. This enormous velocity offered some of the earliest clues that the Sombrero was really another galaxy, and that the universe was expanding in all directions.

The Hubble Heritage Team took these observations in May-June 2003 with the space telescope's Advanced Camera for Surveys. Images were taken in three filters (red, green, and blue) to yield a natural-color image. The team took six pictures of the galaxy and then stitched them together to create the final composite image. One of the largest Hubble mosaics ever assembled, this magnificent galaxy has an apparent diameter that is nearly one-fifth the diameter of the full moon.



<http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/28/image/a>

### **The Majestic Sombrero Galaxy (M104)**

STScI-PRC2003-28

NASA's Hubble Space Telescope has trained its razor-sharp eye on one of the universe's most stately and photogenic galaxies, the Sombrero galaxy, Messier 104 (M104). The galaxy's hallmark is a brilliant white, bulbous core encircled by the thick dust lanes comprising the spiral structure of the galaxy. As seen from Earth, the galaxy is tilted nearly edge-on. We view it from just six degrees north of its equatorial plane. This brilliant galaxy was named the Sombrero because of its resemblance to the broad rim and high-topped Mexican hat.

At a relatively bright magnitude of +8, M104 is just beyond the limit of naked-eye visibility and is easily seen through small telescopes. The Sombrero lies at the southern edge of the rich Virgo cluster of galaxies and is one of the most massive objects in that group, equivalent to 800 billion suns. The galaxy is 50,000 light-years across and is located 28 million light-years from Earth.

Hubble easily resolves M104's rich system of globular clusters, estimated to be nearly 2,000 in number — 10 times as many as orbit our Milky Way galaxy. The ages of the clusters are similar to the clusters in the Milky Way, ranging from 10-13 billion years old. Embedded in the bright core of M104 is a smaller disk, which is tilted relative to the large disk. X-ray emission suggests that there is material falling into the compact core, where a 1-billion-solar-mass black hole resides.

In the 19th century, some astronomers speculated that M104 was simply an edge-on disk of luminous gas surrounding a young star, which is prototypical of the genesis of our solar system. But in 1912, astronomer V. M. Slipher discovered that the hat-like object appeared to be rushing away from us at 700 miles per second. This enormous velocity offered some of the earliest clues that the Sombrero was really another galaxy, and that the universe was expanding in all directions.

The Hubble Heritage Team took these observations in May-June 2003 with the space telescope's Advanced Camera for Surveys. Images were taken in three filters (red, green, and blue) to yield a natural-color image. The team took six pictures of the galaxy and then stitched them together to create the final composite image. One of the largest Hubble mosaics ever assembled, this magnificent galaxy has an apparent diameter that is nearly one-fifth the diameter of the full moon.



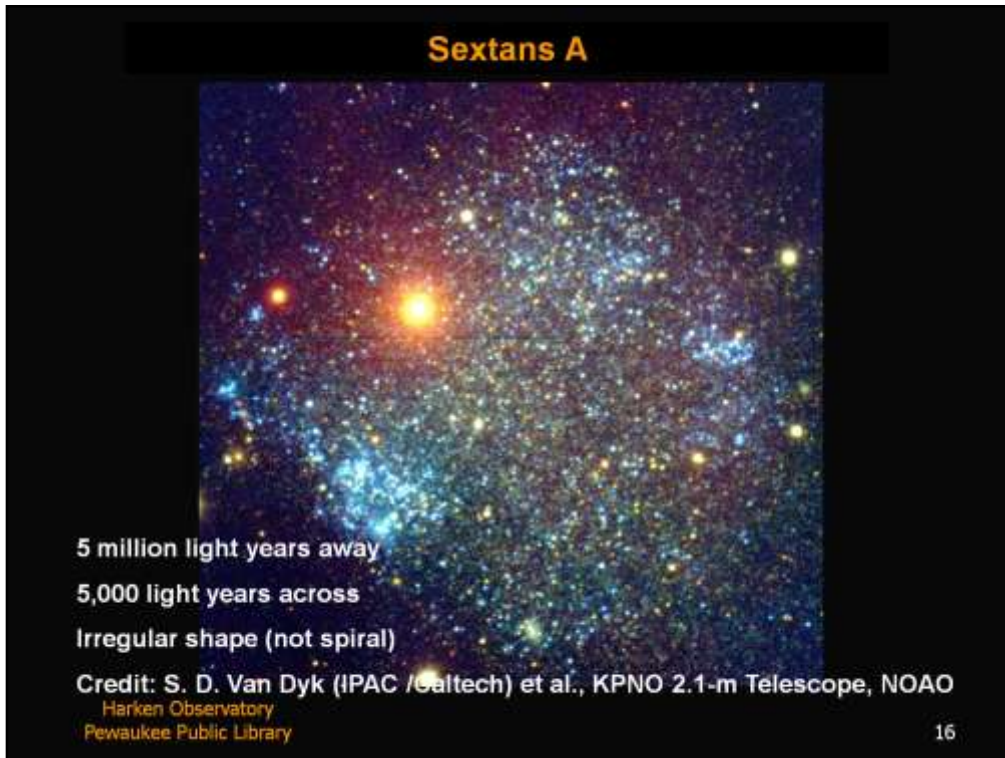
<http://apod.nasa.gov/apod/ap050112.html>

Explanation: Big, beautiful, barred spiral galaxy NGC 1300 lies some 70 million light-years away on the banks of the constellation Eridanus. This Hubble Space Telescope composite view of the gorgeous island universe was released at this week's meeting of the American Astronomical Society as one of the largest Hubble images ever made of a complete galaxy. NGC 1300 spans over 100,000 light-years and the Hubble image reveals striking details of the galaxy's dominant central bar and majestic spiral arms. In fact, on close inspection the nucleus of this classic barred spiral itself shows a remarkable region of spiral structure about 3,000 light-years across. Unlike other spiral galaxies, including our own Milky Way, NGC 1300 is not presently known to have a massive central black hole.



<http://antwrp.gsfc.nasa.gov/apod/ap980315.html>

Explanation: Something strange happened to this galaxy, but what? M82 is a nearby galaxy in the group of galaxies dominated by itself, M81, and NGC 3077. M82 is thought by some to be limping away from a close encounter with M81. This galactic collision might have stirred up the inner stars and gas in M82, causing the unusual dark lanes of dust visible in the above photograph. M82 is a starburst galaxy with a very active center containing star clusters far brighter than any in our own Milky Way Galaxy.



<http://antwrp.gsfc.nasa.gov/apod/ap981103.html>

Sextans A: A Seemingly Square Galaxy

Credit: S. D. Van Dyk (IPAC / Caltech) et al., KPNO 2.1-m Telescope, NOAO

Explanation: What's bothering local galaxy Sextans A? A small dwarf irregular galaxy spanning 5 thousand light years across, Sextans A is located only 5 million light-years away. Named for its home constellation of Sextans, the "diamond in the rough" structure relates to an ancient unknown event. 100 million years ago, something mysterious started a new wave of star formation in Sextans A's center. Massive short-lived stars exploded in supernovae that caused more star formation and yet more supernovae, ultimately resulting in an expanding shell. Today, young blue stars highlight areas and shell edges high in current star formation, a shell that from our perspective appears roughly square. In the above picture, a bright orange star in our own Milky Way Galaxy appears superposed in the foreground.

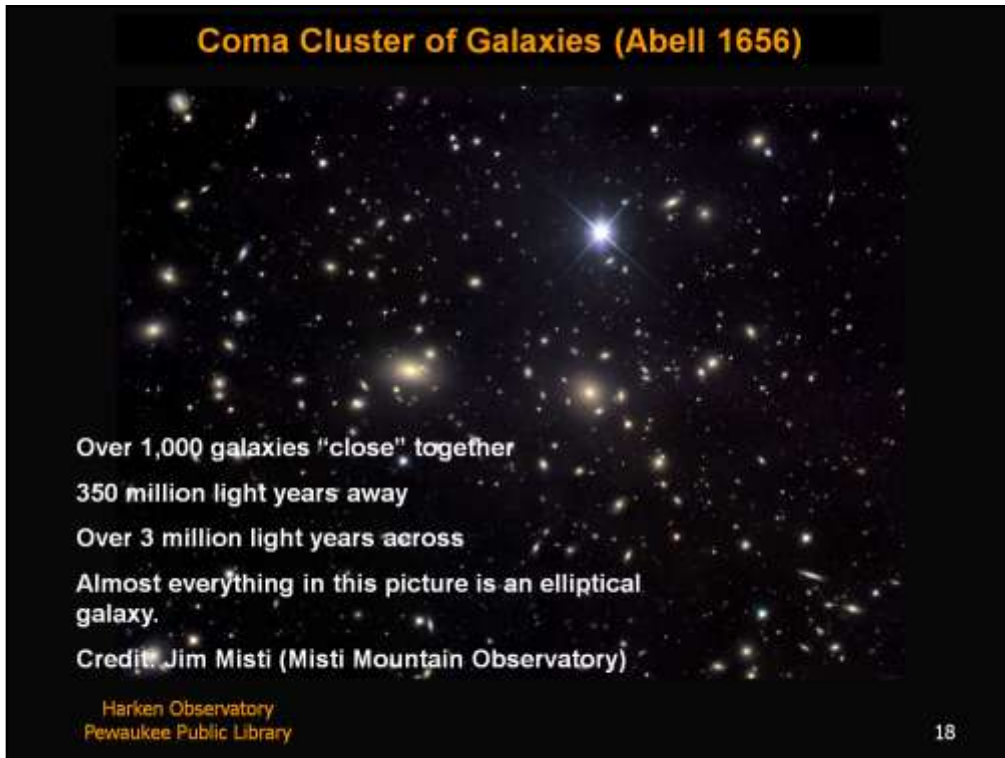


<http://apod.nasa.gov/apod/ap041121.html>

### Spiral Galaxies in Collision

Credit: [Debra Meloy Elmegreen \(Vassar College\) et al.](#), & the [Hubble Heritage Team \(AURA/ STScI/ NASA\)](#)

Explanation: Billions of years from now, only one of these two galaxies will remain. Until then, spiral [galaxies](#) NGC 2207 and IC 2163 will slowly pull each other apart, creating [tides](#) of matter, sheets of [shocked gas](#), lanes of [dark dust](#), bursts of [star formation](#), and streams of [cast-away stars](#). [Astronomers predict](#) that NGC 2207, the larger galaxy on the left, will [eventually incorporate](#) IC 2163, the smaller galaxy on the right. In the most [recent encounter](#) that peaked 40 million years ago, the smaller galaxy is swinging around counter-clockwise, and is now slightly behind the larger galaxy. The space between stars is so vast that when [galaxies collide](#), the stars in them [usually do not](#) collide.



[http://www.mistisoftware.com/astronomy/Galaxies\\_ComaCluster.htm](http://www.mistisoftware.com/astronomy/Galaxies_ComaCluster.htm)

The Coma Cluster of Galaxies

Credit & Copyright: Jim Misti (Misti Mountain Observatory)

Explanation: Almost every object in the above photograph is a galaxy. The Coma Cluster of Galaxies pictured above is one of the densest clusters known - it contains thousands of galaxies. Each of these galaxies houses billions of stars - just as our own Milky Way Galaxy does. Although nearby when compared to most other clusters, light from the Coma Cluster still takes hundreds of millions of years to reach us. In fact, the Coma Cluster is so big it takes light millions of years just to go from one side to the other! Most galaxies in Coma and other clusters are ellipticals, while most galaxies outside of clusters are spirals. The nature of Coma's X-ray emission is still being investigated.

## Astronomer Hubble Studied Galaxies

- Edwin P. Hubble (1889-1953)
- Revolutionized cosmology by proving that the clouds of light astronomers saw in the night sky were actually **other galaxies beyond our Milky Way**.
- His greatest discovery was in 1929, when he identified the relationship between a galaxy's distance and the speed with which it is moving (Doppler shift).



Harken Observatory  
Pewaukee Public Library

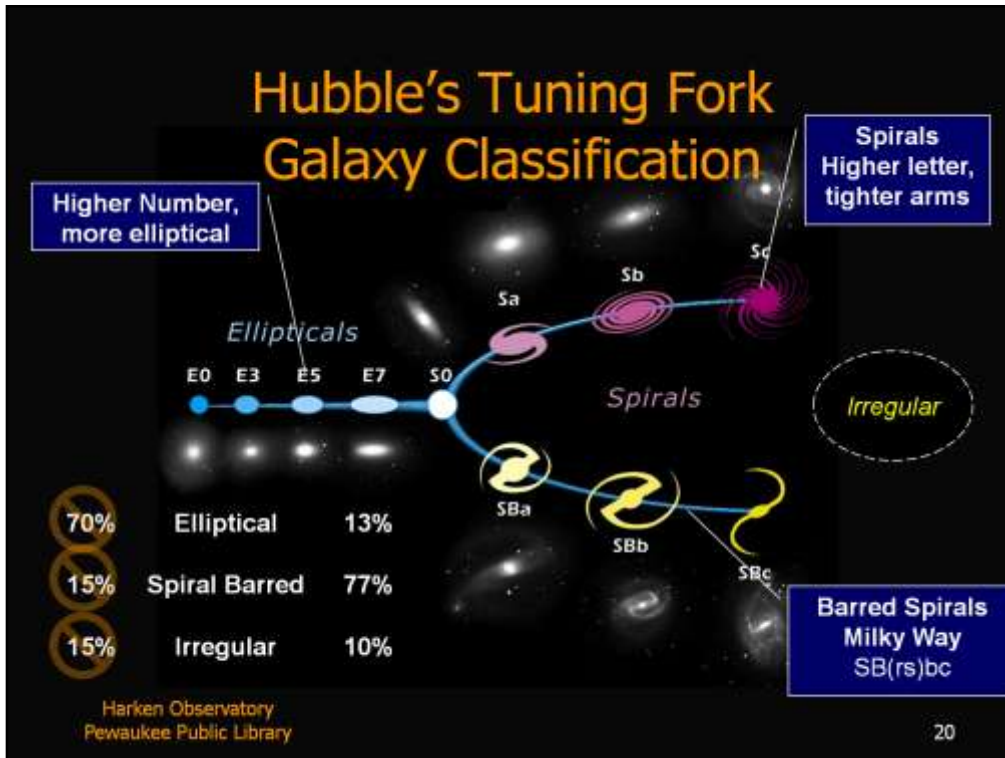
19

[http://hubblesite.org/reference\\_desk/faq/all.php.cat=galaxies](http://hubblesite.org/reference_desk/faq/all.php.cat=galaxies)

The farther a galaxy is from Earth, the faster it is moving away from us. This is known as Hubble's Law. He also constructed a method of classifying the different shapes of galaxies.

Edwin Powell Hubble was born in Marshfield, Missouri. In 1910, he received his undergraduate degree from the University of Chicago and studied law under a Rhodes Scholarship at Oxford University. His true love, however, was astronomy, and he returned to the University of Chicago to earn a Ph.D. in that subject and work at the Yerkes Observatory. He served in the infantry during World War I.

He once said that he "chucked the law for astronomy," knowing that even if he was second-rate or third-rate, it was astronomy that mattered.



Milky way is probably SB(rs)bc, where the lower right pointer is

SB – spiral with a bar in the center

(rs) - weak central ring of stars and gas around the nucleus (extension to Hubble system, recognizing a ring (cylinder) around the nucleus

bc – midway between "b" and "c" closeness of arms

<http://cas.sdss.org/dr5/en/proj/basic/galaxies/spirals.asp>

“About 77% of the observed galaxies in the universe are spiral galaxies.

Our own galaxy, the Milky Way, is a typical spiral galaxy. The images below show three other good examples.”

“Barred spirals are classified as SBa, SBb, SBc. Elliptical galaxies are classified as E0 (spherical)-E7 (highly elliptical). Irregulars are denoted (Irr), ovals with no obvious spiral arms S0, peculiar P, and spiral galaxies as Sa, Sb, and Sc, where Sa have large nuclei with tightly bound spiral arms and Sc have small nuclei with loosely wound arms. Approximately 70% of galaxies are elliptical, 15% are irregular, and are spiral. © 1996-2006 Eric W. Weisstein”

# Galaxies

- What is a galaxy?
- Size and Distance
- Famous Galaxies & Galaxy Types
- Home – The Milky Way
- Galactic Maps & Distances
- Hubble Ultra Deep Field Photo
- Harken Observatory

Harken Observatory  
Pewaukee Public Library

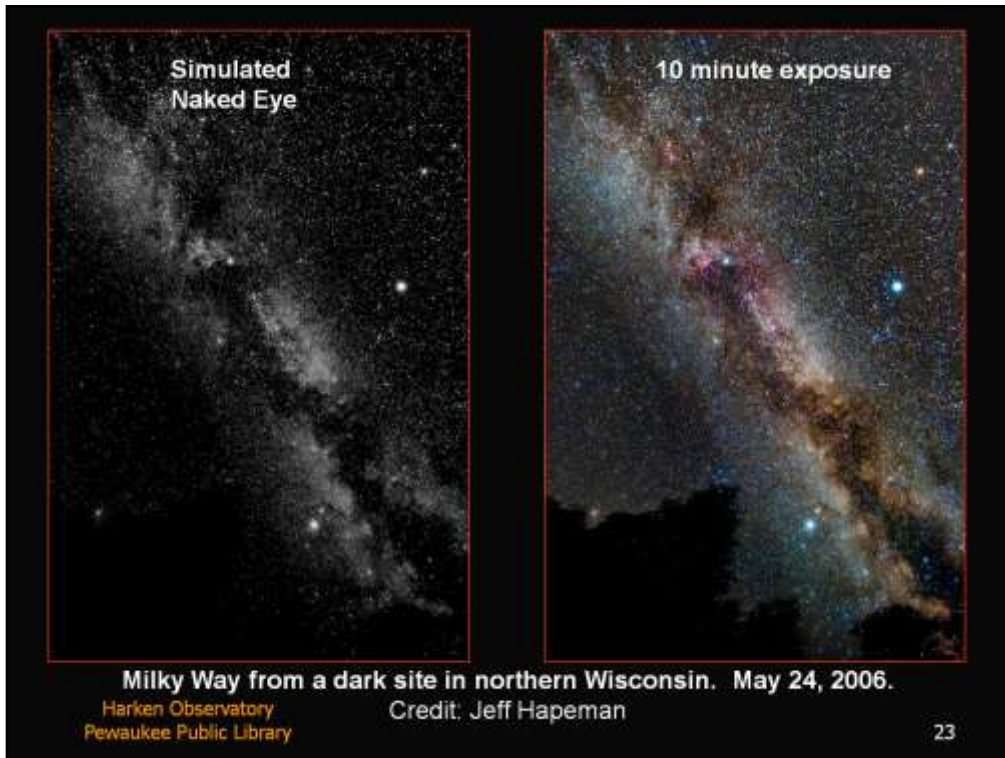
21

# Milky Way

- The **Milky Way** is the galaxy we live in.
- There are no “bird’s eye view” photos of the Milky Way. No one has been “way out there”!
- We can look at stars and their direction and distance from us, then put the puzzle together to make an artist’s drawing.
- All the stars, etc. you are likely familiar with are in the Milky Way.

Harken Observatory  
Pewaukee Public Library

22



Naked eye is approximated from the original 10 minute color exposure using PowerPoints grayscale, contrast and brightness adjustments.

<http://www.photosig.com/go/photos/view?id=1755674&forward=browse>

"This is a single 10-minute exposure of the Milky Way from our home in northern WI, where the skies are very dark. This is close to what it looks like to the naked eye; missing the color of course. Beautiful site. The wide-angle lens let me catch as much of the sky as I could. For those wondering, the dark areas are trees, that moved during the exposure, hence some stars that show through. To track the sky for the 10-minute exposure, I used my Kenko SkyMemo II tracking mount. Jeff"

Title The Late Spring Milky Way  
 Photographer [jhapeman/Jeff](#) (5,522)  
 Portfolio [Astrophotography](#)  
 F-stop [f/3.5](#)  
 Shutter speed [60 sec or more](#)  
 Categories [Sky](#)  
[Astrophotography](#)  
 Lens [Canon EF 14mm L USM](#)  
 Camera [Canon EOS 20Da](#)  
 Film [ISO 800](#)  
 Content advisory [G \(general audiences\)](#)  
 Submitted May 24, 2006 5:01:09 AM EDTViews 616Rating 10  
 \*\*\*\*\*

From: Jeff Hapeman [mailto:[jeff.hapeman@cliftoncpa.com](mailto:jeff.hapeman@cliftoncpa.com)]  
 Sent: Sunday, September 10, 2006 11:15 PM  
 To: bergsa/Scott  
 Subject: Re: photoSIG mail: Milky Way photo

Sure, just credit me by name. Let me know if you need a slightly larger version than the one posted on photoSIG.

Jeff  
 --

Jeff Hapeman  
 Chief Technology Officer  
 Clifton Gunderson LLP  
 1111 Deming Way, Suite 101  
 Madison, WI 53717  
 608.833.8638 x48230 / FAX 608.833.0194  
[Jeff.Hapeman@cliftoncpa.com](mailto:Jeff.Hapeman@cliftoncpa.com)  
[www.cliftoncpa.com](http://www.cliftoncpa.com)



[http://spiff.rit.edu/classes/phys240/lectures/milky\\_way/milky\\_way.html](http://spiff.rit.edu/classes/phys240/lectures/milky_way/milky_way.html)  
under Creative Commons copyright  
<http://creativecommons.org/licenses/by-nc-sa/2.0/>



<http://apod.nasa.gov/apod/ap010202.html>

Explanation: This quite stunning panorama of the entire sky is a mosaic of 51 wide-angle photographs. Made over a three year period from locations in California (USA), South Africa, and Germany, the individual pictures were digitized and stitched together to create an apparently seamless 360 by 180 degree view. Using a mathematical prescription like one often used to map the whole Earth's surface onto a single flat image, the complete digital mosaic was distorted and projected onto an oval shape. The image is oriented so the plane of our Milky Way Galaxy runs horizontally through the middle with the Galactic center at image center and Galactic north at the top. Most striking are the "milky" bands of starlight from the multitude of stars in the galactic plane cut by the dark, obscuring dust clouds strewn through the local spiral arms. In fact, almost everything visible here is within our own Milky Way Galaxy. Two fuzzy patches in the lower right quadrant of the mosaic do correspond to external galaxies, though. Known as the Magellanic Clouds, these are small, nearby satellite galaxies of the magnificent Milky Way.

# Current Artist's Conception of the Milky Way Galaxy

Harken Observatory  
Pewaukee Public Library

26



If the earth is near the edge of the Milky Way's disk (as indicated) and you looked towards the center (direction of arrows), what would you see?

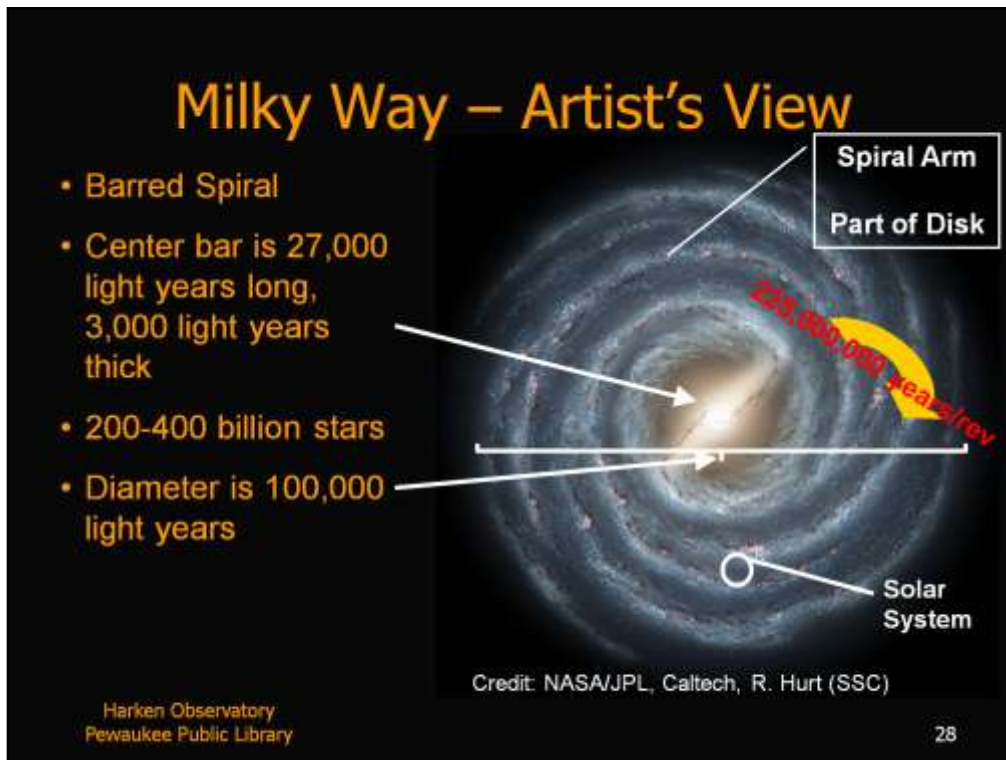
\*\*\*\*\*

<http://www.atlasoftheuniverse.com/milkyway.html>

### The Shape of the Milky Way - The Evidence

There are two methods traditionally used to map the spiral structure of our Galaxy. The first method is to study the density of the neutral hydrogen (HI) in the plane of the Galaxy which is enhanced in the spiral arms. This was first attempted by Jan Oort, Frank Kerr, and Gart Westerhout in 1958. They studied the galactic system as a spiral nebula by using radio-telescopes in the Netherlands and Australia. The early version of their map (incomplete on the left side) shows various sections of the spiral arms. The second method is to plot the giant HII regions (bright nebulae of ionised hydrogen) which are usually formed in the spiral arms. This was attempted by Yvonne and Yvon Georgelin in 1976. They studied the spiral structure of our Galaxy determined from H II regions. Their map allowed them to determine where the spiral arms are.

For a recent attempt at mapping the Milky Way in neutral hydrogen (although only the outer parts) see *The Spiral Structure of the Outer Milky Way in Hydrogen* by Levine, Blitz, and Heiles, (2006). For a recent map of the HII regions in the Milky Way see *Star-forming complexes and the spiral structure of our Galaxy* by Delphine Russeil, (2003). These various maps can be analysed to show the precise spiral form of the Galaxy, see Jacques Vallée's various studies of the Milky Way ( 1, 2, 3). The Milky Way is probably a four-arm logarithmic spiral.



Milky Way was originally thought to be a pure spiral galaxy. In the 1980's the thinking changed to a barred spiral. Work at UW-Madison published in August, 2005 strengthens the barred spiral view.

SB – spiral with a bar in the center

(rs) - weak central ring of stars and gas around the nucleus

bc – midway between "b" and "c" closeness of arms

The Astrophysical Journal, 630:L149–L152, 2005 September 10

copyright 2005. The American Astronomical Society. All rights reserved. Printed in U.S.A.

"FIRST GLIMPSE RESULTS ON THE STELLAR STRUCTURE OF THE GALAXY"

R. A. Benjamin,<sup>1</sup> E. Churchwell,<sup>2</sup> B. L. Babler,<sup>2</sup> R. Indebetouw,<sup>3</sup> M. R. Meade,<sup>2</sup> B. A. Whitney,<sup>4</sup> C. Watson,<sup>5</sup>

M. G. Wolfire,<sup>6</sup> M. J. Wolff,<sup>4</sup> R. Ignace,<sup>7</sup> T. M. Bania,<sup>8</sup> S. Bracker,<sup>2</sup> D. P. Clemens,<sup>8</sup> L. Chomiuk,<sup>2</sup> M. Cohen,<sup>9</sup>

J. M. Dickey,<sup>10</sup> J. M. Jackson,<sup>8</sup> H. A. Kobulnicky,<sup>11</sup> E. P. Mercer,<sup>8</sup> J. S. Mathis,<sup>2</sup> S. R. Stolovy,<sup>12</sup> and B. Uzpen<sup>11</sup>

Received 2005 April 22; accepted 2005 August 2; published 2005 August 19

\*\*\*\*\*

<http://arxiv.org/abs/astro-ph/0606201>

Authors: [M. Lopez-Corredoira](#), [A. Cabrera-Lavers](#), [T. J. Mahoney](#), [P. L. Hammersley](#), [F. Garzon](#), [C. Gonzalez-Fernandez](#)

Comments: 24 pages, 6 figures, submitted to AJ; 1) we thank the GLIMPSE team

## Size of Milky Way

- If the Solar System was the size of a penny, the Milky Way would be the size of North America. The earth isn't even a speck of dust!
- If the galaxy were reduced to 130 km (80 mi) in diameter, the solar system would be a mere 2 mm (0.08 in) in width.

This is a diagram of the Milky Way from an old textbook (pre-2000 or so). Note it shows a pure spiral, not a barred spiral. The features are still correct.

Credit: <http://casswww.ucsd.edu/public/tutorial/MW.html>



Harken Observatory  
Pewaukee Public Library

30

<http://casswww.ucsd.edu/public/tutorial/MW.html>

The Milky Way system is a spiral galaxy consisting of over 400 billion stars, plus gas and dust arranged into three general components as shown to the left:

The halo - a roughly spherical distribution which contains the oldest stars in the Galaxy,

The nuclear bulge and Galactic Center.

The disk, which contains the majority of the stars, including the sun, and virtually all of the gas and dust



<http://apod.nasa.gov/apod/ap050112.html>

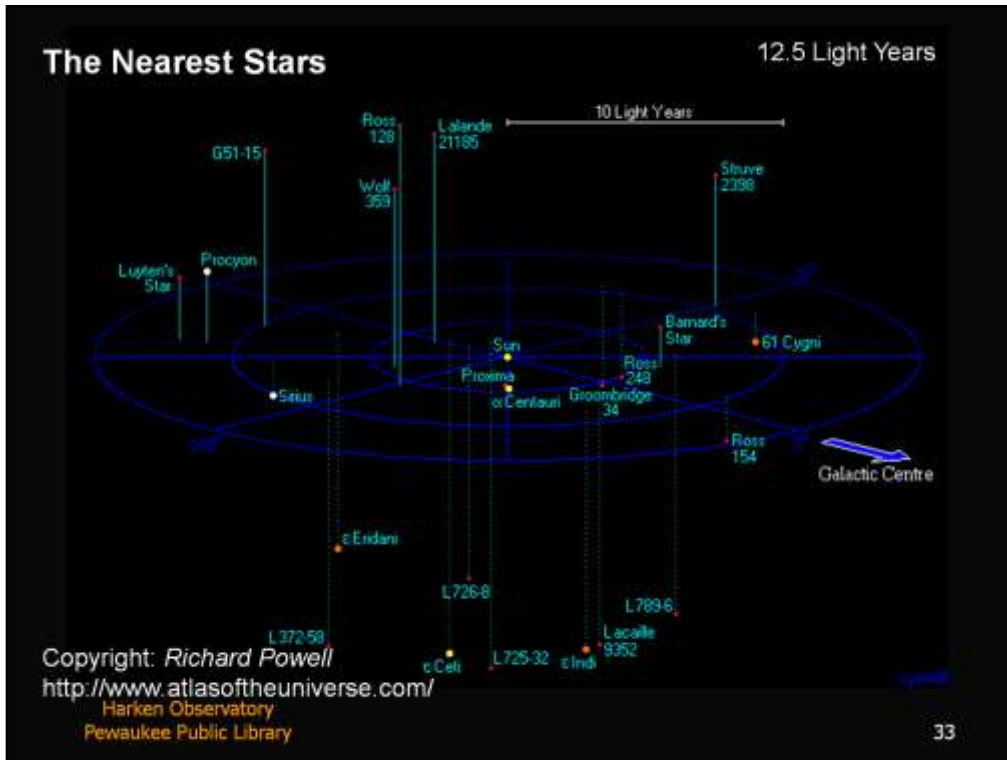
Explanation: Big, beautiful, barred spiral galaxy NGC 1300 lies some 70 million light-years away on the banks of the constellation Eridanus. This Hubble Space Telescope composite view of the gorgeous island universe was released at this week's meeting of the American Astronomical Society as one of the largest Hubble images ever made of a complete galaxy. NGC 1300 spans over 100,000 light-years and the Hubble image reveals striking details of the galaxy's dominant central bar and majestic spiral arms. In fact, on close inspection the nucleus of this classic barred spiral itself shows a remarkable region of spiral structure about 3,000 light-years across. Unlike other spiral galaxies, including our own Milky Way, NGC 1300 is not presently known to have a massive central black hole.

# Galaxies

- What is a galaxy?
- Size and Distance
- Famous Galaxies & Galaxy Types
- Home – The Milky Way
- Galactic Maps & Distances
- Hubble Ultra Deep Field Photo
- Harken Observatory

Harken Observatory  
Pewaukee Public Library

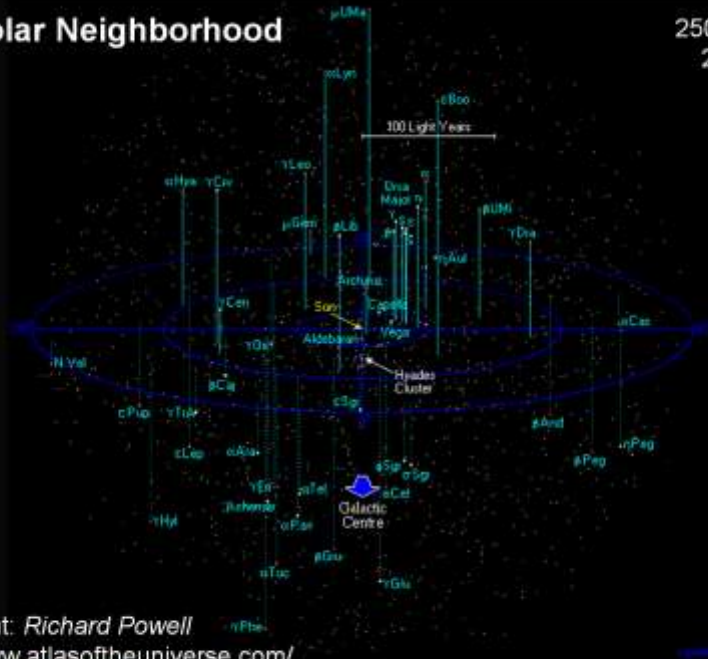
32



<http://www.atlasoftheuniverse.com/>

# The Solar Neighborhood

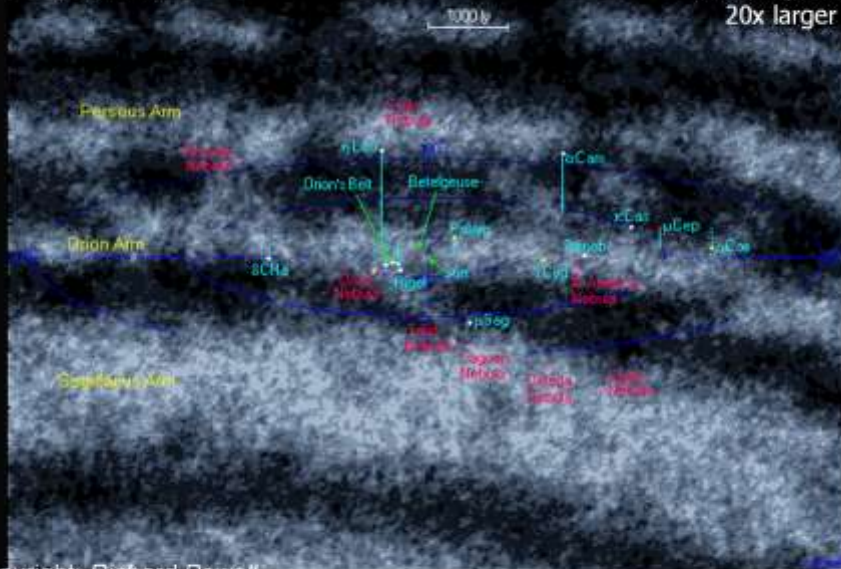
250 Light Years  
20x larger



Copyright: *Richard Powell*  
<http://www.atlasoftheuniverse.com/>  
Harken Observatory  
Pewaukee Public Library

# The Orion Arm

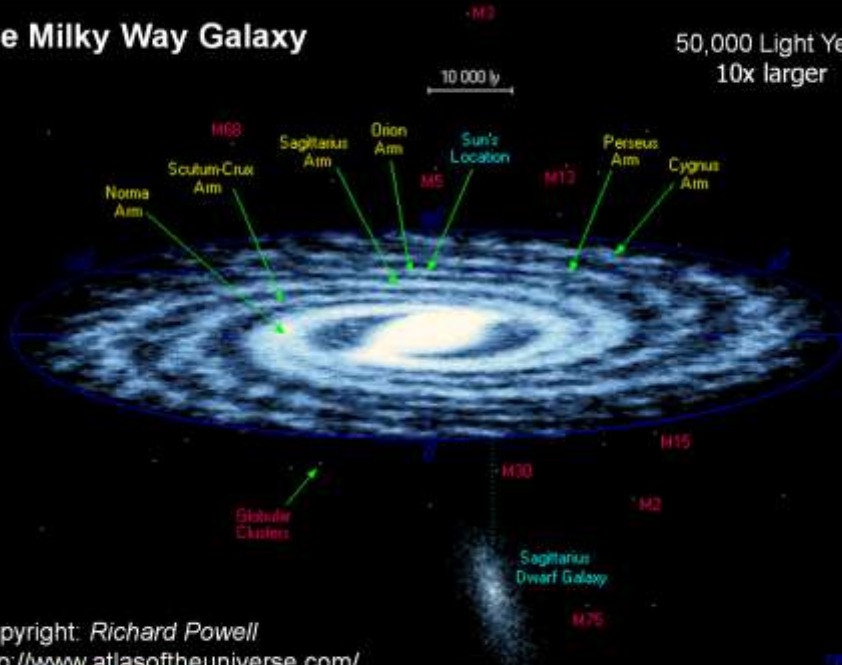
5,000 Light Years  
20x larger



Copyright: Richard Powell  
<http://www.atlasoftheuniverse.com/>  
Harken Observatory  
Pewaukee Public Library

# The Milky Way Galaxy

50,000 Light Years  
10x larger



Copyright: Richard Powell  
<http://www.atlasoftheuniverse.com/>  
Harken Observatory  
Pewaukee Public Library

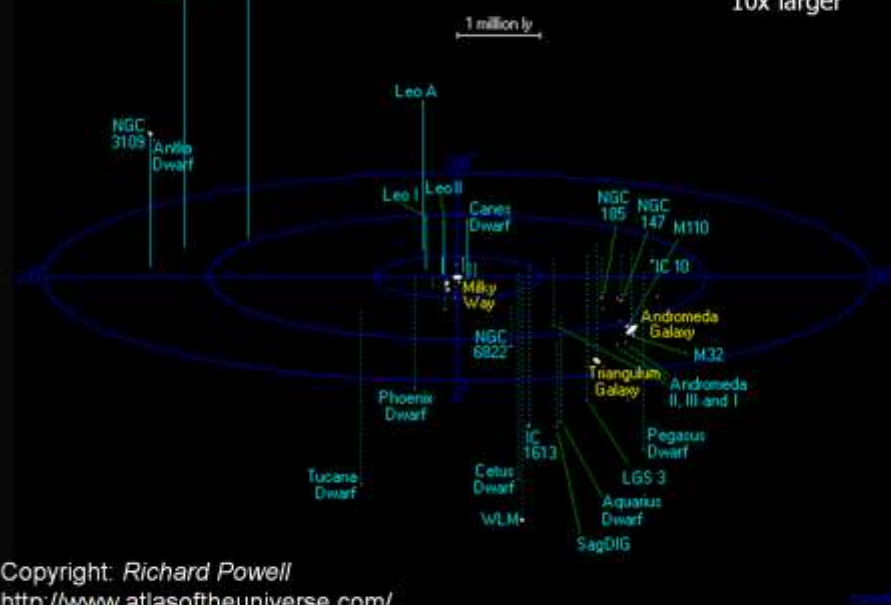
# The Satellite Galaxies



Copyright: Richard Powell  
<http://www.atlasoftheuniverse.com/>  
Harken Observatory  
Pewaukee Public Library

# The Local Group of Galaxies

5,000,000 Light Years  
10x larger

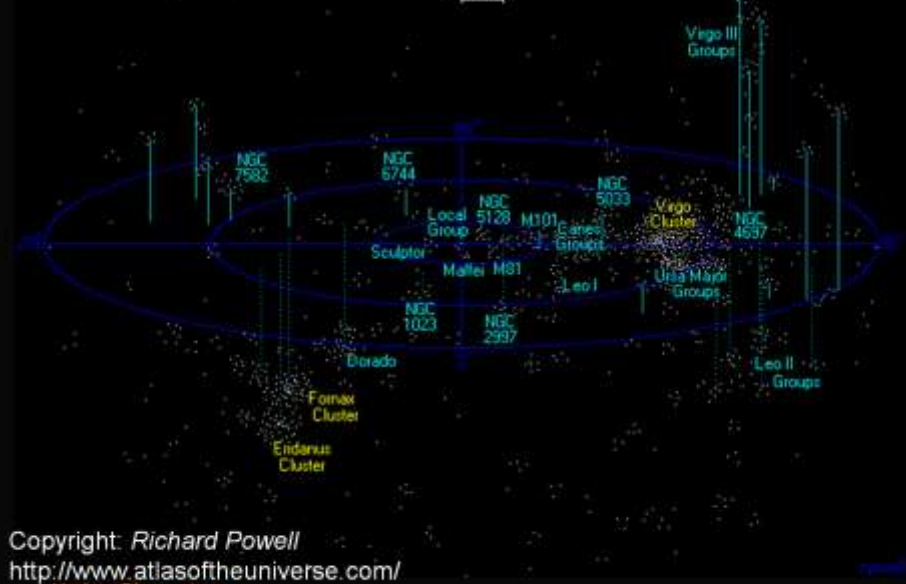


Copyright: Richard Powell  
<http://www.atlasoftheuniverse.com/>  
Harken Observatory  
Pewaukee Public Library

# The Virgo Supercluster

100,000,000 Light Years  
20x larger

10 million ly



Copyright: Richard Powell  
<http://www.atlasoftheuniverse.com/>  
Harken Observatory  
Pewaukee Public Library

# The Neighboring Superclusters

1 billion Light Years  
10x larger



Copyright: Richard Powell  
<http://www.atlasoftheuniverse.com/>  
Harken Observatory  
Pewaukee Public Library

# Galaxies

- What is a galaxy?
- Size and Distance
- Famous Galaxies & Galaxy Types
- Home – The Milky Way
- Galactic Maps & Distances
- Hubble Ultra Deep Field Photo
- Harken Observatory

Harken Observatory  
Pewaukee Public Library

41

Hubble Space Telescope  
as seen from  
Space Shuttle Discovery, February, 1997

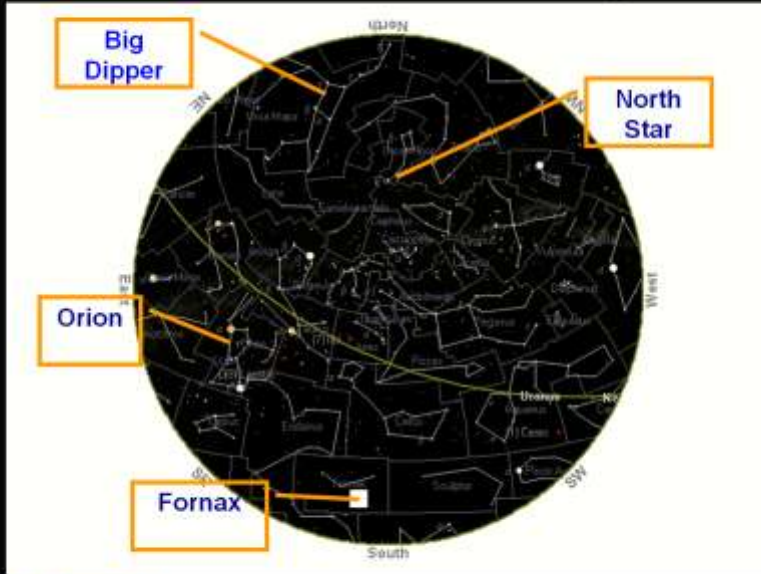


Harken Observatory  
Pewaukee Public Library

## Hubble Ultra Deep Field (HUDF)

- A **tiny** area in constellation Fornax (sort of near Orion) was selected for intense observation. Seemed like there was "nothing interesting" there.
- "Tiny" means:
  - Smaller than a grain of sand held at arm's length
  - Size of FDR's eye on a dime at arm's length
  - 3 arc minutes square

# Mid-December Sky

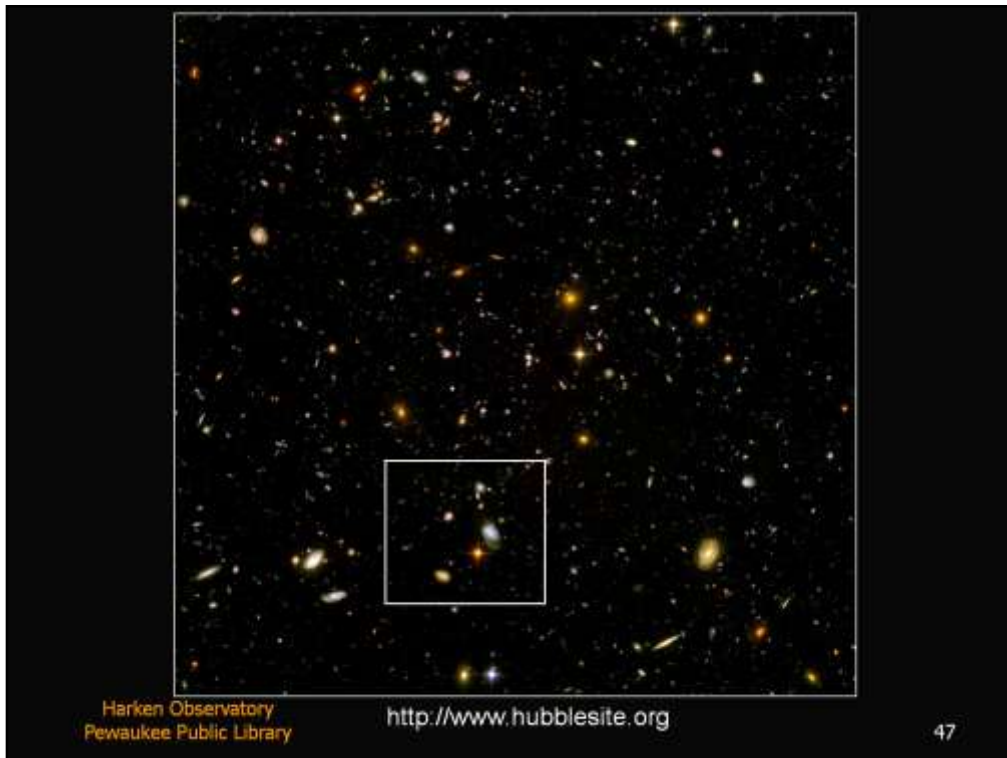


Harken Observatory  
Pewaukee Public Library

## Hubble Ultra Deep Field (HUDF)

- The area was observed from September 3, 2003 to January 16, 2004
- 800 exposures from two cameras were taken over the course of 400 Hubble orbits.
- Complex image processing created a mosaic image

The result is one of the most famous astronomical photos ever produced.



Over 10,000 galaxies are in this photo collage  
Over 400 astronomy research papers are based on this photo

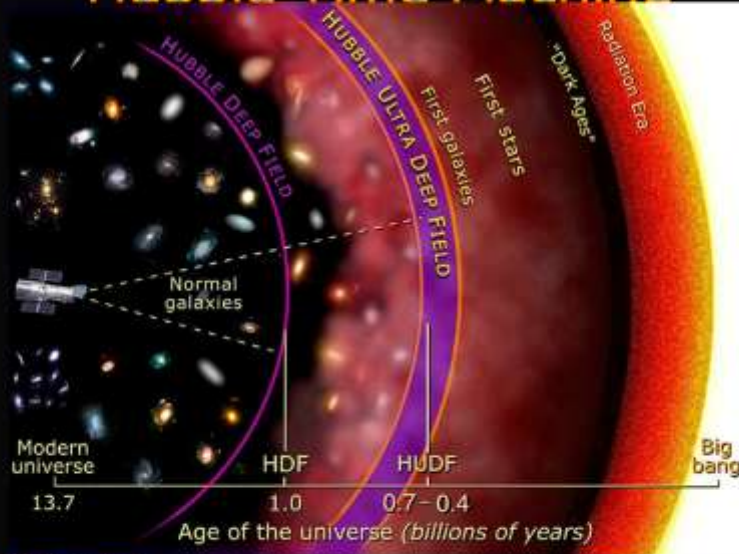


As you zoom in, you see more of the same  
homogeneous – when you get to a very large scale, space is the same everywhere

## Time Machine

- There is a way to estimate how far away a galaxy is. (A standard candle or red shift, but that's another story.)
- Since you know how far away a galaxy is and you know the speed of light, you can compute the time it took the light to get here, i.e. light years.
- The farther away a galaxy is, the older the light is. **A way of looking into the past!**

# Hubble Time Machine



Harken Observatory  
Pewaukee Public Library

<http://www.hubblesite.org>

50

# Observations

- On a very large scale like this, the universe is "homogeneous and isotropic"  
**Looks about the same in every direction**
- Far away galaxies (formed near time of Big Bang) look different than nearby galaxies (formed recently)



Harken Observatory  
Pewaukee Public Library

# Galaxies

- What is a galaxy?
- Size and Distance
- Famous Galaxies & Galaxy Types
- Home – The Milky Way
- Galactic Maps & Distances
- Hubble Ultra Deep Field Photo
- Harken Observatory

Harken Observatory  
Pewaukee Public Library

53

## Mission Statement

The Harken Astronomical Observatory provides education and brings the wonders of our incredible universe to families of our community in the friendly and casual environment of our new library.

It is a hands on experience with rare access to high tech and powerful equipment.

All funds, including original construction and equipment, are donated.

# Pewaukee Library



Harken Observatory  
Pewaukee Public Library

55

# Scope

Harken Observatory  
Pewaukee Public Library



# Equipment

- Meade LX200-GPS Schmidt-Cassegrain Reflector Telescope
  - Aperture: 12 inches (305 mm)
  - Focal Length: 120 inches (3048 mm)
  - Focal Ratio: f/10
- Digital Cameras (StarLight Express SXV-H9C, Meade LPI, Meade DSI-2)
- Computerized Control Station w/ remote Station



LPI imager is the box on top of the right angle eyepiece. Other cameras stick straight out the back.

# Scope & DSI-2 camera



Harken Observatory  
Pewaukee Public Library

59

Operate the scope

- in the dome
- on the platform
- downstairs



Harken Observatory  
Pewaukee Public Library

## Access to Dome

- Since we do not have access for the handicapped to go up into the dome, we are, by law, prohibited from letting the general public up there.
- Only instructors are allowed upstairs.
- Anyone can become an instructor (hint, hint!)

- "Turn left at Orion : a hundred night sky objects to see in a small telescope-- and how to find them" by Guy Consolmagno
- "The backyard astronomer's guide" by Terence Dickinson
- "The complete idiot's guide to astronomy" by Christopher De Pree
- National Geographic encyclopedia of space

On the television show Star Trek, Vulcans would greet each other with "Live long and prosper". Amateur astronomers say "Clear Skies!" (Actually, only the geeks without a real life say that.)

# Clear Skies!

<http://www.harkenobservatory.com>

Harken Observatory  
Pewaukee Public Library

63

On the television show Star Trek, Vulcans would greet each other with "Live long and prosper". Amateur astronomers say "Clear Skies!" (Actually, only the geeks without a real life say that.)