SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

May 2020

NGC 891 by Gary Miller

NGC 891, also known as Caldwell 23, was discovered by the Herschels in the night of October 6, 1784. The mag 9.9 spiral galaxy in Andromeda has high surface brightness, so it can be seen in 6-8" telescopes on a good night. It is 31 million light-years from us. It's tilted just 6 degrees from edge-on and its central dust lane is easily visible in images.

The galaxy has been called the "Silver Sliver" but more recently it was nicknamed the "Outer Limits" galaxy by the prolific astronomy author Stephen O'Meara, in his book *The Caldwell Objects,* because of its inclusion in the first episode (1963) of TV's *The Outer Limits*, which obviously made a big impression on the then-7 year-old O'Meara.

Note tiny mag 12.9 NGC 898, offset about one NGC 981-diameter at about 1 o'clock from the brightest star, HD14771, mag 6.72, spectral class K0. NGC 898 is much farther away, at 260 million light-years.

Gary's usual set-up at Ward Pound: Explore Scientific 127 mm triplet refractor on Losmandy GM811G Mount, auto-guided with PHD2, Canon T7i DSLR.

Due to the COVID-19 pandemic, all WAA group events are canceled until we are given notification by public health authorities that such group activities are permitted.

As of this writing, Ward Pound Ridge Reservation is open. Updated accessibility information can be found at https://parks.westchestergov.com/covid19-updates. WAA members may observe at Ward Pound Ridge with proper identification by notifying the park 24 hours in advance. Call the number on the back of your ID card, which was sent with your membership or renewal, and bring the card. Remember that social distancing is applicable on the observing field. It is reasonable for each instrument to be used by a single individual or family to prevent possible contamination.

WAA Members: Contribute to the Newsletter!
Send articles, photos, or observations to
waa-newsletter@westchesterastronomers.org

Editor: Larry Faltz
Assistant Editor: Scott Levine
Editor Emeritus: Tom Boustead

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

WAA Club Video

We prepared a 5 minute narrated promotional video, with lots of information about the club and images of members, for the "Virtual NEAF" that took place on Saturday, April 4th. We were apparently the only local club to make such a presentation.

After the show, we revised the video with some more images, including more members' astrophotos, extending it to just under 7 minutes.

The video can be seen on the opening page of the club web site, www.westchesterastronomers.org. It's not a slick production (it would be less authentic if highly produced), but it got great reviews from some of the members who saw it on the Virtual NEAF broadcast. Many of you will see yourselves or your work in it. We put it on a YouTube channel and linked to it so it would run on every browser and device that can display our site. Check it out!

Westchester Amateur Astronomers

New Members

Joseph Trerotola	Woodbridge
Alexandr Zaytsev	Holtsville

Renewing Members

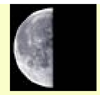
Paul Alimena	Rye
Garfield Boston	Yorktown

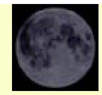
Also In This Issue

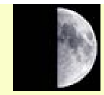
ALMANAC For May 2020

Bob Kelly, WAA VP for Field Events


Full
May 7

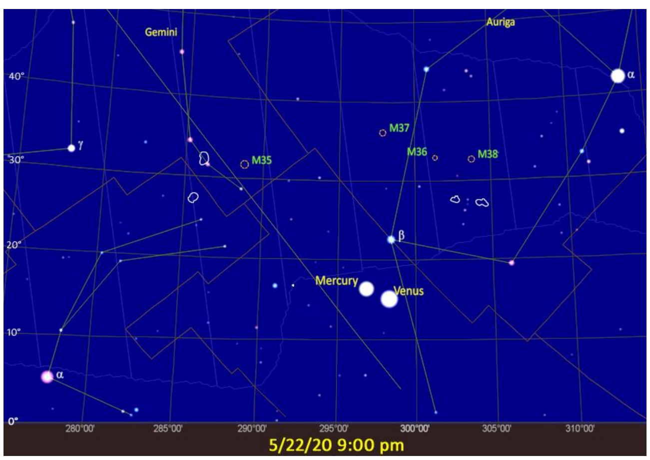

3Q
May 14


New
May 22


1Q
May 29

We start the month at the stroke of midnight on the 1st, when, by chance, Mercury and Uranus cross paths in the glare of the Sun. The SOHO C3 camera[1] may show us this conjunction. Run the movie version[2] to see these planets moving out of sync with the background stars.

Venus had a spectacular run in the evening sky the past several months. This sparkling planet appears to fall off the end of the table into the Sun's glare by the end of May. Watch Venus noticeably drop further toward the horizon each night. On its way out, it has some great scenes with Mercury and the Moon. Unfortunately it will NOT be lining up with Jupiter and the Moon on the 16th to make a celestial smiley face, as purported by some on the Internet. Jupiter, of course, is in the morning sky now, not anywhere near Venus.



Follow Venus downward as Mercury shoots upward to join it on the 21st and 22nd. In a telescope, compare Mercury, at 67 percent illuminated and 6 arc seconds wide, to Venus at 5 percent illuminated and 54 arc seconds wide. Mercury gains more altitude in the evening sky into early June. Get a photo of Mercury, Venus, and the almost impossibly thin Moon nearby, on the 24th or 25th. If you see both Venus and Mercury one evening, get up early the next morning and catch Mars, Saturn and Jupiter to get the Big Five brightest planets in one 24-hour period.

Venus will have the largest apparent size of any planet this year. Some observers can resolve the crescent with only their own eyes; many more can see it using binoculars.

If you have a solar telescope that shows some of the outer atmosphere of the Sun, get it ready for June 3rd. Venus is at inferior conjunction with the Sun around 2pm EDT, just 0.2 degrees from the Sun. Murray Paulson, in the Royal Astronomical Society of Canada's Observer's Handbook, wonders if specially outfitted telescopes could catch Venus silhouetted against the tenuous outer atmosphere of the Sun.

WARNING: Use only a solar telescope for this. Looking through a telescope or binoculars without proper solar safety filters in place could cause permanent vision damage. Never look directly at the Sun with the naked eye.

The Moon joins Jupiter and Saturn on the morning of the 12th. It should be a great sight in wide-angle binoculars. Jupiter and Saturn tease us by getting close enough to cover with one hand at arm's length, closest on the 18th. Just when you think they are coming together, they will move apart, just teasing us in advance of the great conjunction in December.

In the morning sky, Jupiter and Saturn move to the right (west) while Mars appears to do social distancing from its next two outer planets. Why is Mars running away from the big boys? Mars is moving higher on the ecliptic due to the combination of Earth's and Mars's motion round the Sun. Jupiter and Saturn will remain in the southern latitudes of the sky, at low declination, for the rest of the year. Mars will still be in that window where you have been watching the morning planets this spring. Jupiter and Saturn made a nice scene if you have a window out to the east-southeast unless you are frustrated by a hill or tree blocking the view from your COVID-19 shelter.

It's time to get an app for Jupiter or Saturn's moons or sign up at Sky&Telescope for their plots of outer planets' moons. The mornings of the 3rd and 28th

[1] https://sohowww.nascom.nasa.gov/data/realtime/c3/512/
[2] https://soho.nascom.nasa.gov/data/Theater/. Be sure to put in start and end dates.

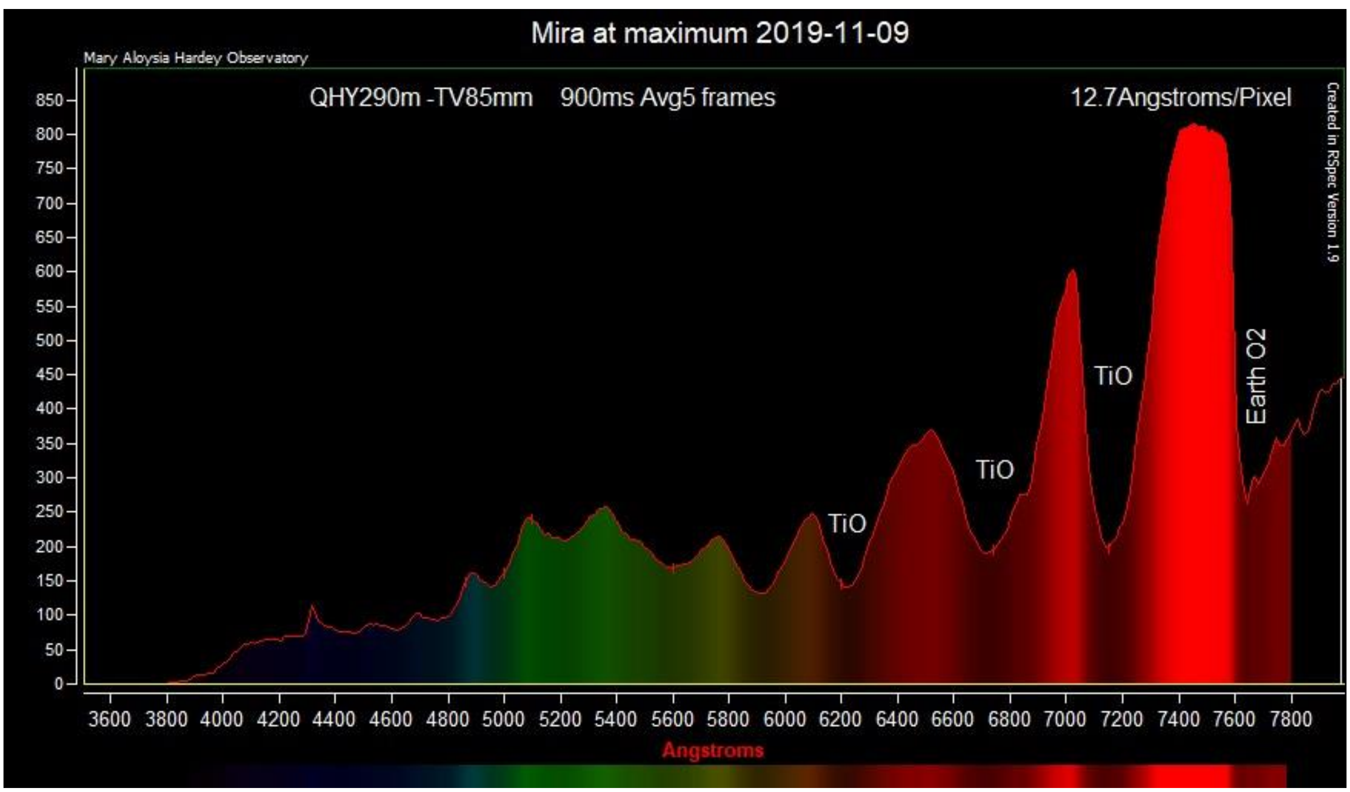
have lots of interesting action with Jupiter and its moons, including two moon shadows on Jupiter at once on the 28th. Saturn's brightest moon Titan (eighth magnitude) lines up on the inside of Iapetus twice this month. Around the 2nd they are to the southeast of the planet when Iapetus is showing its dimmer side (near magnitude +12) and near the 24th on the northwest side when Iapetus is closer to magnitude +10.

Comets come, brighten, fall apart. I'm concerned that by the time you read this it will be out of date! Comet C/2019 Y4 (ATLAS) was a promising contender, but appears to have fallen apart. Like a mid-season replacement on television, C/2020 F8 (SWAN) has a chance at brilliance. It'll be no more than ten degrees above the northeastern horizon in morning twilight, brightest in the middle of the month. While it is forecast to reach magnitude +3.5, binoculars will help find it. C/2017 T2 (PanSTARRS) has been consistently near eighth magnitude in Camelopardalis. By the way, let's just call Camelopardalis a camel. I can't see any of its stars, so I can't tell it's supposed to be a giraffe, which refers to a story about someone riding a camel.

Since I can't resist listing some unobservable events, the Moon will occult minor planet Vesta on the 24th around 11 a.m. I don't think anyone can observe an eighth-magnitude object in the daytime, but the books list it. Dwarf planet Ceres is the brightest of the little ones presently visible at night. It's hanging out in Aquarius in the morning sky at magnitude +9. The Moon puts itself between Mars and Ceres on the 15th.

In mid-May, the International Space Station has as many as five or six overflights a night. Before then, the ISS is visible in the dawn skies and after mid-month, in the evening skies.

Spectrum of Mira — Rick Bria



Mira (Omicron Ceti) is a pulsating variable star, actually part of a binary system. Its variability was first recorded in 1596. Its magnitude generally varies from +2.0 to +4.9 over a period of about 300 days. Most of its energy is emitted in the infrared, and its spectrum shows absorption by titanium oxide in its atmosphere, typical of red giants. Rick obtained this spectrum with a Star Analyzer 100.

Member Profile: Chris Plourde

Home town: I was raised in Chicopee, Ma. I've been living in New Rochelle for the past 14 years.

Family: I have a 19-year-old daughter, Julia, who is freshman at Skidmore College.

How did you get interested in astronomy? I've been interested in astronomy – in the most casual sense – since I was a child. My curiosity about celestial bodies and the stars was piqued by several early experiences: My parents took me to the Seymour Planetarium at the Springfield Science Museum in western Massachusetts when I was 4 or 5 years old. The show began with a theatrical "lights out," and that claustrophobic, absolute darkness terrified me. I remember crying. But then the dome lit up with a vast veil of stars, and I was mesmerized – and hooked. When I was 7, my father took me to see *2001: A Space Odyssey* during its initial run in the theaters in 1968. The movie's hypnotic procession of images held me spellbound, and I was never bored, even though I had no idea what was going on. I also followed the Gemini and Apollo missions on television in the 1960s and early '70s, and I was an early fan of the original "Star Trek." All of these elements of my childhood stoked my fascination with the heavens.

Do you recall the first time you looked through a telescope? What did you see? The first telescope that I looked through was an inexpensive refractor – the kind you could get in the toy section of any department store – that my parents bought me as a gift when I was 10 years old. With a short, somewhat wobbly tripod, it was good only for bird-watching, spying on the neighbors and gazing at the Moon. During the Apollo 16 and 17 missions in the spring and late autumn of 1972, I pointed it at Earth's satellite in the misguided hope that I'd be able to spot the Lunar Module and see the astronauts cruising around in their bitchin' lunar rover. Disappointment ensued, and the telescope spent most of the remainder of its life in a closet. I took my first look through a serious telescope in 2009, when my daughter and I visited the Lowell Observatory in Flagstaff, Az. We saw Saturn and its rings, and that entrancing view rekindled my interest in astronomy.

What's your favorite object(s) to view? It's a tie between Saturn and Jupiter with its brood of Galilean moons. When I take my telescope out, either at WAA's star parties or on my own, I consider it a successful night even if I'm able to view only one of those two planets.

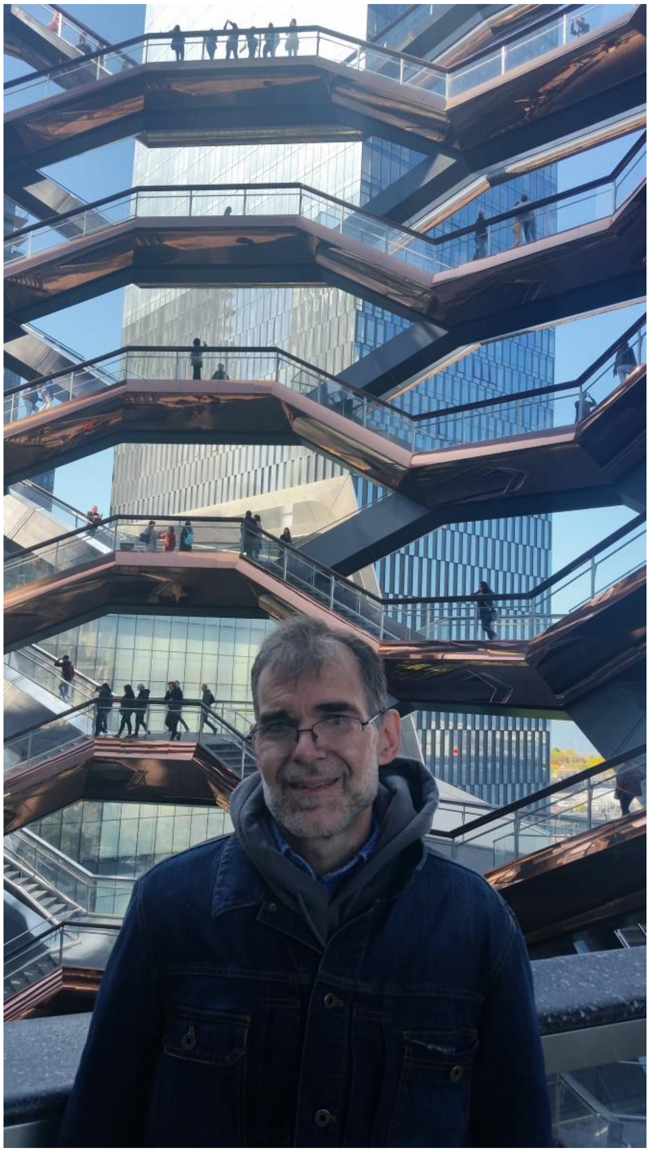
What kind of equipment do you have? I have a Schmidt-Cassegrain go-to scope, a Celestron NexStar 5SE. I confess: It was an impulse buy. In the summer of 2018, I had amassed a bunch of Amazon gift cards from friends and relatives and was wondering what to spend them on. Mars was particularly close to Earth during that period – so close that I could spot it in the sky with the naked eye even from light-polluted Midtown Manhattan. That got me to thinking about telescopes, and I looked up reviews of them on the Wirecutter website, which recommended the NexStar 5SE for beginners. I ordered the 'scope and have never regretted it. I've since amassed a number of eyepieces. My favorites are an 8-24 mm Celestron zoom, a 32 mm Celestron Omni Plössl and a wide-field 15 mm Celestron Luminos.

What kind of equipment would you like to get that you don't have? I'd like to get something with a bigger aperture for better deep-sky viewing. I have had some modest success observing star clusters, galaxies and nebulae with my 5SE, but more often than not, they look like mere smudges of light. I've been accumulating Amazon gift cards again, so suggestions are welcome for my next purchase.

Have you taken any trips or vacations dedicated to astronomy? Tell us about them. No. Right now, my priority is helping to put my daughter through college, but eventually, when I'm able to set aside money for travel again, I'd like to indulge in some astro-tourism.

Are there areas of current astronomical research that particularly interest you? I am keenly interested in the search for signs of life, past or present, in our own solar neighborhood, particularly on the Jovian moon Europa, on the Saturnian moons Titan and Enceladus, and, of course, on Mars. Even the discovery microbes, or microbe fossils, would radically transform how we view our place in the universe.

Do you have any favorite personal astronomical experiences you'd like to relate? I have two favorites. The first was a date in 1996: I took my girlfriend at the time to Robert Moses State Park at night so that we could view the Comet Hyakutake through my binoculars. About a year later, she told me she had found the outing very romantic.



The second experience was my first star party with WAA, in August 2018. It was also the first time I used my newly purchased NexStar 5SE. As I pulled into the parking lot at Ward Pound Ridge, buyer's remorse was already starting to set in, and I felt foolish, doubting whether I'd be able to spot anything that night. As the sky darkened and celestial objects began to wink into view, I could hear Bob Kelly call out their locations in the sky. The first one was Jupiter. I skewed my scope to it – just a pinprick of light to the naked eye – and I brought it into focus: As the fuzzy doughnut of light resolved into a well-defined planet with familiar, clearly delineated bands, the sight took my breath away. I couldn't believe that I'd been able to pull it into view. In addition to looking at Jupiter that night, I also observed Venus (at a quarter phase, I believe), Saturn and its rings, and Mars – all within 90 minutes of my arrival in the parking lot. Suddenly the night sky seemed much more accessible. I've been to almost every WAA star party since then.

What do you do (or did you do, if retired) in "real life"? I'm a senior staff editor on the Print Hub at The New York Times. I'm part of a team that preps articles for the print version of the Times. We provide a final layer of editing, trim text to fit the space, write headlines and captions, and inspect and sign off pages.

Have you read any books about astronomy that you'd like to recommend? I've read The Stars: A New Way to See Them and Find the Constellations, both by H.A. Rey, one of the authors of the "Curious George" children's books. Unfortunately, these books, originally published more than 60 years ago, assume easy access to dark, clear skies. This assumption limits their usefulness.

How did you get involved in WAA? I saw a listing for one of the organization's star parties in the newspaper the Journal News.

What WAA activities do you participate in? I participate in the star parties, the monthly meetings and the annual picnic. I took part in one outreach event last summer at Onatru Farm Park in Lewisboro.

Full Moon rising over Long Island Sound

From Manor Park in Larchmont 4/7/20.
Photo by the editor.

In the Naked Eye Sky — Scott Levine

On a warm, clear night a week or two ago, I got dinner on and off the table and stepped out to my favorite south-facing spot. As the last of the shadows dissolved around me, my phone rang. Not video, just a regular voice call from an old friend. While star after star popped into the night, like bubbles in a glass of champagne, we chatted about old times and talked about today's scary, abbreviated life.

While we all cope with the turmoil around us and look for consistent and reliable things, there's good news! The skies haven't been canceled! We can still look out across the galaxy together, and take comfort in knowing, with some minor differences in the details, we're all connected to the same sky, and it connects us. Each night it's the same all over Westchester, across the country, and around the world. The exact placing and timing of the stars might change, but the patterns themselves are the same. Maybe we can use this uncomfortable time to have something of a social distancing star party; invite anyone you want!

First, let's look to the north and find the Big Dipper. As May comes along, it's high toward the top of the sky, upside down, pouring soup onto your neighbors' roofs. If you watch from night to night, or even hour to hour, you'll see the Dipper turn, and revolve counterclockwise around the sky. It's there, as steady and reliable as the sky itself, every night of the year. Six months from now, it'll be just above the horizon, catching the soup it poured this month.

Next, follow the curve of the Dipper's handle away from the bowl. The next bright star you see is Arcturus, the second brightest we can see in our night sky. It's an old red giant, nearing the end of its life. Billions of years from now, when our Sun has used up most of the hydrogen that powers it, it will cool and grow into a star similar to Arcturus. So, in a way, looking at Arcturus is like looking at our own future.

Do you ever spot the Moon one night and point to remind to yourself — maybe a little too loud for passersby — that it'll be in that seemingly blank patch of sky tomorrow night? The next full Moon is on May 7. Let's look for it a few nights before and after, and notice when it rises each night, and what the far-off stars around it look like when it does. What phase is it in? How does the terminator, the line that separates the lunar day from night look? Is it curved? Can you see any shadows stretching across its face?

Or maybe do my favorite thing of all: just look. Don't worry about names, or distances, or constellations or any of it. Just look, and imagine... space. What's it like there or there, or there? What's hiding in that seemingly empty gap overhead? Let your mind go anywhere it wants.

Whether you call a friend and look up, or just take some comfort knowing that we're all looking at the same thing, the consistency of the sky is a great tool for togetherness and getting through social distancing.

It's tough these days, but little by little we're making our way though. I hope you can look up this month. Drop me a line and let me know what you see. We'll be on the other side, and be better for it, before we know it.

Scott Levine's astronomy blog, *Scott's Skywatch*, can be found at https://scottastronomy.wordpress.com/ or email him at astroscott@yahoo.com

NASA's Juno mission captured these elaborate atmospheric jets in Jupiter's northern mid-latitude region on April 20, 2020. This detailed, color-enhanced image reveals a complex topography in Jupiter's cloud tops. If you look closely, relatively small, bright, "pop-up" clouds — which rise above the surrounding features — stand out at the tops and edges of the swirling patterns, while the darker areas nearby reveal greater depth.

In Defense of Astronomer Royal Rev. Dr. Nevil Maskelyne Robin Stuart

In its March 2020 issue, *Sky & Telescope* magazine published an interesting article by Ted Rafferty entitled "Captain Cook's Astronomy." Rafferty is a retired US Naval Observatory staff member. Unfortunately the article contains some basic errors on how to convert between time and degrees of longitude. It incorrectly describes the tables of lunar distances that were published in the *Nautical Almanac* as being those that would be "observed from Greenwich," when in fact that they were geocentric distances. In addition the article echoes the widely circulating view that in the story of finding longitude Astronomer Royal Rev. Dr. Neville Maskelyne plays the villain. Rafferty writes "Maskelyne also evaluated the contenders for the Longitude Prize, and his bias for using lunar distances delayed the acceptance of John Harrison's H4 chronometer as the best method for determining longitude at sea." The notion appears to have arisen in the early 20th century and was further propagated and popularized by Dava Sobel's successful 1995 book *Longitude*. It is an idea that makes for a good, easily digestible soap opera-style account of history but it is a reputation that Maskelyne does not deserve. The statement in Sky & Telescope quoted above simply falls apart when subjected to any sort of logical scrutiny.

The Longitude Prize

To find latitude at sea, all a ship's navigator need do is to accurately measure the altitude above the horizon of a celestial body as it crosses the meridian. This would normally be done with the Sun at the so-called *Noon Sight*, but stars or planets could also be used. Combining the true altitude with the object's declination yields latitude by simple addition or subtraction.

Finding longitude is a whole different story. From the rotating Earth, celestial objects are seen to be in constant motion, tracing out arcs from east to west. If the observer's latitude and an object's declination are known then its altitude above the horizon depends only on the observer's longitude and the time (GMT by convention). Conversely, measurement of an object's altitude yields longitude - but you need to know the time.

The ability to find longitude offered significant economic and strategic advantages. Without it ships were often forced to undertake *parallel sailing*. First sail to the latitude of your final destination and then sail along that parallel of latitude until landfall is made. This means traversing two sides of a triangle compared to the direct route. Being able to find longitude would provide benefits in the speed and efficiency with which goods and military resources could be transported around the globe.

So it was that through the Longitude Act of 1714 that the British Parliament launched the Longitude Prize offering substantial monetary rewards for advances toward a viable solution to the problem of finding longitude and the ultimate award of £20,000 for a method with an accuracy of 30 arc minutes (30 nautical miles at the equator) or better. The Longitude Prize previously was discussed in my February 2019 SkyWAAtch article.

Finding Longitude: What Time is it?

As noted above, to find longitude you need to know the time, which in turn requires having something that can act as a clock. A mechanical device, a chronometer, would do nicely if one could be constructed that ran reliably over long periods at sea. Alternatively the time can be obtained by astronomical observation. Suitable types of observations, such as timing the eclipses and occultations of the moons of Jupiter, are feasible on land but could not be carried out on the heaving deck of a ship. The position of the Moon changes sufficiently rapidly against the background stars that measuring its distance from the Sun, a star or a planet allows the time to be determined. This is a measurement that can be performed shipboard and with instruments, octants, that were already part of the navigator's standard kit.

Let's compare the two approaches for getting the time as things stood in the mid-18th century.

Time by Chronometer

Just read the time off the clock face. What could be easier? Well you've got to actually have a chronometer for starters. Despite his brilliant innovations in the field of horology, John Harrison had made three unsuccessful attempts over the course of nearly thirty years to win the Longitude Prize with his chronometers H1, H2 and H3. However for shipboard use their design was found to be fundamentally flawed. Even if suitable mechanical chronometers could be constructed they would likely be expensive and challenging to produce in the numbers needed to be widely distributed across the fleet. A mechanical chronometer requires a great deal of care and attention to operate reliably. If it stops, you are lost, literally and figuratively. As Isaac Newton pointed out, “a good watch may serve to keep a reckoning at sea for some days and to know the time of a celestial observation; and for this end a good Jewel may suffice till a better sort of watch can be found out. But when longitude at sea is lost, it cannot be found again by any watch.”

Portrait of Rev. Dr. Nevil Maskelyne (1732-1811) by Dutch artist Louis François Gérard van der Puyl (Royal Society, Carlton House Terrace, London). His left arm rests on a copy of *Maskelyne's Observations Greenwich* and he holds a diagram of a prismatic micrometer. The Royal Observatory at Greenwich is shown in the background.

Time by Lunar Distance

To use the Moon, weather permitting, three skilled observers simultaneously measure altitude of the Moon and another body. Then you sit down with your copy of the *Nautical Almanac* (which takes the distance of the Moon into account) and logarithm tables, do some calculations and out pops the time. On the upside, because this method uses instruments already in the hands of any navigator, it can be quickly and easily rolled out across the fleet. The problem is that the motion of the Moon is complex, not just a simple ellipse, and so the positions in the almanac could not yet be generated with the required level of accuracy. Moreover the calculations could take hours.

Despite the implication of Rafferty’s statement, no amount of bias could possibly blind Maskelyne to the fact that it would be easier and better to just to read the time from a clock than to extract it by observation and calculation.

After his H4 chronometer had undergone requisite vetting John Harrison did eventually receive a total payout of £23,065 from the Board of Longitude. The “delay” mentioned in the *Sky & Telescope* article probably refers to the requirement that Harrison needed to show how his chronometer could be replicated before he received the final £10,000 installment of the prize money. Is this evidence of a bias by Maskelyne, or were the Commissioners of the Board of Longitude merely exercising due diligence over the public funds that had been placed in their care? Would Harrison’s single example of a working chronometer, the H4, without information as to how it works and how more can be made, really represent a viable or meaningful solution to the problem of reliably finding longitude? It is not unreasonable that the Commissioners would want to make quite sure they had a practical solution that could be rolled out across the fleet before making the full disbursement. Despite his admiration for Harrison, Humphrey Quill, Senior Warden of the Clockmakers’ Company and author of a 1966 biography of Harrison, showed a generous understanding of Maskelyne’s and the Board’s decisions, given the risk of gambling a large amount of money on a unique device.

Predictably, the early chronometers were rare, expensive and delicate beasts that demanded considerable effort be devoted to their care and feeding. Great tomes were written on this subject (Shadwell 1861). As a case in point, even in the 20th century, Shackleton's Imperial Trans-Antarctic Expedition of 1914 set out with 24 chronometers onboard. After a total of eight months under way and trapped in the ice, despite the best possible care, attention and monitoring, they were found to be in error by about 4½ minutes which is, in fact, remarkably good for devices of the day (Bergman and Stuart 2018). This error could only be determined by astronomical observation through timings of lunar occultations which is actually a special case of the lunar distance method. For reference, 4½ minutes of time corresponds to over a degree in longitude or 18.6 nautical miles at their latitude of 74° South.

Popular accounts may give the reader the impression that the advent of Harrison's chronometers was a "slam dunk" and that the "misguided" lunar distance method vanished off the face of the Earth. That is far from the case. The lunar distance method was regularly used through the 18th and 19th centuries, although with declining frequency as chronometers became more readily available. Drawing on advances by Leonhard Euler, in 1755 the German astronomer Tobias Mayer produced tables predicting the Moon's position with sufficient accuracy to make lunar distances a viable method. Maskelyne's publication of the first *Nautical Almanac* (1767), containing tables of lunar distances, and his *Tables Requisite* (1767) greatly streamlined the calculations needed. Eventually additional clever shortcuts were invented and further tables published that reduced the work required down to a matter of minutes and a few lines of figures in the logbook. The *American Nautical Almanac* published by the US Naval Observatory continued to print tables of lunar distances for this purpose until 1911. Maskelyne's influence and bias was far reaching indeed!

Maskelyne: The Man and the Myth

Neville Maskelyne was born in 1732, the son of a clerk to the British Secretary of State. He entered Cambridge University in 1749 and was elected Fellow of Trinity College in 1756. Although by his own admission he studied mathematics as a means to his end of pursuing astronomy, he was highly accomplished and very well regarded in that field. The Royal Society selected Maskelyne to be an observer on the 1761 Transit of Venus expedition to St. Helena Island. Although the event was clouded out, it gave him the opportunity to develop his skills in making astronomical observations both onshore and at sea. As a result the Board of Longitude appointed him to conduct trials of three contenders for the Longitude Prize, one of them Harrison's H4, on a voyage to Barbados in 1763-64.

Nevil Maskelyne was appointed Astronomer Royal in 1765. He was based at the Royal Observatory in Greenwich, which was founded in 1675 to improve astronomy for the purpose of aiding navigation. Maskelyne worked hard to make it a more orderly and accountable institution. He set up a constant regime of utilitarian observations and oversaw their publication.

An achievement of which he was justifiably proud was the annual publication, starting in 1767, of the *Nautical Almanac*. To calculate the table entries he set up and employed a network of up to 35 human *computers*. Calculations were performed by two independent computers and sent to London for the scrutiny of the *comparer*. The computers were distributed across the length and breadth of England to discourage cheating by copying results, which had occurred in the early stages of the project. After all, the cost of getting the numbers wrong could be paid for in sailor's lives. This geographically distributed network of computers must surely be considered the 18th century precursor of the Internet!

In 1775 Maskelyne was awarded the Royal Society's prestigious Copley Medal for measurements of the gravitational attraction of the Scottish mountain Schiehallion in Perthshire, Scotland (see the December 2018 SkyWAAtch). This involved having two observers positioned to the north and south of the mountain who precisely measure their latitudes by the meridian transit of a star. The results they will obtain are affected by the deflection of the observers' verticals due to the gravitational attraction of the mass of the mountain. Comparing the difference in the latitudes obtained to the difference found by land surveying allows the deflection to be extracted. The measurement yielded a value of the mass and hence average density of the Earth within 20% of today's value. This was important because astronomical observation had provided values for masses of solar system bodies as a ratio of that of the Earth, so these values could now be made absolute. Moreover since the Earth's average density was found to be greater than that of rock, it was correctly surmised that it must possess a metallic core.

The exact reasons behind Maskelyne's current ill repute are somewhat murky. For a more complete exposition of its possible origins I recommend

Maskelyne: Astronomer Royal by Rebekah Higgitt (2014). A condensed summary appeared in the *New Scientist* (Pain 2014). Over time Maskelyne has been variously accused of greed for wanting the Longitude Prize money for himself, although as Astronomer Royal he was not eligible to receive any, or that he harbored personal animosity towards John Harrison, although he recommended Harrison's son William for election to the Royal Society even though the Harrisons were effectively in the midst of accusing him of corruption.

John Harrison's displeasure at not being immediately given the full £20,000 prize by the Board of Longitude would have been well known at the time since he circulated a pamphlet arguing his case. But there are no credible contemporary accounts or histories that suggest that Maskelyne or the Commissioners acted any way other than correctly and honorably. There are even some contemporaries who suggested that Harrison's treatment by the Board had been overly generous, such as French astronomer Jean Baptiste Joseph Delambre in his *Histoire de L'Astronomie*.

The modern misperception of Maskelyne may trace its origins to a 1923 history written by Rupert Gould, whose interests extended beyond horology to cryptozoology and the paranormal. While acknowledging that Harrison's version of events was not entirely justified, he states that Maskelyne appeared as the "declared and bitter enemy" of the Harrisons. It was Gould who rediscovered Harrison's first 3 chronometers, H1, H2 and H3, in poor condition at the Greenwich Observatory and was responsible for their restoration.

In his biography of Harrison, Quill concluded, "John Harrison and his son seem to have persuaded themselves, without apparent justification, that they were being victimized by the Board." Unaccountably, the new Astronomer Royal of the time, Harold Spencer Jones, described Quill's book as "a story of a somewhat discreditable kind" as far as the Board of Longitude was concerned. Perhaps a tale of a humble underdog triumphing over a powerful but corrupt establishment is more compelling than the actual truth.

From there the story seems to have taken a life of its own and existed without any actual evidentiary support. Its ascendency was assured when Dava Sobel picked it up, which resulted in a number of spin-off films and documentaries that were widely seen.

Astronomer Royal Rev. Dr. Nevil Maskelyne is responsible for important developments in astronomy and navigation and in that respect his contributions have surely saved countless lives. For that he should be thanked and admired. His unjustly tarnished reputation should be restored to the elevated position in the popular psyche that he rightly deserves.

On his second voyage Captain James Cook named the Maskelyne Islands in the South Pacific in his honor and there is a 22 kilometer diameter lunar crater in the Sea of Tranquility that also bears his name. ■

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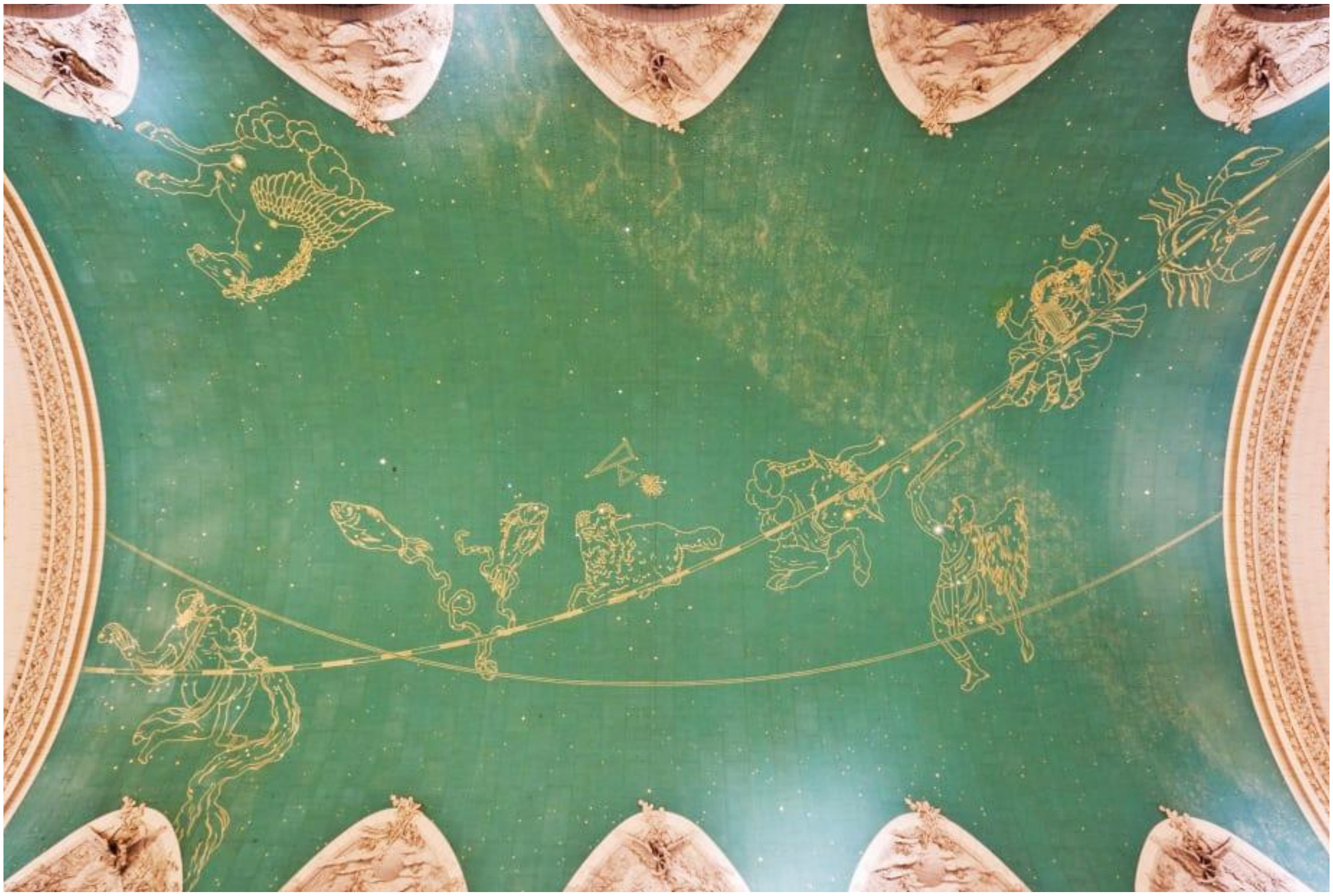
The Ceiling of Grand Central Terminal

Larry Faltz



There's probably not a member of WAA who hasn't taken Metro North down to the city and emerged into the main concourse of Grand Central Terminal (its formal name), New York's greatest indoor public space. Most of us haven't paid much attention to the ceiling, brilliantly restored in 1997, being the hurrying and perhaps jaded New Yorkers that we are.[3] The constellations on the ceiling tell an interesting story, one that I delved into because I had been asked to give a talk at the Mamaroneck Library in conjunction with their annual "One Read" program, in which a book is assigned for a town-wide "book club" and the library arranges a series of events relating to it. This book was *The Masterpiece* by Fiona Davis, a recent novel in which Grand Central plays a major role. The ceiling itself is unimportant to the book's plot, but for us astronomers it's the most interesting aspect of the building (although I do admit to a special affinity for the Oyster Bar).

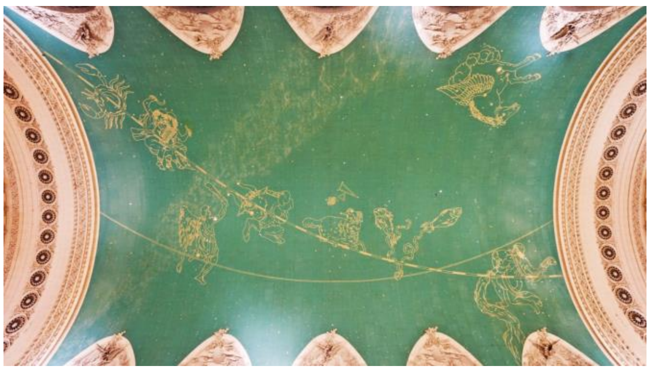
The ceiling over the football field-sized concourse was originally going to be a skylight, but practical considerations resulted in a closed, barrel-vault roof. The star map was the inspiration of architect Whitney Warren and artist Paul César Helleu. They asked Columbia University astronomer Harold Jacoby to make an astronomical chart, which he derived from Johann Bayer's *Uranometria*, the first complete[4] printed star atlas (1603). A number of artists worked on the ceiling, which showed a section of the zodiac and a swath of the Milky Way. The 63 brightest stars were originally (but are no longer) illuminated by electric light bulbs. It wasn't long after CGT's opening on February 2, 1913 that an astronomically knowl-

[3] We disdain the "touristy" sites. When was the last time you went to the top of the Empire State Building or visited the Statue of Liberty? I bet it's been a while!

[4] Complete in the sense of showing brighter stars of the southern hemisphere down to the South Pole.

edgeable commuter noticed that the constellations were backwards!

The ceiling shows a view of the heavens from “outside,” as it would be seen on a celestial globe (a.k.a. “God’s eye view”). That’s a very odd perspective for someone standing on the Earth. Aquarius, on the easternmost side of the ceiling (that is, the Lexington Avenue side) is really the westernmost constellation of the group and vice-versa for Cancer on the Vanderbilt Avenue side. Each of the zodiacal constellations (Aquarius, Pisces, Aries, Taurus, Gemini, Cancer) is a mirror image of those seen in Bayer.



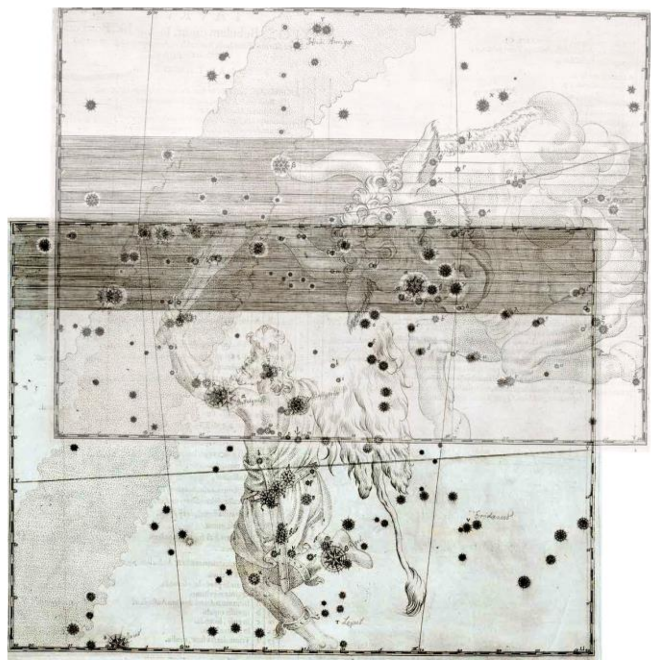
The way the ceiling should have been oriented, looking up from the north (train platform) side.

The *post-hoc* explanation offered by the CGT leadership after the error was discovered, that they *wanted* to show the external God’s eye view, is clearly belied by their own words. The week before the opening of the terminal, newspaper reporters were given a tour of the station by G.A. Harwood, the chief engineer of the station and L.F. Vosburgh, General Passenger Agent of the New York Central Railroad.

> The view presented is a section of the heavens seen from October to March, from Aquarius to Cancer. Extending across the ceiling from east to west are two broad bands of gold, representing the Ecliptic and the Equator. The figures and signs in their relation to one another and to the Ecliptic and Equator are as nearly as possible astronomically correct, it is said…. To insure astronomical accuracy and beauty of form, the highest authorities were consulted, among them being Dr. Harold Jacoby of Columbia University.[5]

Strangely, however, the stars in the figure of Orion, a non-zodiacal constellation, are shown from an earthly perspective and the image exactly matches Bayer. It seems rather odd, to say the least.

Since on the GCT ceiling Orion is shown facing Taurus, we would expect that Bayer also had Orion facing the bull, but that’s not the case. Bayer’s plates are of the individual constellations, so Orion doesn’t show Taurus, and vice versa. With Photoshop, it was easy to align and merge images from an excellent on-line version of Uranometria.[6] Fortunately, the stars of the Hyades are shown on both plates and the scale of the plates is identical. So we discover that Bayer drew Orion facing *away* from Taurus, and away from us, showing us his back. One would think that the great hunter would always be keenly aware of the charging beast, and be portrayed that way. Where did Bayer get this strange arrangement?



Merged plates of Orion and Taurus from Bayer’s *Uranometria*

As I mentioned in my article on celestial globes in the March 2020 SkyWAAtch, the earliest printed constellation maps are a pair of woodcuts by the prolific German artist and printmaker Albrecht Durer. These date from 1515. The 48 Ptolemaic constellations are shown on two maps, both of them using the “God’s eye” view from outside the Aristotelian sphere of the fixed stars, the orientation seen on a celestial globe.

[5] “Grand Central Terminal Opening on Sunday. Men Working Day and Night to Finish Main Section of the Great Station,” *New York Times* January 29, 1913, p. 13.

[6] https://www.wallhapp.com/urano/johann-bayer

One map shows the constellations in the northern hemisphere using the ecliptic as the circumferential boundary, and the other shows those in the south. Durer draws a smaller number of southern constellations because in 1515 the southern skies had not been charted, Ptolemy's home in Alexandria being at 31° North latitude. Taurus is on the northern map and Orion on the southern. If you combine the maps properly (that is, back-to-back), Orion will be facing Taurus with his club in his right hand. We see his back, and his head appears to be looking up (tilted back).

Durer's 1515 maps. One of the three hand-colored versions sold at Sotheby's in 2011 for $578,542.

In the celestial globes of Hondius and Blaue (the earliest of which predated Bayer's atlas by about five years), Orion is also facing the bull with the club in his right hand, and like in Durer we see him from the back. On the Farnese Atlas, the earliest celestial globe in existence, Orion is looking *away* from Taurus, but also showing us his back. Atlas' thumb obscures Orion's right arm, but it's clear that the club is being held on that side, across his body from Taurus, because the hunter's left hand holds the droopy lion skin that is sometimes shown as his shield.[7]

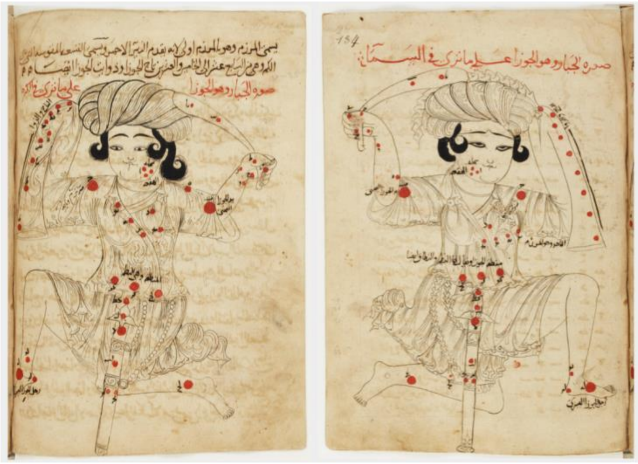
One would suppose that when Orion was placed in the sky (there are several myths as to how this occurred) the gods would honor him by showing him to us from the front. His club would be held by the arm away from the bull (*i.e.* his right hand), across his body so that he could gain the maximum leverage for a strike, just like a tennis player or baseball batter. If we are "outside" of the celestial sphere, we ought to see Orion's back, and we do in the Farnese Atlas, and in Durer, Hondius and Blaeu. From the inside, we should see his front. In that case, the club would remain in his right hand because we are really rotating around the figure, not mirror-imaging it. Since Orion is carrying the club in his right hand, from the outside it would be to our right, but if we travel inside the sphere and turn back to look at the stars, the club is still in his right hand (since he hasn't done anything), but it would appear to our left.

Taurus and Orion on the Farnese Atlas. Orion is looking away from Taurus.

So why did Bayer show Orion facing away from Taurus, club in his left hand and showing us his back? Al-Sufi's *Book of the Constellations of the Fixed Stars* (964) shows each constellation in both Earthly and external views, but Orion is depicted from the front in both perspectives. The earthly perspective view has Orion's holding the club in his right hand and his left holds the shield/lion skin, while the external view is simply a mirror image and not a rotation. I wonder if perhaps Bayer, who most likely didn't read Arabic, could have seen a copy of al-Sufi, picked the wrong image and then rotated it. Orion, famed in myth for having a high sex drive, is sometimes thought to be chasing the Pleiades, the daughters of Atlas (and in

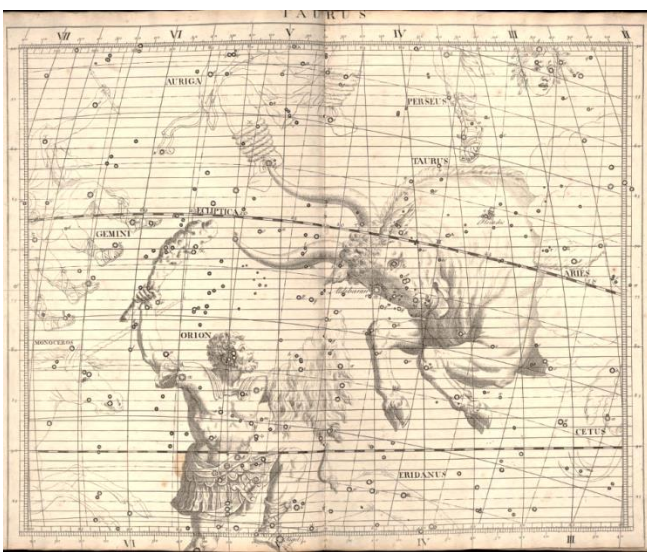
[7] The lion skin is properly the shield of Hercules. As his first labor, Hercules killed the Nemean lion. He couldn't use a spear because its skin was impenetrable, so he strangled it. He used one of the dead lion's sharp fangs to strip off its hide. Because of its solidity it made a fine shield. Perhaps celestial cartographers confused the hero Hercules with the brave hunter Orion. No connection between Orion and Taurus is mentioned by Eratosthenes, Aratus or Hyginus.

one telling actually seduces Merope). In that case he ought to be facing the bull because the Seven Sisters are located on the other side of the animal. Bayer clearly didn't use that reasoning either.



Orion in celestial globe view (L) and geocentric view (R) from a 14th century edition of al-Sufi.

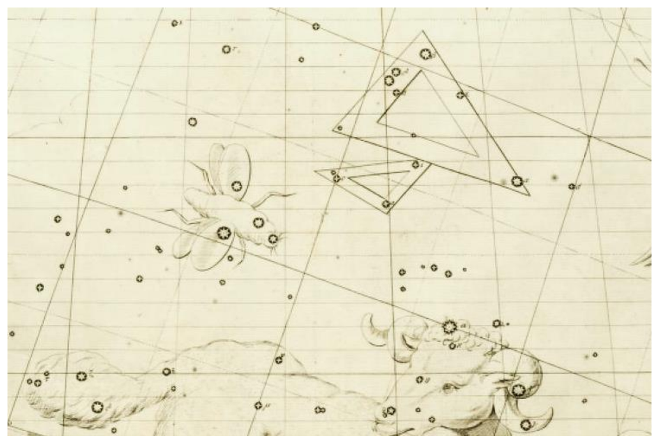
Orion faces Taurus in all subsequent geocentric star atlases, for example those by Flamsteed (*Atlas Coelestis*, 1729) and Bode (*Uranographia*, 1801). In addition, on these maps Orion holds his club in his right hand, while the shield is in his left, pointing toward the bull, so he's ready to give the charging beast a real whack. And we see him from the front, as we should and undoubtedly the gods wanted.



Orion and Taurus, Flamsteed, *Atlas Coelestis* (1729)

Left-right confusion is a common problem for humans. How often have you heard "Turn left, dear. No, the *other* left." It was even mentioned in the Bible. "Nineveh, that great city, wherein are more than sixscore thousand persons that cannot discern between their right hand and their left hand." (Jonah 4:11.) Research studies published in the 1970's and 80's reported that 71 of 364 (19.5%) college professors and 311 of 1185 (26.2%) college students said that they "occasionally," "frequently" or "all of the time" had difficulty when they had to quickly identify right from left. Maybe that was a problem for Bayer too.

Why isn't the Grand Central Terminal's Orion reversed like the other constellations? The method that was used to outline the figures hasn't been preserved in detail. Historians mention "projecting" the images onto the ceiling, which may have reversed them, so why wasn't Orion reversed too? I suspect it must have made no sense to the artists that Orion should be facing away from a charging bull, so they simply left him the way Bayer drew him.



Triangulum and Musca Borealis, Flamsteed, *Atlas Coelestis*

There's another peculiarity. To Aries' north in the sky is the constellation Triangulum. On the GCT ceiling we see the triangle, but below it there is a smaller triangle and a bug of some kind. Bayer's *Uranographia* has a plate of Triangulum, an original Ptolemic constellation said to stand for the first letter of Zeus's name (Δίας). But Bayer's Triangulum stands alone, with no other objects surrounding it. Since Bayer was used for the ceiling art, where did this second constellation come from and what's with the bug? We know there's another triangle in the southern sky (Triangulum Australis) and near it the constellation Musca (fly in Latin) but there's no reason for them to be on the GCT ceiling.

All the major atlases after Bayer show Triangulum as a double triangle and place a fly just below it. The two constellations persisted into the early 20th century. They are shown as late as the 1904 edition of the *Atlas Céleste* by Dien and Flammarion.

We must recall that Bayer's atlas was published six years before Galileo pointed his telescope at the heavens. Once astronomers used optics to see deeper into the cosmos, they distinguished patterns that would not be perceptible to the naked eye. Sometimes cartographers commandeered parts of existing Ptolemaic constellations to create new groupings. Since fixed constellation boundaries were not established until 1930, anything was fair game. The artists who drew the constellation figures might naturally be expected to fill in blank spaces with characters.

Musca Borealis (the Northern Fly) was created by Petrus Plancius, a celestial globe maker, in 1612. He named it Apes, for "bees", but it was transformed into a fly and renamed Musca Borealis by Johannes Hevelius.[8] Triangulum Minus (not Minor) was another of Hevelius' inventions. Both appeared in his *Firmamentum Sobiescianum, sive Uranographia* from 1687. These two were hardly the only constellations eliminated by the International Astronomical Union in 1930. In addition to Musca Borealis and Triangulum Minus, the IAU killed off Herschel's Telescope (originally Tubus Herchelii Major, created by Maximilian Hell in 1781 to honor the discoverer of Uranus), Antinous (created by Roman Emperor Hadrian in 132 CE to immortalize his young male lover), Frederici Honores (Fredrick's Honors, created by Bode to honor Prussian Emperor Frederick the Great) and, among others, a reindeer, rooster, a cat, a flying squirrel, a wasp, a veil with Jesus' image on it, the oak tree that English King Charles II hid in to escape the Roundheads in 1651, the crossed swords of the Elector of Saxony and even Alessandro Volta's battery. Perhaps the most prolific constellation inventor was the English botanist John Hill, author of the 1754 book *Urania: Or, a Complete View of the Heavens; Containing the Ancient and Modern Astronomy, in Form of a Dictionary: Illustrated with a Great Number of Figures ... A Work Intended for General Use, Intelligible to All Capacities, and Calculated for Entertainment as Well as Instruction*. Hill gave us an eel, a spider, a toad, a tooth shell, a an extinct oyster, a sea horse, a leech, a slug, an earthworm, a pangolin, a limpet, a mussel, a rhinoceros beetle, a tortoise, and, appropriately, a stargazer fish (family *Uranoscopidae*). The IAU assassinated all of those innocent celestial beings in 1930 as well.

Aries and Musca Borealis in *Urania's Mirror* (1824), a set of cards based on drawings from Alexander Jamieson's *A Celestial Atlas.*

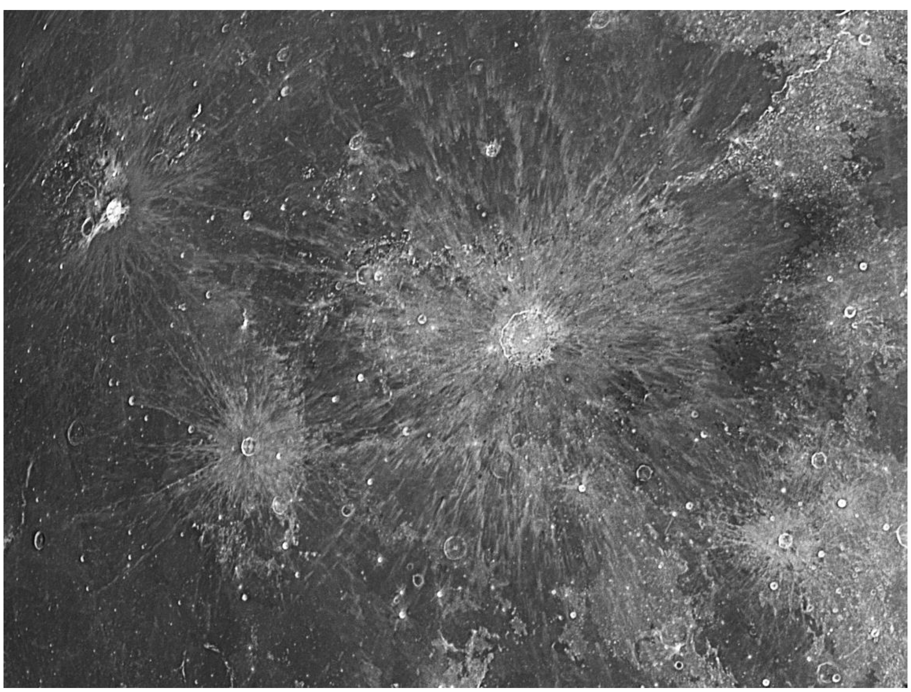
The one photo of the original GCT ceiling I could find shows Musca Borealis but not Triangulum Minus. Musca must have been Harold Jacoby's doing, and he undoubtedly found it in one of the many post-Bayer sky atlases that were at his disposal. But why did he choose to add this obscure non-Bayer constellation? There are plenty of other constellations close to the ecliptic that were drawn by Bayer but were not portrayed. We can't argue that the ceiling was only supposed to show constellations of the zodiac: if so, then why the non-zodiacal Orion and the big Triangle? The smaller triangle was added when the original ceiling, badly deteriorated, was replaced in 1945. Who was responsible for Triangulum Minus, and why? It couldn't have been Professor Jacoby, who died in 1932. We'll probably never know.

And there is one other non-zodiacal constellation on the ceiling. Tucked in the northeast corner is Pegasus, the flying horse. Why Pegasus but not other notable constellations north of the ecliptic: Andromeda, Perseus, Cassiopeia or Cepheus? Perhaps the fleet Pegasus (shown in the "God's-eye" view of the rest of the ceiling, *sans* Orion), who can fly over any obstruction, is situated on the side of the ceiling closest to the train platforms to symbolize modern railroad transportation. Or maybe just to remind rush hour commuters that they should fly to catch their trains. ■

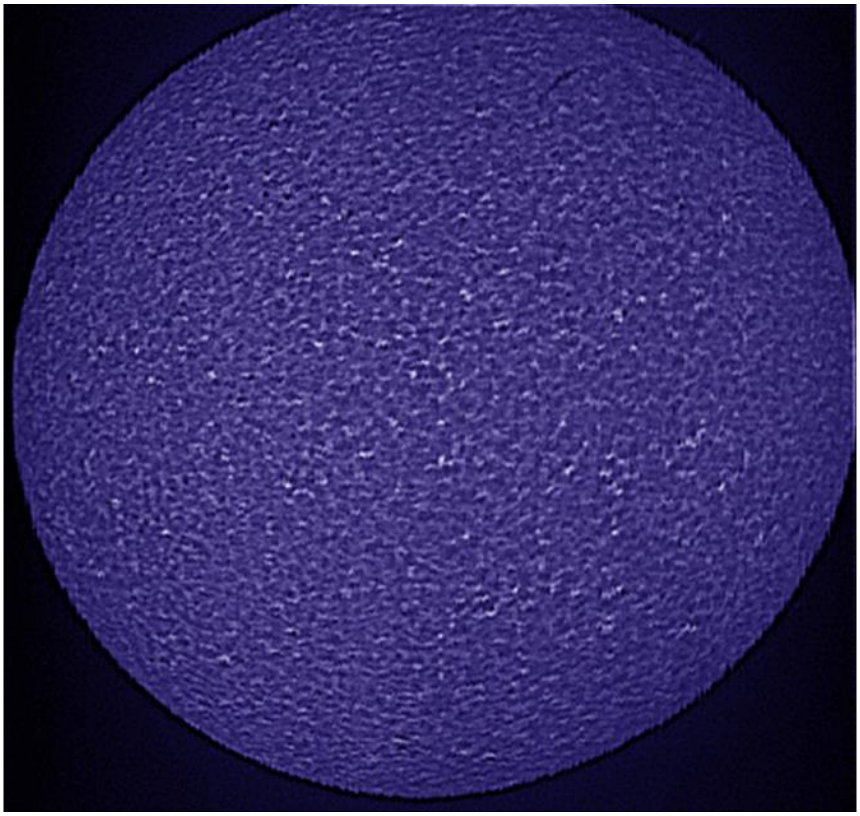
[8] For more on Hevelius, see the article "Strange Brew" in the March 2015 SkyWAAtch.

Images by WAA Members

The full Moon isn't much to look at through a telescope. Since there are no shadows, there's little contrast to distinguish surface features. But it can be photographed quite nicely. Larry Faltz made this image on March 8, 2020 at 8:58 p.m., just 17.3 hours before full, from his driveway in Larchmont. Orion 127 mm Apex f/12.1 Maksutov telescope, Canon T3i ISO 400, 1/2000 sec, monochrome mode, single frame. A 0.5x focal reducer was needed in the optical train because the 1540 mm focal-length Apex projects an image just a tad larger than the camera's APS-C sensor (and he was too lazy to go back inside and get a shorter focal length scope). The contrast in the RAW image was enhanced a little with Canon Digital Professional 4 and then very mild wavelet processing in Registax 6.1 to sharpen the features.

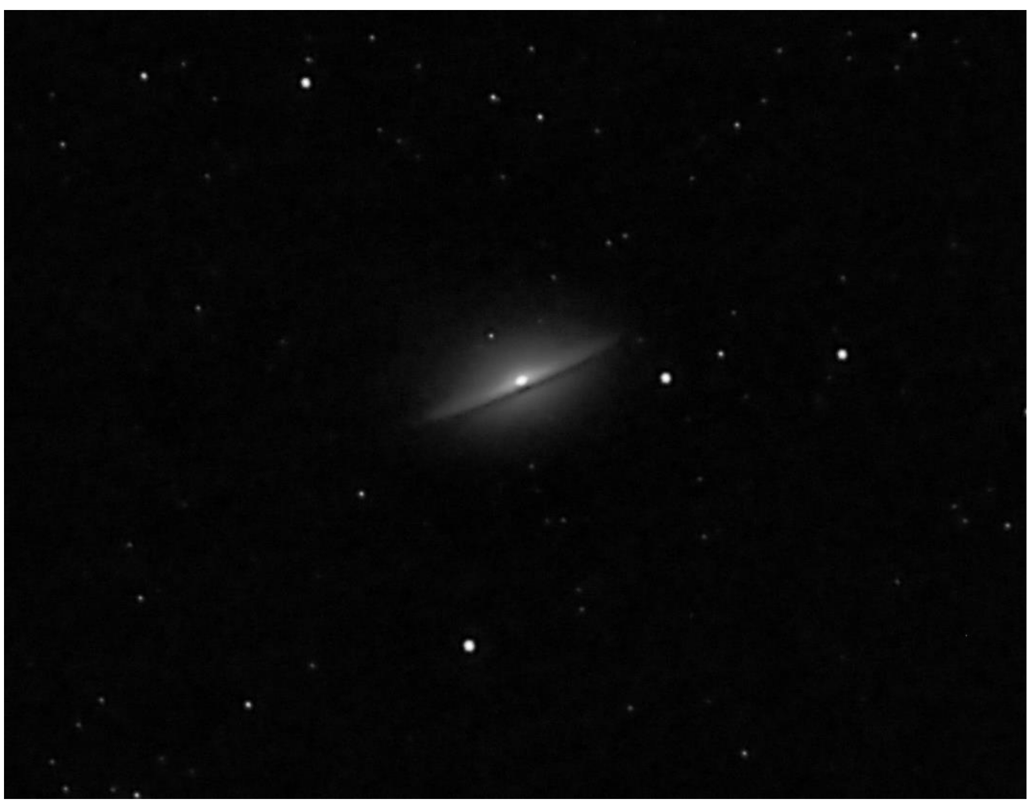


Robin Stuart's image, made in Valhalla at almost the same time as Larry's, shows the spidery tendrils of the ejecta blankets surrounding craters Copernicus (center) and Kepler (lower left). Aristarchus is the bright crater at upper left with Schroter's Valley, sometimes called the Cobra, visible to its upper left. The normally prominent crater Eratosthenes sits at the base of the Apennine Mountains, extending diagonally to upper right, but it is practically invisible because of the direct overhead lighting. Robin made a stack of 75 images with a Meade LPI-G camera at prime focus of his Televue NP127 refractor.



John Paladini used his home-made spectroheliograph to record this image of the Sun in the CaK line , around 393 nm in the ultraviolet. The spectroheliograph uses a slit, a diffraction grating and a rotating disk to record the Sun's image at any wave-length. See John's articles in the April 2017 and August 2019 SkyWAAtch.

The spectroheliograph was invented by George Ellery Hale while he was still an undergraduate at MIT, around 1890.



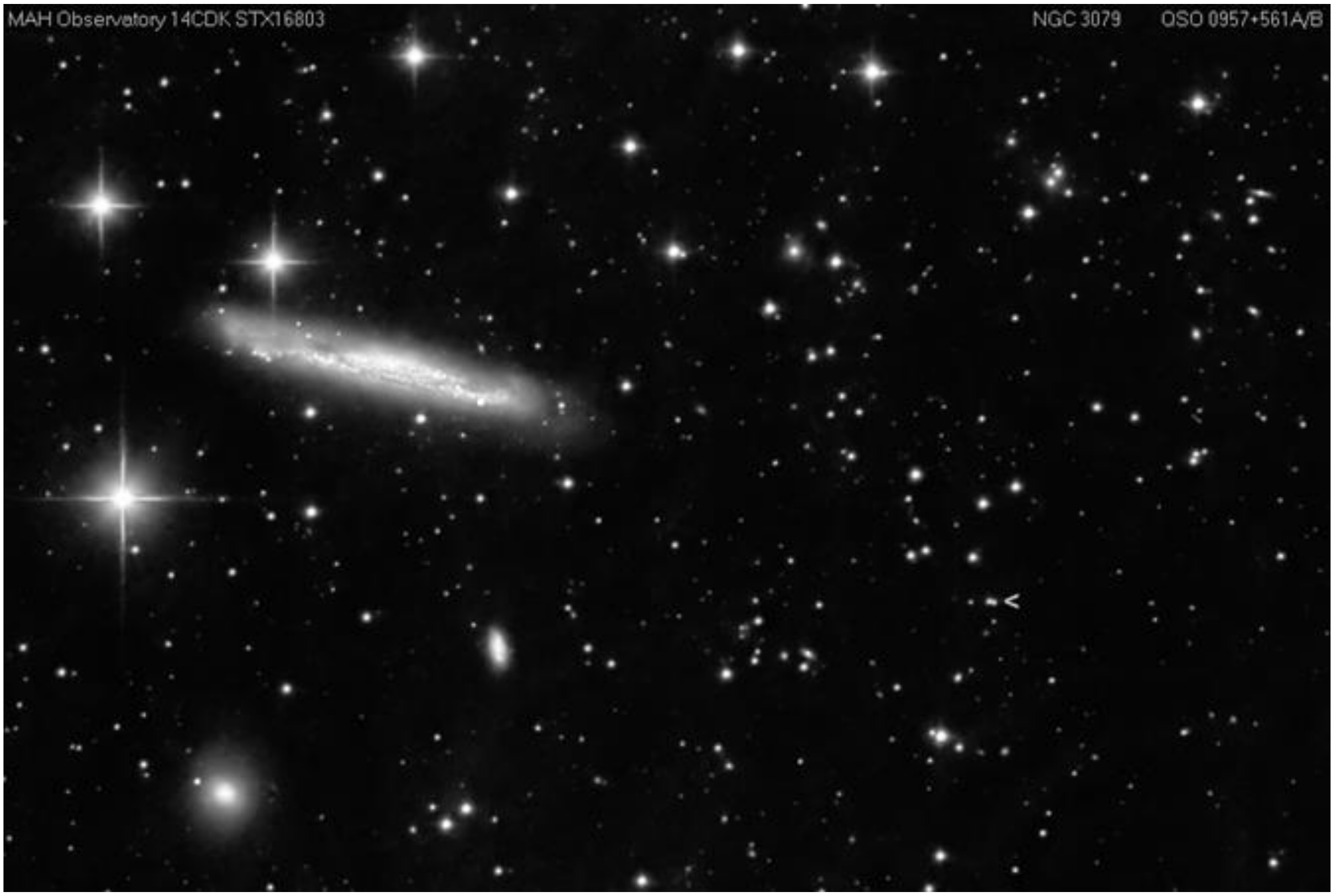
Gary Miller sent in this image of Messier 104, better known as the "Sombrero Galaxy." The 8.0-magnitude lentincular galaxy is about 9.55 megaparsecs (31.1 million light-years) distant from Earth. Its prominent dust lane makes it a nice complement to Gary's cover image of NGC 891 in this issue.

The Rosette Nebula by Leandro Bento

Leandro took this photo on March 21st at Ward Pound Ridge Reservation. He used a William Optics Redcat 51 mm refractor, iOptron SkyGuider Pro, Optolong L-enhance dual band filter and a ZWO ASI533MC Pro CMOS cooled camera, gain 360. It was first light for the camera. Thirty-three four-minute exposures. Darks, flats and bias frames were also taken. The image was processed in Pixinsight. This shows what great results can be achieved with a small telescope and mount, a sensitive camera, the right filters, good software, and expertise.

The Rosette Nebula (Caldwell 49) is actually composed of five NGC objects. The open cluster near its center, NGC 2244, was discovered by John Flamsteed in 1690, but missed by Messier 90 years later. The giant HII region surrounding the cluster is excited by ultraviolet radiation from the hot, young stars of the cluster. Active star formation continues inside the nebula. Distance 5,000 light-years, diameter 130 light-years.

The Twin Quasar in Ursa Major, QSO 0957+561 A/B — Rick Bria



The gravitationally split quasar is identified by the small caret in the lower right quadrant of the image.

This picture, taken from the Mary Aloysia Hardey Observatory, again reminds us that the sky has depth. The picture approaches the limits of our new telescope/camera combination. If you look carefully, you can find no fewer than five galaxies [actually there are over a dozen very tiny and faint ones. Ed.] Most are very distant and appear as tiny fuzzy patches. The largest galaxy in the picture is NGC 3079 located left of center. NGC 3079 is a spiral galaxy 54 million light-years away, containing over 200 billion stars. But galaxies were not the reason for this picture. The intended target was QSO 0957+561 A/B, also called the Twin Quasar. I marked it with < so you can find. It looks like two very close tiny stars, but Twin Quasar is much more.

The word Quasar is a contraction of Quasi-Stellar. “Quasi-stellar” means “star like,” but not a star. Quasars are also referred to as Quasi-Stellar-Objects (QSO). It is an object that looks like a star but is actually the core of a very distant, active galaxy, thousands of times brighter than the galaxies in the Local Group and closer clusters that we are familiar with. These active galactic nuclei (AGN’s) have super massive black holes that pull in enormous amounts of matter and eject unimaginable amounts of energy. Quasars are the brightest objects in the universe. Since Quasars are so bright, they can be imaged at enormous distances. The Twin Quasar in our picture is 8.7 billion (with a “b”) light-years away. The radius of the entire observable universe is 13.6 billion light years.

But the story doesn't end there. Twin Quasar is really a single object. It is an active galactic nucleus gravitationally lensed by an unseen galaxy cluster between Earth and the Twin Quasar. Earth, the galaxy cluster and the Twin Quasar are aligned in such a way that the galaxy cluster is warping spacetime into a giant lens. The result is one quasar appearing as two.

The warping of space-time was predicted long ago by Albert Einstein in his theory of General Relativity. For him, it was just a theoretical possibility and he predicted: "Of course, there is no hope of observing this phenomenon directly." Thankfully, he was wrong. Even he could not predict the advances in equipment and technology that would take place in the future. Twin Quasar QSO 0957+561 A/B was the first confirmed gravitationally lensed object. It was found in 1979 at Kitt Peak Observatory outside of Tucson, Arizona.

There are now countless images displaying gravitational lensing taken by professional and amateur astronomers. If you Google “Gravitational Lensing” you will see many examples of distorted arcs and crescents of light from very distant galaxies. My favorite example of gravitational lensing was taken by the University of Tennessee. Described as an Einstein Cross, it is a single Quasar that appears as four!

I feel blessed to be living at a time when we can see direct evidence of spacetime being warped!

Special Thanks to SkyWAAtch editor Larry Faltz for suggesting the Twin Quasar as a target and supplying information needed for data acquisition.

Commentary by the Editor

In early March, Rick sent me a lovely image of M81, also known as Bode’s Nebula, the most easily observed galaxy after Andromeda (not counting the Magellanic Clouds or the Milky Way, of course). It will be next month’s cover image. In his email, he commented about a small galaxy in a corner of the image, which he estimated to be 408 light years distant based on its size. Rick wrote “I suspect this very distant galaxy is the farthest object imaged at the Mary Aloysia Hardey Observatory to date.” A little research with the on-line astronomy databases Aladin and Simbad proved that the object Rick identified was SDSS J095353.89+685253.5, magnitude 18.29, redshift 0.05925, distance estimate around 800 million light years. If he could capture this faint wisp, I was sure he could image an object *ten times* further away and scientifically much more interesting: the gravitationally split quasar QSO 0957+561 A/B, better known as the Twin Quasar. So I challenged him to capture it, and he did so, producing his spectacular image on the next clear night.

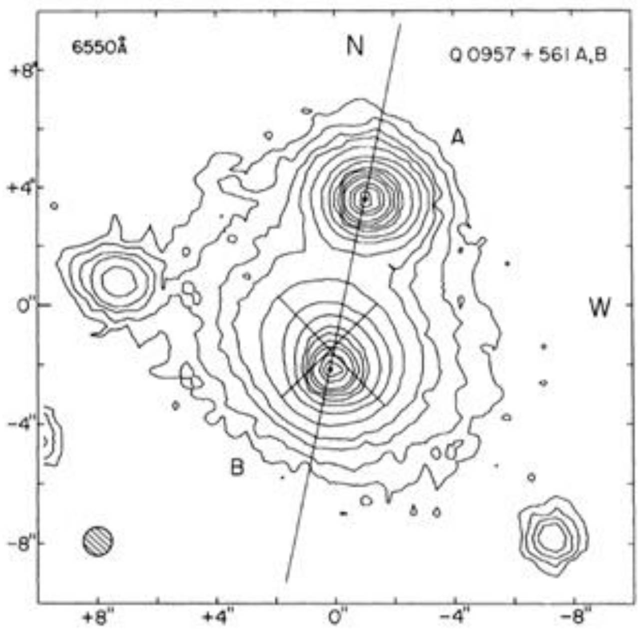
When I got my first Mallincam, John Paladini, who had introduced me to the device, suggested that I try for the Twin Quasar with my 8-inch Celestron SCT. It initially seemed pointless to try to capture a 17th magnitude object with an 8-inch telescope, even with a video camera, but John’s enthusiasm was unrelenting. I prepared a star chart using Cartes du Ciel. CdC makes it very easy to download catalogs from the VizieR professional astronomy database at the University of Strasbourg, and then integrate them into the display. I used the Asiago Catalog of QSO’s, from 1983. It has the 2000 brightest quasars, but if you’re really insatiable there’s a catalog of a million quasars on VizieR just waiting for you. On May 15, 2010, a particularly clear star-party night at Ward Pound, John and I were able to image the quasar.

Larry & John’s Mallincam image of the Twin Quasar (labeled, upper right), stack of five 56-second frames. A black-on-white detail is shown, same scale. The diagonal in the optical train causes the orientation to be vertically flipped from Rick’s image.

The Mallincam is very sensitive, but it’s not a high-resolution camera. Its older CCD sensor is only 640 x 480 pixels. An f/10 scope needs focal reducers to get enough photons to the sensor, which prefers to operate around f/3. The field of view at that speed is about 35 arc-minutes across, which means that each pixel spans about 3.25 arc-seconds. Since the Twin Quasar’s components are 6 arc-seconds apart, at best they would light up two adjacent pixels, giving a smudge rather than two dots. And that’s what we got. Nevertheless, we were elated when we saw it on the screen and we got great feedback when we posted the captured image on CloudyNights. A smudge, but an 8-billion light-year distant smudge, and with an 8-inch telescope.

Advances in astro-camera technology, a larger telescope with much sharper optics than an SCT and precise equatorial tracking meant that Rick could gather enough photons to make a high-resolution image and split the quasar. It's a beautiful image, even resolving some of the internal structure of the edge-on magnitude 10.9 spiral galaxy NGC 3079. Rick's SBIG STX 1603 camera has 16 million pixels compared to the Mallincam's 307 thousand.

The Twin Quasar lies 8.7 billion light-years distant, at a redshift of z = 1.41. The quasar was active when the universe was just one-third of its present age. The lensing galaxy, a giant elliptical named YGKOW G1, is 3.7 billion light-years away from us, at redshift z = 0.355. Much fainter than the quasar, it has apparent dimensions of 0.42 × 0.22 arc-minutes and lies almost in line with the quasar's B image.



The Twin Quasar system. The "x" shaped pair of lines near B are the major and minor axes of the brightest galaxy of the surrounding cluster. From Young, P. et. al., *Astrophys J* 1980; 241:507-520.

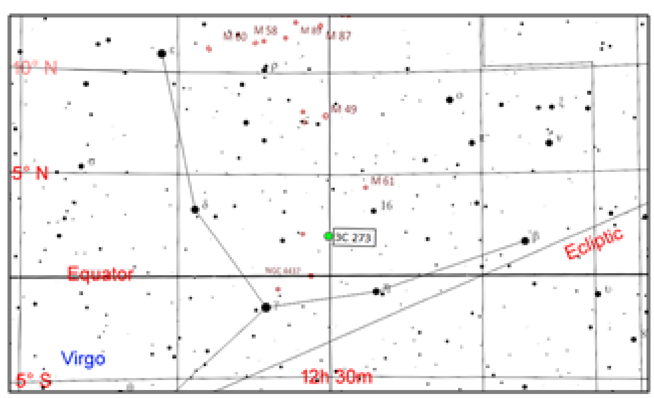
The light from component B is delayed by 417 ± 3 days compared to A, meaning the path difference between the two images is 1.1 light-years. Relativistic jets have been detected from both quasars.

In 2014, the Hubble Space Telescope was able to image the quasar and the intervening galaxy, as well as many members of the cluster of which it is the largest member.

Central part of the HST image showing the Twin Quasar (the two "stars" with diffraction spikes) behind YGKOW G1, in the midst of multiple other galaxies in G1's cluster. The nucleus of YGKOW G1 is 1 arc-second from the B image of the quasar.

Quasars were far more common in the early universe. There are far fewer close to us. Quasar counts show a peak at a red shift of around z = 2-3, about 10 billion light years distant.

The only quasar that is viewable with a reasonable-sized amateur telescope is 3C 273 in Virgo, which has an apparent magnitude of 12.9. It would look like a star, so to pick it out from stars in our galaxy you would need to make a really good, high-magnification finder map with your planetarium program. 3C 273 is relatively close, with a red shift of 0.158, but that's still 2.4 billion light years away. If it were the distance of Pollux (32.6 LY) it would be as bright as the Sun. If your scope is 8 inches or more, you can look for it at RA 12h 30m 08.4s, Dec +01d 56m 30s (epoch J2000), about 10 degrees south of the main part of the Virgo cluster. If you have a Star Analyzer transmission grating, you can try to record the spectrum and demonstrate the red shift by the displacement of the H-alpha line. ■

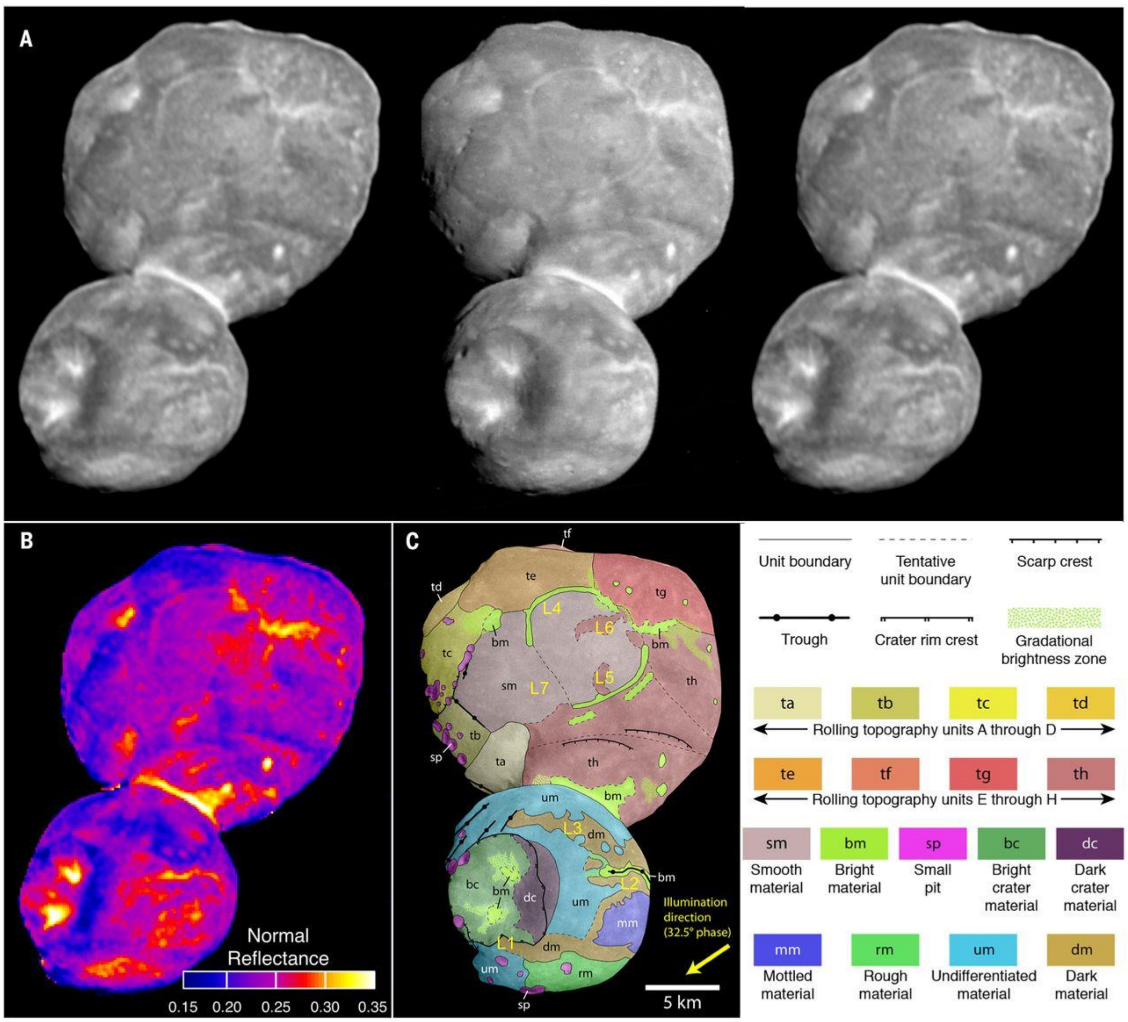


Wide field finder chart for 3C 273.

Research Highlight of the Month

Spencer, J.R., et. al., The geology and geophysics of Kuiper Belt object (486958) Arrokoth, *Science* 2020 367:998

The spectacular and historic flyby of Pluto by New Horizons in 2015 was followed by the even more-improbable and equally successful examination of (486958) Arrokoth on January 1, 2019. The probe passed within 3538 km of the peanut-shaped remnant of the early solar system. In three papers in the February 28, 2020 issue of *Science*, Alan Stern's team presented the first detailed topological, geological, and geophysical information about Arrokoth. The first paper concerned the structure and formation of this tiny (total volume 18 km^3) distant (6.47×10^9 km, 43.28 AU at the time of the flyby) object. The other papers were on its composition and origin. More data remains in transmission, which won't be completed until late 2020, so we'll learn even more about this fascinating relic in a year or two.



The top images are 3D stereo pairs, and can be viewed cross-eyed (left+center) or direct (center+right). For more information on 3D viewing, see Robin Stuart's "A Different Perspective" in the <u>October 2019 SkyWAAtch</u>.

Arrokoth's peanut-like structure was evident on the first images released after the fly-by. These more detailed images are evidence that the two lobes were independent bodies that gently coalesced during the formation of the Solar System. There is no compressive deformation at the neck, which implies low velocity, perhaps a few meters per second, caused by residual gas or the gravitation effects of other close bodies in the nascent Solar System acting as a viscous brake.

Member & Club Equipment for Sale

Item	Description	Asking price	Name/Email
Celestron CPC800 8” SCT (alt-az mount)	Like new condition, perfect optics. Starizona Hyperstar-ready secondary, allows inter-changeable conversion to 8” f/2 astrograph if you buy a Hyperstar from Starizona. ADM top rail, Starizona counterweight bottom rail. Telrad finder with dew shield. Several coun-terweights for ADM rail. 2” visual back. SCT-to-T adapter with Canon EOS No eyepieces or diagonal.	$950	WAA ads@westchesterastronomers.org
Meade 395 90 mm achromatic refrac-tor	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.	$100	WAA ads@westchesterastronomers.org
Meade LX-70 Equa-torial Mount	Dual Axis Drive and Polar Scope - Brand New. Bought during the closeout sale of these mounts. Owner thought he might like to have a light GEM, but decided to stick with alt-az mounts. Set up once in the garage to be sure it all works, and it does, but never saw first light in the field. Price paid: $365.	$240	Eugene Lewis genelew1@gmail.com
Sky-Watcher 10” f/5 reflector OTA	Brand new in box. Newtonian optical tube, 2” focuser, tube rings. No eyepieces, finder or dovetail. Would make a great Dobsonian or use on a decent sized GEM. These listed at over $500 when new. Donated to WAA.	$225	WAA ads@westchesterastronomers.org
Celestron 6-inch f/5 reflector OTA	Same tube as the Orion 6” StarBlast. 1¼” rack-and-pinion focuser, Celestron 25 mm EP, tube rings, dovetail plate. 5x30 straight through finder. Dark canvas carrying case with com-partments, room for accessories. Excellent condition, unblemished optics. This size OTA is hard to find without a mount. An Orion Star-Blast 6 with 1¼” focuser and table-top Dob-sonian mount lists for $379. Meade’s 6” f/5 OTA, admittedly with a 2” Crayford focuser but no case, lists for $339. Donated to WAA.	$175	WAA ads@westchesterastronomers.org
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 submit only 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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