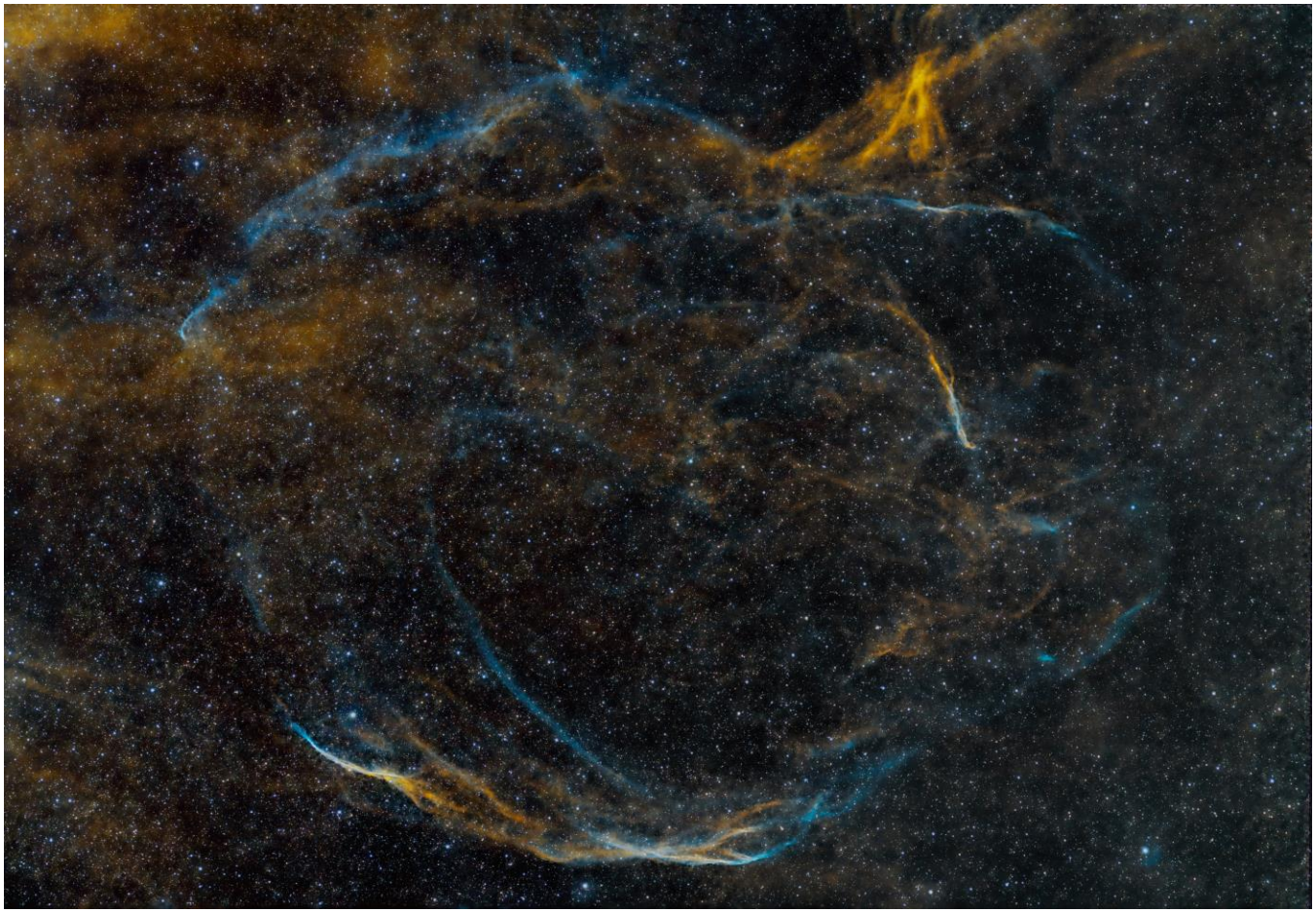
SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

2021 APEX® AWARDS FOR PUBLICATION EXCELLENCE 2022 APEX® AWARDS FOR PUBLICATION EXCELLENCE

October 2022



A Rarely Seen Supernova Remnant by Steve Bellavia

About 300 supernova these remnants are currently known in our galaxy, of which the two most commonly encountered by amateurs are the Crab Nebula in Taurus and the Veil Nebula in Cygnus.

G65.3+5.7 is an extremely faint supernova remnant, also in Cygnus. It contains the Pencil Nebula, Sh2-91 (near the bottom). Not recognized as a complete object until 1977, it's quite large, approximately 4 degrees x 3 degrees, similar in size to the nearby Cygnus loop (of which the Veil Nebula is the greatest part). It's estimated to be about 25,000 years old. Distance is 2,900 ± 300 light years.

This image was made over three nights at the Rockland Astronomy Club's new observing site in the Catskills. It's a total of 30 hours of exposure. Technical information at https://www.astrobin.com/cibuek/.

WAA October Meeting

Friday, October 14 at 7:30 pm

**David Pecker Conference Room
Willcox Hall, Pace University,
Pleasantville, NY, or on-line via Zoom**

A Synthesized View of Planetary Systems

Malena Rice, PhD
51 Pegasi b Fellow,
Massachusetts Institute of Technology

A tremendous diversity of exoplanets and proto-toplanetary disks has been discovered over the past three decades, offering an unprecedented lens into the range of formation pathways available for planetary systems. In parallel, studies of the solar system have revealed tantalizing, complementary constraints with exquisite detail. Dr. Rice will describe how, taken in conjunction, these two lines of evidence can be combined to advance our current understanding of planetary systems.

WAA lectures are now available on the WAA YouTube channel.

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 11 at 7:30 pm

**David Pecker Conference Room
Willcox Hall, Pace University,
Pleasantville, NY, or on-line via Zoom**

The McCarthy Observatory: A Refuge for Science

Bill Cloutier
McCarthy Observatory, New Milford, CT

Starway to Heaven

**Ward Pound Ridge Reservation,
Cross River, NY**

October 1 "International Observe the Moon Night"

October 22 (rain/cloud date October 29)

New Members

Kathy Dietz	Port Chester
Timmy Froessel	Brewster
Amy Garwood	Dobbs Ferry
Jennifer Kemper	Yorktown Heights
David Mullen	Yorktown Heights
David Perlow	Briarcliff Manor
Colin Rehm	Valhalla
Chris Stritmater	Peekskill

Renewing Members

Jorge and Priscilla Camino	Mt. Kisco
Jose E. Castillo	Pelham Manor
Rick Faery	Rye
Bob Kelly	Ardsley
Josh & Mary Ann Knight	Mohegan Lake
Joe Lisle	White Plains
Kevin Mathisson	Millwood
William Meurer	Greenwich
Siva and Ram Narayanan	Scarsdale
Hugh Osborn	New Rochelle
Olivier Prache	Pleasantville
Cliff Wattley	Danbury

Westchester
Amateur Astronomers

ALMANAC For October 2022

Bob Kelly, WAA VP for Field Events


Bob Kelly


1Q 10/2


Full 10/9

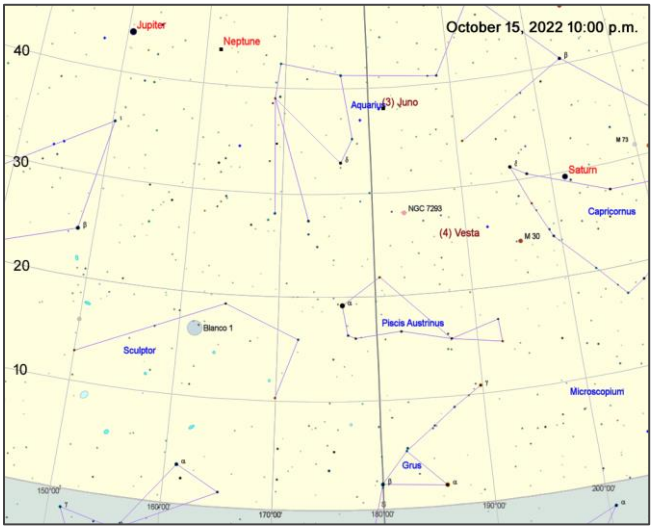

3Q 10/17


New 10/25

Evening Giants

Jupiter and **Saturn** are already out in the evening sky when the Sun sets. They are relatively easy to spot, since Jupiter, at magnitude -2.9, is brighter than any of the stars in the evening sky and Saturn, at +0.5, is only outranked by a few.

Jupiter's moons may still be visible in good binoculars leaned against something solid, like a tree or the side of a building. Saturn's ying-yang moon **Iapetus**, turns its bright side toward us this month as it swings east of Saturn. Brighter Titan joins it, about one-third as far out from Saturn, around October 19th. Observers at our September star party were happy to see that Saturn's rings are tilted open this year for easy viewing.

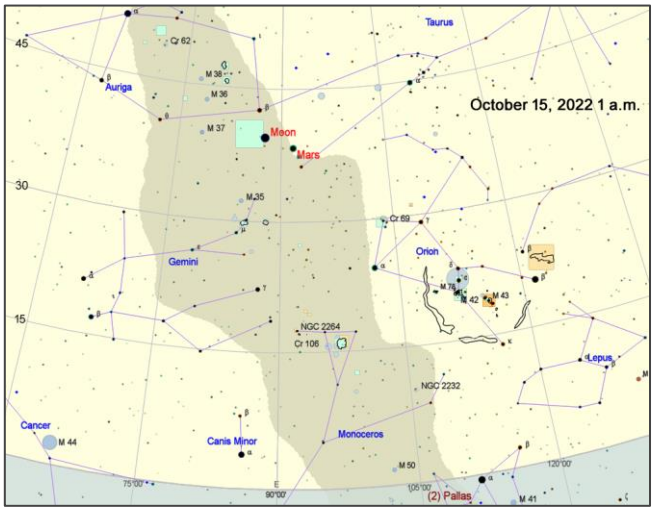


Between Jupiter and Saturn, the asteroids **3 Juno** and **4 Vesta** are past opposition, but still within reach of small telescopes at magnitude +8.4 and +6.4, respectively. Juno resides in Aquarius and Vesta is in Capricornus, not far from where we see Saturn. **Neptune** is nearby at magnitude +7.8.

Use the mostly full Moon to find **Uranus** a half degree north above the Moon on the 12th.

Mars Makes an Entrance

If you can stay out late enough after **Mars**-rise in the nine o'clock hour, the Red Planet is getting large enough for observers to see surface details, even in a small telescope. For the best views, Mars is still highest in the morning sky. We get closer to Mars about every two years, but those close encounters are farther away each time for the next decade, so catch Mars now for a better view. The Moon is near Mars (3.0 degrees apart) on the 14th. That's getting us ready for December's spectacular Mars Opposition Day, including Mars right next to a full Moon (and being occulted for observers venturing up the Hudson Valley), on December 7th. See map on next page.

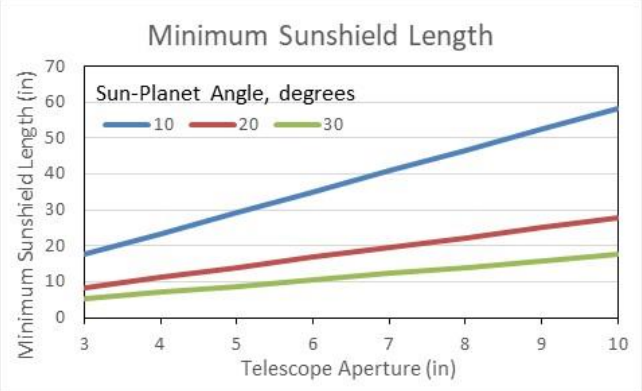


Mercury Low Down in the Morning

Mercury reaches greatest elongation – it's farthest apparent distance from the Sun -- on the 7th and 8th at 18 degrees above the horizon. It rises at the start of morning twilight on the 8th, the best time of the month to spot this elusive planet. It will get slightly brighter, but closer to the Sun, as the month goes on.

Mercury gets maybe too close for comfort and hides behind the Moon after sunrise on the 24th. The occultation begins at 10:28 a.m. and ends at 11:25 a.m. The Moon will be less than 1% illuminated. However, Mercury will be only 11 degrees ahead of the Sun. Trying to observe this event poses a serious danger of the Sun sneaking into the field of any telescope that can't stay ahead of the Sun by tracking its quarry. You must really know what you are doing and have had experience with daytime planetary observation to

attempt this observation. Some observers say Mercury may be easier to find then the very, very thin Moon. To keep sunlight from falling onto the front of your scope at all, you will need to fabricate a very long sunshade. A 3-inch scope would need at least a 15.8-inch extension. See the August 2021 SkyWAAtch, page 4, for more information.



Venus is Outta Sight

Venus begins its two-month residency behind the Sun, through late November. Venus reaches superior conjunction, where it is directly behind the Sun from our point of view, on the 22nd. It will be on the other side of the Sun from us through late November. Mercury joins Venus in the SOHO C3 camera field of view around the 27th. They depart together around November 22. Venus is fully lit as it passes on the far side of the Sun. Maximum brightness this round is -3.9 on October 19th. It remains this bright through the end of the year but is still too close to the Sun for viewing this month.

The Moon has Issues

For fans of the **Moon** photobombing the Sun, there is a partial solar eclipse on the 25th, but it's not visible from here.

Be ready for the November 8th total lunar eclipse visible from our area, with the totality beginning at 5:16 a.m. in our area. The Moon will set in the morning just before totality ends. The full eclipse is visible in the western US, Hawaii and Pacific island nations.

Meteors

The **Orionid meteor shower** peaks on the night of the 20th/21st. Some years, this show has had lots of meteors, but there's no indication of that happening this year. We'll have to settle for 10 or maybe 20 per hour. There may be a mini-peak on the 18th. Rates should be higher after midnight, when Orion, the shower's radiant, rises. A last-quarter Moon will also rise by 2 a.m. It's pretty, but it may add unwanted light to the sky. This is the same meteor chain we saw in May as the Eta Aquarids, since they are both fragments of Comet Halley.

Comets

Nothing bright for our area this month.

Visible Human Outposts in Space

The **International Space Station**, with a crew-swap scheduled for early October, peaks at magnitude -3.9. Overflights are visible in the evening through the 7th. Morning overflights can be seen starting on the 19th. Tiangong often peaks at magnitude -2. It's visible in the evening from the 6th through the 22st.

Preview: The December 7 Occultation of Mars by the Full Moon

At the September "Member's Night" meeting, Joe Rao showed detailed maps of the coming Occultation, when Mars and the Moon are both at opposition. In our area (at Ward Pound Ridge), the closest approach of Mars to the Moon's limb will be about 43 arcseconds at 11:03 p.m. EST. North of Albany the Moon will fully occult the planet. Along a line about 20 miles wide, the occultation will be "grazing" and the planet may peek in and out of lunar valleys along the Moon's edge. The line crosses the Hudson River around the town of Rhinebeck, NY. We'll get a better map for the next issue of SkyWAAtch.

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

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Editor: Larry Faltz
Assistant Editor: Scott Levine
Almanac Editor: Bob Kelly
Editor Emeritus: Tom Boustead

Two WAA September Outreach Events

WAA at the Children's Museum, September 10

The Children's Museum at Rye Playland held an astronomy-themed, day-long event, "Out of This World: A day to explore space." The event was in partnership with NASA to showcase the initial James Webb Telescope images. The museum asked WAA to bring some telescopes for solar observing. Mike Lomsky set up a hydrogen-alpha scope and Bob Kelly showed a white-light image using a Baader filter on his 8-inch Dob.

The museum often has science-themed events on Saturdays.

Pound Ridge Family Camp-Out, September 17

Jordan Webber writes:

I had my 8" manual Dob, another pair of Newtonians (8" and 10") riding on the Atlas Pro, and a 102-mm Mak. Dave Butler had his 8-inch Meade SCT, and Mike Lomsky brought his 6" refractor. Lydia Maria provided excellent mythological stories. My cousin Timmy Froessel came along to help. He had a great time learning to use the Dobsonian and to help me keep the planets centered in the other scopes.

Saturn and Jupiter were the main targets for the evening, but the Ring Nebula and Hercules Cluster were shown to a few folks. Sky conditions were better than I had expected, but bright streetlights near the field limited dark adaptation. Views of the planets were excellent, eliciting plenty of "wows" from both children and adults.

Many people expressed interest in coming to star parties in the future.

Thanks again Lydia, Dave, Mike, and Timmy for helping to make last night a success.

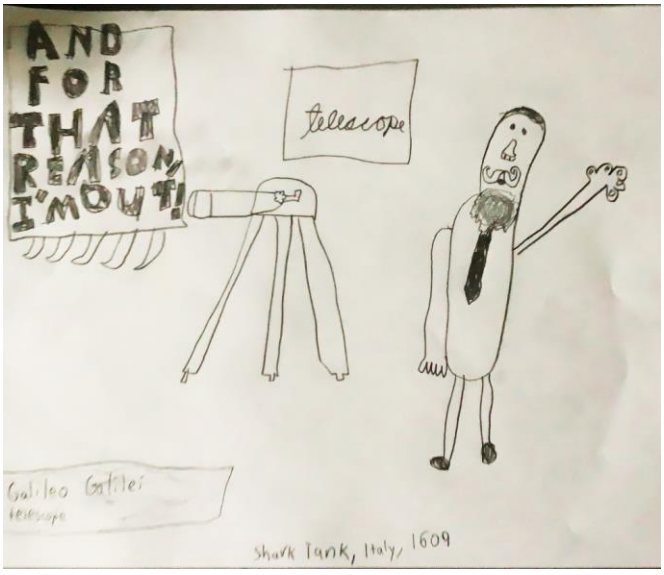
Celestial Navigation in Shackleton's *Endurance* Expedition

The 1914-1917 Imperial Trans-Antarctic Expedition led by Ernest Shackleton may be the greatest example of perseverance and heroism in the face of adversity in the history of exploration. One of the least known aspects of this story is the challenge of determining position, for which sightings of the Sun, Moon and stars play a critical role. WAA's **Robin Stuart** has long had an interest in celestial navigation. In August he gave a webinar for Britain's Royal Institute of Navigation, using the expedition's actual log entries in his analysis. The analysis helped a 2022 expedition discover the exact site of the wreck of the *Endurance,* which was crushed in the ice and sank in 1915. The webinar is available at https://www.youtube.com/watch?v=y3sMS5p8Pgk.

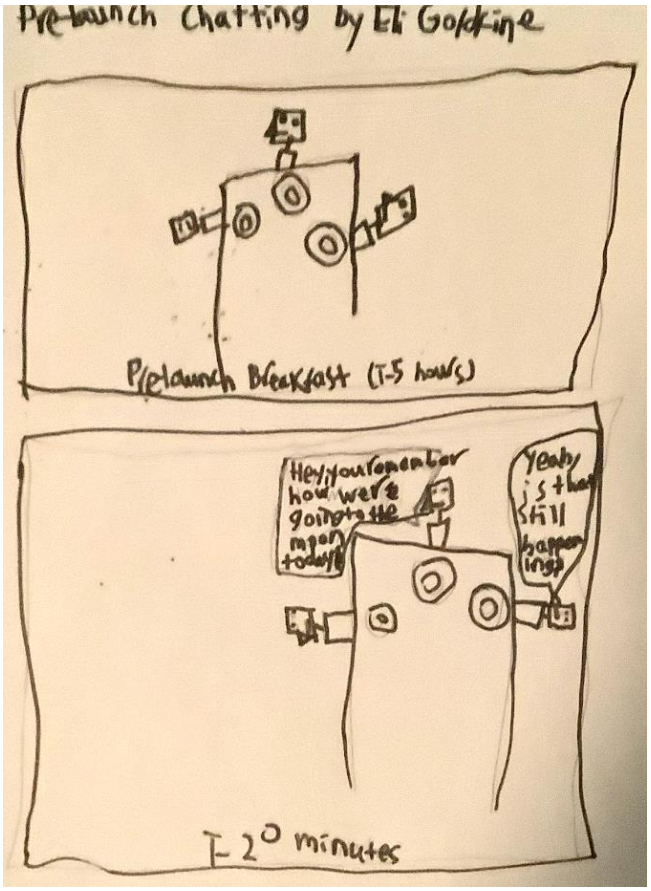
The Unfortunate Return of My Astronomically Bad Cartoons by Eli Goldfine

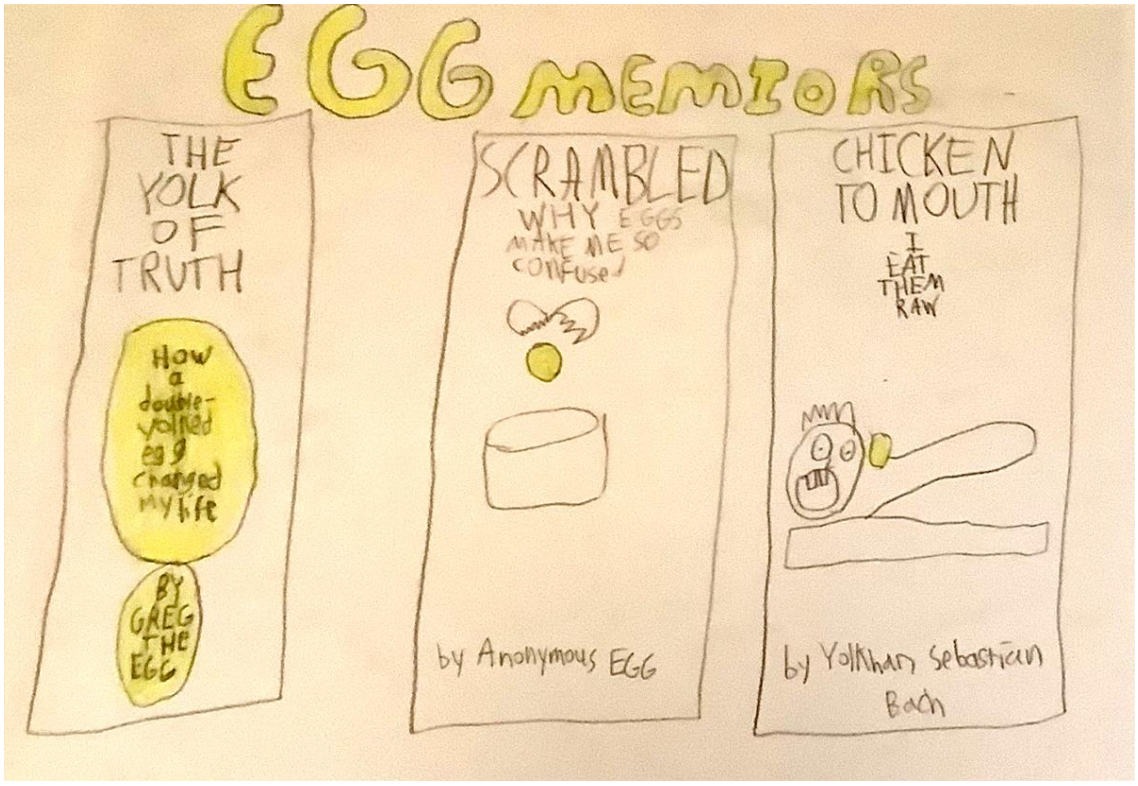
At the September Members' Night meeting, our precocious, inventive and droll young member Eli presented some of his cartoons (not all related to astronomy), and some of astronomy-themed cartoons by others that inspire him. Here are three of his recent musings.

His full presentation is at https://bit.ly/3LFqcfK.



Galileo at Shark Tank, Italy, 1609





Another Movie Telescope

We're in a lookout station high in the Andes in Howard Hawk's 1939 romantic drama *Only Angels Have Wings*, starring Cary Grant and Jean Arthur. Grant manages an air freight company needing to transport mail across a high mountain pass from the fictional seaport of Barranca. The dangerous pass is monitored from a small observing station that can only be contacted by radio. In the background of this scene is a small refractor, but it's never used in the film.

Grant plays the hard-bitten but ethical manager of the airline. Arthur plays an entertainer who comes into town by boat on her way back to the U.S. and decides to stay. The mail has to be delivered in terrible, dangerous weather in order to fulfill a contract and stave off bankruptcy. There are some plot complications in the form a fatal plane crash and a new pilot with a bad reputation who happens to be married to Grant's ex-girlfriend (Rita Hayworth in her first major film role).

Hawks' previous film with Cary Grant was the hysterically funny screwball comedy *Bringing Up Baby*, one of our favorites. These two films show the tremendous range of both Hawks and Grant. Some consider *Only Angels Have Wings* Hawks' finest film, among a wide range of great movies including westerns (*Red River*, *The Big Sky*, *Rio Bravo*, *El Dorado)*, dramas and crime films (*Scarface*, *To Have and Have Not*, *The Big Sleep*, *Sergeant York*, *Land of the Pharaohs*), musicals (*Gentlemen Prefer Blondes*, *A Song is Born*) and more great comedies (*Twentieth Century*, *His Girl Friday*, *Ball of Fire*, *I Was a Male War Bride*).

With a life-long passion for aviation, Hawks named his daughter Kitty. Kitty Hawks, get it?

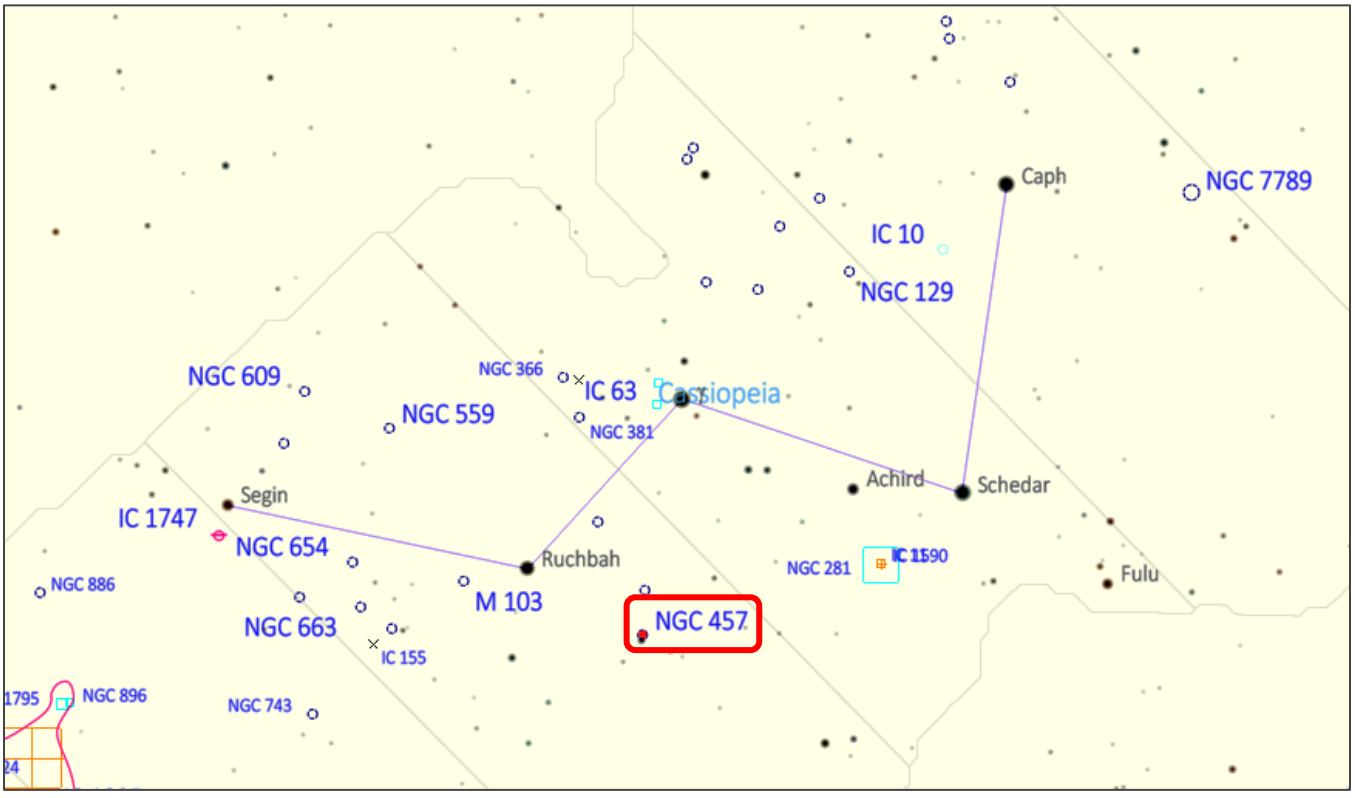
Deep Sky Object of the Month: NGC 457

NGC 457	
Constellation	Cassiopeia
Object type	Open Cluster
Right Ascension J2000	01h 19m 32.7s
Declination J2000	+58° 17’ 27”
Magnitude	6.4
Size	13 arcminutes
Distance	7500 LY
Discovery	W. Herschel, 1787
Caldwell Catalogue	C13
Other names	Owl Cluster Dragonfly Cluster ET Cluster

Cassiopeia is in an area of the Milky Way rife with open clusters (and for imagers, emission nebulas). Perhaps the most prominent is NGC 457. It’s a great showpiece at star parties, its stellar distribution provoking a variety of concrete images. It was first called the “ET Cluster” in 1987 by Lorenzin and Schecler in an observing handbook. Among other names are the Owl, Dragonfly, Airplane, Stick Man, Kachina Doll, Worry Doll cluster and the Phi Cas Cluster.

Visibility for NGC 457			
10:00 p.m. EDT	10/1/22	10/15/22	10/31/22
Altitude	52° 39’	59° 47’	57° 10’
Azimuth	44° 18’	42° 05’	33° 38’

ET’s “eyes,” are Phi Cassiopeiae, a mag-4.95 star of stellar class F0, and HD 7902, a mag-6.99 B5 star. There is debate as to whether they are actual cluster members; the most recent paper we’ve seen suggests they are (Negueruela, I, High mass stars in Milky Way clusters, https://arxiv.org/pdf/1803.07986.pdf).

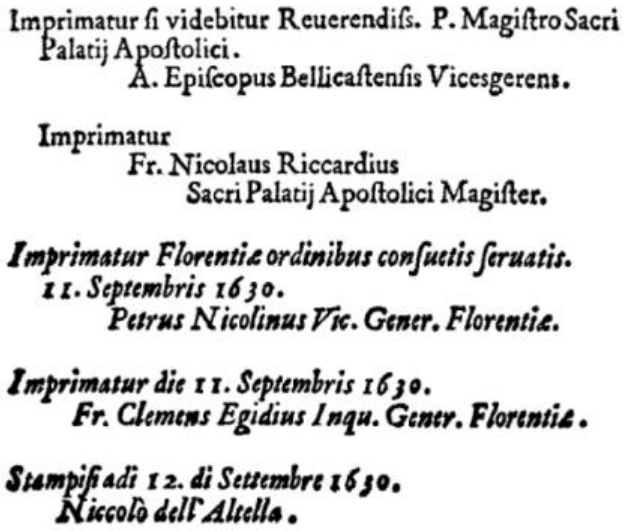


In the Footsteps of Galileo, Part Four: Dénouement — Larry Faltz

As I related in the September 2022 Sky*WAA*tch, the powers that be in the Vatican and the Roman College greeted Galileo's *Dialogo sopra i due massimi sistemi del mondo* (Dialogue Concerning the Two Chief World Systems) with frowns, scowls and outright rage. Egged on by conservatives among the Jesuits and worrying about his own precarious political situation, Pope Urban VIII, once Galileo's friend Maffeo Barberini, could not accept the obvious promotion of Copernicanism by Galileo's alter ego Salviati and its ineffective rebuttal by Simplicio, especially when the pope had explicitly directed Galileo to present a balanced view and provide "medicine" by forcefuly concluding that only God could actually know the structure of the universe. While those words are in the *Dialogo*, they were given to Simplicio, whose intellect and objectivity had been bashed throughout the work. Urban may have even thought Simplicio was a caricature of him, although more likely it was Galileo's composite of the Jesuits Orazio Grassi and Johann Scheiner, with whom Galileo had sparred in print over comets and sunspots, respectively.

In August 1632, Urban appointed a three-member committee to review the *Dialogo* to determine whether it should be referred to the Inquisition. The panel consisted of the Dominican Niccolò Ricciardi, the chief censor of Rome and the man who had ostensibly cleared the *Dialogo* for publication even though he had not seen the final draft, theologian Agostino Oreggi, Urban's theological advisor, and the Jesuit Melchior Inchofer. Inchofer was relatively new to Rome. He was a Hungarian Lutheran who converted to Catholicism and then joined the Jesuits. Sent to Messina in Sicily, he developed some peculiar ideas about a local legend of uncertain provenance that held that the Virgin Mary had written a letter to the people of Messina instructing them in the true faith. The Spanish Inquisition, which was powerful in Palermo, became concerned that there were elements of heresy in this legend. Inchofer managed to extricate himself and went to Rome. The matter was suppressed, and he became a friend of the powerful Ricciardi, who, because of his size and influence was known as "Father Monster."

Inchofer was a rabid anti-Copernican and a sympathizer of Scheiner. He was assigned the job of reviewing an anonymous accusation, based on Salviati's proposals regarding matter in *Il Saggiatore,* that Galileo was an atomist and thus by extension a denier of transubstantiation in the Eucharist, a true heresy. This accusation, possibly from Scheiner, had once been floated and dismissed, but was now in play again. An unsigned document in the files of the Congregation of the Index, clearly in Inchofer's hand, reports the accusation.



Imprimatur ſi videbitur Reuerendiſs. P. Magiſtro Sacri Palatij Apoſtolici.
A. Epiſcopus Bellicaſtenſis Vicesgerens.

Imprimatur
Fr. Nicolaus Riccardius
Sacri Palatij Apoſtolici Magiſter.

Imprimatur Florentiæ ordinibus conſuetis ſeruatis.
11. Septembris 1630.
Petrus Nicolinus Vic. Gener. Florentiæ.

Imprimatur die 11. Septembris 1630.
Fr. Clemens Egidius Inqu. Gener. Florentiæ.

Stampiſi adì 12. di Settembre 1630.
Niccolò dell' Altella.

The imprimaturs in the *Dialogo.* These are printed on the back of the title page.

Recall that the *Dialogo* was published in Florence because Galileo didn't want to come to Rome because of a plague. Rather than sticking to the original plan, that Ricciardi would review the printed sheets as they came off the press in Rome, Ricciardi, perhaps initially well-disposed to Galileo, accepted the change in venue and transferred to the Florentine inquisitor the responsibility to see that the work did not violate the church's position on Copernicanism. The inquisitor, Egidi di Montefalco, must not have been attuned to the requirements for the "medicine." The committee concluded that Galileo had misused the Roman imprimatur (explicitly using Ricciardi's name: see the image above) and put "the medicine of the end in the mouth of a fool." Galileo was further accused of declaring that he understood geometry as well as God did and insulting authors "most used by the Holy Church" (probably meaning Scheiner). He was explicitly charged with defending the motion of the Earth

through his theory of the tides (which of course he did, even though he was wrong about them).

The panel gave its report in September 1632. It exonerated Ricciardi from any responsibility, even though he was supposed to have had the final word on the text and presumably his own neck was on the line.

Urban VIII's "cardinal nephew," Cardinal Francesco Barberini, Vatican Secretary of State and Galileo's fellow Lynx, was instructed to tell Galileo to come to Rome and meet with the Holy Office in October 1632. Galileo, claiming age (he was 68) and infirmity (he was frequently ill with a variety of subacute ailments, and the plague was still around) asked that he be interrogated in Florence.

Urban believed that when he was a cardinal he had helped keep Galileo's name out of the Inquisition's condemnation of Copernicus in 1616. He came to believe that Galileo had paid him back in an ungrateful way. Galileo was examined by three physicians in October 1633 and found to have a "general debilitation of the vital faculty." Francesco Niccolini, the Florentine ambassador to Rome, argued on Galileo's behalf. The Holy Office didn't care and planned to send an Inquisitor to Florence. Galileo relented. He left for Rome on January 20, 1633, stopping for a few weeks in Siena to quarantine. He arrived in Rome on February 14 and stayed with Niccolini. Although he started lobbying church officials, he was told to desist from socializing and so he waited in Niccolini's home. On February 26, Niccolini was informed by Urban, with the cardinal nephew present, that the main problem appeared to be a violation of the personal injunction that Galileo had received from Pope Paul V, through Bellarmine, in 1616. On March 13, in a meeting with Niccolini, Urban seemed angrier than ever, and said "God is omnipotent and can do anything: but if He is omnipotent, why do we want to bind him?" When Niccolini replied that this was Galileo's opinion too, Urban lost his temper. Niccolini wrote to a friend, "I do not like His Holiness's attitude, which is not at all mollified."

Urban again asked the panel of three (Oreggi and Imhofer, with theologian Zaccaria Pasqualigo replacing Ricciardi) to consider whether Galileo had violated the injunction of 1616, "not to hold, teach or defend Copernicanism in any way whatever, orally or in writing." They all agreed that he taught and defended it in the *Dialogo*; whether he "held" it was less certain. Inchofer, however, was adamant, writing that Galileo was "vehemently suspected of firmly adhering to the opinion, and indeed that he holds it." He cited 27 passages in the *Dialogo*, particularly those that impugned the opinions of other Jesuits, whom he described as being treated "despicably." Inchofer was clearly an attack dog for Scheiner and Grassi. Christoph Grienberger, Clavius's successor as professor of mathematics at the Roman College, wrote that had Galileo known how to "keep on friendly terms with the fathers of the College, he would be enjoying fame in the world, he would not have had any misfortunes, and he would be able to write freely about anything, even the motion of the earth." But Galileo had never suffered fools gladly, and he thought quite few of these people were fools.

L: Santa Maria sopra Minerva as seen from the front door (as far as we could get in). R: Bernini's statue with the Pantheon behind.

The Inquisition interviewed Galileo for the first time on April 12, 1633. During the interrogation he stayed for 2½ weeks in the Inquisition's offices at the convent of the church of Santa Maria sopra Minerva, one of the major Dominican churches. It is located just behind the Pantheon, not far from the Piazza Navona to the west and the Roman College to the east. It was built over the ruins of a Roman temple to the Egyptian goddess Isis that had been misattributed to Minerva (the Greek Athena), thus the name. The Egyptian connection is commemorated in a peculiar monument in the square in front of the church, the *Pulcino della Minerva*, a statue of an elephant with a small Egyptian obelisk on its back. The obelisk, probably from the first century AD, was discovered during excavations around the church in 1655. The statue was designed by Bernini and executed by one of his students in 1667. On the base is a Latin inscription which reads ""Let any beholder of the carved images

of the wisdom of Egypt on the obelisk carried by the elephant, the strongest of beasts, realize that it takes a robust mind to carry solid wisdom." One wonders whether this is a slight knock on the activities of the Inquisition three decades earlier.

The church has been closed for several years for renovations (we tried to visit in 2019 as well but were turned away). There are plaques on the façade showing the height of several floods. The Tiber overflowed its banks periodically until flood control was implemented in the 1800s. This area, known as the Campus Martius, had been the most populous neighborhood of ancient Rome, in spite of the floods.

Galileo was interrogated by the Inquisition a total of five times between April 12 and June 21. During the first interrogation, Vincenzo Maculano, the Dominican Commissary General, probed the accusations that Galileo had violated the 1616 injunction and had obtained the Roman imprimatur by deception. Galileo had the letter he received in 1616 from Bellarmine which stated that Galileo had not been required to abjure or to do penance. When questioned by Maculano, Galileo first claimed he didn't recall receiving a copy of the papal injunction, didn't really know any details and said he relied upon Bellarmine's letter, which was much less restrictive. In addition, Galileo claimed that he had not actually defended the Copernican doctrine and that the *Dialogo* showed that "Copernicus' reasons are invalid and inconclusive," which anyone reading the text would have a tough time believing.

Had there been any true due process, Galileo or his supporters might have pointed out that Copernicanism had never actually been officially declared a "heresy." The Holy Office had determined that a moving Earth was "formally heretical because [it was] contrary to scripture" on February 24, 1616 but its public announcement placing *De Revolutionibus* on the Index had only declared it "false and altogether opposed to the Holy Scripture," not mentioning the word "heresy." The proper process for declaring something officially heretical had not been followed. The church had all sorts of fine levels of transgressions of various intensities, of which heresy was the most extreme. To be convicted of being "vehemently suspected of heresy" was not the same thing as being convicted of "heresy," which might have brought Galileo permanent imprisonment or even execution. It was only 33 years earlier that Giordano Bruno had been burnt at the stake in the Campo de' Fiori, just 500 meters to the southwest of Santa Maria sopra Minerva. Galileo knew, however, that splitting heretical hairs wouldn't work. In addition, Galileo finally let out that he knew about the injunction, whether it contained the word "heresy" or not, and that was enough.

On April 30, Galileo confessed. He said he re-read the *Dialogo* and now realized he had overstated the case for Copernicanism. "My error then was, and I confess it, one of vain ambition, pure ignorance and inadvertence." Trying to escape a potentially calamitous outcome, he had the *chutzpah* to offer to write another couple of days of the *Dialogo* in which things would get sorted out and the "medicine" made to work. The inquisitors weren't interested. He groveled again in early May, explaining again that his transgression was due to "vain ambition, a fault but not a deceit." He appealed for clemency, citing "my advanced age and pitiable state of health," and he cited as exacerbating factors his infirmity and "the constant slanders of those who hate me."

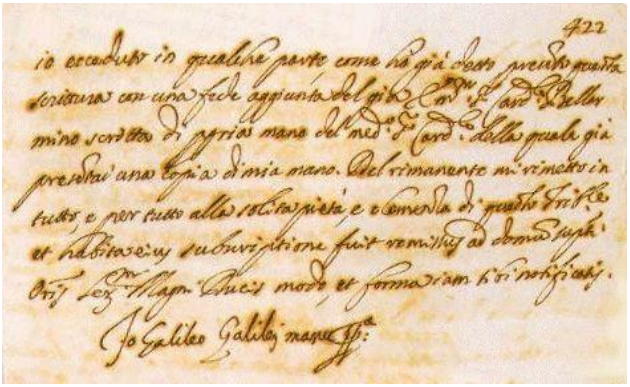
The Supreme Sacred Congregation of the Roman and Universal Inquisition rendered its judgment at the end of May. In their report to Urban, they cited not only the *Dialogo*, but the *Letter to Christina*[1] and the *Letters on Sunspots*, as well as a summary of accusations by Tommaso Caccini, a Florentine Dominican preacher who had denounced Galileo to the Inquisition as early as 1611. These bits of evidence were combined to suggest that Galileo's transgressions were of long standing, not just something that was manifest in the *Dialogo*. Urban ordered another interrogation. On June 21, the final grilling took place. Galileo stated that he "does not hold the Copernican opinion and [I] have not held it after being ordered by injunction to abandon it." The claim was not

[1] Written in 1615 and circulated in manuscript, it is an analysis of how Copernicanism is consistent with Scripture. It is in the form of an 80-page letter to the Grand Duchess Christina of Tuscany, a follow up to a discussion Galileo's former student Benedetto Castelli had with the Duchess, at her instigation, in 1613. Typical of Galileo's sharp pen and arrogant attitude, the tone is hostile and personally deprecating to many church officials, particularly Jesuits.

believable. The next day, the sentence was passed by seven of the ten inquisitors:[2] Galileo was "vehemently suspected of heresy, namely of having held and believed a doctrine that is false and contrary to the divine and Holy Scripture." Galileo would have to renounce his transgressions "with a sincere heart and unfeigned faith." But that wasn't enough. He would be imprisoned and have to recite the seven penitential psalms once a week for three years. And of course the *Dialogo* would be banned, as would any future works.

Galileo had no choice. On June 22, 1633, he knelt before the inquisitors and twenty witnesses, and read a statement prepared for him:

> I, Galileo, son of the late Vincenzo Galilei, Florentine, aged seventy years, arraigned personally before this tribunal, and kneeling before you, Most Eminent and Reverend Lord Cardinals, Inquisitors-General against heretical depravity throughout the entire Christian commonwealth, having before my eyes and touching with my hands, the Holy Gospels, swear that I have always believed, do believe, and by God's help will in the future believe, all that is held, preached, and taught by the Holy Catholic and Apostolic Church. But whereas -- after an injunction had been judicially intimated to me by this Holy Office, to the effect that I must altogether abandon the false opinion that the Sun is the center of the world and immovable, and that the Earth is not the center of the world, and moves, and that I must not hold, defend, or teach in any way whatsoever, verbally or in writing, the said false doctrine, and after it had been notified to me that the said doctrine was contrary to Holy Scripture -- I wrote and printed a book in which I discuss this new doctrine already condemned, and adduce arguments of great cogency in its favor, without presenting any solution of these, and for this reason I have been pronounced by the Holy Office to be vehemently suspected of heresy, that is to say, of having held and believed that the Sun is the center of the world and immovable, and that the Earth is not the center and moves:
>
> Therefore, desiring to remove from the minds of your Eminences, and of all faithful Christians, this vehement suspicion, justly conceived against me, with sincere heart and unfeigned faith I abjure, curse, and detest the aforesaid errors and heresies, and generally every other error, heresy, and sect whatsoever contrary to the said Holy Church, and I swear that in the future I will never again say or assert, verbally or in writing, anything that might furnish occasion for a similar suspicion regarding me; but that should I know any heretic, or person suspected of heresy, I will denounce him to this Holy Office, or to the Inquisitor or Ordinary of the place where I may be. Further, I swear and promise to fulfill and observe in their integrity all penances that have been, or that shall be, imposed upon me by this Holy Office. And, in the event of my contravening, (which God forbid) any of these my promises and oaths, I submit myself to all the pains and penalties imposed and promulgated in the sacred canons and other constitutions, general and particular, against such delinquents. So help me God, and these His Holy Gospels, which I touch with my hands.
>
> I, the said Galileo Galilei, have abjured, sworn, promised, and bound myself as above; and in witness of the truth thereof I have with my own hand subscribed the present document of my abjuration, and recited it word for word at Rome, in the Convent of Minerva, this twenty-second day of June, 1633.
>
> I, Galileo Galilei, have abjured as above with my own hand.



Last page of Galileo's signed confession

He was able to escape two accusations, that he was "not a good Catholic" and that he had "consciously deceived others." He did not mutter "Eppure si muove." He was too crushed, and in any case smart enough not to show any sign of disrespect with more than two dozen hostile pairs of eyes staring at him, looking for any excuse to be even harsher. The famous muttering first appeared in print the mid-18th century and in a painting attributed to Bartolomé Esteban Murillo that now appears to be a forgery. But undoubtedly he thought it.

[2] It is a bit of a mystery to this day why three did not sign it. One, the cardinal nephew Francesco Barberini, was absent; of the other two, Guido Bentovoglio had been a student of Galileo's and thus perhaps favorably inclined to the Florentine, while the motivation for the third, Antonio Barberini, is unknown.

After the trial, Galileo returned to Niccolini's residence. On June 30 he received permission to go to the palace of the archbishop of Siena, where he stayed for six months. There he began to work on a new book on mechanics, which he called the "Dialogues on motion." At the end of the year he returned to his house in Arcetri.

Milton Visiting Galileo when a Prisoner of the Inquisition
Solomon Alexander Hart (1806–1881)
Wellcome Collection (London)

The terms of his sentence put Galileo under house arrest on his estate rather than in a dungeon. He was not allowed to travel to Florence, merely a mile away. In a letter to Elia Diodati in 1634, written the day before his daughter Maria Celeste died, he wrote that "a deputy of the Inquisitor [came] to tell me of an order from the Holy Office in Rome that I must stop asking for permission to return to Florence or they will make me return to a real prison of the Inquisition." Galileo was allowed, however, to receive visitors and apparently there was a fairly lively traffic of acolytes and students to the estate, although the Inquisition tried to restrict callers to Catholics from Catholic countries. They insisted that Copernicanism not be discussed. Some students stayed with him for extended periods (Toricelli for three months, Viviani for three years). In August 1638 the now-blind Galileo was permitted a visit from the not-yet-blind poet John Milton. In *Paradise Lost*, Milton describes Satan with a reference to Galileo (the *Tuscan Artist*) and his finding that the Moon had a rough surface:

> He scarce had ceas't when the superiour Fiend
> Was moving toward the shoar; his ponderous shield
> Ethereal temper, massy, large and round,
> Behind him cast; the broad circumference
> Hung on his shoulders like the Moon, whose Orb
> Through Optic Glass the Tuscan Artist views
> At Ev'ning from the top of Fesole,
> Or in Valdarno, to descry new Lands,
> Rivers or Mountains in her spotty Globe.

Diodati, a Swiss lawyer working in Paris, helped keep Galileo's works from being suppressed. He arranged for a Latin translation of the *Dialogo* to be published in Strasbourg. In 1636, Galileo sent the manuscript for the "Dialogues on motion" to his friend Fulgenzio Micanzio , a Venetian Servite monk and a disciple of the brilliant polymath Paolo Sarpi, whom we encountered at the time of Galileo's telescopic discoveries. The Jesuits, who were explicitly cited in Diodati's preface of the *Letter to Christina* as Galileo's main antagonists, were still absent from Venice. Sarpi had been happily (but warily, having survived assassination attempts) on the outs with the Church fathers after having published a scathing critique of the Council of Trent in 1619. Galileo decided that publishing in Venice was too close to home and thus too risky. Micanzio gave a copy of the manuscript to the printer Louis Elsevier (in Dutch, Lodewijk Elzevir). Another copy reached Paris in a peculiar way. The French ambassador to Rome, the Comte de Noailles, was permitted by Urban VIII to visit Galileo in Arcetri on his way home. There he was given a copy of the manuscript, right under the noses of the Inquisition. This copy too went to Elsevier, who published the work in 1638 in Leiden. Galileo apparently didn't like the title, *Discorsi e dimostrazioni matematiche intorno a due nuove scienze* (Discourses and Mathematical Demonstrations Relating to Two New Sciences), but he apparently had nothing to fear from the work. Fifty copies were sold in Rome in 1639 without any outcry from the Inquisition. Elsevier also published the *Letter to Christina*, in Latin with a preface by Diodati. Others involved, liberal Catholics and Lutherans, took great pleasure in pointing out "to what stupidity those purple-coated priests have come," as the translator Matthias Bernegger wrote.

Although he was going blind, Galileo managed one more celestial discovery, that of the libration of the Moon. He had alluded to it in the *Dialogo*, but wrote to Micanzio that he had identified more complex motions, saying it moved "in all possible ways …around the line joining its center with the earth's."

Galileo suffered greatly in his last four years, and not just with blindness. He was terribly arthritic, had renal colic and a large ventral hernia. He suffered from frequent fevers. He died on January 8, 1642, surrounded by his son Vincenzo and his students, among them Vincenzo Viviani and Evangelista Toricelli.

The room where he died is small. The only furniture in it today is a carved limewood panel that reproduces a painting by Nicolò Barabino, an otherwise undistinguished 19th century Italian artist. In a cartouche at the top of the frame is a ladder, the symbol of Galileo's family, and below it a scroll with the words *Galileus Lynceum*, reminding us of his pride as a member of the Accademia dei Lincei, the Lynxes. At the bottom is the coat of arms of Pisa, his birthplace. The panel was carved in 1914 by G. Mariutto, about whom I could find no information.

Mariutto's carved relief version of Barabino's painting, *The Death of Galileo*.

The room where Galileo died.

Santa Croce in Florence

Santa Croce is the largest Franciscan church in the world. It is sometimes called the *Temple of Italian Glories* because it is the site of the tombs of Machiavelli, Michelangelo, Galileo, Rossini, and several dozen other Italians of note. There's a grand monument to Dante, who was exiled from Florence in 1301 and is buried in Ravenna. Santa Croce hosts some beautiful works of art, most notably early 14th century frescoes by Giotto, a bas relief by Donatello and a 13th century cross by Cimabue that was unfortunately damaged in the 1966 flood.

Galileo's wish was to be buried in the tomb of his ancestors in Santa Croce. Grand Duke Ferdinando De' Medici planned a monument to rival that of Michelangelo, but Pope Urban VIII nixed the idea and communicated his decision to Fernandino through the Florentine Inquisitor, obviously a figure not to be trifled with. Galileo's son chose a small chamber under the church's bell tower.

Galileo's original tomb, in the wall, and Foggini's monument in which he is now interred.

The original tomb is still there, but history and reason have prevailed. It took almost 100 years for the stain of Galileo's punishment to fade enough for the church to honor him with a fitting monument without papal objection. Galileo is entombed (with his daughter Maria Celeste) in a grand monument in the north aisle of the church, erected in 1737 by Giovanni Batista Foggini. It includes statues representing Astronomy and Mathematics.

Progress in science and astronomy meant that the Vatican couldn't continue to suppress Galileo's writings without accruing the embarrassment Galileo himself had fretted about and tried to prevent. In 1718 an edition of his works was published in Rome with the proper imprimaturs, except for the *Dialogo*, which was still thought to be insulting to the papacy; a complete edition (with some minor editing of the *Dialogo*) was published in 1741. In 1835 all books supporting Copernicanism were removed from the Index, which of course no one outside of the Church hierarchy really paid any attention to anyway. In 1979, Pope John Paul II convened a council to study the Galileo matter. He was concerned that the Church was being seen as denying the validity of science. Ultimately, in 1992, the Pope acknowledged that "errors were made" during Galileo's trial: the evidence relied on extraneous sources, and the assumption that Copernicanism was formally a heresy was never properly vetted through the official Church process for doing so. The Church still needed to assert its authority over Catholic dogma: such was the lasting impact of the Council of Trent after more than 430 years. So to save the appearances, the Church did not say "We were wrong about heliocentrism and Copernicus and Galileo were right." Instead, in a sense, Galileo was let off on a technicality. Nevertheless, at the present time the Vatican's support of modern science (except perhaps for birth control) is often enlightened and contrasts greatly with the rigidity and paranoia of its early 17th century leaders.

With Santa Croce we come to the end of the Galileo part of our *Sky & Telescope* "In the Footsteps of Galileo" tour, but we had three more astronomical experiences before the group split up in Padua.

After our visit to Il Gioiello, Galileo's house in Arcetri, we drove to the other side of the small valley behind the villa and up a winding street to the Arcetri Observatory. It was founded in 1868 by the astronomer Giovanni Battista Donati, the discover of the 1858 comet that bears his name.[3] We had serendipitously passed his birthplace the previous day in Pisa. It was marked by a plaque with his portrait.

The observatory is a component of the *Instituto Nazionale di Astrofisica*, the Italian astronomy agency. The main instrument is a 36-cm (14.2") refractor with a Zeiss objective made in 1925. It replaced an older telescope with a 28-cm lens that was made by Amici in 1841 and used on an altazimuth mount in the original *Specolo* (observatory) in central Florence. Donati had worked with the old instrument. He made sure its clumsy alt-az mounting was replaced with a proper equatorial mount in the new observatory. Arcetri being so close to Florence, the telescope is now only used for outreach, of which they do quite a bit. The staff astronomers participate in a variety of international research projects. The original Amici lens is on display, along with some other historic instruments. A separate room displays some more modern equipment, including a spark chamber and a small mirror with actuators for adaptive optics.

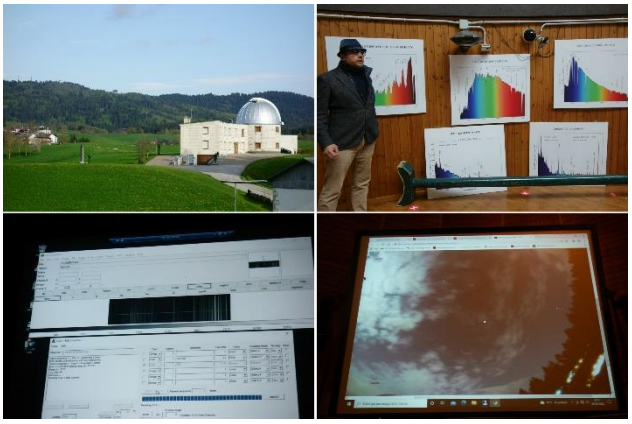
36-cm refractor at Arcetri Observatory

[3] See The Astronomer at the Museum: Donati's Comet, in the February 2022 SkyWAAtch, page 13.

On our short trip back to Florence we stopped at the close-by Piazzale Michelangelo to take in the famous view of Florence that, even in the rain, is magical.

On the last night of the tour, we went by van from Padua to the beautiful sub-alpine village of Asiago, a 1½ hour trip. There, among cheesemakers, the University of Padua has its modern observatory.

Two domes sit at the main campus. One has a 122-cm telescope, the Galilei telescope, built between 1940 and 1942., mounted on an English yoke The parabolic mirror has a focal length of 600 cm (f/5). It can be used as a Newtonian, but is currently configured as a Cassegrain with a hyperbolic secondary giving f/16. A Boller & Chivens spectrograph is mounted at the focus. Four gratings, from 150 lines/mm to 1200 lines/mm are available. The spectral images are acquired by an Andor CCD camera with 512x2048 pixels of 13.5 microns on a side. The other dome is a classroom with spectrographic demonstration equipment. High on a ridge above the pastures is the Cima Ekar Observing Station, housing 92-cm Schmidt telescope and a 182-cm reflector, the Copernicus telescope, the largest instrument in Italy.



Clockwise frum upper left: Asiago Observatory; spectroscopy lecture; all-sky view from the telescope; our spectral data.

The telescope and spectrograph at Asiago Observatory

After seeing the 122-cm scope, we walked over to the classroom dome for a lecture and demonstration on spectroscopy. The sky was hazy, but we were rewarded with a sun dog and a bit of the associated 22 degree arc formed when sunlight is bent by ice crystals.

We had the farewell dinner of our tour at a fine local restaurant, and then returned to the observatory to actually acquire the spectrum of a star. The big scope is controlled remotely by two computers. One manages the scope and dome, the other the spectroscope. The operator connected to each of them with Microsoft Remote Desktop from a single laptop. The dome opened and fortunately the sky was just clear enough overhead to pick out a star. Its spectrum was captured and displayed with a few clicks of the mouse. We would have stayed for more but the heavy dinner and the lateness of the hour was making our lids heavy, and the prospect of an hour and a half drive back to Padua, with early departures the next morning, meant we had to take our leave.

The formal tour ended in Padua, Elyse and I went to Venice for a few days, then to Bologna and finally Como. In Venice we climbed the Scala Contarini del Bovolo, the peculiar spiral staircase erected in the 15th century from which in 1859 Ernst Wilhelm Tempel discovered the Merope nebula with a 4-inch Steinheil telescope.[4] Tempel was appointed director of the Arcetri Observatory after its founder Donati died from cholera just a year after it opened. There's a nice view over the Venetian rooftops from the top of the staircase, although for the best view of Venice, take a boat to San Giorgio Maggiore and go to the top of the bell tower.

The last bit of astronomy of the trip, excepting a lovely moonrise over Como, was in Bologna. The main cathedral, San Petronio, has an important meridian line, built in 1655 by Giovanni Domenico Cassini. It is longer than the one in Rome's Santa Maria degli Angeli (see the July 2022 SkyWAAtch).

As our hotel was right off the Piazza Maggiore, we stopped at the church several times, and on our last full day in Bologna we decided to test the meridian line's accuracy. The line itself is at longitude 11° 20' 36" East. We stood at a point (using Google Earth and estimating where we were under the roof of the large church) at latitude 33° 29' 35" North. Central European Savings Time meant that 12 noon clock time would register as 1 p.m. on our clocks. We arrived a few minutes ahead and watched as the solar disc moved across the floor. I snapped a photo when it appeared exactly on the meridian line. It took between one and two seconds between the time I snapped the image of the Sun and took the image of the clock (1:11:02) on my phone. So we'll say local noon was between 1:11:00 and 1:11:01. When I got home, I put our coordinates into *Cartes du Ciel* and found the time that the Sun would be at *exactly* 180° 0' 0" azimuth that day (May 15, 2022), local noon. The time would be 1:11:00.5. Cassini's 1655 meridian line still tells the time very accurately!

The meridian line in San Petronio, Bologna. You can seee the oculus in the ceiling in the left image.

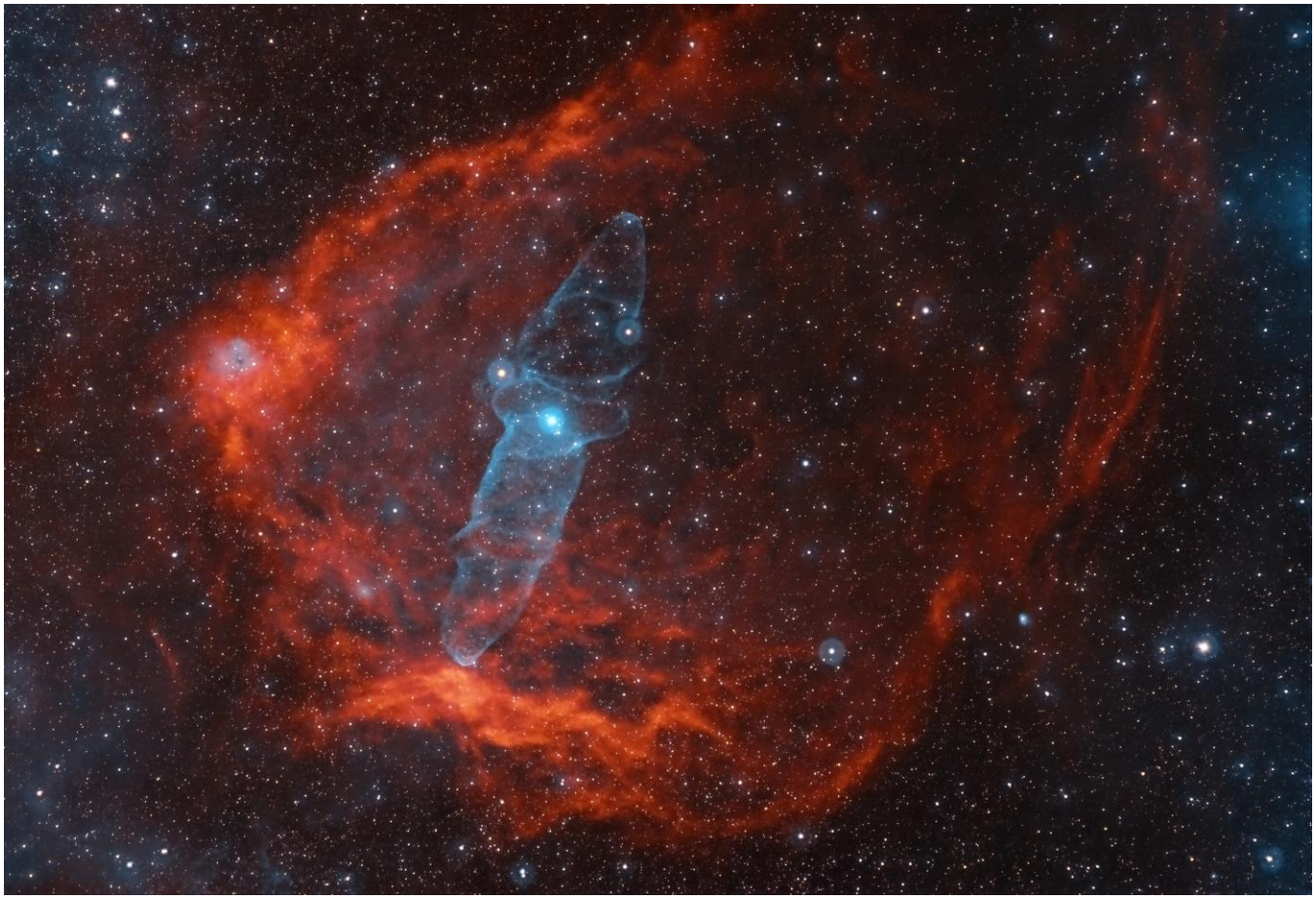
Like all trips to Italy, this one featured a vast amount of great food, wine, art, history, beautiful scenery, wonderful people and pleasant surprises. We took in two operas (in Rome and Bologna), learned how balsamic vinegar is made (near Modena) and how chocolate candy is made (in Perugia). We even went to the Ferrari Museum, also near Modena. In Bologna we visited the world's oldest university (1088), its spectacular library and its elegant anatomic theater. In the ancient Umbrian town of Spello, we had a truly memorable, wine-fueled lunch of fresh pasta with black truffles grated in front of our eyes by noted wine impresario and restauranteur Roberto Angelini. As terrific as Italy can be, delving deeply into the life and struggles of Galileo made this trip extra special.■

A 1966 Ferrari 275 GTS4. 3.3-liter 60° DOHC V12 engine, 5-speed manual gearbox. Body by Pinin Farina.

[4] For more on Tempel, read "The Astronomer at the Museum: Max Ernst and Wilhelm Tempel" in the January 2018 SkyWAAtch, p. 5.

Images by Members

The Squid and the Bat by Steve Bellavia



The Giant Squid Nebula in Cepheus, cataloged as Ou4, lies within the Flying Bat Nebula, SH2-129. It is extremely faint, and was only discovered in 2011 by French amateur astrophotographer Nicolas Outters.

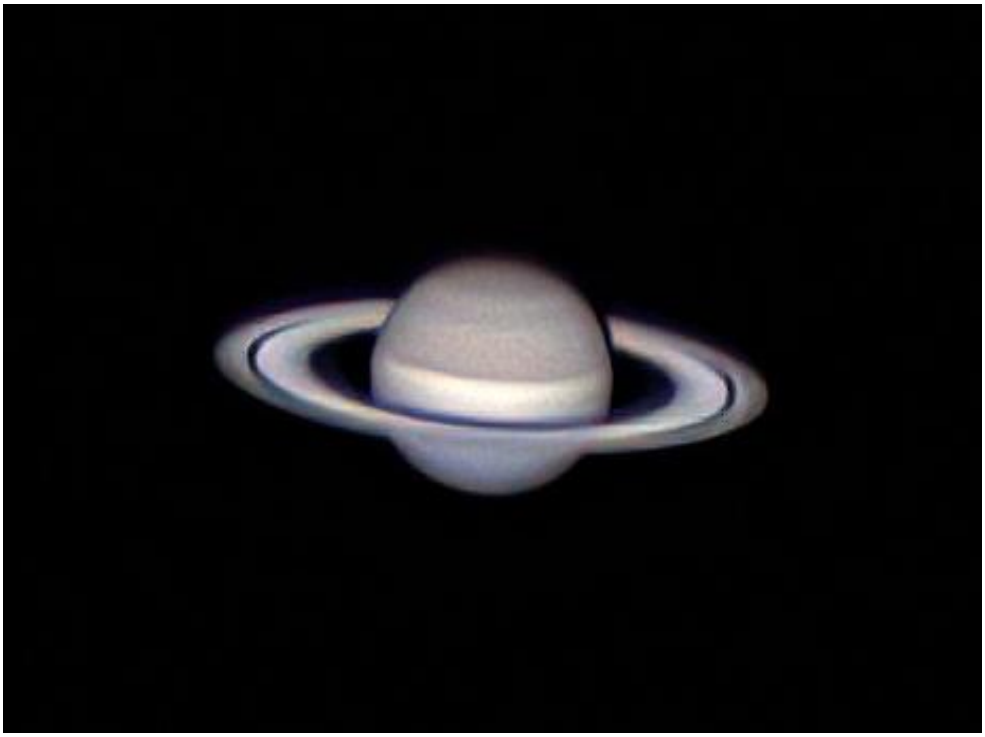
The field of view is three degrees or six full Moons across. The Squid Nebula's blue-green emission is from doubly ionized oxygen atoms (OIII), typical of a planetary nebula. Though apparently completely surrounded by the reddish hydrogen emission region Sh2-129, the true distance and nature of the Squid Nebula have been difficult to determine. More recent investigation suggests Ou4 really does lie within Sh2-129 at a distance of 2,300 light years. Consistent with that scenario, Ou4 would represent a spectacular outflow driven by HR8119, a triple system of hot, massive stars seen near the center of the nebula. The truly giant Squid Nebula would physically be nearly 50 light-years across.

I have never captured The Flying Bat and Squid Nebulas, and based on what I read, I thought it might be it was beyond my capabilities. But I hit it with everything I could: A 91-mm telescope operating at f/3.8 (my fastest, with the exception of a HyperStar C6), a 15-hour round-trip-drive to dark skies at Cherry Springs, electronic focusing, and utilizing every minute of darkness, including doing some H-alpha images in morning and evening twilight, concentrating the OIII capture with the object closer to the meridian during the darkest portions of the evening, and also gathering 50% more OIII data than H-alpha, since the Squid is so faint.

I made the image on two very good Cherry Springs nights, July 29-30 and 30-31. The image was made using two filters: 6nm H-alpha, 48 x 5 minutes (4 hours) and 6nm OIII 70 x 5 minutes (6 hours).

Steve Bellavia

Gas Giants by John Paladini



John used a 7" Meade Maksutov telescope and ASI290MC camera for these images on the night of August 30th. Io's shadow is seen crossing Jupiter's disk over the South Equatorial Belt. The Great Red Spot is dramatically seen. Jupiter's disc was 48.5 arcseconds across at the time of the image.

Saturn, showing a disc of 18.7 arcseconds, shows some color differentiation in the bands on its surface.

With a slightly larger aperture instrument, a Celestron 9.25-inch SCT, and a monochrome camera, John was able to capture detail on the surface of Jupiter's satellite Ganymede on September 3. He used an ASI290MM camera. Ganymede is the largest moon in the solar system, with a diameter 41% that of Earth. It was bright (magnitude +4.4) when this image was taken, but only 1.8 arcseconds in diameter.

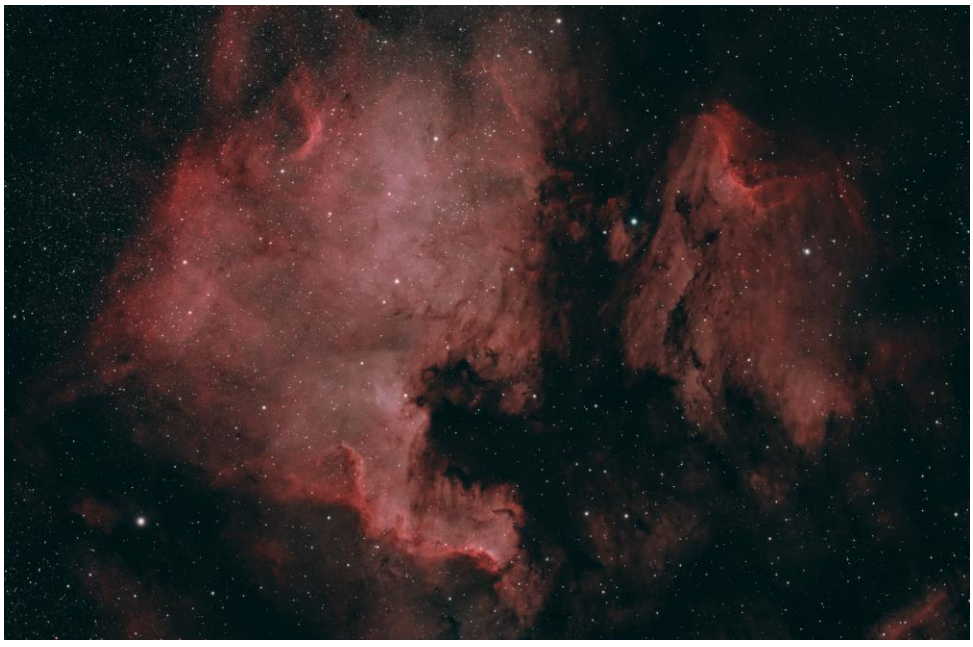
Shadow Transits of Jupiter for October 2022

Date	Moon	Ingress	Egress	Altitude at Ingress	Altitude at Egress
10/1	Io	23:50 (9/30)	02:04	47	43
10/8	Io	01:45	03:59	41	22
10/8	Europa	21:25	23:47	36	48
10/9	Io	20:44	22:28	25	46
10/16	Europa	00:01	01:32	47	38
10/16	Io	22:09	00:23 (10/17)	45	45
10/24	Io	00:05	02:19	44	26
10/25	Io	18:34	20:48	20	40

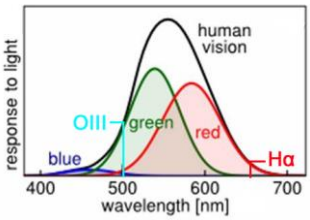
Here are the shadow transits of Jupiter that are visible at night and with the planet at least 20 degrees above the horizon for the entire event. Three multiple shadow transits this month occur mid-day and so would not be visible from our area.

The North American & Pelican Nebulas in Hubble Palette by Gary Miller

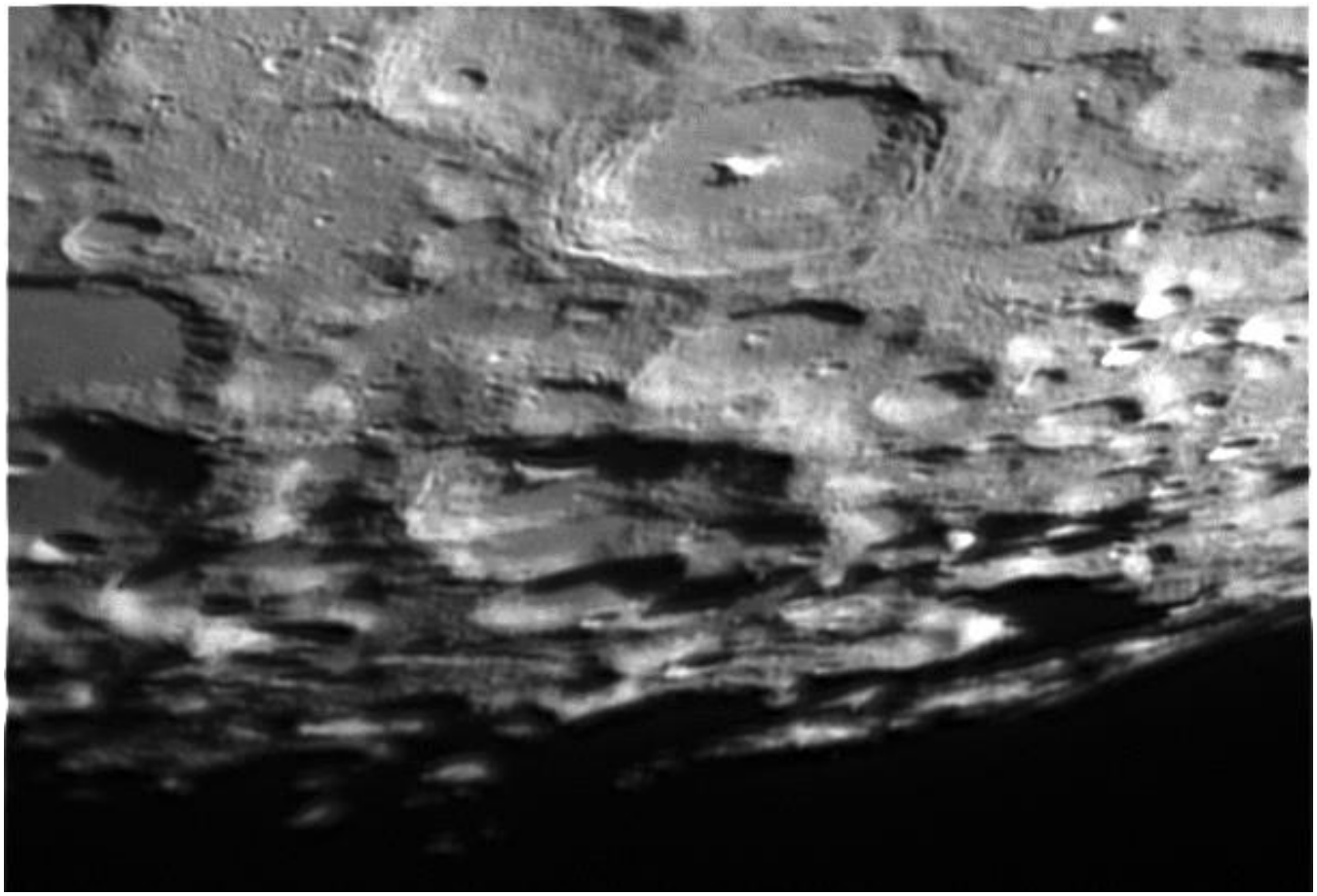
Gary made this image on June 30, 2022 at Ward Pound Ridge with with a William Optics GT71g telescope and a WO 0.8x FR/flattener. A Radian Triad Ultra filter passed Hα and OIII wavelengths into the ZWO ASI 2600MC Pro one-shot color camera. Using PixInsight, Gary deconstructed the color image, reassigning the colors to the Hubble palette. He cited a YouTube video for this technique: https://youtu.be/OVb1_Nqcs5I.



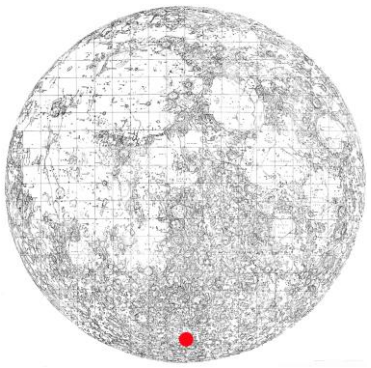
Here's the original image. The conversion to the Hubble palette makes detail in the nebula far easier to perceive. The human eye is more sensitive in the blue-green than the red, as can be seen in the graph below. The "true" Hubble palette with a monochrome camera requires three narrowband filters.



Near the Moon's South Pole by Larry Faltz



The 114-km wide crater Moretus, with its prominent central mountain, is at lunar latitude 70.6 degrees south. Abutting it to the south is the crater Short, and below that on the left is the rather distorted Newton. You would think Isaac Newton would get a more prominent crater than Théodore Moretus, a 17th century Belgian mathematician. Moretus was a colleague of Giovanni Battista Riccioli, whose lunar map, published in 1651 in his epic 1500-page astronomy treatise *Almagestum Novum*, quickly replaced the 1647 map by Johannes Hevelius. Honoring someone with a lunar crater after 1651 meant they will have to settle for one that is smaller, less prominent or even out of sight on the Moon's far side.



Riccioli was a Jesuit, as was Moretus. There are plenty of lunar features named after Jesuit mathematicians and astronomers of Riccioli's time who are marginal to the historical sweep of astronomy that is registered on the surface of the Moon. Riccioli favored Tycho's geo-heliocentric theory, in which the Earth is in the center of the universe with the Moon and Sun revolving around it, and the planets revolving around the Sun. Although he honored Copernicus with a crater, he did not honor Galileo, undoubtably because his Jesuit loyalties, and the need for an imprimatur from the Inquisition, could not tolerate the almost-heretical Galileo (see page 9). Newton's honor came in 1802 in a map by Schröter (who also honored James Short, an important 18th century English telescope-maker). I doubt that anyone naming previously anonymous lunar features would dare to give some minor crater the name Galileo. So, there's no Galileo on the Moon.

5" f/12.1 Orion Apex Maksutov, ASI290MM, Autostakkaert!3, Registax. April 13, 2022.

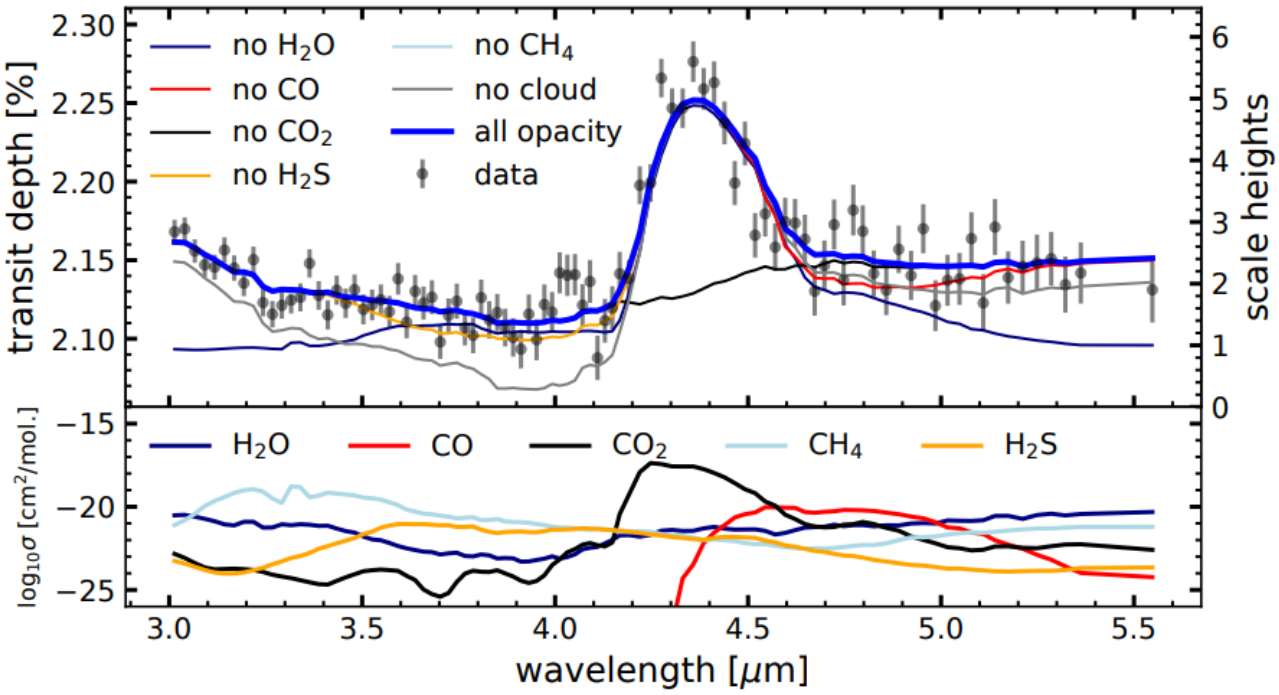
Research Highlight of the Month

The JWST Transiting Exoplanet Community Early Release Science Team, Identification of carbon dioxide in an exoplanet atmosphere, https://arxiv.org/abs/2208.11692, posted August 24, 2022. Accepted for publication in *Nature*.

Although the public has been mesmerized by spectacular images from the James Webb Space Telescope, what has been truly amazing is the torrent of scientific findings already pouring out of its mid-infrared imager and spectrograph. Among the most important targets for the JWST are the atmospheres of transiting exoplanets.

The JWST gathered data during a transit of the planet WASP-39b, a "hot Jupiter" circling a G7 star some 200 parsecs from the Sun. The planet was discovered in 2011. It has a mass of around 28% that of Jupiter (about the same mass as Saturn), but is only 4 million miles (0.0486 AU) from its parent star. Its orbital period is 4.055 days. During the 8-hour observing period on July 10th that included the 2.8-hour transit, the Webb's NIRSpec instrument recorded 21,500 integrations, each 1.38 seconds in length.

The planet had previously been imaged by the Spitzer Space Telescope, which found water vapor, sodium and potassium in the atmosphere. Carbon dioxide was suggested but the range of concentrations was so vast that its presence could not really be established with any certainty. The JWST data shows a clear absorption peak at 4.3 microns consistent with one of the vibrational modes of CO_2. Testing the data against various models of exoplanet atmospheres, the results are consistent with a significance of 26σ. Considering the Higgs boson was considered "discovered" at a significance of 5σ, this result is as close to "certainty" as one might get in science. It's a remarkable demonstration of the capabilities of the instrument, considering that the total amount of light absorbed was just 0.15%.



The finding suggests that the planet is enriched in "metals" (elements heavier than hydrogen and helium) at a concentration least ten times greater than the star itself. The data fit several models of planet formation. Continued observation of this and other exoplanets will shed more light on the various formation theories. ■

Member & Club Equipment for Sale

Item	Description	Asking price	Name/Email
Meade 90-mm refractor	Meade 90-mm f/1000 DS series refractor. Computer controlled. Diagonal, tripod, manuals and batteries included, no eyepieces. Fits perfectly in included Orion case. Great condition. Picture at https://is.gd/Meade90.	Best offer	Marc Favreau mfavreau@optonline.net
Meade 8" SCT LX-80	Go-to mount, tripod. Tube wrapped in Reflectix for faster cooling. See https://is.gd/16F0Tv.	$600	Greg Borrelly gregborrelly@gmail.com
Celestron SE mount	No optical tube. Go-to alt-az mount and tripod. Can carry 12 lb payload or tube up to 17". Upgradeable hand control.	$300	Greg Borrelly gregborrelly@gmail.com
Celestron Binoviewer	Use both eyes with your telescope. Original case, with two 18-mm eye pieces.	$180	Greg Borrelly gregborrelly@gmail.com
Celestron Cometron telescope	Small, lightweight 114 mm f/4 reflector. Red dot finder, 25 mm eyepiece. Dovetail mount. A starter scope for a smart child. No tripod (use a camera tripod). Excellent condition.	$50	WAA ads@westchesterastronomers.org

Want to list something for sale in the next issue of the WAA newsletter? Send the description and asking price to ads@westchesterastronomers.org. Member submissions only. Please 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). Sales of WAA equipment are final. *Caveat emptor!*

The Astronomer at the Museum: Edmond Halley Medal

Among the Met's large collection of European and Decorative Arts are several medallions made in the 1740s by Swiss medalist Jacques-Antoine Dassier. A set of 54-mm diameter medals were sponsored by England's Royal Mint and the Society of Antiquaries to honor a number of important Britons of the age. In addition to Halley, they depict King George II, politician Robert Walpole, poet Alexander Pope, physician Sir Hans Sloane, and several important members of the British nobility.

On the back of this medallion is inscribed ASTRONOMUS REGIS MAGNAE BRITANNIAE (Astronomer to the King of Great Britain). Halley was the second Astronomer Royal, succeeding John Flamsteed in 1720, serving until his death in 1741 at the age of 86. He made major contributions to astronomy (far beyond recognizing the periodicity of the eponymous comet), meteorology, mathematics and even the study of Stonehenge.

From the NASA Night Sky Network

This article is distributed by NASA's Night Sky Network (NSN). The NSN program supports astronomy clubs across the USA dedicated to astronomy outreach. Visit nightsky.jpl.nasa.gov to find local clubs, events, and more!

Fomalhaut: Not So Lonely After All

David Prosper

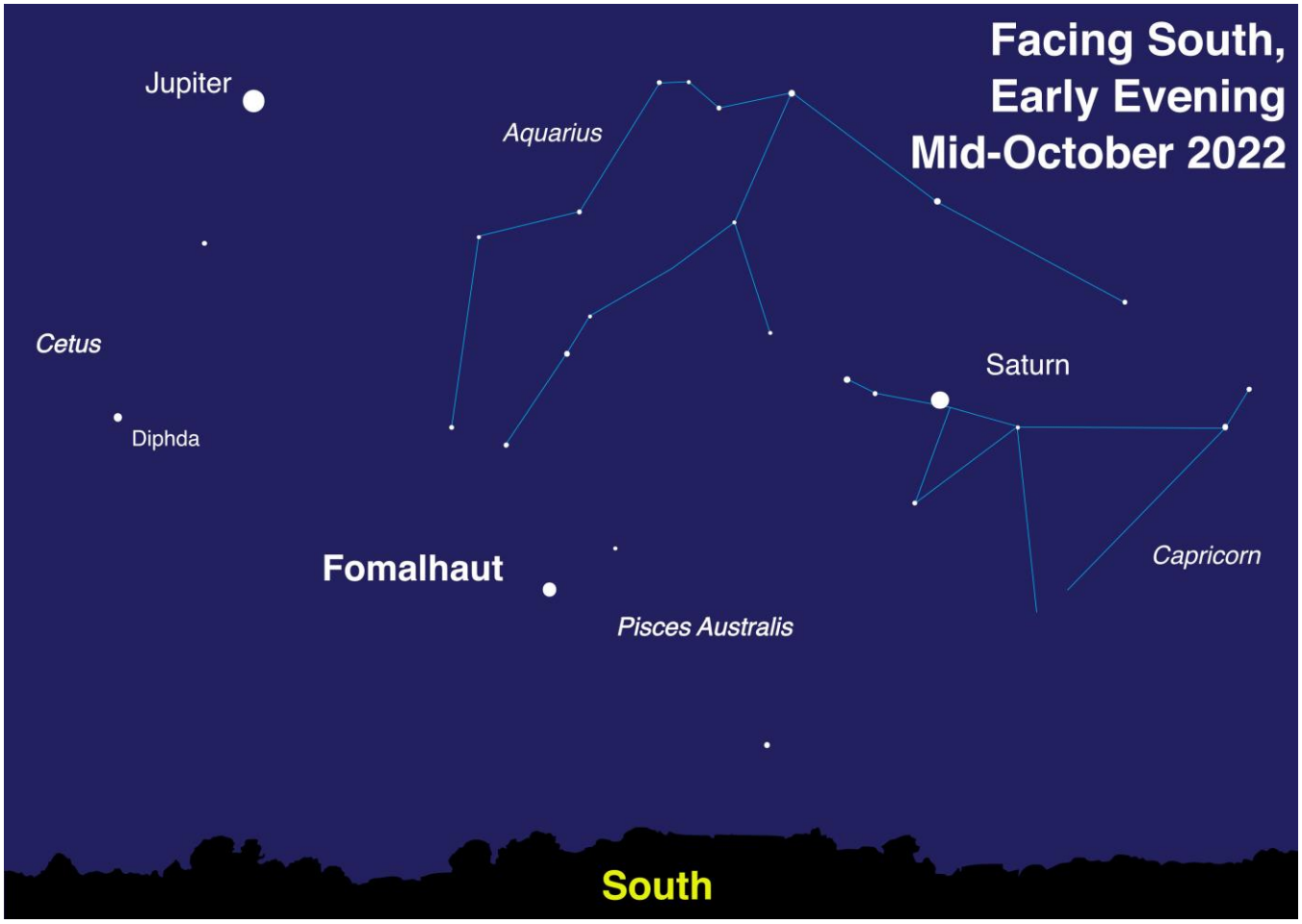
Fall evenings bring a prominent visitor to southern skies for Northern Hemisphere observers: the bright star **Fomalhaut**! Sometimes called "The Autumn Star," Fomalhaut appears unusually distant from other bright stars in its section of sky, leading to its other nickname: "The Loneliest Star." Since this star appears so low and lonely over the horizon for many observers, is so bright, and often wildly twinkles from atmospheric turbulence, Fomalhaut's brief but bright seasonal appearance often inspires a few startled UFO reports. While definitely out of this world – Fomalhaut is about 25 light years distant from us – it has been extensively studied and is a fascinating, and very identified, stellar object.

Fomalhaut appears solitary, but it does in fact have company. Fomalhaut's entourage includes two stellar companions, both of which keep their distance but are still gravitationally bound. Fomalhaut B (aka TW Piscis Austrini, not to be confused with former planetary candidate Fomalhaut b*), is an orange dwarf star almost a light year distant from its parent star (Fomalhaut A), and Fomalhaut C (aka LP 876-10), a red dwarf star located a little over 3 light years from Fomalhaut A! Surprisingly far from its parent star – even from our view on Earth, Fomalhaut C lies in the constellation Aquarius, while Fomalhaut A and B lie in Piscis Australis, another constellation! – studies of Fomalhaut C confirm it as the third stellar member of the Fomalhaut system, its immense distance still within Fomalhaut A's gravitational influence. So, while not truly "lonely," Fomalhaut A's companions do keep their distance.

Fomalhaut's most famous feature is a massive and complex disc of debris spanning many billions of miles in diameter. This disc was first detected by NASA's IRAS space telescope in the 1980s, and first imaged in visible light by Hubble in 2004. Studies by additional advanced telescopes, based both on Earth's surface and in space, show the debris around Fomalhaut to be differentiated into several "rings" or "belts" of different sizes and types of materials. Complicating matters further, the disc is not centered on the star itself, but on a point approximately 1.4 billion miles away, or half a billion miles further from Fomalhaut than Saturn is from our own Sun! In the mid-2000s a candidate planetary body was imaged by Hubble and named Fomalhaut b. However, Fomalhaut b was observed to slowly fade over multiple years of observations, and its trajectory appeared to take it out of the system, which is curious behavior for a planet. Scientists now suspect that Hubble observed the shattered debris of a recent violent collision between two 125-mile-wide bodies, their impact driving the remains of the now decidedly non-planetary Fomalhaut b out of the system! Interestingly enough, Fomalhaut A isn't the only star in its system to host a dusty disc; Fomalhaut C also hosts a disc, detected by the Herschel Space Observatory in 2013. Despite their distance, the two stars may be exchanging material between their discs - including comets! Their co-mingling may help to explain the elliptical nature of both of the stars' debris discs. The odd one out, Fomalhaut B does not possess a debris disc of its own, but may host at least one suspected planet.

While Hubble imaged the infamous "imposter planet" of Fomalhaut b, very few planets have been directly imaged by powerful telescopes, but NASA's James Webb Space Telescope will soon change that. In fact, Webb will be imaging Fomalhaut and its famous disc in the near future, and its tremendous power is sure to tease out more amazing discoveries from its dusty grains. You can learn about the latest discoveries from Webb and NASA's other amazing missions at nasa.gov.

**Astronomers use capital letters to label companion stars, while lowercase letters are used to label planets.*



Sky map of the southern facing sky for mid-latitude Northern Hemisphere observers. With Fomalhaut lying so low for many observers, its fellow member stars in the constellation Piscis Australis won't be easily visible for many without aid due to a combination of light pollution and atmospheric extinction (thick air dimming the light from the stars). Fomalhaut is by far the brightest star in its constellation, and is one of the brightest stars in the night sky. While the dim constellations of Aquarius and Capricorn may also not be visible to many without aid, they are outlined here. While known as the "Loneliest Star," you can see that Fomalhaut has two relatively close and bright visitors this year: Jupiter and Saturn!
Illustration created with assistance from Stellarium

WAA is a member of the NASA Night Sky Network, which operates out of the Jet Propulsion Laboratory. We post the schedule of our meetings and star parties on the NSN calendar. You can find lectures, meetings and events from other clubs, some of which are broadcast on Zoom, by going to, https://nightsky.jpl.nasa.gov. Each month, we receive an article and we've decided to include it in our newsletter this month. Please let the Editor know if you find it interesting by sending an email to waa-newsletter@westchesterastronomers.org.