Observing List for FSAD on 2021.09.25

1) *Messier 08 or NGC 6523, The Lagoon Nebula & NGC 6530, an Open Cluster, both in Sagittarius*
2) *Messier 20 or NGC 6514, The Trifid Nebula in Sagittarius*
3) *Messier 17 or NGC 6618, The Omega or Swan Nebula in Sagitarius*
4) *Messier 22 or NGC 6656, a Globular Cluster in Sagittarius*
5) *Messier 16, The Eagle Nebula & NGC 6611, an Open Cluster, both in Serpens Cauda*
6) *Messier 11 or NGC 6705, The Wild Duck Cluster in Scutum*
7) *Messier 27 or NGC 6853, The Dumbbell, a Planetary Nebula in Vulpecula*
8) *Messier 57 or NGC 6720, The Ring, a Planetary Nebula in Lyra*
9) *Messier 13 or NGC 6205, The Great Globular Cluster in Hercules*
10) *Messier 51 or NGC 5194, The Whirlpool Galaxy & NGC 5195, a Companion Galaxy, both in Canes Venatici*
11) *Messier 31 or NGC 224, The Great Andromeda Galaxy*
12) *NGC 6960, The Western Veil Nebula; NGC 6992, The Eastern Veil Nebula & NGC 6995, The Bat Nebula, all in Cygnus*

Visit our Star Parties at Crestview Park in San Carlos

Hi all. I'm Mike Ryan, President of the San Mateo County Astronomical Society. I want to welcome you, and thank you, for joining us at tonight's livestream star party. Our presentation in the next hour will feature twelve of the most spectacular, diverse and interesting objects of the Deep Sky. We will also provide a simultaneous descriptive narration, to help you, the viewers, understand and enjoy the features and origins of these objects.

If time permits, once the presentation has concluded, there may be a few minutes for anyone who wishes to ask questions, or to request further explanation.

Our Society also holds in-person outdoor star parties on at least one Saturday evening per month. These are open to the public, and take place at Crestview Park in San Carlos, near the intersection of Brittan Avenue and Crestview Drive. If you would like to view tonight's objects, and more, live through telescopes, you and the public are invited to join us; no passes, reservations or tickets necessary. The star party dates are posted at our SMCAS website; www.smcasastro.com. I'll repeat this invitation at the end of our program.

Observing List for FSAD on 2021.09.25

The descriptions for the following objects are derived from SkySafari Pro, Wikipedia, Brittanica and NASA sources.

All objects on this list lie at least 20-degrees of altitude above the horizon as seen from San Mateo on September 25th at 9:00 pm. Except for the Veil Nebula, all objects on the list are Messier objects that are imaged with our Society members' eVscopes. For those interested in the details, the Veil Nebula is photographed by an astrophotography setup described in the August-September 2021 issue of our SMCAS Event Horizon newsletter.

A Note on Catalogue Abbreviations:

The letters NGC, IC and M are abbreviations for historical astronomical catalogues - published lists of known stars, nebulae, supernova remnants, galaxies, & other Deep Sky Objects, also called DSO's.

NGC represents the New General Catalogue. It was originally published in 1888 by the Royal Astronomical Society, and it lists 7,840 objects.

The Index Catalogue, or IC, describes an additional 5,286 galaxies, nebulae, and star clusters, all discovered between 1888 and 1907.

Names beginning with the letter M are Messier objects, named after Charles Messier, a French astronomer and comet hunter active In the 1760s and 70s. He discovered 11 comets, but he and other astronomers of his time frequently found fuzzy or diffuse objects that resembled comets, but which did not move among the stars as comets do. So, he made a now-famous list of some 103 objects he actually preferred to avoid. Virtually all Messier objects can be seen with binoculars or through small telescopes under clear, dark skies.

Simulcast Star Party Object Script

1) Messier 08 or NGC 6523, The Lagoon Nebula & NGC 6530, an Open Cluster, both in Sagittarius

The Lagoon Nebula in the constellation of Sagittarius, the Archer (a Centaur in Greek mythology), is one of the finest star-forming regions in the sky, and is faintly visible to the naked eye. It is a giant glowing cloud of interstellar gas, located in the Sagittarius-Carina arm of the Milky Way galaxy and is divided into eastern and western regions by a dark lane of dust called "the Lagoon".

The eastern region contains a cluster of young stars that have formed from the nebular cloud. This cluster appears as entry NGC 6530 in the New General Catalogue.

The western region includes a bright feature known as the "Hourglass Nebula" along with 9 Sagittarii, a magnitude 5.9, spectral class O5, binary star whose ultraviolet radiation causes the nebular gas to fluoresce. Magnitude 5.9 is the star's brightness on a scale based on the 5th root of 100. On this scale, Sirius, the Dog Star, the brightest star we see is 0 magnitude. First

magnitude is 2.5X fainter, and second magnitude 2.5X fainter still. 6th magnitude is as faint as good eyes can see in a dark sky.

The Lagoon Nebula also contains a number of dark globules. They represent collapsing clouds of proto-stellar material with diameters of about 10,000 Astronomical Units, or AU's. One AU is 93 million miles, the distance from Earth to the Sun. At magnitude 6, the Lagoon Nebula is faintly visible to the naked eye under good conditions. It is one of only two star-forming regions visible to the eye from mid-northern latitudes, the other being the Orion Nebula. The nebula spans a solid angle of 90 by 40 arc minutes, three times that of the full Moon.

The earliest observations of this object were made by Giovanni Battista Hodierna in 1654. It was independently described as a "nebula" by John Flamsteed around 1680. The object was again seen, by Philippe Loys de Chéseaux, in 1746, who was able to resolve some stars, and consequently classified it as a cluster. One year later, in 1747, it was observed by Guillaume Le Gentil, who found the nebula along with the cluster. Abbe Nicholas Louis de la Caille cataloged it in his 1751-52 compilation. And Charles Messier cataloged this object on his Messier List in 1764.

In the eastern region, the open star cluster, NGC 6530, spans an angular diameter of 10 arc minutes. A recent survey by the Italian National Institute for Astrophysics estimates the median age of stars within the cluster to be 2.3 million years, and the distance to the cluster about 4,100 light years, significantly less than previous estimates of 6,000 light years, making the nebula's true size about 110 x 50 light years. The Light Year is the distance that light, moving at 670 million miles per hour, travels in a year; about 5.88 trillion miles.

The "Hourglass Nebula" in the western region is brightly illuminated by the star Herschel 36 (a magnitude 9.5 star of spectral class O7). In 2006, four Herbig-Haro objects, bright patches of nebulosity associated with newborn stars, were detected within the Hourglass, providing the first direct evidence of active star formation by internal accretion.

2) *Messier 20 or NGC 6514, The Trifid Nebula in Sagittarius*

The Trifid Nebula in the northwest region of Sagittarius is in an H-II, or star-forming, region in the Milky Way's Scutum-Centaurus Arm. It was discovered by Charles Messier on June 5, 1764. Its name means 'three-lobe'. This object is an unusual combination of an open cluster of stars, an H-II emission nebula, a reflection nebula (the blue portion, mainly north by northeast), and a dark nebula (constituting the apparent 'gaps' that cause the trifurcated appearance, also called Barnard 85). John Herschel was the one to name the nebula Trifid after ob-serving the dark dust lanes that separate it into three lobes.

The nebula is some 5,200 ly from Earth and is about 40 ly across. The angular size is about 28 arc minutes and its apparent magnitude is 6.3.

The Trifid Nebula is relatively young. M20 is a mere 300,000 years old, which makes it one of the youngest star-forming regions in our sky.

The most massive star that has formed in the emission nebula is HD 164492A, an O7 star with a mass more than 20 times that of our Sun. This star is surrounded by a cluster of about 3.100 young stars. The ultraviolet radia-tion from these stars causes the surrounding nebula to

fluoresce. In contrast, the blue portion of the nebula is due to the reflection of light from nearby stars.

3) Messier 17 or NGC 6618, The Omega or Swan Nebula in Sagitarius

Messier 17 in the constellation of Sagittarius, the Archer, is one of the brightest diffuse nebulae in the sky. Commonly known as the Omega, Swan, Horseshoe, and (especially in the sout0hern hemisphere) the Lobster nebula.

M17 was first observed by Philippe Loys de Cheseaux in the spring of 1746, and discovered independently by Charles Messier in June of the same year. De Cheseaux's discovery was not widely known, so Messier catalogued it as number 17 on his list in 1764.

M17 is located in the rich Milky Way star fields in Sagittarius. With a visual magnitude of 6.0, it's visible to the eye from low latitudes under good conditions.

The overall color of the Omega Nebula is reddish, due to light emitted from the hot hydrogen gas excited by stars recently formed within it. However, the brightest region is actually white, due to light emission from hot gas mixed with bright starlight reflected from dust. A large amount of dark obscuring material has been heated by the hidden young stars, and shines brightly in the infrared.

Distance estimates to M17 range between 5,000 and 6,000 light years – a little less than its apparent

neighbor, M16. Physically, these two star forming regions may be part of the same giant complex of interstellar matter.

While the visible nebula is about 15 light-years across, the entire gaseous cloud extends to at least 40 light-years. The total mass of the gas has been estimated at about 800 Suns, a good deal more than in Messier 42 and 43, the Orion Nebula of the winter skies.

Some 35 bright stars, each about six times hotter and 20-to-30 times more massive than our Sun, are embedded in the nebulosity. Unlike with other emission nebulae, however, these stars are not seen in optical images, but are, instead, hidden inside the nebula. Star formation is either still active, or has ceased very recently.

The radiation from these stars erodes the dense cloud of cold gas around them, exposing dense gas pockets. These may contain other stars being formed. Because these dense pockets are more resistant to the radiation than the surrounding cloud, they appear as isolated islands in a sea of glowing gas.

4) Messier 22 or NGC 6656, a Globular Cluster in Sagittarius

The globular cluster Messier 22 in Sagittarius, also known as NGC 6656, was among the first to be discovered. With a visual magnitude of 5.1, it can be seen with the unaided eye on a clear night, and is the third-brightest in the sky, after Omega Centauri and 47 Tucanae. At a distance of 10,400 light years, M22 is also one of the nearest globulars to us. Its angular diameter corresponds to a linear dimension of about 97 light years. It has an absolute magnitude of -8.5, and a luminosity of 210,000 Suns - both average for a globular cluster.

The first recorded sighting of M22 is usually credited to the obscure German astronomer Abraham Ihle in 1665, but it may have been spotted previously by Polish astronomer, Johannes Hevelius. This globular was included in Edmond Halley's list of 6 nebulous objects, published in 1715. It was also observed by De Cheseaux, Le Gentil, and by Nicholas Louis de Lacaille, who added it to his catalog of southern objects as Lacaille I.12.

Charles Messier, who catalogued M22 on June 5, 1764, stated that it is also included in John Bevis' English Atlas. M22 was also one of the first globular clusters to be

studied by Harlow Shapley in 1930. Shapley counted 70,000 stars in this great stellar swarm.

M22 is a distinctly elliptical globular cluster with a diameter of 32 arc minutes, slightly larger than the full Moon. It contains approximately 500,000 stars; the brightest about magnitude 11. The relatively loose core, of 5 arc minutes diameter, is a mass of faint, well-resolved stars. Stars are distributed over its halo along a multitude of arcs and streams, and in several clumps.

M22 lies less than 1 degree off the ecliptic, so conjunctions with planets are frequent and conspicuous. The globular's setting on the northern fringe of the Great Sagittarius Star Cloud adds to the richness of the scene.

M22 is one of only four globulars known to contain a planetary nebula. The others are M15, NGC 6441 and Palomar 6. This planetary nebula was discovered by the Infra-Red Astronomical Satellite, IRAS.

Hubble Space Telescope investigations of M22 discovered a number of planet-sized objects which appear to float through this globular cluster, and which may have masses only 80 times that of Earth. These objects were discovered by micro-lensing effects; that is, the bending of light from background member stars of the cluster.

5) Messier 16, The Eagle Nebula & NGC 6611, an Open Cluster, both in Serpens Cauda

Messier 16 is a region of active star formation, in the constellation Serpens Cauda, the Tail of the Snake. This giant cloud of interstellar gas and dust is commonly known as the Eagle Nebula, with an open cluster within called NGC 6611. With an overall visual magnitude of 6.4, and an apparent diameter of 7 arc minutes, the star cluster is visible in low power telescopes. The brightest star in the cluster has an apparent magnitude of +8.24, easily visible with good binoculars. M16's stellar swarm is only about 5.5 million years old, with its hottest, youngest stars of spectral type O6. Excited by high-energy ultraviolet radiation from these massive stars, this great cloud of interstellar gas glows by fluorescence.

The Eagle Nebula lies some 7,000 light years away in the Sagittarius-Carina spiral arm of our galaxy, the next arm inward from our own Orion arm. At this distance, the cluster's angular diameter corresponds to a linear size of about 15 light years, but extends much farther out, to about 70 x 55 light years. M16 might form one giant complex with M17, the Omega Nebula, which lies to the south, in Sagittarius.

The cluster was discovered by Philippe Loys de Cheseaux in 1745, who reported the cluster, but made no mention of a nebula. Charles Messier independently rediscovered the object in 1764, and described its stars as "enmeshed in a faint glow", showing that he had spotted the nebula as well.

William and John Herschel, father and son, also did not perceive the nebula, so their catalogs (and consequently the New General Catalogue) describe only the cluster of stars. The nebula was probably first photographed by E.E. Barnard in 1895, or by Isaac Roberts in 1897. From Roberts's finding, the nebula was added to the second Index Catalog in 1908 as IC 4703.

Images made in 1995 by the Hubble Space Telescope greatly improved our understanding of the star formation process taking place inside the nebula. One of these images, a famous photograph named the "Pillars of Creation", depicts a large region of star formation whose small dark areas are believed to be protostars. They've also been described as 'proplyds', or proto-planetary disks. At the end of each Pillar, the intense ultraviolet light of newborn stars is vaporizing some of the hydrogen gas, and shaping structures called Evaporating Gaseous Globules, or "EGG's".

In 2007, scientists using the Spitzer Space Telescope discovered evidence that the Pillars were actually destroyed by a supernova explosion about 6,000 years ago. But the light showing their destruction, and the new shape of the nebula, will not reach the Earth for another millennium.

6) Messier 11 or NGC 6705, The Wild Duck Cluster in Scutum

The Wild Duck is an open Cluster in the constellation of Scutum, the Shield. It's one of the richest and most compact open clusters in the sky.

M11 was discovered by the German astronomer Gottfried Kirch in 1681, and first resolved into stars by William Derham around 1733. Charles Messier catalogued it in 1764. The 'Wild Duck' common name comes from an Admiral Smyth, who noted that its fan-shaped appearance resembled "a flight of wild ducks."

The Wild Duck Cluster is 14 arc minutes in diameter, about 1/3 the size of the full Moon. An arc-minute is an angular distance equal to 1/60th of a degree as measured on the sky. One degree of arc is 1/180th of the distance along a great circle from one horizon to the other. It's also an arc 1/15th the angle through which see the sky appear to rotate in the course of one hour.

With a total magnitude of 6.3, M11 is visible in binoculars, but truly stands out through a telescope at low power. It contains an estimated 2,900 stars, about 500 brighter than magnitude 14, the limiting magnitude of a 6-inch telescope. The cluster's stars are distributed in a network of knots and clumps, mixed with some

meandering dark lanes. The two most conspicuous of these wind from the cluster's center to its northern and western edges. Although hard to find among the profusion of stars, careful scrutiny shows an east-pointing V of brighter stars.

The Wild Duck is so rich that it resembles a loose globular cluster. It's of intermediate age; about 250 million years old. It's extremely luminous for an open cluster, with an absolute magnitude of -6.9, The term 'absolute magnitude' refers to its brightness as if seen from a standard distance of 10 parsecs, or 30 light years. It's luminosity is that of 48,000 Suns. The cluster is about 6,000 light years away from Earth, and receding from us at 22 km/sec.

7) Messier 27 or NGC 6853, The Dumbbell, a Planetary Nebula in Vulpecula

The Dumbbell Nebula is the first planetary nebula ever discovered, and perhaps the finest in the sky. It is easily seen in binoculars, and is a popular observing target for amateur telescopes.

Charles Messier discovered this object in 1764, and described it as an oval nebula without stars. William Herschel invented the name "Planetary Nebula" for this class of objects around 1784, because he found them to resemble his newly discovered planet, Uranus. The name "Dumbbell" goes back to William's son John Herschel, who compared M27 to a "double-headed shot".

This planetary nebula is certainly the most impressive object of its kind in the sky. But at visual magnitude 7.4, it is only the second brightest. While the Helix Nebula in Aquarius (NGC 7293) is slightly brighter, at magnitude 7.3, it has a much lower surface brightness because of its larger size.

The two bright triangular lobes, that give rise to the Dumbbell's, name extend north and south to an overall length of 8 x 6 arc minutes. A faint halo extends out to over 15 arc minutes, half the apparent diameter of the

Moon. Several stars are superimposed on the nebula, the most conspicuous lying in the center of the northern lobe.

The central star of M27, just visible at magnitude 13.5, is surrounded by a slightly darker area. It has a faint (magnitude 17) yellow companion 6.5 arc seconds away.

As with most planetary nebulae, the distance to M27 is not very well known. Existing estimates range from 490 to 3,500 light years. Adopting a value of 1,200 light years, the nebula's intrinsic luminosity is about 100 times that of the Sun. Its central star has about 1/3 the Sun's lumi-nosity, and its companion is nearly 100 times fainter.

As with all planetary nebulae, M27's central white dwarf is the collapsed core of a formerly sunlike star which, after exhausting its hydrogen fuel, became a red giant and ejected its outer layers. The expanding gas shell is excited by high-energy radiation from the central white dwarf, forming the visible nebula.

M27’s central white dwarf star contains an estimated 60% the mass of our Sun. Though it’s only about 5% of the Sun's diameter, it is the largest white dwarf known. With a surface temperature of 85,000 degrees Kelvin, this blue-white star has a spectral type of O7. The high-

energy ultraviolet radiation from its extremely hot surface is ab-sorbed by the nebular gas, and re-emitted as visible light, mostly at only one wavelength, 500.7 nm, which corresponds to the greenish spectral line of doubly-ionized oxygen.

8) Messier 57 or NGC 6720, The Ring, a Planetary Nebula in Lyra

Messier 57 or NGC 6720, is the famous Ring Nebula, a showpiece of the northern summer sky, often regarded as the prototype of all planetary nebulae. These objects are the remains of sunlike stars which have blown away their outer envelopes, leaving planet-sized white dwarfs at their centers.

The Ring Nebula was discovered by the French Astronomer Antoine Darquier de Pellepoix in January, 1779. Only days later, Charles Messier independently found it while searching for comets, and entered it as the 57th object in his catalogue. William Herschel, who discovered the planet Uranus, found other nebulous objects resembling M57 (as well as his newly discovered planet), and introduced the term "Planetary Nebulae" to describe them.

In 1800, Count Friedrich von Hahn discovered the faint central star at the heart of the Ring. In 1864, William Huggins examined the spectrum of M57, finding that it displayed the bright emission lines characteristic of fluorescing gases. Huggins concluded that most planetary nebulae were not composed of unresolved stars, as had

been previously thought, but instead consisted of glowing gas.

As with most planetary nebulae, the distance to the Ring is not very well known. The US Naval Observatory and Hubble Space Telescope used improved techniques in 1997-1999 to determine a trigonometric parallax for the central star, yielding a distance of about 1,400 light years.

Assuming this distance, the Ring's apparent dimensions correspond to a linear diameter of 0.9 x 0.7 light years, but its halo extends out to 2.4 light years. Its visual magnitude of 8.8 corresponds to an absolute magnitude of -0.3, or an intrinsic brightness about 100 times that of the Sun. Assuming constant expansion, the age of the Ring Nebula can be roughly estimated at 6,000 to 8,000 years. It is approaching us at 21 km/sec.

The Ring Nebula itself has been estimated to contain about 0.2 solar masses, with a density of about 10,000 ions per cubic centimeter. The innermost region appears darker because it emits mainly UV radiation, and has a blue-green tinge emitted by doubly-ionized oxygen. The reddish hue in the outer region is caused by emission from ionized hydrogen and nitrogen.

The mass of the central star illuminating M57 is approximately 1.2 solar masses. This 15th-magnitude white

dwarf, now the size of a terrestrial planet, is actually fainter than our Sun, with an absolute magnitude of +5 to +6. Although it currently has a surface temperature of 100,000 to 120,000 Kelvin, it will cool over several billion years, and eventually end up as a cold, dead, "black dwarf".

9) Messier 13 or NGC 6205, The Great Globular Cluster in Hercules

Messier 13 is the largest, brightest globular cluster visble in our northern skies. At magnitude 5.8, M13 is just visible to the eye on very dark nights. It lies about 1/3 of the way from Eta to Zeta Herculis, the two western-most stars in the Keystone asterism of Hercules. M13 has an absolute magnitude of -8.7, equal to a luminosity of a quarter-million Suns. Physically, the cluster contains several hundred thousand stars. Toward the center of M13, the stars are about 500 times closer together than in our own Solar neighborhood. If there were beings on a planet in the midst of such a cluster, they would never see a dark sky.

The Hercules Cluster was discovered by Edmond Halley (of Halley's Comet fame) in 1714. Fifty years later it was examined by Charles Messier, who catalogued it in 1764. M13 is also reported in John Bevis' Celestial Atlas. In 1787, Sir William Herschel pronounced it "a most beautiful cluster of stars, exceedingly compressed in the middle, and very rich."

Unlike open clusters like the Pleiades and the Wild Duck, globular clusters are tightly bound together by gravity, and contain very old, mostly red stars. The age

of M13 has been revised to 12 billion years - nearly as old as the Milky Way galaxy itself. Born before the Galaxy's stars had created metals, and spread them to its star-forming regions, M13's iron content relative to hydrogen is just 5% that of our Sun.

Strangely for such an old cluster, M13 also contains a number of young blue stars. These are known as “blue-stragglers”, main-sequence stars that are bluer in color, much hotter at the surface, and much more luminous than normal main sequence stars typical for the cluster. Most likely, blue stragglers are the result of collisions that formed stars of higher mass, which now behave as young stars.

10) Messier 51 or NGC 5194, The Whirlpool Galaxy & NGC 5195, a Companion Galaxy, both in Canes Venatici

Messier 51 (M51 or NGC 5194) is the famous "Whirlpool" galaxy in Canes Venatici, the Hunting Dogs. It is one of the most conspicuous and best-known spiral galaxies in the sky. M51 is interacting with its much smaller neighbor, NGC 5195. The two galaxies may be seen with binoculars under very dark skies.

Charles Messier discovered M51 on 13 October 1773. Pierre Mechain discovered its smaller companion in March 1781. The Whirlpool's spiral pattern was not seen until 1845.

M51 is a showcase grand design spiral galaxy. With overall dimensions of 11 x 7 arc minutes, and a visual magnitude of 8.4, M51’s structure is highly apparent in the eVscope. It has a bright core and readily visible spiral arms separated by dark swirls north and southwest of the core. The spiral arm east and northeast of the core is the most prominent. The various spiral bands and H-II (star-forming) regions are also visible, as well as an apparent "bridge" between M51 and NGC 5195. Long exposures reveal a large halo extending beyond the visible circular appearance.

Three supernovae have been discovered in M51 so far: Type-1c SN 1994I, Type-II SN 2005cs and Type-II SN 2011dh.

From observations of the 2005 supernova, M51's distance is estimated at 23 million light-years. The galaxy's bright circular disk has an estimated radius of about 38,000 light-years, and is estimated to contain stars totalling 160 billion solar masses.

An image of the core taken with the Wide Field Planetary camera on the Hubble Space Telescope shows a striking, dark "X" silhouetted across the galaxy's nucleus. An analysis of this pattern indicates the presence of a one-million solar mass black hole at the heart of the spiral.

The very pronounced spiral structure of the Whirlpool is believed to be the result of the close interaction between M51 and it’s companion. Recent simulations suggest that M51's spiral structure was caused by NGC 5195 passing through M51’s main disk 500 to 600 million years ago.

11)Messier 31 or NGC 224, The Great Andromeda Galaxy

The Great Andromeda Galaxy, Messier 31, is the nearest spiral galaxy to our own Milky Way, 2.5 million light years away. Hence, we see M31 as it was 2.5 million years ago.

A rough mirror image of the Milky Way, M31's huge aggregation of stars, gas, and dust lets us study features of our own galaxy that we cannot observe from inside.

The Persian astronomer Abd al-Rahman al-Sufi was the first to describe the Andromeda Galaxy in his "Book of Fixed Stars" in AD 964. The first telescopic description of M31 was provided by Simon Marius in 1612. Giovanni Batista Hodierna independently rediscovered this object in 1654. In 1764, Charles Messier catalogued Andromeda as object M31.

William Huggins, the pioneer of spectroscopy, observed the spectrum of M31 in 1864. The Andromeda "nebula", as it was then called, displayed a star-like, continuous spectrum, unlike the line spectra of gaseous nebulae. From this, Huggins deduced that M31 had a stellar nature.

In 1912, Henrietta Leavitt discovered the period-luminosity law for Cepheid variable stars, which became a crucial step in measuring distances to other galaxies.

In 1923, Edwin Hubble observed a Cepheid variable in M31, and used the Leavitt technique to estimate the distance to Andromeda as 800,000 light years, far outside the boundaries of our Milky Way. This measurement firmly established Andromeda to be an "island universe", rather than a nebula within our own galaxy.

Since then, the distance estimates have been refined, with the current result being that Andromeda is 2.54 million light years distant.

The Andromeda Galaxy has a stellar diameter of about 220,000 light years, making it the largest member of the Local Group of galaxies in terms of extension. However, Andromeda may not be the most massive. Recent findings suggest the Milky Way contains more dark matter, implying that it' s denser than M31. The total halo mass of M31 is estimated at 1.23 trillion solar masses, versus 1.9 trillion for the Milky Way.

The core of the Andromeda Galaxy is the farthest objects visible to the unaided eye. The Hubble Space Telescope has revealed that the Andromeda Galaxy's nucleus is in fact double. The brighter concentration is offset from the center of the galaxy by about 5 light

years. The dimmer concentration falls at the true center, and contains a black hole of up to 500 million solar masses.

The actual extent of the galaxy only becomes apparent in time exposures. It is seen as an edge-on ellipse whose apparent size is 3 x 1 degrees, 6 times the diameter of the full Moon.

Observations by the Spitzer Space Telescope in 2006 revealed that M31 contains up to one trillion stars, several times the number in our own galaxy (at about 200 to 400 billion). The estimated luminosity of M31, some 26 billion times that of our Sun, is about 25% higher than the Milky Way's. However, the rate of star formation in the Milky Way is much higher, with M31 producing only about 1 solar mass in stars per year, compared with 3 to 5 per year for the Milky Way.

The rate of supernovae occurrence in M31 has also been just one-third that of the Milky Way, which has witnessed three supernovae in the last millenium. Only one supernova has ever been recorded in the Andromeda Galaxy, in 1885. At the time, M31 was thought to be a nebula within the Milky Way, so this supernova was mis-takenly thought to be a much less luminous event, a nova. It is now known as SN1885A, the first extragalactic supernova ever observed.

The Andromeda Galaxy is directly approaching the Milky Way at about 110 km/sec. It's expected to collide with our own galaxy in about 4.5 billion years. A likely outcome of the collision is that the galaxies will merge to form a giant elliptical, or perhaps a large lenticular, galaxy.

The fate of the Earth and the Solar System in the event of such a collision is highly uncertain. Before the galaxies merge, there is a small chance that the Solar System could be ejected from the Milky Way or perhaps join the Andromeda Galaxy.

12) NGC 6960, The Western Veil Nebula; NGC 6992, The Eastern Veil Nebula & NGC 6995, The Bat Nebula, all in Cygnus

NGC 6960 (Caldwell 34) is also known as the Western Veil Nebula or The Witch's Broom. It forms the western segment of the Great Cygnus Loop, a supernova remnant. The source of the supernova was a star 20 times more massive than the sun which exploded between 10,000 and 20,000 years ago. At the time of explosion, the supernova would have appeared brighter than Venus in the sky, and visible in daytime. The remnants have since expanded to cover an area roughly 6 times the diameter, and 36 times the area, of the full Moon. The Cygnus Loop has been measured to be about 2400 light years from Earth, and is expanding at a rate of about 1.5 million kilometers per hour.

William Herschel discovered the Cygnus Loop in 1784 with his 18-inch reflector telescope.

In the visible range, the Cygnus Loop emits light primarily from doubly-ionized oxygen (O-III) fluorescence. Other sources of nebular radiation are from fluorescing hydrogen (H-alpha), sulfur and nitrogen. The Cygnus Loop is also a strong emitter of radio waves and x-rays.

The setup used to record the images of the Veil employs a special narrowband filter to selectively capture the O-III and H-alpha photons coming from the nebula.

Each of the two Veil nebula photographs is a composite of ten 60-second exposures. In these false-color images, the color purple represents O-III, and green represents H-alpha.

In the photo of the Western Veil, the 4th-magnitude star in the middle of the field, 52 Cygni, is much closer to Earth and is not associated with the nebula itself.

In the photo of the Eastern Veil, NGC 6992 is the arcing structure from the left to the middle of the field. NGC 6995, the Bat Nebula, is the right-of-center portion of the arcing nebula.

Visit our Star Parties at Crestview Park in San Carlos

Once again, I'm Mike Ryan of the San Mateo County Astronomical Society, and I hope you have enjoyed tonight's livestream star party. I want to repeat the reminder that our Society also holds in-person outdoor star parties on at least one Saturday evening per month. These are open to the public, and take place at Crestview Park in San Carlos, near the intersection of Brittan Avenue and Crestview Drive.

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