SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

October 2024

M16, the Eagle Nebula, by Justin Accetturi

This is an unusual, elegant wide-angle view of the often-imaged Eagle. The telescope is a William Optics FLT 132 triplet APO refractor at f/6.9 and an ASi294MM camera with narrowband filters. Justin imaged 11 hours through an Hα filter, 8 hours of OIII signal and 14 hours of SII, an additional 1.5 hours through RGB filters to show the stars and of course darks and flats. The field is 62.9 x 38.4 arcminutes, per astronmetry.net.

The Pillars of Creation are nicely outlined against the blue oxygen signal. We usually think of planetary nebulas when encountering OIII emission, for example the blue body of the Dumbbell Nebula or the Blue Snowball, but the Eagle is a star-forming region. In this case the nebular gas has been enriched in oxygen from local supernovas and is then ionized by ultraviolet emission from very hot young stars that have just formed.

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

WAA October Meeting

Friday, October 18 at 7:30 pm

Monster Black Holes at the Edge of the Universe

Zoltan Haiman, PhD
Department of Astronomy, Columbia University

Black holes as massive as several billion solar masses appeared within a billion years after the Big Bang. The origin of these objects remains a mystery. Prof. Haiman will present state-of-the art speculations on how such massive black holes may have formed in the early universe from black hole remnants of the first stars, via rapid gas accretion, or via successive mergers. Observations with the James Webb Space Telescope (JWST) and with the space-based gravitational-wave detector called Laser Interferometer Space Antenna (LISA) will help us understand the origin of massive black holes, as well as their subsequent growth through gas accretion and mergers.

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

Also In This Issue

WAA November Meeting

Friday, November 8 at 7:30 pm

Evaporating Exoplanet Atmospheres

W. Garrett Levine
Department of Astronomy, Yale University

October Starway to Heaven

Ward Pound Ridge Reservation, Cross River, NY

Saturday, October 5 at 6:30 p.m.
Weather permitting. Use your judgment! Check email or the WAA phone hotline for weather updates.

October Special Member Event

Saturday, October 26 at 6:30 p.m.
Observing with the Westport Astronomical Society at the Rolnick Observatory in Westport, CT. RSVP required. More information will be sent via email.

New Members

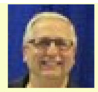
Anthony Chang	Ridgewood
Jennifer Morrissy	Ossining

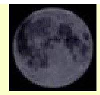
Renewing Members

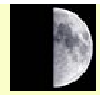
Thomas Boustead	White Plains
Jorge and Priscilla Camino	Mt. Kisco
Jim Carroll	Peekskill
Jose E. Castillo	Pelham Manor
Rick Faery	Rye
Joan Indusi	Ossining
Bob Kelly	Ardsley
George & Susan Lewis	Mamaroneck
Joe Lisle	White Plains
Scott Mellis	New Rochelle
Anthony Monaco	Bronx
Hugh Osborn	New Rochelle
Jeremy Pantlitz	Port Chester
Harry Vanderslice	Mamaroneck
Jose Vega	Yonkers
Cliff Wattley	Danbury

ALMANAC For October 2024

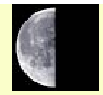
Bob Kelly, WAA VP of Field Events


Bob Kelly


New 10/2


1Q 10/10


Full 10/17


3Q 10/24

Yay, October

Just about the perfect month. Still light when driving home from work. Gets dark soon enough and the kids can see some stars before bedtime. Sunrise is late enough to get a glance at the planets in the morning sky.

Eclipse? Not Here

Paired with last month's partial lunar eclipse, an annular eclipse of the Sun occurs on the 2nd. It'll cross Easter Island and southern Chile and Argentina.

Out West in the Evening

Venus is still very low in the evening sky, even as it separates farther from the Sun. Venus is closest to the Moon on the 5th, but it will be easier to spot the following evening when the Moon will be about the same height above the horizon as Venus. In a telescope, Venus looks like a small, slightly out of round dot.

Mercury tries to join the scene, maxing its elongation from the Sun on the 24th. It keeps its height above the horizon into early November, but it doesn't get anywhere near Venus' not-so-high altitude.

Look Up, Way Up!

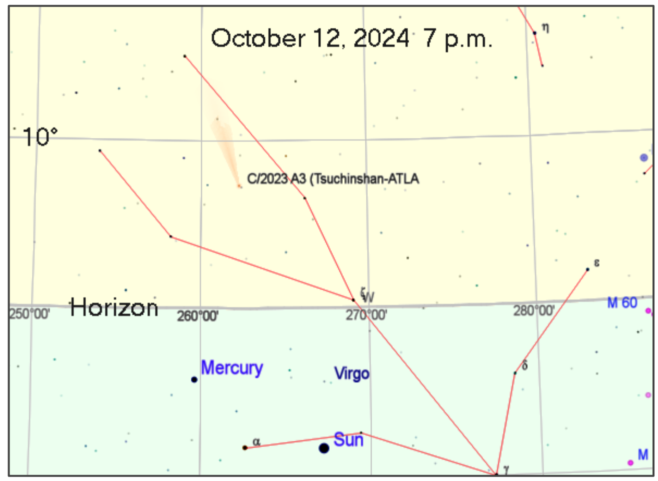
Jupiter has been brilliant, high in the pre-dawn sky. The giant planet rises just after 10 p.m. at the start of the month. This beacon of a planet heralds the coming of the winter constellations behind and below it.

Mars, Where Art Thou?

Mars continues to lag behind its fellow planets. It is getting large enough to see some of its surface features in a moderate aperture telescope (see page 23). It is slightly less gibbous than Venus. Mars-rise moves up an hour to 11 p.m. by the end of the month. It doesn't get to its highest elevation in the sky until well into morning twilight.

Bright Comet?

The long-awaited Comet C/2023 A3 Tsuchinshan-ATLAS appears in our skies. After a brief low-altitude morning apparition in the first few days of the month, C/2023 A3 makes a foray into the evening sky in the middle of the month. By the 11th, it may be visible right after sunset. By mid-month, it'll gain altitude but lose brightness. See page 5 for more information.



Ring, Ring, Saturn's Calling

Saturn is in a lovely place in the evening sky, transiting in the late evening. We recede from the butterscotch-colored planet, but it still appears as the second-largest planet as seen from Earth this month.

Iapetus, Saturn's two-faced moon, is brightest when well to the west of the planet. It gets farthest away on the 14th. Titan, Saturn's brightest moon, makes a couple of trips out, and seems to be reeled back in, closest on the 7th and 23rd. The rings are tilted only five degrees toward us, opened a bit wider than the minimum of 1.9 degrees in July. The narrower view of the rings makes it easier to see more of Saturn's seven brightest moons.

Superest Moon

October's full Moon on the 17th is the closest and largest full moon of the year. The usual notices about higher than normal tides in the following days apply. The only closer perigee was about 175 miles nearer, back in March.

Who's Up?

The SpaceX Crew 9 launch is planned for September 26 as of this writing. A crew of just two astronauts are going to the ISS this time, to leave two seats open for the ill-fated Boeing Starliner crew (Butch and Suni) so they can return to Earth with Crew 9 six months from now. https://whoisinspace.com/ keeps track of how many humans are off the planet at any given time.

China's Tiangong space station has three taikonauts on board. They are entering their fifth month of their Shenzhou (divine boat)-18 mission.

In October, International Space Station and Tiangong overflights will be visible in the morning starting on the 15th. Check https://heavens-above.com/ for the latest updated times and dates.

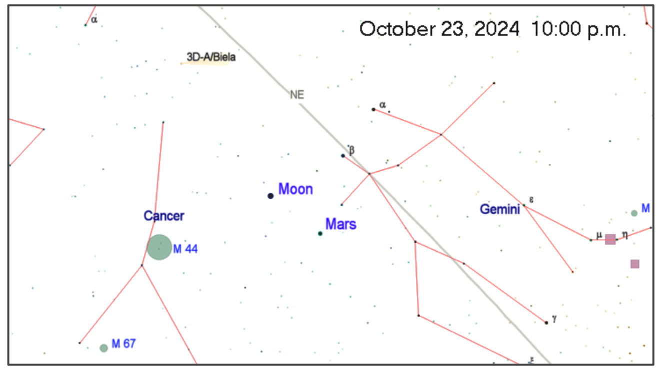
Incoming!

The Orionid meteor shower peaks on the night of the 20th/21st. The highest rates of meteors are in the pre-dawn skies. The waning gibbous Moon will make these tiny pieces of Comet Halley hard to see. The Moon will illuminate the skies for all three major meteor showers for the rest of 2024, the Orionids, Leonids and the Geminids.

Not-So-Close Encounters

The Moon swings wide of the ecliptic in late October, so it keeps its distance from Jupiter on the 21st, passing right next to Beta Tauri. This star is better known as Elnath, and is part of the horns of Taurus, or the five-sided base of Auriga. Take your pick.

It's a stretch, but can you imagine the Moon joining hands with Mars, in the arms of Gemini, on the 23rd?



International Observe the Moon Night, September 14th

Bob Kelly and Jordan Webber performed a bit of what we might call "just-off-the-sidewalk" astronomy on the lawn of Our Lady of Mt. Carmel Church and School in Elmsford from around 6:30 to 10:00 p.m. in honor of International Observe the Moon Night, a NASA-sponsored outreach event. Around 40 passers-by stopped to look at the nearly 12 day old Moon as well as Saturn. The left photo shows Bob explaining how telescopes work to one of the first families that stopped by. The photo on the right shows some of the equipment set up before the Moon moved out from behind a nearby building and we could start viewing.

WAA Members: Contribute to the Newsletter!

Send articles, photos, or observations to waa-newsletter@westchesterastronomers.org

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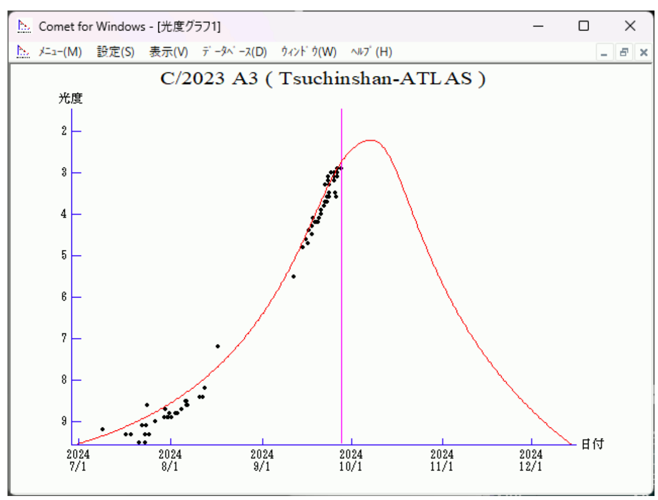
More On Comet C/2023 A3 Tsuchinshan-ATLAS

Just as we were ready to send out this month's issue, the intrepid Steve Bellavia sent in this image of the comet taken in from his home in eastern Long Island on September 30 just before dawn. It's a stack of 40 one-second images taken with a DSLR and a 100-mm f/2 lens.

Here is a table of the elevation of the comet in the morning ½ hour before sunrise or ½ hour after sunset.

Date	Time	Alt	Time	Alt
10/1/2024	6:21	07° 34'		
10/2/2024	6:22	07° 08'		
10/3/2024	6:23	06° 27'		
10/4/2024	6:24	05° 29'		
10/5/2024	6:23	04° 17'		
10/6/2024	6:22	02° 49'		
10/7/2024	6:21	01° 05'		
10/10/2024			18:50	01° 40'
10/11/2024			18:49	05° 30'
10/12/2024			18:48	09° 29'
10/13/2024			18:47	13° 23'
10/14/2024			18:45	17° 17'
10/15/2024			18:44	20° 44'



Brightness curve from aerith.net as of 9/30/24

Taro Ietaka, New Manager of Ward Pound Ridge Reservation

On Friday, August 29th, WAA President Jordan Webber and Vice President for Field Events Bob Kelly met with the new manager of Ward Pound Ridge Reservation, Taro Ietaka. We presented a “Certificate of Appreciation” to Taro in recognition of our long and productive relationship with the park. WAA has been holding star parties at WPRR for more than 30 years. The certificate shows a spectacular image of the Andromeda Galaxy photographed at the park by WAA member Justin Accetturi.

Taro was very positive about the club’s arrangement with the park to permit members to observe or image on non-star party nights. He commended our members for being diligent in providing the required advance notification and said we have been good stewards of the park’s resources.

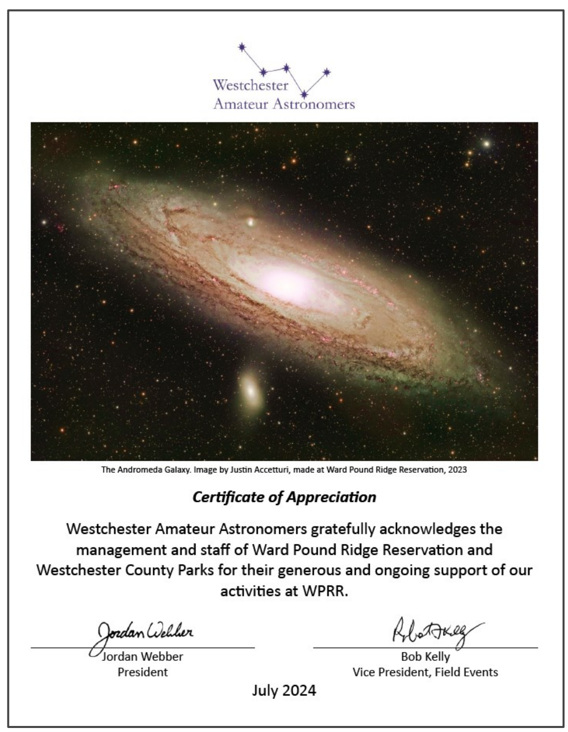
The park is officially closed at sunset except for registered campers and WAA members who have provided the required notification. WAA has a Special Use Permit with the park that specifies the conditions under which members have access.

Left to right: Bob Kelly, Jordan Webber, Tar Ietaka

Observing at Ward Pound Ridge

To gain entry to the Meadow Parking Lot at Ward Pound Ridge Reservation on non-star party nights:

- You must be a current member of Westchester Amateur Astronomers.
- You must call the park no later than mid-day of the day you wish to observe. Give your name and cell #.
- You must carry your WAA ID card and show it to the park ranger if asked.
- You may bring a family member or a guest.
- You may not hold impromptu star parties or other events for non-members groups.
- You must not leave any refuse or litter at the site.
- The WAA ID card is sent to new and renewing members as an attachment to the acknowledgement email. It is good until the expiration date on the card.
- Replacement ID cards can be obtained by emailing waa-membership@westchesterastronomers.org.



Westchester Amateur Astronomers

The Andromeda Galaxy. Image by Justin Accetturi, made at Ward Pound Ridge Reservation, 2023

Certificate of Appreciation

Westchester Amateur Astronomers gratefully acknowledges the management and staff of Ward Pound Ridge Reservation and Westchester County Parks for their generous and ongoing support of our activities at WPRR.

Jordan Webber
President

Bob Kelly
Vice President, Field Events

July 2024

Deep Sky Object of the Month: Messier 15

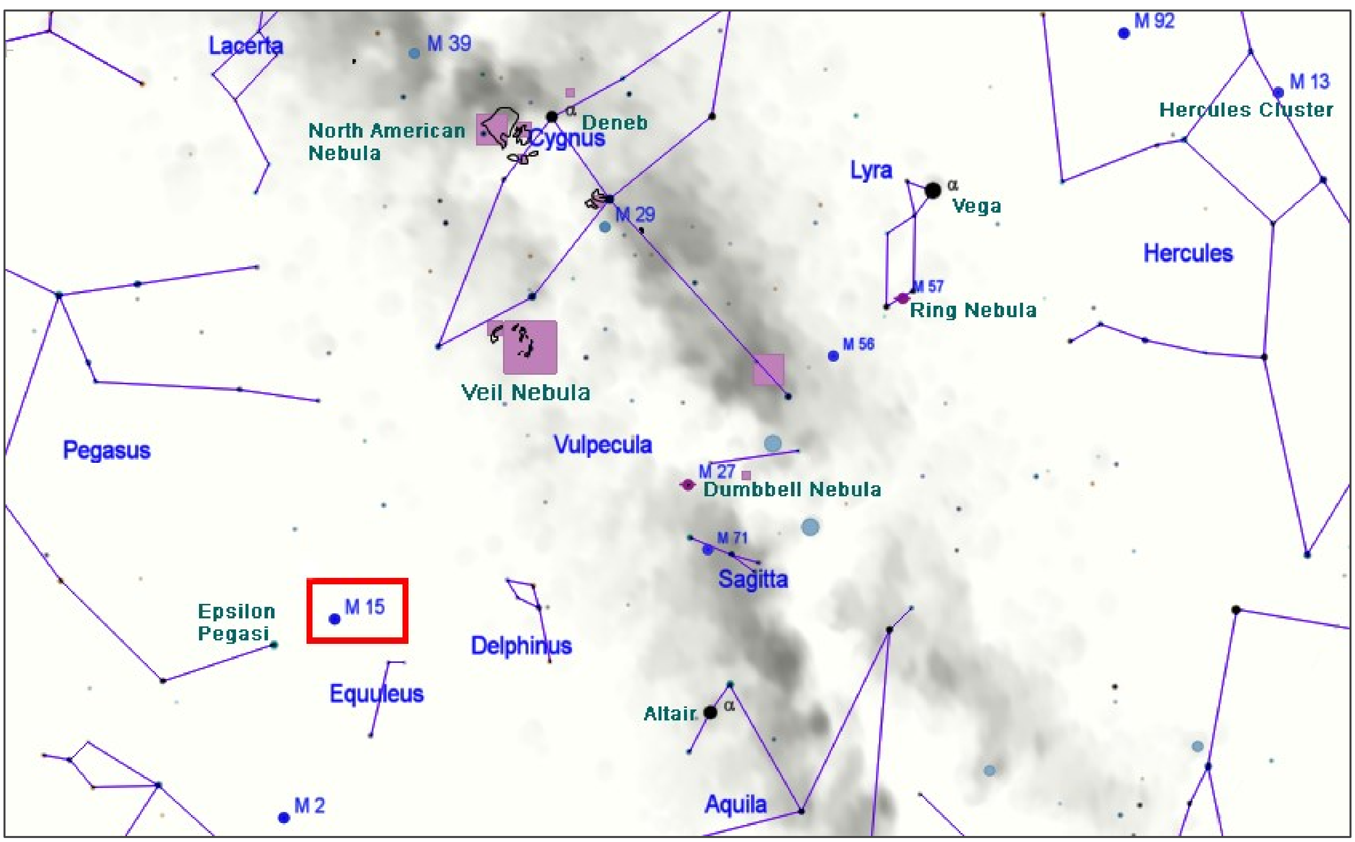
Messier 15	
Constellation	Pegasus
Object type	Globular Cluster
Right Ascension J2000	21h 29m 58.3s
Declination J2000	12° 10' 01.2"
Magnitude	6.4
Size	18 arcminutes
Distance	35,690 light years
NGC designation	NGC 7078
Other names	The Great Pegasus Cluster
Discovery	Jean-Dominique Maraldi, 1746

Visibility for M15			
2200	10/1	10/15	10/31
Altitude	60° 42’	56° 43’	48° 13’
Azimuth	189° 50’	214° 49’	236° 07’

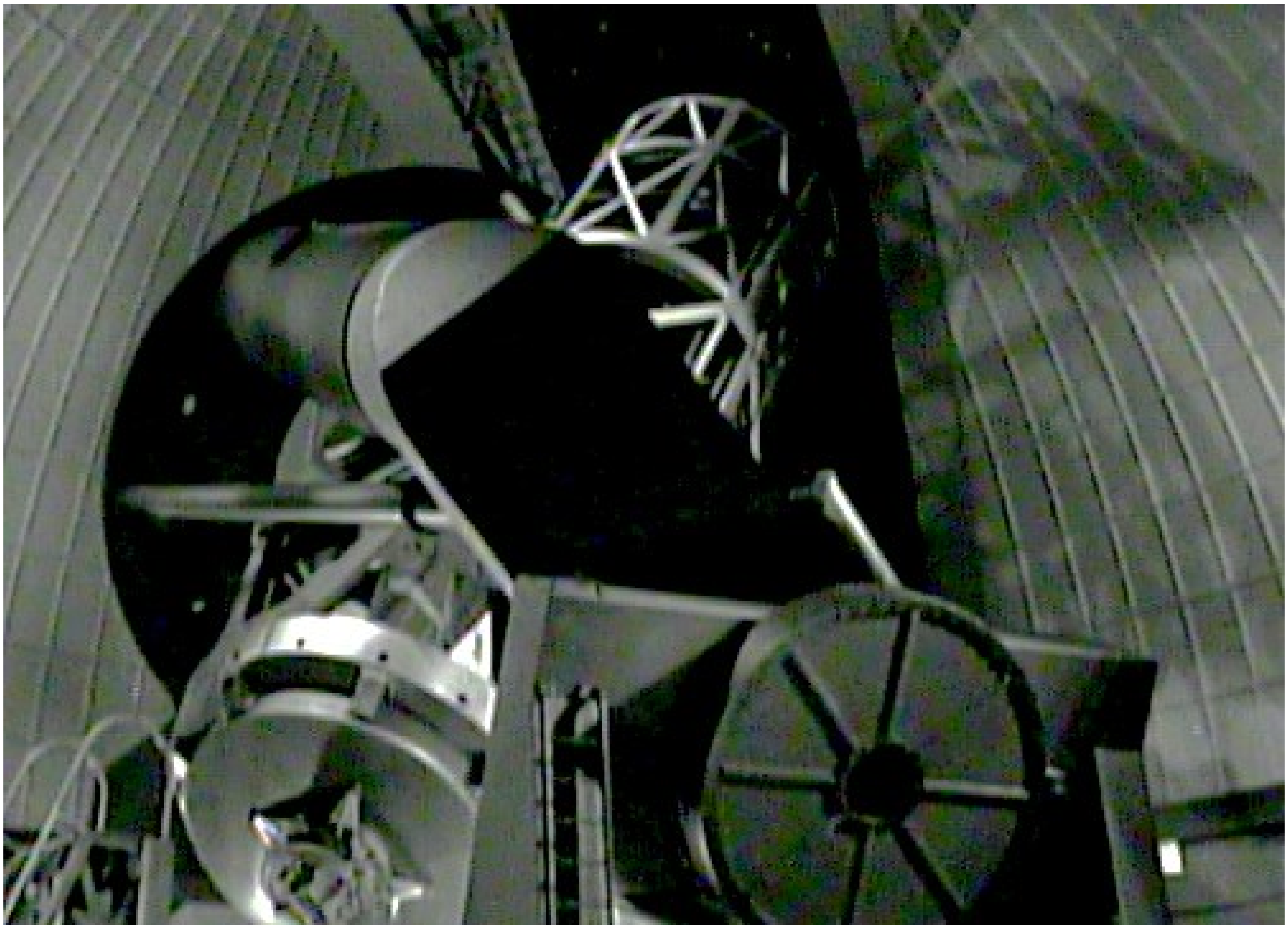
Typical of Milky Way globular clusters, M15 is old (12 billion years) and has a high metallicity ([Fe]/[H] ratio of –2.37). Visually, it has a very bright central core, which is densely packed with stars. The core has a high X-ray flux and may contain a central black hole.

M15 contains a 15th magnitude planetary nebula, Pease 1. Alas, it is impossible to see visually among the densely packed stars except perhaps with a gigantic telescope, an OIII filter and dark skies.

M15 is just 4° northwest of the magnitude 2.4 red supergiant star Epsilon Pegasi.



Another Movie Telescope: *The Heavenly Body*



The 1944 romantic comedy *The Heavenly Body* opens with a custodian lovingly polishing one of the struts of a huge observatory telescope. We meet William S. Whitley (William Powell), an astronomer at the "Mt. Jefferson Observatory." He's discovered a comet that he calculates will crash into the Moon at an exact time. His wife Vicki (Hedy Lamarr) is having difficulty with the conflict in their schedules: he sleeps during the day and is served breakfast at her dinner time, so their lives are completely out of sync. We meet them at one of those breakfasts.

Whitley: I'll have a few days off just as soon as this comet business is over.

Vicki: You've said that before.

Whitley: Yeah, but this time it's in the bag. Because I know now my calculations are exact. Our comet is going to make astronomical history.

Vicki: Oh my clever little man! My clever little astrologer.

Whitley: (Grabs his forehead and slumps in frustration). Oh, Vicki…darling…Scientist, mathematician, physicist, bacon-eater (pointing to his breakfast), yes, but <u>not</u> astrologer.

Vicki: Oh, I'm sorry.

Whitley: Darling, astronomy and astrology may sound alike, but that's all. Astronomy is a science. Astrology is…oh…superstition.

Vicki: Aren't you a little intolerant? For thousands of years, astrology has been highly respected.

Whitley: Astrology, my love… stinks.

The couple's neighbor (a ditzy Spring Byington) is into astrology and convinces Vicki to have her horoscope cast by the unctuous Mrs. Sybill, astrologer to the rich and famous. Complications ensue, but all is well in the end. Most of the comedy concerns Whitley's desperate attempts to win back his wife's affection.

The telescope looks a good bit like the 200-inch Hale at Mt. Palomar, which had not yet seen first light when the movie was made but was already famous. (For a tour, see the September 2016 SkyWAAtch). Early in the film Powell looks at a small screen at the telescope's Cassegrain focus, as if there's a video camera inside the instrument. Wishful thinking: video cameras in 1944 would have been too large to fit inside a telescope. If anything, it would have been a huge contraption sticking out the back of the instrument.

Whitley's comet crashes into the Moon on time, the event shown on a screen to a large crowd of astronomers at the observatory. Such a presentation might have been possible in 1944 (with one of those large cameras) at least for the brightest objects (see "The History of Photoelectric Astronomy" in the November 2021 SkyWAAtch).

Every night at 11:00 p.m., Whitley looks through a small refractor while the stunning Vicki (in 1938, Louis B. Mayer promoted Hedy Lamarr as "The World's Most Beautiful Woman") stands in the window of their bedroom and waves. Although she made several comedies, Lamarr is not a particularly adept comedienne and the chemistry between the leads just isn't there. The relatively silly plot might have come off better had the wife's part been played by someone like Myrna Loy, with whom Powell made 14 films, notably six *Thin Man* films and our favorite, the immensely funny and clever 1936 screwball comedy *Libeled Lady*, which also starred Spencer Tracy and Jean Harlow.

Lamarr was an inventor in her spare time, and famously teamed with avant-garde composer George Antheil to develop and patent (U.S. patent 2,292,387) a frequency-hopping radio guidance system for torpedoes. The Navy never implemented it but it forms the basis for cell phone and GPS technology. The story is told by Pulitzer Prize-winning author Richard Rhodes (for *The Making of the Atomic Bomb*, 1987) in the 2012 book *Hedy's Folly*.

The Atmosphere of Uranus: Spectroscopy and Recent Imaging Larry Faltz

The development of astronomical spectroscopy in the 19th century opened the cosmos to a new level of scientific discovery. No longer were astronomers limited to simply cataloging the positions and brightnesses of astronomical objects, or distinguishing nebulas from comets. Spectroscopy can probe the actual makeup of astronomical bodies. In addition to differentiating stars by their absorption and emission lines, the composition and even the rotation of planets could be determined.

Among the pioneers of astronomical spectroscopy was the Italian astronomer Angelo Secchi. He made the first classification scheme for stellar spectra, which was later adopted and expanded into the Draper Classification that we use today. Secchi also did pioneering work on the solar surface. His equipment is displayed in the Copernican Museum at the headquarters of the Istituto Nazionale di Astrofisica (INAF) in Rome, which we visited in 2022.

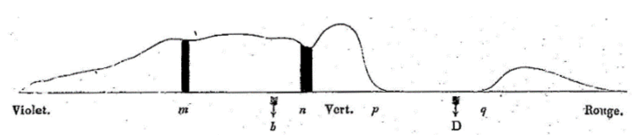
One of Secchi's spectroscopes and his drawings of sunspots. Note the prisms at the lower right corner of the image (LF)

Secchi worked at the Collegio Romano, the Jesuit college in central Rome. He constructed an observatory atop the adjacent Church of St. Ignatius (Sant'Ignazio), a building famous for its *trompe d'oiel* cupola.[1] In 1870, Rome fell to the forces of the newly united Kingdom of Italy and the Papal States ceased to exist. The Vatican was confined to its current 121-acre campus in Rome (Vatican City) and the 135-acre Apostolic Palace at Castel Gandolfo, where the Vatican Observatory is headquartered (see the July 2022 SkyWAAtch). The Jesuits were forced from the college but, recognizing Secchi's prominence and international reputation (he had trained and worked in England and the United States) and in spite of his refusal, as a Jesuit, to give up his allegiance to the Pope, the new secular government allowed the observatory to function until Secchi's death in 1878.

Secchi had already examined a large number of stars spectroscopically (all by eye) and was studying the 6th magnitude R Geminorum [SAO 79070, HD 53791]. He reported[2] in French in the *Comptes Rendus*, the journal of the French Academy of Sciences, that,

> Busy studying the little star R of Gemini… I turned the spectroscope towards Uranus, which was in the field [it was 34 arcminutes away in February 1869—Ed.], without hoping to see anything particular there, because the planet barely seemed a star of 6 magnitude, and the Moon, which was not far away, was quite large. To my surprise, I saw a very vivid spectrum and with a very pronounced band near its end!

He labeled this band *n*. With further study, he found a second absorption band, labeled *m*. Both were distinct from and broader than the Frauenhofer lines D (sodium doublet at 583 nm) and b (magnesium at 518 nm).



Secchi's drawing of the spectrum of Uranus (from ref, 2).

Spectral lines were referenced to the lines in the solar spectrum, which had lettered identifiers first

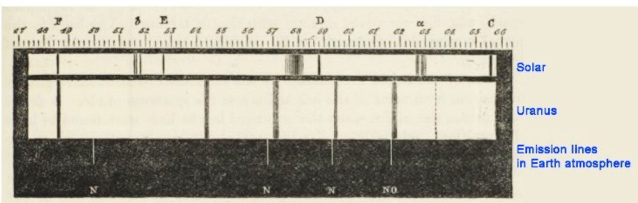
[1] Sant'Ignazio was designed by the Jesuit mathematician, astronomer and architect Orazio Grassi, with whom Galileo tangled over comets. Galileo's *The Assayer* (1623) was a brutal and effective attack on "Sarsi,". Grassi's *nom de plume*.

[2] Secchi, A., Résultats fournis par l'analyse spectrale de la lumière d'Uranus, de l'ètoile R des Gémeaux, et des taches solaires. *Comptes Rendus* 68: 761-765 (1869) https://is.gd/secchiuranus

proposed by Frauenhofer in 1814. Their chemical origin had only recently been explored by Kirchoff and Bunsen. Comparing Uranus' spectrum to that of the Sun, Secchi wrote,

> We therefore see that the spectrum of this planet has no resemblance with the solar spectrum…. If this spectrum is purely due to reflected solar light (which one could perhaps question), it must undergo a considerable modification [and get] degraded in its atmosphere. The absorption found here would be analogous to that which we observe with solids or transparent colored liquids.

William Huggins had observed planetary spectra in 1864, but the light from both Uranus and Neptune was too feeble to be analyzed. In 1871, he presented the spectrum of Uranus obtained using a new 15-inch Grubb refractor.[3]



Huggins's drawing of the spectrum of Uranus, our annotation.

Huggins was able to perceive a continuous background spectrum from the planet, but also noted that there was a "remarkable absorption taking place at Uranus [that] shows itself in six strong lines, which are drawn in the diagram." Huggins identified one line as belonging to hydrogen (labeled F in the diagram). This is the hydrogen beta line at 486.13 nm. The other lines had no equivalents in the solar spectrum. He drew no conclusions about the nature of the Uranian atmosphere.

For a brief time, astronomers toyed with the idea that the planet's mysterious spectrum was evidence that Uranus might be a self-luminous body. This theory was supported by no less a personage than Norman Lockyer, discoverer of a mysterious absorption line in the Sun's spectrum that he assumed was an unknown element, which he named helium. Helium itself was not chemically isolated until 1895.

Huggins was able to obtain a photographic spectrum of Uranus in 1889. In a letter to a colleague that was read to the Royal Astronomical Society, he wrote,[4]

> You may like to know an interesting new result I have just got. I have succeeded by photography in solving the question of solar lines in the spectrum of Uranus. With an exposure of two hours I got on June 3 a fine spectrum from about [Frauenhofer lines] F to N in the ultra-violet. On the same plate a solar spectrum is photographed for comparison. In the spectrum of the planet all the principal Fraunhofer lines are distinctly seen, and I am unable to distinguish any other lines bright or dark. It is certain, therefore, that the light of the planet, for this region of the planet at least, is solar.

Not self-luminous, but also not simply reflective.

In 1903, Vesto Slipher at Lowell Observatory in Flagstaff, Arizona mounted his new Brashear spectrograph on the 24-inch Clark refractor and made photographic spectra of Uranus and Neptune. Using "isochromatic" film that was optimally sensitive in the yellow part of the spectrum, he obtained spectra with unprecedented detail. Although the paper does not specify the exposure duration for Uranus, spectra for Neptune required 14 and 21 hours of exposure! The Uranus spectra were restricted to the wavelength range 4647 Å to 5910 Å because the photographic emulsion was saturated at yellow and longer wavelengths.

The Brashear spectrograph, now on display at Lowell Observatory (LF, 2011)

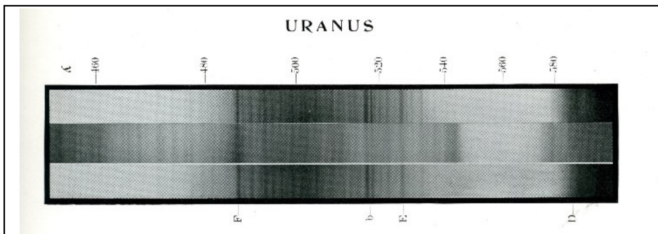
Slipher was able to measure absorption lines down to one Ångstrom (0.1 nm) accuracy. He identified many

[3] Huggins, W, Note on the Spectrum of Uranus and the Spectrum of Comet I, 1871. *Proceedings of the Royal Society of London* 19: 488-491 (1871) https://royalsocietypublishing.org/doi/epdf/10.1098/rspl.1870.0077
[4] Huggins, W., The Spectrum of Uranus, *Monthly Notices of the Royal Astronomical Society*, 49: 404 (1889). https://articles.adsabs.harvard.edu/pdf/1889MNRAS..49Q.404H

lines, some of which appeared to be of solar origin, but many were not. Some bands were peculiarly broad.

Slipher wrote,[5]

> It will be noticed that *F* [the H-beta line at 486 nm) is stronger in the spectrum of Uranus than in the lunar spectrum, but not nearly so strong as in the spectrum of Neptune. It appears, therefore, that although there is considerable free hydrogen in the atmosphere of Uranus, it does not prevail so abundantly as in the atmosphere of Neptune…. The fact that free hydrogen is so plentiful in the atmosphere of these two planets intimates that some unknown light gases, related to hydrogen and helium, might be here at work. That such gases have not been met with in stars could be due to unfavorably high temperatures [in the stars—Ed.] …. It is of interest to point out here that the bands λ543 and λ577 are in fair agreement in wavelength with two groups of aqueous vapor lines…. It suggests aqueous [water] vapor as the origin of these two most prominent bands.

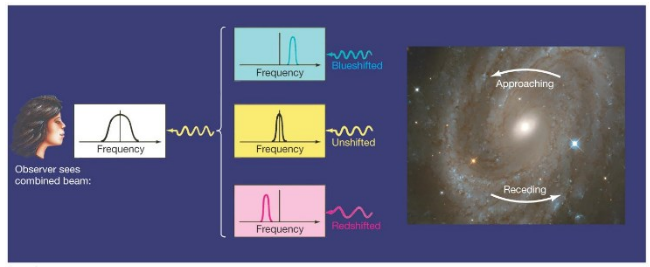


The spectrum of Uranus from Slipher's 1904 paper, kindly provided to the author by Lauren Amundson, Lowell Observatory Archives librarian and archivist. The planet's spectrum is in the center, above and below are comparison lunar spectra (i.e., reflected solar spectra) with absorption lines purely of solar origin. The Frauenhofer lines are identified (F=Hβ 486 nm, E=Fe 527 nm, D=Na 588/589 nm). Multiple lines not present in the solar spectrum are seen and the F line is thickened.

Slipher continued to make spectrographic images of Uranus and the other planets. Using a technique developed by Henri Deslandres, director of the Meudon Observatory, he determined planetary rotation rates. This was a clever and novel use of spectroscopy and bears a detailed explanation.

Slipher's 1912 paper reports the "inclination" of the spectra lines as the measure of rotation velocity. This confused me. I couldn't understand what it meant for the lines to be inclined. I asked Lowell Observatory's official historian Kevin Schindler if he understood what Slipher meant by "inclination." He put me in touch with noted astronomy author William Sheehan, and with his help I was able to reason out just what was being "inclined."

We are familiar with the use of spectroscopy to determine rotation rates of galaxy clusters (by Fritz Zwicky in 1937) and galaxies (by Vera Rubin in 1970). If the axis of rotation is relatively perpendicular to our line of sight, light from the side approaching us will be slightly blueshifted while that from the side receding will be redshifted. The rotation would cause a broadening of the spectral line.



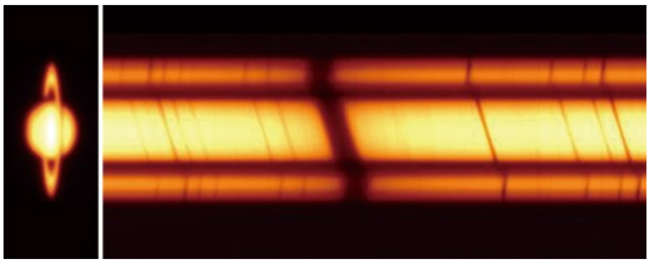
Line broadening due to rotation, in this case from a galaxy.

Slipher didn't have equipment that could scan the spectra and measure line-broadening accurately (only in 1978 was line broadening used to measure Uranus' rotation rate). Deslandres' method measures the velocities of the approaching and receding limbs of rotating planets, but not in the way you might think at first.

When the light of planet is passed through a prism, it is spread out according to wavelength. In a sense, the planet is "spaghettified," to use a word now familiar from black hole theory. The thickness of the spectrum is the width of the face of the planet but the long axis is its light spread out by wavelength. The spectrograph's slit is perpendicular to the prism. The lines in a spectrum are really images of the slit, dark if there is absorption and bright when there is emission. When the slit is positioned across the planet's equator (perpendicular to the axis of rotation), one edge of the spectrum is the limb of the planet coming towards you, and the other is the limb rotating away from you. Light from the side coming towards you is slightly blueshifted and light from the side going away is slightly redshifted. The velocity of rotation in the line of sight direction changes continually across the

[5] Slipher, V., On the Spectra of Uranus and Neptune, *Lowell Observatory Bulletin* 13: 87-90 (1904) https://articles.adsabs.harvard.edu/pdf/1904LowOB...1...87S

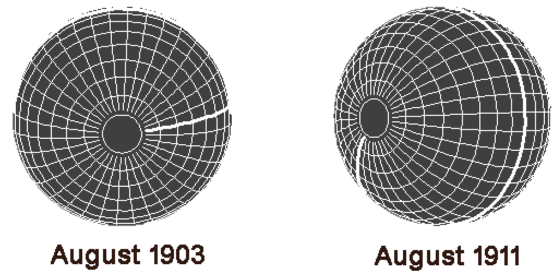
face of the planet, maximal at the approaching edge, zero in the center and then maximally negative at the receding edge. This results in spectral lines appearing slightly angled. With a faster rotation rate the shifts in either direction would be greater and the angle more displaced from the vertical. Shifts can be translated into velocities. If you know the planet's diameter, the rotation period can be calculated. Uranus' apparent diameter had been a concern of astronomers starting with Herschel, and once its distance was known (from its orbital period) its diameter could be estimated.



Saturn's spectrum from the Subaru Telescope's High Dispersion Spectrograph. Shorter (bluer) wavelength to the left.

You can see this effect quite clearly in a modern image of Saturn's spectrum, shown above. The slit is in the ring plane, which is also the planet's equatorial plane. The central part of the image is the planet, rotating such that the upper edge is coming towards you and the bottom going away from you. The ring at the top is also rotating towards us, but at a slightly higher velocity (because it is more distant from the axis of rotation but tidally locked) and so is even more displaced blue-ward than the planet's adjacent limb, while at the bottom the ring is receding at higher-velocity than the planet's edge on that side and so is redshifted even more than the edge of the planet. The planet's spectrum shows the inclination that is caused by the differential radial velocities to our line of sight.

Slipher first applied this technique to the brighter planets. For Mars, he got a rotation rate of 24 hours 37.2 minutes, which is exactly correct. For Venus, he found that the rotation rate was very small, defying the resolution of his equipment (Venus, as we know now, has a rotation rate of 243 days). For Jupiter he seemed content to simply report the rotational velocity. He was unable to detect rotation in Uranus, blaming the dearth of light entering his apparatus from the distant planet, but later he realized that in 1903 the pole of Uranus was pointing almost directly at Earth, due to Uranus' oblique angle of rotation.



Uranus as seen by Slipher in August 1903 and August 1911. (Made with WinJUPOS)

In 1909, Percival Lowell, the Mars-obsessed founder of Lowell Observatory, pointed out to Slipher that Uranus' axis of rotation might be sufficiently orthogonal to the line of sight to warrant spectroscopic observation again. Slipher by that time had succeeded in making photographic emulsions that could record longer wavelengths, including the important hydrogen alpha line at 656.28 nm. He could even perceive the oxygen line at 759.4 nm. After two years of experimentation with the equipment, in August and September 1911 Slipher obtained several high-quality spectra.[6] He calculated a rotation rate of 10 hours 50 minutes from the spectra. Recall that based on surface features (that may not have been real) Thomas Hughes Buffham and Leo Brenner had estimated rotation rates of 12 hours and 8½ hours, respectively (see the September 2024 SkyWAAtch). Lowell himself participated in the analyses and published his own paper on the rotation in a French journal and then in the Lowell Observatory Bulletin. Slipher and Lowell cited each other in their papers; the work was clearly cooperative. One of the Uranus spectral plates used in this work was provided to me and is shown on the next page.

The broad non-solar absorption lines in Uranus' (and Neptune's) atmosphere did not fit any known elements or compounds whose spectra had been studied in the laboratory. To identify their source, help

[6] Slipher, V., Detection of the Rotation of Uranus, *Lowell Observatory Bulletin* 2:19-20 (1912) https://articles.adsabs.harvard.edu/pdf/1912LowOB...2...19S

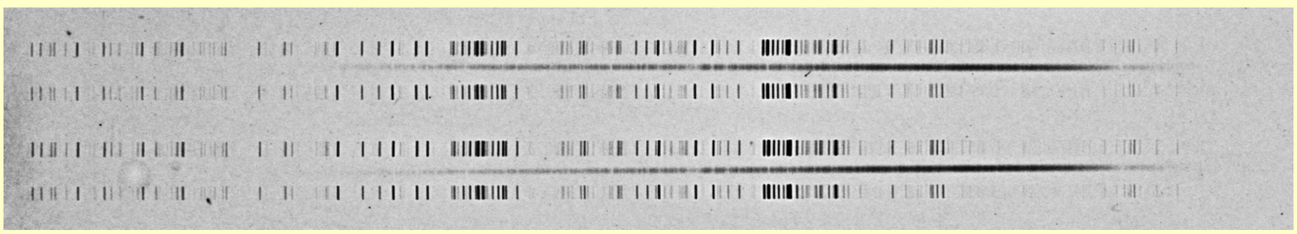
had to come from the field of physical chemistry and the new science of quantum mechanics.

Before 1923, it was believed that the outer planets had hot atmospheres. It was known that the planets' densities were quite low, Uranus' being about 1.2 gm/cc (Earth-5.5 gm/cc, water 1.0 gm/cc, Saturn a mere 0.687 gm/cc), and so it was suspected that they were mostly composed of gases. In a paper published that year,[7] Harold Jeffreys, a geophysicist at Cambridge University, used his knowledge of thermodynamics to calculate that the outer planets had to be cold and solid, and because their densities were so low the solidity was in the form of ices of light compounds. He also proposed that,

> the effective radiating and absorbing layer of an outer planet may reasonably be supposed to be, not the solid surface of the planet, if any, but a cloud layer at a height in the atmosphere corresponding to the height where cumulus and strato-cumulus clouds occur on the earth. Indeed… that what we see is not the surface of a solid body is clearly shown by the fact that it does not rotate as a rigid body, the period rotation depending on the latitude. [This differential rotation of clouds had been observed on Jupiter, and Saturn, but the data for Uranus and Neptune was "not available" at the time—Ed.]

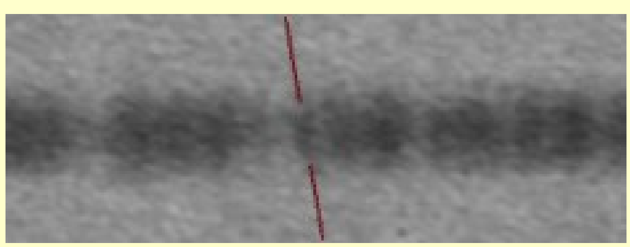
In addition, Jeffreys noted that the outer planet's water-like density "compels us… to suppose that these planets are all composed of matter very different from the chief constituents of the earth." Jeffreys argued that the larger mass of the outer planets would have permitted them to retain lighter chemical species than the rocky inter planets (*e.g.* low atomic weight elements and molecular weight compounds).

Vesto Slipher's Sept. 9, 1911 spectrum of Uranus



The original plate, in the Lowell Observatory Archives, was scanned for me at very high resolution by Lauren Amundson, Lowell's archivist, and Stephen Levine, Director of Education at Lowell Observatory.

This is the spectrum for which detailed measurements are given in Slipher's paper (ref. 6) There are two spectra of Uranus on the plate. Above it (not shown) is a brighter and thicker spectrum of Mars. Slipher used the width of the Mars spectrum to determine the focal length of the apparatus (since Mars' diameter could be precisely measured). The sharp comparison lines on either side of the spectrum are from a "V-Fe spark," added at the beginning and end of the exposure, to check for flexure of the apparatus. A microscope was needed to examine Uranus' spectral lines. Blowing up the image, it is hard to see how Slipher and Lowell could have been confident that they saw angulation in the lines. I made an enlargement of one section and identified one line that seemed sufficiently resolved and angled for measurement. But I thought of Antonioni's 1966 movie *Blow-Up*. Slipher measured 14 lines from this plate and took great pains not to bias himself when making measurements, but he did note that "the difficulties … were considerable."

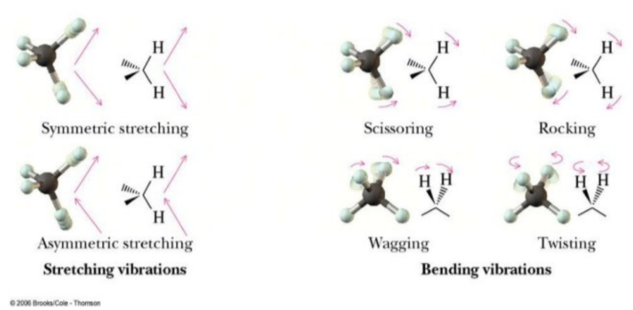


[7] Jeffreys, H, The Constitution of the Four Outer Planets, *Monthly Notices of the Royal Astronomical Society*, 83: 350-354 (1923) https://articles.adsabs.harvard.edu/pdf/1923MNRAS..83..350J

Jeffreys also used arguments from the orbits and masses of the Jovian and Saturnian satellites and wrote that "the high albedo of Saturn's ring again suggests that it is composed of some colourless substance in a state of fine division," possibly ice or some other light non-metallic compound, which has "much lower melting points than water." He also noted that "In the great planets the cloud layers must be practically opaque, so that the solid surfaces cannot be heated directly [by solar radiation]." Uranus is the coldest planet in the solar system and has no interior source that radiates heat beyond its surface.

The critical breakthrough for understanding the chemical source of the spectral absorptions came in the early 1930s. Rupert Wildt, then at the University of Göttingen and later at Princeton, used physical chemistry arguments to propose that water vapor, still favored by many astronomers as the main constituent of clouds in Uranus' atmosphere, could not exist in the cold cloud layers of the outer planets' atmospheres. Wildt utilized new information about the vibrational modes of diatomic molecules.[8]

The bonds between hydrogen and the heavier element (such as carbon in methane (CH_4). nitrogen in ammonia (NH_3) or oxygen in water (H_2O) and all larger compounds) are not rigid sticks. They bend and stretch, and can be modeled as harmonic oscillators (basically springs) that follow well-known formulas to describe their energies. Those energies are quantized, and each mode can absorb or release a photon of a specific frequency, enhancing or damping the vibrations. The fundamental frequencies are in the infrared range.



Stretching and bending bond vibrational modes

Like vibrations of a violin string, the vibrations have overtones in specific ratios. These correspond to shorter wavelengths that are in the IR or even visible range of the spectrum. An animated display of methane's fundamental vibrational modes is at https://www.chem.purdue.edu/jmol/vibs/ch4.html. You can rotate the figures to provide the optimum viewing angle to see the gyrations of all the hydrogen atoms.

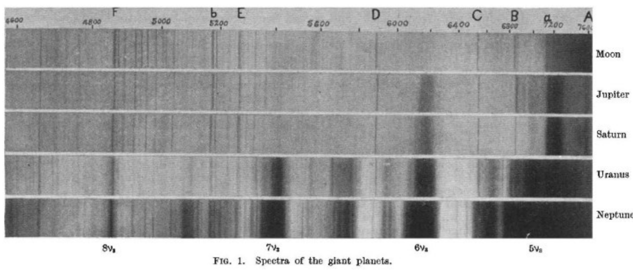
Using special emulsions, Wildt detected and mapped absorption lines with wavelengths as long as 950 nm, calculating that at least one of the bands could be a harmonic of a known vibrational mode of methane, the fundamental of which is in the infrared at around 3 microns (3,000 nm). The harmonic bands had not been seen in experiments on Earth because the path length of the gas through which light passed (sunlight on the planet, a light source in the laboratory) had to be very long for the absorption to be manifest.

Spectroscopists did experiments utilizing long tubes of methane under pressure. Spectrograph resolution had improved, so what might have appeared earlier as a wide blur could be resolved into multiple discrete bands differing by an Ångstrom or two. Reinhard Mecke at the University of Heidelberg used a tube 20 meters long filled with methane at 5 atmospheres. Theodore Dunham at Mt. Wilson Observatory passed sunlight from the Snow Solar Telescope through 40 meters of methane at atmospheric pressure. These experimenters, and others, were able to find multiple lines in the near IR that matched spectral lines from the outer planets. Using the new science of quantum mechanics, the exact energies of the vibrations could be calculated.

Adel and Slipher analyzed the absorption spectrum of methane contained in a 2-inch steel tube 45 meters long with optical windows at each end. The gas was at a pressure of 40 atmospheres.[9] They were able to show that the non-solar bands in Uranus' spectrum coincided with the harmonic series of vibrational modes above (at shorter wavelengths) a fundamental mode with a wavelength of 3.3 microns. They were even able to identify the broad *n* band that Secchi

[8] Wildt, R, Absorptionsspektren und Atmosphären der großen Planeten, *Veroeffentlichungen der Universitaets-Sternwarte zu Göttingen* 22:171-180 (1932) https://articles.adsabs.harvard.edu/pdf/1932VeGoe...2..171W
[9] Adel, A, Slipher, VM, The Atmospheres of the Giant Planets, *Nature* 134:148-149 (1934) https://www.nature.com/articles/134148a0

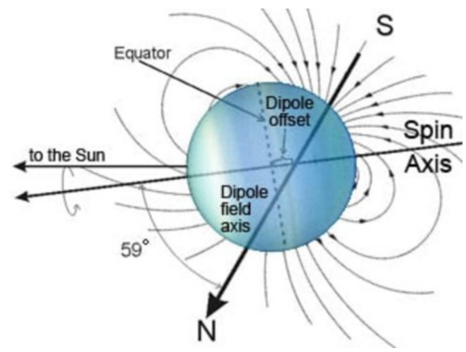
had found in 1869 with a grouping of distinct vibrational overtone bands. One of the bands (the $8\nu_3$ band) even overlaps the Hβ line. You can see that in the spectra from their paper, which shows that the band labeled F (the Frauenhofer designation for Hβ) is thickened in Uranus' spectrum, and even more in Neptune's, as compared to the Moon (i.e. solar radiation), Jupiter and Saturn.



Spectra of the outer planets from Adel & Slipher (ref 9). The Moon is chosen as the comparison standard since it has no atmosphere and thus simply reflects sunlight.

In 1949, Gerald Kuiper, for whom the Kuiper Belt is named and who is considered the "father of planetary science," found new absorption features in Uranus' atmosphere that could not be attributed to methane. Retreating to the spectroscopy laboratory at Yerkes Observatory, he tested a variety of possible gases but could not identify the source. Four years later, Gerhard Herzberg, working at the National Research Council in Canada, showed that this line was due to a rotation-vibration band of the hydrogen molecule (H_2). He used an 80-meter path length of the gas in the laboratory at 100 atmospheres to find the absorption. Herzberg went on to win the 1971 Nobel Prize in Chemistry for his spectroscopic work on molecular structure.

The picture of the Uranian atmosphere that emerged prior to 1986 was that of a mixture of hydrogen and helium in close proportion to the solar nebula, the original mixture of gases from which the Sun condensed, enriched with about 2.3% methane. If there was water or ammonia, most of it would have condensed at the frigid temperatures and settled to a lower layer, at least 300 km below the nominal "surface" (the radius at which the atmospheric pressure is 1 bar). Physicochemical considerations suggested the possibility of transient clouds of ammonia, but there was no observational evidence for anything other than methane.



The Uranian magnetic field

With the passage of Voyager 2 through the Uranian system in early 1986,[10] much more was revealed about the atmosphere, in addition to a vast range of discoveries[11] about the planet's structure, moons, rings, auroras and magnetic field. The magnetic field was found to be offset from the planet's rotational axis by an angle of 59°, much greater than Earth's 11°. The center of the field is displaced from the planet's center by 30% of its radius, for reasons that still defy explanation. The magnetic field is generated by conductivity of the frozen water-ammonia layer under high pressure that forms the planet's mantle. The water and ammonia are ionized and thus electrically conducting. The magnetic field rotates at a rate of 17.24 hours. The planet's tilted rotational axis and its displaced and angled magnetic field are presumed to be evidence of a major collision early in Uranus' history.

Voyager 2 resolved the question of whether there were bands and clouds in the atmosphere. Both were present. The bands were thought to be due to haze in the upper atmosphere, sunlight reflecting off particles about 0.25 to 0.35 µm in diameter, at a zone where the pressure` was in the tens of millibars. Voyager 2 confirmed the presence of a "polar cap," a brighter haze on the Sun-facing pole. Voyager 2 also detected several small clouds, which were bright at short wavelengths and thought to be methane ice. The clouds rotated slightly faster than the magnetic

[10] Smith, BA, et. al., Voyager 2 in the Uranian System: Imaging Science Results, *Science* 233: 43-64 (1986)
[11] The scientific findings were reported in the July 4, 1986 issue of *Science*. A summary article and eleven papers were published, a total of 70 pages of scientific output. A summary can be found on the NASA Planetary Data System at https://pds-rings.seti.org/voyager/uranus/#planet.

field. One cloud was tracked for ten days. The wind patterns were zonal (along lines of latitude). The clouds gave rotation rates of 16.3 to 16.9 hours. Uranus' atmosphere and its magnetic field rotate at different rates.

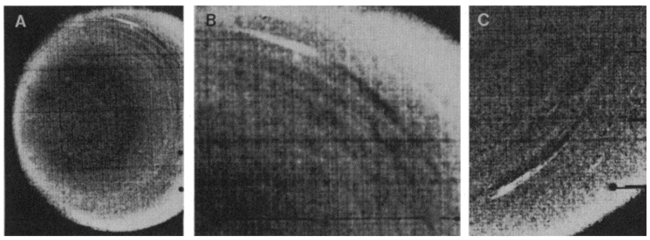
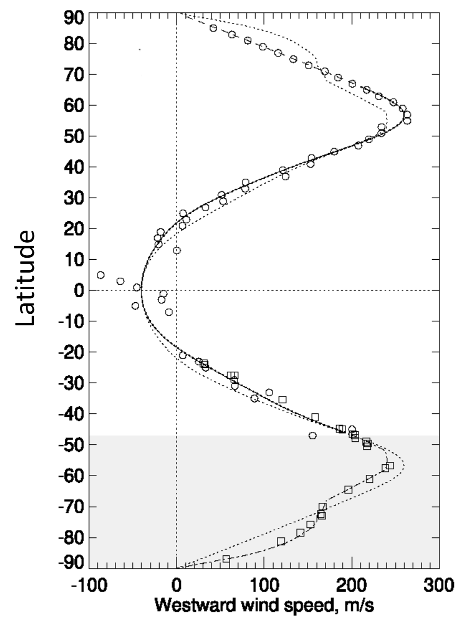


Fig.7 from Smith et. al. (ref. 10) showing a convective plume at -35° latitude. The two right images are 10 hours apart. Voyager 2.

Once Voyager 2 left the Uranus system, observation of the planet reverted to terrestrial telescopes. Fortunately the astronomy world was given powerful new tools in the form of 8- and 10-meter class telescopes, CCD imagers sensitive in the infrared, new image processing routines and adaptive optics. Among the most prolific of these instruments for the study of Uranus are the two 10-meter Keck telescopes on Mauna Kea.

Clouds were detected in the near-infrared with the Hubble Space Telescope (HST) in 1997.[12] In 2001, a group led by Heidi Hammel reported[13] observations of Uranus' cloud features by HST and Keck from 1994 to 2000, 14 observing sessions (12 HST, 2 Keck) totaling 46 hours of observation. On the night of June 17, 2000, the two instruments observed Uranus simultaneously for 35 minutes, which permitted confirmation of the positions of seven cloud features. Tracking the clouds showed that wind velocities were prograde (in the direction of rotation) in the temporal latitudes above and below the equator but retrograde at the equator. The wind speeds were not quite symmetrical above and below the equator.

What is the impact of Uranus' radical axial tilt on the behavior of its atmosphere? One would think that during the long period that one pole is in darkness it would be colder than the Sun-facing pole, but Voyager 2 found that the temperature at each pole was the same. There must be a process that dynamically redistributes the meager solar energy that reaches out 19 astronomical units to land on Uranus. The atmosphere at 40° N and 25° S latitude is 2 or 3 degrees below the global average of 52 K (-221° C), measured at the tropopause, the boundary of the troposphere and stratosphere, where the pressure is 100 millibars. There is no colder place in the solar system, and only Neptune is windier.



Wind speeds on Uranus, from ref. 15. Grey area is Voyager 2 data

In the last 30 years astronomers have imaged the planet at many wavelengths to probe its atmospheric dynamics. How does the methane concentration in the atmosphere vary by altitude, latitude and pressure? How do chemical concentrations and phases (gas, ice) of the various atmospheric compounds change with the orientation of the planet's axis of rotation to the Sun? How do clouds form, rise and fall at different latitudes with the Uranian seasons? Do the wind profiles change with the planet's seasons, each lasting 21 years? Do the magnetosphere and the solar wind play a role?

The polar cap increases in intensity as Uranus approaches the solstice (pole facing the Sun). A study observing Uranus in 2014 with the Hubble Space

[12] Karkoschka, E, Clouds of High Contrast on Uranus, *Science* 290: 570-572 (1998). https://www.science.org/doi/10.1126/science.280.5363.570

[13] Hammel, H, et. al., New Measurements of the Winds of Uranus, *Icarus* 153, 229–235 (2001) https://www.sciencedirect.com/science/article/abs/pii/S0019103501966898

Telescope and the Very Large Telescope in Chile found that the polar cap is mainly caused by,

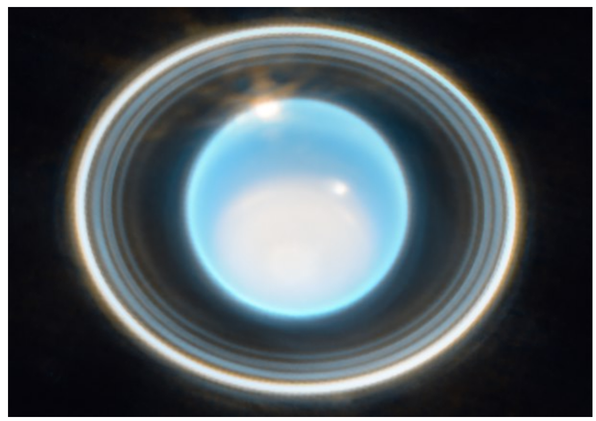
> [a] decrease in the methane concentration at polar latitudes. By observing the brightness spatial variations, the VLT observations show the presence of the polar cap at latitudes 40° to 90°N, indicating a hole-like depletion of methane. This methane latitudinal distribution supports scenarios consisting of an upwelling of methane gas at low latitudes, a condensation of methane in the cooler troposphere, and a descent of the now dried-out gas back to the deep atmosphere at high latitudes.[14]

However, in a major new paper just published this year,[15] Hammel's group finds that,

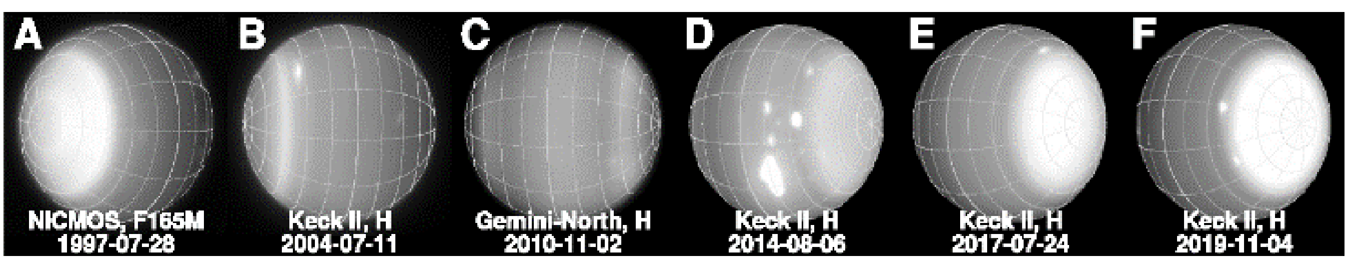
> There may be a permanent north–south asymmetry in the zonal wind profile of Uranus. …The lifetimes of many of the small discrete polar features are surprisingly long…. More prominent features seen at low latitudes seem to persist for multiple years and vary in latitude and drift rate in a cyclical fashion…. The possibility remains that a dramatic circulation change might take place between 2022 and the next solstice in 2030. Using simplified radiation transfer modeling we infer a largely unchanging upper layer of small particles of very low optical depth vertically distributed above an active deeper mid-level layer, at an effective pressure of ~2–2.5 bar. That middle layer increased in reflectivity at 1.6 μm by more than a factor of 2 from 2015 to 2022 and is the main source of the top-of-atmosphere brightness increase seen over that period, rather than any significant temporal change in polar methane abundance.

In other words, the origin of the polar cap has not been unequivocally resolved. Hammel and her colleagues will keep looking, but ultimately we have to get closer to the planet to solve its many mysteries.

Objects like Uranus and Neptune may be the most common type of planet in the universe. Their composition and dynamics challenge models of planet formation and atmospheric behavior. While powerful telescopes on Earth and in local space can examine many aspects of the two ice planets, only spacecraft will allow planetary scientists to achieve the next level of understanding of these complex bodies. The Uranus Orbiter and Probe has a high priority in the 2023–2032 *Planetary Science Decadal Survey*. However, a launch before the late 2030s seems not to be possible primarily due to a plutonium shortage. Already scheduled missions need all the available Pu^{238} to power their radioisotope thermoelectric generators and radioisotope heating units. US production of ^{238}Pu for NASA is scheduled to increase to 1.5 kg/year in 2026, after which more concrete planning for a Uranus mission might commence. ■



JWST image of Uranus and its rings on February 6, 2023, Near-Infrared Camera (NIRCam) at 1.4 and 3.0 microns. The polar cap is evident, as well as two bright clouds. (STScI)



A sequence of images in the Infrared from HST (A), Gemini North (C) and Keck II (B, D, E, F). The change in Uranus' orientation towards Earth is evident. From ref. 15.

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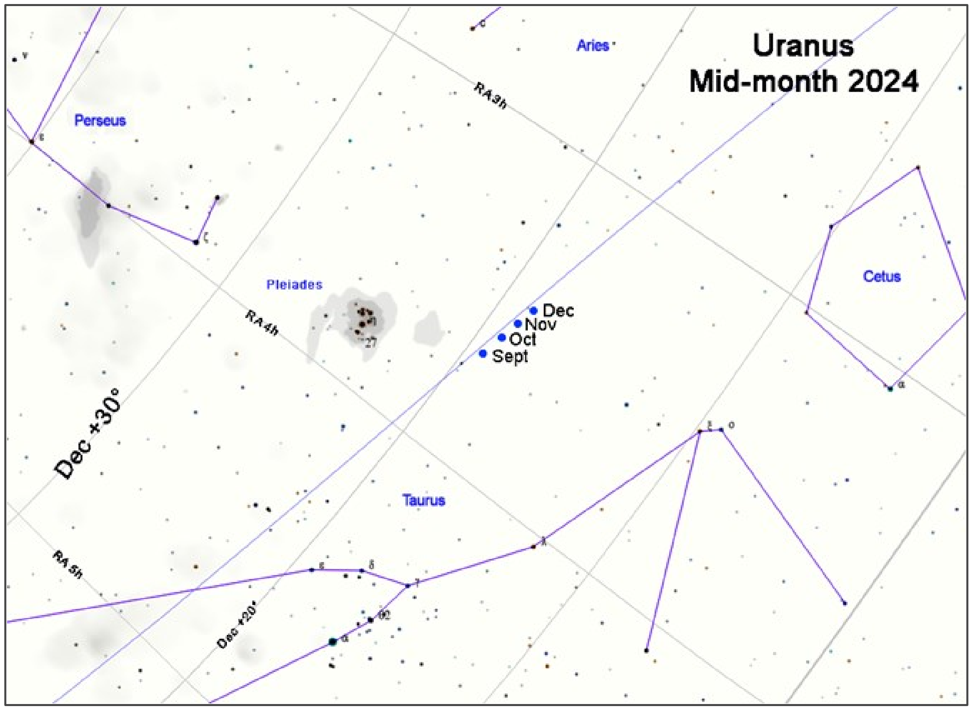
[14] Toledo, D, et. al., Uranus' Polar Cap in 2014, *Geophysical Research Letters* 45: 5329-5335 (2018) https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2018GL077654

[15] Sromovsky, LA, Fry, PM, de Pater, I, Hammel, HB, The puzzling north polar region of Uranus: Continued zero-shear winds and increasing brightness from 2015 through 2022 according to 7 years of Keck AO imaging, *Icarus* 420: 1-39 (2024) https://www.sciencedirect.com/science/article/abs/pii/S001910352400246X?via%3Dihub. The author thanks WAA member Cliff Wattley for sending me this paper back in June. It stimulated my two articles on Uranus.

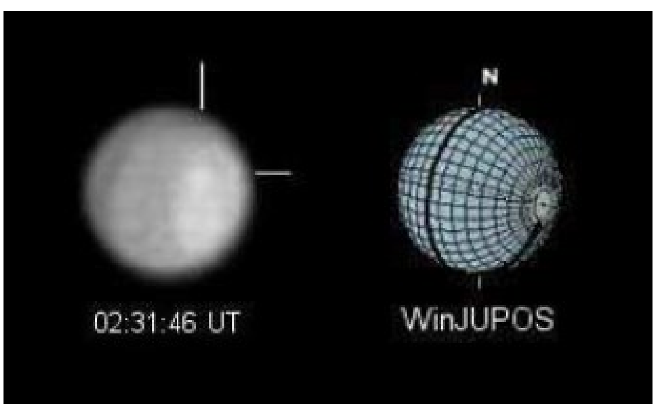
Uranus at Opposition 2024



Uranus will be easy to find this fall even if you don't have a go-to telescope. It will be well up in the evening sky, just 5½° south of the Pleiades in October (7½° by year's end). Opposition occurs on November 16 at 21:36 EST. It will then be at an altitude of 55 degrees, azimuth 121 degrees. The disk diameter will be 3.7 arcseconds, shining at magnitude 5.6. In a very dark sky it might be perceived by the naked eye. It will remain in a good position until early spring 2025.

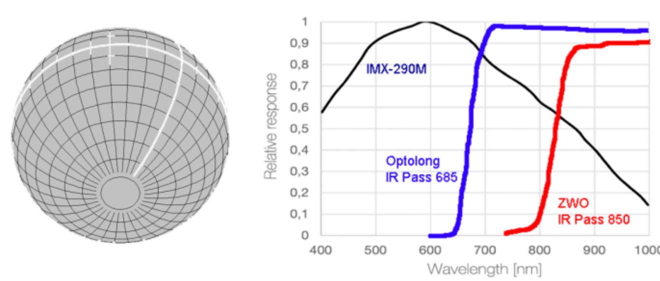
Amateurs have imaged Uranus with larger telescopes at long focal lengths using red or infrared filters and "lucky imaging." Dutch amateur John Sussenbach imaged the polar cap with a 14" SCT and identified a bright spot in the planet's northern hemisphere.

This year Uranus' south pole will be pointing almost directly at us as the planet heads for its solstice in 2030. The bright polar cap should be detectable in a camera with an IR filter. A monochrome sensor is needed since the Bayer matrix of a color camera will reduce the resolution by 75% because the green and blue pixels will not receive any signal. You can use the imaging FOV calculator at astronomy.tools to find your set-up's resolution per pixel. For an 8" SCT with a 2X Barlow and an ASI290MM, the system gives 0.15" per pixel, meaning Uranus' disk will be 24 pixels across. Seeing will have to be perfect since actual resolution is atmosphere-dependent. For a Celestron Edge 1100 with a 2X Barlow, which a couple of WAAers own, the disc will be 33 pixels across.



Bright spot and polar cap on Uranus, Aug 15. 2016. C14, ASI290MM camera & IR filter. A WinJUPOS simulation shows the planet's orientation. The bright spot is at the intersection of the markers. Adapted from Fig. 8 in Sussenbach, J, Observing Uranus and Its Satellites, 2006-2016, *Journal of the British Astronomical Association* 127: 203-206 (2017)

IR filters available for astrophotography come with cutoffs at 610, 685 or 850 nm. ZWO sells the 850 nm cutoff version for just $22. Most CMOS sensors have 50% or more loss of sensitivity in the IR, as shown in the graph below. Longer exposures and/or more gain will be needed. Seeing will obviously be critical. imaging Uranus is a huge challenge, but it can be done!



Left: Uranus at 2024 opposition (south pole facing). WinJUPOS.
Right: Sony IMX290M sensor response and filter transmission (LF)

Images by Members

M13 by Manish Jadhav

Here's Manish's take on the venerable Hercules Cluster, a summer favorite of visual observers and imagers alike. It was made with an Orion 8" f/8 Ritchey-Chretien Astrograph telescope, a Canon EOS RP mirrorless camera and an IR/UV cut filter on an iOptron HEM27 Strain Wave Mount. Manish only had time for ten one-minute subs, which he then processed with Siril and Photoshop. The field of view is 53.8 x 46.3 arcminutes.

The spiral galaxy NGC 6207 (magnitude 11.6) is seen near the upper right corner of the image. The bright red star above the cluster is HD150998 (magnitude 6.86, class K7) and the blue star to the lower left is HD 150679 (magnitude 7.29, class A8).

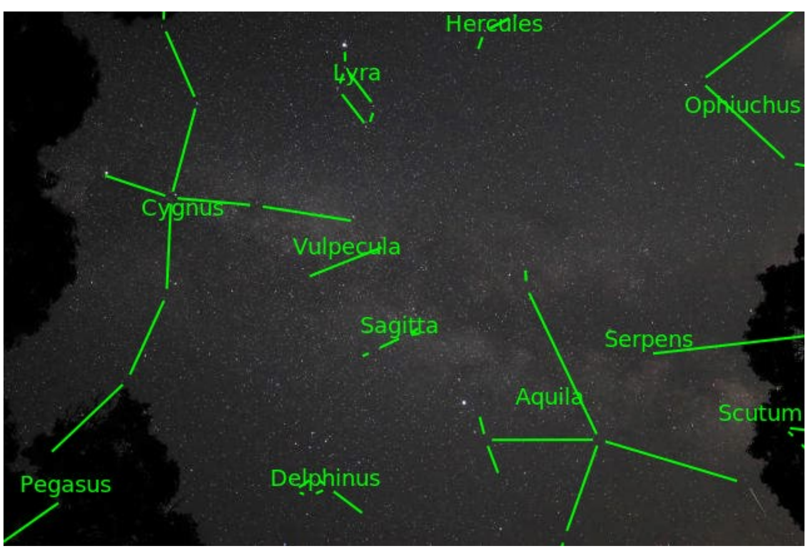
At a distance of about 23,000 light years, M13 is 145 light years across and contains at least 300,000 and perhaps 500,000 stars. It's two-thirds the diameter of the full Moon. Edmund Halley first recorded the object, Messier catalogued it, and William Herschel resolved its stars.

Manish's image nicely shows the large population of red giants in the cluster.

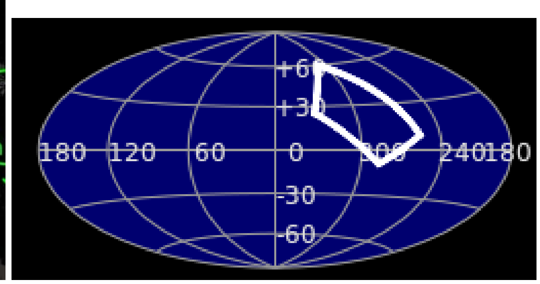
Wide Angle Milky Way from Eastern Long Island by Steve Bellavia

Steve did some observing the evening before Labor Day from his home in Mattituck, using a 15x70 binocular. Just before some clouds came in, he made a wide-angle shot with a Rokinon 14-mm lens on a Canon DSLR, mounted on a fixed tripod. The exposure was 15 seconds at f/2.8. The field of view is 71.9 x 48.0 degrees, as measured by astrometry.net.

The three brightest stars are the familiar Summer Triangle: Deneb, Vega and Altair. In the lower right corner, a meteor track is seen in the Aquila-Scutum border.



Here are the graphics provided by astrometry.net, labeling the field and showing its position on the celestial globe in an elliptical projection map.

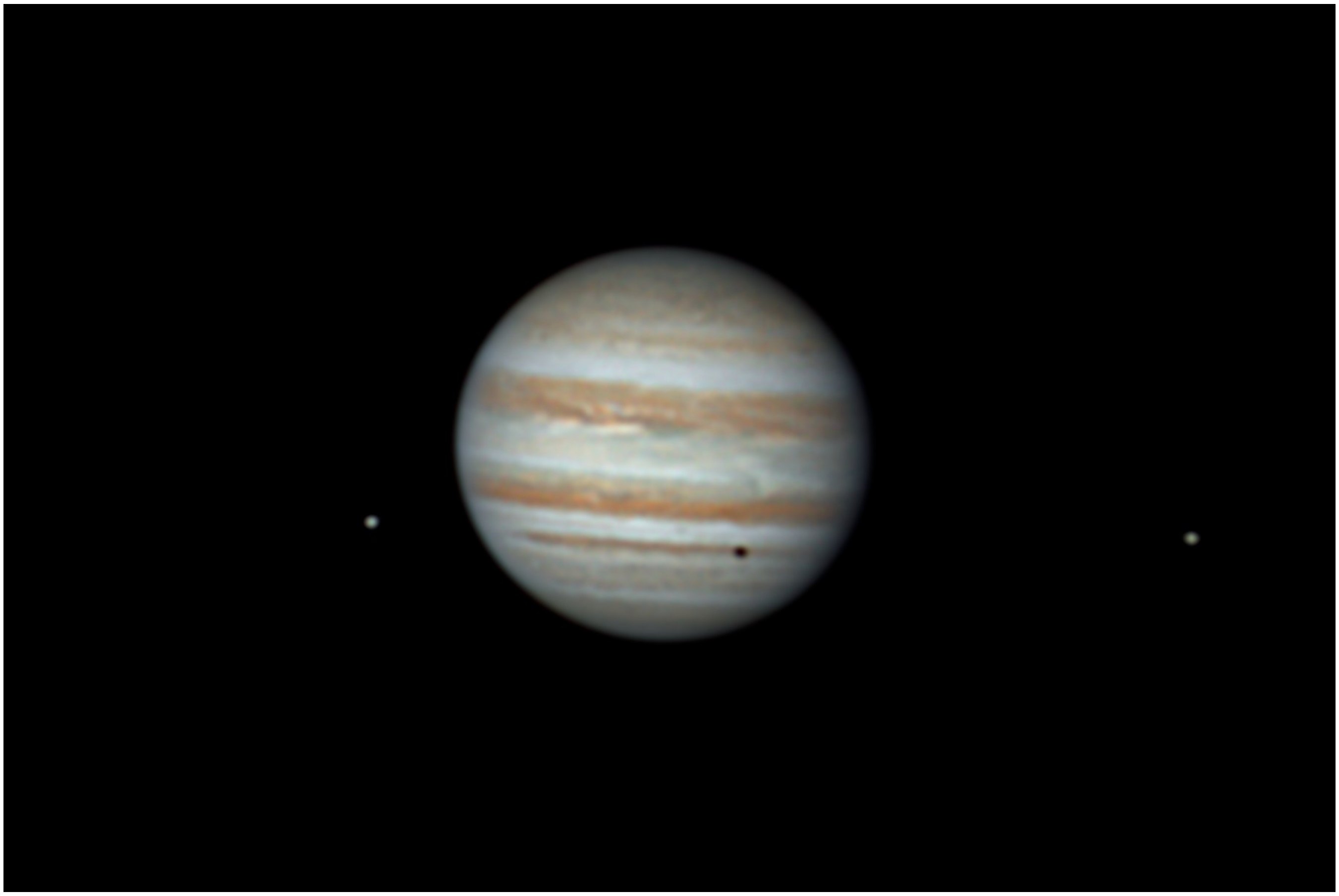


Conjunction of Moon and Jupiter, March 13, 2024 by Steve Bellavia

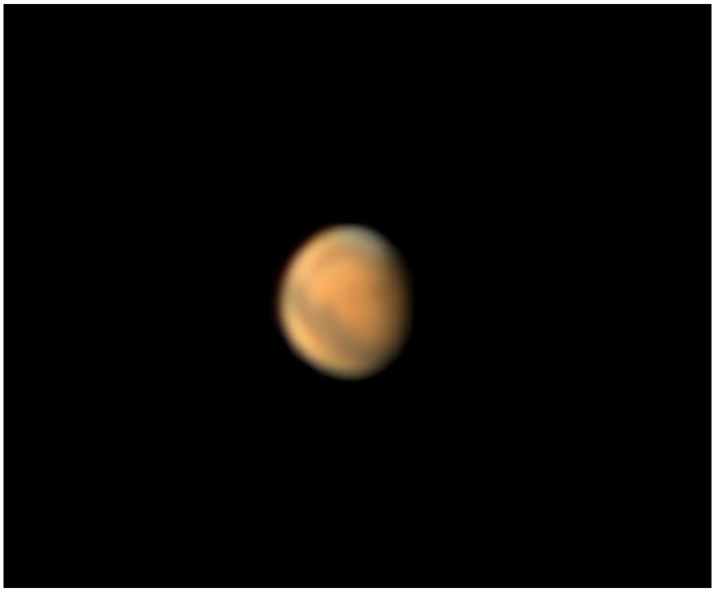
The magnitude -8.25 Moon was just19% illuminated Moon was just three degrees from Jupiter that evening. Imaging a planet in conjunction with the Moon is always daunting. Lunar brightness often overwhelms the camera's sensor. A closeup of the image (below) shows that the four Galilean satellites were indeed captured, but at the expense of having the Moon's image oversaturate the sensor so that detail on the illuminated part of Luna is lost in the glare. Similarly for any detail on the face of the planet.

When Steve made this image, the magnitude -8.25 Moon was 288 times brighter than Jupiter, at magnitude -2.1. The planet was 1,202 times brighter than the faintest satellite, Callisto, magnitude +6.2. [Recall that a difference of one magnitude is a brightness ratio of 2.512, the fifth root of 100.] That makes the brightness difference between the Moon and Callisto over 600,000, an obvious challenge even for the most sensitive cameras. You could consider making three separate images, one exposed for the illuminated lunar surface, one for the surface of Jupiter, and one for the Galilean stars, and then combine them. The brightness proportions would be spurious, but the relevant details of the objects and their positions could be shown without requiring enlargement.

Jupiter and Mars by Steve Bellavia



Speaking of Jupiter, here's Steve's image of a shadow transit of Europa at 0439 on September 8, 2024. Europa is the moon on the left and Io is on the right. North is up, east is left. The planet's disc is 39.3 arcseconds across, and it was shining at magnitude -2.3. The planet was 55° above the horizon. Steve's 3-frame time lapse (54 minutes of rotation) showing movement of the moons and shadow is at https://www.astrobin.com/cn01ah/.



Mars' disc was 6.8 arcseconds across when Steve made this image at 0456 on the 8th. Mars was 49° above the horizon, The gibbous disc is 78% illuminated and shined at magnitude +0.7.

For both images, Steve used an Explore Scientific 152-mm Maksutov and a ZWO ASI183MC Pro camera, mounted on a SkyWatcher EQ6-R Pro mount.

Mars will be in opposition on January 15, 2025, when the disc will be 14.6 arcseconds across. That's the biggest it will be until May 2031.

SeeStar Images by John Paladini


M8-Lagoon Nebula


M17- Omega (Swan) Nebula

John comments: “Not bad for a 2 inch lens that's basically a well corrected magnifying glass.”

The North American and Pelican Nebulas by David Parmet

David made this image at Cherry Springs State Park in Pennsylvania in May, Forty 3-minute light subs, 20 each dark, flat and bias subs, with a William Optics Redcat 51-mm f/4.9 telescope, ASI533 MC Pro camera on a Star Adventurer GTi, controlled by a ZWO ASIAir Plus. The field of view is a grand 2.42 x 2.42 degrees. David said the image was “tortured with PixInsight,” but your Editor, seeing how complex PixInsight can be, assumed that David was more tortured than the image.

The North American Nebula is NGC 7000 but contains several other NGC-designated objects, and the Pelican is IC 5070. The bright star in the body of the Pelican is 56 Cygni (mag 5.0, class A6V) and the bright star just above the beak is 47 Cygni (magnitude 4.8, class B4IV. The open cluster NGC 6997 is the sprinkling of small stars within the body of NGC 7000, somewhere in Canada we suppose.

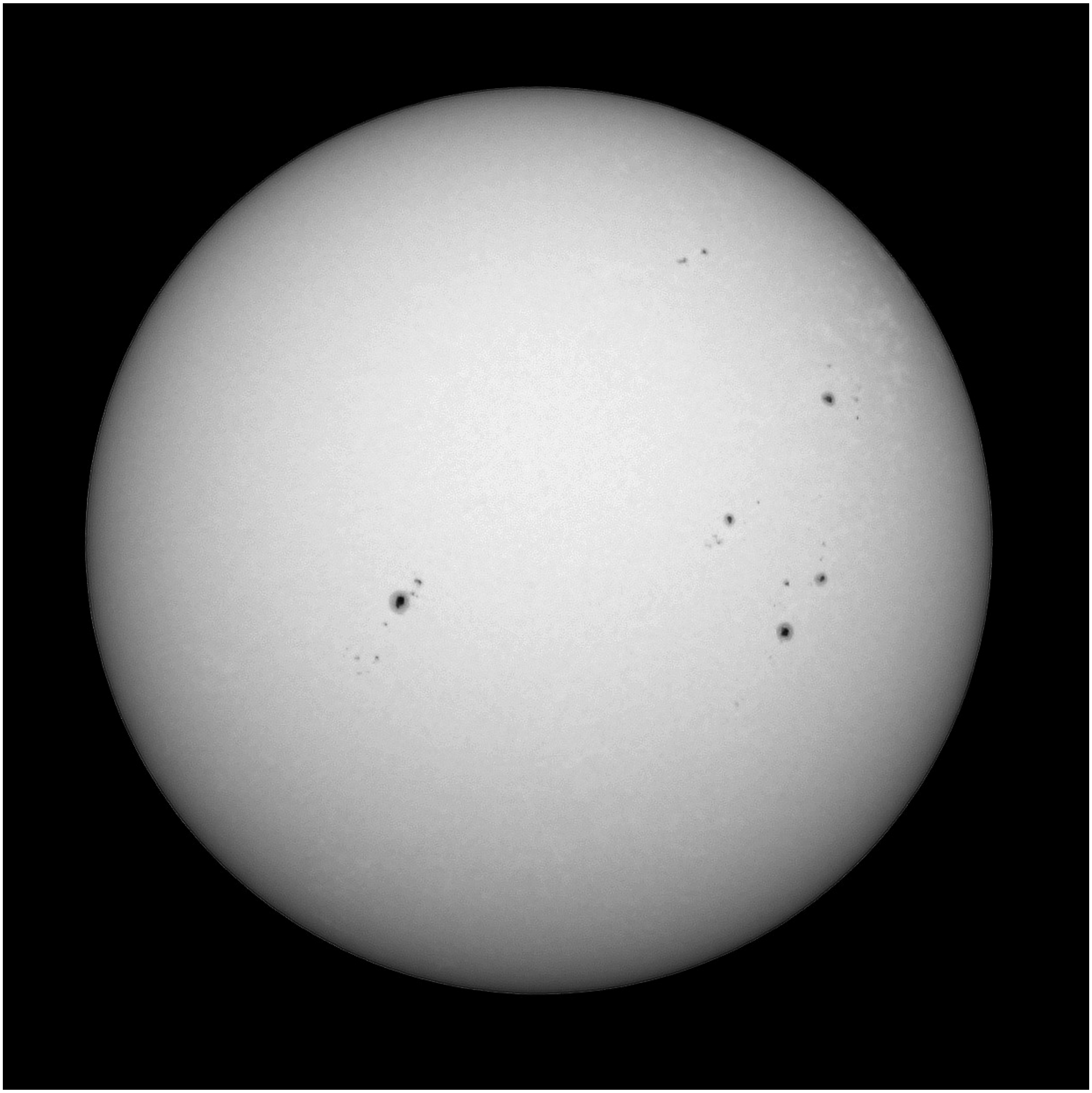
The Hickson Galaxy Group 44 in Leo by Arthur MIller

In the May 2024 SkyWAAtch we published the first version of this image that Arthur sent us. He has since reworked it with Affinity Photo2 and Adobe Photoshop CS6. The image is much brighter and far more detailed, with more natural colors, and the smattering of background galaxies is more evident.

Arthur's M51 With and Without Stars

There's an old saying: "If you like sausage, you don't want to watch it being made." Nevertheless, we're presenting two intermediate images from Arthur's reprocessing of an image of M51 that was published in the January 2023 SkyWAAtch. Several software packages (PixInsight, Siril, StarXterminator among others) can separate the point sources from background nebulosity, allowing the astrophotographer to work on them separately and then recombine to rebalance the image. As we've written before, all astrophotographs are guesses and artistic creations. Star removal and recombination is another tool in the imager's kit. Enlarge the page to see more detail. Celestron C11 at f/7, shot in Arizona.

The Sun in White Light, September 9, 2024 by Larry Faltz



Stellarvue 80-mm f/6 doublet refractor, Canon T3i DSLR on SkyWatcher AZ-GTI mount. ISO 100, 1/2500 sec. Best 12 of 16 images stacked with Registax 6.1, converted to greyscale with Photoshop Elements, then sharpened with imPPG and cropped.

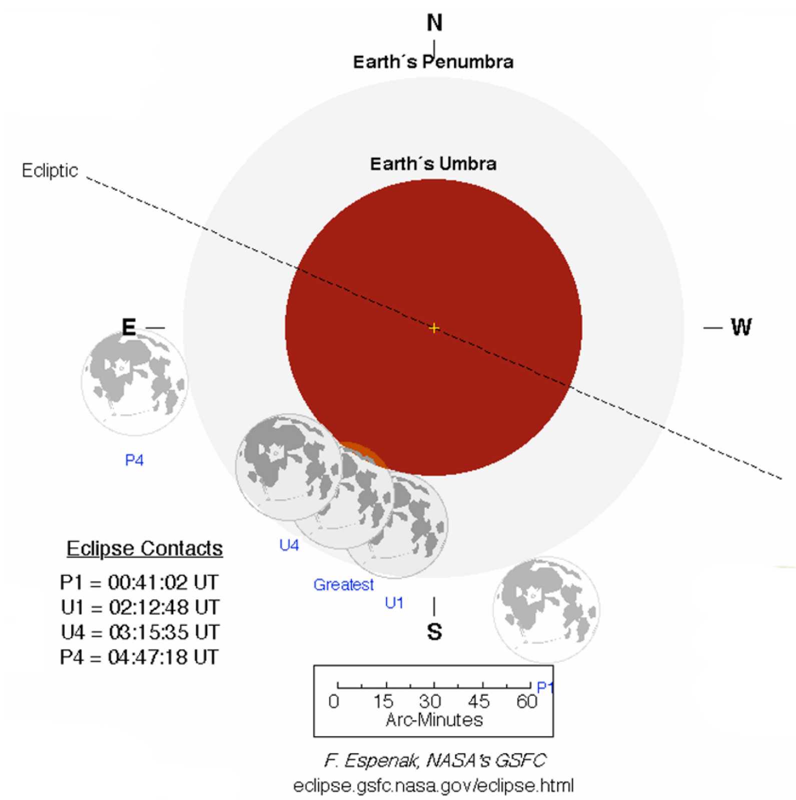
The Sun continues its progress within solar cycle 25 to its maximum, which may be occurring as you read this. Sunspot numbers are higher than predicted since late 2022 and have been even higher in 2024. In August, there were twice as many sunspots (215) as predicted (108). The predictions were made in 2019 by an international panel of solar experts, which is to say an internation panel of solar good guessers. The full mechanism of the solar cycle remains speculative.

Lunar Eclipse September 17, 2024 by Rick Bria

The Earth's umbra obscured the northern edge of the Moon, covering just 8.5% of the lunar surface at maximal eclipse, which occurred at 10:44 p.m. EDT. At the beginning of the umbral phase, thin clouds in our area washed out the lunar surface more than is usual for a full Moon. Fortunately, the clouds thinned out just enough for Rick to make this image in Greenwich, Connecticut. He used the Bowman Observatory's TeleVue 127 refractor telescope and a Canon R6m2 mirrorless camera for a shot at 1/500 second. A very thin layer of clouds softened the image a little, but the amount of detail and contrast is still impressive after Rick processed the image in PixInsight.

This eclipse is a member of lunar saros cycle 118, a run of 73 eclipses that began on March 2, 1105 and will end on May 7, 2403. Only the central 38.4% of eclipses of this cycle will be total; 20.5% will be partial, like this one, and 41.1% will only be penumbral. Eclipses in a saros cycles occur every 6,585.3 days (18 years 11 days 8 hours). Like solar eclipse saros cycles, the geometry of each eclipse is similar, but the Moon is slightly displaced from the prior event as it crosses the ecliptic. The penumbral shadow of the first eclipse in cycle 118, in 1105, just clipped the Moon's south pole, the penumbral eclipse lasting 56.3 minutes. The first total eclipse (Moon fully within the Earth's umbra) in cycle 118 occurred on August 22, 1393, lasting 39 minutes. The maximum duration total eclipse in cycle 118 occurred on April 7, 1754, when totality lasted 99.4 minutes. This is the last eclipse in the cycle that will have any of the Earth's umbra fall on the Moon. The next one, on September 29, 2042, will only be a penumbral eclipse.

This information is from the NASA Eclipse web site, https://eclipse.gsfc.nasa.gov/eclipse.html.



Research Highlight of the Month

Rivera, YJ, et. al. (20 authors), In situ observations of large amplitude Alfvén waves heating and accelerating the solar wind, *Science* 385: 962-966 (30 August 2024)

Among the Sun's many fascinating properties are the temperature of the corona, which is much hotter than would be expected from gas physics, and the acceleration of solar wind ions as they escape from the corona. There are both "slow" and "fast" solar winds. It is thought that Alfvén waves have something to do with these phenomena, particularly the fast component. First proposed in 1942 by Swedish physicist Hannes Olof Gösta Alfvén, Alfvén waves describe the motion of ions in a magnetic field. The movement induces additional electrical and magnetic currents and bulk flow of matter, the whole process being referred to as "magnetohydrodynamics." Alfvén wrote,

> If a conducting liquid is placed in a constant magnetic field, every motion of the liquid gives rise to an E.M.F. [electromagnetic force] which produces electric currents. Owing to the magnetic field, these currents give mechanical forces which change the state of motion of the liquid. Thus a kind of combined electromagnetic–hydrodynamic wave is produced.[1]

Alfvén won the 1970 Nobel Prize for this work, only one of his many contributions to science.

In February 2022, NASA's Parker Solar Probe, orbiting the Sun at 13.3 solar radii, passed through a stream of the fast solar wind that two days later was intercepted by the European Space Agency's Solar Orbiter 127.7 solar radii away. This rare and fortuitous radial alignment allowed comparison of the properties of a single stream of the solar wind and the local magnetic field. From the data, the investigators determined that the magnetic fields interacted with the particles to transfer the energy needed to heat and accelerate them. The energy added to the solar wind particles was matched by the loss of energy in the Alfvén waves (due to the conservation of energy), confirming that the Alfvén waves drive the acceleration of the particles.

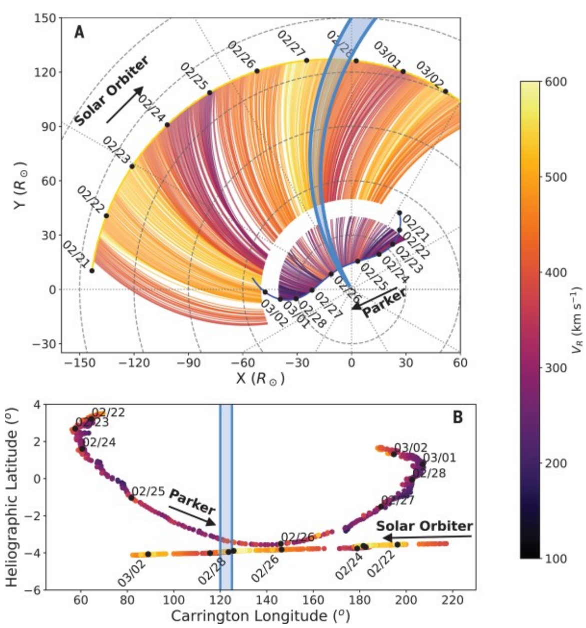
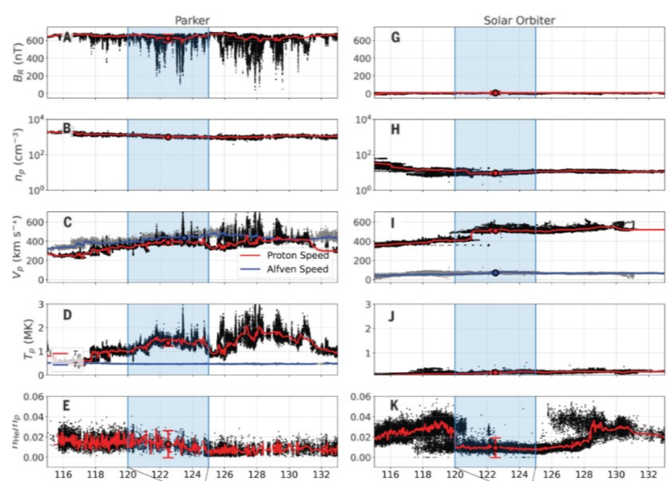


Fig. 1 from the paper showing the trajectories of the two probes and the solar wind velocities. Upper graph is projected onto the solar equatorial plane; the lower graph is a heliographic projection.



Excerpt from Fig. 2 showing the comparison of data from the two probes (L Parker, R Solar Orbiter). (A & G) Radial magnetic field; (B & H) Proton density, (C & I) Proton bulk speed and Alfvén velocity; (D & J) Proton temperature; (E & K) helium to proton ratio.

[1] Alfvén, H, Existence of Electromagnetic-Hydrodynamic Waves, *Nature* 150; 405-406 (1942).

Member & Club Equipment for Sale

Item	Description	Asking Price	Name/Email
NEW LISTING Celestron StarSense Explorer DX 102AZ	Brand-new condition 102-mm f/6.5 refractor, uses cell phone to find objects. Slow-motion stalks for movement. The original owner installed a laser finder bracket for easier alignment (laser included). 25-mm and 9-mm eyepieces, red-dot finder, aluminum tripod with tray. Still in production, see it on Celestron's web site. Lists for $469. Great starter scope. Donated to WAA.	$175	WAA ads@westchesterastronomers.org
NEW LISTING 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 available on iOptron's web site. Donated to WAA.	$400	WAA ads@westchesterastronomers.org
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
Celestron Nexstar 5SE	Mint condition white Celestron 5-inch f/10 (1250-mm) Schmidt-Cassegrain. Go-to alt-azimuth, single fork arm. Only used a couple of times. Complete with hand control, tripod, finder, eyepiece, diagonal. Picture here. Celestron lists this instrument now for $939. Weight 17.8 lbs complete, including tripod. Runs on 8 AA batteries or external 12-volts. A fantastic telescope for lunar, planetary and bright DSO observing. A great deal!	$400	Heather Morris heathermorris4381@gmail.com
ADM R100 Tube Rings	Pair of 100 mm adjustable rings with large Delrin-tipped thumb screws. Fits tubes 70-90 mm. You supply dovetail bar. Like new condition, no scratches. See them on the ADS site at https://tinyurl.com/ADM-R100. List $89.	$30	Larry Faltz lfaltzmd@gmail.com
1.25" Filters	Thousand Oaks LP-3 Oxygen III (2 available) Astronomic UHC (2 available) High Point Neutral Density (2 available)	$50 $75 $10	Eugene Lewis genelew1@gmail.com

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.

Buying or selling items is at your own risk. WAA is not responsible for the satisfaction of the buyer or seller. Commercial listings are not accepted. Items must be the property of the member or WAA. WAA takes no responsibility for the condition or value of the item, or for the accuracy of any description. We expect but cannot guarantee that descriptions are accurate. Items subject to prior sale. WAA is not a party to any sale unless the equipment belongs to WAA (and will be so identified). All receipts from sale of WAA equipment are used to support club activities. ***Prices are negotiable*** unless otherwise stated. Sales of WAA equipment are final. *Caveat emptor!*

This article is distributed by NASA's Night Sky Network (NSN).
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October's Night Sky Notes: Catch Andromeda Rising!

By Dave Prosper & Kat Troche

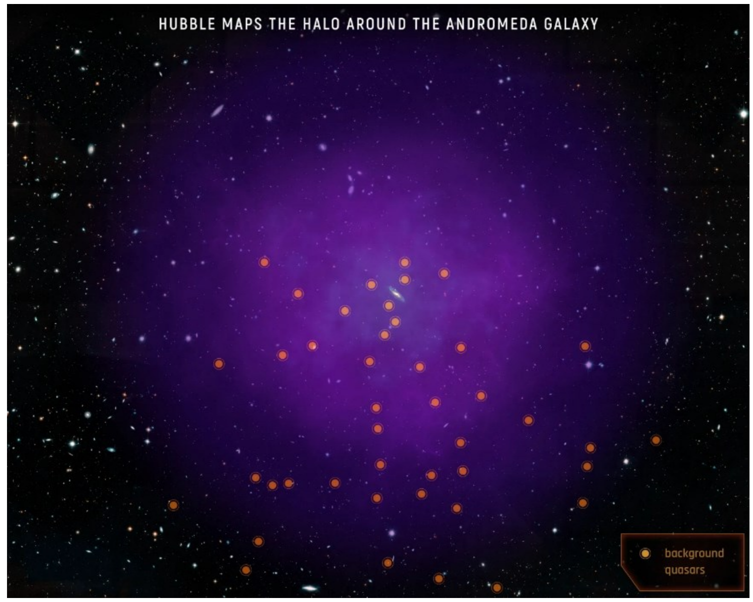
If you're thinking of a galaxy, the image in your head is probably the Andromeda Galaxy. Studies of this massive neighboring galaxy, also called M31, have played an incredibly important role in shaping modern astronomy. As a bonus for stargazers, the Andromeda Galaxy is also a beautiful sight.

Spot the Andromeda Galaxy! M31's more common name comes from its parent constellation, which becomes prominent as autumn arrives in the Northern Hemisphere. Surprising amounts of detail can be observed with unaided eyes when seen from dark sky sites. Hints of it can even be made out from light polluted areas. Use the Great Square of Pegasus or the Cassiopeia constellation as guides to find it. Credit: Stellarium Web.

Have you heard that all the stars you see at night are part of our Milky Way galaxy? While that is mostly true, one star-like object located near the border between the constellations of Andromeda and Cassiopeia appears fuzzy to unaided eyes. That's because it's not a star, but the Andromeda Galaxy, its trillion stars appearing to our eyes as a 3.4 magnitude patch of haze. Why so dim? Distance! It's outside our galaxy, around 2.5 million light years distant - so far away that the light you see left M31's stars when our earliest ancestors figured out stone tools. Binoculars show more detail: M31's bright core stands out, along with a bit of its wispy, saucer-shaped disc. Telescopes bring out greater detail but often can't view the entire galaxy at once. Depending on the quality of your skies and your magnification, you may be able to make out individual globular clusters, structure, and at least two of its orbiting dwarf galaxies: M110 and M32. Light pollution and thin clouds, smoke, or haze will severely hamper observing fainter detail, as they will for any "faint fuzzy." Surprisingly, persistent stargazers can still spot M31's core from areas of moderate light pollution as long as skies are otherwise clear.

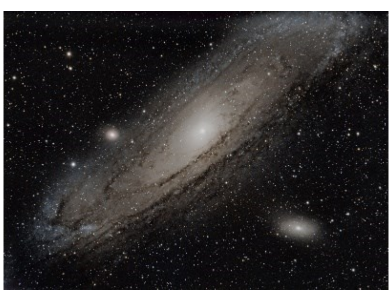
Modern astronomy was greatly shaped by studies of the Andromeda Galaxy. A hundred years ago, the idea that there were other galaxies beside our own was not widely accepted, and so M31 was called the "Andromeda Nebula." Increasingly detailed observations of M31 caused astronomers to question its place in our universe – was M31 its own "island universe," and not part of our Milky Way? Harlow Shapley and Heber Curtis engaged in the "Great Debate" of 1920 over its nature. Curtis argued forcefully from his observations of dimmer than expected nova, dust lanes, and other oddities that the "nebula" was in fact an entirely different galaxy from our own. A few years later, Edwin Hubble, building on Henrietta Leavitt's work on Cepheid variable stars as a "standard candle" for distance measurement, concluded that M31 was indeed another galaxy after he observed Cepheids in photos of Andromeda, and estimated M31's distance as far outside our galaxy's boundaries. And so, the Andromeda Nebula became known as the Andromeda Galaxy.

While M31's disc appears larger than you might expect (about 3 Moon widths wide), its "galactic halo" of scattered stars and gas is much, much larger – as you can see in the image on the right. In fact, it is suspected that its halo is so huge that it may already mingle with our Milky Way's own halo, which makes sense since our galaxies are expected to merge sometime in the next few billion years! The dots are quasars, objects located behind the halo, which are the very energetic cores of distant galaxies powered by black holes at their center. The Hubble team studied the composition of M31's halo by measuring how the quasars' light was absorbed by the halo's material. See https://iopscience.iop.org/article/10.3847/1538-4357/aba49c/pdf. Image credits: NASA, ESA, and E. Wheatley (STScI).



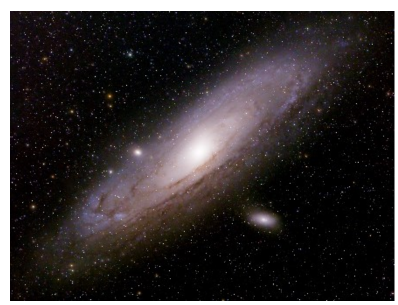
These discoveries inspire astronomers to this day. They continue to observe M31 and many other galaxies for hints about the nature of our universe. One of the Hubble Space Telescope's longest-running observing campaigns was a study of M31: the Panchromatic Hubble Andromeda Treasury (PHAT). Dig into NASA's latest discoveries about the Andromeda Galaxy, on their Messier 31 page.

M31 by WAA members (all images previously published in SkyWAAtch)

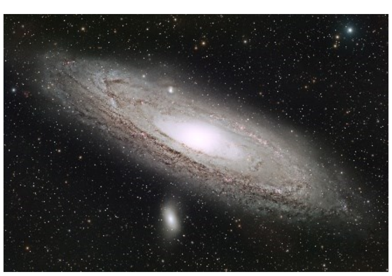


Gary Miller

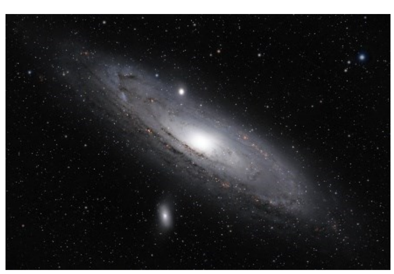
Arthur Miller



David Parmet



Justin Accetturi



Steve Bellavia

Manish Jadhav