SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

January 2025

The Horsehead and Flame in Hydrogen-Alpha by Jordan Webber

The often-photographed nebulas near Zeta Orionis (Alnitak) are particularly elegant in monochrome. The hydrogen in the Flame (NGC 2044) is excited by emission from the hot late-O, early-B star IRS2b, a member of a cluster embedded in the nebula, and not Alnitak, which is about 100 light years closer to us than the Flame. The relationship was only discovered in 2003. The Horsehead (B33, embedded in IC 434) was the subject of a detailed article in the April 2023 SkyWAAtch. Jordan made this image at Ward Pound Ridge Reservation last year.

Our club meetings are held at the David Pecker Conference Room, Willcox Hall, Pace University, Pleasantville, NY, or on-line via Zoom (the link is on our web site, www.westchesterastronomers.org).

WAA January Meeting

Friday, January 10 at 7:30 pm

The James Webb Space Telescope: Humankind's greatest space science facility

James Beletic, PhD
Chief Scientific Officer, Teledyne Imaging Systems

This talk presents the scientific motivation behind the James Webb Space Telescope (JWST), the technical challenges and solutions, its orbit in space, its observing cadence, and details about the infrared focal plane arrays that are the unique "eyes" of the observatory. JWST's technical performance will be discussed and of course many scientific images will be shown.

Also In This Issue

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

Editor: Larry Faltz
Almanac Editor: Bob Kelly
Editorial Consultant: Scott Levine
Editor Emeritus: Tom Boustead
Proofreader: Elyse Faltz

WAA February Meeting

Friday, February 14 at 7:30 pm

Exotic Sandy Clouds in the Atmospheres of Extrasolar Worlds

Genaro Suarez, PhD
Postdoctoral Fellow, American Museum of Natural History

Starway to Heaven

Ward Pound Ridge Reservation, Cross River, NY. Resume in March.

New Members

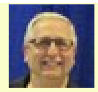
Judith Dronzek	Putnam Valley
Alan L. Frankel	Mt. Kisco
Lisa Hooper	Rye
Yaron Shlesinger	Toronto, Canada
Jeffrey Spitzer	Scarsdale
Ronan and Anna Zable	Katonah

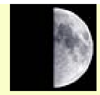
Renewing Members

Robert Blake	Bedford
Giuseppe Colombo	Mamaroneck
Larry and Elyse Faltz	Larchmont
Peter Germann	Katonah
Michael Jen	Baldwin Place
Penny Kelly	Wappingers Falls
Josh Knight	Mohegan Lake
Zachary Maller	Stamford
Satya Nitta	Cross River
Robert Peake	Pleasantville
Daniel R. Poccia	Cortlandt Manor
Olivier Prache	Pleasantville
Mauri Rosenthal	Scarsdale
William Rothman	Bronxville
Richard Segal	Yorktown Heights
James Steck	Mahopac
Robin Stuart	Eustis, Maine
Woody Umanoff	Mount Kisco
Cathleen Walker	Greenwich
Charles Wiecha	Hastings on Hudson

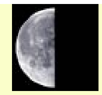
ALMANAC For January 2025

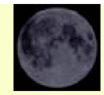
Bob Kelly, WAA VP of Field Events


Bob Kelly


1Q Jan 6


Full Jan 13


3Q Jan 21


New Jan 29

Evening Planet Excitement

January is a great month for "rapid astronomy." On one of those "severe clear" nights, with cold temperatures but cloudless skies, get outside after sunset for a few minutes to quickly spot up to four planets. First, glance to the southwest, above and to the left of where the Sun set. There's a bright dot looking like an aircraft coming in for a landing. It's not a drone! It's Venus, at magnitude minus four and a half this month! Then turn around in the opposite direction and look for a bright dot half-way up in the east – that's Jupiter. Look down and a bit to the left as Mars, dimmer but discernably redder, rises. The Moon will pair up with Venus on the 3rd, Jupiter on the 10th, and Mars on the 13th. Then promise yourself: now that you know where to find at least three bright planets, you'll be back out there with your telescope on a clear, but not quite as cold night with optical aid to see the phase of Venus, the moons of Jupiter and, with high power on the telescope, some fuzzy details on Mars. And this is the last month to get a good look at Saturn until the fall.

Let's Follow the Planets This Month

Venus reaches greatest elongation on the 9th, 47 degrees out from the Sun. The cloudy planet will appear larger and brighter, but its phase will decrease through half-lit. That'll make the featureless planet more interesting to investigate. You may need a filter to see the planet's phase, or look during twilight.

Venus in January 2025

Date	Mag	% illum	Diam	Distance
Jan 1	-4.4	55%	22.6"	0.74 AU
Jan 15	-4.5	48%	26.3"	0.64 AU
Jan 31	-4.6	38%	32.2"	0.52 AU

As the sky gets darker, look to the upper left of Venus to see Saturn sliding down the ecliptic toward Venus this month. The ringed planet passes Venus from the 16th though the 19th. Get your telescope on it this month before it goes into the Sun's glare in February. Saturn's ring inclination this month decreases from being tilted four degrees open toward Earth to less than three, making them appear very thin from our vantage point.

Jupiter, at magnitude -2.2, is still hanging out in the horns of Taurus the Bull. Get a telescope or good binoculars to see its four brightest moons shuttle back and forth during the night. Jupiter is the classic example of taking three looks at an object, 'tres veces' in Spanish. In my scopes, the first look is to make sure we have a bright object in the field of view, that it didn't move out or get lost due to bumping the scope. The second look is to see if there are any tiny dots nearby; moons or stars, and in Saturn's case, any extensions from the planet's disk (rings). The third look is to see if there are any details on the planet, mainly atmospheric bands, or for Jupiter, the Red Spot.

Mars comes to opposition with the Earth this month. Due to the fact that its orbit is more elliptical than the other planets (except Mercury), opposition is three and a half days after Mars and Earth are closest on the 12th. See "Some Mars Viewing Tips" on page 7.

Starset, Starrise

The Summer Triangle of Deneb, Vega and Altair is finally sinking into the northwestern horizon. Orion and Gemini announce the arrival of the New Year.

Daytime Peak

The Quadrantid meteor shower can show us 60 meteors an hour at their peak. The American Meteor Society says the peak will be near 12:45 p.m. EST on the 3rd. This peak parade of pieces of asteroid 2003 EH only lasts for six hours, so we may only get to see a few in the morning and evening of the 3rd. The crescent Moon won't hinder the viewing.

Human-made Satellites

Heavens-above.com lists the times of parades of Starlink communications satellites adding to distractions in our skies.

Human occupation of space continues with the International Space Station and Tiangong platforms.

Tiangong may be visible in the evening skies through the 14th, and the morning starting on the 23rd. The ISS is up and about in our skies in the morning through the 5th, then in the evening from the 10th through the end of January.

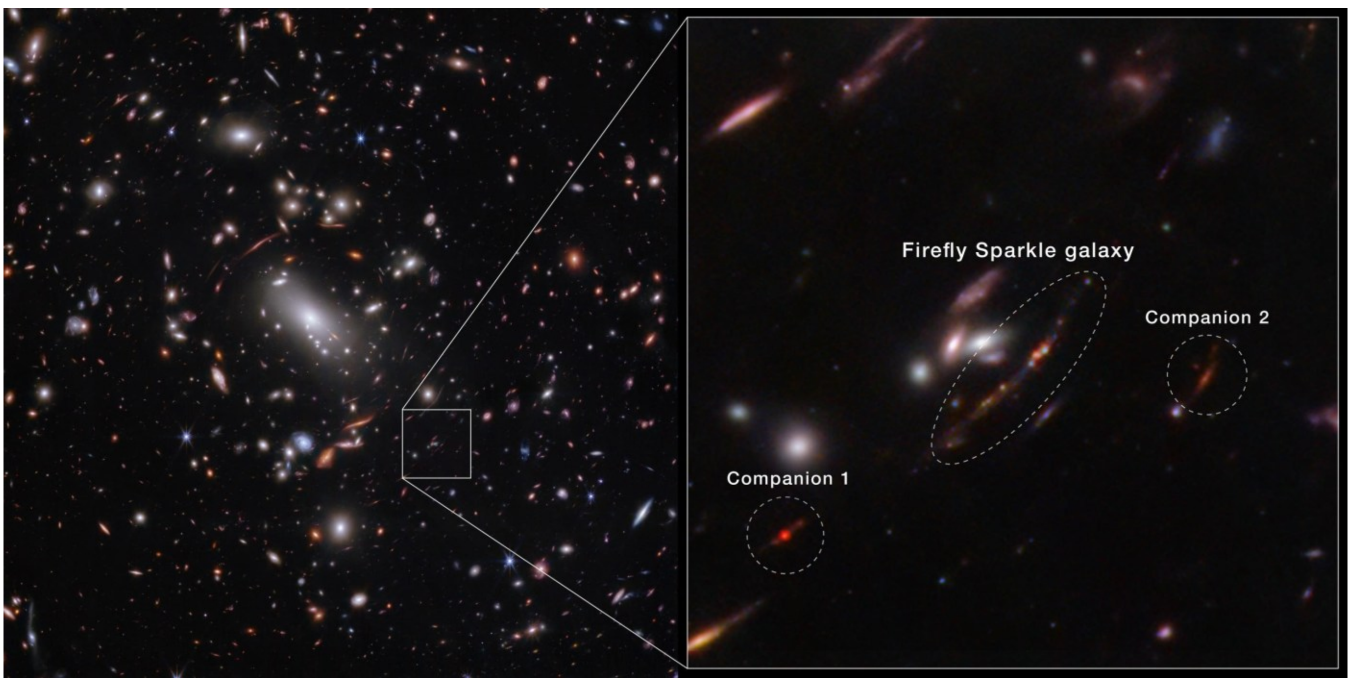
Occultation of Mars by the Moon

On January 13th, the Moon occults Mars. Since both Mars and the Moon are almost exactly on the opposite side of Earth from the Sun, the Moon will be full and Mars will be swallowed up on the Moon's glare some time before and after the Moon blocks the red planet. Can you see this in binoculars? A telescope will help see if Mars actually takes a few moments to be totally covered by the Moon. Mars disappears at 10:21 pm, popping out on the other side at 11:37 pm. Not planning to be up that late? Check out the close paring of the Moon and Mars after they rise just after sunset. Do the grays of the Moon accentuate the rosiness of Mars?

The Royal Astronomical Society of Canada says 2025 will be chock-full of occultations of bright stars, with 50 occultations of stars and planets of first magnitude or brighter worldwide. But, for all of 2025, this is the only occultation of first magnitude or brighter objects listed for our area in their *Observers Handbook 2025* or on the International Occultation Timing Association's website. How did we get missed?

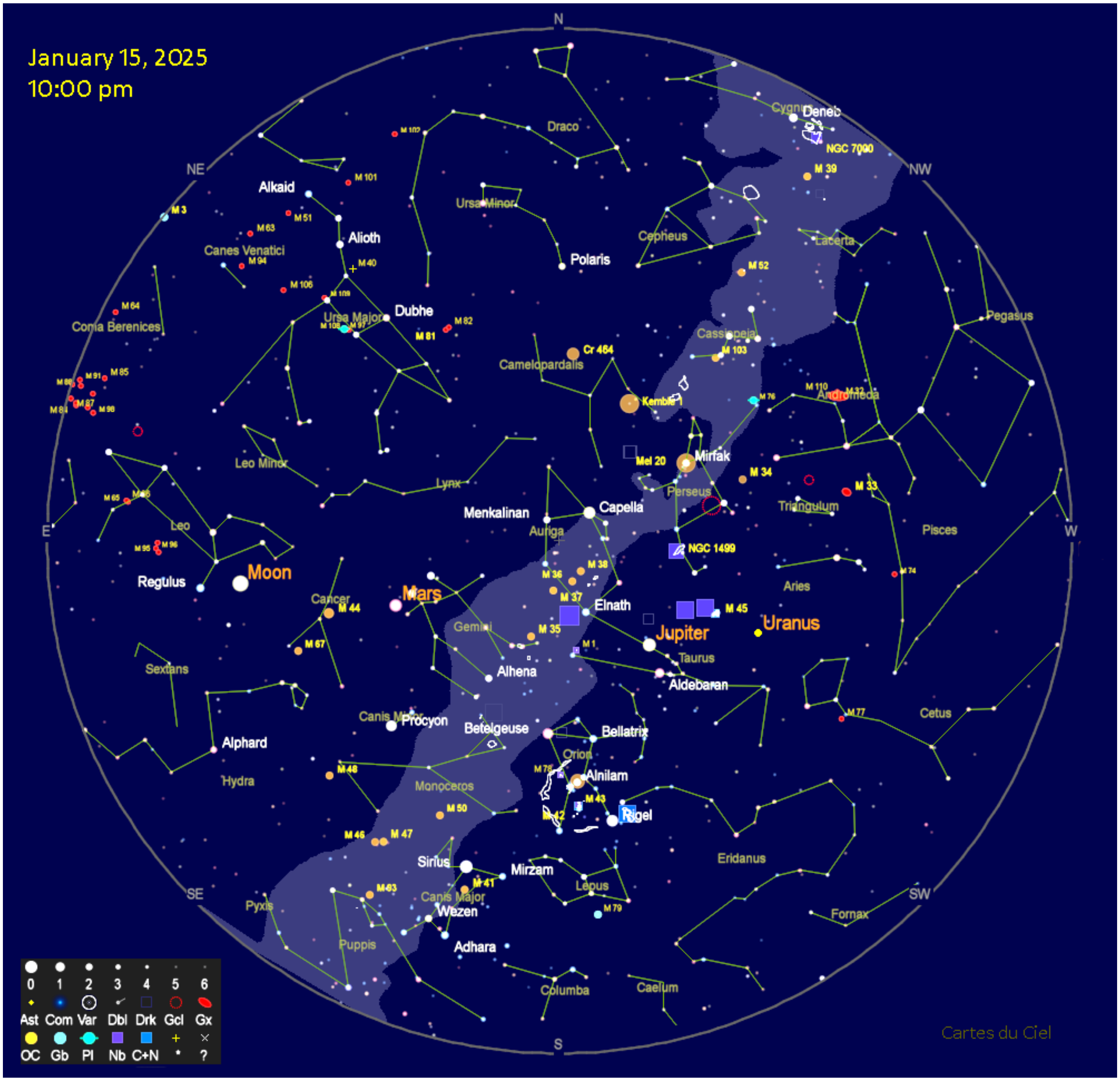
Call: **1-877-456-5778** (toll free) for announcements, weather cancellations, or questions.
Also, don't forget to visit the WAA website, https:westchesterastronomers.org.

White Space Filler: Another Amazing JWST Image

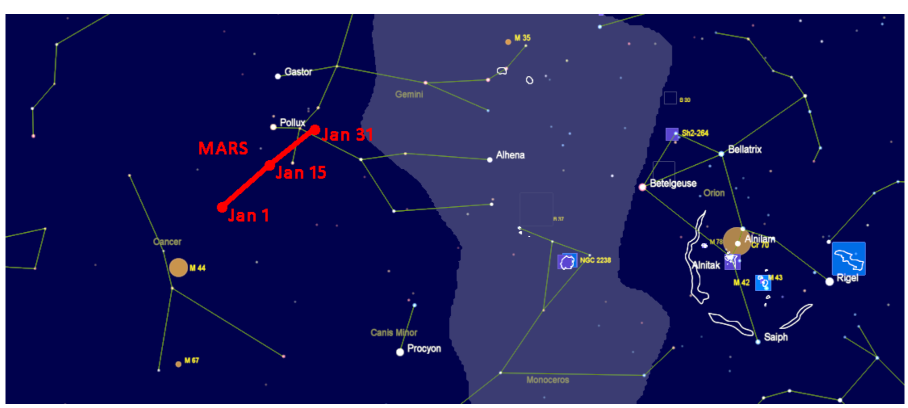


The Firefly Sparkle is a strongly lensed z = 8.296 galaxy, cocooned in a diffuse arc in the Canadian Unbiased Cluster Survey. It is a young, gas-rich galaxy in its early formation stage. It's mass is concentrated in 10 star clusters (49–57% of total mass), with individual masses ranging from 10^5 $M_\odot$ to 10^6 $M_\odot$. These unresolved clusters have high surface densities (>10^3 $M_\odot$ pc^{-2}), exceeding those of Milky Way globular clusters and young star clusters in nearby galaxies. The central cluster shows a nebular-dominated spectrum, low metallicity, high gas density and high electron temperature, hinting at a top-heavy initial mass function. These observations provide the first spectrophotometric view of a typical galaxy in its early stages, in the very early universe. Mowla, L., et. al., Formation of a low-mass galaxy from star clusters in a 600-million-year-old Universe *Nature* 636:332 (2024).

January Night Sky Map



The map above shows the night sky from Westchester at 10 p.m. on January 15. Solar system objects will be in similar positions, except for the position of the Moon, at 10:45 p.m. on January 1 and 9 p.m. on January 31. Mars will move the most, as shown on the right.



Solar System Highlights for 2025 — Bob Kelly

March is Eclipse Month for Us!

There are four eclipses in 2025: two total lunar eclipses and two partial eclipses of the Sun. We get to see two of the four. Our area is treated to a deep total lunar eclipse in the morning hours of March 14. On March 25, at sunrise, 28 percent of the Sun will be covered by the Moon. That's the max obscuration for this partial eclipse for us. Coverage decreases until the partial eclipse ends at 7:06 a.m. EDT. There are no total solar eclipses until August 12, 2026.

Moon Blocks Mars in January

On January 13, the Moon occults Mars. Mars disappears at 10:21 p.m., popping out on the other side at 11:37 p.m. The Moon and Mars rise very close to each other on February 9.

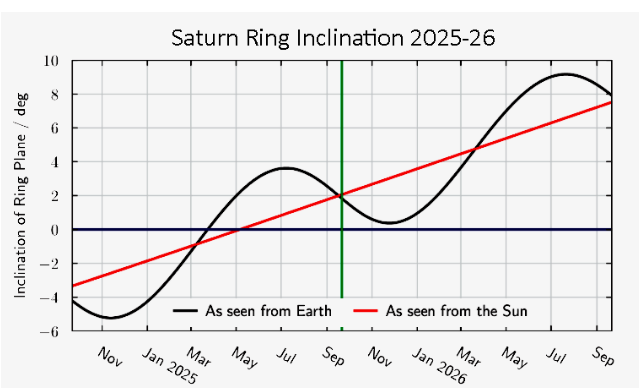
When to See the Planets

The best times to see Mercury in 2025 are, in the morning sky, in the second half of August and first half of December, and in the evening sky the first half of March.

Venus is visible in the evening sky through mid-March and in the morning sky from April until November.

Mars is in opposition on January 15 at 8:17 p.m. Earth is closest to Mars on January 12. The Red Planet is in the evening sky for much of the rest of the year until November.

Jupiter is an evening object through June and a morning sight from July through the rest of the year.



Saturn drops into the solar glare from the evening sky in February. Its rings are edge-on to Earth on March 23, but it will be too close to the Sun (9°) to see the phenomenon. On that day it will rise just 12 minutes before the Sun. Saturn will be viewable in the morning sky starting in mid-April. The rings will be open widest for 2025 in July, tilted about 3½ degrees and then narrow again but not to zero. Saturn reaches opposition on September 21. Neptune is within one degree of Saturn from late June through August and reaches opposition just two days after Saturn.

Uranus is an evening object through mid-April, peaking at magnitude +5.7 early in the year. It ascends into the morning sky in June. Opposition is November 21. It hangs in the neighborhood of the Pleiades, about 4 degrees away, in September.

Size Matters

Venus gains the top spot as largest planet as seen from Earth from February through mid-May as it catches up to Earth in its orbit.

In its January 2025 opposition, Mars appears almost as large as Saturn. It's one of Mars' farthest oppositions from Earth, but it is well-placed high in our skies.

The full Moons that are the most "Super" occur on November 5 and December 4. Watch out for higher-than-normal tides on those days and for a few days afterwards. Those sneaky super New Moons happen on March 29, April 27 and May 27 with similar tidal effects.

Meteor Shower Prospects

The Perseids peak on August 12 and 13, awash in an almost full Moon. The Orionids max out on the night of October 20/21 with a dark sky for the post-midnight peak. The Leonids peak in our afternoon, but only have a thin morning Moon for their November 17 and 18 mornings. Geminids peak on the mornings of December 13 and 14, with a waning Moon those mornings.

No returning comets are predicted to be bright in 2025, but maybe something new will pop into our neighborhood. We can only hope.

The Sun

Peak solar activity should continue through 2025, but cycle 25 may begin to wane later in the year. Use you hydrogen alpha scopes and full-aperture filters properly!

Some Mars Viewing Tips — The Editor

Observing the major planets takes more patience than you might think. Earth's atmosphere is your enemy. If you can go to the top of a tall mountain in clear, dry weather conditions, you will have the best view (true for observing in general, of course but especially true for planets and double stars). Schlepping your equipment to a mountain in Colorado or Arizona (or Chile) is not very feasible, especially in the winter. Closer to home, Bailey Benchmark, at an elevation of 980 ft. (299 m.), is the highest point in Westchester County, NY. It is located within the Sal J. Prezioso Mountain Lakes Park in North Salem, NY, very close to the Connecticut state line. It's on a hiking trail in the middle of a forest, so not good for observing and possibly impassable in January. The Meadow Parking Lot at Ward Pound Ridge Reservation is at an elevation of about 300 feet, and less than five miles from North Salem.

Setting up on grass is preferable to a paved surface since there is more heat rising from the concrete or asphalt, creating disruptive thermals. It's less of a problem in winter, of course. Similarly, viewing over roofs adds more atmospheric heat cells in your line of sight but will be impossible to avoid if you are viewing close to home. Also, check the weather report to see if the jet stream is going over the area. Your telescope should come to thermal equilibrium, which depends on the type of scope, size and the temperature difference between where it was stored and where you are observing. Be patient! For reflectors and SCT's, accurate collimation maximizes planetary detail. Dew heaters keeping the scope's optics just above the dew point are a good idea unless the humidity is extremely low. They might add a few thermals, but that's better than fogged optics.

The presence of the Moon in the sky is never a problem for viewing the bright planets, so you can observe on any reasonably clear night. Light pollution is also less of an issue.

High quality eyepieces with the fewest lens elements are preferred by planetary observers: Orthoscopics are possibly a little bit better than Plössls, but eye relief is very short at high-power with both. Field of view is smaller in Orthos than the now-ubiquitous Plössls. Three-element monocentric eyepieces are considered the *ne plus ultra* of planetary viewing, but they have only a 25-30 degree field of view, poor eye relief and anyway apparently no one makes them anymore. High-quality multi-element eyepieces like Televue Naglers (82°), Delite (72°) and Delos (62°) can give sharp views with good eye relief.

The maximum useful magnification depends on many factors, so have a range of eyepieces and perhaps a good Barlow available. The image always looks sharper at lower magnification. You'll have to find your "sweet spot" between size and resolution of surface features. I can't go higher than 225X with my 8" Celestron SCT in Westchester, but once in Maine with incredibly seeing I had superb views of Saturn and Jupiter with a 5-mm Nagler T6 (400X)

An orange or red filter will lighten Mars' desert regions and darken the rest of the planet and is extremely helpful for resolving surface markings. I like the Orange #21 (46% transmission) for general use on Mars. A light red filter (#23A, 25% transmission) is even better but will need more aperture, and the deep red (#25, 14% transmission) gives the most contrast, demanding at least 8 or 10 inches of aperture, since you are effectively dropping your telescope's speed by three f/-stops with a #25, and that's a lot of light loss. A green filter (#56, 53% transmission or #58, 24% transmission) will enhance the overall contrast of the image and help with the polar caps. A blue filter (#82A, 73% transmission; #80A, 29% transmission) can also enhance the polar caps.

You need to be patient at the eyepiece and catch the rare, precious moments of steady seeing. If you are showing Mars to other people, be sure to encourage them to look for at least a couple of minutes and wait for those brief moments of clarity. Beginners, especially children, tend to look for two seconds, see a fuzzy orange ball and then if you ask them "Did you see it?" they say "Yes," not wanting to disappoint you or their parents. Some years ago at a WAA outreach program at the Quaker Ridge School (Scarsdale), I sat next to the scope and talked each viewer, adult or child, through the observation, saying "Keep looking…wait for the view to settle…it will just be an instant and you'll see the polar cap…you'll see markings on the surface…wait for it…wait for it…" And each one, after 20 or 30 or 40 seconds, burst out with an excited "I see it!!" And they really did. ■

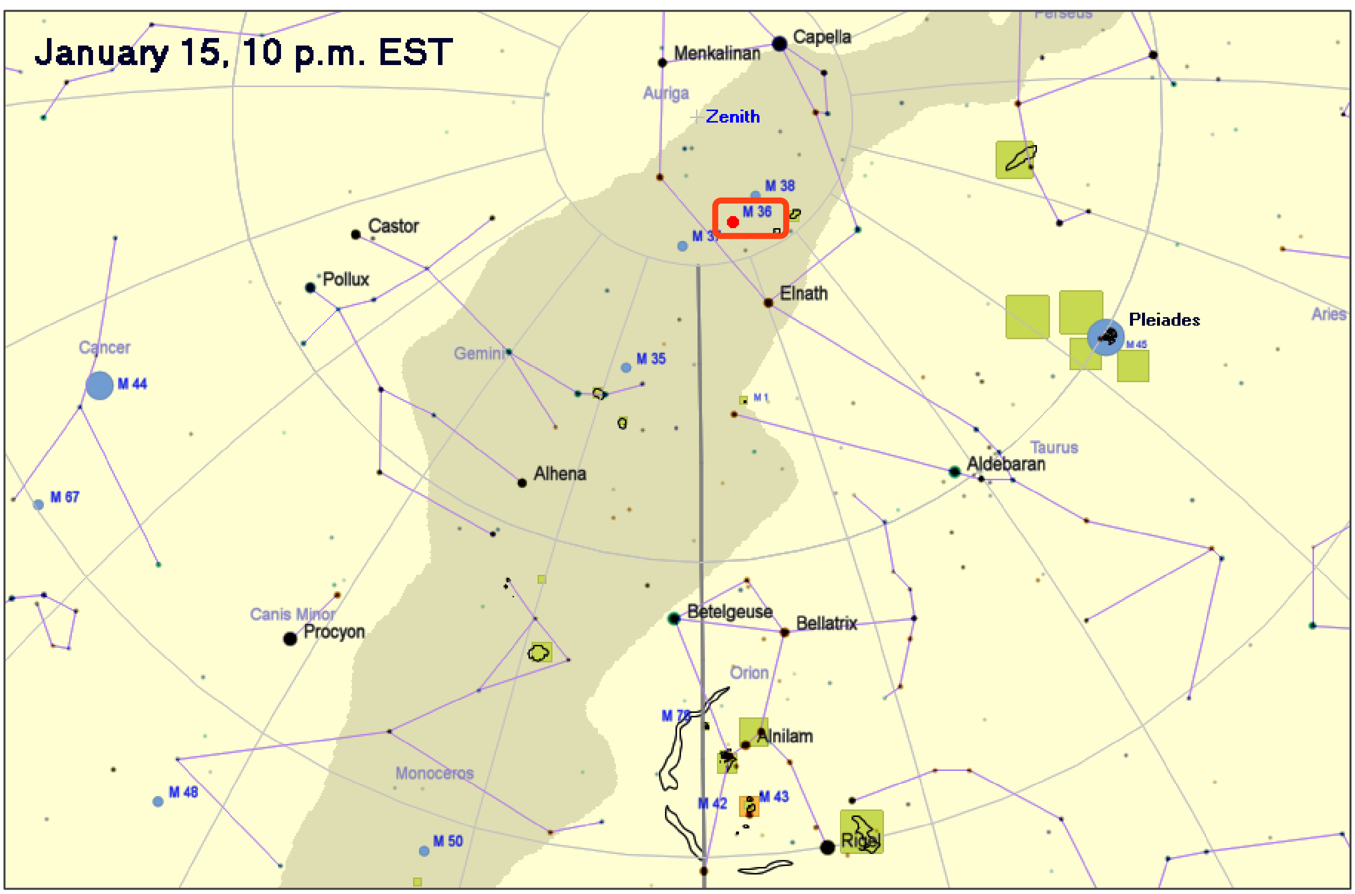
Deep Sky Object of the Month: Messier 36

Messier 36	
Constellation	Auriga
Object type	Open Cluster
Right Ascension J2000	05h 36m 18.0s
Declination J2000	+34° 08’ 24”
Magnitude	6.3
Size	12 arcminutes
Distance	4,340 light years
NGC designation	NGC 1960
Discovery	Hodierna, before 1654

High overhead in January, this rich open cluster, sometimes referred to as the Pinwheel Cluster, has a mass of 746 M☉. Estimates put its age at about 25 million years.

The distribution of star magnitudes and colors in M36 has been used to study the shape of the initial mass function curve (see the June 2023 SkyWAAtch, page 11 for more information about the IMF and https://is.gd/NGC1920IMF for a paper on the subject.

Visibility for M36			
22:00 EST	1/1/25	1/15/25	1/31/25
Altitude	78° 74’	82° 34’	73° 46’
Azimuth	125° 32	197° 47	250° 02’



Another Movie telescope: *Galileo*

What better subject for our *SkyWAAtch* movie telescope feature than the world's first astronomical telescope, Galileo Galilei's 1609 instrument?

We see it in *Galileo*, a 1975 film version of Bertholt Brecht's 1938 play *The Life of Galileo*, starring Topol as Galileo. The film was produced and directed by Joseph Losey as part of the American Film Theater's limited-run subscription series of filmed plays that ran from 1973 to 1975.

Brecht (1898-1956) developed a novel form of drama called "epic theater," in which the action was abstracted using devices such as songs (but not like a musical or opera) and direct addresses to the audience by the lead character to provoke reflection and analysis of the play's ideas. In *Galileo*, each of the dramatic sections is preceded by a trio of boy sopranos singing a short hymn referring to the ensuing action. The music was written by Hanns Eisler, with whom Brecht worked closely during the Weimar period. Kurt Weill was another close Brecht collaborator. The *Threepenny Opera* (1928), a "play with music," is the most famous of Brecht's works.

Brecht was a dedicated Marxist and infused his works with dialectical materialism, which affirms that ideas are inevitably created by material conditions. *Galileo* is subtly infused with this and other Marxist concepts. The film starts with Galileo needing money and making a telescope that he could license to the Venetians for mutual profit. But he has examined the heavens with it and realizes that what he has seen overthrows Aristotle's cosmic model, itself the basis of Church teachings. He bounces his ideas off his friend Sagredo (Giovanni Francesco Sagredo, 1571-1620), a Venetian anti-Jesuit, played in the film by Michael Gough (he played Alfred in the first few Batman movies). What is the telescope's purpose? Is it an instrument of discovery or a commodity for profit? Does what it reveal inevitably command the viewer. no matter how reluctant, to reject previously held ideas?

The conflict of science with religious orthodoxy of course plays the major role in the drama. Against Sagredo's advice, Galileo names the satellites of Jupiter the "Medicean Stars" to curry favor (and a higher salary) with Cosimo II de' Medici, the Grand Duke of Florence, who is portrayed in the film as a 9 year old but who was actually 20 when Galileo made his discoveries. Unlike Venice, which had expelled the Jesuits, Florence, like the rest of Italy, was under their dogmatic thrall. In a remarkable scene, Galileo begs Cosimo to look through the telescope, but a smarmy Jesuit insists that if something is seen in the telescope that contradicts biblical and

Aristotelian dogma, it must be false, and thus it would be dangerous to observe it. Although he wants to look, the boy is prevented and Galileo is derisively dismissed. Thus begins the conflict between Galileo and the Church that is played out in the remainder of the drama.

A corrolary theme of orthodoxy is that social order will be threatened if people think for themselves, justifying a controlling authority to suppress our base natures. In *Galileo*, this concept is ridiculed in an extended musical number during which the townspeople go crazy while an outrageous song is sung by an inebriated Clive Revill and whorish Georgia Brown. The pair played Fagin and Nancy in the very successful Broadway production of *Oliver!* In 1963.

The film takes many liberties with the details of Galileo's story, but not with the overall timeline or the major events. It was not Brecht's purpose to make a "biopic." This is theater, not cinema, and it is designed to force the audience to react to the intellectual and political implications of Galileo's achievements. To keep the drama moving, many interesting details had to be left out. You can find the most important of them in four essays about Galileo in the July 2022, August 2022, September 2022 and October 2022 issues of *SkyWAAtch*.

Brecht left Germany in 1933, moving to Denmark and then Sweden. He eventually came to the United States and was part of the German émigré community in Southern California that included composers Eisler, Arnold Schoenberg and Ernst Toch, conductor Otto Klemperer, director Fritz Lang and authors Thomas Mann and Lion Feuchtwanger. Both Brecht and Eisler were interrogated by the House Un-American Activities Committee in 1947. Brecht left the US the day after his testimony, moving to East Germany. Eisler was deported shortly thereafter, saying "I leave this country not without bitterness and infuriation. I could well understand it when in 1933 the Hitler bandits put a price on my head and drove me out. They were the evil of the period; I was proud at being driven out. But I feel heartbroken over being driven out of this beautiful country in this ridiculous way."

We caught *Galileo* on Turner Classic Movies. Topol's manic intensity is appropriate considering what we know of Galileo's irascible and arrogant nature. The film is based on a version of the play in English produced in 1947 that starred Charles Laughton (among his great roles *The Hunchback of Notre Dame*, *The Private Life of Henry VIII*, *Mutiny on the Bounty*, and most of all *Witness for the Prosecution*) and we can only imagine what a tour-de-force his performance would have been. Topol is quite fine as Galileo, driven yet rational, not backing down until his final defeat by the Inquisition, yet even after that, sad but persevering in the service of science. ■

$32 Million Telescope Settlement: What's It About? The Editor

Many WAA members received an email from Amazon on December 13 describing the settlement of a class action lawsuit that alleged price-fixing in the telescope business. It was brought against telescope manufacturers Synta and Ningbo Sunny and some of their executives.

This suit followed an earlier action brought in 2016 by Orion, the online telescope vendor, alleging various anticompetitive actions by Synta, which had acquired Celestron in 2003, and Ningbo Sunny, which acquired Meade in 2013, preventing its acquisition by Orion. This was complex litigation, and as one legal web site described it, "The claims in this case are nearly as numerous as the stars themselves."

Synta settled, but the case against Ningbo Sunny went to trial. In November 2019 a jury found for the plaintiff and Orion was awarded $16.8 million, which was trebled by the judge to $50.5 as permitted by Section 4 of the Clayton Act, 15 U.S.C.S. §15. There were various appeals and a later finding of contempt of court by the President of Ningbo Sunny. There is a summary of the case in a 2021 appellate decision at https://is.gd/orionsunny. Subsequently, Orion acquired Meade, which was bankrupt, but earlier this year Orion ceased operations.

Celestron and Meade were once bitter rivals yet they had tried to merge in 1991, only to be rebuffed by the Federal Trade Commission because it was deemed anti-competitive. Ultimately, they both became part of an extended, interlocking and at times inscrutable corporate network now based in China.

The class action suit (https://is.gd/telsclassaction) alleges violations of various Federal and State antitrust laws, resulting in inflated telescope prices, harming purchasers. Given the jury verdict in the Orion suit, it would probably be hard to defend, but It is important to note that this case is being settled, not concluded at trial. The defendants deny any wrongdoing. A settlement is not an admission of guilt.

Assuming that further court decisions do not change the plan, $32 million will be divided among the plaintiff's attorneys, who get one-third (apparently, they put in over 20,000 hours of legal work to make their case), $1.5 million for the administrator of the claim process, and the rest to be divided among claimants.

To be eligible to make a claim, you must have purchased one or more telescopes branded as Celestron, Orion, Skywatcher, Zhumell or Meade from a retailer or distributor. The purchase must have been made between January 1, 2005, and September 6, 2023, and at the time of the purchase, you must have resided in one of 33 states, which includes New York and Connecticut but not New Jersey. Separate mounts, binoculars and accessories do not qualify for inclusion in the settlement. Many WAA members will qualify for a claim.

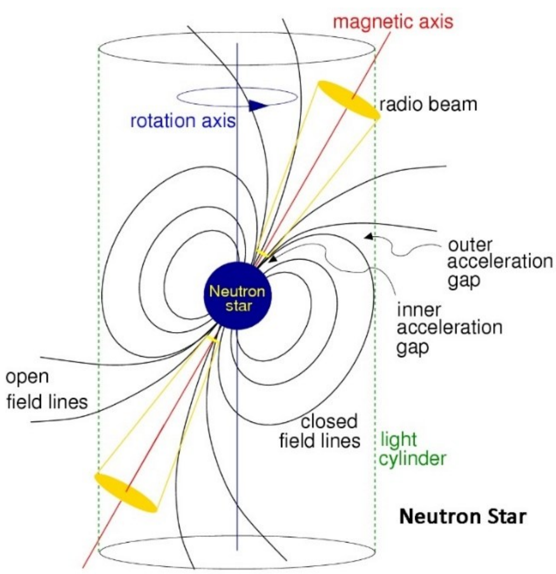
The process for filing a claim is easy. The online form at https://www.telescopesettlement.com/ is simple. It asks for your name, address, the make and model of the telescope, the vendor, the date purchased, and the price. You do not have to send them a copy of the receipt, at least not at this time, but if you don't have one that might be a problem in the future. Credit card records might be OK. Some buyers will receive a postcard with a claim number. Those purchases are already in a database, making the claim process even simpler (but you still have to go online to register). It looks like payments won't be made until 2026.

If, like me, you didn't buy a telescope from Amazon, why did they send you an email? The answer, I suspect, is that at some point you must have looked at astronomical equipment or parts on amazon.com, and so they know you're an astronomer!

In spite of the claim that telescope prices have been inflated, it seems clear to this writer that consumer telescopes have gotten better and cheaper (in inflation adjusted dollars) over the years. Consider this example: An orange tube Celestron C8 with 110-volt RA drive, a simple tangent arm on the declination axis, 6x30 finder, wedge and tripod cost about $1,000 in 1975. That's the equivalent of $5,864 today, due to inflation. The equivalent basic fork-mounted Celestron 8" SCT today is the CPC800 GPS XLT, which has the same optics, an 8x50 finder, motor drives on both axes, GPS, computerized go-to-hand control with 40,000 objects, easy alignment, a much better tripod and runs on 12 volts DC so it's easy to take it in the field. It costs $2,199 (a pre-Christmas sale price; the current list price is $2,599) not $5,864 or more. A remarkable increase in capability, usability and value (value is always defined as quality divided by cost). ■

Fast Radio Bursts Larry Faltz

Serendipity often drives science. In 1609, Galileo wanted to provide the Venetian navy with a useful military device, so he made a telescope, but he turned it on the heavens and changed humanity's conception of the cosmos. In 1896, Henri Becquerel was studying X-ray fluorescence, discovered the previous year by Wilhelm Roentgen, by surrounding a photographic plate with fluorescing salts and exposing the wrapped plate to the Sun. It being cloudy that day, he placed the wrapped plates in a drawer. After a few days he decided to develop the unexposed plate, and saw that the salt grains, which happened to contain uranium, had left an image on the plate, and discovered radioactivity. In 1932, Karl Jansky wanted to improve radio reception from Europe, but his antenna in New Jersey picked up radio emissions from the Milky Way galaxy. In 1998, two groups competing to measure the expansion rate of the Universe, which they thought was slowing, determined the distance of Type Ia supernovas in distant galaxies, and found that the expansion was accelerating.



The discovery of fast radio bursts in the first decade of the 21st century is a similar story of serendipity. It followed another unexpected detection, that of pulsars in 1967 by Jocelyn Bell (now Jocelyn Bell Burnell). She was examining the output of a new radio telescope when she noticed regular pulsations at an interval of 1.337 seconds. Her first thought, probably facetious, was that the pulses were the work of extraterrestrial intelligence, which led to their being labeled as "LGM-1," for "little green men." But ultimately the only model that would fit required a rapidly rotating compact object of immense density. Neutron stars had been predicted by Walter Baade and Fritz Zwicky in 1934 as the remains of the collapse of massive stars. They are not rare: could be as many as one billion in the Milky Way.

Neutron stars can rotate several hundred times a second (the fastest rotation measured so far is 716/sec, giving a speed at its equator of 0.24 *c*). The rotation rate will gradually slow by emission of gravitational radiation. Newly formed neutron stars can have surface temperatures as high as 10^{12} K.

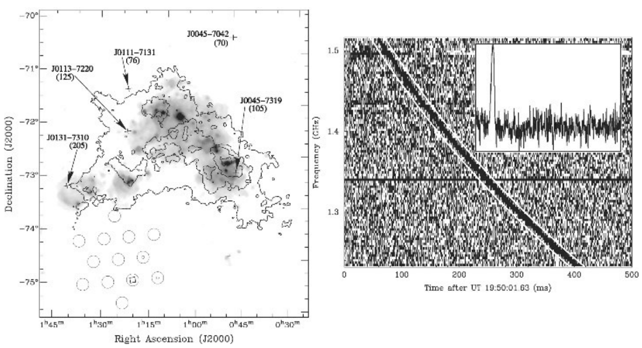
In 1964 Lodewijk Woltjer had proposed that they generate enormous magnetic fields, on the order of 10^{14}-10^{16} gauss. One of those small disc-shaped neodymium magnets now in common use has a strength at its surface of around 10^4 gauss. The magnetic field strength on the Earth's surface is around 0.5 gauss.

The rapidly rotating magnetic field of a neutron star accelerates electrons, which generate a high-intensity radio beam from the star's magnetic poles. If the pole points at Earth as it precesses around the star's rotational axis, we receive a pulse of radio emission, and we call that a pulsar. Not all neutron stars are pulsars: the beam has to cross our line of sight to register as a pulsar. Non-pulsar neutron stars can be detected by other means, for example measuring binary star orbits or detecting thermal X-ray emission from accreting matter falling onto its surface. A subclass of neutron stars with even stronger magnetic fields but slower rotation rates (2-10 revolutions per second) are called magnetars. They were proposed in 1992 by Robert Duncan and Christopher Thompson to explain "soft gamma ray repeaters," which have gamma ray emissions at frequent but irregular intervals.

The magnetic field of a magnetar is so intense that it can polarize the vacuum, meaning that spontaneous electron-positron pairs are produced that affect the matter and electric fields at the surface of the object. Star-quakes, fractures in the dense surface crust, are one consequence.

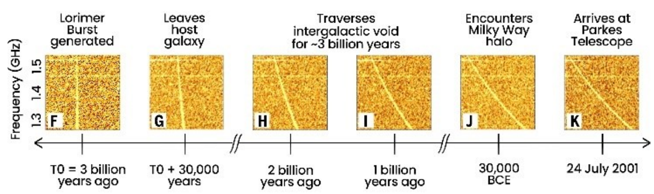
In 2006, Duncan Lorimer and his graduate student David Narkevic from the University of West Virginia were hunting for pulsars in archived data from the

Parkes Radio Telescope in Australia, a venerable 64-meter telescope built in 1961.[1] The data from the earlier observing runs were preserved on magnetic tape; new software could efficiently scan the data looking for radio impulses. They discovered a single very strong pulse of radio emission that had been captured on August 21, 2001.[2] The source was located about 3 degrees south of the Small Magellanic Cloud, but the telescope did not have the resolution to lock in the exact location. It lasted just 5 milliseconds and was received at an intensity of 30 Janskys, which isn't very much, a thousandth the strength of your cell phone transmitting from the Moon, but much stronger than the usual pulsar pulses. Unlike a pulsar, it did not repeat. Possible contamination by terrestrial sources was suggested but none could be found.[3]



Left: Fig. 1 from Lorimer, et. al., showing the location of the burst in the beams (circles) of the Parkes Radio Telescope. The strongest detection is marked with a square; two other beams had lower intensity detections (small circles). Right: Fig. 2 from Lorimer et. al. Frequency evolution and integrated pulse shape of the radio burst.

The pulse had a peculiar quality: the detected wavelength increased during the short period of detection. Lorimer proposed that this progressive delay was due to interaction of the radio waves with electrons in cold ionized plasma between the source and the detector. The velocity of electromagnetic radiation in a vacuum, regardless of wavelength, is 299,792,458 meters/second, but in the presence of matter, even at the nearly negligible concentration of intergalactic space, the speed slows. Think of this as a form of "refractive index," the difference in velocity of the electromagnetic wave between the medium (in astronomy, a lens) and a pure vacuum. Most of the matter in deep space is made of ionized hydrogen and helium. Charged particles, particularly electrons, interact with photons. The intervening matter, rarified as it may be, slows the radio photons, delaying the less energetic (longer wavelength) ones so they arrive at the detector at a slightly later time. This can be thought of as the analogue of "chromatic aberration" that occurs when light passes through a lens. The magnitude of the delay of a radio wave from a distance source thus becomes a measurement of the amount of matter between the source and the detector. This is known as the dispersion measure (DM). The DM is the sum of the matter content of the source's environment (the interstellar medium ISM within a galaxy), the intergalactic medium (IGM) between galaxies, and the ISM of the Milky Way in the line of sight.



What the Lorimer burst would have looked like at different times from its creation. The increasing dispersion reflects the electron density as the radiation travels through the cosmos.[4]

For the mathematically inclined, the DM is $\int_0^L n_e dL$, where L is the distance to the source and n_e is the free electron density at any point between 0 (us) and L. The formula gets a correction for red shift when the distance source is known from spectroscopy. In other words, the DM is the column density of electrons between us and the source. Most of the baryonic matter in the universe is not in stars or galaxies. The average density of free electrons in intergalactic

[1] The Parkes telescope was used to receive television images from Apollo 11. A slightly fictionalized account of what happened at Parkes is given in the excellent film *The Dish* (2000), a "historical comedy-drama" that stars Sam Neill.

[2] Lorimer, D, Bailes, M, McLaughlin, MA, Narkevic, DJ, Crawford, F, A Bright Millisecond Radio Burst of Extragalactic Origin, *Science* 318:777-780 (2007)

[3] In 2013, some pulses though to be FRBs were traced to a microwave oven 100 meters from the Parkes telescope. If you open the door of a microwave oven while it is still operating, it will emit radiation for an instant until the magnetron turns off. This radiation has been given the name "peryton," after a mythical beast that has the head of a stag and the body of a falcon. The beast was invented by the wonderful Argentinian writer Jorge Luis Borges in *The Book of Imaginary Beings*.

[4] From Bailes, M, The discovery and scientific potential of fast radio bursts, *Science* 378: 615 (2022).

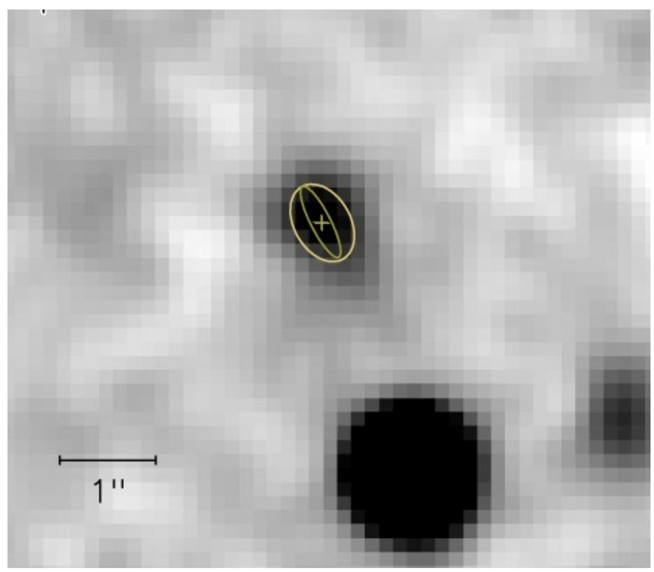
space is just 1 per cubic meter, but the distances are vast, so it adds up.

The dispersion measure of what is now called the "Lorimer burst," formally named FRB 070821,[5] was calculated to be 375 cm^{-3} pc, more than twice the DM of known pulsars in the nearby (200,000 light years) Small Magellanic Cloud. Lorimer et. al. were able to place an upper bound of 1 gigaparsec (3.26 billion light years, red shift about 0.2) as the distance to the source of the burst, but they had no way of being sure since no optical counterpart could be identified. At such a large cosmic distance the 30-Jansky signal strength must have been generated by an enormously powerful event. The estimate is about 10^{38} to 10^{40} ergs. The Sun emits 3.2×10^{38} ergs per day, but an FRB emits as much or more energy in a small range of the radio band, and in only a few milliseconds. The object was a trillion times more luminous than any known pulsar. No gamma-ray, X-ray or supernova events were noted anywhere near the position of the Lorimer burst at the time the signal was received. Clearly this must have been a previously unencountered phenomenon.

An emission just milliseconds in duration must be generated in a very small area, 1500 km or less. The only known sources capable of producing an emission of such power from such a small region are rotating radio transients (RRATs), which are probably neutron stars nearing the "death line," the rotation rate at which radio emission turns off, and giant pulses from millisecond or young energetic pulsars. But both of these sources would have produced lower luminosity events and there would have been many more detected in the Parkes instrument. The authors note, "[the FRB] appears to represent an entirely new class of radio source."

It wasn't until 2012 that a second burst, FRB 121102, was detected and four more were found in 2013, all with the Parkes telescope. The FRBs seemed to be random, unique events generally located away from the Milky Way, although precise locations were impossible. Single-dish radio telescopes like Parkes have relatively poor resolution for point sources. Their exact distance and cosmic environment couldn't be determined by matching them to optical telescope images since there were multiple objects in each radio field. The DM can be considered a proxy for distance since the difference between the electron density of the intergalactic medium (IGM) and the interstellar medium (ISM) is fairly well known. The DM is not an exact distance measure, however, since it can be affected by atypical local concentrations of matter, such as if the FRB occurred in a high-density environment like a supernova remnant. A distance measure using the red shift of a host galaxy would be preferable. Better identification of FRB positions had to await observations by telescopes that used radio interferometry, the output of many small detectors distributed over a wide area. The Jansky Very Large Array is a good example, and other instruments came online in the late 2020s and early 2020s.

In 2015, ten additional bursts from FRB 121102 were found in archival data from the 300-meter Arecibo telescope. Many additional pulses from this object were found in the ensuing years. This suggested that at least some FRBs were "repeaters" and could not be cataclysmic events like supernova explosions. The pattern of repeats is generally not regular, so these objects are not simply anomalously powerful pulsars.

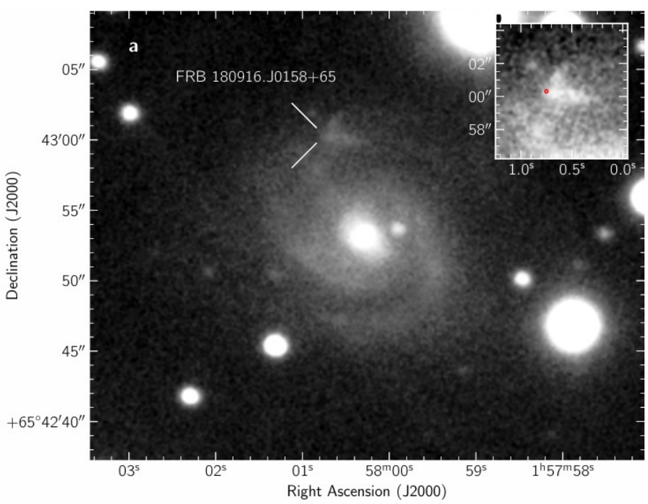


Localization of FRB 121102, from Tendulkar, SP, et. al., The Host Galaxy and Redshift of the Repeating Fast Radio Burst FRB 121102, *Astrophysical Journal Letters* 834:L7 (2017). The image was made with the Gemini North telescope on Mauna Kea.

[5] FRBs are named for the date of the event. Many of the earliest FRBs were found by searching through archival data, so the burst happened much earlier than the date of discovery. The Lorimer burst is properly FRB 070821 even though it was first noted in 2006 and reported in the literature in 2007.

In 2017, FRB 121102 was localized to a faint dwarf galaxy at red shift z = 0.19273, distance 972 megaparsecs (3.16 billion light years). The galaxy was actively making stars at a rate of 0.4 M⊙ per year, which is very high for a galaxy whose total mass was estimated to be only 4-7 × 10^7 M⊙. For comparison, the mass of the Small Magellanic Cloud is 7 x 10^9 M⊙.

In 2015, FRB 110523 was noted to have a large amount of polarization, which indicated that its source must have been embedded in a highly magnetic environment. Most FRBs appear to have a substantial degree of polarization. Among the most credible explanations for the repeating FRB 121102, which were also found to be polarized, is that the bursts arise from the surface of a neutron star that is closely orbiting a magnetized black hole. Magnetars were also invoked as possible sources, but they could not generate the pulses simply by their own rotation.



Gemini North image of SDSS J015800.28+654253.0, the host galaxy of FRB 180916 (red dot in the inset). The uncertainty in the position of FRB 180916.J0158+65 is smaller than the resolution of the image.[6]

In 2018, the CHIME (Canadian Hydrogen Intensity Mapping Experiment) telescope became operational. With high sensitivity and resolution, it's found many FRBs, several thousand to date. One of its most important early findings was FRB 180916, a repeating FRB that was localized to a star-forming region in a spiral galaxy at a distance of 500 million light years.

It might make sense that FRBs are found in star-forming regions of galaxies. Star formation depends on gravitational compression of cold gas, but the rate of star formation might be increased if supernova explosions from massive stars compress surrounding gas. Core-collapse (type II) supernovas are the progenitors of neutron stars, so if FRBs are related to neutron stars or magnetars, one would expect to find them where stars are born.

In 2019, a paper[7] summarized the possible explanations for FRBs. A total of 38 viable models were presented. The majority involve compact objects (white dwarfs, neutron stars, magnetars, black holes) either merging or collapsing. The models also include theoretical objects like quark stars, axion stars, white holes, cosmic strings and primordial black holes. Emissions powering alien light sails was proposed by Avi Loeb. A later review paper on FRBs commented that "there were more models than there were then known bursts." The authors set up a "living" web site, https://frbtheorycat.org/, to tabulate all current theories and provide links to the papers. As of December 2024, there were 51 models listed. The majority of FRBs are non-repeating, although more and more repeaters are being found. It has been suggested that all FRBs may be repeaters but the repetitions have either not been detected because they are too infrequent or because local circumstances block or absorb the emissions. It is likely that there are several ways in which the bursts can be generated. In addition, the models must account for the fact that the "brightness temperature," the temperature at which a blackbody would have to be to generate an FRB radiation spectrum, is calculated to be as high as 10^{36} K. The only way this could be achieved is if the radiation is coherent, that is, all in phase. The maximum brightness temperature of "incoherent" radiation is just 10^{12} K. Maybe not "just," since that's a trillion degrees!

FRBs are almost all (with one exception) at cosmic distances, far beyond the Milky Way. Regular pulsar

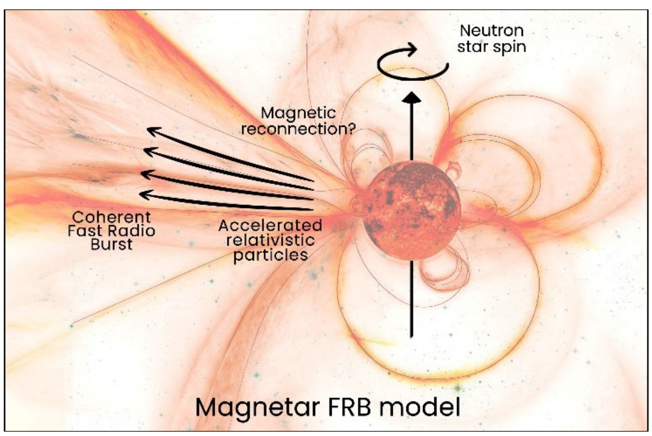
[6] Marcote, B.; et al. A repeating fast radio burst source localized to a nearby spiral galaxy. *Nature*. 577: 190–194 (2020).

[7] Platts, E. et. al., A Living Theory Catalogue for Fast Radio Bursts, *Physics Reports*, 821:1-27 (2019)

emissions are not strong enough to be detected if the pulsar is in a distant galaxy, except for one that may have been identified in the core of Messier 31. There are 29 pulsars in the two "nearby" Magellanic Clouds.

The soft gamma ray repeater SGR 1935+2154 was discovered in 2014 by the Swift telescope. It is 30,000 light years from the solar system, but still within the Milky Way. It is generally agreed that SGRs are magnetars. Their irregular bursts of soft gamma rays and X-rays are powerful, as much as 10^{41} erg/sec, and rarely they can have giant flares up to 10^{46} erg/sec, with the bursts generally lasting about 100 milliseconds. These bursts do not have FRB-level energies at radio wavelengths.

FRB 200428 was localized to SGR 1935+2154. Its energy was somewhat less than FRBs from distant galaxies but was still 4×10^3 times stronger the most extreme radio outburst from the Crab Nebula pulsar. FRB 200428 was found to be a repeater. The infall of debris from a disrupted planet in orbit around the magnetar has been proposed to explain the bursts and their periodicity.

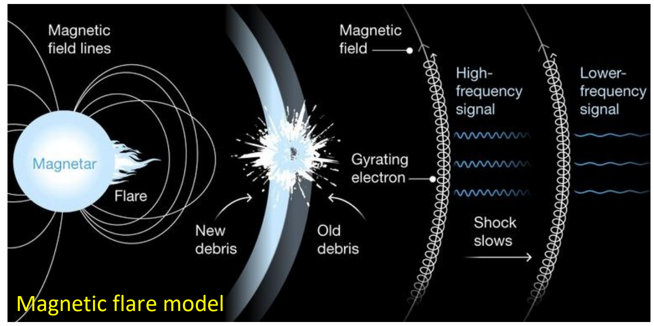


Magnetar FRB model

Magnetar FRB model from reference 4.

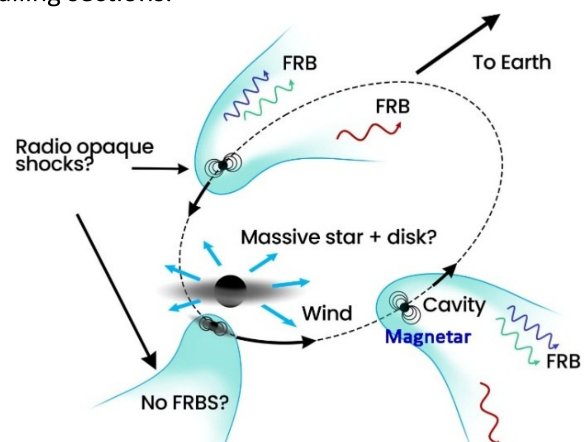
A significant proportion of FRB models involve magnetars. Mechanisms must create vastly more energetic radio emissions than typical pulsars. Among these models, one that seems probable is that the magnetar's intense magnetic field undergoes sudden reconfiguration, accelerating particles to relativistic (near light speed) velocities, which generate coherent radio emission in the magnetosphere (above).

Another possibility is that a flare from the surface of a magnetar sends a large mass of particles into slower-moving remnants of a previous flare, generating shock waves that induce a new, stronger magnetic field in which electrons gyrate, emitting coherent synchrotron radiation in the radio band.



Magnetic flare model

Another repeating FRB model[8] involves the interaction of a hot, massive star's stellar wind with an orbiting magnetar. The interaction produces cavities surrounding the magnetar, separated by a shock front. The cavities preferentially emit high-frequency FRBs at the leading edge and lower-frequency FRBs in the trailing sections.



Orbiting magnetar model

One problem with any magnetar scenario is that magnetars are relatively short-lived. Within 10,000 years after their formation from a core-collapse supernova, their magnetic fields decay and they become ordinary, if slowly rotating, neutron stars. Some FRB models invoke ordinary neutron stars merging with other neutron stars, white dwarfs or black holes, or even collapsing into "quark stars" (which have never been observed). These objects still have significant magnetic fields at their surface.

[8] Zhang, B, A "cosmic comb" model of fast radio bursts. *Astrophysical Journal Letters* 836, L32 (2017).

In 2017, Lingam and Loeb[9] proposed that FRBs could be due to "artificial beams that have been set up as beacons, or for driving light sails." This was not a new idea, having been alluded to in the pioneering paper on SETI by Cocconi and Morrison.[10] Lingam and Loeb calculate that the transmitter would have to be twice the diameter of the Earth and use the energy of a star, and that a light sail would need a boost every seven days but could carry a 10^6 ton payload. The paper concludes "Although the possibility that FRBs are produced by extragalactic civilizations is more speculative than an astrophysical origin, quantifying the requirements necessary for an artificial origin serves, at the very least, the important purpose of enabling astronomers to rule it out with future data." It's a peculiar argument to justify publication since so many of the assumptions, while rational, are arbitrary. In the face of some contravening observation the authors might just tweak the assumption to explain the new finding. On the other hand, in the SETI world we are obligated to make some guesses, lest we have no imagination at all.

In another paper in 2017 from the astronomy department at Harvard, Fialkow and Loeb calculated that there could be an FRB occurring somewhere in the observable universe every second.[11] This was based primarily on their analysis of the behavior of the first repeater, FRB 121102, and its localization to a specific galaxy. It's now accepted that there are "thousands" of FRBs daily, of which we detect only a small proportion. But they must be rare in any given galaxy, otherwise we would have detected one or more enormous bursts from the Milky Way, not just the relatively mild FRB 200428.

By 2017, only 17 FRBs had been discovered. Fialkow and Loeb predicted a massive increase as new radio telescopes came online. That prediction has been borne out. The Square Kilometre Array Pathfinder in Australia, CHIME in Canada, the Survey for Transient Astronomical Radio Emission 2 (STARE2), a 3 radio telescope in California and Utah, and MeerKAT in South Africa, among other new radio survey telescopes, have now detected well over 1,000 FRBs, localizing many of them to specific galaxies with the enhanced resolution of these new instruments.

Building on this proposed mechanism for FRB 200428, a paper posted in November[12] suggests that FRBs could result from the impact of interstellar objects ejected from the nebula around newly formed stars onto the surface of neutron stars. The arguments are statistical and make many assumptions about the size, velocity, density and energy contributed by these so-called Interstellar Objects (ISOs). Of course, to date only two have been detected: 1I/'Oumuamua and 2I/Borisov, and their exact nature is still uncertain. Theoretical models of star formation predict the creation of a lot of what we might call "space junk." The authors suggest that they "have demonstrated that the expected ISO-NS collision rate is consistent with the cosmic rate of FRBs within the order-of-magnitude uncertainties," which could mean that almost all FRBs are accounted for by this model! That seems hard to believe, but it's essentially as credible as any other explanation to date. I can imagine that journal reviewers would have much to say about the assumptions underlying this proposed mechanism.

Another recent paper[13] claimed that the preferential environment for FRBs was in rarer, more massive galaxies with higher metallicities (more elements heavier than H and He) than in smaller, younger galaxies with higher rates of star formation. Other transient phenomena like X-ray and gamma-ray bursts and supernovas are usually found where new star formation is high. The authors suggest alternative routes for magnetar formation, such as binary neutron star mergers, that could be localized to older star neighborhoods. The sample size for this paper was small, and considering that the first FRB repeater, FRB 121102, was found in a small galaxy, I'm not sure this will hold up. But it may very well be evidence that that there is more than one way of making an FRB. ■

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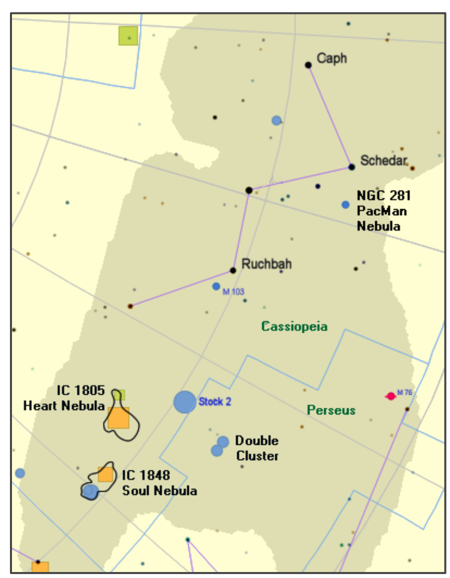
[9] Lingam,M, Loeb, A, Fast Radio Bursts from Extragalactic Light Sails, *Astrophysical Journal Letters* 837: L23 (2017)
[10] Cocconi, G., Morrison, P., Searching for Interstellar Communications, *Nature*, 184, 844-846 (1959)
[11] Fialkow, A, Loeb, A, A Fast Radio Burst Occurs Every Second throughout the Observable Universe, *Astrophysical Journal Letters*, 846, L27 (2017)
[12] Pham, D., et. al., Fast Radio Bursts and Interstellar Objects, https://arxiv.org/pdf/2411.09135
[13] Sharma, K., et. al., Preferential occurrence of fast radio bursts in massive star-forming galaxies, *Nature* 635: 61-66 (2024) (published 7 November 2024)

Images by Members

The Soul Nebula by Steve Bellavia

In the Second Index Catalog, the discovery of IC 1848 is credited to E. E. Barnard, whom we highlighted in last month's SkyWAAtch page 22-23 in connection with Rick Bria's image of NGC 281, the Pac-Man Nebula. There is no report in the literature of this discovery that I could find, but one on-line reference suggested that Barnard had communicated it directly to John Louis Emil Dreyer, who compiled the NGC catalogue and its two IC supplements.



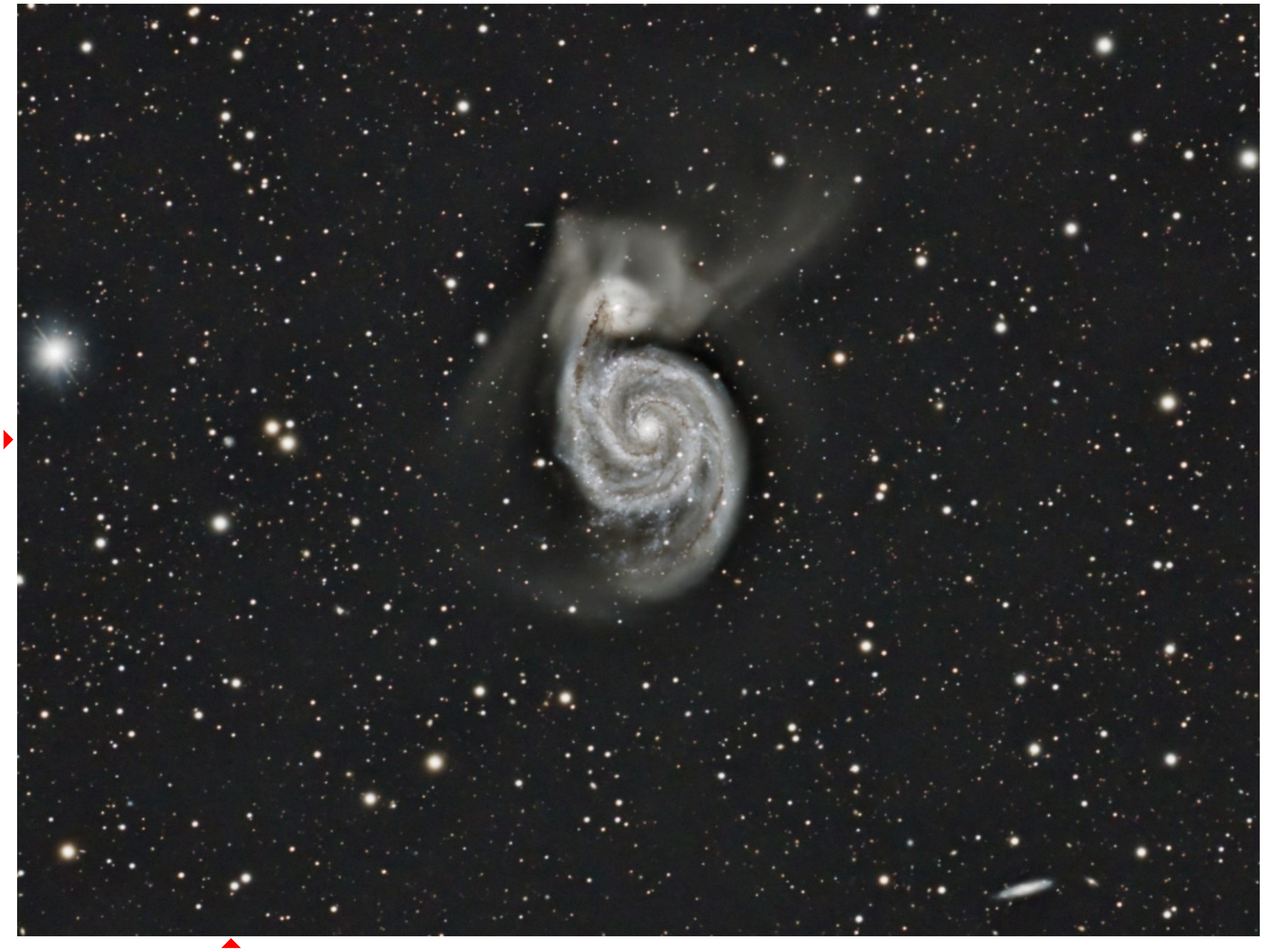
IC 1848 is properly one of the open clusters embedded in the nebula, with several other IC and LBN designations for the areas of emission.

Steve wrote,

> I haven't imaged the Soul Nebula (it looks like a bear to me), in over four years. So I came back to it, using Ha, OIII and SIII narrowband filters with a monochrome camera and my own adaptation of the Hubble Palette. This was First Light for my backyard in Smithfield, Virginia [Steve moved there in November—Ed.]. I had to hide behind the house due to a new streetlight that was recently installed, but it worked out okay. I am hoping to have Dominion Energy put a full-cut-off shield on that light. It is actually dark sky compliant with a flat shield on top, but it shines in all directions, outward, into my house and yard.

The full technical information is at https://www.astrobin.com/p39ebm/.

Star Streams of the Whirlpool Galaxy by Robin Stuart



Messier 51, in the constellation of Canes Venatici, is made up of a pair of gravitationally interacting galaxies. The larger Whirlpool Galaxy is designated NGC 5194 or M51a and the smaller is companion galaxy smaller NGC 5195 or M51b. The pair lie 31 million light years from Earth. M51a is 60,000 light years across.

The interaction has caused M51b to disgorge multiple long streams of stars, pairs of which can be seen both to the east (left) and west (right). M51a is producing its own stream of stars seen to the to the left of the lower spiral arm. The star streams were studied and labeled in a 2015 paper from Case Western University (read it at https://is.gd/m51streams). The small spiral galaxy in the lower right is IC 4263, magnitude 15.1, distance 130 million light years. Triangulate the red markers to find IC 4282, a magnitude 17.83 elliptical galaxy at redshift z=0.045892, distance 624 million light years.

William Parsons, the 3rd Earl of Rosse observing with his 72 inch Newtonian reflector, the largest telescope of the 19th century, was the first recognize M51 as a "spiral nebula" although its identity as a galaxy was not understood at the time. The telescope was constructed at Birr Castle in Ireland in 1845 and was dubbed the “Leviathan of Parsonstown.” For more on the Whirlpool Galaxy, see the June 2016 SkyWAAtch, page 4.

This image is 43.8×32.9 arcminutes and is a stack of 23 x 10 minute subframes giving a total exposure time of 3 hours 50 minutes. The subframes were taken in Eustis, Maine on the 1st and 3rd of April 2024 using a ZWO ASI2600MC camera on a Televue NP 127 refractor.

-Robin Stuart

Comet C/2023 A3 Tsuchinshan-ATLAS and Open Cluster IC 4665 by Steve Bellavia

We couldn't fit this image into the November issue. Steve made it on October 24, 2024, with a 70-mm lens. A spur-of-the-moment effort, a stack of 25 four-second shots, no tracking or calibration.

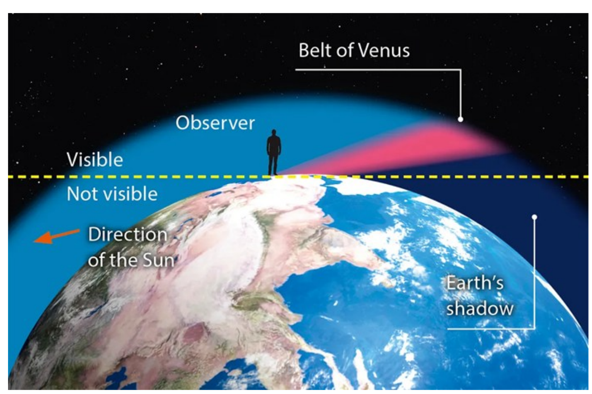
The Belt of Venus by Karen Seiter

Karen was in San Diego for a medical conference and snapped this picture from her hotel shortly before sunrise on December 7th. The dark blue shadow of the Earth sits below a red band of reflected sunlight. The Earth's shadow is higher above the horizon on the right than on the left, due to the Earth's spherical shape. If you had an unobstructed view of the entire horizon, the Belt of Venus would be a gentle arc that is highest at the anti-Sun point. This, and the shape of the Earth's umbra on the Moon during a total lunar eclipse, are the two phenomena that you can see with your own eyes that proves that Earth is a sphere.

Aphrodite, the Goddess of Love, wore a "girdle" that had the power to excite amorous passion, and not only in mortals. In Homer's *Iliad*, Hera asks Aphrodite to lend it to her so she can seduce Zeus and distract him from intervening against the Greeks, whom Hera supported.

…[Aphrodite] loosed from her breasts the breastband,
Pierced and alluring, with every kind of enchantment
Woven through it…There is the heat of Love,
the pulsing rush of Longing, the lover's whisper,
irresistible—magic to make the sanest man go mad.

Homer *The Iliad*, Book 14, l. 256-261. Translated by Donald Fagles



BBC The Sky at Night

Research Highlight of the Month

Schultz, TR, et. al (23 authors), The coevolution of fungus-ant agriculture, *Science* 386: 105-110 (2024)

We often comment that astronomy connects to all other areas of science. Here's an exotic but perfect example.

There are 247 New World ant species that cultivate fungus. Fungus-farming ants have a complex social structure, perhaps the most complex after *Homo sapiens*. Individual ants slice up leaves and carry up 20 times their body weight back to the colony to feed specific species of fungus. Other ants actively maintain the fungus colony, which serves as the food source for ant larvae. They pay attention to how the fungi respond to different leaves, changing the leaf source if the fungi are not thriving. It is a remarkable example of symbiosis: the ants need the fungus and the fungus needs the ants.

Leafcutter ants

Genetic and taxonomic studies can trace the evolution of certain traits. The ants have been extensively studied, and previous data showed that the ability to cultivate fungus evidently arose tens of millions of years ago. For this study, evolutionary biologists looked at the genomes of 475 species of fungus, tracing their connections back in time. Then the research team made a timeline of the ant-fungus pair evolution. Matching dates were found in both evolutionary trees.

The studies show that ant and fungus taxonomies involved in farming interactions arose 66 million years ago. This is exactly the time that the Chicxulub meteor smashed into the Yucatan. Debris in the atmosphere blocked sunlight and shut down photosynthesis throughout the world for at least several months. Dinosaurs were exterminated. While many other plant and animal species perished, fungi that decompose plant material had plenty of nourishment, and so they flourished.

There had previously been some degree of ant-fungus interaction, and these species of ants were able to take advantage of the increased availability of wild fungus. They began to farm the fungus in a more organized manner. Then about 27 million years ago, a subset of ants domesticated their fungal cultivars, the equivalent of human beings domesticating animals that are now genetically removed from their origins. This corresponds to a period of global cooling and droughts in South America. The fungi separated from their native gene pools and became totally dependent on the ants. And vice-versa.

In Darwinian evolution, organisms evolve into ecological niches, but the niche can't be predicted before the organism evolves into it. A complex ant society farming fungus, because of a meteor. Evolution due to astronomy!

What the taxonomic data looks like:

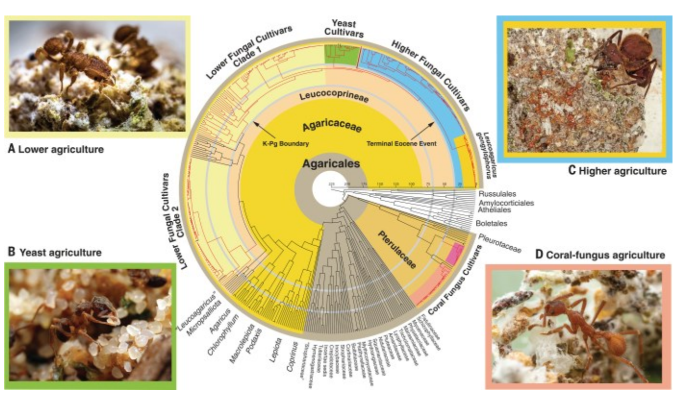


Fig. 1 from the paper. Chronogram resulting from Bayesian divergence-dating analyses of phylogenomic data for 288 ant-cultivated and 187 non–ant-cultivated fungi.

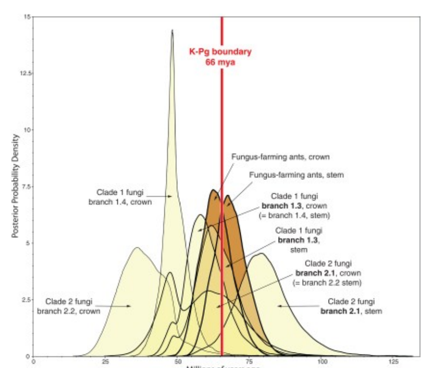


Fig. 3 from the paper. Posterior-probability distributions for stem and crown node ages of the ancestral branch of fungus-farming ants (brown) on the ant phylogeny and for four branches on the fungal phylogeny (yellow) on which "cultivation by ants" may have originated.

Member & Club Equipment for Sale

Item	Description	Asking Price	Name/Email
NEW LISTING 6-inch f/8 reflector optical tube	Orion 6-inch f/8 reflector in very good condition. 2-inch focuser. Has Telrad finder base; you'd need to buy a Telrad. You would also have to supply tube rings or figure out how to make it into a Dobsonian. Mirror has center dot for collimation. Image of scope is here.	$25	David Parmet davidparmet@icloud.com
NE-W LISTING Skywatcher 120-mm f/5 refractor	This 600-mm focal length doublet achromat comes on a Sky-Watcher AZ-GTI mount. 2-inch diagonal, red dot finder. Eyepieces not included. The AZ-GTI mount is operated via wi-fi connection to a phone or tablet [it works well; your Editor has one]. You need to download the free SynScan app. A new AZ-GTI mount alone is $400. A great beginner scope	$550	Anthony Maida lvam1521@yahoo.com
Explore Scientific 10-inch f/5 Hybrid Truss Tube Dobsonian.	25-mm and 10-mm eyepiece s, red dot finder, collimation rod, two 2.5 lb. counterweights for using heavier 2-inch eyepieces. Just a few months old. Excellent condition, optically and cosmetically. Have the original box and packaging. Image at https://is.gd/XPwDUh. Local pickup; asking price reduced.	$500	Manish Jadhav manish.jadhav@gmail.com
iOptron IEQ45Pro equatorial mount head	Traditional German equatorial mount. Includes Go2Nova 8407 hand control (358K objects), counterweight, QHY PoleMaster for easy polar alignment, but no tripod. Payload 45 lbs (without counterweight). Mount weighs 25 lbs. This model is also discontinued by iOptron. The current very similar mount (GEM45) lists for $2,598 (plus $269 for the PoleMaster). A 1.75" iOptron "Lite-Roc" steel tripod costs $350; piers and other tripods are available. Specs for the IEQ45 are still on iOptron's web site. Donated to WAA.	$400	WAA ads@westchesterastronomers.org
ADM R100 Tube Rings	Pair of 100 mm adjustable rings with large Delrin-tipped thumb screws. Fits tubes 70-90 mm. You supply the dovetail bar. Like new condition, no scratches. See them on the ADS site at https://tinyurl.com/ADM-R100. List $89.	$50	Larry Faltz lfaltzmd@gmail.com
iOptron CEM25P equatorial go-to mount	A complete IOptron "center-balanced" equatorial mount. Includes Go2Nova 8408 hand control with >50,000 objects, 4.7 kg counterweight, heavy-duty tripod, QHY PoleMaster for easy polar alignment (laptop required). Low periodic error. Payload 27 lbs (without counterweight). The mount weighs 10.4 lbs. Excellent condition. Although this model is discontinued by iOptron, the current very similar mount lists for about $2,097. Details of the CEM25P and an image are still available on iOptron's web site. Donated to WAA.	$350	WAA ads@westchesterastronomers.org
1.25" Filters	Thousand Oaks LP-3 Oxygen III (2 available)	$50	Eugene Lewis genelew1@gmail.com
	Astronomic UHC (2 available)	$75	
	High Point Neutral Density (2 available)	$10	

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 offer only serious and useful astronomy equipment. WAA reserves the right not to list items we think are not of value to members. All receipts for items owned by WAA goes to support club activities.

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