SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

December 2023

The Great Orion Nebula by David Parmet

Made at the Black Forest Star Party, Cherry Springs, PA, in September 2023. RedCat 51, ASI533MC Pro.

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 December Meeting

Friday, December 8 at 7:30 pm

Navigating the Cosmos: Satellites, Astrophysics, and the Balancing Act

Emma Louden
Department of Astronomy, Yale University

This lecture explores the dynamic relationship between astronomy, satellites, and the redesign of astrophysics, while also addressing the nuanced impact of satellites on astronomical observations. Satellites have remarkable capabilities for unraveling the universe's mysteries, but also pose challenges by their increasing presence in the night sky. This thought-provoking lecture offers a comprehensive look at the benefits and drawbacks of satellite technology.

Emma Louden is an astrophysicist and consultant on space policy and industry trends. As a 4th year Ph.D. candidate in astrophysics at Yale University, Emma is passionate about future-focused strategy for astrophysics, engaging the public with space exploration, & applying evidence-based solutions to solve the world's most pressing problems. When not working on her Ph.D., she focuses on her STEM workforce project & supporting the next generation of astronomers through the Summer Science Program.

This is also the official WAA Annual Meeting.

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

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

WAA January 2024 Meeting

Friday, January 12, 2024 at 7:30 pm

Topic to be Announced

Marc Taylor
Andrus Planetarium, Hudson River Museum

Starway to Heaven

Ward Pound Ridge Reservation, Cross River, NY

There are no formal star parties in December, January or February.

New Members

Dawn Eschert	Hawthorne
Patrick Guidera	Dobbs Ferry
Katelyn Haig	Beacon
Zachary Maller	Stamford, CT

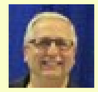
Renewing Members

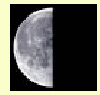
Cathy Carapella	Eastchester
Dina Carreras	Mahopac
Peter Germann	Katonah
Sharon and Steve Gould	White Plains
Michael Jen	Baldwin Place
Bob Kelly	Ardsley
Michael Lomsky	Wilton, CT
William Meurer	Greenwich
William Newell	Mt. Vernon
Tracy Ostroff	Ardsley
Robert Peake	Pleasantville
Bruce Rights	Mount Kisco
Richard Segal	Yorktown Heights
James Steck	Mahopac
Robin Stuart	Eustis, ME
Jose Vega	Yonkers

Also In This Issue

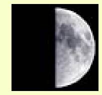
ALMANAC For December 2023

Bob Kelly, WAA VP of Field Events


Bob Kelly


3Q 12/5


New 12/12


1Q 12/19

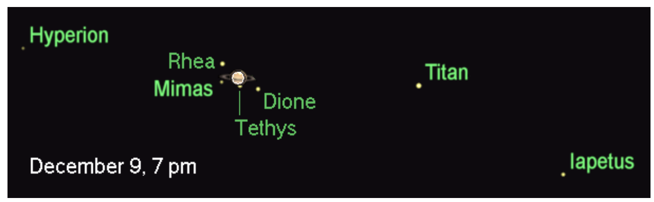

Full 12/16

The annual **Geminid meteor shower** is one of the strongest interactions our atmosphere has with space dust. The shower peaks on the night of the 13th-14th. The meteors appear to radiate from near the heads of the Gemini. Once the constellation rises, the rate of meteors per hour increases. You might see a fair number of Geminids starting around 9 p.m. EST. The peak is nearly 100 meteors per hour during the hours after midnight until morning twilight starts to drown them out about 5:30 a.m. The best place to look is wherever you can view the widest amount of open sky, looking at the darkest part of the sky from your viewing location. Keep lights out of your eyes to remain dark-adapted. The Moon will be a thin crescent, setting at 4:50 p.m., and will not interfere with viewing this meteor show.

Another meteor shower of interest is the very weak **Sigma Hydrid shower**. It is visible between December 9th and 12th. Historically, there are about three meteors per hour in this show. What makes the Sigma Hydrids interesting is the possibility of more meteors than usual this year. Some scientists think the shower may be crumbs from Comet Nishimura, which passed through the inner solar system earlier in 2023. If more meteors than usual are observed this year, it will support the hypothesis that Nishimura is the source for this shower and its recent visit replenished the trail of meteors.

Jupiter remains king of the evening sky. Just a month after opposition, it is high in the sky after sunset. Check *Sky & Telescope* or your favorite app for times when Jupiter's four brightest moons or their shadows cross the planet. They are great fun to see in a telescope (see page 23 for a couple of examples from November). The Great Red Spot is smaller than it used to be but is still visible. It's easier to spot in a larger telescope. The best viewing is when it's nearest the center of Jupiter's disk, a two hour window during Jupiter's 9-hour 55-minute rotation. *Sky & Telescope* lists good times for evening observers (say 7 to 9 p.m.) on the 5th, 12th, 17th, 24th and 31st. Good seeing always helps. Try a Wratten 80A blue filter to enhance its visibility. There are a number of visible shadow transits in December, and a fine double shadow transit of Io and Ganymede in the evening of December 30th starting at 5:16 p.m., 49 minutes after sunset with Jupiter at 46 degrees elevation and rising.

You can catch **Saturn** when it is highest in the sky right after sunset. The fantastic ringed planet sets around 11 p.m. at the start of the month around 9 p.m. at the end of the year. **Iapetus** and **Titan** line up to the west of Saturn for several days around the 9th. Titan is magnitude +8.8, so it is easily seen even in a small telescope, but Iapetus is a challenging 11.6. After Titan, the brightest Saturnian moon is Rhea, magnitude 10.2.

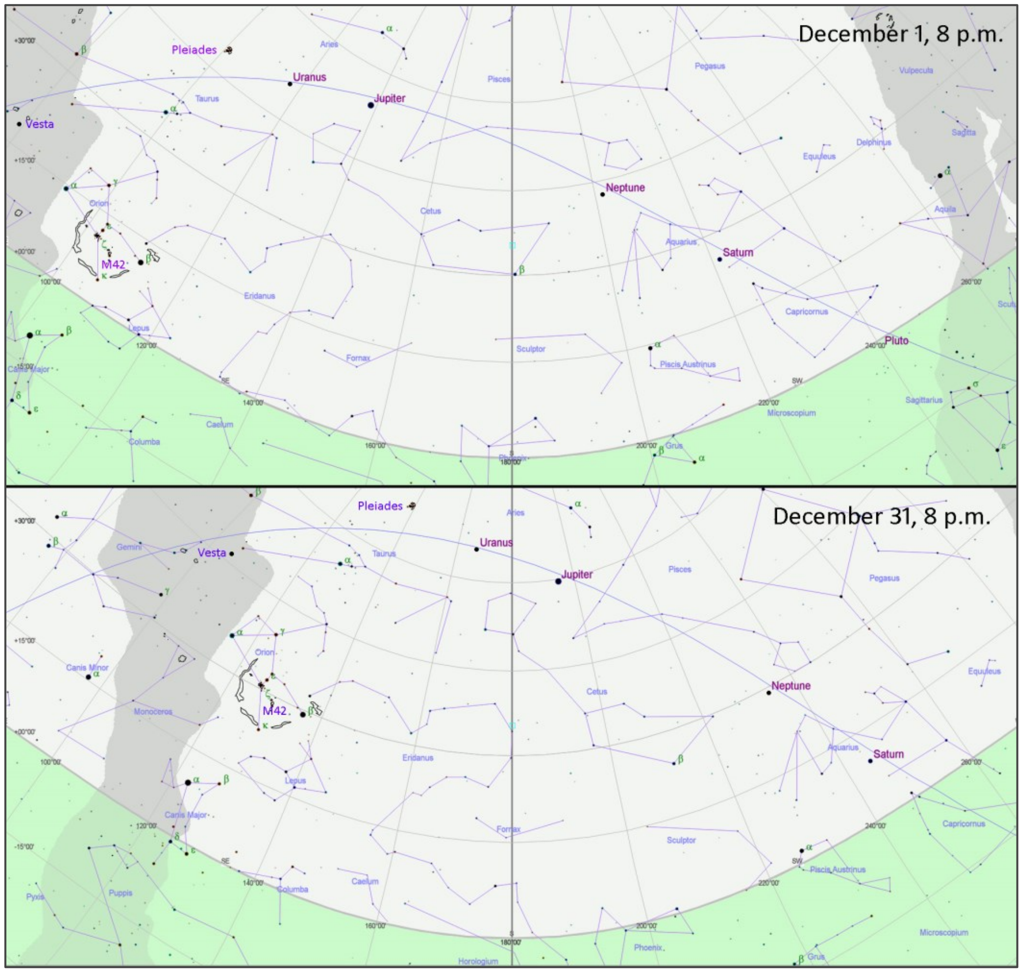


Want to review the stars of the year? Dig out a copy of the December 2018's *Sky & Telescope* with WAAer Scott Levine's article about seeing many of the year's bright stars by going out once an hour all night on New Year's Eve. Here's a link to the video version: https://is.gd/NYEStars.

While you are at it, get a copy of January 2024's *Sky & Telescope*, which includes a colorful, graphical almanac of the rise and set times of objects in the night sky. This year, they have indicated the close approaches of the planets to each other. I enjoy that more than the "Moon is near <star or star cluster>", (perhaps blotting it out from our view for that night). The crescent Moon is pretty when it's near Venus, as it is on the 9th. The day before, it passes Spica.

Uranus and **Neptune** trail after Jupiter and Saturn, respectively, in the evening sky. **Mars** is still in the Sun's glare, on the opposite side of the Sun from us.

Venus slides by Spica on the 1st. While they are no closer than four degrees apart on this pass as seen from our neck of the woods, it will be one of the closest approaches of Venus to a first magnitude or brighter star for a while. Spica will get some attention even from casual observers because of its proximity to Venus, since Venus is well up in a dark sky before sunrise all month.



Mercury peeks out from behind the Sun in early December. It does a sideways shuffle from our point of view, not getting more than 10 degrees above the horizon at sunset at greatest elongation on the 4th. Since Mercury (and the Sun) are well into the southern part of the ecliptic, the southern hemisphere gets to see Mercury get good separation from the Sun during this evening elongation. Mercury ends 2023 starting its trip into the morning sky after solar conjunction on the 22nd.

Guy Ottewell's *Astronomical Calendar* has good illustrations of the inner planets' elongations. The 2024 edition is available as a hard copy ($22) or downloadable pdf ($12). See https://is.gd/ottewell24.

Minor planet **4 Vesta**, typically the brightest denizen of the asteroid belt, peaks at magnitude +6.4 on December 21 while passing the tip of Orion's outstretched club.

The **December solstice** occurs on the 21st at 10:27 p.m. EST. There will be only 9 hours, 13 minutes and 14 seconds of sunlight on the 21st and 22nd, the least amount in 2023.

The **International Space Station** is visible in the evening sky through the 9th and in the morning from the 14th onward. **Tiangong** is visible in the evening through the 4th; then in the morning starting on the 14th until the 29th. ■

Shadow Transits of Jupiter in December
Visible after sunset from Westchester, with the planet above 30° elevation for any part of the transit.

Date	Moon	Ingress		Egress	
		Time	Alt °	Time	Alt °
12/2	G	01:07	39	02:49	16
12/5	I	01:08	32	03:19	8
	E	19:56	55	22:16	57
12/6	I	19:37	53	21:47	59
12/12	E	22:31	52	00:51	29
12/13	I	21:33	59	23:43	40
12/20	I	23:28	38	01:39	14
12/22	I	17:57	49	20:08	60
12/29	I	19:53	60	22:04	46
12/30	I	17:01	44	19:21	60
	G	17:16	46	18:56	59
	Double	17:16	46	18:56	59

Sunset on 12/30/23 is at 16:47 (4:37 p.m.).

Doug Towers

We were sad to learn of the passing of Doug Towers, one of the longest-serving members of Westchester Amateur Astronomers, on October 16, 2023 at the age of 88.

At the 2006 WAA picnic. Trom left to right, Vivian Towers, Doug Towers, Ann Cefola, Pat Mahon

At Ward Pound Ridge, 2013

At the 2012 WAA Picnic, with Larry Faltz

In 1986, Doug's wife Vivian noticed a newspaper article about an astronomy club in Yonkers, called the Andrus Observers Group, which later became WAA. It met at the Hudson River Museum. He and Vivian joined and were active members until her death in 2015 and then his relocation to South Carolina in 2017.

Pat Mahon recalls that "before the newsletter had gone completely electronic, he would invite me to go up to his house to help put the newsletter together so it could be mailed out." A small group of WAAers would gather around the Towers's dining room table to collate printed pages, stuff envelopes, write addresses and lick stamps, after which Vivian would reward them with coffee, tea and a big box of donuts.

Doug was a fixture at star parties. He and Vivian attended lectures and the annual picnic. After Vivian's death, Doug moved to South Carolina to be near his daughter Karen and her family. Just before Doug moved south, we presented him with a framed certificate of appreciation that read "In recognition and gratitude for his many years of membership in and service to Westchester Amateur Astronomers. His many friends in WAA enthusiastically award this certificate with appreciation and best wishes for health, happiness and clear skies." See the November 2017 SkyWAAtch, p. 18 for a photo.

Karen told us that Doug viewed the August 21, 2017 total solar eclipse. He made friends with some of the local astronomy club members. Eventually, Doug had to move to assisted living, where he proudly displayed the WAA certificate in his room. Although he was hospitalized for his final illness, Karen told us that Doug wanted to go outside, tubes and all, to see the October 14th partial solar eclipse. He thought he could convince the medical staff, but his condition simply wouldn't permit it. It's hard to keep a good astronomer down!

Doug spent most of his career as a mechanical engineer at the Loma Machine Company in New Rochelle, designing factory equipment. Karen told us that Doug will be interred next to Vivian at the Ferncliff Cemetery in Hartsdale sometime in the spring or early summer of 2024. There will be a celebration of Doug and Vivian's lives afterwards. WAA members will be invited, and we'll send an eblast when the arrangements are made.

Deep Sky Object of the Month: The Ghost of Mirach

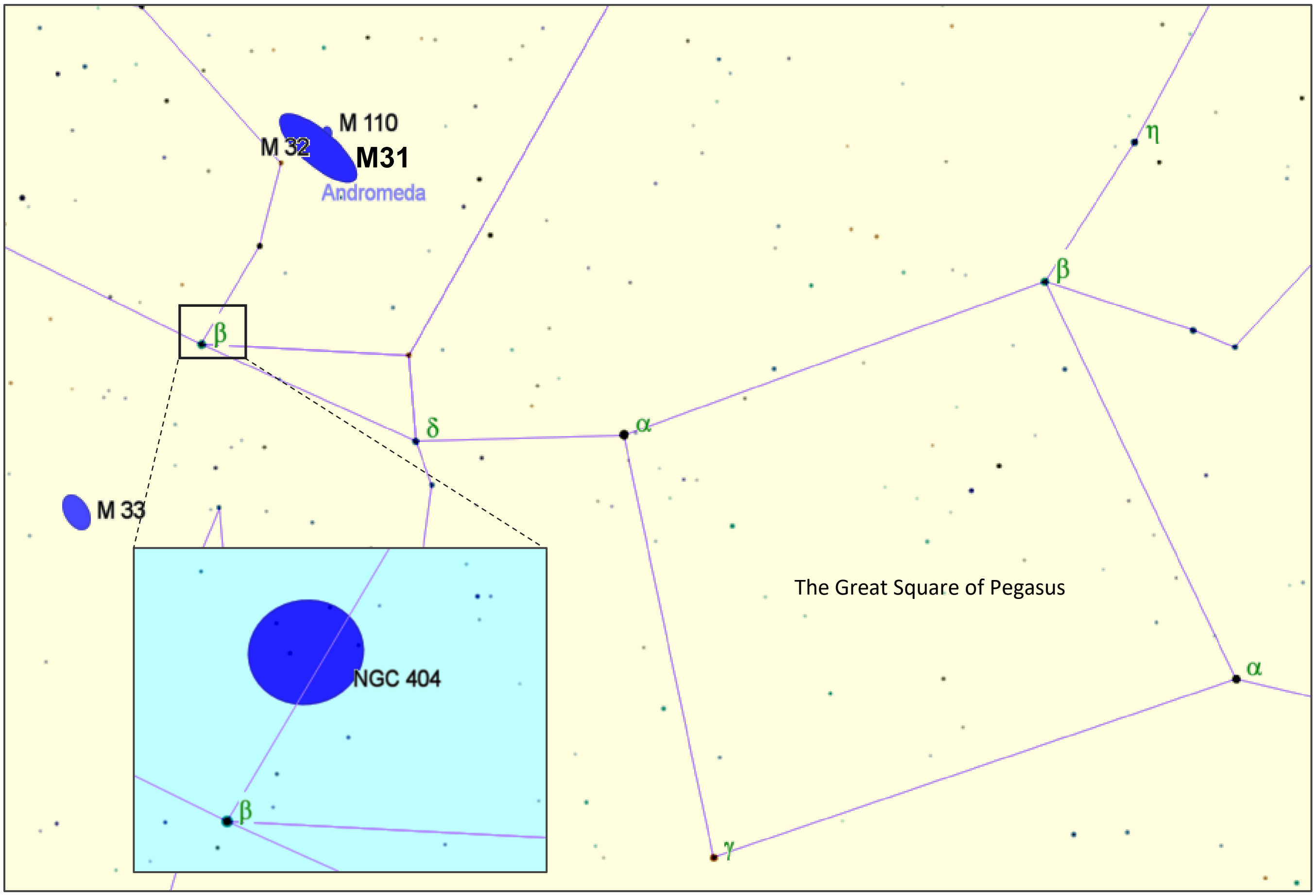
NGC 404	
Constellation	Andromeda
Object type	Galaxy
Right Ascension J2000	01h 09m 24s
Declination J2000	+35° 43′ 00″
Magnitude	10.3
Size	4.3′ x 3.9′
Distance	10 million LY
NGC designation	NGC 404
Discovery	W. Herschel, 1784

The Ghost of Mirach is a small galaxy that lies just 7 minutes of arc from the magnitude 2.0 star Mirach (β Andromedae). The star's brightness can overwhelm the galaxy, making it a challenge for observers who may think they are seeing a flare in the eyepiece.

Start at α-And (Alpheratz) at the corner of the Great Square of Pegasus and go east to the second bright star, which is Mirach. Try to find NGC 404 in the star's glare. Go north from Mirach to the third "star" and you'll find the Andromeda galaxy, M31.

Visibility for NGC 404			
22:00 EST	12/1	12/15	12/31
Altitude	70° 21′	60° 08′	48° 28′
Azimuth	259° 54	270° 55	279° 59′

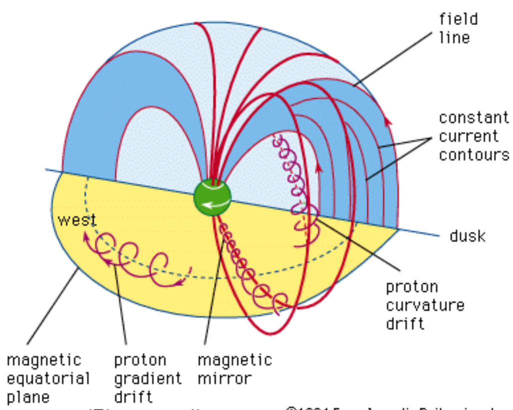
Some observers place a thin strip of foil at the field stop of an eyepiece to block the star's light, making the galaxy more visible. This is also a good technique if you are trying for Sirius B.



Remember, Remember, the 5th of November — Robin Stuart

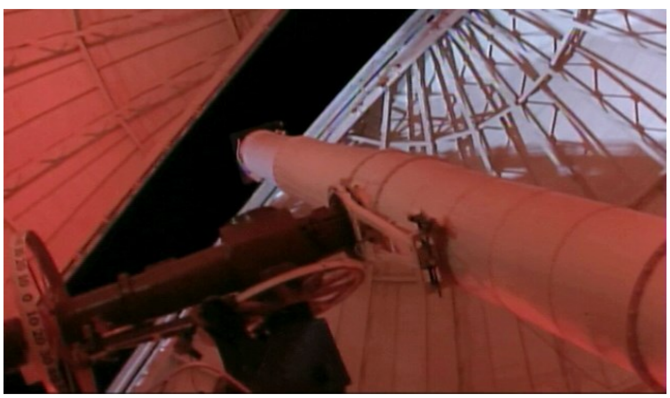
The impact of a full halo coronal mass ejection (CME) unleashed Guy Fawkes Night (November 5th) fireworks in the form of a G3-class geomagnetic storm. Soon after astronomical dusk in Eustis, Maine I photographed an auroral glow along the northern horizon that was very similar to, but somewhat brighter than, the one shown in the image on page 6 of the March 2023 SkyWAAtch. The image appearing on my camera's screen displayed a distinct red swath in the northeast that was nearly invisible to my still poorly dark-adapted eyes. Shown above is a 10 second exposure at ISO 1600 with a Canon 60Da using a 50mm lens at f/1.4. Processing was done with PixInsight. The field is 24.6x16.4 degrees, mostly in Taurus, as reported by astrometry.net.

I was perplexed by what I had seen until an explanation appeared on Spaceweather.com (https://spaceweather.com/archive.php?view=1&day=07&month=11&year=2023), which reported that the arc had been widely observed across the United States and around the world. It is definitely not an aurora despite being having been given the misleading moniker of Stable Auroral Red arc (SAR) when it was discovered in 1956. The Earth is encircled by a ring of current lying near the equatorial plane at a distance of three to eight Earth radii with millions of amps being carried by circulating positive ions, mainly protons. The ring circulates in the opposite direction of the Earth's rotation. During a geomagnetic storm the particle numbers increase and heat energy leaks into the upper atmosphere resulting in the appearance of a SAR. ■



(Ring current)

More Movie Telescopes



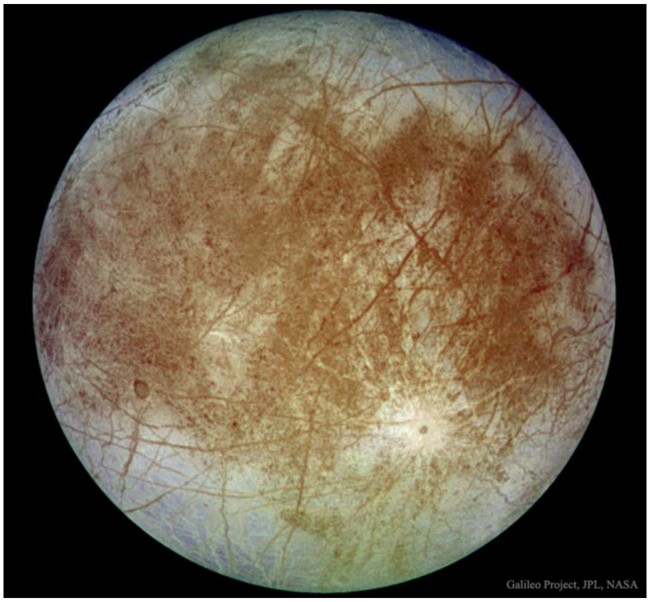
We get a couple of very nice looks at beautiful Yerkes Observatory and its iconic 40-inch Clark refractor in the 1996 innocent man accused/conspiracy/chase thriller *Chain Reaction*. The film stars Keanu Reeves and Rachel Weisz. It concerns a putative new source of hydrogen power. Reeves is a machinist and Weisz a physicist on the project at the University of Chicago. They get blamed for a murder and for the destruction of their lab in a massive explosion. The couple goes on the run, chased by police and mysterious evil forces.

After a clever scene in which Reeves scrambles up the opened DuSable Bridge across the Chicago River, the couple manages to get to Williams Bay, Wisconsin. Reeves has an astronomer friend (Joanna Cassidy), who lives at the observatory. After a scene in her office, where in the background we see a 5-inch Clark from 1875 and a 6-inch wooden-tube 1855 Fitz, the bad guys show up and more mayhem, murder and chasing ensue. Of course, Reeves and Weisz end up safe and exonerated. The Clark and Fitz scopes are now in John Briggs's Astronomical Lyceum in Magdalena, NM. Briggs was a telescope operator at Yerkes when the film was made and assisted with production.

For his role in this film, Keanu Reeves was nominated for the Razzie Award for Worst Actor but lost out to Tom Arnold and Pauly Shore. I would have voted for Reeves, who in his entire movie career seems never to have moved a single muscle on his face. But we're happy the observatory was featured. See the September 2018 SkyWAAtch for our own (less violent) trip to Yerkes.

Europa and Its Ocean

Larry Faltz



Europa's trailing hemisphere in natural color, Galileo Orbiter 1997. Distance 677,000 km (NASA)

In January 1610, in Padua, Galileo Galilei turned his primitive telescope to the planet Jupiter. He discovered the four objects we know as the "Galilean Moons." He dedicated the March 1610 pamphlet *Sidereus Nuncius* (Starry Messenger) to the Florentine ruler Cosimo II De' Medici, with whom he was trying to curry favor, so he referred to the Jovian satellites as the "Medicean Stars." In the *Sidereus Nuncius* he described and drew the appearance of the Jupiter system over the period January 7, 1610 to March 2, 1610, reporting a total of 65 observations within that two-month period (on some evenings he made two observations a few hours apart, and of course he was clouded out a few times).

It is possible, however, that he wasn't the first to see the four satellites. The German astronomer Simon Marius claimed to have seen them in December 1609. He didn't publish until 1612, expanding on his claims in *Mundus Jovialis Anno 1609 detectus* (The World of Jupiter, as detected in 1609), published in 1614. Although his data for the satellites' period of revolutions was more accurate than Galileo's, the latter's fame and the many copies of the *Sidereus Nuncius* in circulation made his priority irrefutable. In any case, a formal investigation in Holland in 1903 concluded that Marius' notes commenced on January 8, 1610, one day after Galileo's first observation. The first example of "publish or perish"?

In the *Sidereus Nuncius*, Galileo first calls the Jovian satellites "stars" (*stellae*) but later in the text also refers to them as "planets" (*planetae*). He did not give them individual names. Both Marius and Galileo understood the Copernican implication of their observations. Marius decided that since the Jupiter system was a solar system in miniature the satellites should be named analogously to the actual solar system. He proposed "Mercurius Jovialis" for the innermost moon, "Venus Jovialis" for the second, "Jupiter Jovialis" for the third (the brightest) and "Saturnus Jovialis" for the outermost. He left out "Terra" (Earth) altogether, and Mars was rejected because Marius was uncomfortable linking the god of war to Jupiter.

But Marius realized that this scheme was clumsy, and so he then proposed a different nomenclature,

> … without superstition and with the sanction of theologians. Jupiter especially is charged by the poets with illicit loves. Especially well known among these are the three virgins, whose love Jupiter secretly coveted and obtained, namely: Io, the daughter of the river god Inachus, then Callisto, daughter of Lycaon, and finally Europa, the daughter of Agenor. Yet even more ardently did he love the beautiful boy Ganymede, son of the king of Troy…And so I believe that I have not done badly in naming the first Io, the second Europa, the third, on account of the splendor of its light, Ganymede, and lastly the fourth Callisto.

We are undoubtedly seeing the influence of Ovid's *Metamorphoses* in 16th and 17 century Europe. It's probably the most influential work of literature in western culture after the Bible.

Galileo objected to these names, primarily because they were proposed by Marius, who was another contemporary astronomer with whom the egotistical Florentine scrapped. Willy Ley, in *Watchers of the Skies*, suggests that had the classical naming scheme been proposed by Marius' friend Johannes Kepler, whom Galileo viewed favorably, he might have accepted them. We'll never know. The influential mid-17th century astronomer Gian Domenico Cassini later proposed Pallas, Juno, Themisque, and Ceres for the four satellites, but that never caught on, and so he reverted to the simple naming convention that Galileo himself invented in 1611: J-I, J-II, J-III, and J-IV. This nomenclature was generally used thereafter. In 1892, E.E. Barnard discovered a fifth moon, which was interior to J-1. He proposed calling it "Satellite V," while the name Amalthea was suggested by the French astronomer Camille Flammarion. Amalthea was Jupiter's nurse. In 1894 Barnard presciently noted,

> It would be dangerous and absurd to change the present notation to introduce the new satellite as I, and it would be equally absurd to call it 0, as some have suggested, for we cannot tell what development the great telescopes of the future may bring about in the Jovian satellite system.[1]

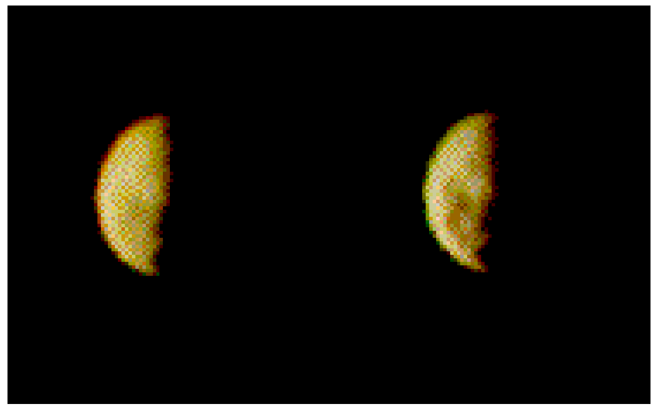
The Jovian satellites retained the J-# nomenclature through the middle of the 20th century. For example, the 1945 edition of *Astronomy* by the noted Princeton astronomer Henry Norris Russell and two collaborators, states

> They [the moons of Jupiter] are usually known as the first, second, etc. in the order of their distance from the primary [Jupiter] but they also have names — Io, Europa, Ganymede and Callisto, respectively, — which, however, are seldom used.

Stanley Wyatt's widely used textbook *Principles of Astronomy* from 1964 says the satellites are referred to by their Roman numerals. Twelve were known at the time. But the second edition of the book, published just seven years later in 1971, uses their mythological names. Wyatt notes in the second edition that the "faint [non-Galilean] satellites are not designated by names, but by their Roman numerals in order of discovery." Names were only given to J-VI and beyond starting in 1975. Many more moons have since been discovered either photographically by large telescopes or by orbiters, and many of them have also been given names. The transition to the common use of mythological names undoubtedly was tied to the public's increased interest in spaceflight and its potential targets.[2] J-I through J-V (or J-XII or beyond) are simply too soulless to describe a world.

That the moons may have distinct surface compositions might be expected from their different albedos (Io 62%, Europa 68%, Ganymede 44%, Callisto 19%).[3] Visual and photographic observations in the pre-spaceflight era noted albedo variations on some of the moons, particular a whitish spot on Ganymede, the largest Jovian moon. It was thought possibly to be a polar cap, analogous to Mars, provoking some thoughts that these bodies might have surface water. Since at Jupiter's distance there is not enough solar radiation to preserve liquid water on the surface, heat emanating from the giant planet was proposed as a mechanism to maintain temperature in the proper range. Heat turns out to be a prescient idea, but not in the way that its originators thought.

Probing Europa in the Era of Space Flight



The best images of Europa from Pioneer 10 (NASA)

Pioneer 10 flew by Europa in December 1972. At a distance of 324,000 km and with a camera resolution of 167 km/pixel, the fuzzy image sent back to Earth confirmed albedo variations but gave no other details. Pioneer 11 also passed through the Jovian system but paid no attention to Europa.

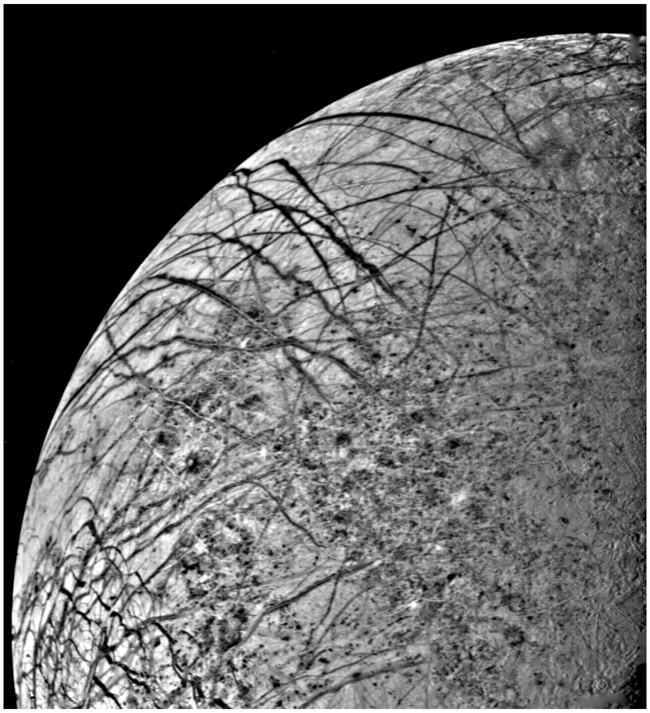
I can remember the excitement when the first Voyager images of the Jovian satellites came down and were shown live on television as they were received in 1979. Astronomers hooted with joy and wonder when the images appeared. Each of the four Galilean satellites showed unique features. Europa's high albedo had suggested an icy surface, but the cracked, complex, nearly craterless skin that appeared on the monitors was a complete surprise. One hopeful interpretation of the fractured surface was that water ice is floating over a subsurface ocean. The absence of craters means the surface was young, so it must be periodically (or continuously) reconstituted from a

[1] There are, as of mid-October 2023, 95 satellites of Jupiter, a number likely to grow in the future. The most recently discovered moons are bits of rock or ice. Only the four Galilean moons are spherical.

[2] The International Astronomical Union has an extensive set of rules for naming objects and the features on them. See https://www.iau.org/public/themes/naming/.

[3] The albedo of Earth's Moon is 14%.

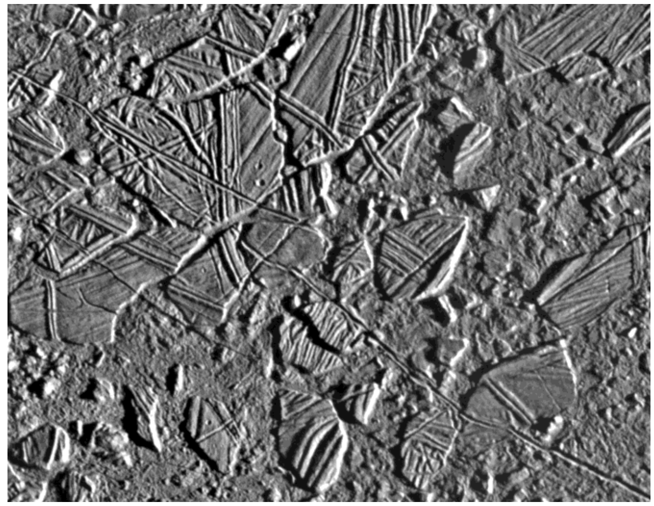
source within the satellite. A liquid subsurface ocean is an obvious deduction. Magnetometer data has been interpreted to show that Europa's magnetic field is most likely caused by circulation of a salty subsurface ocean. [Moving charges create a magnetic field. Remember Maxwell's equations!]



First close look at Europa from Voyager 2 July 9, 1979, distance 246,000 km (NASA)

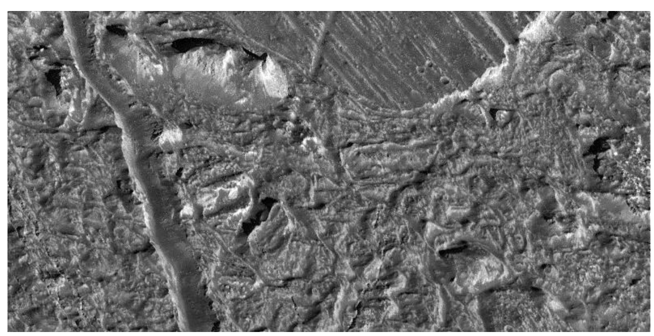
The Galileo Orbiter mission was launched in 1989, with a program to explore the environment of Jupiter in detail and pay close attention to its satellites. Galileo confirmed and extended the findings of the Voyager probes, providing incredibly detailed imaging, spectroscopic, magnetic and gravimetric data, all of which support the interpretation that there is a large body of subsurface water.

In spite of its appearance in close-up images, Europa is actually the smoothest object in the Solar System. The maximum elevation of surface features is just a few hundred meters. The depth of the surface ice is still controversial. While most planetary astronomers think the ice is fairly thick, ranging from 10 to 30 km, a vocal minority claim that in some areas the ice may be just 600 meters thick. A good reference for this controversy, told by thin-ice proponent Richard Greenberg of the University of Arizona, is his 2008 book *Unmasking Europa*.



Europa surface, Galileo orbiter 1997 (NASA)

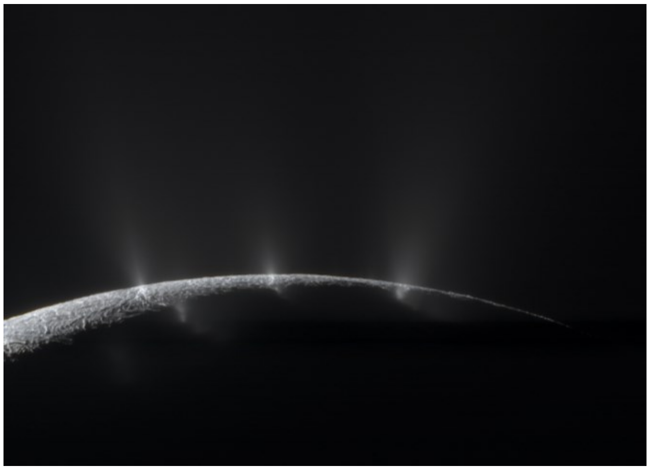
All the Galilean satellites are tidally locked to Jupiter, so they keep one face aligned with the planet, just like the Earth-Moon system. As Europa revolves around Jupiter it experiences tidal stresses that distort its core, generating enough heat to keep subsurface water in a liquid state. On Io, closer to the massive planet, tidal effects are greater, so much so that the overlying mantle is melted, rising to the surface to form volcanoes, of which there are at least 400. Smaller Europa is 59% farther away from Jupiter than Io and has an orbital period of three days, 12 hours compared to Io's more hectic one day, 18 hours. Europa's orbit is nearly but not exactly circular, and the orbital inclination relative to Jupiter's equatorial plane is 0.47°.



Conamara Chaos region, Dec. 16, 1997 (Galileo, NASA)

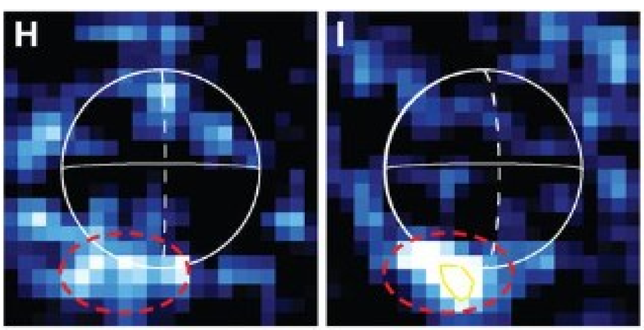
Stresses on surface ice provoke a form of plate tectonics, facilitating the turnover of the young, nearly craterless surface with its many cracks and ridges. In addition, there are areas of more disordered topography, called "chaos terrain," which have been interpreted as regions where the subsurface ocean may have melted through the icy crust.

Escape of water from the subsurface ocean



Water vapor jets from Enceladus' south pole (Cassini, NASA)

In 2005, the Cassini orbiter around Saturn directly imaged plumes of material escaping the surface of Enceladus, a satellite with a surface like Europa's. Cassini found instrumentation evidence for a subsurface ocean in Enceladus. Spectroscopy showed that the plumes were made of water vapor. Infrared spectroscopy showed warmer temperatures along cracks in Enceladus' surface. Is there equivalent evidence for Europa?



An excerpt from Fig 2 of Roth, et. al., Transient Water Vapor at Europa's South Pole, *Science* 343:171-174 (2014) showing water vapor (persistent material in red circles).

There were no plumes seen by the Galileo orbiter, but in 2014 the imaging UV spectrograph on the Hubble Space Telescope detected water vapor signals from Europa's limb. The plumes were calculated to be ejecting water at a rate of 10^{32} molecules of water per second, which is equivalent to a mass of around 9,200 kg of water each second.

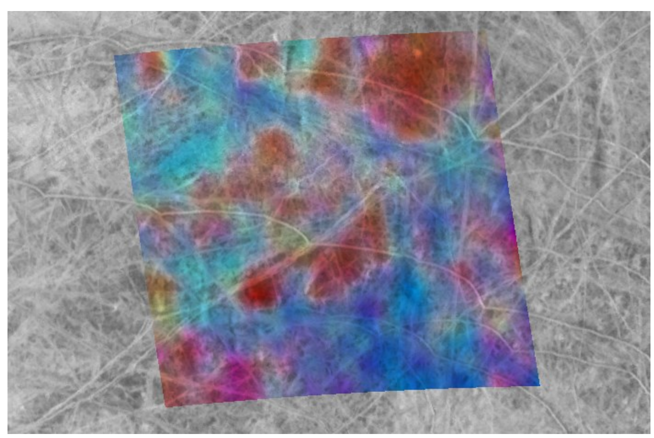
More evidence for plumes comes from magnetic and plasma wave data gathered by Galileo but not published until 2018. Jia, et. al,[4] reported on observations acquired on Galileo's closest encounter (<400 km) with Europa. The authors noted,

> the location, duration and variations of the magnetic field and plasma wave measurements are consistent with the interaction of Jupiter's corotating plasma with Europa if a plume with characteristics inferred from Hubble images were erupting from the region of Europa's thermal anomalies. These results provide strong independent evidence of the presence of plumes at Europa.

In 2021, studies with Hubble Space Telescope showed an atmosphere of water vapor on the trailing side of Europa (recall that it keeps one face to Jupiter) but made no claim that plumes were actively ejecting water into space.

What's on the surface, and how does it get there?

Galileo's Near Infrared Mapping Spectrometer detected variations in surface composition attributed to hydrated salts. The distribution suggested the material was concentrated along the linear stress faults. Inorganic material is either upwelling through cracks in the surface or being ejected under pressure into space and then falling back onto the surface. It does not appear to be deposited from distant interplanetary space.



Dual Galileo image 1999. The colored overlay is from the Near IR Mapping Spectrometer. (NASA)

Color images from Galileo and Juno[5] show a red color along many of the ridges, as seen in the full-disk

[4] Jia, X, Kivelson, M, Khurana, K, Kurth, W, Evidence of a plume on Europa from Galileo magnetic and plasma wave signatures, *Nature Astronomy* 2: 459–464 (2018)

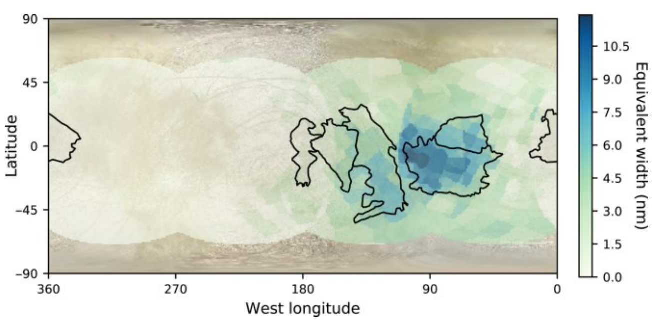
[5] The Juno mission, currently in orbit around Jupiter, has found mineral salts on the surface of Ganymede and evidence for a subsurface ocean there as well.

image from Galileo on page 9. Laboratory spectra of hydrated salt minerals such as magnesium sulfates and sodium carbonates provide a close match to the Europa spectra.

Jupiter's intense radiation readily transforms surface materials. In 1999, Galileo found high concentrations of sulfuric acid, derived from radiolytically transformed sulfate salts.

In 2007, infrared spectroscopy by the New Horizons spacecraft, passing by Jupiter to get a gravity boost on its way to Pluto, also demonstrated inorganic material overlying portions of the icy surface of Europa. The Hubble Space Telescope detected sodium chloride deposits on the surface, concentrated in the chaos region Tara Regio.[6] The authors note that,

> Using spectra obtained with the Hubble Space Telescope, we present the detection of a 450-nm absorption indicative of irradiated sodium chloride on the surface. The feature correlates with geologically disrupted chaos terrain, suggesting an interior source.

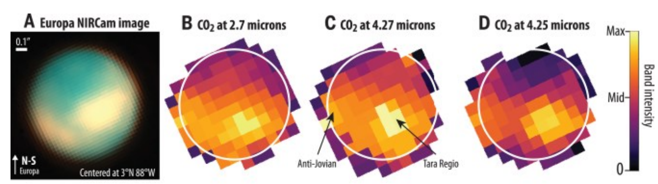


Sodium chloride on the surface of Europa (Trumbo and Brown)

Europa is now yielding its secrets to the James Webb Space Telescope. The outer planets and their satellites are attractive targets for JWST's superior resolution and infrared capabilities. JWST can gather a lot of information on solar system objects in a short observing window (Europa is a lot brighter than a galaxy at *z*=10, which JWST seems to have no trouble showing us). Two papers published in *Science* in September 2023 analyzed Europa's surface using data from JWST's Near IR Spectrograph (NIRSpec).

A group led by Guillermo Villanueva of the Goddard Space Flight Center looked at spectra of Europa's leading hemisphere and surrounding space out to a distance of 400 km.[7] They were unable to detect absorption lines of water, methane, ethane, carbon monoxide or methanol in space. If there was a plume it would have had an emission rate of less than 10^{28} molecules of water per second. Perhaps Europa plumes are intermittent, or just very weak.

The JWST spectra demonstrated carbon dioxide ice on Europa's surface. The CO_2 signal is substantially concentrated in Tara Regio, a large chaos region, just like the sodium chloride found by HST. The ratio of carbon isotope C^{12} to C^{13} was determined to be 83±19, similar to that of the "Earth inorganic standard" and to values obtained for Saturn's moon Iapetus and the asteroid Ryugu. This suggests that the CO_2 may have originated from carbonaceous material in the protosolar nebula, but it also could have accreted later from primitive organic matter in the solar system. The C^{12}/C^{13} ratio in biogenic sources on Earth is as high as 104, so a result of 83 would decrease the likelihood of an organic source on Europa, but the authors point out that other data is needed to answer the question of whether the surface CO_2 comes from biologic processes in a salty subsurface ocean.



Distribution of CO2 on Europa (from Villanueva *et. al*.)

In an accompanying paper[8] in the same issue of *Science*, Samantha Trumbo and Michael Brown (the famous Pluto-killer and Planet X searcher from Caltech) made an independent analysis of the same JWST spectral data. They conclude that the concentration of CO_2 in chaos terrain such as Tara Regio

[6] Trumbo, S, Brown, M, Hand, K, Sodium chloride on the surface of Europa, *Science Advances* 2019 https://www.science.org/doi/10.1126/sciadv.aaw7123.

[7] Villanueva, GL, *et. al*., Endogenous CO2 ice mixture on the surface of Europa and no detection of plume activity, *Science* 381:1305-1308 (2023) https://www.science.org/doi/10.1126/science.adg4270

[8] Trumbo, S, Brown, M, The distribution of CO_2 on Europa indicates an internal source of carbon, *Science* 381:1308-1311 (2023) https://www.science.org/doi/10.1126/science.adg4155

cannot be explained if the surface CO_2 comes from outside of Europa. They state,

> Our interpretation implies that carbon, a biologically essential element, is present in Europa's subsurface ocean and has reached the surface ice on a geologically recent timescale.

Neither Trumbo and Brown nor Villanueva *et. al*. assert that the CO_2 is necessarily of biologic origin.

How do we answer the open questions?

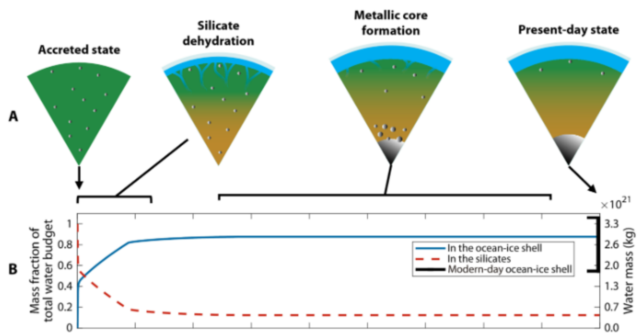
NASA's Europa Clipper mission is currently under construction for an anticipated October 2024 launch and insertion into orbit around Jupiter in 2030. The spacecraft will carry cameras, spectrographs, radar, a magnetometer, a dust analyzer and a mass spectrograph to analyze gases near Europa. During the four-year science mission, Europa Clipper will make nearly 50 flybys of the moon, some as close as 16 miles above its surface.

The European Space Agency's Jupiter Icy Moon Explorer (JUICE) is a mission to Ganymede that launched on April 14, 2023. It will include two flybys of Europa, which it will reach in July 2031. JUICE also has a suite of modern instruments to evaluate the Jovian habitable zone –the oceans, icy shells, compositions, surfaces, environments and activity of Ganymede, Europa and Callisto – as well as looking at Jupiter's atmosphere, magnetic environment, ring system and some of its other satellites.

Although there has been talk of a lander that could drill through the icy surface down to the subsurface ocean, a lander would have to carry its own analytical laboratory since a sample return mission would be impossible. A lander mission could not carry enough fuel to escape Jupiter's gravity well for the return to Earth. The success of the laboratories on the Mars Curiosity and Perseverance rovers sets a good example for Europa. Drilling anything more than a meter or two would also be unfeasible. One can't imagine a few kilometers of drilling pipe coming along on a Europa lander. Perhaps a lander with the capabilities of Mars Insight, which looked for seismic events and heat transfer, would yield valuable data. A robotic submarine that could dive under Europa's ice (if a hole could be found or made), called DEPTHX, was built and a prototype tested in a sinkhole in Mexico in 2007, but the device is not part of any current NASA planning.

Manned exploration of Europa is completely unfeasible. The length of the trip, even under the best circumstances, would be a decade, but there would not be enough fuel for a return to Earth. The ionizing radiation level at Europa's surface is equivalent to a daily dose of about 5.4 Sieverts (540 rem), an amount that would cause severe illness or death in human beings exposed for a single Earth day. The otherwise very good 2013 movie *Europa Report*, which chronicles a manned mission to search for life on Europa, minimizes the radiation threat to allow the plot to move.

The evolution of Europa's ocean



Formation history of Europa, extracted from Fig 3 of Trinh *et. al.*

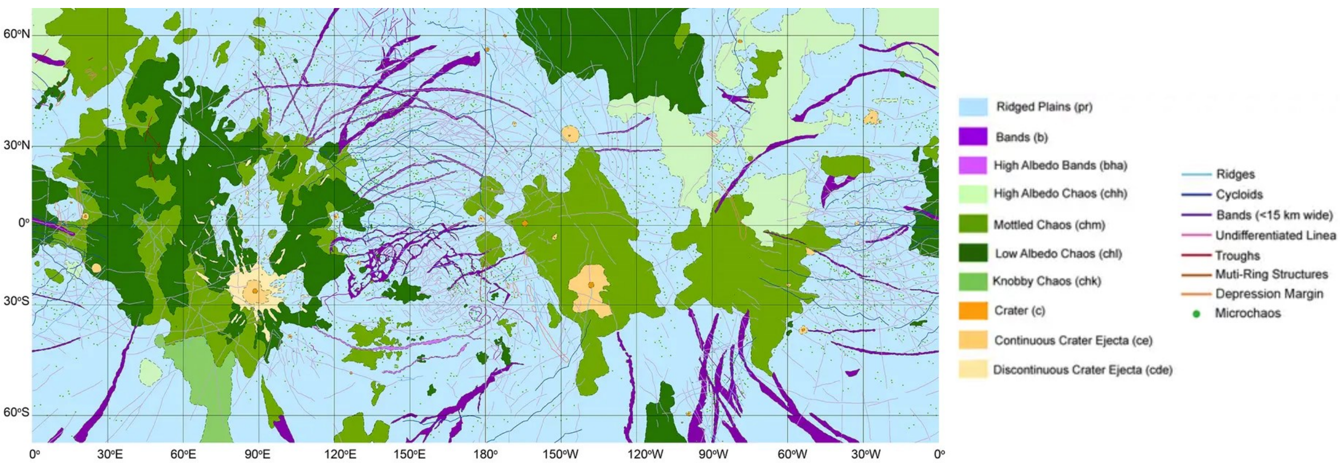
There is now enough information available, and enough understanding of solar system history, to propose a schema for the evolution of Europa from its formation in the protosolar nebula to the current day. A group from Arizona State University made such a proposal in a paper published in July.[9] Their findings are summarized in the paper's abstract:

> Europa's ocean lies atop an interior made of metal and silicates. On the basis of gravity data from the Galileo mission, many argued that Europa's interior, like Earth, is differentiated into a metallic core and a mantle composed of anhydrous silicates. Some studies further assumed that Europa differentiated while (or soon after) it accreted, also like Earth. However, Europa probably formed at much colder temperatures, meaning that Europa plausibly ended accretion as a mixture containing

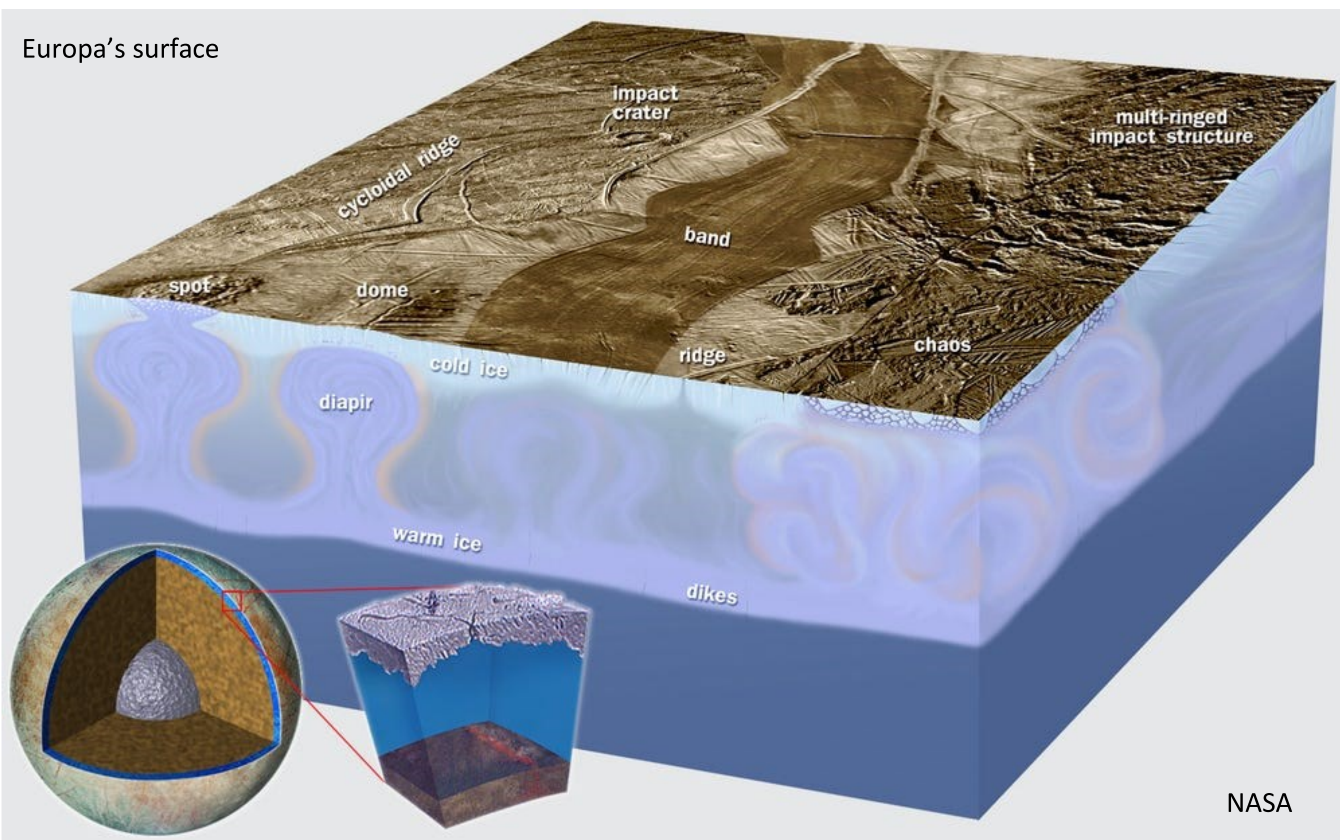
[9] Trinh, KT, Bierson, CJ, O'Rourke, JG, Slow evolution of Europa's interior: metamorphic ocean: origin, delayed metallic core formation, and limited seafloor volcanism, *Science Advances* 9:eadf3955 (2023) https://www.science.org/doi/10.1126/sciadv.adf3955.

water-ice and/or hydrated silicates. Here, we use numerical models to describe the thermal evolution of Europa's interior assuming low initial temperatures (~200 to 300 Kelvin). We find that silicate dehydration can produce Europa's current ocean and icy shell. Rocks below the seafloor may remain cool and hydrated today. Europa's metallic core, if it exists, may have formed billions of years after accretion. Ultimately, we expect the chemistry of Europa's ocean to reflect protracted heating of the interior.

If life evolved in Europa's ocean it might be very different from Earth's, even if it has the same chemical building blocks. Time will tell, but we probably won't know for sure for many decades. ■



Global geologic map of Europa, Mercator projection. NASA/Erin Leonard, Alex Patthoff, and Dave Senske, building on work by Ron Greeley, Thomas Doggett and Melissa Bunte. The large green area on the left side of the map is Tara Regio. (NASA)



Images by Members

The Cone Nebula and Christmas Tree Cluster (NGC 2264) by Arthur Miller

11-inch Celestron SCT, from Quail Creek, Arizona

The Pelican Nebula (IC 5070) by Steve Bellavia

October 13, 2023 from Surry, Virginia. Technical details at https://www.astrobin.com/ntb9am/C/

Two Vaonis Expera Images by Jordan Solomon

The Horsehead Nebula (B33) indenting IC 434.

The bright nebula just below the Horsehead is NGC 2023, and at the lower left edge is the southern end Of the Flame Nebula, NGC 2024. For more on the Horsehead, see the April 2023 SkyWAAtch, page 8.

The Rosette Nebula NGC 2237 in Monoceros

The nebula itself is Caldwell 49 in Sir Patrick Moore's catalog; the star cluster associated with the nebula is NGC 2244 and Caldwell 50. You can view the Caldwell catalog at https://is.gd/CaldWAA.

The Vaonis Vespera uses a Sony IMX 462 sensor, which has 1920x1080 pixels, giving a rectangular field of view of 1.6 x 0.9 degrees. The sensors 2.9 micron pixels give a resolution is 2.99 arcseconds per pixel. The Editor chose not to crop these two images to show the field of view that the telescope delivers.

Messier 33 by Manish Jadhav

Manish made this image from his home in Ossining on November 18th. He used an 8-inch RC telescope and Canon EOS RP mirrorless camera, 5x180 second + 20x60 second subs. Local streetlights impose a major challenge to image contrast and to background gradients in the already light-polluted Westchester environment. But one has to live (and image) in the real world.

The Triangulum Galaxy, M33, is the third-largest member of the Local Group, with a mass of 50 billion Suns, as compared to about 1.5±0.5 trillion M☉ for Messier 31 and 1.54±0.1 trillion M☉ for the Milky Way. It is 3.2 million light years distant from us. And, of course, the streetlights are a lot closer.

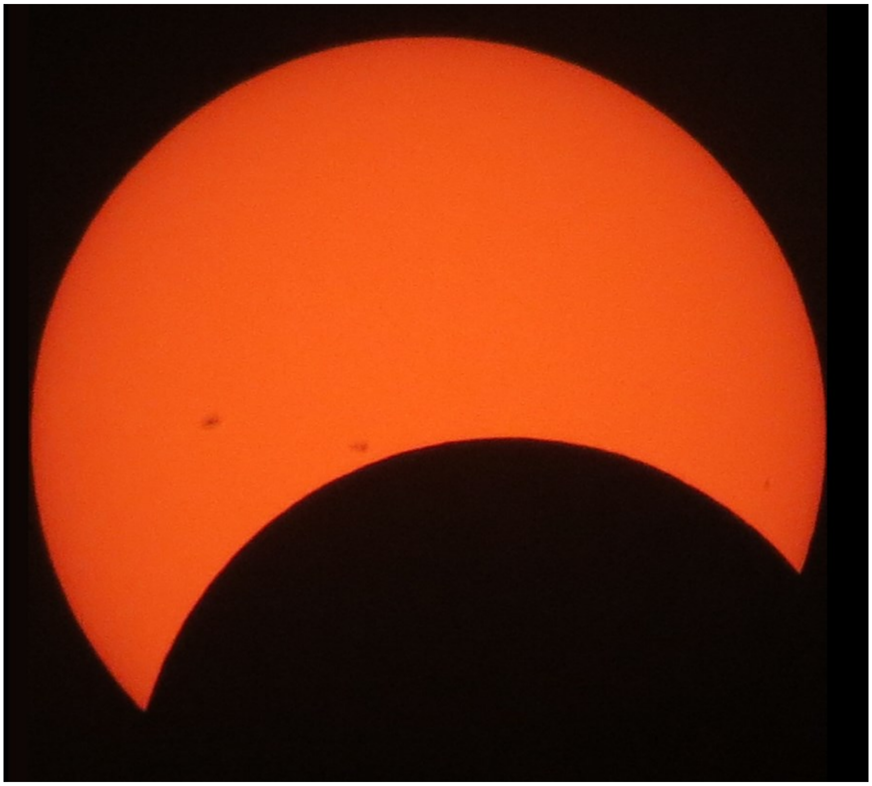
The Blue Snowball Nebula by Larry Faltz

The Blue Snowball (NGC 7662, Caldwell 22) is a 30 arcsecond-diameter, magnitude 8.3 planetary nebula 5,730 light years distant in Andromeda. It is located about 14 degrees west of the Andromeda galaxy M31. Even a small telescope will show its intensely blue color, emitted by doubly ionized oxygen (OIII) in the gaseous shell surrounding its central star, a subdwarf O star with a surface temperature of 100,000 Kelvin.

This image, highly cropped from the original, was made at Ward Pound Ridge in July with a 105-mm Stellarvue triplet refractor and ZWO ASI 533 MC Pro camera on a ZWO AM5 mount, processed with ASIStudio, Siril and Topaz DeNoise AI. The field of view is 8.07 x 7.84 arcminutes, as determined by astrometry.net.

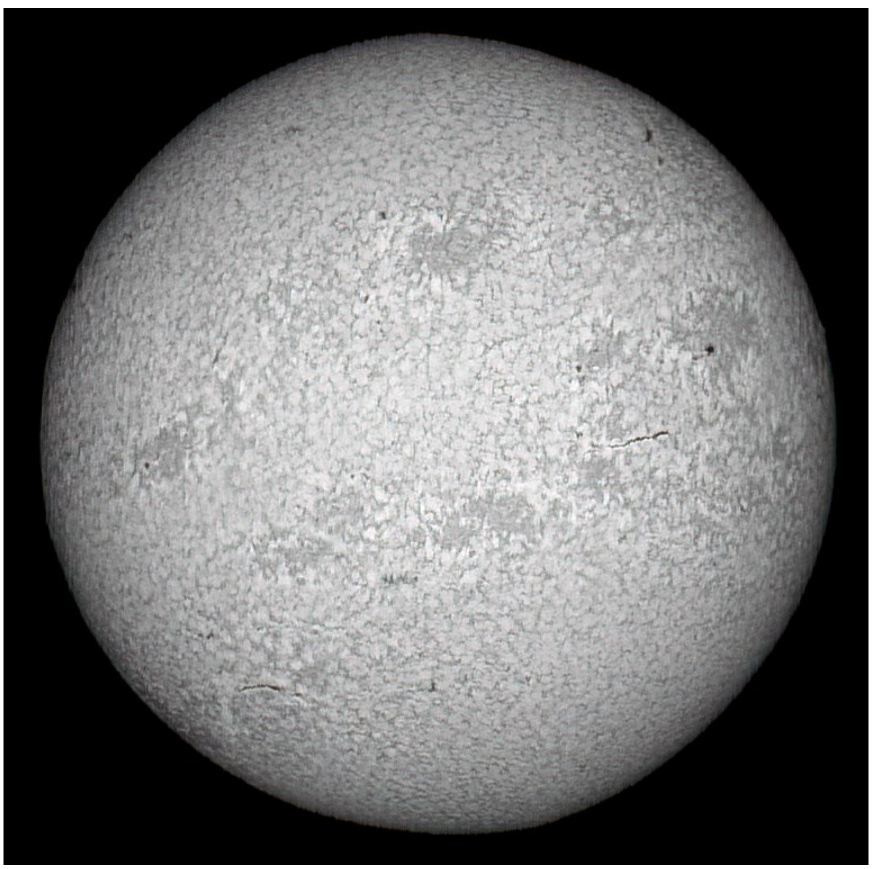
Hubble Space Telescope image of NGC 7662

Solar Images in October



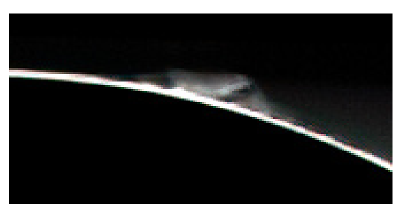
Jim Steck was in Wilmington, NC and managed to catch some breaks in the clouds to see the partial solar eclipse on October 14th.

The eclipse was annular on a path from Oregon to Texas and then through the Yucatan peninsula and on to South America. The weather in the western United States was excellent for the event. New York was clouded out for what would have been a 22.3% partial phase.



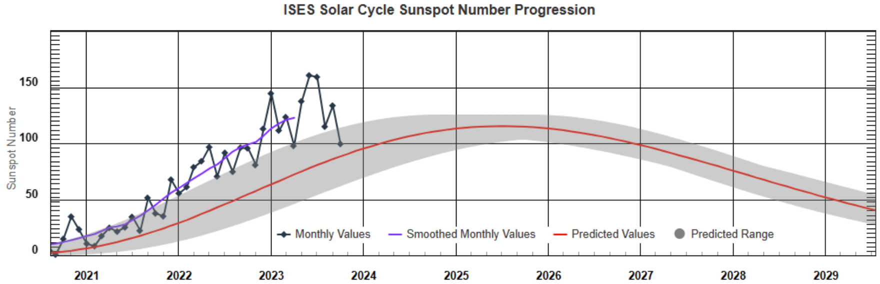
John Paladini again employed his spectroheliograph to make this image of the Sun on October 13^{th}. He imaged in the rarely visualized hydrogen gamma wavelength, in the blue end of the visible spectrum at 434.0472 nanometers.

He was able to capture prominences in this wavelength, as shown in a detail from a longer-exposure full-disk image.



Sunspots by Steve Bellavia

Sunspot numbers are ahead of predictions for Cycle 25, Steve imaged the busy Sun on Thanksgiving Day around 1:10 pm. 5-inch Celestron f/10 SCT and Canon EOS SL3, ISO 100, 1/320 second.



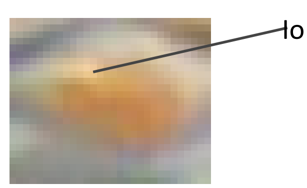
Here is the data on sunspot numbers per month for cycle 25, through October 2023. From the NOAA's Space Weather Prediction Center. The full interactive graph is at the bottom of the "enthusiasts' page, https://is.gd/SWPCSpots.

Three Images of Jupiter

Rick Bria made this image on November 4th with the 14” CDK at Mary Aloysia Hardey Observatory in Greenwich. The camera was a Skyris 132C with 1.2-megapixels. The shadow of Europa is seen just below the South Temperate Belt.

In Mahopac, **John Paladini** used his venerable 6-inch f/8 Criterion RV-6 reflector to catch Io about to disappear behind Jupiter on November 12th around 9:45 p.m. He used a 3.5X Barlow and 2-MP ASI290MC camera. John commented, “The RV-6 is some scope!” Owned by many amateurs in the decade before SCTs became popular, the RV-6 was entirely made in the USA. It cost $194.95 in 1959, the equivalent of at least $2,061.97 today. For more about the RV-6. See http://www.company7.com/library/criterion_rv6.html.

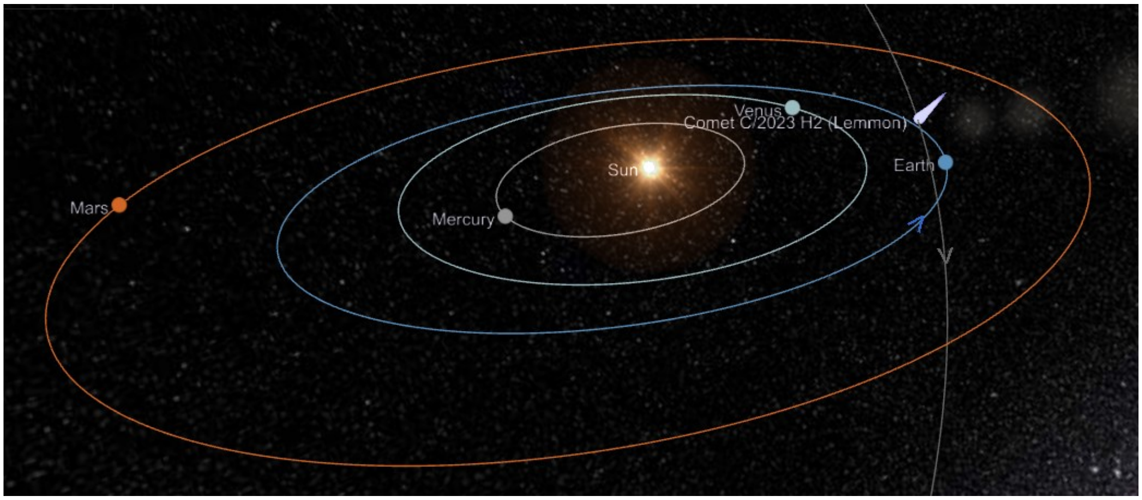
Larry Faltz was at the parking lot of the Quaker Ridge School on Weaver Street in Scarsdale to capture a shadow transit of Io at 1:30 a.m. on November 12th. CPC800, 3X Barlow and 0.38 MP Mallincam DS287 color camera. The tiny white dot on the northwest edge of the Red Spot is Io transiting 217,000 miles above Jupiter’s surface.



Comet C/2023 H2 (Lemmon) by Steve Bellavia

Steve was comet-hunting in November. Here's Comet C/2023 H2 (Lemmon), discovered at magnitude 20.7 on April 23rd by the comet survey telescope on Mt. Lemmon in Arizona. It had brightened to perhaps magnitude 6.5 when Steve made this image on November 9th around 6:45 p.m. Field 89.7' x 59.8'. Steve also made a video of the comet's movement over a ten minute period, which you can see at https://www.astrobin.com/rucrpk/.

The comet was near maximum magnitude when this image was made. It was 0.1956 astronomical units from Earth and about 0.92 AU from the Sun, but past perihelion and heading south. By December 1st it will have faded to less than magnitude 11 and will be too close to the horizon after sunset to be well seen from our latitude.



The position of Comet C/2023 H2 at the time Steve made his image. Diagram from TheSky Live.

Two November Periodic Comets by Steve Bellavia

Comet 62P/Tsuchinshan (November 12, 2023, 3:30 a.m.) Orbital period 6.18 years. Field 26.2’ x 17.5’.

Comet 103P/Hartley (November 12, 2023, 4:00 a.m.) Orbital period 6.48 years. Field 26.3’ x 17.5’.
Steve has imaged 53 comets since he began making astrophotographs.

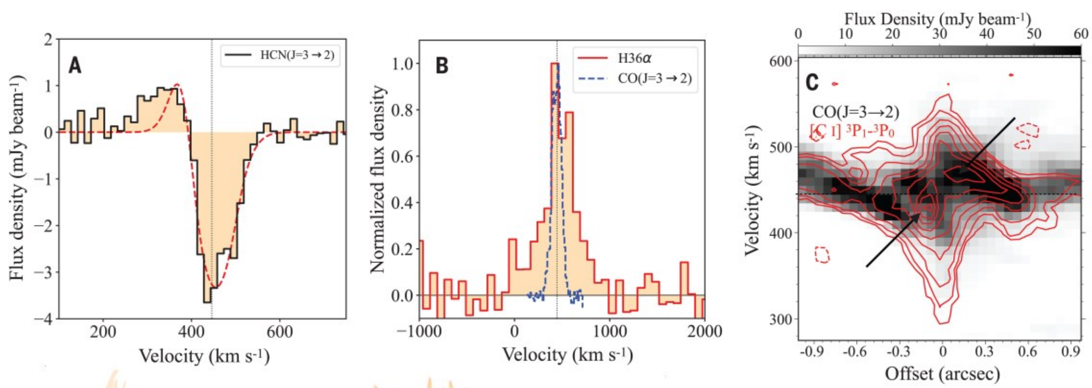
Research Highlight of the Month

Isumi, T, Wada, K, Imanishi, M, et. al, Supermassive black hole feeding and feedback observed on subparsec scales, *Science* 2023, 382: 554-559 (published November 3, 2023)

Abstract: Active galaxies contain a supermassive black hole at their center that grows by accreting matter from the surrounding galaxy. The accretion process in about the central 10 parsecs has not been directly resolved in previous observations because of the small apparent angular sizes involved. We observed the active nucleus of the Circinus Galaxy using submillimeter interferometry. A dense inflow of molecular gas was evident on subparsec scales. We calculated that less than 3% of this inflow is accreted by the black hole, with the rest being ejected by multiphase outflows, providing feedback to the host galaxy. Our observations also reveal a dense gas disk surrounding the inflow that is gravitationally unstable, which drives the accretion into about the central 1 parsec.

ESO 95-13, also called the “Circinus Galaxy,” is the closest Seyfert galaxy to the Milky Way. It is 4.2 parsecs (13.6 million light years) distant, in the southern constellation Circinus. Situated just south of Alpha Centauri and close to the plane of our galaxy, the magnitude 12.1 spiral is difficult to see among the Milky Way’s stars. It has a 2 million solar mass supermassive black hole (SMBH) surrounded by a gas disk that is heavily obscured by dust.

To assess the flows of material into and out of the region of the SMBH, the authors probed the core of the galaxy at high resolution with the Atacama Large Millimeter/submillimeter Array (ALMA), measuring spectral features from various atomic and molecular species. The authors identified dense molecular gas (as hydrocyanic acid, HCN and carbon monoxide, CO) flowing into the nucleus of the galaxy. They determined that in the innermost region, within a few parsecs of the SMBH, atomic gas forms a thick disk while denser molecular gas is confined to a thin disk. The inflow rate was estimated to be 0.20 to 0.34 M⊙ per year. They were also able to map the routes of inflow and outflow into the region of the nucleus, and proposed mechanisms for the atomic and molecular flows.



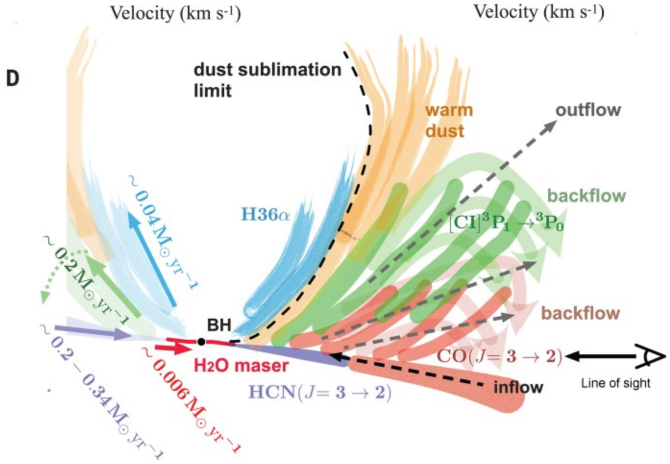


Fig. 3 from Isumi, et. al. showing (A) the HCN spectrum, (B) atomic hydrogen (H36α) and CO flow velocities, (C) molecular gas densities and (D) a cross section of the multiphase gas flows. The image of ESO 95-13 is not from the paper. It was made with a 1-meter telescope at OBSTech in Chile by Mike Selby; 29 hours of data were processed.

Member & Club Equipment for Sale

Item	Description	Asking price	Name/Email
NEW LISTING Celestron StarSense auto-alignment	Automatically aligns a Celestron computerized telescope to the night sky. Includes finder camera, hand control (substitutes for the original HC), two mounting brackets, cables. Works with any computer controlled Celestron scope that has a hand control. Like new condition, in original box. Image here. Celestron's description and FAQ are here..	$350	Manish Jadhav manish.jadhav@gmail.com
Orion 6-inch f/5 reflector on EQ mount	Little used, if at all. Solid EQ4-type non-go-to equatorial mount with an electric RA drive as well as slow-motion stalks. The setting circles are large and very readable, unlike most EQ mounts for scopes of this size. An image of the mount head is here. 9 and 25 mm Plössl eyepieces, polar alignment scope with reticle, Orion flashlight, finder, counterweights, gold-colored aluminum tripod (missing tripod tray, but you can make one easily enough). Good intro scope for a bright young person. A 6" f/5 OTA alone costs at least $300. Donated to WAA.	$150	WAA ads@westchesterastronomers.org
Celestron Cometron telescope	Small, lightweight 114 mm f/4 Newtonian wide-field reflector (not a Bird-Jones). Red dot finder, 25 mm eyepiece. Dovetail bar. A light travel scope or a wide-angle starter scope for a smart, interested child. Optical tube only, will fit on a camera tripod. Excellent condition. Donated to WAA.	$40	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
Tiltall photo/spotting scope tripod	TE Original Series solid aluminum tripod with 3-way head, center stalk. Very solid. 3-section legs. Height range 28.5"-74". Can carry up to 44 lbs. Folded length 29.6". Weighs 6 lbs. Carry bag. Image here. List $199.50. Donated to WAA.	$75	WAA ads@westchesterastronomers.org
RUBYLITH Screens	I have two 1/8" thick rubylith screens for placing over a laptop or tablet screen. Sizes are 14½x9" (for 17" diagonal 16:9 laptop) and 10½ x 7" for a tablet. Includes strong rubber retainers. I don't need them anymore. First come, first served.	Free	Larry Faltz lfaltzmd@gmail.com

Want to list something for sale in the next issue of the WAA newsletter? Send the description and asking price to waa-newsletter@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). Prices may be negotiable. Sales of WAA equipment are final. *Caveat emptor!*

年暮れぬ / 笠きて草鞋 / はきながら

Another year gone—
hat in my hand,
sandals on my feet.
— Matsuo Basho (1644-1694) (trans. Robert Hass)