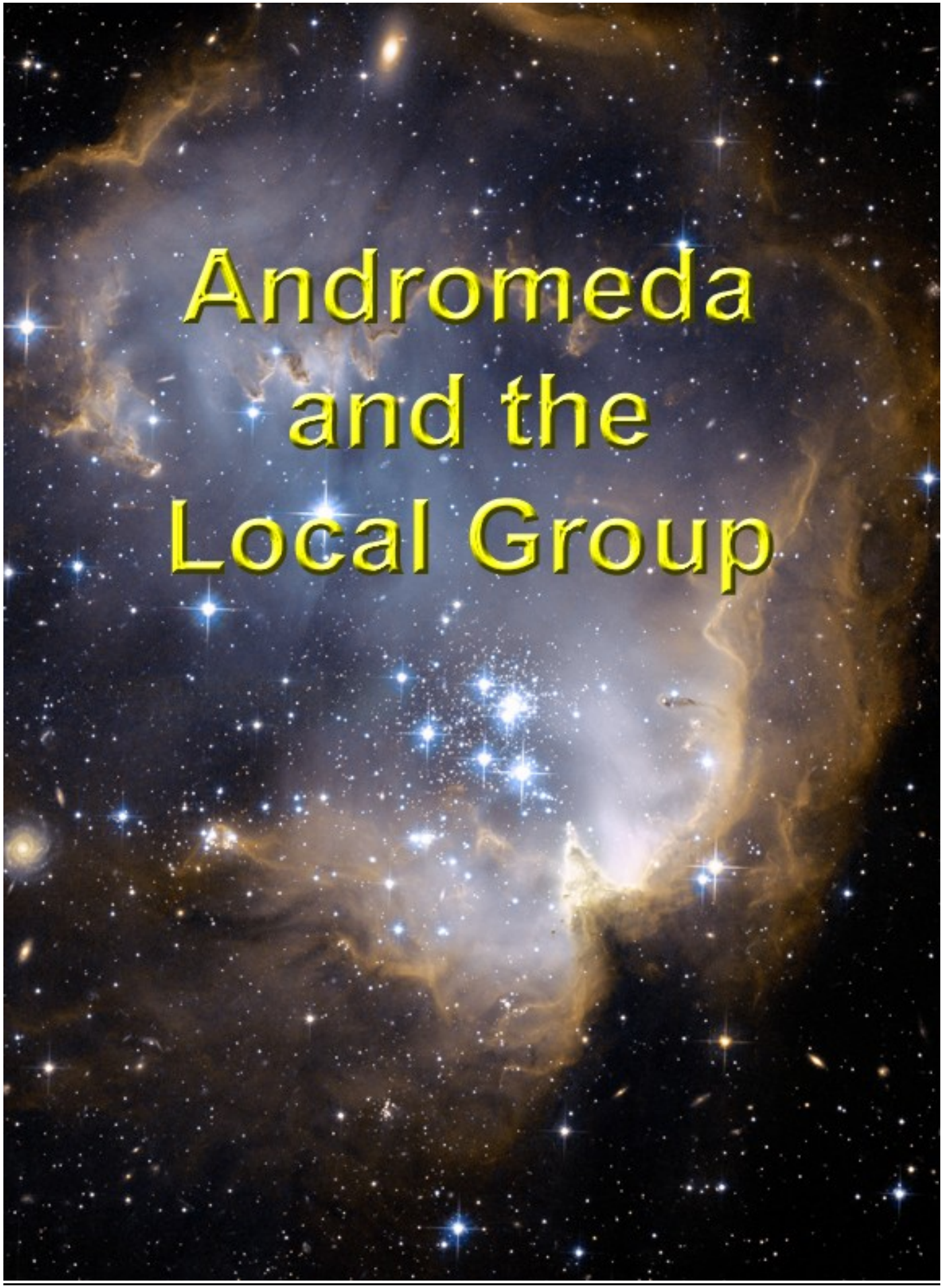

Andromeda
and the
Local Group

Andromeda and the Local Group

{Abstract *– In this segment of our "How far away is it" video book, we cover the Andromeda galaxy along with our local group of galaxies, including some of the dwarf galaxies orbiting the Milky Way.*

We begin with Edwin Hubble's discovery of a Cepheid variable star in what was thought to be a Milky Way nebula. The star was V1 and it changed the history of astronomy. We cover the black hole at the center of Andromeda, highlight the size of this beautiful galaxy with its trillion stars, and point out what was going on here on our planet when the light we see left Andromeda on its journey into our telescopes.

Next we identify the local group of galaxies including: Triangulum with its great star birth H II region NGC 604; irregular galaxy NGC 6822 with its unique Hubble V H II region; the recently discovered galaxy IC 10; nearly edge on galaxy 3109; and Sextans A.

Then we focus on the two main galaxies orbiting the Milky Way – the Large Magellanic Cloud and the Small Magellanic Cloud. Then we take a look at some of the amazing nebula within these two dwarf galaxies including: Supernova Remnant N 63A, SN 0509-67.5, the Tarantula Nebula, 30 Doradus, Hodge 301, the Double Bubble, LH 95, NGC 2074, NGC 602, and NGC 346.

*We conclude with a review of the galaxies we covered marked on a map of the Local Group.****}***

Introduction

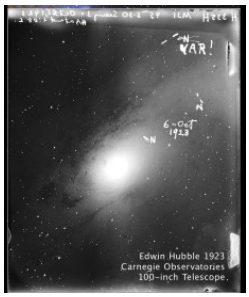
> **[Music:** *Alexander Borodin – "Nocturne" – Written in 1881, this is the third movement in his famous String Quartet Number 2. It had the right exotic flavor and lush melodies for Kismet, the 1953 Tony Award winning musical. This same exotic flavor makes it a good fit for introducing the exotic Andromeda Galaxy.***]**

Visible to the naked eye and studied by Persian astronomers around 900 AD, the Andromeda nebula was thought to be a part of the Milky Way. In fact it was thought that all the stars in the Universe were in our Milky Way galaxy.

That changed in the early 1900s. In 1923, Edwin Hubble found a Cepheid variable in the nebula. This star altered the course of modern astronomy. The star goes by the name V1.

Andromeda, M31 – 2.65 mly

Here's Edwin Hubble's image of Andromeda, which was made on a 4 by 5 inch glass plate and dated Oct. 6, 1923. He originally identified three stars and marked each of them with an "N" for

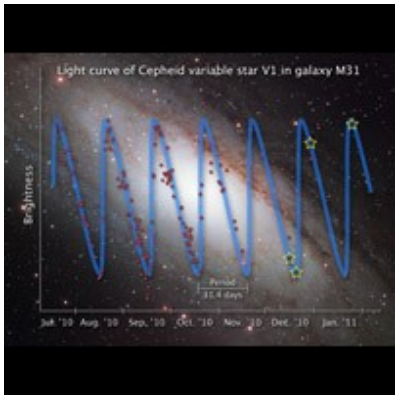


novae, a class of exploding star. Later, Hubble realized that the nova at the top right was actually a Cepheid variable. He crossed out the "N" and wrote "VAR" for variable.

He added an explanation point because he knew that this variable would allow him to calculate the distance.

And indeed, once the period was measured (at 31.4 days), he knew he had another galaxy! Before V1, distances to stars were measured in thousands of light years. After V1, the universe became a much bigger place. V1 was over two and a half million light years away.

[Additional info: Studying the light curve for V1, Hubble determined its luminosity. Measuring its apparent brightness here on Earth, he calculated its distance. Remember that our galaxy is only 100,000 light years wide. So V1 was definitely too far away to be a part of it. This also meant that all the stars in the entire nebula were also well outside our galaxy. It was in fact, another galaxy altogether. This made V1 the most important star in the history of cosmology.**]**



Andromeda is a beautiful barred spiral galaxy with two spiral arms that glow with a massive number of new stars. This is very much like our Milky Way. But it is 220,000 light-years wide and contains around a trillion stars. That makes it a good deal larger than our galaxy.

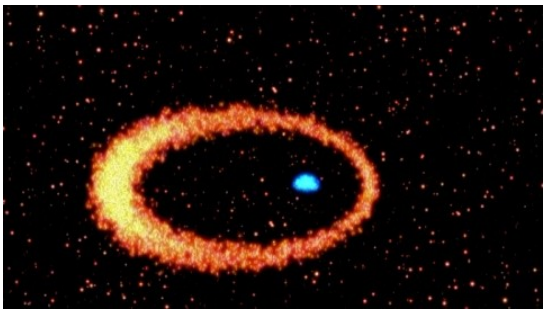
Light from this magnificent galaxy left its stars just over two and a half million years ago. When the light that entered Hubble's telescope left Andromeda, there were no humans on Earth. While the light traveled towards Earth: we came into

being; we created and lost great civilizations; and we built the telescopes that caught that light when it finally reached our planet.

Andromeda's Central Black Hole

Here we see the 100-million-solar-mass black hole at the Andromeda's core. This is the sharpest visible-light image ever made of the nucleus of an external galaxy. There is a blue glow at the center of what appears to be a double nucleus.

Astronomers using the Hubble Space Telescope have identified the source of the blue light surrounding this supermassive black hole in Andromeda's core.



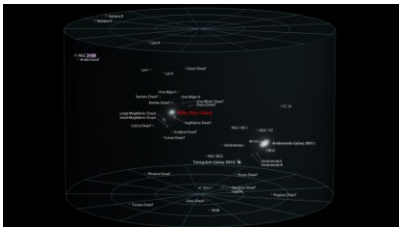
New spectroscopic observations reveal that the blue light consists of more than 400 stars. The stars are tightly packed in a disk that is only one light-year across. The disk is nested inside an elliptical ring of older, cooler, redder stars. When the stars are at the farthest point in their orbit they move slower and give the illusion of a second nucleus.

[Additional info: Astronomers are trying to understand how apparently young stars were formed so deep inside the black hole's gravitational grip and how they survive in such an extreme environment. The fact that young stars are also closely bound to the central black hole in our Milky Way galaxy suggests this may be a common phenomenon in spiral galaxies.**]**

The Local Group

> **[Music:** *Edward Elgar – "Enigma Variations" – Completed in 1899, the work consists of a main theme, followed by 14 variations. Each variation conveys a general impression of its subject's personality - quite appropriate as we move into the various odd looking galaxies in the Local Group, each with their own personality.***]**

There are 54 galaxies in the local group. Andromeda is the largest. The Milky Way is second and Triangulum is third. All the rest are dwarf galaxies, and most of these are obiting one or the other of the three big ones.



The Milky Way has 16 satellite galaxies. Andromeda has 25. The Triangulum Galaxy might have one. The other members of the group are gravitationally not orbiting any of these three larger galaxies. We'll take a look at some of these and then move closer to home, and have a good look at some of our dwarf galaxies.

Triangulum M33 – 2.85 mly

The Triangulum Galaxy is the third-largest member of the Local Group of galaxies, with a diameter of about 50,000 light years. Triangulum is home to around 40 billion stars. That's small compared to our 400 billion and Andromeda's trillion.

NGC 604 in Triangulum – 2.85 mly

NGC 604, a gigantic star forming region lies in this outer Triangulum spiral arm. This monstrous star-birth region contains more than 200 brilliant blue stars within a cloud of glowing gases some 1,300 light-years across. That's nearly 100 times the size of the Orion Nebula. By contrast, the Orion Nebula contains just four bright central stars. The bright stars in NGC 604 are extremely young by astronomical standards, having formed a mere 3 million years ago.

NGC 6822 – 1.6 MLY

This small, irregular galaxy is one of the Milky Way's closest neighbors and is considered prototypical of the earliest fragmentary galaxies that inhabited the young universe. What's striking about NGC 6822 is its unusually high abundance of HII region emission nebulae. These are visible surrounding the small galaxy, particularly toward the upper right.

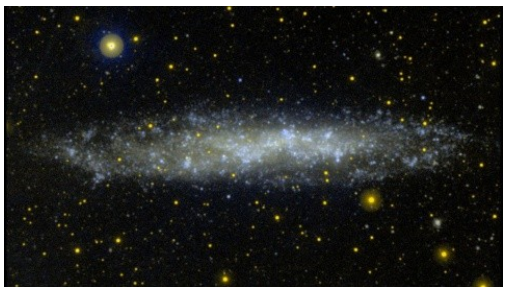
Hubble V Nebula inside NGC 6822

This is one of them. The glowing gas cloud, called Hubble-V, has a diameter of about 200 light-years. A faint tail of nebulosity trailing off the top of the image sits opposite a dense cluster of bright stars at the bottom of the irregularly shaped nebula.

IC 10 – 2.2 mly

IC 10 is another irregular galaxy. Edwin Hubble suspected it might belong to the Local Group of galaxies, but its status remained uncertain for decades. Its membership in the group was finally confirmed in 1996 by direct measurements of its distance based on observations of Cepheids. The reason it took so long is that, despite its closeness, the galaxy lies near the plane of the Milky Way and is therefore heavily obscured by our galaxy's interstellar matter.

NGC 3109 – 4.7 mly



NGC 3109 looks like a small spiral galaxy. If it is a spiral galaxy, it would be the smallest in the Local Group. It is oriented edge-on from our point of view, and may contain a disk and a halo. It does not appear to possess a galactic nucleus. But it does seem to contain an unusually large number of planetary nebulae.

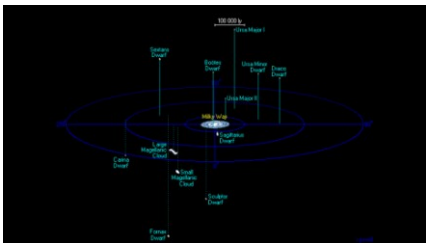
[The disk appears to be composed of stars of all ages, whereas the halo contains only very old stars.**]**

Sextans A – 4.3 mly

Here's a satellite galaxy of NGC 3109. It's a small irregular gumdrop-shaped dwarf galaxy. The bright foreground yellowish stars are in the Milky Way. Beyond them lie the stars of Sextans A with young blue star clusters clearly visible.

Dwarf galaxies Orbiting the Milky Way

This map shows the closest dwarf galaxies. They are all gravitationally bound to the Milky Way, requiring billions of years to orbit it. **[**Dwarf galaxies typically contain a few tens of millions of stars, which is insignificant compared with the number of stars in the Milky Way itself.**]**



Sagittarius Dwarf

Sagittarius Dwarf is the closest. It is so close that it is slowly being ripped apart by our galaxy.

Fornax Dwarf

Fornax is the furthest away. **[**It has six globular clusters orbiting it.**]**

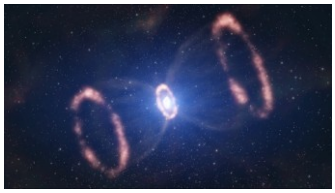
Large and Small Magellanic Clouds

But the two dwarfs of the most interest can be seen in the southern night sky. They are the Large Magellanic Cloud 160 to 170 thousand light years away and the Small Magellanic Cloud a bit further at 200,000 light years from us.

The Large Magellanic Cloud or LMC for short is the brightest galaxy in the sky. It contains several billion stars and many stars are still forming in it.

The Small Magellanic Cloud or SMC for short contains at least several hundred million stars. Like the LMC, there is still a lot of star formation taking place within it.

You may have noticed that as we went through our segment on Supernova, N 63A and 1987A were listed at 160,000 light years away or greater.



That was further than the maximum extent of our galaxy. That put these objects outside the Milky Way. They are actually in the LMC dwarf galaxy.

Objects in the Large Magellanic Cloud – 170,000 light years

Here are a few more of the beautiful nebulae in the LMC.

SNR 0509-67.5 – 170,000 light years

This image of supernova remnant 0509-67.5 was made by combining data from two of NASA's Great Observatories: Hubble and the Chandra X-ray Observatory. The result shows soft green and blue hues of heated material from the X-ray data surrounded by the glowing pink optical shell, which shows the ambient gas being shocked by the expanding blast wave from the supernova.

[Music: *We return to and conclude with the exotic and lush melodies in Alexander Borodin's "Nocturne".***]**

30 Doradus in the heart of the Tarantula Nebula

Several million young stars are vying for attention in this Hubble image of a stellar breeding ground in 30 Doradus, located in the heart of the Tarantula Nebula. Early astronomers nicknamed the nebula because its glowing filaments resemble spider legs.

30 Doradus is the home to the most massive stars ever seen, weighing more than 100 times the mass of our Sun. No known star-forming region in our galaxy is as large or as prolific as 30 Doradus.

The image reveals the stages of star birth, from embryonic stars a few thousand years old still wrapped in their eggs to behemoths that die young in supernova explosions.

Hodge 301

Hodge 301, seen in the lower right hand corner of this image, lives inside the Tarantula Nebula. Many of the stars in Hodge 301 are so old that they have exploded as supernovae. These exploded stars are blasting material into the surrounding region at speeds of almost 200 miles per second. The high-speed matter is plowing into the surrounding Tarantula Nebula, shocking and compressing the gas into a multitude of sheets and filaments, seen in the upper left portion of the picture.

Double Bubble DEM L 106 and N30B – 160,000 light years

A unique peanut-shaped reflection nebula surrounds a cluster of young, hot stars in this view from Hubble. The "double bubble - N30B" is inside a larger nebula. The very bright star at the top of the picture, called Henize S22, illuminates the dusty cocoon like a flashlight shining on smoke particles. This searing supergiant star is only 25 light-years from the N30B nebula.

LH -95

Swirls of gas and dust reside in this ethereal-looking region of star formation. It reveals a region where low-mass, infant stars and their much more massive stellar neighbors reside. This is just one of the hundreds of star-forming systems, located in the LMC.

Star Cluster NGC 2074 – 170,000 light years

This region is a firestorm of raw stellar creation, perhaps triggered by a nearby supernova explosion. The three-dimensional-looking image reveals dramatic ridges and valleys of dust, serpent-head "pillars of creation," and gaseous filaments glowing fiercely under torrential ultraviolet radiation. The region is on the edge of a dark molecular cloud that is an incubator for the birth of new stars.

Small Magellanic Cloud – 200,000 light years

Now let's take a look at a couple of objects in the Small Magellanic Cloud.

NGC 602

At the heart of the SMC, lies star cluster NGC 602. The high-energy radiation blazing out from the hot young stars is sculpting the inner edge of the outer portions of the nebula, slowly eroding it away and eating into the material beyond. Elephant trunk-like dust pillars point towards the hot blue stars and are tell-tale signs of their eroding effect.

NGC 346

The NGC 346 cluster, at the center of this Hubble image, is resolved into at least three sub-clusters and collectively contains dozens of hot, blue, high-mass stars, more than half of the known high-mass stars in the entire SMC galaxy. A myriad of smaller, compact clusters is also visible throughout the region.

Conclusion

Here are the Local Group galaxies we saw in this segment. The Local Group is part of a larger structure known as the Local Volume. We'll explore this Local Volume in our next segment.