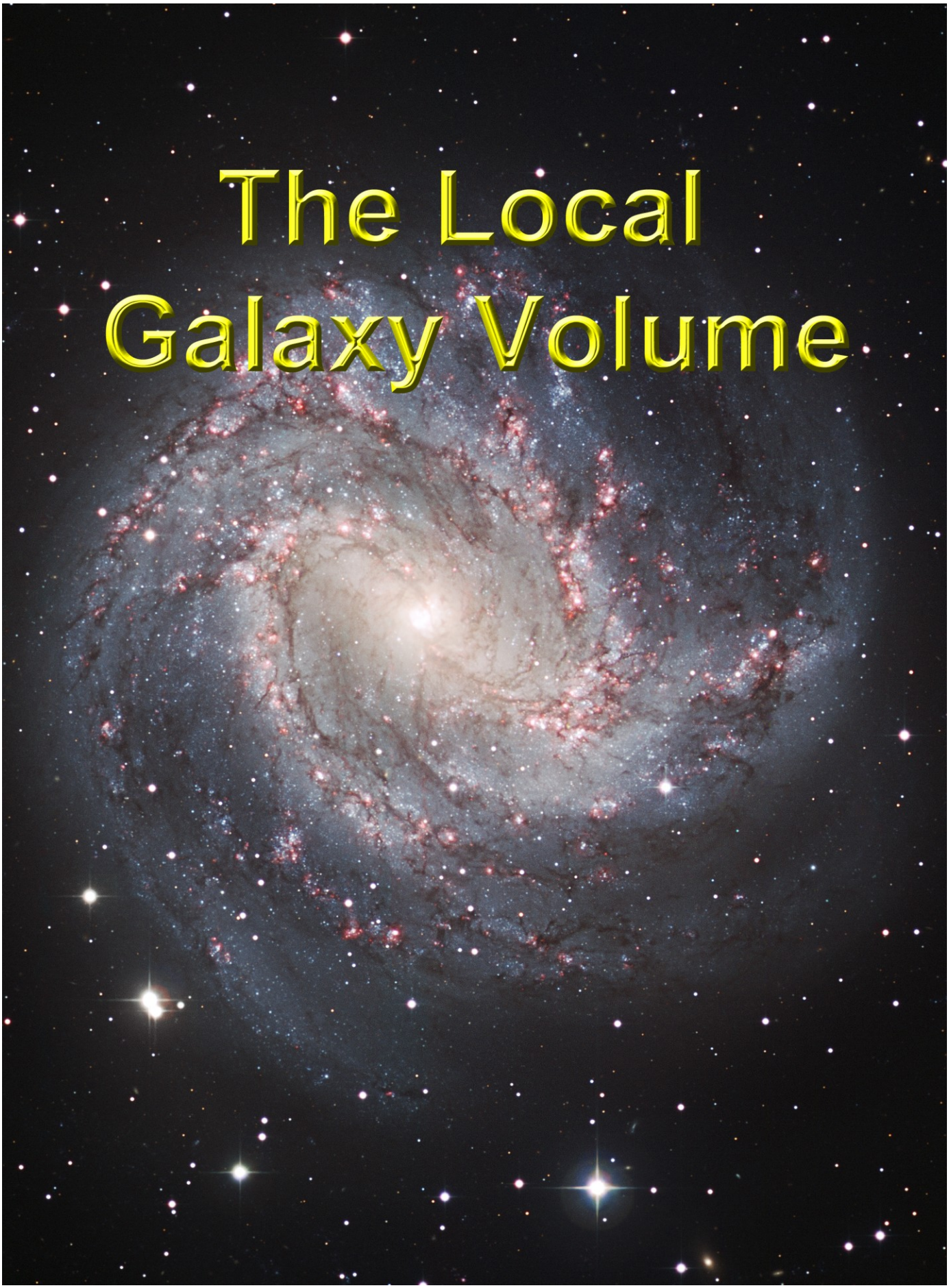

The Local
Galaxy Volume

The Local Galaxy Volume

{Abstract *– In this segment of our "How far away is it" video book, we cover the local galaxy volume compiled by the Spitzer Local Volume Legacy Survey team.*

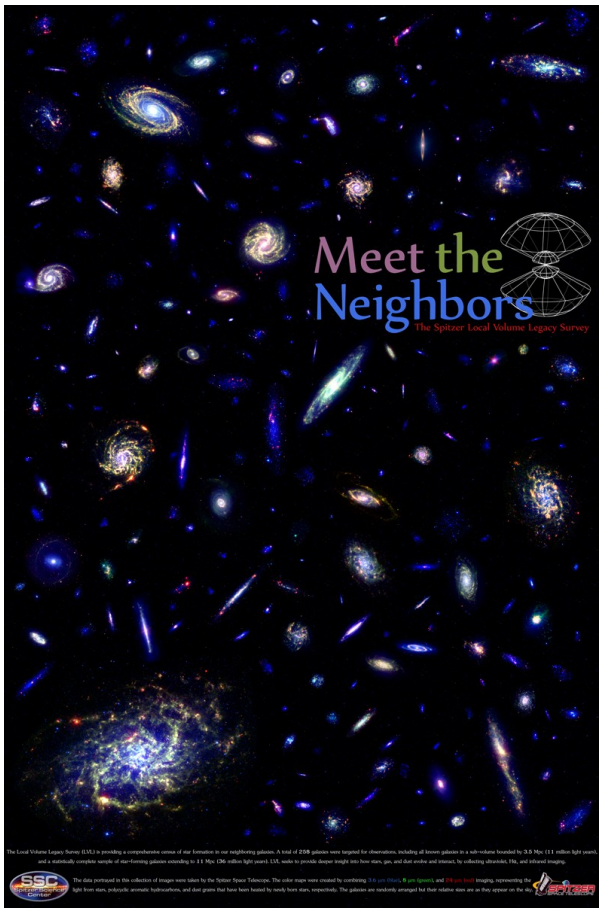
The survey covered 258 galaxies within 36 million light years. We take a look at just a few of them including: Dwingeloo 1, NGC 4214, Centaurus A, NGC 5128 Jets, NGC 1569, majestic M81, Holmberg IX, M82, NGC 2976,the unusual Circinus, M83, NGC 2787, the Pinwheel Galaxy M101, the Sombrero Galaxy M104 including Spitzer's infrared view, NGC 1512, the Whirlpool Galaxy M51, M74, M66, and M96.

*We end with a look at the tuning fork diagram created by Edwin Hubble with its description of spiral, elliptical, lenticular and irregular galaxies.**}***

Introduction

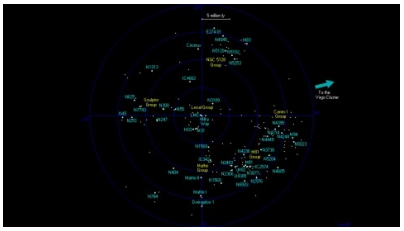
> **[Music:** *Johann Pachelbel – "Canon in D" – This is Pachelbel's most famous composition. It was written in the 1680s between the times of Galileo and Newton. The term 'canon' originates from the Greek kanon, which literally means "ruler" or "a measuring stick." In music, this refers to timing. In astronomy, "a measuring stick" refers to distance. We now proceed to galaxies more distant than the ones in our Local Group.***]**

The Local volume is the set of galaxies covered in the Local Volume Legacy survey or LVL, for short, conducted by the Spitzer team. It is a complete sample of 258 galaxies within 36 million light years. This montage of images shows the ensemble of galaxies as observed by Spitzer. The galaxies are randomly arranged but their relative sizes are as they appear on the sky.



[Additional info: The broad goal of LVL is to provide critical insight into two of the primary processes that shape the growth of galaxies: star formation and its interaction with the interstellar medium.**]**

Here we have the galaxies laid out by distance from us. We'll take a look at a number of them.



Dwingeloo 1 – 10 mly

This visual light image of a newly discovered galaxy called "Dwingeloo 1," was taken with the Isaac Newton Telescope in the Canary Islands. This newly discovered collection of more than 100 billion stars has gone undetected previously because it is hidden from view behind our Milky Way galaxy.

The galaxy appears as a distinctive barred-spiral-shaped object embedded in a dense starfield of hundreds of foreground stars comprising our own Milky Way galaxy. Because the galaxy is only faintly visible through obscuring dust and gas in the Milky Way, it is possible that astronomers are seeing only the central part of a much larger galaxy.

[Additional info: The new galaxy was initially detected in radio light that penetrates this obscuring dust, and then the ground-based telescopes were used to directly observe the galaxy.**]**

NGC 4214 – 10 mly

The dwarf galaxy NGC 4214 is ablaze with young stars and gas clouds. The galaxy's close proximity, combined with the wide variety of evolutionary stages among the stars, make it an ideal laboratory to research the triggers of star formation and evolution.

Intricate patterns of glowing hydrogen formed during the star-birthing process, cavities blown clear of gas by stellar winds, and bright stellar clusters of NGC 4214 can be seen in this optical and near-infrared image.

NGC 5128, Centaurus A – 11 mly

Resembling looming rain clouds on a stormy day, dark lanes of dust crisscross the giant elliptical galaxy Centaurus A. Hubble's panchromatic vision, stretching from ultraviolet through near-infrared wavelengths, reveals the vibrant glow of young, blue star clusters and a glimpse into regions normally obscured by the dust.

The warped shape of Centaurus A's disk of gas and dust is evidence for a past collision and merger with another galaxy. The resulting shockwaves cause hydrogen gas clouds to compress, triggering a firestorm of new star formation. These are visible in the red patches in this Hubble close-up.

At a distance of just over 11 million light-years, Centaurus A contains the closest active galactic nucleus to Earth. The center is home for a supermassive black hole that ejects jets of high-speed gas into space, but neither the supermassive black hole nor the jets are visible in this image.

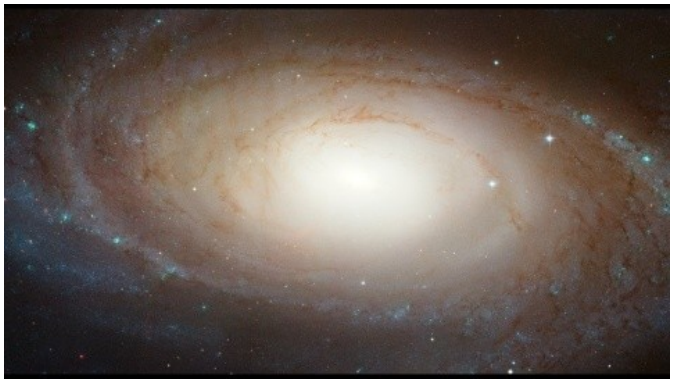
But they are in this one. This Color composite image of Centaurus A reveals the lobes and jets emanating from the active galaxy's central black hole.

NGC 1569 – 11 mly

This image showcases the brilliant core of one of the most active galaxies in our local neighborhood. The entire core is 5,000 light-years wide. NGC 1569 sparkles with the light from millions of newly formed young stars. It is pumping out stars at a rate that is 100 times faster than the rate observed in our Milky Way Galaxy. This frenzied pace has been almost continuous for the past 100 million years.

M81 – 11.6 mly

This beautiful galaxy is tilted at an oblique angle on to our line of sight, giving us a "birds-eye view" of this "grand design" spiral galaxy. It is similar to our Milky Way, but this favorable view provides a better picture of the typical architecture of spiral galaxies. The spiral arms, which wind all the way down into the nucleus, are made up of young, bluish, hot stars formed in the past few million years. A number of sinuous dust lanes also wind all the way into the nucleus of M81.



The galaxy's central bulge is significantly larger than the Milky Way's bulge. A black hole of 70 million solar masses resides at the center. This is about 15 times the mass of the Milky Way's black hole. Hubble research shows that the size of the central black hole in a galaxy is proportional to the mass of a galaxy's bulge.

[Music: *Richard Wagner – "Rienzi Overture" – Written between 1838 and 1840, Rienzi is an opera about a late medieval Italian populist figure who succeeds in outwitting and then defeating the nobles and their followers and in raising the power of the people. In the end, he loses it all. The music has a fine sound appropriate for the dance of these beautiful galaxies.***]**

Holmberg IX – 12 mly

This loose collection of stars is actually a dwarf irregular galaxy, called Holmberg IX. It resides just off the outer edge of M81. Holmberg IX is of the so-called Magellanic type of galaxy, as its size and irregularity in structure are similar to the Small Magellanic Cloud.

A close encounter with M81 may have triggered the newer star formation that has occurred. By understanding how Holmberg IX was formed, scientists hope to understand their role as building blocks for large galaxies.

M82 – 12 mly

Here we are zooming into M82. The galaxy is remarkable for its bright blue disk, webs of shredded clouds, and fiery-looking plumes of glowing hydrogen blasting out of its central regions.

Throughout the galaxy's center, young stars are being born 10 times faster than they are inside our entire Milky Way Galaxy. A huge concentration of young stars has carved into the gas and dust at the galaxy's center. The fierce galactic superwind generated from these stars compresses enough gas to make millions of more stars.

Young stars are crammed into tiny but massive star clusters. These, in turn, congregate by the dozens to make the bright patches, or "starburst clumps," in the central parts of M82. The clusters in the clumps can only be distinguished in the sharp Hubble images. Most of the pale, white objects sprinkled around the body of M82 that look like fuzzy stars are actually individual star clusters about 20 light-years across that contain up to a million stars each.

NGC 2976 – 12

NGC 2976 does not look like a typical spiral galaxy. In this view of the galaxy's inner region, there are no obvious spiral arms. Dusty filaments running through the disk show no clear spiral structure. Although the gas is centrally concentrated, the galaxy does not have a central bulge of stars.

What look like grains of sand in the image are actually individual stars. Studying the individual stars allowed astronomers to determine their color and brightness, which provided information about when they formed.

Circinus Galaxy – 13 mly

This galaxy is called Circinus. Much of the gas in its disk is concentrated in two specific rings — a larger one 1,300 light-years wide, and a previously unseen ring 260 light-years wide. Both rings are home to large amounts of gas and dust as well as areas of major "starburst" activity.

At the center of the starburst rings is the supermassive black hole that is accreting surrounding gas and dust. The black hole and its accretion disk are expelling gas out of the galaxy's disk and into its halo. The detailed structure of this gas is seen as magenta-colored streamers extending towards the top of the image.

Located near the plane of our own Milky Way Galaxy, the Circinus galaxy is partially hidden by intervening dust along our line of sight. As a result, the galaxy went unnoticed until 1999.

M83, the Southern Pinwheel – 15 mly

Nicknamed the Southern Pinwheel, M83 is undergoing more rapid star formation than our own Milky Way galaxy, especially in its nucleus. This Hubble close-up has captured hundreds of young star clusters, ancient swarms of globular star clusters, and hundreds of thousands of individual stars, mostly blue supergiants and red supergiants. The remains of about 60 supernova blasts can be seen in the image.

[Music: *Pyotr Ilyich Tchaikovsky – "Capriccio Italien" – Written in 1880, Tchaikovsky was inspired by the sights and sounds of a carnival he attended in Rome. Although there are no sounds in space, the fantastic sights of these Local Volume galaxies inspired me to choose Capriccio Italien to conclude this segment.***]**

NGC 2787 – 24 mly

Tightly wound, almost concentric, arms of dark dust encircle the bright nucleus of galaxy NGC 2787. This lens-shaped galaxy shows little or no evidence of any grand spiral arms. Also visible in the image are about a dozen globular clusters hovering around the galaxy. What appear to be stars are, in fact, gravitationally bound families of 100,000's of ancient stars orbiting the center of NGC 2787.

Pinwheel Galaxy M101 – 25 mly

Here we are zooming into the Pinwheel galaxy, M101. This is the largest and most detailed photo of a spiral galaxy that has ever been released from Hubble. The galaxy's portrait is actually composed of 51 individual Hubble exposures, in addition to elements from images from ground-based photos.

The giant spiral disk of stars, dust, and gas is 170,000 light-years across or nearly twice the diameter of our galaxy. M101 is estimated to contain at least one trillion stars. Approximately 100 billion of these stars could be like our Sun in terms of temperature and lifetime.

Sombrero Galaxy M104 – 28mly

This is the Sombrero galaxy. The galaxy's hallmark is a brilliant white, bulbous core encircled by the thick dust lanes comprising the spiral structure of the galaxy. It is 50,000 light-years across. M104's rich halo system of nearly 2,000 globular clusters is 10 times as many as orbit our Milky Way galaxy.

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.

Here's what it looks like in inferred from Spitzer.

NGC 1512 – 30mly

NGC 1512 is a barred spiral galaxy spanning 70,000 light-years.

In this view of the center of the magnificent barred spiral galaxy NGC 1512, Hubble's broad spectral vision reveals the galaxy at all wavelengths from ultraviolet to infrared. The colors (which indicate differences in light intensity) map where newly born star clusters exist in both "dusty" and "clean" regions of the galaxy.

The galaxy's core is unique for its stunning 2,400 light-year-wide circle of infant star clusters, called a **circumnuclear starburst ring**.

Whirlpool Galaxy M51 – 31 mly

Here's a deep dive into the Whirlpool galaxy, M51. These images of the Whirlpool galaxy highlight the attributes of a typical spiral galaxy, including graceful, curving arms, pink star-forming regions, and brilliant blue strands of star clusters.

M74 – 32 mly

Here we are zooming into Messier 74, a stunning example of a "grand-design" spiral galaxy that is viewed by Earth observers nearly face-on.

It's perfectly symmetrical spiral arms emanate from the central nucleus and are dotted with clusters of young blue stars and glowing pink H II regions of ionized hydrogen Tracing along the spiral arms are winding dust lanes that also begin very near the galaxy's nucleus and follow along the length of the spiral arms.

M66 – 35 mly

Here's a deep look into M 66, the proud owner of unusually asymmetric spiral arms which seem to climb above the galaxy's main disc and a displaced nucleus. Astronomers believe that M66's once orderly shape has most likely been distorted by the gravitational pull of its two neighbors.

M66 boasts a remarkable record of supernovae explosions. The spiral galaxy has hosted three supernovae since 1989, the latest one occurring in 2009.

M96 – 35 mly

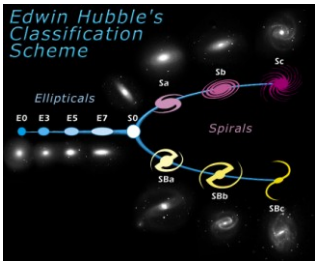
M96's core is also displaced from the galactic center. Its gas and dust are distributed asymmetrically and its spiral arms are ill-defined. But this portrait, taken with the ESO's Very Large Telescope, shows that imperfection can be beautiful.

The galaxy's core is compact but glowing, and the dark dust lanes around it move in a delicate swirl towards the nucleus. And the spiral arms, patchy rings of young blue stars, are like necklaces of blue pearls. Its graceful imperfections likely result from the gravitational pull from nearby galaxies.

M96 spans some 100,000 light-years in diameter — about the size of our Milky Way.

Galaxy classifications

In 1926, there were enough galaxies known for Edwin Hubble to create a morphological classification scheme. This is his diagram. His students called it the "Hubble tuning-fork".



Hubble's scheme divides galaxies into 3 broad classes based on their visual appearance.

Elliptical galaxies have smooth, featureless light distributions and appear as ellipses in images like Centaurus A. They are denoted by the letter E, followed by an integer n representing their degree of ellipticity on the sky.

Spiral galaxies consist of a flattened disk, with stars forming a spiral structure, and a central concentration of stars known as the bulge like the Whirlpool galaxy. They are given the symbol S or SB if it has a bar core like the Milky Way.

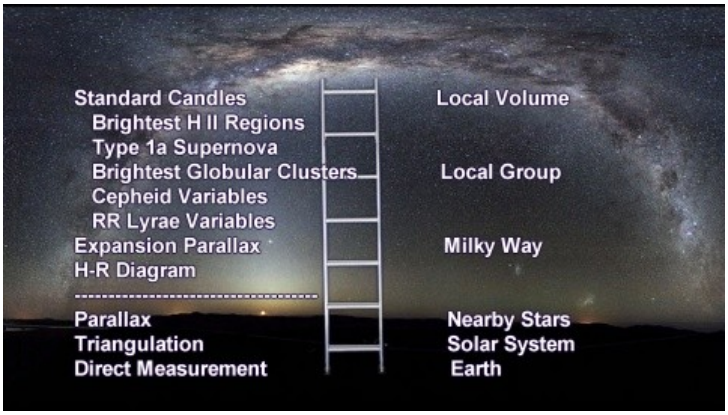
Lenticular galaxies also consist of a bright central bulge surrounded by an extended, disk-like structure but, unlike spiral galaxies, the disks of lenticular galaxies have no visible spiral structure and are not actively forming stars in any significant quantity. NGC 2787 is an example of these. They are designated S0.

These broad classes can be extended to enable finer distinctions of appearance and to encompass other types of galaxies, such as **irregular galaxies**, which have no obvious regular structure (either disk-like or ellipsoidal). The Large Magellanic Cloud is an excellent example of this.

Since then, others have added characteristics such as Bars, Rings, and Spiral arm characteristics.

Distance Ladder

[Additional info: We've seen a wide variety of shapes and sizes as we toured the Local Volume of stars studied by the Spitzer LVL team. In each galaxy, it was not to hard to find at least one Cepheid Variable, RR Lyrae Variable, Type 1a Supernova, Bright HII and/or Globular cluster. Star spectra and the H-R diagram were also useful for red supergiants which are abundant in many of these galaxies. These were used to calculate galaxy distances.**]**



We lost parallax when we went beyond the nearby stars. But, so far, the rest of our distance ladder has taken us through the local group and the local volume. But at the outer reaches, RR Lyrae variables leave our list. They are just not bright enough to be seen well beyond 20 million light years. But Cepheids, H II Regions, Globular Clusters, and Type 1a Supernova are still going strong. They will take us well into the Virgo Supercluster, our next segment.