# The Local Group of Galaxies:

***(What are They, and How to Observe Them)***

**Introduction:**

The Local Group,,,,,
Over the years, I've clipped and saved interesting articles from the various astronomy related magazines that have come and gone, and some that are still with us. One of my favorite 'observing' oriented publications was the old 'Deep Sky' magazine. In their fall 1984 issue there was a detailed article titled "*All About M31*", which was about observing the Great Andromeda Galaxy's internal open and globular clusters and M31's attendant satellite galaxies. They followed that up a few years later in the autumn of 1991 with an article on "*Observing the Local Group*". I've held on to those issues over the years, wanting someday to do an observing project based on them. Then more recently both 'Astronomy' magazine 'Sky and Telescope' came out with a number of great observing articles on other 'Local Group' themed topics such as the December 2013 Sky & Telescope issue - "*Exploring the Triangulum Galaxy*", and "*Local Group Dwarf Galaxies*" , and the entire March 2019 issue of 'Astronomy' about galaxies.

It was that December 2013 Sky& Tel issue that inspired me to finally start an observing project in the spring of 2014 to explore our Local Group of galaxies. So I started diving into these articles with their photographs and finder charts, comparing with what I've observed or video-captured over the years.
I was able to identify a number of extra-galactic globular clusters and H-II regions in M31 & M33, along with already having several additional Local Group members video-imaged. Then I learned of Alvin Huey's downloadable observing book - "*The Local Group*", from his website www.faintfuzzies.com, and my journey into the Local Group began in earnest.

So today, we'll discuss what I've learned during that journey among the Local Group, along with some of the people, both historical and modern, behind these objects, and how to go about observing them. Along the way, we'll also review a number of my personal observations of Local Group members.
Hopefully, when we are done, you will find them as interesting to hunt as I do.

**Discussion outline:**

- **Galaxies – What are they:**
- **What is the "Local Group":**
- **Historical and Modern Astronomers associated with the Local Group:**
- **How to Observe the Local Group:**
- **Observations of the Local Group Galaxies:**
- **Conclusion**

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**Galaxies – What are they?**

Galaxies are large systems of stars and interstellar matter, typically containing from several million to several trillion stars. They run in size from a few 10's of thousands to several 100,000 light years in size, and are separated from other galaxies by millions of light years.

*How do Galaxies form?*

They originate from large cosmic primordial clouds of gaseous matter (hydrogen and helium) in our Universe that slowly collapsed. Most galaxies have formed at about the same time, within the first billion years after the universe started to expand, from an initial hot state.

Thus, they are all almost as old as the universe itself, currently thought to be about 14 billion years.

*Where are Galaxies Located?*

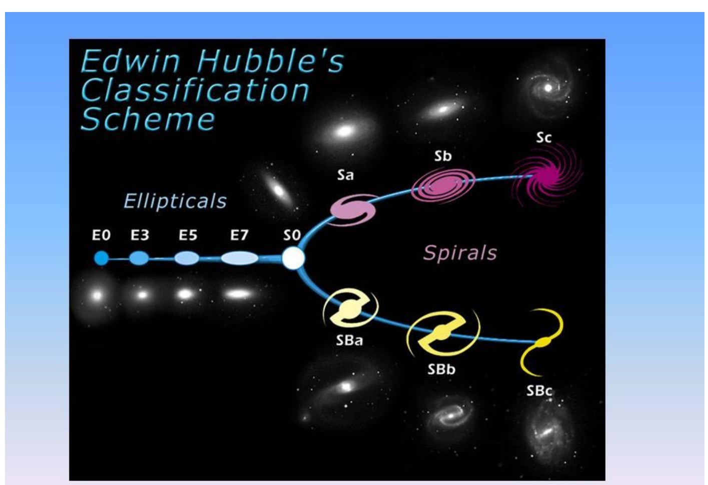
Galaxies are scattered throughout the visible universe. We live inside a giant spiral galaxy, called the Milky-Way Galaxy. The Milky-Way is about 100,000 light years in diameter and contains a mass equal to about a trillion stars. Our galaxy has several small dwarf galaxies orbiting around it that are only a few 100,000 light years distant. The nearest giant galactic neighbor, the Andromeda Galaxy, also a spiral, is about 2-3 million light years distant. Some galaxies are isolated "island universes" which float lonely through an otherwise empty region of the universe. But the distribution of matter in the Universe is not uniform. That causes groups of galaxies, running to few dozens of galaxies, or even large clusters of up to several thousands of galaxies, to form. The galaxies of these groups are in mutual gravitational interaction, which may have significant influence on their appearance.

*Classic Morphology*

Galaxies come in several types, and though of a wide variety of shapes and appearances, have many basic common features. They are huge conglomerations of stars like our Sun. From their appearance, galaxies are classified as spiral, lenticular, elliptical, and irregular. In the early 20th century, astronomer Edwin Hubble devised a galaxy classification diagram based on their visual appearance.

This classification is commonly called the: Hubble Tuning Fork diagram. Hubble divided the galaxies into three broad classes: spirals, elliptical, and lenticulars, along with a fourth class of irregulars.

All the main types have sub-category classifications, and we still use a modified version of this today.




https://en.wikipedia.org/wiki/Hubble_sequence

*Elliptical*

Elliptical galaxies are shaped like giant luminous cosmic balls, and have no spiral or disk components. They have little or no rotation as a whole. Normally, elliptical galaxies contain very little or no interstellar matter, and consist of older population stars only:

*Lenticular*
Lenticular galaxies are shaped like spiral galaxies without a spiral structure.
They are smooth disk galaxies, where stellar formation has stopped long ago, because the interstellar matter was used up. They consist of mostly older population stars only. From their appearance and stellar contents, they can often be observationally confused with ellipticals.

*Spiral*
Spiral galaxies usually consist of three major components:
A flat, large disk which often contains interstellar matter visible as diffuse glowing emission nebulae or as dark dust clouds. Young open star clusters, associations, and random stars arranged in conspicuous and striking spiral patterns and / or bar structures.
Finally, a central bulge or core, consisting of older stellar populations with little interstellar matter, and often surrounded by a halo of older globular star clusters.

*Irregular*
Irregular galaxies have many different shapes and sizes due to distortion by the gravitational pull of their intergalactic neighbors. These galaxies do not fit into the scheme of spirals, disks and ellipsoids, and exhibit no particular shape.

*Peculiar Galaxies*
Peculiar galaxies come in various types, those with jets, split arms, diffuse tails, filaments and ejected material, and for the most part, peculiar galaxies can be found anywhere along the Hubble classifications system. But a large number can be found along the 'spiral' sections of Hubble's Tuning Fork, such as interacting galaxies (colliding galaxies being the most interesting), whose gravitational fields result in a disturbance of one another.

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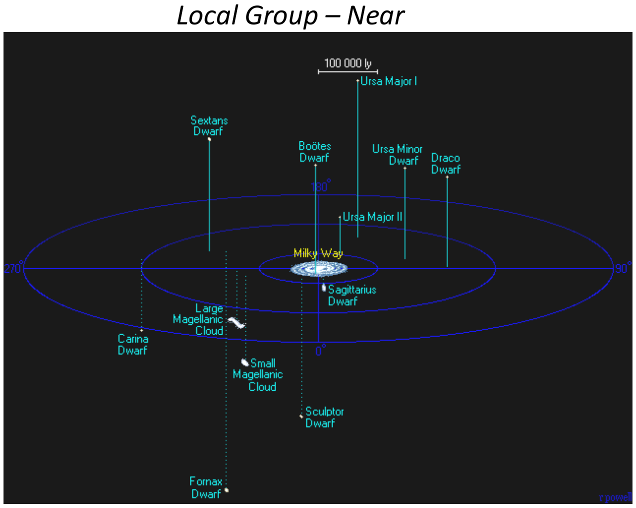
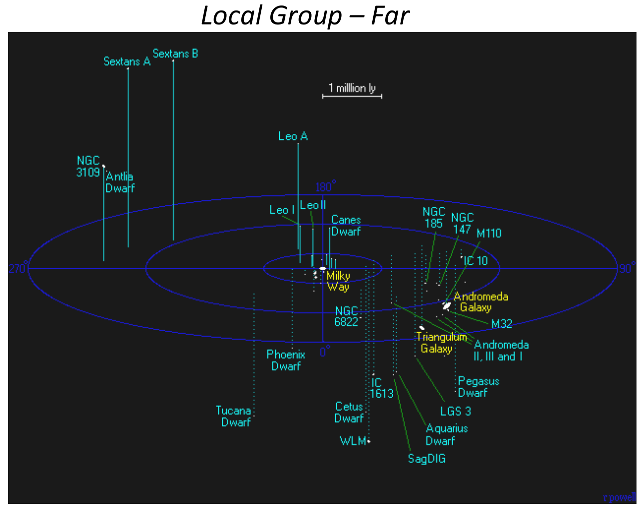
**What is the "Local Group"?**
The "Local Group" is the group of galaxies that includes our home galaxy, the Milky Way, among others. It comprises more than 54 galaxies, counting low surface brightness dwarf galaxies, divided into three main sub-groups. The most massive member of the group is M31, the Andromeda Galaxy, followed next by the Milky Way, with the third being M33, the Triangulum Galaxy. Both the Milky Way and Andromeda galaxies each have a system of satellite dwarf galaxies. The gravitational center of the Local Group is located between the Milky Way and the Andromeda Galaxy. Overall, the Local Group has a rough diameter of around 10 million light-years, and contains three spirals, two elliptical, nine irregulars, and forty dwarf galaxies.

*Local Group – Near*




*Local Group – Far*




*Charts by Richard Powell: http://www.atlasoftheuniverse.com/localgr.html*

The Local Group is near the outer edge and part of the larger Virgo Cluster.
The Virgo Cluster is a grouping of over 1500 galaxies with a cluster diameter of around 54 million light-years centered on M84, M86, and M87. Other nearby galaxy groups within the Virgo Cluster in our neighborhood includes Maffei-1, NGC253 and M81 groups. Moving up in scale, the Virgo Cluster is part of the Coma-Virgo Supercluster, (also called the Local Supercluster), a giant grouping of around 100 galaxy groups with a total of over 20,000 galaxies, and a diameter of over 110 million light-years centered on the Virgo Cluster.

The Coma-Virgo Supercluster is itself part of an even larger structure called the Laniakea Supercluster, (Hawaiian for "immense heaven'), made up of at least four smaller superclusters totaling over 100,000 galaxies stretched over 520 million light-years. And Laniakea in turn may be part of an even greater structure! The Universe is a big place!!

Getting back to the smaller scale "Local Group" and its three sub-groups:
The Milky Way's satellite system consists of the Large Magellanic Cloud, Small Magellanic Cloud, Sagittarius Dwarf Galaxy, Canis Major Dwarf, Ursa Minor Dwarf, Draco Dwarf, Carina Dwarf, Sextans Dwarf, Sculptor Dwarf, Fornax Dwarf, Leo I, Leo II, and Ursa Major I Dwarf and the Ursa Major II Dwarf.
The much larger Milky Way is cannibalizing several of its smaller dwarf galaxies such as the Sagittarius and Canis Major dwarfs, which are in the process of being stretched into remnant stellar steams.

Andromeda's satellite system consists of the brighter members M32, M110, NGC 147, NGC 185, along with much fainter Pegasus Dwarf, Cassiopeia Dwarf, And I, And II, And III, And IV, And V, And VIII, And IX, and And X. The Andromeda galaxy is also in the process of gobbling-up several of its own smaller satellite galaxies.

The third sub-group is the Triangulum Galaxy, M33, which is the only unbarred spiral galaxy in the Local Group. M33 currently does not have any know satellite system of smaller galaxies.

Finally, there are a number of small dwarf galaxies that are not bound to any of the three main galaxies. These include Sextans-A and the Antlia Dwarf, IC 10, Leo A, Cetus Dwarf, Pegasus Dwarf Irregular, Aquarius Dwarf, and the Sagittarius Dwarf Irregular.

While there's currently 54 individual galaxies identified as members of the Local Group, with the Milky Way blocking a large band of the sky, new discoveries of galaxies with extremely low surface brightness, obscured by our galaxies dust are still being discovered, so the group membership will rise as we develop better instruments.

The first astronomer to identify our local grouping of galaxies as the "Local Group" was Edwin Hubble. Hubble gave these galaxies this name in his 1936 book, *The Realm of Nebulae*, where he referred to the initial 12 galactic members as "a typical small group of nebulae".

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**<u>Historical and Modern Astronomers associated with the Local Group:</u>**
In addition to the glowing cloud band of light known as the Milky Way, Ancient people also noticed other smaller patches of unmoving 'little clouds' up in the night sky, one in the constellation of Andromeda, and another in the stars of the triangle. Having only their naked-eyes, most people could only speculate as to what these night-time clouds were. Across the ages, people attempted to explain what the Milky Way was. Some thought it was a great mass of luminous vapor. Then there were those who claimed it marked the sun's path across the sky. And still others who thought it was the seam in the sky where the celestial vault didn't quite fit, and was pulling apart. But there were a few ancient Greek philosophers, such as Aristotle, who speculated that these clouds were made of faint groupings of stars too distant to see individually.

With modern science, we now understand what the Milky Way and the Andromeda and Triangulum galaxies are. While Hubble was the first to coin the phase "Local Group", we can trace the beginnings of scientific observations of the Local Group members back through history over the last four centuries.

**Galileo:**

After the invention of the telescope, Italian astronomer Galileo Galilei was the first to use one to observe the Milky Way. Galileo reported in his book “The Starry Messenger” published in 1610, that he was able to resolve the nebulous glowing band into a multitude of individual stars so densely packed that without a telescope they appeared as clouds to the naked-eye.

During this period, German astronomer Simon Marius used his own telescope in 1612 to observe the Andromeda nebula which he described as a dull, pale light, “like a candle shining thru horn”, but was not able to resolve it into stars.

**Immanuel Kant:**

In 1755, German Enlightenment philosopher Immanuel Kant in a paper titled “*Universal Natural History and Theory of the Heavens*” theorized that the stars of the Milky Way, like the sun and planets of the solar system, formed from a large spinning disk of gas and was held together by gravitational forces. This was known as his “Nebular Hypothesis“. The reason that the Milky Way galaxy looked like a band was due to our being inside the disk. Kant also thought that other distant "nebulae", which he called ‘Island Universes’, might be other separate galaxies located outside the Milky Way.

**Charles Messier:**

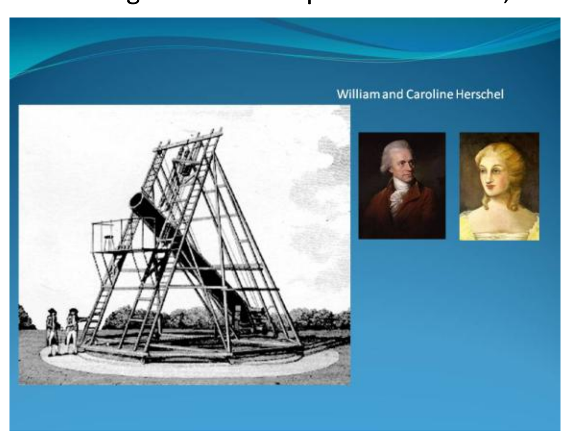
While both the Andromeda and Triangulum nebula were well known in Charles Messier’s time, in 1764 he still went ahead and listed both small clouds as the 31st and 33rd entry on his list of objects to avoid while comet hunting. Messier used various small telescopes from his observatory in Paris to view both nebulas describing M31 as “Beautiful nebula, shaped like a spindle, center appears clear without any stars appearing, and the light gradually diminishes until extinguished”. And for M33 – “of a whitish light of almost even density and contains no stars”.

**William Herschel:**

In 1785, As the ‘Kings Personal Astronomer’ to England’s King George III, as part of his work to study everything about the night sky, William Herschel made the first attempt to define the actual shape of the Milky Way from observation and measurement by carefully counting the number of stars in different regions of the sky. From his observations, William created a diagram of the Milky Way, placing the solar system at its center, and devised his own theory that our galaxy was disk-shaped.

Herschel also used his “20 foot” reflector to observe both the M31 and M33 nebulas, resolving some features of each and giving them their own designations, such as NGC206 which is a bright section of spiral arm in M31, and NGC604 which is a bright HII region within M33. Additionally, Williams sister, Caroline, discovered the second satellite galaxy to M31, NGC205, also known in modern times as M110. Herschel described M31 as “brightest part approaches resolvable nebulosity, faint reddish hue to its core”, and M33 as “Milky nebulosity, and has a mottled aspect”.

Herschel believed that both nebulae we know today as galaxies were clusters of unresolved stars which he called “Island Nebulae” to distinguish them from Kant.



**Lord Rosse:**
Using his 72" reflector, in 1850, Anglo-Irish astronomer William Parsons, the 3rd Earl of Rosse reported that the disks of both M31 and M33, along with a number of other nebula, (particularly M51 which he nicknamed the "Whirlpool Galaxy'), exhibited a spiral shape, and he began referring to these as 'spiral nebula' to distinguish them from the various other nebula. Parsons was also able to visually resolve some individual stars in the spiral nebula that he observed.

**Herber Curtis:**
American astronomer Herber Curtis (1872 – 1942), born in Muskegon, Michigan and after attending the University of Michigan, earned his PHD in Astronomy in 1902 from the University of Virginia.
Herber was known for his studies of solar eclipses, having participated in 11 eclipse expeditions.
During his professional career, Curtis worked at Lick Observatory and served as president of the Astronomical Society of the Pacific. In 1918, he was the first astronomer to observe the jet coming out of the core of M87. He later was appointed in 1920 as director of the Allegheny Observatory in Pittsburgh. In 1930, Curtis accepted a position as director of the University of Michigan's astronomical observatories where he finished his career.

While at Lick Observatory in 1917, researching the spectrum of a prior nova, (1885A, S Andromedae), that appeared to be from within the Andromeda Nebula, Curtis uncovered 11 more examples of nova from within the nebula. Curtis determined all 12 of the 'Andromeda' nova had similar magnitudes that were at least 10 times fainter than similar nova from within the Milky Way. Taking into account the differences in nova magnitudes, Herber calculated that the Andromeda Nebula must be at least 490,000 light-years distance, well outside of the Milky Way galaxy. From this, Curtis became a leading proponent of Kant's 'Island Universe' hypothesis that spiral nebula were all external from the Milky Way.

**Harlow Shapley:**
American astronomer Harlow Shapley, (1885 - 1972), born in the small town of Nashville Missouri, studied astronomy at the University of Missouri starting in 1907, and later earned his PH.D from Princeton University. After graduating, Shapley was hired by George Hale to work at Mt Wilson Observatory with the 60" reflector, at the time, the largest telescope in the world.

Shapley served as director of the Harvard College Observatory from 1921–1952, and published a number of books on astronomy. One of the lesser known catalogs of open star clusters is the Harvard catalogue, of 21 open clusters and was compiled in 1930 by Shapely. His other major accomplishments include correctly estimating the size of the Milky-Way galaxy using RR Lyrae stars and their Period-Luminosity Relationship, and the sun's position within the Milky Way of being two-thirds toward the outer edge rather than in the center of the galaxy. Shapley was elected president of the American Association for the Advancement of Science in 1947. In 1953, he came up with the "Liquid Water Belt" habitable zone theory of planetary formation around stars.

During his early career, Shapley as an avid supporter of the Milky Way being the entire universe, with spiral nebula as just another type of nebulous gas object within the Milky Way.

While initially criticizing and opposing astronomer Edwin Hubble's galaxy distance observations, after seeing and analyzing Hubble's data, Shapley realized that Hubble was fundamentally correct, and became a supporter of Hubble's theory. Shapley went on to make significant contributions in the research of galaxy distribution, mapping over 76,000 galaxies. He was one of the first astronomers to support the theory of galaxy superclusters.

**The Great Debate - external galaxies vs. internal nebula:**
At the turn of the 20th century, one of the major questions that professional astronomers were trying to answer was "how far away are the galaxies?" In April of 1920, the question of what were spiral nebulae and the size of the universe came to a head. The National Academy of Sciences hosted a public lecture at the Smithsonian Museum between astronomers Curtis and Shapley who both presented opposing papers.

Shapley defended that spiral nebulae were all small objects located inside the Milky Way, and Curtis argued that the spiral nebulae are large 'island universes' that were located far outside the Milky Way.

Shapley's main line of argument was that as the overall luminosity of the Andromeda nova generally matched nova elsewhere in the Milky Way so that the nova observed in M31 must also be nearby.
But his key supporting fact was based on observations from another astronomer (Adriaan Van Maanen) that rotation had been observed in M101, 'Pinwheel' Galaxy'. If the M101 spiral nebula was external to the Milky Way, this visible rotation would be a violation of the speed of light!

Curtis used his Andromeda nova magnitude research as his key evidence in arguing for galaxies being much further away external objects. He also used the measurable Doppler Redshift and the dark dust lanes visible in the spiral nebula arms that resembled the Milky Way's as additional proof that spiral nebulae were independent external galaxies.

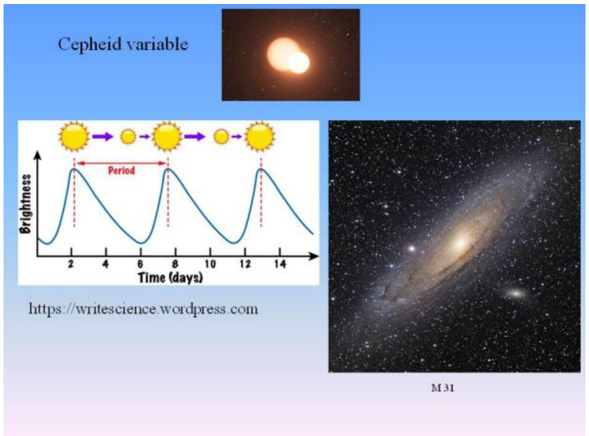
The general consensus of the astronomical world after the debate was it was mostly a draw, with Shapley having the edge in being a stronger debater than Curtis. But, it soon turned-out that Curtis had the better observational facts, as Shapley's key supporting argument that rotation had been observed in M101 was based on Van Maanen's using an old optically defective blink-comparator machine and his observations were disproven. The answer to the question on spiral nebulae would have to wait until another astronomer could more accurately measure the distance to the galaxies.

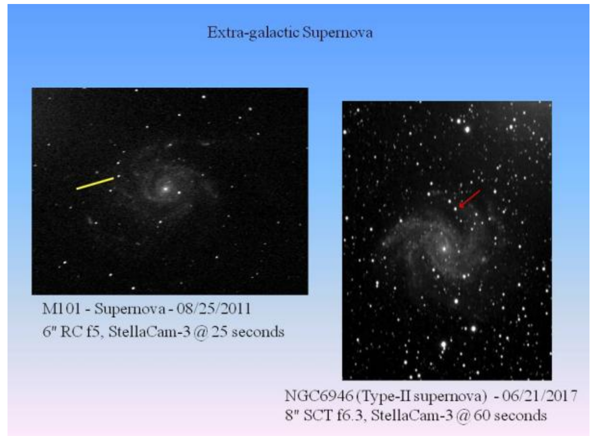
**<u>Edwin Hubble:</u>**
American astronomer Edwin Hubble, (1889 – 1953), was born in Marshfield, Missouri but grew up in Wheaton, Illinois where he developed a passion for astronomy. Hubble attended the University of Chicago, where he studied law and graduated with a BS in 1910, and spent three years as one of the first Rhoades Scholars at Queens College, Oxford England which he graduated from in 1913 with a master's degree. After spending several years teaching high-school physics in Indiana, Hubble re-enrolled back at the University of Chicago to study astronomy, and while there worked at the Yerkes Observatory using its 40" refractor. Hubble graduated with his PHD in astronomy in 1917 and enlisted with the US Army to fight in WWI. Before Hubble could make it over to the European battlefront, the war ended.
Hubble then went to work for George Hale at the Mt Wilson Observatory in 1919 and was one of the first groups of astronomers to utilize the new 100" Hooker reflector in studying Cepheid variables.
Hubble remained at Mount Wilson for the remainder of his career and became the first astronomer to use the completed 200" Hale reflector.

While using the 100" Hooker telescope in 1923 for a photographic study of the Andromeda nebula, Hubble discovered a number of Cepheid variables within the spiral nebula. Using Shapley's own RR Lyrae based Period-Luminosity Relationship theory; Hubble was able to determine their distance to be greater than the accepted size of the Milky Way.

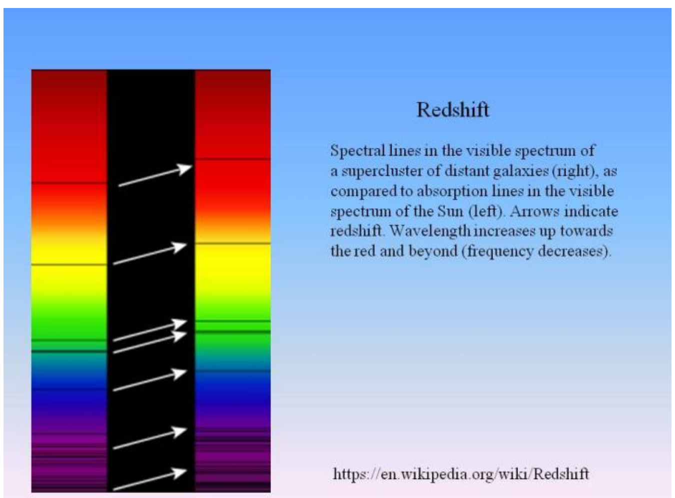
By 1925, Hubble's observations of additional Cepheid's in the Andromeda and Triangulum nebulas proved conclusively that they were too distant to be located inside of the Milky Way and that spiral nebula were in fact external to the Milky Way. The first accurate distances to galaxies had finally been determined by Edwin Hubble using Cepheid variables.
Hubble had finally answered the old question of external galaxies vs. internal nebula and settled the Great Debate in favor of Immanuel Kant's 1755 'island universes'!

Cepheid variables are stars that vary their brightness by a specific range and timeframe.
This relationship between the star's luminosity and period of change allows astronomers to determine what its true brightness is and allows them to determine the star's distance. Using this relationship, astronomers were able to accurately calculate distances to Cepheid's in our Milky-Way galaxy. With the discovery of Cepheid's in the nearby galaxies, such as M31 the Andromeda Galaxy, this allowed astronomers to extend accurate distances throughout the Local Group of galaxies.




But in galaxies much further away, Cepheid's were not identifiable, so astronomers turned to another celestial yardstick, supernovas. Extra-galactic nova's and supernova's are similar to Cepheid's in that their intrinsic brightness could be compared against these stellar explosions that have occurred within our own galaxy. This allowed us to measure distances out into our nearby supercluster of galaxies, (Virgo and Coma Clusters). To go even further out into the universe, Hubble, working with astronomers Vesto Slipher and Milton Humason in 1929, discovered that every galaxy has a measurable redshift that could be utilized. The greater the spectral lines of an object are shifted towards the red end of the spectrum, the greater its distance is from us. The symbol for redshift, expressed as a fractional displacement of wavelength is 'z'. An object with z=0.0 or smaller has a low redshift and is nearby. A redshift greater than z=0.0 is a high redshift and represents an object very far away. The bigger the number, the father away it is. A central part of today's 'Big Bang' cosmology this key tenet is named Hubble's Law. Basically stated, Hubble's Law is that the larger an objects redshift, the farther away it is and the faster it is receding from us. It is a critical piece of the expanding universe theory.

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**How to Observe the Local Group:**

So, where can you find the Local Group Galaxies? Galaxies in general can be found opposite the glowing band of light that we call the "Milky-Way", our home galaxy. Usually, when we want to observe bright or dark nebula and star clusters, the Milky-Way is exactly where we want to look, but for galaxies, this is the "Zone of Avoidance', as all the gas and dust nebula and stars of the spiral arms of our galaxy tend to obscure all the faint extra-galactic 'nebula' that we want to observe. Generally, galaxies come in all shapes, sizes, and brightness, and many are very interesting and worth the effort to find, regardless of the equipment that you use. With the exception of M31 & M33 and a few other brighter members, most of the galaxies of the Local Group are small faint, and will require large aperture telescopes or imaging setups, along with a dark-sky location such as Cherry Springs.

It helps to have a list of the Local Group catalog. There are a number of good observing guides available to the amateur astronomer that includes a list of Local Group members.

One of my favorites is “*The Night Sky Observers Guide – Volumes 1 & 2.* These handbooks were written by George Kepple and Glen Sanner, each chapter covering a specific constellation, along with finder charts, sketches, images, and visual descriptions of various deep sky objects, including the Local Group galaxies.

Amateur astronomer Alvin Huey has a great observing book on his website [www.faintfuzzies.com](http://www.faintfuzzies.com)
Called “Observing Local Group Members” devoted specifically to the Local Group. It contains finder charts, and DSS images for Local Group members.

*Ingredients to successfully observe Local Group Galaxies:*
While most Local Group galaxies can be challenging, this is what makes them interesting to find and attempt to visually see or capture an image of.

Observing them visually requires maintaining dark-adaptation, good starcharts, and slow sweeping with a wide-field low-power eyepiece and a fast low focal-length telescope. A nice 80mm F6 or shorter refractor piggybacked on a 10” or greater telescope would work very well. The 80mm acts as a low-power RFT giving you a wide-field in which to find the galaxy and the larger telescope it is attached to allows use of higher magnifications, depending on the object. You’ll need all your visual observing skills to find and bring out these subtle objects. Many Local Group galaxies are very faint, and depending on what size telescope you are using, may not be visible. But like any deep-sky object, half the fun is just successfully finding it and knowing what it is that you are observing.

For the Imagers, Local Group galaxies can also be challenging due to their faintest, in that even with an accurate GOTO mount, it may not position the telescope squarely on the object to where it’s framed the way you want it. Having a photographic atlas or picture of the galaxy will help you in both locating and identifying the object and in framing your image. I’ve found that using short-exposure video-astronomy cameras works great in positioning and identifying Local Group galaxies.

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**Observations of the Local Group Galaxies:**

**The Milky-Way**
The Milky Way, second largest galaxy of the Local Group, is a barred-spiral galaxy (type Sbc) with spiral arms radiating off of either end of the bar and has a diameter between 150,000 and 200,000 light-years and about a 1,000 light-years thick. An example of what the Milky Way may look like is NGC3953, a barred-spiral in the constellation of Ursa Major. Recent studies have indicated that the Milky Way has a bit of a warp to its shape from interacting with its satellite galaxies. With the overall shape of the Milky Way still being a little uncertain, the disk of the Milky Way is believed to be organized into four major spiral arms with several minor arms and spurs. It is estimated to contain close to 400 billion stars and 10’s of billions of planets. The Milky Way’s galactic core, located just to the west of the Large Sagittarius Starcloud, contains an intense radio source, Sagittarius A*, which is a supermassive black hole of around 4 million solar masses. The Solar System is located about 27,000 light-years from the galactic core, on a spur along the inner edge of the Orion Spiral Arm. (more recently, astronomers have begun referring to the Orion Arm as the “Local Arm”). The Orion/Local Arm is located between the inner Sagittarius Arm and the outer Perseus Arm. It’s estimated to be about 16,000 to 20,000 light-years long and includes nearly all the naked-eye stars. The Sun rotates around the Milky Way about every 220 million years. The Milky Way galaxy itself is moving at around 600 km per second in the direction of the Andromeda Galaxy.

The Milky Way’s two main satellite galaxies are the Large and Small Magellanic Clouds, with the LMC being the fourth largest member of the Local Group, but only about one-hundredth the size of the MW.
The LMC is about 163,000 light-years distant and around 14,000 light-years in diameter. The SMC is around 200,000 light-years away and about 7,000 in diameter. Both the LMC and SMC are classified as spiral galaxies with a central bar structure and both may have once been barred-spirals that have been disrupted by

interactions with the much larger Milky Way. The LMC still has at least one spiral arm and is home to the Tarantula Nebula (30 Doradus), one of the largest HII star forming regions in the Local Group. While both satellite galaxies are naked-eye patches comparable to bright Milky Way starclouds, neither the LMC nor SMC are visible for the majority of the Earth's northern hemisphere observers, being only above the horizon for people living no greater than 15 degrees north.

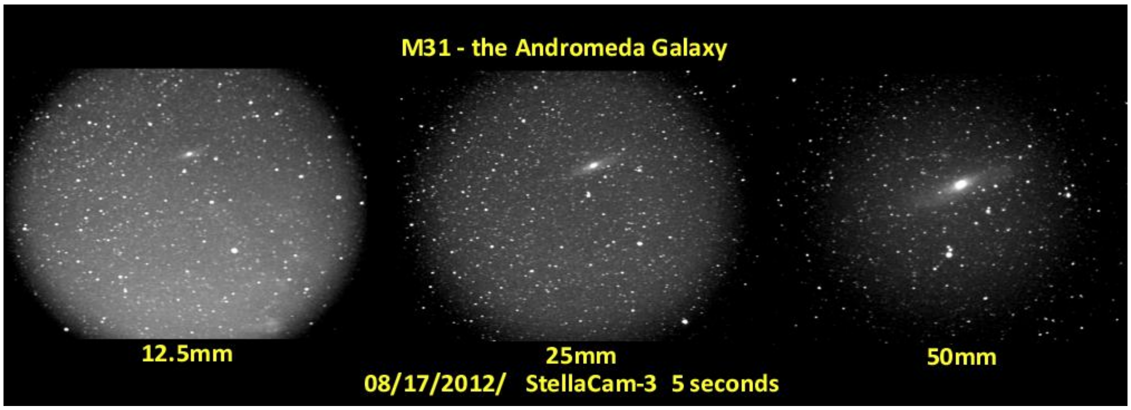
The Milky Way is a low-surface brightness hazy band of light formed from stars that cannot be individually seen by the naked-eye. It appears as a band because we are viewing its disk-shaped structure from within. Any kind of stray light such as from a natural source like the Moon or man-made sources such as light pollution from cities will wash-out most of its faint detail, and can make it difficult to even see from brightly lit urban or suburban areas. Living today in the 21st century's light polluted skies, we can seldom see and enjoy the beautiful splendor of the Milky Way, which can be viewed on a clear, moonless night from the countryside. The light from any nearby city will obliterate much of the faint haze like glow in the night sky that we know of today as our own home galaxy. It is estimated that close to half the world's population can no longer see the Milky Way from where they live, and must travel to a dark-sky park, such as Cherry Springs, where on good nights it can still be bright enough to cast shadows on the ground.

Visually, the Milky Way is made-up of bright knots and star clouds intertwined with dark regions of interstellar gas and dust that blocks the background stars giving the appearance of rifts and holes in the overall shape. Generally the Milky Way is around 30 degrees in width, with the widest and brightest section located in the region around the constellations of Sagittarius and Scorpius which lay in the direction of the galactic center of our galaxy. Other bright sections that are visible from our northern hemisphere can be found running from nearby constellations of Scutum up thru Aquila into Cygnus where it is bisected by the Great Rift. The stars of the Summer Triangle, (Vega in Lyra, Deneb in Cygnus, and Altair in Aquila), can be used as a guide to find the Milky Way as it passes thru the triangle.
The narrowest section is centered on the constellations of Auriga, Gemini, and Orion. Overall, the band of the Milky Way can be found running thru 30 out of the 88 constellations of the night sky. Because of the high inclination difference in the plane of our solar system and the Milky Way, (about 60 degrees), depending on the observer's location and the time of year, the band of the Milky Way can be seen to arch from the Northeast, high overhead, and down to the Southwest. The late summer, fall season is the best time for this at Cherry Springs. During our northern winter and into spring, the Milky Way occupies lower latitude constellations which further dim its appearance as we're looking thru more of an angle towards the horizon, and thru more of Earth's atmosphere.

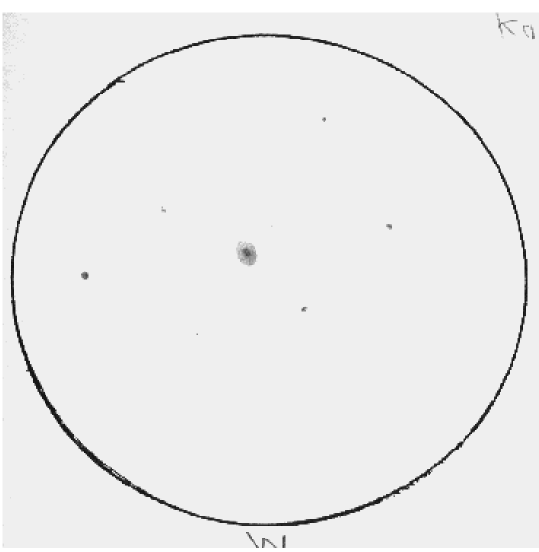
The Milky Way is best observed with your naked-eyes or low power binoculars or a spotting scope.
You'll want to be dark adapted and at a dark-sky location. A planetsphere will help you identify which constellations are best suited for viewing the Milky Way depending on the date and time.

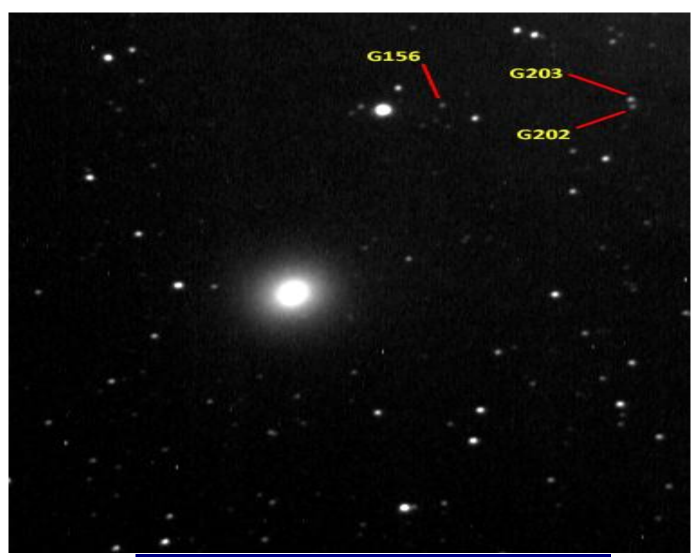
**M31** – The Andromeda Galaxy: (including M32 & M110, associations & globular clusters)

The Andromeda Galaxy, is the largest member of the Local Group, is also a barred-spiral galaxy with the bar oriented along the length of the galaxy, and including at least two tightly-wound spiral arms has a diameter of around 220,000 light-years with about one trillion stars. Andromeda's galactic core contains a radio source called 2C 56, with a supermassive black hole of 3 to 5 million solar masses, and a possible double nucleus. The galaxy has over 450 globular clusters, including the most massive cluster of the entire Local Group named Mayall-II, and may be the remnant core of a small galaxy that merged with Andromeda. The Andromeda galaxy is the nearest major galaxy to the Milky Way at about 2.5 million light-years distant, and is moving at around 110 km per second in the direction of the Milky Way, which it will collide with in about 4.5 billion years.




The compact 8.7 magnitude elliptical satellite galaxy M32 (with a diameter of about 6500 light-years) is thought to have once been a small spiral galaxy that had a close interaction with M31 around a billion years ago, which stripped away most of M32's arms and disk, leaving only the core which then underwent renewed star formation from infalling gas and dust, and partly regenerated the small galaxy. M32 contains a massive central black hole of between 1.5 to 5 million solar masses and is a faint radio and x-ray source.



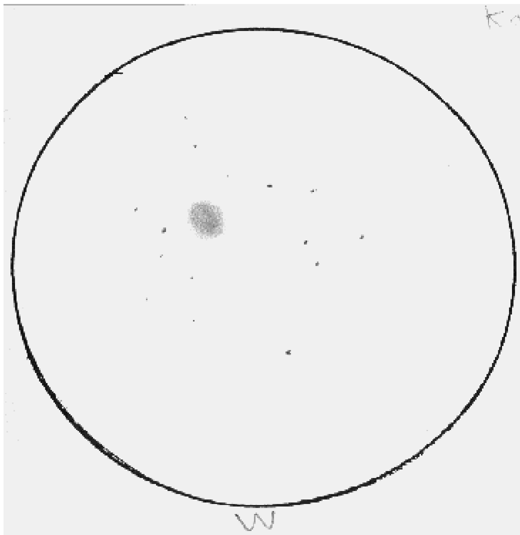


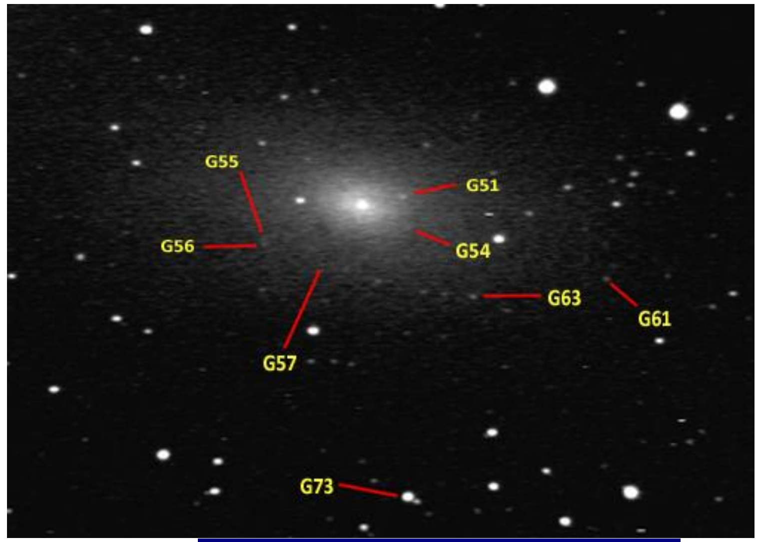

8" SCT f5, StellaCam-3, @ 30 seconds

*LM – 09/25/1989, 8" Dob f4.5, 8mm EP 143x: @ suburban backyard*

***Object: M32*** *"Small, round shape, with bright nucleus".*

Andromeda's second satellite galaxy, NGC205 (or M110) at 8.5 magnitude, is a dwarf elliptical, (about 12,000 light-years across), and also shows signs of recently interacting with M31 from a stream of stars and gas stretching between the two. It is classified as being a 'peculiar' galaxy in that unlike most ellipticals, M110 has dust clouds and younger stars near its core. Astronomers have not observed any signs of M110 having a black hole in its galactic center.

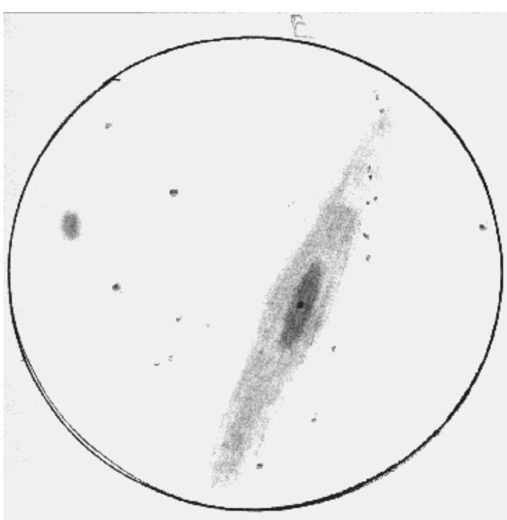


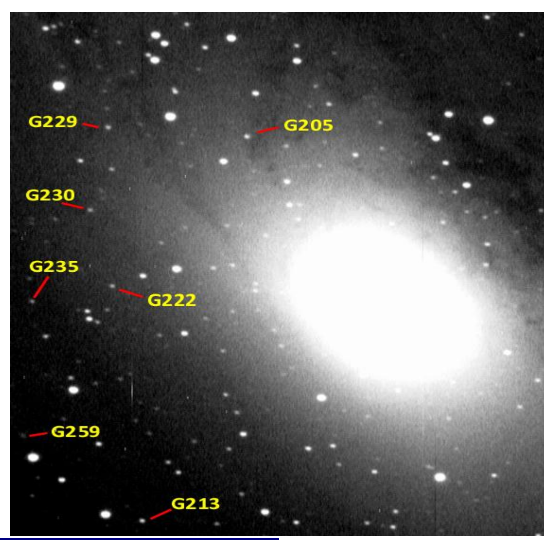




8" SCT f5, StellaCam-3, @ 30 seconds

*LM – 09/25/1989, 8" Dob f4.5, 16mm EP 57x: @ suburban county park*
***Object: M110*** *"Moderate size, but very faint. No central bright core".*

At a magnitude of 3.4, the Andromeda Galaxy is visible to the unaided-eye as a bright patch even from suburban areas on moonless nights. On fall nights, it is well-placed almost directly overhead for observing with binoculars or small to medium size telescopes which under good seeing conditions can reveal the galaxy's extended disk and dust lanes, along with its brightest globular clusters. Also visible is the large starcloud NGC206, along with two small satellite galaxies M32 and NGC205 (M110) and several of their globular clusters.
Larger size telescopes of 18" or greater will allow the observer to see additional internal structures within the spiral arms including clusters of OB associations and HII star forming regions.
Andromeda's galactic plane is highly inclined to our point-of-view, around 77%, giving it a near edge-on look, making it difficult to observe its spiral arms.



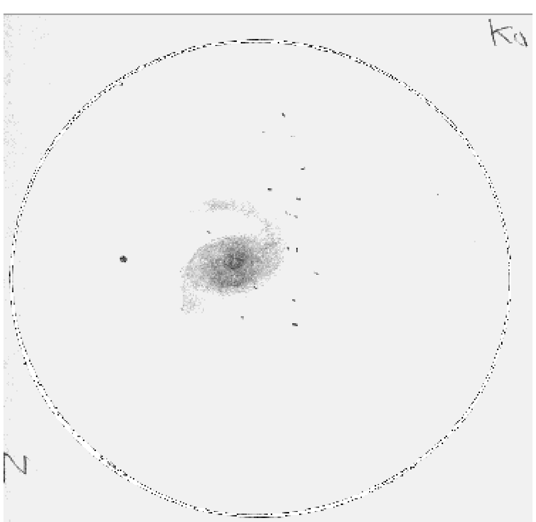

8" SCT f6.3, StellaCam-3, @ 45 seconds

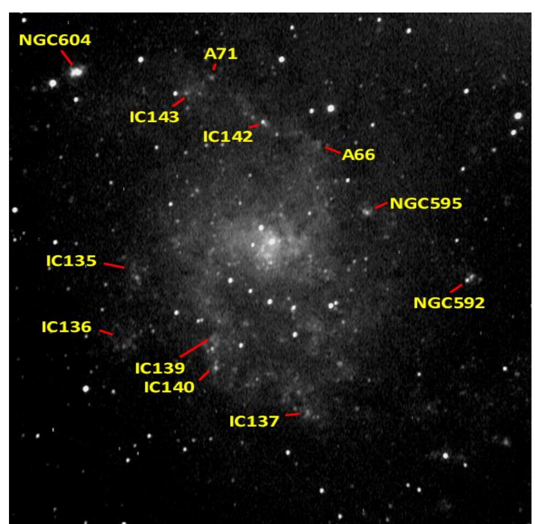
*LM – 08/31/1984, 10" Dob f5.6, 27mm EP 52x: @ suburban county park*
***Object: M31*** *"Galaxy extends to either side of the eyepiece. Central core has a star-like point".*

**M33** – The Pinwheel Galaxy: (associations & globular clusters)

The Triangulum Galaxy, while it is the third largest member of the Local Group, is only about one-tenth the size of the Milky Way, but it is the only classic shaped spiral galaxy of the Local Group. It has two bright, loosely wound spiral arms, along with multiple connecting spurs, giving the galaxy an overall diameter of around 60,000 light-years with about 40 billion stars. Triangulum's galactic core does not contain either a radio source or a black hole, just a large HII nucleus. The galaxy has over 54 globular clusters identified, along with a number of OB associations. Triangulum does not have any satellite companions, though the Pisces Dwarf galaxy could possibly be in a very distant orbit around M33. The Triangulum Galaxy is about 2.7 million light-years distant, and is moving at around 190 km per second in the direction of the Andromeda galaxy. M33 may be gravitationally bound to the larger Andromeda galaxy. Depending on modeling, the Milky Way may actually collide with M33 just prior to colliding with M31. A three galaxy interstellar pileup!!!

At magnitude of 5.7, the Triangulum Galaxy (also called the Pinwheel), may be visible to the naked-eye from a dark-sky country location on moonless nights. M33's galactic plane has an inclination of about 54° to us, allowing its spiral arms to be viewed without significant obstruction by gas and dust. There is no central bulge visible at the nucleus. On fall nights, like M31,it is well-placed overhead for observing with small to medium size telescopes which under good seeing conditions can reveal the galaxy's extended spiral arms, dust lanes, bright globular clusters, and HII star forming regions such as NGC588, 592, 595, IC132, IC133, with the largest and brightest being NGC604. With a diameter of around 1500 light-years, NGC604 is one of the largest and brightest known HII emission nebula in all of the galaxies of the Local Group. It, along with three other HII regions is located in the northern spiral arm, to the northeast of the central core. The southern arm of M33 has been a major source of extra-galactic supernova, with at least 100 supernova remnants having been identified.




6" RC f5, StellaCam-3, @ 45 seconds

*LM – 10/22/1989, 8" Dob f4.5, 16mm EP 57x: @ suburban county park*

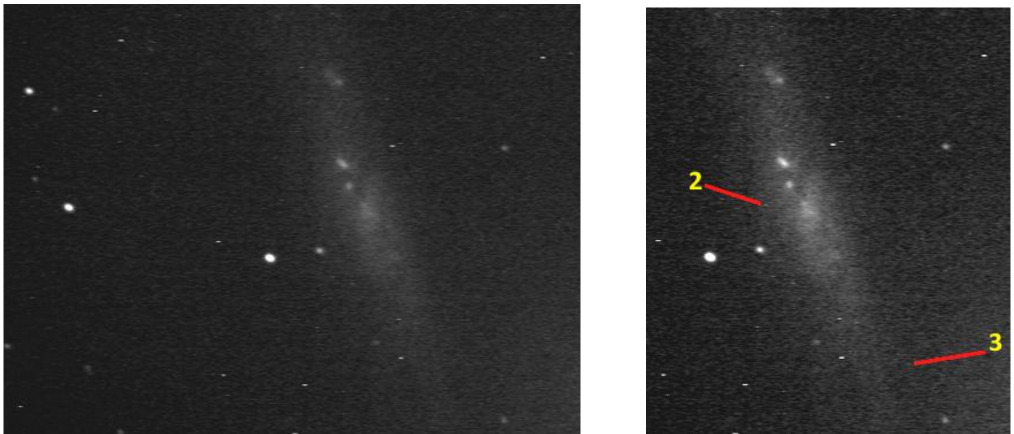
***Object: M33*** *"Very large, but dim. Two faint arms visible aligned north & south. Also faint knots".*

**Other bright local members**

NGC55

The 8.4 magnitude small Irregular barred-galaxy NGC55 is located about 5.8 million light-years distant from the Milky Way, and is located in the constellation of Sculptor. (it is probably actually a member of the Sculptor Galaxy Group instead of the Local Group) It has a diameter of about 50,000 light-years, and has active star formation ongoing in its central region.

Visibly, NGC55 is oriented nearly edge-on to our view point. It has a bright core, with dust clouds and knots of HII star forming regions, along with several globular clusters visible in medium to large telescopes.

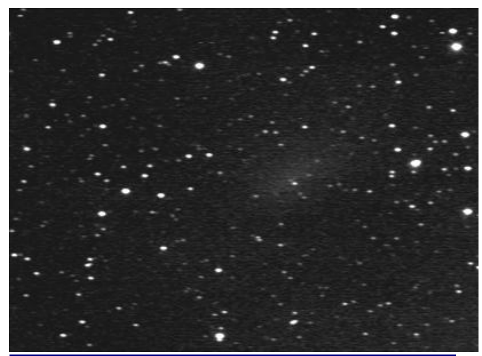



8" SCT f6.3, StellaCam-3 @ 30 seconds

NGC147

The 10.4 magnitude dwarf Elliptical galaxy NGC147 is located about 2.6 million light-years distant from the Milky Way, and located in the constellation of Cassiopeia. It has a diameter of about 4,500 light-years across.

Visibly, NGC147 has a faint, low-surface brightness, and has an elongated lenticular shape.



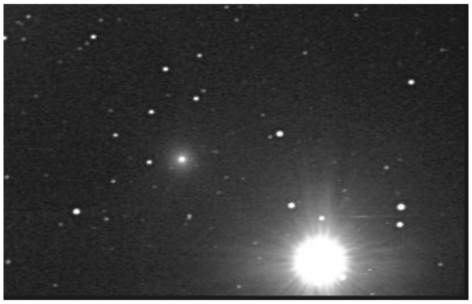
6" RC f5, StellaCam-3 @ 20 seconds

NGC185

The 9.2 magnitude dwarf Elliptical galaxy NGC185 is located about 2.2 million light-years distant from the Milky Way, and located in the constellation of Cassiopeia. It has a diameter of about 2,300 light-years, and shows active star formation. NGC185 is classified as a quasar-like Seyfert galaxy with an Active Galactic Nucleus (AGN), and is the closet known Seyfert galaxy to the Milky Way. Both NGC185 and NGC147 lay about seven degrees to the north of are gravitationally bound to M31 and are considered to be satellites of the giant spiral, with NGC185 being the brighter of the pair. Visibly, NGC185 is a moderately faint low-surface brightness galaxy that somewhat resembles an unresolved globular cluster. A small dark dust patch is often visible in larger telescopes.

6" RC f5, StellaCam-3 @ 20 seconds

NGC404 (Mirach's Ghost)



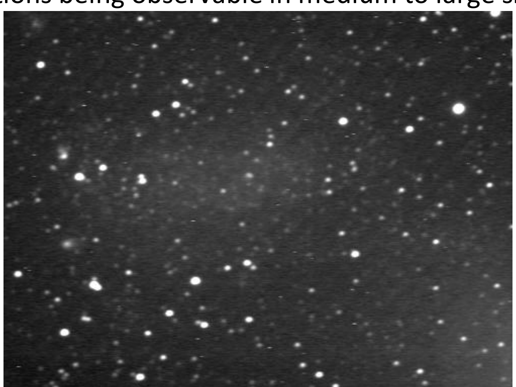
The 10.1 magnitude dwarf Lenticular galaxy NGC404 is located about 10 million light-years distant from the Milky Way, just beyond the edge of the Local Group boundary, and today is technically considered to be no longer a member of the Local Group. NGC404 is located in the constellation of Andromeda. The galaxy has a diameter of about 65,000 light-years, and contains a likely small central black hole of less than 50,000 solar masses. Visibly, NGC404 can be difficult to observe, as it lays just seven degrees away from the 2nd magnitude bright star of Beta Andromedae (Mirach). It has a bright round central core that gradually decreases in brightness. This deep-sky object and star is a good example of line-of-sight distances as the star is only 200 light-years away, while the galaxy is 10 million light-years from us.

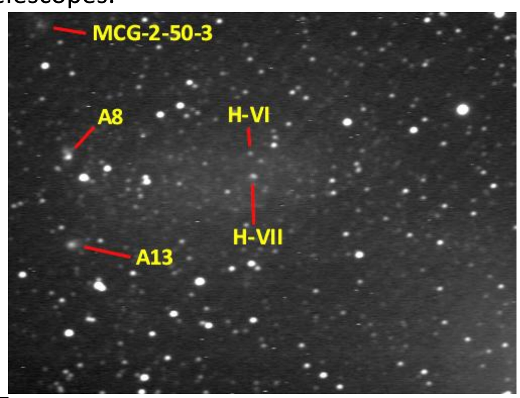
8" SCT f6.3, StellaCam-3, 45 seconds

NGC6822 (Barnards Galaxy)

The 8.5 magnitude Irregular barred-dwarf galaxy NGC6822 is located about 1.5 million light-years distant from the Milky Way, and is located in the constellation of Sagittarius and heavily obscured by the Milky Way. It has a diameter of about 7,000 light-years, and shows active star formation. After the Magellanic Clouds and the Sagittarius Dwarf galaxies, NGC6822 is the fourth closet galaxy to the Milky Way.

Visibly, NGC6822 is highly inclined to our view point, with several HII star forming regions and large OB associations being observable in medium to large size telescopes.

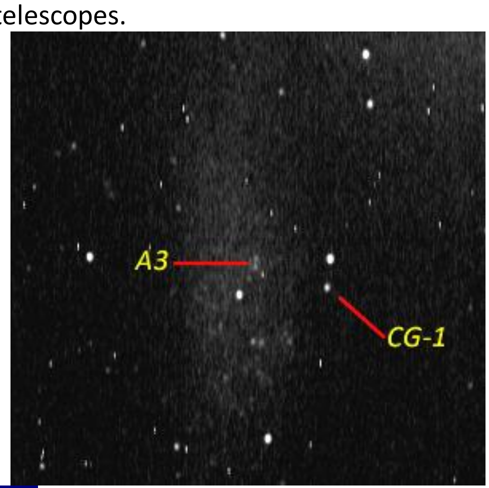





8" SCT f6.3, StellaCam-3 @ 180 seconds

WLM (MCG-3-1-15) (Wolf-Lundmark-Melotte)

The 10.9 magnitude Irregular dwarf galaxy WLM is about 3.4 million light-years distant from the Milky Way, one of the most remote members of the Local Group, in the constellation of Cetus. It has a diameter of about 8,000 light-years, and shows active star formation. Visibly, WLM is large diffuse low-surface brightness galaxy with an elongated oval shape. It has no defined core, but shows visible mottling all along its length, along with several OB associations and globular clusters in large telescopes.



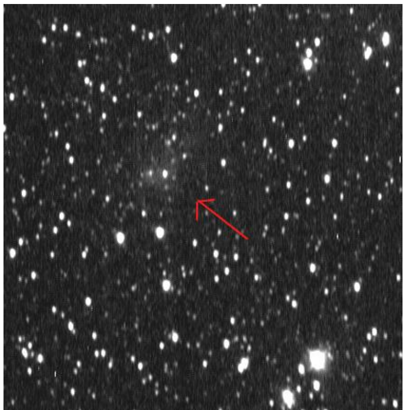

8" SCT f6.3, StellaCam-3 @ 120 seconds

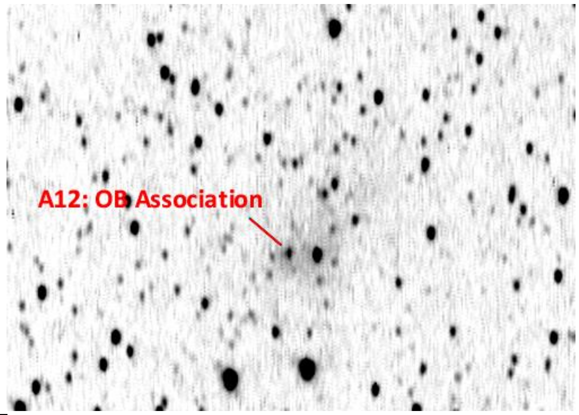
**The really faint stuff**

IC10

The 10.4 magnitude Irregular dwarf galaxy IC10 is located about 2.3 million light-years distant from the Milky Way, and located in the constellation of Cassiopeia. It has a diameter of about 5,000 light-years, and shows active star formation as a starburst galaxy with an HII nucleus. IC10 is one of the few galaxies that exhibit a blueshift as it is moving toward the Milky Way at 350km/s.

Visibly, IC10 is difficult to observe as it is heavily obscured by the Milky Way, and has a small faint irregular shape. Through a large telescope at a dark sky site, several knots of knots of HII star forming regions are visible.






6" RC f5, StellaCam-3 @ 30 seconds

Aquarius Dwarf (MCG-2-53-3)

The 13.9 magnitude Irregular dwarf galaxy Aquarius Dwarf is located about 3.4 million light-years distant from the Milky Way, and located in the constellation of Aquarius. The Aquarius Dwarf is one of the youngest galaxies in the local group at about 6.8 billion years, not much older than our solar system. It is one of the dimmest members of the Local Group with a very low level of star formation and contains a large amount of neutral hydrogen.

Visibly, the Aquarius Dwarf is extremely faint irregular patch, requiring a larger 20” or greater telescope.

8" SCT f6.3, StellaCam-3, @ 120 seconds

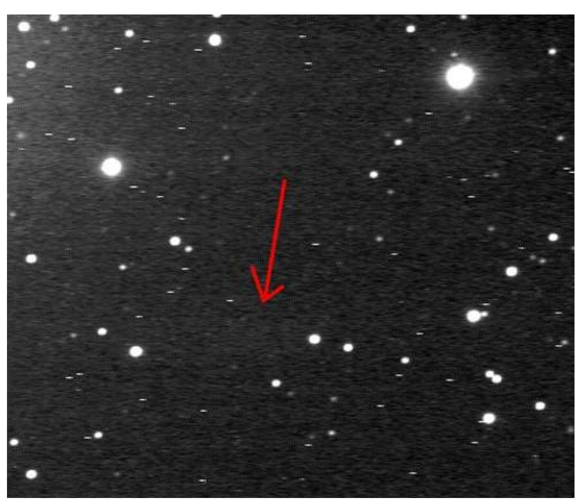
Pisces Dwarf

The 15.4 magnitude Irregular dwarf galaxy Pisces Dwarf is located about 3 million light-years distant from the Milky Way, and located in the constellation of Pisces.

The galaxy shows little active star formation.

Visibly, the Pisces Dwarf is another extremely faint elongated smudge that will be barely visible in 25” telescopes and requiring deep exposures from imaging setups.

8" SCT f6.3, StellaCam-3 @ 300 seconds

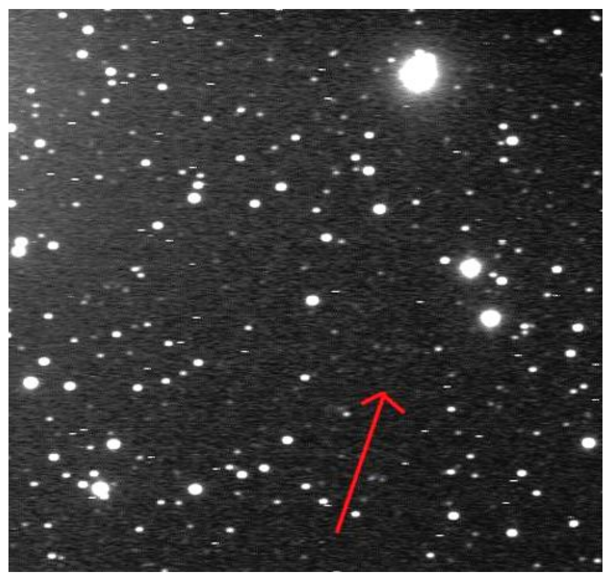


UGCA-86  (PGC14241)
The 15.2 magnitude Irregular  galaxy UGCA-86 is located about 6.2 million light-years distant from the Milky Way, and can be found in the constellation of Camelopardalis.  As UGCA-86 lies close to the Local Group boundary, there is some question as to whether it is an actual member.
Visibly, UGCA-86 is heavily obscured by the Milky Way and is quite faint!  Fortunately a number of bright stars help to identify the galaxy's location in the field-of-view.  Still, you'll need a large telescope or imaging rig to pull this one in.

8" SCT f6.3, StellaCam-3 @ 180 seconds

Andromeda-I thru X   (forget about it!,,, seriously,, just don't!)
The 16.1 magnitude dwarf Elliptical galaxy Andromeda-X is located about 2.4 million light-years distant from the Milky Way, and located in the constellation of Andromeda.
Visibly, Andromeda-X is probably impossible, unless you have a 30" or greater telescope.  It is considered to be the dimmest Local Group member, and will even drive imagers to pull out their hair.

8" SCT f6.3, StellaCam-3 @ 180 seconds



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**Conclusion**
So today, we've learned what the "Local Group" is, some of the people, both historical and modern, behind these objects, and how to go about observing them.  We've also reviewed observations of the more prominent members of the Local Group, along with a number of the fainter ones.
Hopefully, you now find them as interesting to hunt as I do.

So I encourage everyone to get out tonight and try your hand at finding and observing our neighborhood of galaxies known as the "Local Group"!       *Larry McHenry*

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## Credits

Advanced Observing Program: National Optical Astronomy Observatory - Kitt Peak Az
http://www.noao.edu/outreach/aop/observers/bestof.html
20in RC Optical Systems telescope Operating at f/8.4, Paramount ME Robotic Telescope Mount, SBIG ST10XME CCD camera

M31 - Adam Block/NOAO/AURA/NSF
M51 - Jon and Bryan Rolfe/Adam Block/NOAO/AURA/NSF
M82 - Joe Jordan/Adam Block/NOAO/AURA/NSF
M84 - NOAO/AURA/NSF
M87 - Adam Block/NOAO/AURA/NSF
M101 - Adam Block/NOAO/AURA/NSF
NGC4565 - Bruce Hugo and Leslie Gaul/Adam Block/NOAO/AURA/NSF
M81 - Jeff Cremer/Adam Block/NOAO/AURA/NSF
NGC4535 - Doug Matthews and EJ Jones/Adam Block/NOAO/AURA/NSF
M64 - Anne Beiter and Jon Shallop/Adam Block/NOAO/AURA/NSF
M86 - NOAO/AURA/NSF
M89 - NOAO/AURA/NSF
NGC4449 - John and Christie Connors/Adam Block/NOAO/AURA/NSF
NGC4631 - John Vickery and Jim Matthes/Adam Block/NOAO/AURA/NSF
Stephan's Quintet - Adam Block/NOAO/AURA/NSF
NGC4568 - Bill and Marian Wallace/Adam Block/NOAO/AURA/NSF
M66 - Jeff Hapeman/Adam Block/NOAO/AURA/NSF
NGC6822 - Julie and Jessica Garcia/Adam Block/NOAO/AURA/NSF
M104 - Morris Wade/Adam Block/NOAO/AURA/NSF
NGC7479 - Adam Block/NOAO/AURA/NSF
Coma Cluster - NOAO/AURA/NSF
Abell 671 - Michael Petrasko and Muir Eveden/Adam Block/NOAO/AURA/NSF

**Books:**

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"*Galaxies*", by Harlow Shapley, 1943
"*Astronomy*", by Patrick Moore , 1961
"*Burnham's Celestial Handbook*", by Robert Burnham, 1966
"*Messier's Nebula & Star Clusters*", by Kenneth Glyn Jones, 1968
"*Visual Astronomy of the Deep Sky*", by Roger Clark, 1990
"*The Night Sky Observer's Guide*", by George Kepple & Glen Sanner, 1998
"*The Local Group*", by Alvin Huey, 2008 www.faintfuzzies.com
"*Annals of the Deep Sky*", by Jeff Kanipe & Dennis Webb, 2015.

**Magazines:**

"*All About M31*", Deep Sky , Fall 1984
"*Observing the Local Group*", Deep Sky , Autumn 1991
"*A Universe of Galaxies*", Astronomy, March 2019
"*Welcome to the Neighborhood*", Astronomy, March 2019
"*All About Our Local Supercluster*", Astronomy, March 2019
"*A Visual Tour of M31*", Sky & Telescope, November 1993
"*Exploring Messier 31*", Sky & Telescope, November 2013
"*Exploring the Triangulum Galaxy*", Sky & Telescope, December 2013
"*Local Group Dwarf Galaxies*", Sky & Telescope, December 2013
"*In Search of Extragalactic Globulars*", Sky & Telescope, November 2018
"*Mapping the Milky Way*", Sky & Telescope, November 2019

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"Earth Centered Universe" by David Lane http://www.nova-astro.com/