

= Andromeda Galaxy =

The Andromeda Galaxy ( / ænˈdrʊmˈdʌ / ), also known as Messier 31 , M31 , or NGC 224 , is a spiral galaxy approximately 780 kiloparsecs ( 2 @. @ 5 million light @-@ years ) from Earth . It is the nearest major galaxy to the Milky Way and was often referred to as the Great Andromeda Nebula in older texts . It received its name from the area of the sky in which it appears , the constellation of Andromeda , which was named after the mythological princess Andromeda .

Being approximately 220 @, @ 000 light years across , it is the largest galaxy of the Local Group , which also contains the Milky Way , the Triangulum Galaxy , and about 44 other smaller galaxies . Despite earlier findings that suggested that the Milky Way contains more dark matter and could be the largest in the grouping , the 2006 observations by the Spitzer Space Telescope revealed that Andromeda contains one trillion (  $10^{12}$  ) stars : at least twice the number of stars in the Milky Way , which is estimated to be 200 ? 400 billion .

The mass of the Andromeda Galaxy is estimated to be  $1 @. @ 5 \times 10^{12}$  solar masses , while the Milky Way is estimated to be  $8 @. @ 5 \times 10^{11}$  solar masses . In comparison , a 2009 study estimated that the Milky Way and M31 are about equal in mass , while a 2006 study put the mass of the Milky Way at ~ 80 % of the mass of the Andromeda Galaxy . The Milky Way and Andromeda are expected to collide in 3 @. @ 75 billion years , eventually merging to form a giant elliptical galaxy or perhaps a large disc galaxy .

The apparent magnitude of the Andromeda Galaxy , at 3 @. @ 4 , is one of the brightest of any of the Messier objects , making it visible to the naked eye on moonless nights , even when viewed from areas with moderate light pollution . Although it appears more than six times as wide as the full moon when photographed through a larger telescope , only the brighter central region is visible to the naked eye or when viewed using binoculars or a small telescope , making it appear similar to a star .

= = Observation history = =

In the year 964 , the Persian astronomer Abd al @-@ Rahman al @-@ Sufi described the Andromeda Galaxy , in his Book of Fixed Stars as a " nebulous smear " . Star charts of that period labeled it as the Little Cloud . In 1612 , the German astronomer Simon Marius gave an early description of the Andromeda Galaxy based on telescopic observations . In 1764 , Charles Messier catalogued Andromeda as object M31 and incorrectly credited Marius as the discoverer despite it being visible to the naked eye . In 1785 , the astronomer William Herschel noted a faint reddish hue in the core region of M31 . He believed M31 to be the nearest of all the " great nebulae " and based on the color and magnitude of the nebula , he incorrectly guessed that it is no more than 2 @, @ 000 times the distance of Sirius . In 1850 , William Parsons , 3rd Earl of Rosse , saw and made the first drawing of Andromeda 's spiral structure .

In 1864 , William Huggins observed the spectrum of M31 and noted that it differs from a gaseous nebula . The spectra of M31 displays a continuum of frequencies , superimposed with dark absorption lines that help identify the chemical composition of an object . M31 's spectrum is very similar to the spectra of individual stars , and from this it was deduced that M31 has a stellar nature . In 1885 , a supernova ( known as S Andromedae ) was seen in M31 , the first and so far only one observed in that galaxy . At the time M31 was considered to be a nearby object , so the cause was thought to be a much less luminous and unrelated event called a nova , and was named accordingly ; " Nova 1885 " .

In 1887 , Isaac Roberts took the first photographs of M31 , which was still commonly thought to be a nebula within our galaxy . Roberts actually mistook M31 and similar spiral nebulae as solar systems being formed . In 1912 , Vesto Slipher used spectroscopy to measure the radial velocity of M31 with respect to our solar system ? the largest velocity yet measured , at 300 kilometres per second ( 190 mi / s ) .

= = = Island universe = = =

In 1917 , American astronomer Heber Curtis observed a nova within M31 . Searching the photographic record , 11 more novae were discovered . Curtis noticed that these novae were , on average , 10 magnitudes fainter than those that occurred elsewhere in the sky . As a result , he was able to come up with a distance estimate of 500 000 light years (  $3 \times 10^{10}$  AU ) . He became a proponent of the so called " island universes " hypothesis , which held that spiral nebulae were actually independent galaxies .

In 1920 , the Great Debate between Harlow Shapley and Curtis took place , concerning the nature of the Milky Way , spiral nebulae , and the dimensions of the universe . To support his claim of the Great Andromeda Nebula being , in fact , an external galaxy , Curtis also noted the appearance of dark lanes within Andromeda which resembled the dust clouds in our own galaxy , as well as historical observations of Andromeda 's significant Doppler shift . In 1922 Ernst Öpik presented a method to estimate the distance of M31 using the measured velocities of its stars . His result placed the Andromeda Nebula far outside our galaxy at a distance of about 450 000 parsecs ( 1 500 000 ly ) . Edwin Hubble settled the debate in 1925 when he identified extra galactic Cepheid variable stars for the first time on astronomical photos of M31 . These were made using the 2.5 metre ( 100 in ) Hooker telescope , and they enabled the distance of Great Andromeda Nebula to be determined . His measurement demonstrated conclusively that this feature was not a cluster of stars and gas within our own Galaxy , but an entirely separate galaxy located a significant distance from the Milky Way .

M31 plays an important role in galactic studies , as it is the nearest major galaxy ( although not the nearest galaxy ) . In 1943 Walter Baade was the first person to resolve stars in the central region of the Andromeda Galaxy . Baade identified two distinct populations of stars based on their metallicity , naming the young , high velocity stars in the disk Type I and the older , red stars in the bulge Type II . This nomenclature was subsequently adopted for stars within the Milky Way , and elsewhere . ( The existence of two distinct populations had been noted earlier by Jan Oort . ) Baade also discovered that there were two types of Cepheid variables , which resulted in a doubling of the distance estimate to M31 , as well as the remainder of the Universe .

Radio emission from the Andromeda Galaxy was first detected by Hanbury Brown and Cyril Hazard at Jodrell Bank Observatory using the 218 ft Transit Telescope , and was announced in 1950 ( earlier observations were made by radio astronomy pioneer Grote Reber in 1940 , but were inconclusive , and were later shown to be an order of magnitude too high ) . The first radio maps of the galaxy were made in the 1950s by John Baldwin and collaborators at the Cambridge Radio Astronomy Group . The core of the Andromeda Galaxy is called 2C 56 in the 2C radio astronomy catalogue . In 2009 , the first planet may have been discovered in the Andromeda Galaxy . This was detected using a technique called microlensing , which is caused by the deflection of light by a massive object .

= = General = =

The estimated distance of the Andromeda Galaxy was doubled in 1953 when it was discovered that there is another , dimmer type of Cepheid . In the 1990s , measurements of both standard red giants as well as red clump stars from the Hipparcos satellite measurements were used to calibrate the Cepheid distances .

= = = Formation and history = = =

According to a team of astronomers reporting in 2010 , M31 was formed out of the collision of two smaller galaxies between 5 and 9 billion years ago .

A paper published in 2012 has outlined M31 's basic history since its birth . According to it , Andromeda was born roughly 10 billion years ago from the merger of many smaller protogalaxies , leading to a galaxy smaller than the one we see today .

The most important event in M31 's history was the merger mentioned above that took place 8

billion years ago . This violent collision formed most of its ( metal @-@ rich ) galactic halo and extended disk and during that epoch Andromeda 's star formation would have been very high , to the point of becoming a luminous infrared galaxy for roughly 100 million years . M31 and the Triangulum Galaxy ( M33 ) had a very close passage 2 ? 4 billion years ago . This event produced high levels of star formation across the Andromeda Galaxy 's disk ? even some globular clusters ? and disturbed M33 's outer disk .

While there has been activity during the last 2 billion years , this has been much lower than during the past . During this epoch , star formation throughout M31 's disk was thought to have decreased to the point of near @-@ inactivity , however , such activity had increased relatively recently . There have been interactions with satellite galaxies like M32 , M110 , or others that have already been absorbed by M31 . These interactions have formed structures like Andromeda 's Giant Stellar Stream . A merger roughly 100 million years ago is believed to be responsible for a counter @-@ rotating disk of gas found in the center of M31 as well as the presence there of a relatively young ( 100 million years old ) stellar population .

= = = Recent distance estimate = = =

At least four distinct techniques have been used to estimate distances to the Andromeda Galaxy .

In 2003 , using the infrared surface brightness fluctuations ( I @-@ SBF ) and adjusting for the new period @-@ luminosity value of Freedman et al . 2001 and using a metallicity correction of ? 0 @-@ 2 mag dex ? 1 in ( O / H ) , an estimate of  $2 @-@ 57 \pm 0 @-@ 06$  million light @-@ years (  $1 @-@ 625 \times 10^{11} \pm 3 @-@ 8 \times 10^9$  AU ) was derived .

Using the Cepheid variable method , an estimate of  $2 @-@ 51 \pm 0 @-@ 13$  million light @-@ years (  $770 \pm 40$  kpc ) was reported in 2004 .

In 2005 Ignasi Ribas ( CSIC , Institute for Space Studies of Catalonia ( IEEC ) ) and colleagues announced the discovery of an eclipsing binary star in the Andromeda Galaxy . The binary star , designated M31VJ00443799 + 4129236 , has two luminous and hot blue stars of types O and B . By studying the eclipses of the stars , which occur every 3 @-@ 54969 days , astronomers were able to measure their sizes . Knowing the sizes and temperatures of the stars , they were able to measure their absolute magnitude . When the visual and absolute magnitudes are known , the distance to the star can be measured . The stars lie at a distance of  $2 @-@ 52 \times 10^6 \pm 0 @-@ 14 \times 10^6$  ly (  $1 @-@ 594 \times 10^{11} \pm 8 @-@ 9 \times 10^9$  AU ) and the whole Andromeda Galaxy at about  $2 @-@ 5 \times 10^6$  ly (  $1 @-@ 6 \times 10^{11}$  AU ) . This new value is in excellent agreement with the previous , independent Cepheid @-@ based distance value .

M31 is close enough that the Tip of the Red Giant Branch ( TRGB ) method may also be used to estimate its distance . The estimated distance to M31 using this technique in 2005 yielded  $2 @-@ 56 \times 10^6 \pm 0 @-@ 08 \times 10^6$  ly (  $1 @-@ 619 \times 10^{11} \pm 5 @-@ 1 \times 10^9$  AU ) .

Averaged together , all these distance estimates give a combined value of  $2 @-@ 54 \times 10^6 \pm 0 @-@ 11 \times 10^6$  ly (  $1 @-@ 606 \times 10^{11} \pm 7 @-@ 0 \times 10^9$  AU ) . And , from this , the diameter of M31 at the widest point is estimated to be  $220 \pm 3$  kly (  $67 @-@ 450 \pm 920$  pc ) . Applying trigonometry ( angular diameter ) , this is equivalent to an apparent  $4 @-@ 96^\circ$  angle in the sky .

= = = Mass and luminosity estimates = = =

= = = = Mass = = = =

Mass estimates for the Andromeda Galaxy 's halo ( including dark matter ) give a value of approximately  $1 @-@ 5 \times 10^{12} M_\odot$  ( or  $1 @-@ 5$  trillion solar masses ) compared to  $8 \times 10^{11} M_\odot$  for the Milky Way . This contradicts earlier measurements , that seem to indicate that Andromeda and the Milky Way are almost equal in mass . Even so , M31 's spheroid actually has a higher stellar density than that of the Milky Way and its galactic stellar disk is about twice the size of that of the Milky Way . The total stellar mass of Andromeda is estimated to be  $1 @-@ 1 \times 10^{11} M_\odot$  . , ( i.e. ,

around twice as massive as that of the Milky Way ) , or up to  $1 \times 10^{11} M_{\odot}$  according to other estimates , with around 30 % of that mass in the central bulge , 56 % in the disk , and the remaining 14 % in the halo .

In addition to it , M31 's interstellar medium contains at least around  $7 \times 10^9 M_{\odot}$  in the form of neutral hydrogen , at least  $3 \times 10^8 M_{\odot}$  as molecular hydrogen ( within its innermost 10 kiloparsecs ) , and  $5 \times 10^7 M_{\odot}$  of dust .

Studies made with the help of the Hubble Space Telescope and published in 2015 , have uncovered a large and massive halo of hot gas enveloping M31 . This halo is estimated to contain half the mass of the stars in the Andromeda galaxy itself . As of May 7 , 2015 , the halo is about six times larger and 1,000 times more massive than previously measured . The nearly invisible halo stretches about a million light years from its host galaxy , halfway to our Milky Way galaxy . Simulations of galaxies indicate the halo formed at the same time as the Andromeda galaxy . The halo is enriched in elements heavier than hydrogen and helium , formed from supernovae and its properties are the expected on a galaxy that lies in the green valley of the color magnitude diagram ( see below ) . The supernovae erupt in Andromeda 's star filled disk and eject these heavier elements into space . Over Andromeda 's lifetime , nearly half of the heavy elements made by its stars have been ejected far beyond the galaxy 's 200,000 light year diameter stellar disk .

=== Luminosity ===

M31 appears to have significantly more common stars than the Milky Way , seeming to predominate the old stars with ages  $> 7 \times 10^9$  years , and the estimated luminosity of M31 ,  $\sim 2 \times 10^{10} L_{\odot}$  , is about 25 % higher than that of our own galaxy . However , the galaxy has a high inclination as seen from Earth and its interstellar dust absorbs an unknown amount of light , so it is difficult to estimate its actual brightness and other authors have given other values for the luminosity of the Andromeda Galaxy ( including to propose it is the second brightest galaxy within a radius of 10 mega parsecs of the Milky Way , after the Sombrero Galaxy , with an absolute magnitude of around -22.21 or close )

An estimation done with the help of Spitzer Space Telescope published in 2010 suggests an absolute magnitude ( in the blue ) of  $-20.89$  ( that with a color index of  $+0.63$  translates to an absolute visual magnitude of  $-21.52$  , compared to  $-20.9$  for the Milky Way ) , and a total luminosity in that wavelength of  $3.64 \times 10^{10} L_{\odot}$  .

The rate of star formation in the Milky Way is much higher , with M31 producing only about one solar mass per year compared to 3-5 solar masses for the Milky Way . The rate of supernovae in the Milky Way is also double that of M31 . This suggests that M31 once experienced a great star formation phase , but is now in a relative state of quiescence , whereas the Milky Way is experiencing more active star formation . Should this continue , the luminosity in the Milky Way may eventually overtake that of M31 .

According to recent studies , like the Milky Way , the Andromeda Galaxy lies in what in the galaxy color magnitude diagram is known as the green valley , a region populated by galaxies in transition from the blue cloud ( galaxies actively forming new stars ) to the red sequence ( galaxies that lack star formation ) . Star formation activity in green valley galaxies is slowing as they run out of star forming gas in the interstellar medium . In simulated galaxies with similar properties , star formation will typically have been extinguished within about five billion years from now , even accounting for the expected , short term increase in the rate of star formation due to the collision between Andromeda and the Milky Way .

== Structure ==

Based on its appearance in visible light , the Andromeda Galaxy is classified as an SA ( s ) b galaxy in the de Vaucouleurs-Sandage extended classification system of spiral galaxies . However , data from the 2MASS survey showed that the bulge of M31 has a box like appearance , which

implies that the galaxy is actually a barred spiral galaxy like the Milky Way , with the Andromeda Galaxy 's bar viewed almost directly along its long axis .

In 2005 , astronomers used the Keck telescopes to show that the tenuous sprinkle of stars extending outward from the galaxy is actually part of the main disk itself . This means that the spiral disk of stars in M31 is three times larger in diameter than previously estimated . This constitutes evidence that there is a vast , extended stellar disk that makes the galaxy more than 220 @,@ 000 light @-@ years ( 67 @,@ 000 pc ) in diameter . Previously , estimates of the Andromeda Galaxy 's size ranged from 70 @,@ 000 to 120 @,@ 000 light @-@ years ( 21 @,@ 000 to 37 @,@ 000 pc ) across .

The galaxy is inclined an estimated 77 ° relative to the Earth ( where an angle of 90 ° would be viewed directly from the side ) . Analysis of the cross @-@ sectional shape of the galaxy appears to demonstrate a pronounced , S @-@ shaped warp , rather than just a flat disk . A possible cause of such a warp could be gravitational interaction with the satellite galaxies near M31 . The galaxy M33 could be responsible for some warp in M31 's arms , though more precise distances and radial velocities are required .

Spectroscopic studies have provided detailed measurements of the rotational velocity of M31 as a function of radial distance from the core . The rotational velocity has a maximum value of 225 kilometres per second ( 140 mi / s ) at 1 @,@ 300 light @-@ years ( 82 @,@ 000 @,@ 000 AU ) from the core , and it has its minimum possibly as low as 50 kilometres per second ( 31 mi / s ) at 7 @,@ 000 light @-@ years ( 440 @,@ 000 @,@ 000 AU ) from the core . Further out , rotational velocity rises out to a radius of 33 @,@ 000 light @-@ years ( 2 @.@ 1 × 10<sup>9</sup> AU ) , where it reaches a peak of 250 kilometres per second ( 160 mi / s ) . The velocities slowly decline beyond that distance , dropping to around 200 kilometres per second ( 120 mi / s ) at 80 @,@ 000 light @-@ years ( 5 @.@ 1 × 10<sup>9</sup> AU ) . These velocity measurements imply a concentrated mass of about 6 × 10<sup>9</sup> M<sub>?</sub> in the nucleus . The total mass of the galaxy increases linearly out to 45 @,@ 000 light @-@ years ( 2 @.@ 8 × 10<sup>9</sup> AU ) , then more slowly beyond that radius .

The spiral arms of M31 are outlined by a series of H II regions , first studied in great detail by Walter Baade and described by him as resembling " beads on a string " . his studies show two spiral arms that appear to be tightly wound , although they are more widely spaced than in our galaxy . His descriptions of the spiral structure , as each arm crosses the major axis of M31 , are as follows § pp1062 § pp92 :

Since the Andromeda Galaxy is seen close to edge @-@ on , however , the studies of its spiral structure are difficult . While as stated above rectified images of the galaxy seem to show a fairly normal spiral galaxy with the arms wound up in a clockwise direction , exhibiting two continuous trailing arms that are separated from each other by a minimum of about 13 @,@ 000 light @-@ years ( 820 @,@ 000 @,@ 000 AU ) and that can be followed outward from a distance of roughly 1 @,@ 600 light @-@ years ( 100 @,@ 000 @,@ 000 AU ) from the core , other alternative spiral structures have been proposed such as a single spiral arm or a flocculent pattern of long , filamentary , and thick spiral arms .

The most likely cause of the distortions of the spiral pattern is thought to be interaction with galaxy satellites M32 and M110 . This can be seen by the displacement of the neutral hydrogen clouds from the stars .

In 1998 , images from the European Space Agency 's Infrared Space Observatory demonstrated that the overall form of the Andromeda Galaxy may be transitioning into a ring galaxy . The gas and dust within M31 is generally formed into several overlapping rings , with a particularly prominent ring formed at a radius of 32 @,@ 000 light @-@ years ( 2 @.@ 0 × 10<sup>9</sup> AU ) ( 10 kiloparsecs ) from the core , nicknamed by some astronomers the ring of fire . This ring is hidden from visible light images of the galaxy because it is composed primarily of cold dust , and most of the star formation that is taking place in M31 is concentrated there .

Later studies with the help of the Spitzer Space Telescope showed how Andromeda 's spiral structure in the infrared appears to be composed of two spiral arms that emerge from a central bar and continue beyond the large ring mentioned above . Those arms , however , are not continuous and have a segmented structure .

Close examination of the inner region of M31 with the same telescope also showed a smaller dust ring that is believed to have been caused by the interaction with M32 more than 200 million years ago. Simulations show that the smaller galaxy passed through the disk of the galaxy in Andromeda along the latter's polar axis. This collision stripped more than half the mass from the smaller M32 and created the ring structures in M31. It is the co-existence of the long-known large ring-like feature in the gas of Messier 31, together with this newly discovered inner ring-like structure, offset from the barycenter, that suggested a nearly head-on collision with the satellite M32, a milder version of the Cartwheel encounter.

Studies of the extended halo of M31 show that it is roughly comparable to that of the Milky Way, with stars in the halo being generally "metal poor", and increasingly so with greater distance. This evidence indicates that the two galaxies have followed similar evolutionary paths. They are likely to have accreted and assimilated about 100 ? 200 low-mass galaxies during the past 12 billion years. The stars in the extended halos of M31 and the Milky Way may extend nearly one-third the distance separating the two galaxies.

= = Nucleus = =

M31 is known to harbor a dense and compact star cluster at its very center. In a large telescope it creates a visual impression of a star embedded in the more diffuse surrounding bulge. The luminosity of the nucleus is in excess of the most luminous globular clusters.

In 1991 Tod R. Lauer used WFPC, then on board the Hubble Space Telescope, to image M31's inner nucleus. The nucleus consists of two concentrations separated by 1 @ 5 parsecs ( 4 @ 9 ly ). The brighter concentration, designated as P1, is offset from the center of the galaxy. The dimmer concentration, P2, falls at the true center of the galaxy and contains a black hole measured at  $3 \pm 5 \times 10^7 M_{\odot}$  in 1993, and at  $1 \pm 2 \pm 3 \times 10^8 M_{\odot}$  in 2005. The velocity dispersion of material around it is measured to be  $\sim 160$  km / s.

Scott Tremaine has proposed that the observed double nucleus could be explained if P1 is the projection of a disk of stars in an eccentric orbit around the central black hole. The eccentricity is such that stars linger at the orbital apocenter, creating a concentration of stars. P2 also contains a compact disk of hot, spectral class A stars. The A stars are not evident in redder filters, but in blue and ultraviolet light they dominate the nucleus, causing P2 to appear more prominent than P1.

While at the initial time of its discovery it was hypothesized that the brighter portion of the double nucleus is the remnant of a small galaxy "cannibalized" by M31, this is no longer considered a viable explanation, largely because such a nucleus would have an exceedingly short lifetime due to tidal disruption by the central black hole. While this could be partially resolved if P1 had its own black hole to stabilize it, the distribution of stars in P1 does not suggest that there is a black hole at its center.

= = Discrete sources = =

Apparently, by late 1968, no X-ray sources had been detected from the Andromeda Galaxy. A balloon flight on October 20, 1970, set an upper limit for detectable hard X-ray sources from M31.

Multiple X-ray sources have since been detected in the Andromeda Galaxy, using observations from the ESA's XMM-Newton orbiting observatory. Robin Barnard et al. hypothesized that these are candidate black holes or neutron stars, which are heating incoming gas to millions of kelvins and emitting X-rays. The spectrum of the neutron stars is the same as the hypothesized black holes, but can be distinguished by their masses.

There are approximately 460 globular clusters associated with the Andromeda Galaxy. The most massive of these clusters, identified as Mayall II, nicknamed Globular One, has a greater luminosity than any other known globular cluster in the Local Group of galaxies. It contains several million stars, and is about twice as luminous as Omega Centauri, the brightest known globular cluster in the Milky Way. Globular One (or G1) has several stellar populations and a structure too massive for an ordinary globular. As a result, some consider G1 to be the remnant core of a dwarf

galaxy that was consumed by M31 in the distant past . The globular with the greatest apparent brightness is G76 which is located in the south @-@ west arm 's eastern half . Another massive globular cluster -named 037 @-@ B327- , discovered in 2006 as is heavily reddened by the Andromeda Galaxy 's interstellar dust , was thought to be more massive than G1 and the largest cluster of the Local Group ; however other studies have shown is actually similar in properties to G1 .

Unlike the globular clusters of the Milky Way , which show a relatively low age dispersion , Andromeda 's globular clusters have a much larger range of ages : from systems as old as the galaxy itself to much younger systems , with ages between a few hundred million years to five billion years

In 2005 , astronomers discovered a completely new type of star cluster in M31 . The new @-@ found clusters contain hundreds of thousands of stars , a similar number of stars that can be found in globular clusters . What distinguishes them from the globular clusters is that they are much larger ? several hundred light @-@ years across ? and hundreds of times less dense . The distances between the stars are , therefore , much greater within the newly discovered extended clusters .

In the year 2012 , a microquasar , a radio burst emanating from a smaller black hole , was detected in the Andromeda Galaxy . The progenitor black hole was located near the galactic center and had about 10 <formula> . Discovered through a data collected by the ESA 's XMM @-@ Newton probe , and subsequently observed by NASA 's Swift and Chandra , the Very Large Array , and the Very Long Baseline Array , the microquasar was the first observed within the Andromeda Galaxy and the first outside of the Milky Way Galaxy .

= = Satellites = =

Like the Milky Way , the Andromeda Galaxy has satellite galaxies , consisting of 14 known dwarf galaxies . The best known and most readily observed satellite galaxies are M32 and M110 . Based on current evidence , it appears that M32 underwent a close encounter with M31 ( Andromeda ) in the past . M32 may once have been a larger galaxy that had its stellar disk removed by M31 , and underwent a sharp increase of star formation in the core region , which lasted until the relatively recent past .

M110 also appears to be interacting with M31 , and astronomers have found in the halo of M31 a stream of metal @-@ rich stars that appear to have been stripped from these satellite galaxies . M110 does contain a dusty lane , which may indicate recent or ongoing star formation .

In 2006 it was discovered that nine of these galaxies lie along a plane that intersects the core of the Andromeda Galaxy , rather than being randomly arranged as would be expected from independent interactions . This may indicate a common tidal origin for the satellites .

= = Collision with the Milky Way = =

The Andromeda Galaxy is approaching the Milky Way at about 110 kilometres per second ( 68 mi / s ) . It has been measured approaching relative to our Sun at around 300 kilometres per second ( 190 mi / s ) as the Sun orbits around the center of our galaxy at a speed of approximately 225 kilometres per second ( 140 mi / s ) . This makes Andromeda one of about 100 blueshifted galaxies that we observe . Andromeda 's tangential or side @-@ ways velocity with respect to the Milky Way is relatively much smaller than the approaching velocity and therefore it is expected to directly collide with the Milky Way in about 4 billion years . A likely outcome of the collision is that the galaxies will merge to form a giant elliptical galaxy or perhaps even a large disc galaxy . Such events are frequent among the galaxies in galaxy groups . The fate of the Earth and the Solar System in the event of a collision is currently unknown . Before the galaxies merge , there is a small chance that the Solar System could be ejected from the Milky Way or join M31 .