

Sky WAA tch



Image Copyright: Mauri Rosenthal

Great Nebula in Orion

Mauri Rosenthal captured this conventional image of M42 on January 26th. He used his Televue-85 scope with a ZWO ASI1600MC Astro-cam on a Skywatcher Star Adventurer mount. The image integrates about 20 minutes' worth of exposures at 2 and 8 seconds. The short and longer exposures and High Dynamic Range processing utilities in PixInsight bring out detail in both the bright core and the outer edges of this unique celestial target.

For another perspective on M42, try this NASA/JPL link for a tour of the Orion Nebula in both visible and narrowband:

<https://www.jpl.nasa.gov/news/news.php?feature=7035>

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Events for February

WAA February Lecture

"The Astronomical Search for Aliens on Mars"

Friday February 2nd, 7:30pm

Leinhard Lecture Hall, 3rd floor

Pace University, Pleasantville, NY

Our speaker, Brother Robert Novak, will address one of the questions pondered by thinkers for thousands of years – "Does life exist outside of the Earth?" From studying life on our planet, a set of conditions including the presence of liquid water, an energy source, and a protective shield from space radiation, is considered necessary for life to exist. If these conditions can be found on another object in space, then that object could possibly harbor life. Within our solar system, Jupiter's moon Europa, Saturn's moons Titan and Enceladus, and the planet Mars have been candidates.

Since 1996, Br. Novak has been collaborating with the Astrobiology Group headed by Dr. Michael Mumma at NASA's Goddard Space Flight Center, studying the composition of comets and the atmosphere of Mars using infrared spectrographs on large research telescopes. While studying heavy water (HDO), there were indications that methane exists on Mars. The origin of the methane is unclear. On Earth, most atmospheric methane originates from living organisms. Is the source of methane on Mars biological, or is it geological? The telescopic search for these gases on Mars will be presented. With new instrumentation, the origin of methane could be determined. If conditions for life exist on Mars, then perhaps life does exist on Mars. Various scenarios will be discussed, with implications that may change our own view of life on Earth. Free and open to the public.

Brother Robert Novak, C.F.C. is a Professor of Physics at Iona College in New Rochelle NY; he began teaching there in 1976. He holds degrees in Physics from Iona College (B.S., 1972), Stevens Institute of Technology (M.S., 1977), and Columbia University (M.Phil, Ph.D., 1980). Free and open to the public. [Directions](#) and [Map](#).

Upcoming Lectures

Leinhard Lecture Hall

Pace University, Pleasantville, NY

Our speaker on March 2nd will be Dr. Andrew MacFayden of NYU who will speak on gravitational waves. Free and open to the public.

Starway to Heaven

Ward Pound Ridge Reservation, Cross River, NY

There will be no Starway to Heaven observing date for February. Monthly observing sessions will resume on March 17th (the rain/snow/cloud date is March 24th).

New Members. . .

Michael H Tarlowe - New Rochelle

Renewing Members. . .

Robert Rehrey - Yonkers

John Higbee - Alexandria

Bob Quigley - Eastchester

Jonathan Gold - Ossining

Carlton Gebauer - Granite Springs

Robert M. Hales - Montrose

Claudia & Kevin Parrington - Harrison

Harry S. Butcher, Jr. - Mahopac

David Butler - Mohegan Lake



Courtesy of Bob Kelly is this attempt at indoors astronomy. It shows through the window, framed by curtains, the January 7th conjunction of Jupiter and Mars (Canon XS on tripod, f4.5 10 seconds exposure ISO-800. Brightened to show curtains.)

Call: 1-877-456-5778 (toll free) for announcements, weather cancellations, or questions. Also, don't forget to visit the [WAA website](#).



ALMANAC

For February 2018 by Bob Kelly

The bright planet trifecta in our southern skies gets going in February, with Jupiter, Mars and Saturn as the (non-stellar) stars of our show.

Jupiter reaches its highest altitude at the break of dawn, only 30 degrees above our southern horizon. With Jupiter at quadrature, 90 degrees from the Sun, it rises in the middle of the night and its moons do marvelous disappearing and reappearing acts in Jupiter's shadow and behind the planet. Some of the best mornings are on the 4th, 6th, 13th, 24th and 17th, for Western Hemisphere locations. See [Sky & Telescope](#) for a full set of times. Any telescope will show most of these events. Just for fun, on one of those mornings, follow Jupiter in the daytime sky and see how long you can spot it.

Mars seems lost. At magnitude plus 1, it doesn't stand out much in the dawn sky. While its tiny size (6 arc seconds) makes it a featureless orb in all but the largest telescopes in the steadiest skies, it looks noticeably lopsided in any telescope. It stays around 90 percent sunlit through April. By then, Mars will appear almost twice as large as it does now, on its way to 24 arc seconds wide, during what will become known as the summer of the giant planets!

February is a good month to compare Ares (Mars) to its nearby rival anti-Ares (Antares). They are both about magnitude plus 1.0. Look the difference between the two: Antares shimmering as a point source of light and Mars' light averaged out as it is spread across the variations in our atmosphere.

Saturn completes the trifecta, low in the southeast, but worth a glance if you are already out to see Jupiter. Mercury and Venus are deep in the Sun's glare. Watch early in March as these two pop up together into bright evening twilight.

At plus seventh magnitude, the two brightest of the not-really-members of the planet club are Minor Planet Ceres, near Mars in our skies, and asteroid Vesta, in the evening skies in Cancer. The Dawn spacecraft has visited both of these tiny worlds, and is still orbiting Ceres. Ceres and Mars are almost the same distance from Earth this month, but Mars is seven times larger in diameter.



Jan 31



Feb 7



Feb 15



Feb 23

No talk of 'supermoons' this month! February's 28 days are shorter than the lunar 'month'. With the lack of a full moon in February, there may be little note of lunar perigee occurring just two days and ten hours before the next full moon on March 1st. Zero magnitude Regulus seems to hover just under the barely-less-than-full moon on the 1st. On the morning of the 11th, Saturn, looking more like a flying saucer than Regulus, floats under the thin moon.

The Milky Way still arches high across our evening skies. We are looking out the backdoor of our galaxy, so the pale stream of stars is thinner than the summer-side view. We are lucky to have the Orion arm of the galaxy draped across our sky. Having this relatively nearby swath of stars and gas and dust in the extended darkness of winter nights makes this season so anticipated by stargazers.

Eclipse fans only get a partial solar eclipse on the 15th, visible from Antarctica and southern South America. Our next chance is a midnight total lunar eclipse in January 2019. The last quarter Moon sits between Jupiter and Mars in our morning skies on the 8th. A tiny crescent Moon, at lunar apogee, points to Saturn on the 11th. The International Space Station has a series of evening performances through the 14th. Morning viewings start around the 25th.

Jupiter, Mars and Saturn will be wonderful in the evening sky this summer. They will appear as large as 45, 23.4 and 18 arcseconds wide. Think about booking that trip to the southern hemisphere winter! With the planets so high in the southern sky and the continuing advances in planetary photography, this year will be a banner year for planetary photos.



Mapping the Milky Way

Larry Faltz



WAA member Eric Baumgartner at the 2015 Medomak Astronomy Retreat. Photo by Babak Tafreshi.

Probably the greatest pleasure we can have under a dark sky is the thrill of seeing the arch of the Milky Way as it crosses from horizon to horizon.

Flammarion's monumentally influential (and very lengthy) *Astronomie Populaire* (1880) describes the feeling:

In the calm and silent hours of beautiful evenings, what pensive gaze is not lost on the vague windings of the Milky Way, in the soft and celestial gleam of that cloudy arch, which seems supported on two opposite points of the horizon and elevated more or less in the sky according to the place of the observer and the hour of the night?

Light pollution has hidden this marvelous sight from most of the populated areas of our planet [Please join the [International Dark-sky Association](http://www.darksky.org/)!]. The Milky Way can be made out when sky quality is darker than 20.2 magnitudes per square arc-second. A really dark night at our star party site at Ward Pound Ridge Reservation gets to 20.35, and we can definitely, if barely, see it on our best nights. Far away from civilization the Milky Way can be bright enough to cast a shadow.

The ancients didn't know what the Milky Way was, and so they invented all sorts of wonderful origin sto-

ries for it. Primitive cultures attributed it to a god, or a dog, or a little girl who spilled something, maybe fiery embers, or straw, or cornmeal, creating the glowing light. The Chinese thought it was a river separating two lovers. The imagination of our western cultural ancestors was equally creative. Eratosthenes called it Κύκλος Γαλαξίας (Kýklos Galaxías), the circle of milk. He attributed it to a trick played by Zeus on Hera. When Hera was asleep, Hermes places Zeus' illegitimate son Herakles at Hera's breast for her to nurse. She woke up suddenly and, startled, pushed the infant away, spilling her milk across the sky. Rome's affinity for Greek culture naturally converted it to the Latin *Via Lactea*, exactly translated into English as "Milky Way."

Ovid's *Metamorphoses*, that wonderful collection of stories about the transformations of gods, nymphs, heroes, villains and ordinary mortals, was written in 8 AD. In the first book, Ovid describes the creation of the world, and imagines the Milky Way as a divine roadway:

When the nighttime sky is clear, there can be seen
a highway visible in heaven, named
The Milky Way, distinguished for its whiteness.
Gods take this path to the royal apartments
of Jove the Thunderer; on either side
are palaces with folding doors flung wide,
and filled with guests of their distinguished owners;
plebian gods reside in other sections,
but here in this exclusive neighborhood,
the most renowned of heaven's occupants
have *their* own household deities enshrined;
and if I were permitted to speak freely,
I would not hesitate to call this enclave
the Palatine of heaven's ruling class.

(Translation by Charles Martin, 2004)

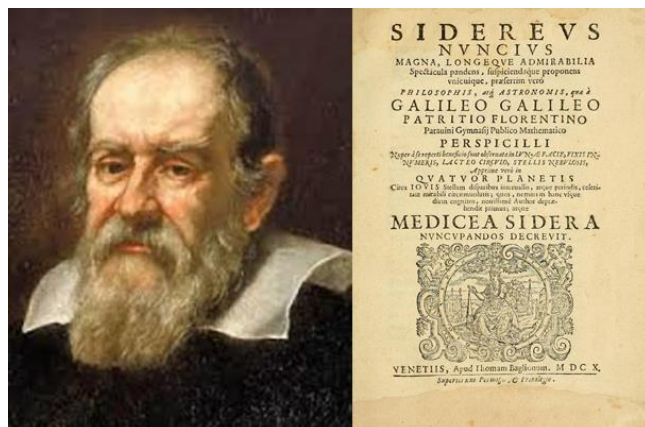
Metamorphoses was written after Emperor Augustus banished Ovid to the outer reaches of the Roman Empire (the Black Sea to be exact) in 8 AD because he was apparently offended by Ovid's rather lascivious poem *The Art of Love*. With the *Metamorphoses*, Ovid hoped to get back into Augustus' good graces, thus the reference to the Palatine, the hill near the Roman Forum where Augustus' palace was built, a few ruins of which remain today. It didn't work: Ovid lived out his days in the seaside town of Tomi, now the Roma-

nian city of Constanta. The *Metamorphoses* may be the most influential book in western culture, the source of many familiar Greek myths and the inspiration for innumerable works of art, opera, ballet, plays and novels. If you want to understand many references in Shakespeare, it helps to have read Ovid, as all educated people did, once upon a time.

Less allegorical explanations for the Milky Way were catalogued by the 1st century Roman poet Marcus Manilius. His poem *Astronomica*, primarily intended to support the practice of astrology, lists a number of possible physical explanations for the Milky Way. It might be the seam where the two halves of the heavens are joined, or a crack where they are coming apart. It could be the ashes left in a former path of the Sun where it scorched the sky in transit. Manilius cites the 5th century BC Greek philosopher Democritus, developer of the atomic hypothesis, as considering the Milky Way to be a mass of faint stars. As usual, a Greek philosopher got an aspect of astronomy right (think of Aristarchus), only for it to be forgotten for more than 1500 years.

Galileo turned his 1-inch aperture, 20-power cardboard tube telescope to the sky in the winter of 1609-1610. In the pamphlet *Sidereus Nuncius* (Starry Messenger), published in March 1610, Galileo wrote

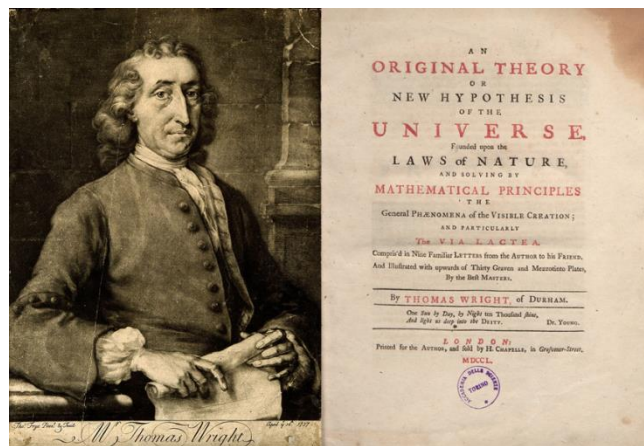
I have observed the nature and the material of the Milky Way. With the aid of the telescope this has been scrutinized so directly and with such ocular certainty that all the disputes which have vexed philosophers through so many ages have been resolved, and we are at last freed from wordy debates about it. The galaxy is, in fact, nothing but a congeries of innumerable stars grouped together in clusters. Upon whatever part of it the telescope is directed, a vast crowd of stars is immediately presented to view. Many of them are rather large and quite bright, while the number of smaller ones is quite beyond calculation.



In the last decade of the 18th century, William Herschel, with the assistance of his ever-patient and loyal sister Caroline, attempted to map the three-dimensional distribution of stars. Assuming that he could see stars in every direction, and that areas with lower star counts were closer to the edge of the galaxy, he accurately concluded that the Milky Way was a disk, but erroneously placed the Sun near its center. Among other problems, he had no knowledge of interstellar dust and its extinction effect on starlight.

It was naturally assumed by most astronomers that the Milky Way was the entire universe. All of Messier's and Herschel's nebulae, catalogued between 1781 and 1799, were thought to be within our galaxy. However, Thomas Wright had suggested that there might be other "island universes" (Immanuel Kant's 1754 term) that mimicked the structure and dimensions of the Milky Way. Wright wrote in his 1750 treatise *An Original Theory or New Hypothesis of the Universe*,

...the many cloudy spots [nebulae], just perceivable by us, as far without our Starry regions, in which tho' visibly luminous spaces, no one star or particular constituent body can possibly be distinguished; those in all likelihood may be external creation, bordering upon the known one, too remote for even our telescopes to reach.



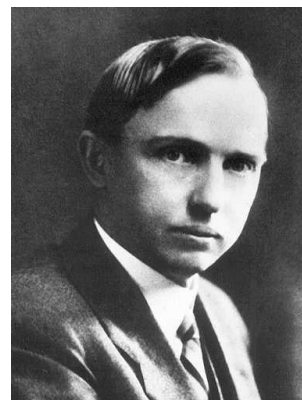
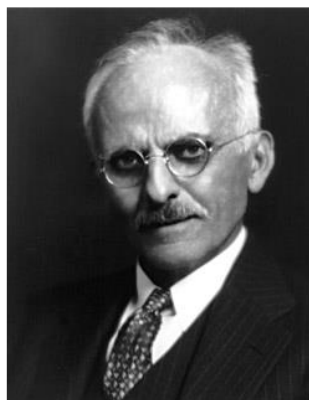
During the 19th century, astronomy was mostly concerned with stars and the new science of spectroscopy. It wasn't until 1845 that the spiral nature of the Whirlpool Galaxy, M51, was truly evident as the result of observations with Lord Rosse's 72-inch speculum-metal "Leviathan of Parsonstown" reflector, but it was commonly believed that it was a new planetary system in formation as described by the Kant-Laplace "nebular hypothesis." The words "universe" and "Milky Way" were essentially equivalent. In the 1906 edition of his book *Sidelights on Astronomy*, Edward

Pickering, Director of the Harvard College Observatory, wrote, "For us the great collection of millions of stars which are made known to us by the telescope, together with all the invisible bodies which may be contained within the limits of the system, form the universe." But Pickering, an astute scientist who was familiar with stellar spectroscopy, parallax and proper motion, hedged his bets: "Here the term 'universe' is perhaps objectionable because there may be other systems than the one with which we are acquainted. The term stellar system, is, therefore, a better one by which to designate the collection of stars [the Milky Way] in question." He goes on to credit Wright as the originator of that theory, although he says it did "not appear that this work [Wright's book] was of a very scientific character, and it was, perhaps, too much in the nature of a speculation to excite notice in scientific circles." Pickering goes on to suggest that the universe is of infinite age and extent, although were that to be true he asks why we do not see a point of light in every direction, since our line of sight will eventually encounter a star. Then the entire sky ought to blaze with light as bright as the Sun (this is famous as "Olbers' paradox"). Pickering cites calculations by Lord Kelvin regarding the distribution of stars and then suggests the possibility that "celestial spaces are pervaded by matter which might obstruct the passage of light."

In a chapter entitled "The Extent of the Universe," Pickering says that the Milky Way is "the foundation on which the universe is built." It's not the entire universe but is a major part of it, the scaffold upon which other stars depend. "The universe, so far as we can see it, is a bounded whole. It is surrounded by an immense girdle of stars, which, to our vision, appears as the Milky Way.... Could we fly out to distances equal to that of the Milky Way, we should find comparatively few stars beyond the limits of that girdle." Again, Pickering the scientist leaves open the possibility that the truth is otherwise: "We may fairly anticipate that each successive generation of astronomers, through coming centuries, will obtain a little more light on the subject—will be enabled to make more definite the boundaries of our system of stars, and to draw more and more probable conclusions as to the existence or non-existence of any object outside of it. The wise investigator of today will leave to them the task of putting the problem into a more positive shape."

Within 11 years, Harlow Shapley (who later succeeded Pickering at Harvard) calculated the dimensions of the Milky Way. He used the light curves from RR Lyrae stars and the distribution of globular clusters,

which are dispersed in a spherical halo around the core of the galaxy, to derive a diameter of about 100,000 light years. He placed the Sun about 30,000 light years from the center. These values, published in 1917, are close to the values accepted today. Although Vesto Slipher had demonstrated galactic red shifts in 1912 and found spectroscopic evidence that the Andromeda galaxy was rotating, distances to nebulae were still unknown until Shapley's work.



The Debaters: (L) Heber Curtis (R) Harlow Shapley

Shapley, then at Mount Wilson, and Lick Observatory astronomer Heber Curtis argued the question of whether "spiral nebulae" like M31 and M51 were part of our galaxy in the famous "Great Debate" of April 26, 1920 at the Smithsonian Institution in Washington. Shapley, surprisingly, took the position that these objects were members of our galaxy. Curtis believed that they were galaxies in the own right, external to and distant from the Milky Way.

Just 3 years later, Edwin Hubble, using the new 100-inch Hooker telescope at Mt. Wilson, determined the absolute magnitude of Cepheid variables in M31 and calculated that it was 900,000 light years away, placing it well outside the Milky Way. Hubble's estimate was low because there was no correction for the still-under-appreciated interstellar dust. The current value is about 2.5 million light years.

In 1852, Princeton astronomer Stephen Alexander had suggested that the Milky Way was a spiral, an idea amplified by English astronomer and Mars mapper Richard Proctor in 1869. W.W. Morgan thought that Lord Rosse himself believed that our galaxy was a spiral, but no direct evidence for this claim has been found. In 1900, Cornelis Easton, a Dutch journalist and amateur astronomer who was later supported by Jacobus Kapteyn, used visual and photographic measurements to suggest a somewhat disordered spiral

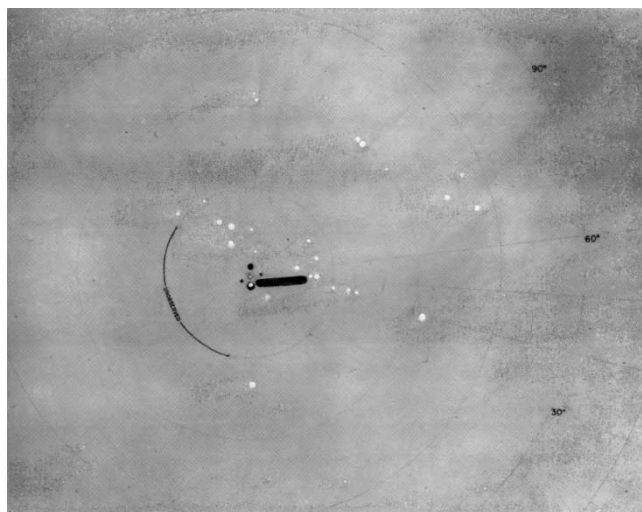
structure, with the center of the galaxy in the direction of Cygnus.

Two of the 400-pages of the *Cape Photographic Durchmusterung*. Not the most interesting reading! (Archived on the NASA Technical Reports server)

Kapteyn, who was at the University of Groningen, was able to determine that the Milky Way was rotating. He plotted the proper motion of stars, work that stemmed from his measurement of photographic plates made at the Royal Observatory at the Cape of Good Hope and published as the *Cape Photographic Durchmusterung*. This catalog lists the positions and magnitudes for 454,875 stars in the Southern Hemisphere. He found that the stars were moving in two opposite streams, publishing his analysis in 1904. Based on data from a multi-observatory stellar cataloging project begun in 1906, Kapteyn tried to estimate the size and shape of the universe, which he took to be the entire Milky Way, by statistically analyzing the distribution of stars, much as Herschel had done. His values, a diameter of 40,000 light years with the Sun 2,000 light years from the center, were wildly off because, like Herschel, he didn't know about reddening and extinction from interstellar dust. When the distance to M31 was calculated to be 900,000 light years in 1923, it was evident that if the Milky Way resembled M31 it would have to be much larger than 40,000 light years in diameter, supporting Shapley's 1917 results.

Optical parallax and proper motion (kinematic distance estimation) are limited tools in a galaxy as large as ours. Fortunately, the galaxy is mostly made of hydrogen. Neutral (H I) and ionized (H II) hydrogen radiate at specific wavelengths. The spiral arms of the galaxy contain star-forming "OB regions," clusters of hot young stars embedded in hydrogen which is then ionized from the stars' radiation. When the hydrogen

nucleus (a proton) captures an electron to become a neutral atom, it emits a photon with a wavelength of 6562.8 Å, the familiar red hydrogen-alpha line. Red-sensitive photographic plates were utilized to capture images of these regions. Analyzing the distribution of young O and B stars and surrounding H II emission, William Wilson Morgan of the University of Chicago, with Stewart Sharpless and Don Osterbrock, showed that these regions of ionized hydrogen outlined parts of spiral arms.

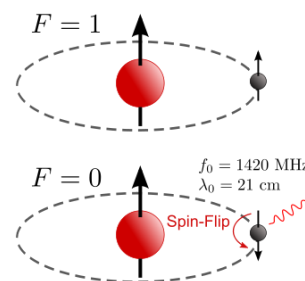


W.W. Morgan's data on the distribution of O and B stars. The Sun is at the center of the coordinates. (W. W. Morgan, S. Sharpless and D. Osterbrock, Some Features of Galactic Structure in the Neighbourhood of the Sun, *Astronomical Journal*.1953; 57:3)

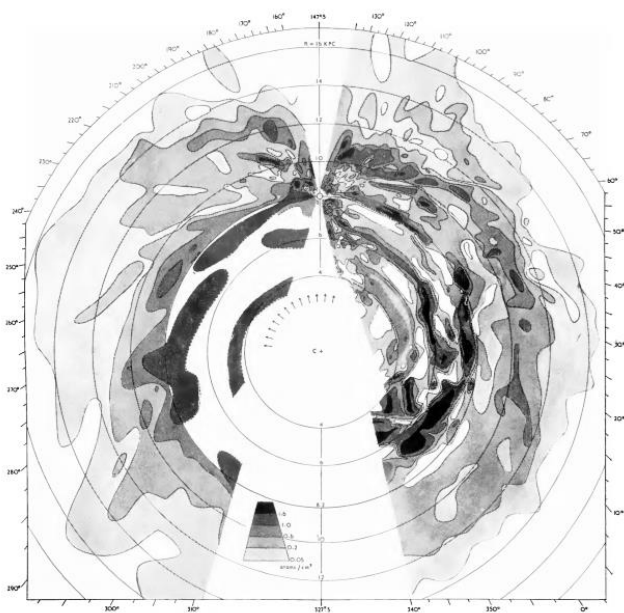
Ionized hydrogen only makes up about 10% of the hydrogen in the Milky Way. In 1932 Karl Jansky serendipitously discovered radio emissions from the galaxy. Grote Reber produced the first radio contour maps of the Milky Way in 1949. You can read more about the development of radio astronomy in the [January 2016 SkyWAatch](#).

The neutral hydrogen (H I) emissions result from the hyperfine splitting of the hydrogen atom, which is composed of a proton and an electron. These are spin ½ fermions. Their spins can be aligned or opposite

(they are not physically spinning as far as we know, but they do possess angular momentum and thus it made sense to call this quantum property "spin"). The aligned spin state has a slightly higher energy than the



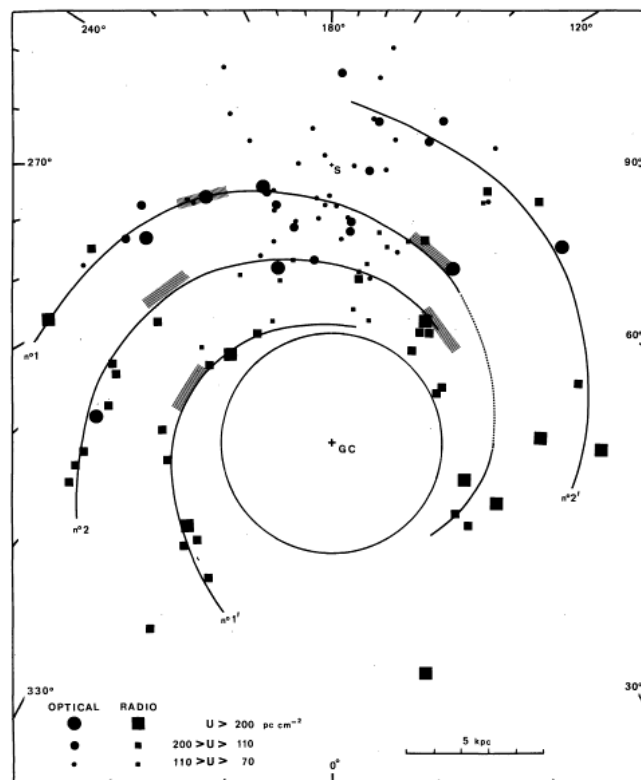
opposed state. When an electron flips, it emits a photon with a wavelength of 21.1061140542 centimeters (1,420,405,751.7667 Hz). The radiation is in the microwave region of the spectrum. Because there is so much hydrogen in galaxies, these emissions are fairly easy to pick up with radio telescopes, and they have the great advantage of passing right through interstellar dust. The hyperfine splitting phenomenon was predicted in 1944 by Hendrik van de Hulst and discovered by Harold Ewen and Edward Purcell in 1951 (Purcell, by the way, won the Nobel Prize for discovering nuclear magnetic resonance, the scientific basis for MRI imaging so ubiquitous in modern medicine). In 1954 van de Hulst, CA Muller and Jan Oort published the first evidence of the spiral structure of the Milky Way using the 21-cm signals.



Distribution of neutral hydrogen in the Milky Way, from Oort, JH, Kerr, FJ Westerhout, G, The galactic system as a spiral nebula, *Monthly Notices of the RAS* 1958; 118:379-389

Modern radio astronomy takes advantage of aperture synthesis, linking multiple dishes to provide much greater resolution than a single telescope. The Very Large Array (VLA) in New Mexico, now named for Jansky, is the most famous example. The Very Long Baseline Array (VLBA) consists of ten 25-meter dishes, the most westerly of which is on Mauna Kea in Hawaii and the easternmost on St. Croix in the Caribbean. It has an effective width of 8,611 km and a resolution of 5 milli-arcseconds at the 21 cm wavelength. These instruments map the fine structure of H I clouds but they can also be used to determine parallax, and thus distance, of these objects when images from op-

posite sides of the Earth's orbit are compared and measured against distant sources of radio waves.



Model of the Milky Way galaxy using ionized hydrogen emissions, from Georgelin, YM & Georgelin, YP, The spiral structure of our Galaxy determined from H II regions, *Astronomy & Astrophysics* 1976; 49: 57-79

In addition to atomic and ionized hydrogen, radio telescopes can detect emissions from molecules. Many molecular species are associated with star-forming regions which are located in the galaxy's spiral arms. The photons come not from isolated orbital electron transitions in the atoms but from vibrational modes in the molecules. The bonds between atoms can stretch and twist. These movements are quantized at specific energy levels. Transitions result in the absorption or emission of photons of specific, well-characterized wavelengths.

The intensity (and therefore the detectability) of these molecular emissions are enhanced when the environment of the molecules permits them to act as masers. Masers are the microwave equivalent of lasers (which were originally called "optical masers.") The acronym "maser" stands for "microwave amplification by stimulated emission of radiation." The first maser was made in 1953 by Charles H. Townes, James P. Gordon, and H. J. Zeiger at Columbia University, using ammonia (NH₃). Masers are essentially electromag-

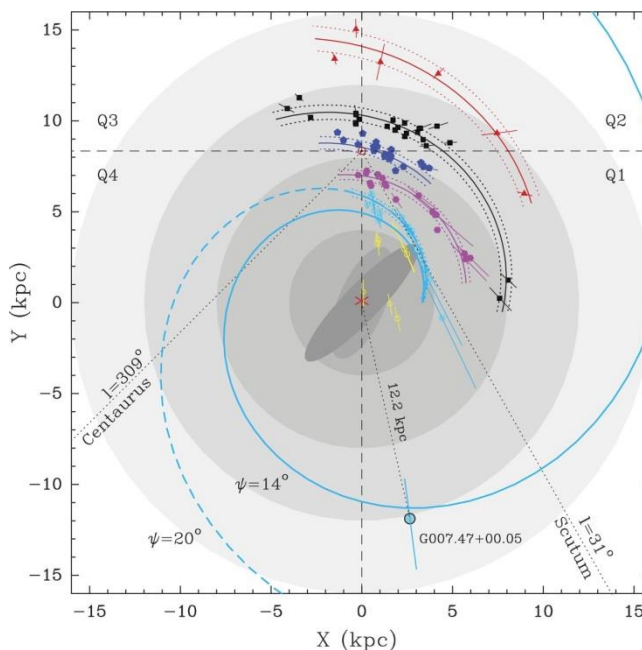
netic chain reactions. When an atom or molecule is excited to a higher energy state, it will usually decay in about 10^{-8} seconds. However, sometimes they achieve a “metastable” state lasting as long as 10^{-3} seconds. Masers and lasers take advantage of that longevity. Molecules in a resonant microwave cavity are excited to a metastable energy state by a source of photons with just the right energy. Before they can radiate a photon and return to a lower energy state, a second photon of the same energy is absorbed, and the subsequent decay results in the emission of two photons. The behavior of the molecules and photons in the cavity amplifies the emitted radiation.

Masers occur in space, even though there is no actual resonant cavity. The first astrophysical maser was discovered in 1965. At that time, molecules were not known to exist in space, and so the emission line at 1665 Mhz was thought to come from “mysterium.” It was eventually identified as coming from the hydroxyl radical OH. Among the species detected in astrophysical masers are H₂O, CH₃OH (methanol), SiO and HCN (hydrocyanic acid). Astrophysical masers can arise in comets, planetary atmospheres, stellar atmospheres, star-forming regions, supernova remnants and galaxies. Emissions from masers, like that of atomic hydrogen, can be examined with radio telescopes and their positions confirmed by parallax.

One problem that confronts Milky Way cartographers is that the central 20 degrees of the galaxy is dense and full of dust, hiding objects on the side opposite our solar system from visual observation. In addition, the rotation around the galactic center of objects in front of or behind the core would be perpendicular to our line of sight, which means they can’t be accurately measured, and so kinematic distance estimation is useless. Radiation from masers is in the microwave region and can pass through denser parts of the galaxy without significant attenuation.

In a remarkable feat, a group using the VLBI to map maser emissions in the Milky Way identified a star forming region on the opposite side of the galactic center from the solar system. Astronomers from the Max Planck Institute in Germany and the Harvard-Smithsonian Center for Astrophysics, participating in the VLBI’s Bar and Spiral Structure Legacy (BeSSel) Survey, observed a molecular cloud named G007.47+00.05 and plotted its location via trigonometric parallax against distant radio sources. Water maser emissions at 22.2 GHz were detected between March 2014 and March 2015. The parallax angle for

this object was 0.049 ± 0.006 milli-arcseconds, corresponding to a distance of 20.4 kiloparsec or 66,000 light years. That places it on the other side of the Milky Way’s central bulge at a far greater distance from the galactic center than the Sun. It is likely to be in the Scutum-Centaurus arm of the Milky Way as it spirals around the “back” of the galaxy.



Plan of the Milky Way. Sanna, A, et. al., Mapping spiral structure on the far side of the Milky Way, *Science* 2017; 358:227-230. Note G007.47+00.05 towards the bottom of the map. The Sun is at the intersection of the two dashed lines.

Most of the 150 molecular clouds mapped to date are within a few thousand light years from us and all but G007.47+00.05 are on our side of the galactic center. From these data and prior studies using the other distance estimation techniques, the Milky Way is now thought to have 4 main arms: Scutum-Centaurus, Sagittarius, Perseus and Outer. There are various spurs and knots. The Sun resides in the Local Spur, between the Sagittarius and Perseus arms.

The Gaia probe will release 3D coordinates for over 1 billion Milky Way objects in April 2018. Since these are optical observations, only the parts of the galaxy not obstructed by the central bulge will be surveyed, but the accuracy of the data will help define the local galactic structure with much greater accuracy than ever before.

An excellent web site with many maps, images and explanations about the Milky Way’s structure as currently understood can be found at galaxymap.org.

A New Way to Teach Astronomy

Daniel Cummings



Introduction

My name is Daniel Cummings. I am a new member of the WAA. I'm writing this to introduce myself to the group and share my new Astronomy outreach service to the community.

In 2016 I started a new EduTech company - *Star In A Star* - to share my ideas about a new way to teach astronomy to kids (and their adults). It is called Physical Astronomy. The guiding idea is that we can learn certain concepts better if we are physically present in the experience.

Most of my teaching ideas are born from this philosophy.

I am a "technology guy" by day and I have a deep and abiding passion for teaching and outreach. I can simplify complex scientific ideas, translate them into interactive experiences, and communicate well to a general audience.

I have been an exhibit designer at the Museum of Natural History, a toy prototyper at LEGO, an inventor, 3D software programmer at several startups, an engineering manager and a teacher.

I wrote this article to introduce myself and reach out to other educators in the local astronomy community. I would love to share ideas and zero in on what helps kids begin a lifelong interest in science in general and astronomy in particular.

How I got started teaching

My son was born in 2001 and as he grew I got to see the world through his eyes. By listening closely to his questions I found that he was really interested in the extremes of star size and distance and heat and color. I began researching how to teach basic astronomy topics and started teaching astronomy to kids in 2006. This was the year I encountered Guy Ottewell's 1000-yard model of the solar system (*aka* "The Earth as Peppercorn"). I realized that there was a world of science that could be opened up using immersive teaching and that the science would be understood experientially. I led the parents and kids from my son's local Cub Scout pack on this solar system experience and they loved it!

After a few outings like this I began to understand that people are thirsty for knowledge of the sky. So in 2009 I teamed up with a local high school Earth Science teacher and wrote an Educational Foundation grant to acquire 2 telescopes for the school district: a Dobsonian and a Schmidt-Cassegrain.



For the next two years we ran monthly star parties observing the Sun, the Moon, satellites, the planets, stars, the occasional comet, a lunar eclipse, and a few Messier objects. One evening we had 70 people attend!

As part of the curriculum and Scout advancement, I created and ran Physical Astronomy experiences for elementary and middle school level kids. These repeated outreach sessions gave me great insight into the kinds of things that people (of all ages and backgrounds) know or don't know. So, I started building out my repertoire of teaching material.

Teaching Examples

Here are a few titles to get you thinking in the Physical Astronomy frame of mind:

Life Stars - 9 visible exoplanets that might host life... aka "Stars like ours".

The Speed of Day - train your brain to see the speed of Earth's Rotation

Walk to Mintaka - See the equator in space!

Orion's Bellybutton - life size 3D depth model sculpture of the stars of Orion

Your Pinkies and Your Elbows - see the orbits of Mercury and Venus

Here is a more detailed example called *29.5 stones - The Moondance*.

Do you want to teach kids about the phases of the Moon?

We could tell them about the shapes and patterns and explain it with words and pictures. We could give them Oreo cookies and have them carve the phases for a (fun and yummy) treat!

But... instead of another flat picture lesson let's teach them a fun and scientifically accurate "dance" that enacts the geometry of the Sun-Earth-Moon system. Let's start by having them point at the Sun and then at the Moon. With that physical motion, they will gain a platform for experiencing the phases. Best of all they can conjure this method and recreate it later on. This is called the "Moondance" and is a tool that can be used easily every day!

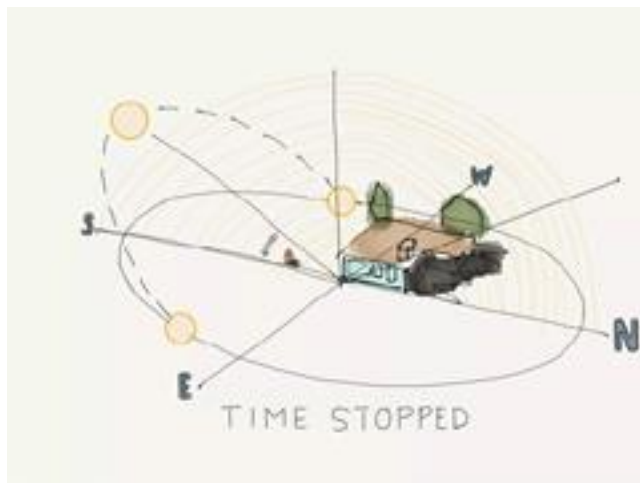


My best work follows this method: Let's create a pattern that kids (and their adults) can repeat and recreate themselves. Each time they look up at the sky they will still wonder "what phase is the moon in right now?" And now that they have the tools and the process they will have the ability to ask the "Why" and not just the "What." With these methods, the goal is to give them physical tools that they can use to recreate the experience and discover on their own. This can

form the basis of scientific thinking and encourage future science endeavors.

What if you could "see" the orbits of Mercury and Venus hanging like radiant necklaces around the Sun - even during the day? The process is a stepping stone towards seeing the entire solar system as a set of integrated rather than discrete parts. It starts with identifying several wintertime stars and using them as guideposts for imagining the actual span of the orbits - as if they were glowing up there as silver gossamer threads.

Or what if you could see and really sense the real speed of day?



Astronomy Koans

As I brainstormed new Physical Astronomy experiences and product ideas, I have developed a few "Astronomy Koans" - simple phrases which distill a Physical Astronomy concept to a single line and maybe to contain several levels of astronomy knowledge. These are phrases you can carry with you and recall as you explore the sky.

For instance you can point at any star and say:

"That star rose earlier today."

Especially to a practiced astronomer, the phrase seems simple and self-evident at first read - it's just saying "stars rise." However, I've learned that even this fact is a new idea to some well-educated people! But, there's more... read this phrase a few more times and the second meaning becomes apparent. This second meaning leads to a more profound understanding of the way the Earth moves. Memorizing and repeating this phrase can bring you a keener knowledge of Physical Astronomy.

Another of these Astronomy Koans is:

"The Moon moves toward the dawn."

I'll let you puzzle that one out.

And a third:

"Night is where you are."

This one helps you think of night as the geometric positions of the Sun and Earth rather than as a "time."

The Future

I have always been captivated by the sky. And I've come to realize that even though everyone has some knowledge of what's "up there" (no matter how much absolute knowledge someone possesses) they always want to know more. The study of the sky is endless! There are so many ways to bring that sense of depth to more and more kids. Let's continue so that we nurture the development of our next Halley, Herschel, Hubble, Einstein, or Hawking.

As 2016 ended I made a resolution for the New Year to start a company focused on Astronomy Education. As I look back on the last year, I see great progress. As a friend said to me recently as I was telling him about my new venture, "when you put yourself out into the world, good things happen."

I encourage you to do the same thing this year! Do you have a project or idea you've been waiting to start? Now is the time - you will be surprised at the results.

By the way... did you "get" the second meaning of the first Astronomy Koan above? "That star rose earlier today" It's about the Earth's orbit. Every star rises earlier each day. So, the Koan is a play on the word "earlier" to mean the star itself rose earlier today. And each day the star rises a bit earlier in the day. This progressively earlier "heliacal rising" is because of the orbital motion of the Earth and results in the seasonal stars. It's like saying "That star rose earlier today (than it did yesterday)." I know, I know, basic sidereal motion... to an astronomer... but to a kid, this concept opens a whole new world of observation!

I have a big goal with my Physical Astronomy education programs: to encourage people to observe the world from a new perspective and to transform them. We can do this by offering repeatable experiences - personal science experiences - that will shape the way they perceive our particular place in the universe.

Daniel Cummings – Founder, *Star In A Star* - an EduTech startup - <https://starinastar.com>

dancroton@gmail.com, 914-266-0033 cell

In the Naked Eye Sky: The Winter Circle (February 2018)

Scott Levine

There's this patch of sidewalk near my house that I love. It faces down along a curve on the side of a hill. It's a great spot, just dark enough. It's just above the rooftops farther down, where the trees thin out and the sky opens up to give an enormous, broad view to the south. As great as telescopes are, and as much as I love my almost comically huge binoculars, that's the place I always go at the end of a long day. Up there, away from the screens and the lenses, I can take a step back, and enjoy the stars with my naked eye; just me and the sky. Whether you're just starting out in astronomy or not, it's a great way to get to know the skies better, or to reconnect with them.

A few weeks ago, on a cold and breezy night after a long stretch of clouds, I sat outside with my daughter with the Moon waxing its way back into the evenings. During the gibbous-to-gibbous phases, I love to look, not just at the Moon itself, but at the stars around it,

even if some get washed out by the Moon's bright light.

As the Moon races toward the well-hyped January 31 full Moon, it cuts across a huge, bright asterism – an informal, but recognizable group of stars – called the Winter Circle. If you're not already familiar with it, it's so big that it takes three days for the Moon to get all the way across. Astronomy makes it easy to spend a lot of time speaking in superlatives, doesn't it? There's always a biggest moon or a most-cratered planet to talk about. The Winter Circle, too. There, in that ring of stars, are six of the brightest we can see from Earth.

First, find the constellation Orion. His bright stars and famous belt are easy to find against the blackness. They're standing tall in the south by mid-evening, figure around 8:30 or 9:00. Then, pull your gaze back, and widen your view. You'll see the Winter Circle

stretched over you, an old tattered blanket of sky. When it comes back to the sky each fall, it's like a bunch of old friends I haven't seen in a while. The rhythm of their names, Capella, Castor, Pollux, Procyon, Sirius, Rigel, Aldebaran, is enough to make me smile. Not everyone includes Castor, but I like to.

Hiding just below the covers, just behind the grand adjectives, is those stars' real magic. Other than Rigel, which forms Orion's right foot, they're all fairly close to our comfortable patches of sidewalk. All of the stars in Orion are off in farther parts of town, but thanks to a little bit of good luck, the rest are close enough to at least try to be able to grab onto a little. One by one, you can follow these stars through the ups and downs, through the milestones of a person's life.

Sirius, which is the brightest star in the entire night sky, is only about eight and a half light years away. So, if you have a third-grader handy, you can tell her that the light she's looking at left it right around when she was born.

Procyon, in Canis Minor, is 11 light years away. As we chatted, I told my middle schooler that light from the star she was pointing at was as old as she is. Pollux, in Gemini, is around 34 light years, maybe when people are getting married or first having kids. Golden yellow Capella, high above, in Auriga, is about 42 light years off. For now, it's my birth star. Its light left it not long after I was born. The light from Castor, also in Gemini, left it about 52 years ago. Finally, the bright red light from Aldebaran, the eye of Taurus, has been traveling through all of that unspeakable emptiness for 65 years, the lifetime of a retiree, holding his first grandkid. Rigel, though, is about 860 light years; far enough for two Yoda lifetimes.

Things in space are really, really far, and it's hard to grasp those distances. If you keep an eye on these few, you might be able to imagine the sky a little differently. Rather than seeing it all as a flat sheet overhead, you might be able to imagine it in three dimensions, with depth, some nearer, some farther.

It was getting late and cold as the clouds started to move back in, so we headed in and watched as the stars vanished. If you have a chance soon, maybe find

a good patch of sidewalk and head outside and have a look, too.

Scott Levine is a writer who lives in Croton on Hudson. You can find him online at:

<https://scottastronomy.wordpress.com> and Twitter @scottlevine13.



The Winter Circle (screen capture from Stellarium)



Art and Astronomy: Paris Observatory Medal

Larry Faltz



Elyse and I will often go to the Metropolitan Museum of Art on Friday or Saturday evenings, when it's open until 8:45 pm. Some of the less-frequented galleries are almost empty, allowing time and space for real contemplation. We were in the European Decorative Arts section on the Met's first floor on January 5th, looking at a display of 17th century French medals and small sculptures. Always on the lookout for astronomy-themed art, I found a medal dated 1667 commemorating the commencement of the building of the Paris Observatory. The medal was sculpted by Jean Warin (sometimes spelled Varin, 1606-1672), who was appointed head of the French mint in 1647. The "reverse" side of the medal was on display, showing the observatory building. The Met's on-line catalogue (currently listing 452,423 objects!) shows both sides of the 50 mm diameter gilt-bronze disk. The face has an image of King Louis XIV. The Latin inscription LUDOVICO XIV REGNANTE ET AEDIFICANTE meaning "Louis 14th reigning and building" wraps around King's image. Above the image of the observatory is SIC ITUR AD ASTRA, "thus we go to the stars", and below it "TURRIS SIDERUM SPECULATORIA" meaning "observing tower of the stars," in other words, "observatory."

The Paris Observatory was completed in 1671, just before the Royal Observatory at Greenwich in England (1675). It is located on the left bank in the 14th Arrondissement, a few blocks south of the famous Jardin de Luxembourg. The medal shows the observatory building sited on top of a fortress-like base, but the actual edifice is at ground level in a small Parisian park. The building has been renovated and enlarged several times. Unfortunately, it is not generally open to the public.

The first director of the Paris Observatory was Giovanni Cassini, discoverer of the Cassini Division in Saturn's rings and four Saturnian moons. Another famous director was Urbain Le Verrier, who calculated the position of the then-unknown planet Neptune, announcing his prediction on August 31, 1846, two days before British astronomer John Couch Adams reported his solution. Le Verrier passed the coordinates to German astronomer Johann Gottfried Galle, who found the planet on September 23, 1846.

The Paris Observatory has branches at Meudon, located between Paris and Versailles, where most of the staff work, and at Nançay, about 100 miles south of Paris, for radio astronomy. ■

Sixty Years of Observing Our Earth

Teagan Wall

Satellites are a part of our everyday life. We use global positioning system (GPS) satellites to help us find directions. Satellite television and telephones bring us entertainment, and they connect people all over the world. Weather satellites help us create forecasts, and if there's a disaster—such as a hurricane or a large fire—they can help track what's happening. Then, communication satellites can help us warn people in harm's way.

There are many different types of satellites. Some are smaller than a shoebox, while others are bigger than a school bus. In all, there are more than 1,000 satellites orbiting Earth. With that many always around, it can be easy to take them for granted. However, we haven't always had these helpful eyes in the sky.

The United States launched its first satellite on Jan. 31, 1958. It was called Explorer 1, and it weighed in at only about 30 pounds. This little satellite carried America's first scientific instruments into space: temperature sensors, a microphone, radiation detectors and more.

Explorer 1 sent back data for four months but remained in orbit for more than 10 years. This small, relatively simple satellite kicked off the American space age. Now, just 60 years later, we depend on satellites every day. Through these satellites, scientists have learned all sorts of things about our planet.

For example, we can now use satellites to measure the height of the land and sea with instruments called altimeters. Altimeters bounce a microwave or laser pulse off Earth and measure how long it takes to come back. Since the speed of light is known very accurately, scientists can use that measurement to calculate the height of a mountain, for example, or the changing levels of Earth's seas.

Satellites also help us to study Earth's atmosphere. The atmosphere is made up of layers of gases that surround Earth. Before satellites, we had very little information about these layers. However, with satellites' view from space, NASA scientists can study how the atmosphere's layers interact with light. This tells us which gases are in the air and how much of each gas can be found in the atmosphere. Satellites also help us learn about the clouds and small particles in the atmosphere, too.

When there's an earthquake, we can use radar in satellites to figure out how much Earth has moved during a quake. In fact, satellites allow NASA scientists to observe all kinds of changes in Earth over months, years or even decades.

Satellites have also allowed us—for the first time in civilization—to have pictures of our home planet from space. Earth is big, so to take a picture of the whole thing, you need to be far away. Apollo 17 astronauts took the first photo of the whole Earth in 1972. Today, we're able to capture new pictures of our planet many times every day.

Today, many satellites are buzzing around Earth, and each one plays an important part in how we understand our planet and live life here. These satellite explorers are possible because of what we learned from our first voyage into space with Explorer 1—and the decades of hard work and scientific advances since then.

To learn more about satellites, including where they go when they die, check out [NASA Space Place](https://spaceplace.nasa.gov). This article is provided by NASA Space Place. With articles, activities, crafts, games, and lesson plans, NASA Space Place encourages everyone to get excited about science and technology. Visit spaceplace.nasa.gov to explore space and Earth science!



This photo shows the launch of Explorer 1 from Cape Canaveral, Fla., on Jan. 31, 1958. Explorer 1 is the small section on top of the large Jupiter-C rocket that blasted it into orbit. With the launch of Explorer 1, the United States officially entered the space age. Image credit: NASA



Member & Club Equipment for Sale February 2018

Item	Description	Asking price	Name/Email
Celestron 8" SCT on Advanced VX mount	Purchased in 2016. Equatorial mount, potable power supply, polar scope, AC adaptor, manual, new condition.	\$1450	Santian Vataj spvataj@hotmail.com
Televue 2X Powermate	PMT-2200. 2" version, with 2"-1¼" eyepiece adaptor. 4 elements, 48mm filter thread. Al Nagler's improvement on the Barlow. Big, weighs 22 oz. New condition. In polypropylene bolt case. Link .	\$175	Larry Faltz lfaltzmd@gmail.com
ADM VCW Counterweight system	Clamping plate for a V series dovetail. 5" long ½" thick threaded rod for counterweights. Original ADM 3.5 lb counterweight plus a second weight. New condition. Lists at \$55. Link .	\$35	WAA ads@westchesterastronomers.org
Celestron Ultima-LX 5 mm eyepiece Celestron Ultima-LX 8 mm eyepiece	70° FOV, fits 2" and 1¼". 16mm eye relief. 28 mm clear aperture eye lens. 8 elements. Rubber coated. Ergonomic contours. Extendable twist-up eyeguards. Takes 1¼" filters. These are large, impressive eyepieces, but no longer in production! New condition.	\$60 each	WAA ads@westchesterastronomers.org
Meade 395 90 mm achromatic refractor	Long-tube refractor, f/11 (focal length 1000 mm). Straight-through finder. Rings but no dovetail. 1.25" rack-and-pinion focuser. No eyepiece. Excellent condition. A "planet killer." Donated to WAA.	\$200	WAA ads@westchesterastronomers.org
Interfit 487 large rolling storage bag	39½x22x16" fabric-sided standing gear bag with rollers, Velcro compartments. Excellent condition. Donated to WAA.	\$50	WAA ads@westchesterastronomers.org
Robotic planetary surface rover	Used. Currently not operational due to repairable mechanical and computer failures. A great do-it-yourself project! When functional, answers to name "Spirit." Pick up at Gusev Crater, Mars.	Free	NASA info@jpl.nasa.gov

Want to list something for sale in the next issue of the WAA newsletter? Send the description and asking price to ads@westchesterastronomers.org. Member submissions only. Please only submit serious and useful astronomy equipment. WAA reserves the right not to list items we think are not of value to members.

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