SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

2021 APEX AWARDS FOR PUBLICATION EXCELLENCE

August 2022

Galileo's Finger

Galileo's right middle finger is on display, along with two of his telescopes (and two other fingers), at the Galileo Museum in Florence. Formerly the Museum of the History of Science, it has an impressive collection of scientific, mechanical and electrical instruments and devices. Photo by Larry Faltz, May 5, 2022.

WAA September Meeting

Friday, September 16 at 7:30 pm

David Pecker Conference Room
Willcox Hall,
Pace University, Pleasantville, NY

Or via Zoom

Members' Night

WAA members are invited to give short presentations on subjects of astronomical interest to the membership: equipment, techniques, observations, trips, education experiences and research. An annual WAA tradition. If you'd like to present, contact Pat Mahon, at waa-programs@westchesterastronomers.org.

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.

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

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WAA October Meeting

Friday, October 14 at 7:30 pm

David Pecker Conference Room
Willcox Hall,
Pace University, Pleasantville, NY

Or via Zoom

A Synthesized View of Planetary Systems

Malena Rice
Massachusetts Institute of Technology

Starway to Heaven

Meadow Picnic Area parking lot
Ward Pound Ridge Reservation,
Cross River, NY

July 23 (Rain/cloud make-up date 7/30)

New Members

Salman Abbasi	Yonkers
Donna Divon	Hastings on Hudson
Liam Garland	Pleasantville
Lee Hemphill	Briarcliff Manor
Arthur Miller	New Rochelle
Daniel Platt	Putnam Valley
Thomas Venditto	Somers

Renewing Members

Greg Alexopoulos	Rye
Liv Andersen	Westport, CT
Winston Archer	Yonkers
Eric and Katherine Baumgartner	Redding, CT
Joel Bender	New York
Leandro Bento	Mohegan Lake
Bill Caspe	Scarsdale
Federico Duay	Briarcliff Manor
Barton Fried	Forest Hills
Joe Geller	Hartsdale
Chetan Karande	Briarcliff Manor
Mark Korsten	Hastings-on-Hudson
Scott Levine	Croton-on-Hudson
George & Susan Lewis	Mamaroneck
Patricia Mahon	Yonkers
Alexander Mold	East Orange, NJ
Ayumi Noda	Elmsford
Alfred J. Padilla	Armonk
Steven Reed	New York
William Rothman	Bronxville
Peter Rothstein	Hastings on Hudson
Robin Schwartz	Riverdale
Jordan Solomon	Pleasantville

ALMANAC For August 2022

Bob Kelly, WAA VP for Field Events


Bob Kelly


1Q Aug 5


Full Aug 11


3Q Aug 19


New Aug 27

Planets Escape to the Evening Sky

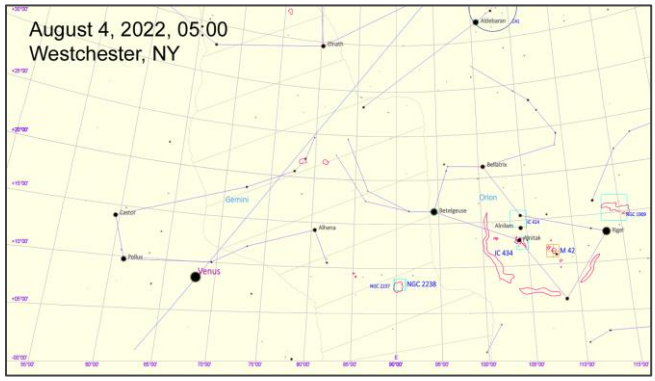
In August, **Saturn** and **Jupiter** lead the planetary migration to the evening sky. Saturn gets as large as it can be when it comes to opposition on the 14th. That night, the **Moon** poses between Jupiter and Saturn as they rise in the southeastern sky. Jupiter-rise moves from 11 p.m. to 8:30 p.m. this month.

More About Saturn

Saturn will be up all night this month. The ringed planet will get to its highest elevation above the horizon, 33 degrees, around 1 a.m., but any time is a good time to turn a telescope on this marvel of the solar system. Saturn's rings will be tilted 13 degrees toward Earth, making a pleasing appearance.

What's Left in the Morning Sky?

Venus is lying low. **Venus** holds on to its brightness, at magnitude -3.9, into the fall, but she is only five degrees above the eastern horizon 45 minutes before sunrise. Earth's cloudy twin must wonder where all the planets in the morning sky went since Saturn, Jupiter and **Mars** are burning rubber heading into the evening sky.



Above Venus, we'll spot **Castor** and **Pollux**, the twins of Gemini are lounging sideways in the dawn sky, as if waking up from a long winter's nap. They resume chasing after **Orion** the Hunter and **Taurus** the Bull, as they are eternally destined to do.

If you want bragging rights for seeing as many planets as possible in the morning sky this month, Jupiter and Mars are still well up in the dawn sky, far to the upper right of Venus. Even Saturn will still be out there, opposite in the sky from Venus, through the 15th. In fact, on the 12th, the full Moon and Saturn will set together during morning twilight.

Blinded by the Light

Perseid meteor watchers will have to contend with the almost full Moon at their peak on the 13th. Watch anytime this month for a few fireballs blazing through the summer haze.

Who's seen PanSTARRS?

Comet C/2017 K2 PanSTARRS will be visible after the end of evening twilight. The 8th magnitude fuzzy may brighten slowly as it slowly sinks in the southern sky during August. The best view may be in a wide-field telescope or binoculars. It's more easily seen after the Moon leaves the evening sky at mid-month. From the 21st though September 8th, PanSTARRS is next to one of the three stars at the head of **Scorpius**. It passes one after the other as if it was trying to get re-ignited by the second-magnitude stars of the scorpion's truncated claws.

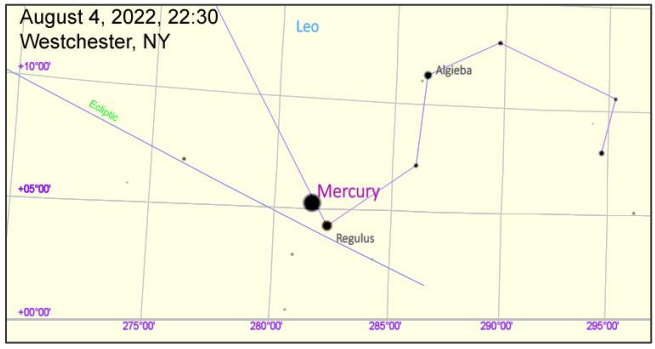
Mercury's Back

Mercury will max out its elongation from the Sun at 27 degrees on the 27th. It won't get very high above the western horizon. This is the lowest spread from the horizon of any of Mercury's apparitions this year.

Pointer Planets

Mars serves as a marker to help find **Uranus** on the night of the 1st into the 2nd. They'll be 1.3 degrees apart at their closest.

Mercury and **Regulus** may be visible in the same binocular field on the 3rd and the 4th, very low on the western horizon right after sunset. If you catch this scene, you can try for Regulus and Venus in the morning sky in early September!



Asteroid Opposition

Not-quite-a-dwarf-planet, **4 Vesta** is at opposition on the 22nd, maxing out at magnitude +5.8. It's easily seen in binoculars, but it may be hard to pick out among so many other equally bright specs of light. It's the second most massive member of the asteroid belt. Find out more at https://is.gd/vestainfo. NASA has made a mosaic of photos taken by the Dawn spacecraft so you can take Vesta for a spin!

More Auroras?

Can you find a clear northern horizon in Westchester County to see faint northern lights? The Sun's activity is increasing, so more auroras (aurorae for you Latin fans) are possible. Auroras are easily lost in twilight, light pollution and haze. Aurora predications are at the NOAA Space Weather Prediction Center, https://www.swpc.noaa.gov/. You can sign up for email alerts.

International Space Station

Overflights by the **International Space Station** are visible during evening twilight through the 3rd and in the dawn sky starting on the 22nd.

My Life on the Moon — Eli Goldfine

In last month's SkyWAAtch newsletter, Bob Kelly wrote a piece titled "My Vacation to the Moon," *a response to the BBC Sky at Night asking people to describe a vacation at a future Moon base. This is my response to the BBC Sky at Night's question, from a slightly different perspective.*

The human race began around 200,000 years ago. Ever since then, man has wonderedabout Earth's natural satellite, the Moon. The Moon came to life 4.5 billion years ago when a Mars-sized ancient planet called Theia collided with the Earth. The collision ejected a lot of the Earth's material into the vacuum of space. Some of it stayed gravitationally bound to the Earth, forming a single spherical object, the Moon, an object that has boggled minds for as long as humans have walked the Earth.

Now, 50 years after the significant year of 2022, man has tried and succeeded in landing on the Moon hundreds of times. In 1969 through 1972, the National Aeronautics and Space Administration (NASA) sent eighteen intensely trained astronauts to the Moon, twelve of whom walked on it. In 2024, NASA launched the Artemis program, accomplishing the 1969 feat again, enhancing it by building a lunar-orbiting space station called "Gateway," and, on the surface, the "Artemis Base Camp." NASA described it as a "place to live and work on the Moon." The Artemis Base Camp concept includes a modern lunar cabin, a rover, and a mobile home." NASA described a simplified version of the Artemis mission's landing and return mission as follows:

1. NASA's Space Launch System (SLS) rocket, the most powerful rocket on Earth, begins its journey from Cape Canaveral.

2. The Orion capsule that holds the cargo and astronauts is freed from the SLS rocket and travels to the Moon.

3. The Orion capsule docks with Gateway, the space station in lunar orbit.

4. The astronauts take a spacecraft called the Human Landing System to the Moon's surface.

5. The astronauts stay at the Artemis Base Camp during their Moon exploration.

6. The astronauts take the Human Landing System back to the still-orbiting Orion spacecraft at Gateway, which then returns to Earth.

7. The Orion spacecraft splashes down in the Pacific Ocean.

This was a very high-tech and well-working system. However, when it first was implemented, NASA was still only letting very select, intensely trained astronauts fly to the Moon.

Now, in 2072, anyone can attend a one-hour training course and fly to the Moon, live there, and get paid a salary to do it. Although the United States government loses money on this, here's what NASA's (currently the most powerful government agency) president, Mike Massimino, had to say about it: "Since the Earth and its seas are already dead from the effects of climate change, transferring humanity to another celestial body seems like the best course of action at this point." Mike Massimino, the 110-year-old president of NASA, is still writing books, governing NASA and cataloging more days in space, thanks to recent advances in genetic engineering that slow aging. Another way the government has incentivized people to move to the Moon is by expanding the Artemis Base Camp to the entire South Pole and building houses that are as nice as a house would be on Earth. These houses are also surrounded by very realistic trees and various other replications of Earth's natural features.

Working on the Moon

On the Moon, every week the Base Camp's residents have to complete one of NASA's citizen science experiments. These can include tasks such as analyzing Shackleton crater's water to detect some form of microscopic bacterial life, driving the lunar rover, or working on ways to improve the lunar sewer system. Some activities that lunar residents do in their free time include low-gravity golf (which dates back to 1971 Alan Shepherd on the Apollo 14 mission), a board game exclusive to the Moon called Crateropoly (which features different Moon craters instead of streets), or during the lunar night going to Shackleton Observatory to view the Earth through their 24" Dobsonian .

Alan Shepard's golf shot, Feb 6, 1971

I will conclude by saying that after my experience living there, the Moon is an amazing place to hang one's hat. From the earliest age of astronomers like Copernicus and Galileo, to spacefarers like Alan Shepard and Mike Massimino, humanity has made huge technological advancements. In the year 1500, the laws and principles of physics, astrophysics, and astronomy were only starting to be discovered. Once discovered, they were very, very intensely challenged by religious groups. Only 450 years later, humanity sent people into space, something that people only in the early 20th century thought would never be possible. Now humans are living and working on another celestial body, which even many people in the significant year of 2022 thought wouldn't be possible. ■

In 2072, Eli will be younger than your editor is now, and may very well be watching Earth with that 24" telescope on the Moon. —Ed.

June 25 Star Party — Larry Faltz

We only occasionally report on our star parties, but the June 25th event was newsworthy, featuring uncommonly fine weather and a large number of scopes, including the debut of WAA's recently upgraded 20-inch f/4.5 Obsession Dobsonian.

A large number of cars were in the lot when we arrived, a group of families with home-schooled students who rent the Meadow Picnic area once or twice a summer. It's a reminder that we share the park with other groups, but at night the Meadow lot is exclusively ours, thanks to our arrangement with the park and their support of astronomy outreach.

At least 20 telescopes were on the field at the peak of the evening. There were instruments of every type, and every astronomy observing activity was happening: visual stargazing, electronic-assisted astronomy and deep sky astrophotography. Several new telescope users got some assistance from club members. It was nice from time to time to just look up at the constellations.

Being late June, it was a little buggy early in the evening. With clear skies the heat of the day radiated away and the temperature was very comfortable. As the evening wore on a good bit of dew formed, as expected, a reminder of the need for dew control in scopes that are prone to fogging (see the February 2020 SkyWAAtch, page 8). Transparency was terrific. Mauri Rosenthal and I brought Sky Quality meters and towards midnight got readings of 20.38-20.40, in the Bortle 5 zone ("suburban sky," limiting magnitude 5.6-6.0). This is about as good as it gets now in northern Westchester. The Milky Way was faintly visible for those who were dark-adapted.

WAA Treasurer Paul Alimena brought the club's 20-inch Obsession, a Dobsonian that was recently upgraded with AstroDevices encoders with the assistance of Rick Bria. When the encoders were first installed, they weren't giving correct readings. After much head-scratching, Rick and Paul realized that the plywood base of the rocker box was very slightly warped. It was replaced with a large disk of ¼-inch aluminum, which eliminated the irregularities that were throwing off the encoder counts. The encoders connect to an AstroDevices Nexus DSC, which acts as a wi-fi hub. Telescope pointing is controlled from an iPod running SkySafari. The scope moved as smoothly as an ice skater. Views of M13 and M17 were superb, and unlike in the past, finding them was effortless. The spiral arms of M51 were not resolved, but averted vision certainly showed their extent.

Paul (up the ladder) and Federico Duay, WAA member and physics teacher at Valhalla High School

Mauri Rosenthal and masked Chris Plourd

Mauri Rosenthal brought his lightweight, back-packable imaging set-up, optimized for recording deep-sky objects in light-polluted environments. With multiple 4-second subs live-stacked by the very powerful SharpCap software, Mauri showed us a terrific high-quality image of the entire Lagoon-Trifid area in Sagittarius. Mauri uses a Borg 55FL f/3.6 astrograph on an iOptron Cube Pro mount positioned equatorially on a sturdy carbon-fiber camera tripod. The

camera is a ZWO ASI1600 MC (16 megapixels). An IDAS LPS -V4 filter helps to bring out the nebular gases. With short exposures and live stacking, the polar alignment doesn't even have to be exact.

Mauri's image and a detailed report on his technique is on page 27.

Mauri is a master at making beautiful deep-sky images in light-polluted environments. He lectured to WAA about it this past June[1] and teaches a course for the Amateur Astronomers Association, the NYC club. Mauri told us at midnight that it was now his birthday (it was also Charles Messier's birthday). A great way to celebrate: under a beautiful night sky with other enthusiastic and friendly astronomers.

CPC800, Elyse Faltz and David Butler

I brought my 8" Celestron CPC and a brand-new Mallincam DS287 camera for "electronically assisted astronomy (EAA)," a bridge between visual observing and deep sky astrophotography. The DS287 is a very small, non-cooled color camera with a tiny 1/3-inch CMOS chip of 720x540 pixels. It boasts 95% quantum efficiency, probably the highest available in a CMOS chip at this time. The goal of EAA is to be able to display relatively faint objects in no more than a minute or two. Many different objects can be shown on-screen as the night progresses, making it easier to cover the range of astronomical phenomena, perfect for outreach. Screen display facilitates teaching, which often works better with a group. I had been using an older Mallincam CCD camera with composite video output to a separate LCD screen, but the DS287 offers a simpler set-up, cleaner images and easier image capture and manipulation, at the cost of a slight reduction in sensitivity (the CCD camera has internal amplification circuits).

NGC 6888, the Crescent Nebula, in Cygnus

Clockwise from upper left: M51, M13, NGC 6946 (Fireworks galaxy), M17 (Omega or Swan nebula).

Live stacking with the ability to incorporate dark frames, a feature not available with the CCD camera, also helps the image quality. Focal reduction on an f/10 scope is needed to get enough light into the camera for short exposures. I use two focal reducers in sequence get the scope to about f/3.2, making a field size of just 25x18 arcminutes. The small field is actually helpful because the focal reducers cause intense vignetting and coma at the edges of the full visual field. Those aberrations are fortunately outside the area seen by the camera. The setup is good for individual celestial objects, not wide fields like Mauri's

[1] The lecture is on the WAA YouTube channel at https://www.youtube.com/watch?v=0-zLQ2icHlg

image. The DS287 can image at 525 frames per second, so it should be an excellent camera to image the planets.

Because of the late sunset and the absence of solar system objects in the evening sky, real observing didn't start until close to 10 p.m. and there were plenty of scopes still on the field at midnight. Saturn rose above the southeastern trees around then. A few people got a look at the ringed planet. Jupiter popped up in a gap in the trees to the east around 1:15 a.m., but by then there were just a few of us left. Elyse and I broke down our setup and left at 1:40 a.m.

Jordan Webber, who was imaging the Veil Nebula throughout the evening, writes that "Gary (Miller), Arthur (Rotfeld) and I stayed pretty late and watched the planets and Moon rise. I didn't get home until almost 5 a.m. and despite very much wanting to get into bed I had to stop and grab this photo of the Moon and Venus over the baseball field at Port Chester Middle School."

Jordan's pre-dawn shot of the Moon and Venus (enlarge the page for a clearer look at the planet)

Another Movie Telescope

The editor admits to generally liking Jackie Chan movies. In his films Chan is put in all sorts of precarious situations and has to fight his way out using his unique and clever "slapstick acrobatic" style. He does all his own stunts. He's often been injured filming them (outtakes shown during the credits document stunts that go wrong) but now at 68 he's probably done with that aspect of his career. Sadly, *The Tuxedo* is not one of his best. In this movie, he plays a chauffeur who ends up being mistaken for a master secret agent whose abilities are enhanced by a special tuxedo with remarkable, frankly magical, properties (and which happens to fit Jackie perfectly). *The Tuxedo* doesn't have the humor and inventiveness of his films with Owen Wilson or Chris Tucker, but it does offer Jennifer Love Hewitt's cleavage.

A Holiday Weekend at Cherry Springs

Steve Bellavia

Here's a report of my trip to the IDSA dark sky site, Cherry Springs State Park, from May 28th to May 31st, 2022.

Saturday, May 28th

I left my house on the North Fork of Long Island around 4:30 a.m., and had my usual breakfast at the Hibernia Diner, just off I-80 in Rockaway, NJ. I've been served by the same owner and waitress for the last 10 years. It rained some of the way, but a clear night was predicted.

When I arrived at the park just after noon, some idiot told me I couldn't set up in the usual spot that I have used about 40 times (and in fact the current Google satellite photo, below, shows me there).

I ignored him and set up anyway. But the next spot over had a giant antenna with a ham radio person talking non-stop. So, I decided to move to a new spot, which was fine. I was quickly surrounded by old friends and some new ones as the park started to fill up. It was very crowded considering the star party sponsored by the Astronomical Society of Harrisburg was still almost a week away.

It cleared as predicted and I began taking data on LBN 558,LDN 1243 and LDN 1251. It was a comfortable night, but very wet with dew.

I stayed up until dawn and was treated with almost the same view as I had seen a month before, a pair of "eyes" clearing the trees but this time, instead of Venus and Jupiter, it was Jupiter and Mars, with almost the same separation, just over half a degree, in the same spot in the sky. It ALWAYS pays to stay up until dawn at Cherry Springs.

Sunday, May 29th

After about two hours of sleep, I took my usual ride into Galeton, which I think is the most beautiful town on Earth. If wealthy people ever discover it, I'm afraid they are going to buy it and kick all those nice poor folks out. I stopped at Lyman Run on the way back, took a shower, stopped in at the park office to pay my $4 shower fee, and headed back to the park. I tried to sleep, but it was noisy and hot in the tent.

After dark, I was joined by fellow Custer Observatory member Conor Woods and his mom. They were staying at the Mill Stream Inn, but he set his gear up nearby and imaged for a while before returning to the hotel. The night was clear but less wet. I took more data on LBN 558, LDN 1243 and LDN 1251, to finish that off. See the image on page 24. And I also took some Milky Way shots.

Monday, May 30th

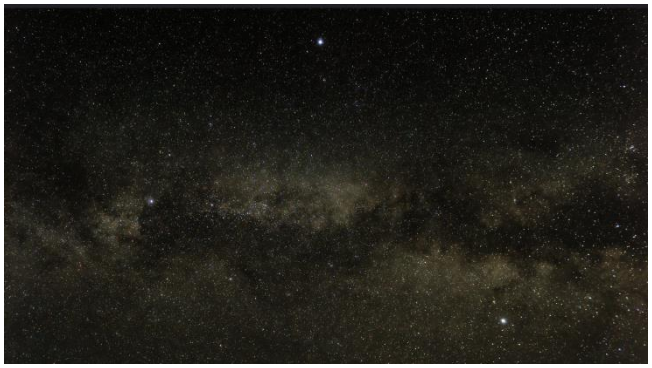
A beautiful Memorial Day. I didn't do much that day, but the day flew by. I wish it would have lasted longer. It was cool in the shade and warm in the sun. I observed Venus at midday with binoculars and showed it to several other people.

I was fairly near a guy named Ed, who comes with an RV to which he's attached a dome with a 14-inch Meade SCT on a pier. Once he parks, there are holes in the floor for the tripod/pier legs to be set on the ground to isolate the scope from the vibrations of the trailer and dome.

I had a nice dinner with a salad bar at the Pine Creek Inn. (Finding vegetables of any kind around there is a rare thing).

Another clear night! The new Tau Herculids meteor shower, caused by the recent breakup of Comet 73P/Schwassmann-Wachmann 3, was predicted to be a possible storm event. I set up my DSLR on a small tripod and set it to take 520 images, each with 8-seconds exposure, with a 4-second delay so there will be time to download the frames. I pointed the camera in the direction of Boötes, but then, noticing that all the ones I saw were near or around Cygnus, I moved the camera. Needless to say, all the really big meteors occurred during the 4-second pauses. I saw about a dozen, as I was also busy imaging the deep sky object I chose for the night, but my neighbor Ken counted 28 in total. Two of my 520 frames had meteors. Here's the better one:

And since I had about 500 images without meteors, I aligned and stacked some of them for a Cygnus region with the summer triangle of stars, Deneb, Altair and Vega. They were all jpegs, but it still came out nice.



The rest of the night was spent capturing the Whale, Pup and Hockey-Stick galaxies. See the image on page 25. I also put a little time on globular cluster M22 in Sagittarius before the light of dawn came:

Tuesday, May 31st

This was my last day and night. It was starting to get hotter, and I attempted to sleep in a hammock in the shade with some success. It may not have been a good sleep, but still peaceful enough.

As evening came, an incredible crescent Moon was between the trees. My neighbor, Bill, spotted it first. I was trying to capture it with the DSLR, while also getting the larger scope pointed at it. It was one of the nicest views of an evening crescent Moon I have ever experienced:

By the time the big scope was ready, the Moon was in the trees.

That last night had many clouds early on, so I did not get much time on the galaxy triplet in Virgo, NGC 4206, 4216 and 4222. By the time it fully cleared, it was after 2:00 a.m., they were setting, and I was tired. I stopped imaging and observed with binoculars for an hour and went to bed as Jupiter and Mars rose. This is the galaxy triplet with only 100 minutes of data, taken between the clouds:

If you're thinking of going to Cherry Springs, here are some tips.

It's a really long drive, especially for me since I live on eastern Long Island. Even without traffic it still takes a lot out of me. But the darker skies are worth it, especially for really faint targets, like the molecular clouds in Cepheus. Westchester is an hour and a half (or more) closer but it's still a trek.

Going just before the new Moon is better and sometimes less crowded. Why? Because before new Moon you can start observing or imaging as soon as it gets dark, and if the Moon comes up at 2 or 3 a.m. that's a nice time to be "forced" to stop and get some rest. Most people show up for the new Moon itself.

I avoid star parties. The next one is late September. I will go before and leave the day of. But that's just me.

It's hot in the day and cold at night, so bring clothing for all conditions. Bring a shade canopy, no matter how small. There are showers and a beautiful lake to swim down the road about 7 miles away at Lyman Run State Park. The lake is a great way to cool off. Have singles handy as the showers are $4, cash. They also have a snack bar with ice cream and some shade too.

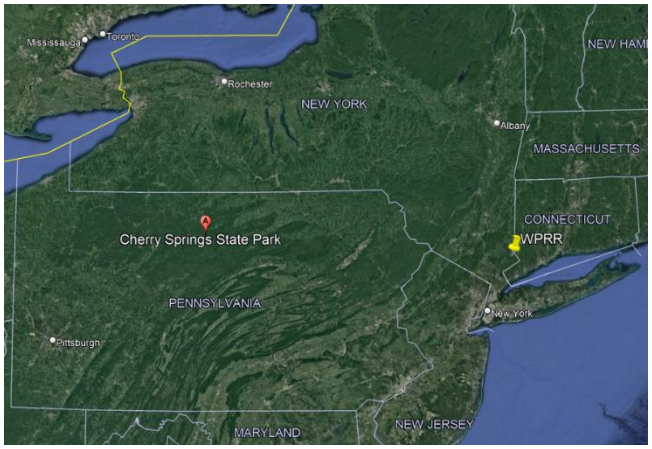
The nights are short in the summer. You might only get 3 or 4 hours of useful imaging and observing. Binoculars and comfy chair are all you really need to enjoy the sky. But having a giant Dob doesn't hurt. My guess is that a 6-inch scope at CSSP is like an 8-inch scope back home.

There's not much food around, so bring lots of your own, though ice and snacks are almost walking distance down the road at the Country Store. They also have sandwiches, (heroes, subs, hoagies, grinders...) and great ice cream. (Have I mentioned ice cream too much?). The Pine Creek Inn has a salad bar. In Coudersport you have Olga's and the Crittenden. Kaytees is gone for good after a fire. Too bad. And there's a McDonald's. Galeton has the Plaza Diner, but that might not meet some people's standards. I happen to like it, and everyone there (the same customers are always there) knows me now and are friendly all the time. Murphy's Pizza is actually not bad either, but I have low standards for food.

Leave early and get there early. And the same coming home (though you Westchester folks might not have to deal with the GW Bridge or Cross Bronx Expressway since you can use the Cuomo/Tappan Zee. The worst for me is usually the Cross-Island Parkway where it exits to the LIE.

Don't pay attention to weather forecasts. They are often wrong, and the top of the mountain is always better than the surrounding area. Bring lots of dew prevention for scopes and eyepieces. There are several power boxes on the field, and they are adding more. If you can't get close, most people bring a 100-foot extension cord.

I am afraid to say it, but even Cherry Springs is not as dark as it used to be, even though it's an official International Dark Sky Association site. I measured 21.1 one night. It used to be 21.7. But the sky to the South is still excellent. North has suffered a little. Zenith is amazing.■

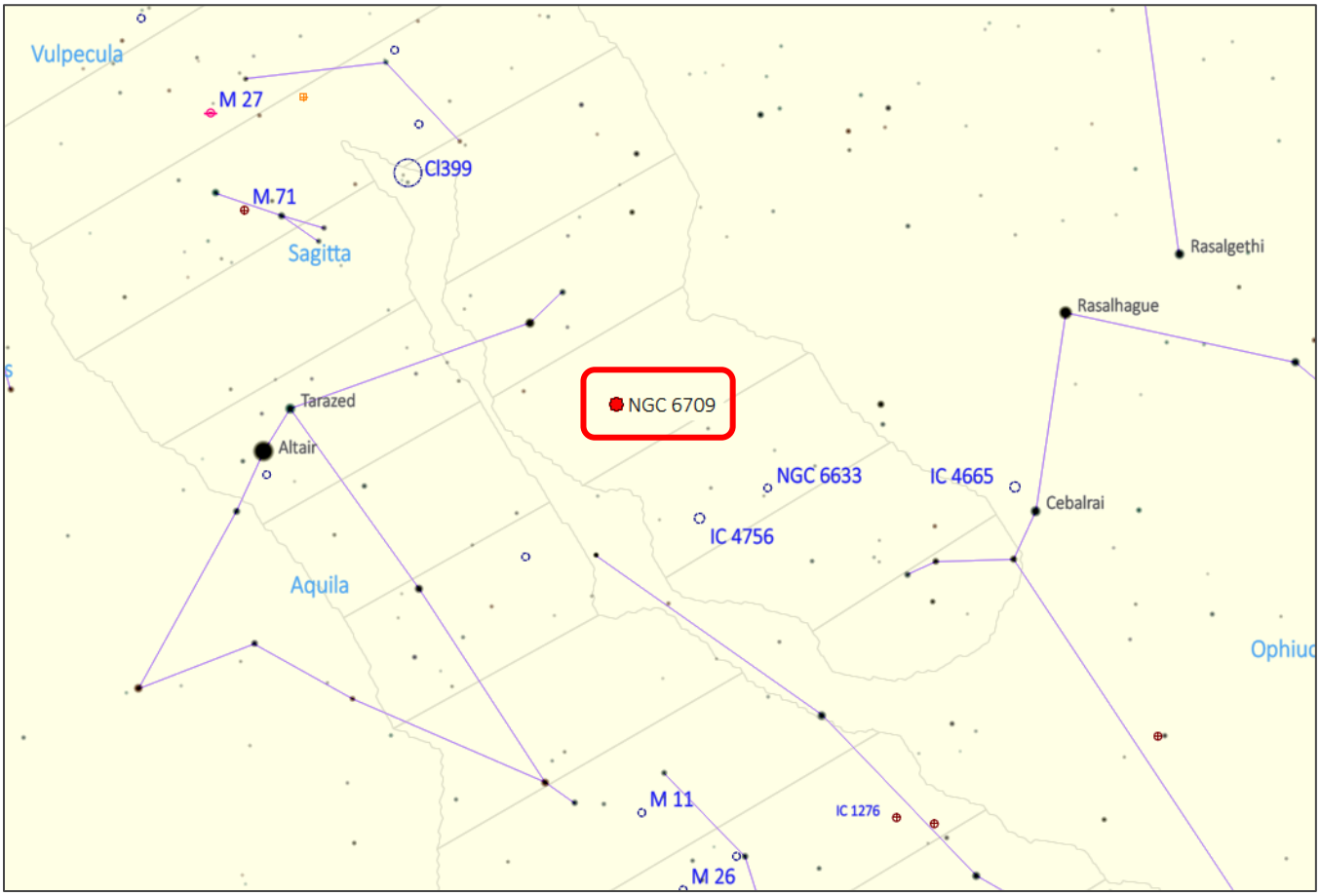


Deep Sky Object of the Month: NGC 6709

NGC 6709	
Constellation	Aquila
Object type	Open Cluster
Right Ascension J2000	18d 51m 18.9s
Declination J2000	+10d 19m 07s
Magnitude	6.7
Size	13’
Distance	3,510 LY
Discovery	John Herschel, 1827

The summer Milky Way is full open clusters, some dramatic, like Brocchi’s cluster (the Coathanger, Cl 399) and the Wild Duck cluster (M11), and some subtle, like NGC 6709. Coming across them while scanning at low power can be a real treat. Steven James O’Meara calls NGC 6709 the “Flying Unicorn Cluster,” although apparently no one else does. He’s impressed with the large number of doubles seen at high power, but some actually might be background stars peeking through the cluster.

Visibility for NGC 6709			
10:00 pm EDT	8/1/22	8/15/22	8/31/22
Altitude	56° 01’	59° 02’	56° 52’
Azimuth	150° 54’	173° 42’	204° 53’



In the Footsteps of Galileo Part 2: Florence, Pisa & Padua[1] Larry Faltz

Galileo was born in Pisa, moved to Florence when he was ten, then went back to Pisa at the age of 17 to study medicine. He switched to mathematics, came back to Florence to teach, moving back to Pisa and then to Padua. Right after he made his astronomical discoveries he returned to Florence where he lived for the remainder of his life (with some eventful trips to Rome). Our *Sky & Telescope* tour could not follow literally in his footsteps, so after starting in Rome we went to Florence, took a side trip to Pisa, came back to Florence and then went on to Padua. To be able to say something coherent about Galileo's life I won't make this a travelogue, but I'll fit our itinerary within a sketch of his biography.

The Duomo of Pisa and the Leaning Tower from next to the Baptistry

We were taken to Pisa by van from Florence, a trip of 42 miles, mostly via autostrada. The town is so popular you now have to park in a large lot about a mile from the *Piazza dei Miracoli* (Square of Miracles) and take a cute "tractor train" to reach it. As you enter the site, in front of you is the Baptistry, and behind it the magnificent *Cattedrale Metropolitana Primaziale di Santa Maria Assunta*, or the Duomo of Pisa. Your first glimpse will make you gasp at the beauty of the buildings, set in a large lawn rather than, as most Italian churches, among a mass of old buildings or behind a paved piazza. But then you can't help smiling when you focus on the *Campanile* (bell tower), better known as the Leaning Tower of Pisa, with its seemingly impossible four-degree tilt. Off to the left is the large *Camposanto Monumentale* (Monumental Cemetery), a building with tombs in the floor or in marble monuments rather than an open space with gravestones. I've been to Pisa three times, and each time I get goose bumps when I enter the *Piazza dei Miracoli*. If you've been there, I am sure you felt the same way.

Galileo was born in Pisa on February 15, 1564. A plaque on a building in the center of the city tells us that his father Vincenzo Galileo lived in this general area when Galileo was born. The exact house is a matter of speculation, but the Casa Ammannati, about seven tenths of a mile from the Leaning Tower, is now claimed to be the exact place. Maybe it was, maybe not. The ground floor is currently occupied by a realtor. Galileo was baptized in the Miracoli Baptistry shortly after his birth on February 15, 1564.

L to R: Plaque about Vincenzo Galilei; the Casa Ammannati, Galileo's presumed birthplace; one of several statues of Galileo in Pisa. He's holding an Earth globe and a telescope.

The Baptistry from the top of the Leaning Tower; the baptismal font in the Piazza dei Miracoli.

Vincenzo Galilei was an accomplished musician and composer, which meant then as it usually does now that he was always financially stressed. He moved to the more cosmopolitan Florence when Galileo was

[1] Read Part 1 in the July 2022 SkyWAAtch

eight years old, but Galileo only followed two years later. Galileo was educated at the Vallumbrosian monastery south of Florence. He certainly must have visited the main Vallumbrosian church in Florence, Santa Trinita, which was very close to our Florentine hotel (the modern, quiet and perfectly located Gallery Art Hotel) and the Ponte Vecchio. Its core is a 13th century structure, with additions over the years. Its main glory is the Sassetti Chapel. Its frescoes, depicting the life of St. Francis, and the painting "The Adoration of the Shepherds," are considered to be the masterworks of Domenico Ghirlandaio. They date from around 1480. Galileo, who had studied and taught fine art, must have had a good look at these superb images.

Back wall of Sassetti Chapel, Santa Trinita, Florence

Although he had thought about the priesthood while with the Vallumbrosians, Galileo's father convinced him to go back Pisa and enroll in the university for a medical degree. While still a student, Galileo noticed the swinging of a chandelier, timed it with his pulse (as the story goes) and from that eventually figured out the law of periodic motion after doing some experiments. It is often said that the chandelier in the Duomo of Pisa is the actual one he saw (I've overheard guides in the church say that to others) but the chandelier there now dates from 1587.

The University of Pisa was founded in 1343, making it the tenth oldest university in the world. It's main building is known as the *Palazzo della Sapienza*, the Palace of Knowledge.

Palazzo di Sapienza

Galileo was not the only important contributor to science who studied at the university. Over one doorway, a plaque identifies the building as the building where Andreas Vesalius taught in 1543-1545. His textbook of human anatomy, *De Humani Corporis Fabrica* (On the Fabric of the Human Body) was published in 1543, the same year as Copernicus' *De Revolutionibus*, and it was equally influential in its sphere. Vesalius declined Cosimo I de Medici's invitation to formally join the faculty at Pisa, opting after 1545 to travel with the court of Emperor Charles V. Another plaque honors Enrico Fermi, who was an undergraduate at Pisa. Among other alumni are five popes, Nobel-prize winning physicist Carlo Rubbia, singer Andrea Bocelli, Cesare Borgia (the inspiration for Machiavelli's *The Prince*) and Tania Bambaci, who was Miss Mondo Italia 2011.

Galileo returned to Florence, where he took a formal teaching job in the *Accademia delle Arti del Disegno*. He was particularly focused on perspective, a natural consequence of his geometrical training. He made his foray into intellectual circles in Florence by presenting two lectures on the geography of hell in Dante's *Inferno*. This seems to us like a silly topic, the *Inferno* being a fictional poem, but whether it reflected concerns about placing the actual hell within the Ptolemean universe or was just an intellectual game, it

was a major academic pursuit in 16th century Tuscany. The tradition was started by Antonio Manetti, the biographer of Filippo Brunelleschi, the architect who built the dome of the Florentine Duomo, undoubtedly the greatest engineering and construction feat of the Renaissance. The basic idea was that hell was merely Brunelleschi's dome inverted. This was first proposed in an edition of the *Divine Comedy* in 1506 that included a half-dozen maps. The *Accademia Fiorentina* took up the problem over the next century, with multiple analyses, lectures, and constructions. Each expositor called on various aspects of geometry, physics and even the properties of various building materials to justify his conception. Galileo's presentation, around 1588, calculated geometric properties of conic sections derived from the circles and sub-circles of Dante's hell. The Catholic hell was a real place, and so it had to have a real structure. For Galileo, that meant it had to obey mathematical rules, just like the rest of the world.

This exercise, and others, contributed to Galileo being offered a professorship of mathematics at the University of Pisa in 1589. There, he worked on a variety of problems in mechanics and geometry. He was quickly recruited by the University of Padua, to which he moved in 1591, with a substantial salary increase.

Our little group was whisked to Padua on the high-speed Italian train in less than an hour and a half, even with stops in Bologna and Ferrara. In Galileo's time, Padua was part of the Venetian Republic. Galileo's official allegiance had to be to the Doge of Venice and not the Duke of Tuscany, then Ferdinando de Medici. As happy as Galileo was in Padua, he never really thought of himself as anything but a Florentine.

The University of Padua was founded in 1222 and is the sixth oldest university in the world. Among its many famous graduates are Copernicus, Vesalius, William Harvey (discoverer of the circulation of blood), philosopher Nicolas of Cusa, poet Torquato Tasso and Giacomo Casanova, whose name is understood in every western language (but I found no Miss Mondo Italianos). The main academic building, dating from the 15th century, is the Palazzo Bo, so named because it had previously been a hotel whose emblem was an ox (thus "bovis"). The building was festooned with flags and draperies honoring its 800th anniversary. With almost 60,000 students at the school, two-thirds of them undergraduates, academic buildings are spread out throughout the city.

The highlight for us was seeing the *Aula Magna*, the Great Hall. Originally built for the School of Law, it was the site of many of Galileo's lectures. The lavishly decorated room is now used for special occasions. Galileo's classes were very popular. The students built a special podium so they could see and hear him properly. It has been preserved in an adjacent room known as the *Sala dei Quaranta* because 40 famous alumni from 23 different countries are depicted in frescoes. A tradition at Padua is for students to affix plaques of their family coats of arms to the walls of the lecture halls, corridors and stairways, and there were many hundreds of them on display.

Clockwise from upper left: he Palazzo Bo, the Aula Magna, a cup of mint espresso at Pedrocchi, and Galileo's podium

The Palazzo Bo is particularly famous for its anatomical theater, the first in the world. We were ushered through a non-descript door into the bottom of the dimly lit, deeply conical auditorium. The theater was built in 1595, during Galileo's tenure at the university. An inscription reads *Hic locus ubi mors east gaudet succurrere vitae* (This is a place where the dead are pleased to teach those who live). One thought I had was that the students sitting at the top of the six-tiered theater couldn't have seen anything of the candle-lit dissection, but perhaps they were called down to file past the body at each important step. Just off the theater was a conference room used by the medical faculty. It was decorated with specimens, notably and eerily a dozen skulls in glass cases, and portraits of famous faculty members, of whom the most honored is the 18th century physician Giovanni

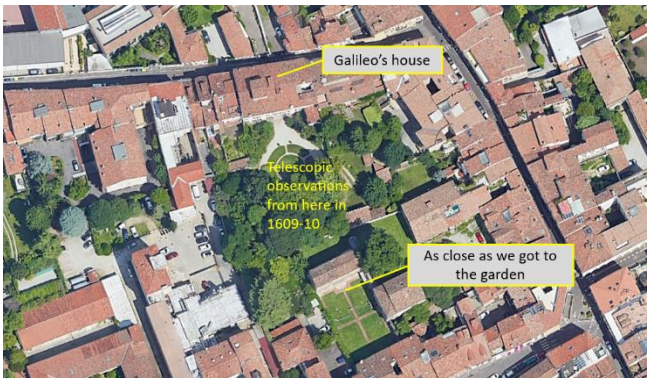
Battista Morgagni, often called the "father of anatomic pathology." I wondered for a moment if the skulls and the portraits were correlated.

Anatomical Theater at the University of Padua (Univ. of Padua)

We went across the street to Caffè Pedrocchi, a famous Italian coffee house established in 1831, the social and intellectual center of the city ever since. It was the locus of an anti-Austrian uprising in 1848 but is more famous these days as a hangout for artists and intellectuals, as well as for its elegant upstairs rooms for private events and assignations among the elite. Its most famous drink is an espresso with cold mint cream layered on top and dusted with cocoa powder. You are not given a spoon (it's considered a terrible gaffe to mix it), and also not permitted to add sugar. Beverage orthodoxy, perhaps. We enjoyed it.

Galileo's house, #17, is the second door from the left. A plaque identifying the site can be seen on the wall over the archway.

We walked through town to a typical Paduan street, now called the Via Galileo Galilei (of course) to his house at number 17. It's a private residence, and although in advance of the trip Kelly Beatty tried to arrange a visit, the occupants were uninterested. We walked around the block to see if we could get a glimpse of the garden where Galileo set up his telescopes. There was a palazzo on that side, one of the buildings of the university. A young lady was on duty at the entrance, under strict instructions not to let anyone in, but when we explained who we were, she relented and allowed us a couple of minutes to explore the palazzo's garden to see if we could get a peek of Galileo's backyard. There was a loggia that blocked the view of Galileo's house and garden, so it was for naught. Looking at the satellite image of the site, the garden is quite large, and Galileo would have had excellent exposure for stargazing, the trees in the image being of far more recent vintage.



Aerial view of Galileo's house in Padua (Google Earth)

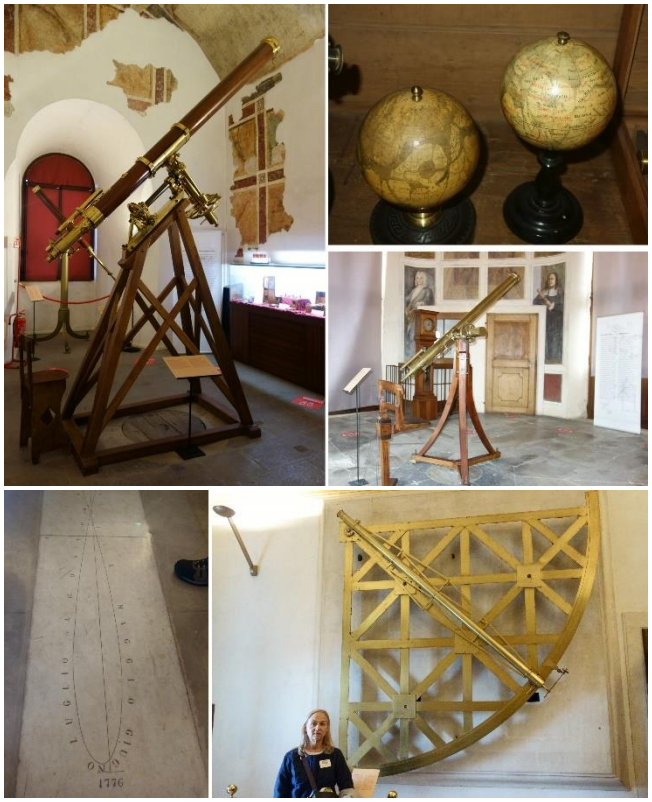
The house is not far from the large *Basilica Pontificia di Sant'Antonio di Padova*, where the body of St. Anthony (the fellow who preached to the fishes) is interred.

We visited *La Specola*, the university's original observatory, established in 1767 in a 14th-century medieval tower that had been used previously as a dungeon. The university moved its research observatory to the mountains north of the river Po in the 1930s. The lower floors of *La Specola* house the offices of the university's Department of Physics and Astronomy and the departmental library. The upper floors and tower are a museum with quite a few interesting instruments. The good stuff is on the top floor, requiring about 200 steps. The main telescope during the last 75 years of its operation in Padua was an 18.7-cm (7.3") f/17 refractor made by Merz in 1862 and purchased from the estate of Baron Enrico Dembowski, a Milanese amateur astronomer, in 1882. Among the many other treasures were two Mars globes from the

1880s, and a beautiful brass refractor with Merz optics made by Christoph Starke in Vienna in 1842. It traveled to India in 1874 for the Transit of Venus.

La Specola, Padua

The Specola also has a large wall quadrant made by Ramsden in London in 1776. A meridian line on the floor, about 4 meters in length, was used to determine the time of local noon and show the equation of time.



Clockwise from top Merz refractor; Mars globes; Starke refractor, Ramsden wall quadrant, meridian line

Padua also has some other sights at least partially relevant to astronomy, and that Galileo no doubt visited. The large *Palazzo della Ragone*, not far from the Palazzo Bo, was completed in 1219. On the ground floor are many specialty food shops selling meat, cheese, pasta, bread, pastries and olive oil. It's Italy, after all! Outside, on the south side of the building is the large *Piazza della Herbe*, with vegetable stands, while on the north side is the equally spacious *Piazza dei Frutti*, with fruit sellers. The top floor of the palazzo is a single room measuring 270 by 90 feet with an 80-foot-high ceiling. The walls are covered with frescoes depicting the zodiac and scenes of daily life relevant to the zodiacal calendar. In medieval and Renaissance times the place served as the court of justice. There is a modern Foucault pendulum at one end.

L: Palazzo della Ragone; R: Astronomical clock

Not far from the *Palazzo della Ragone* is the *Torre dell'Orologio* with a magnificent astronomical clock made in 1430 by Giovanni de' Dondi. This clock has 24 hours, with 18h and 19h at the top (see the detailed image on page 23). There are only 11 zodiac figures, because in pre-Roman times, Scorpio and Libra were one sign. Several statues of the Lion of St. Mark remind us that Padua was part of the Venetian Republic.

One other site that Galileo had surely visited, undoubtedly on more than one occasion because his appreciation of art must have drawn him back, was the Scrovegni Chapel. It was built at the end of the 13th century by the wealthy banker Enrico Scrovegni in the area where the Roman arena once stood (some Roman stones are scattered about). Giotto was commissioned to fresco the interior, completing his task in 1305. The small chapel is completely covered with scenes from the life of Christ, below them figures representing the vices and virtues, with a *Last Judgment* on the wall above the entrance. Because the frescoes are vulnerable to humidity and pollution (think of what has happened to Da Vinci's *Last Supper* in

Milan), only a dozen or so people are allowed in at any one time, after 15 minutes of being dehumidified in a modern antechamber (you are shown a video while you wait). Then you are permitted just 15 minutes in the chapel. But what 15 minutes!

Scrovegni Chapel

Surely this is one of the great masterpieces of Western art, painted by one of its most important artists. Giotto is credited with inventing perspective, changing the entire language of painting. Of astronomical interest, the fresco of the Adoration of the Magi includes as the Star of Bethlehem a depiction of Halley's Comet, which Giotto observed in 1301.

In addition to his popular teaching, Galileo had a fairly successful instrument-making business. He invented the hydrostatic balance (quantifying specific gravity, thus connecting himself to his hero, Archimedes), the first horse-drawn pump; the pendulum clock; the thermoscope; a variety of military compasses; the "sector," a device that aided in determining proportions; and some artillery sighting devices.

Since Padua was part of the Venetian Republic, it is not surprising that Galileo, a respected professor, engineer and intellectual, had many friends in Venice, some in high places. He was well known to Giacomo Contarini, director of the Arsenal, the great shipbuilding facility where 3,000 men labored to turn out up to 50 warships a month. In 1602 Contarini had asked for his scientific views about the optimal location of oars in Venetian galleys. Like Galileo, Contarini had an interest in the arts. Galileo had close friendships with other Venetian intellectuals, foremost among them Giovanfrancesco Sagredo, whom Galileo thought of almost as a brother,[1] and the Servite monk and polymath Paolo Sarpi, theological advisor to the Venetian Senate and a thorn in the side of the papacy in Rome. Galileo was a member of the *Accademia dei Lincei* (the "Lynxes," the name chosen because of their sharp vision), an intellectual society founded in 1603 by Federico Cesi. Although Cesi was a Roman, the group attracted intellectuals from across Italy. Galileo occupied its cerebral center, and not just in scientific matters. The original *Lincei* did not survive Galileo, although it was later resurrected.

A traveling salesman offered a Dutch telescope to the Venetian state in July 1609. Sarpi, who had a knowledge of optics, advised against purchasing it. He thought the mechanically skilled Galileo could make a better one, even though polishing glass had not been one of his major talents. Sarpi gave him some advice, and by the end of August, Galileo had made a 9x instrument. He wrote to the Doge on August 24 to offer his *occhiale*[2] for free. It was accepted, and Galileo was rewarded with a salary increase and tenure for life. Galileo's telescopic discoveries, made in Padua beginning in December 1609, circulated among Venetian intellectuals prior to the publication of the *Sidereus Nuncius* in March 1610.

An important turning point for Galileo was his dedication of the *Sidereus Nuncius* not to the Doge of Venice, who was basically his liege and employer, but to the Grand Duke of Tuscany, now Cosimo II de'Medici, son of Fernandino. He was born in 1590. By 1602, his mother felt he needed tutoring in mathematics, so Galileo was brought down from Padua for the summer. He was requisitioned to teach Cosimo on several subsequent occasions. Galileo made some compasses for the Medici family and was treated very well by them. He must have felt that his future would

[1] And for whom he named one of the characters in the *Dialogue Concerning the Two Chief World Systems.*

[2] Literally "glasses," but meaning "spyglass."

be more secure and more pleasant as a member of the Tuscan aristocracy than if he remained in Padua, even with his academic standing. Galileo seemed to have either not recognized or not cared that he insulted the Venetians by dedicating the *Sidereus Nuncius* to Cosimo, yet having it printed in Venice and seeking a job in Florence less than a year after his promotion at Padua. Cosimo gave him the title of "Principal Mathematician and Philosopher to the Court of the Grand Duke of Tuscany." He did not have any teaching duties, but was free to study, make instruments and write. He moved to Florence in the summer of 1610.

An historical event that undoubtedly had some effect on Galileo's quest for scientific truth in the setting of a society dominated by a powerful religion was a struggle between the Papacy and the Venetian Republic. Venice, a far more secular society than Tuscany or the Papal States, had been squabbling with the Papacy about church property and control. Pope Paul V placed an interdict on the Republic in 1606. The Doge responded by ejecting several religious orders, including the Jesuits, and seizing some church property. War between Venice and the Papal States threatened, but through the diplomatic efforts of French king Henri IV, issues were (relatively) settled and the interdict was lifted in 1607. However, the Jesuits did not return until fifty years later. They were, however, very strong in Tuscany. Galileo must have thought that these educated clerics, as orthodox as they were, would not reject reasonable arguments based on observation. He had previously had many exchanges with Jesuit scholars, including Christopher Clavius.

As I wrote last month, his astronomical discoveries were recognized and confirmed at the Collegio Romano, but the Jesuits split in their acceptance of his explanations. Their support was further eroded after he explicitly professed support for Copernicanism in 1613. Scripture-quoting anti-Copernicans and Jesuits philosophically wedded to Aristotle, Thomism[3] and the dictates of the Council of Trent became more active and critical. Had Galileo stayed in Padua, he might have had the protection of Venice, but he would not have been given access to as many highly placed Church leaders to espouse his arguments, something he was eager to do.

We go back now to Florence (not physically…Padua was the terminus of the *Sky & Telescope* tour). We spent a couple of hours in the Museo Galileo, right on the Arno close to the Uffizi art museum. The museum is hardly just about Galileo; in fact from its formal founding in 1930 until 2010 it was known as the *Istituto e Museo di Storia della Scienza* (Institute and Museum of the History of Science). The museum is housed in an 11th century palazzo. The displays are modern, with detailed explanations when needed.

In addition to its Galilean treasures, its collection of 5,000 historical objects (1,000 on display) includes many astrolabes, armillary spheres, celestial and terrestrial globes, measuring instruments, compasses, some post-Galileo telescopes, microscopes, calculating devices, early electrical apparatus and even a collection of wax obstetrical models from the Santa Maria Nuova Hospital. These depict stages of labor, abnormal lies (breech, for example) and the use of obstetrical instruments like forceps.

Galileo's telescopes

The only two original telescopes made by Galileo that exist are in a case along with an annotated original edition of the *Sidereus Nuncius* and a first edition of the *Dialogo sopra i due massimi sistemi del mondo* (Dialogue Concerning the Two Chief World Systems), the book that sealed his fate in 1633. Also in the case is a device I had never heard of before, a jovilabe.[4] It is a mechanical device to plot the locations Jupiter's moons, Galileo's so-called "Medicean Stars." The

[3] The theological doctrines arising from the work of the 13th century Dominican St. Thomas Aquinas.

[4] The word is analogous to "astrolabe," which is derived from the Greek words for "star" and "taker." So this device is a "Jupiter-taker."

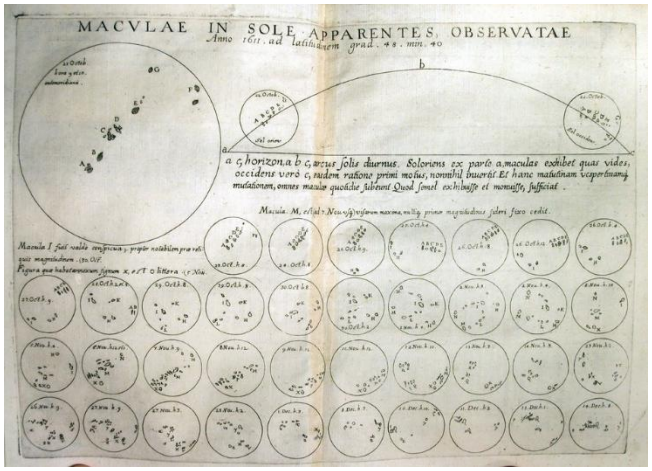
example in the case with his telescopes is not credited to him, but he undoubtedly made one of similar, if not identical, design.

The jovilabe

After Galileo discovered the Jovian satellites, he figured out a way to calculate their orbits and predict where and when they would be in specific configurations around the planet. He realized that this information could be used to determine longitude at sea (at least on nights when Jupiter was visible). He created two graphical plots that corrected the positions of the satellites for the Earth's location in its orbit around the Sun, fixing the time and thus the longitude. Making the plots was laborious, but then he invented a mechanical device to compute the result. The jovilabe is basically an analog computer, a kind of slide rule. He even invented a special helmet with a telescope on it that could be worn by an observer on a ship's rolling deck to sight the satellites. Although he shopped his invention to several European governments, it was never accepted. The critical navigational problem of longitude wasn't solved until the until 1765 (read Dava Sobel's *Longitude* for the full story).

Famously, the museum displays the bones of three of Galileo's fingers in two glass jars. The fingers were detached on March 12, 1737, when Galileo's body was reinterred in Santa Croce in Florence. The thumb and index fingers of his left-hand had disappeared in 1905 but reappeared at auction 100 years later and were authenticated. The anonymous buyer donated them to the museum, along with one of Galileo's teeth. If this seems a little bizarre, recall the Catholic tradition of displaying and venerating body parts of the saints, building elaborate and often bejeweled gold or silver reliquaries to hold them. Displaying the digits is a way of apposing, making Galileo into a secular saint.[5] Some people suggest that the middle finger is pointing at the Vatican, but I didn't confirm that. See the cover page of this issue.

Galileo himself was a religious man. If not overly pious, he was certainly faithful. He never wanted to overthrow Church authority. He just wanted it to accept scientific fact and incorporate it into doctrine. His disputed discovery of sunspots was the lever that moved his heliocentrism into public view. Three letters to the German Marcus Welser detailing his observations were published by the Lyncean Academy in 1613. In claiming that the spots were on the surface of the Sun and moved because the Sun rotated, he opposed the Jesuit astronomer and mathematician Christoph Scheiner, who observed the Sun around the same time (publishing first) and thought the spots were satellites of the Sun. If Jupiter could have them, why not the Sun?



Galileo's drawings of sunspots, 1613

Galileo was sufficiently faithful to worry about the church's credibility. More certain of heliocentrism, he became concerned that the Church would be embarrassed and weakened if it continued to hold that the Earth was the center of the universe. In addition, he and others[6] provided analyses that tried to prove that

[5] As egotistical and arrogant as Galileo could be, I doubt he would be comfortable being called a "secular saint."

[6] Particularly the Venetian theologian Paolo Antonio Foscarini, whose writings were also listed on the Holy Office's decree of March 5, 1616.

Copernicanism was not inconsistent with Scripture, that the traditional interpretations were simply mistaken. He also suggested that the Bible's scope is limited to faith and morality, so science can describe the real world without any conflict.[7] Venus is the only planet mentioned in the Bible, so why would anyone think Scripture has any real interest in the mechanism of the heavens? Church doctrine should simply not concern itself with scientific questions and verified observations. Interpret the Bible to allow it.

Some Jesuits in Florence and Rome spoke out against Galileo and demanded official action. The absolute authority of the Church to interpret Scripture should be reasserted. Although he had a few allies among the Jesuits and was generally respected, even liked, Galileo found the Church leadership to be insufficiently enlightened and impossible to move, most notably Cardinal Bellarmine and Pope Paul V. The Church demanded "proof:" a *demonstratio potissima* (highest form of demonstration) rather than inferences and deductions. The phases of Venus were insufficient: they were just as consistent with Tycho's Earth-based system as with Copernicus' Sun-centered design, and the moons of Jupiter or the plethora of stars in the Milky Way and Pleiades said nothing about the position of the Earth and the Sun. It undoubtedly didn't help that Galileo's theory of tides, which he sent to Cardinal Orsini (and on to the Pope) in January 1616 as his proof,[8] was so obviously wrong. His theory accounted for only one tide per day, rather than two. For two months, Galileo chewed the ears off anyone in the Church hierarchy in Rome who might be willing to listen to him. He was certain that reason would prevail. But as we know, he failed. The long-dead Aristotle, Ptolemy and Thomas Aquinas prevailed.

On February 24, 1616, after five days of deliberation, a committee of the Congregation of the Holy Office of the Inquisition judged the belief in a Sun-centered universe to be "formally heretical since it explicitly contradicts in many places the sense of Holy Scripture, according to the literal meaning of the words and according to the common interpretation and understanding of the Holy Fathers and the doctors of theology." As J.L. Heilbron notes in his monumental biography *Galileo*, "There was no room in the formidable interdiscipline for a salutary opposition between science and religion."[9] The records of the Holy Office record the following:

> Friday, the twenty-sixth [February 1616]. At the palace, the usual residence of Lord Cardinal Bellarmine, the said Galileo, having been summoned and being present before the said Lord Cardinal, was, in the presence of the Most Reverend Michelangelo Segizi of Lodi, of the order of Preachers, Commissary-General of the Holy Office, by the said Cardinal, warned of the error of the aforesaid opinion and admonished to abandon it; and immediately thereafter, before me and before witnesses, the Lord Cardinal being present, the said Galileo was by the said Commissary commanded and enjoined, in the name of His Holiness the Pope and the whole Congregation of the Holy Office, to relinquish altogether the said opinion that the Sun is the center of the world and immovable and that the Earth moves; nor further to hold, teach, or defend it in any way whatsoever, verbally or in writing; otherwise proceedings would be taken against him by the Holy Office; which injunction the said Galileo acquiesced in and promised to obey. Done at Rome, in the place aforesaid, in the presence of R. Badino Nores, of Nicosia in the kingdom of Cyprus, and Agostino Mongardo, from a place in the Abbey of Rose in the diocese of Montepulciano, members of the household of said Cardinal, witnesses.

Galileo thought that reason could win without undermining the basic tenets of Catholicism, but the Church leaders simply could not imagine that possibility. Yet the 1616 decision, as absolute as it sounded, was ultimately more bark than bite, and as we know it did not really delay progress in cosmology and acceptance of Copernicanism in the long run (nor did Galileo's second trial and punishment in 1633). After the 1616 decision, Galileo even had a long audience with Pope Paul V, who assured him that he was not in danger. Bellarmine himself wrote that Galileo had not been required to abjure and did not receive

[7] He expressed this first in December 1613 in a letter to his friend Benedetto Castelli, who had been challenged by Grand Duchess Christina of Tuscany. This letter circulated widely although it was not formally published. It was followed by a lengthy letter to the Duchess herself expanding on the arguments.

[8] We saw the manuscript at the Angelican Library in Rome. See the July 2022 Sky*WAA*tch.

[9] Something that the Catholic Church has by and large achieved in the modern era, unlike some other Christian sects.

penance.[10] If anything, the actions of the Holy Office were designed to squelch something more subtle and dangerous than Galileo's cosmology: the birth of an independent school of Biblical criticism and interpretation, something that echoed Luther's Protestant breakaway of the previous century. This was an outcome the Council of Trent was explicitly designed to prevent. Galileo was a fulcrum that the pope and Bellarmine could use to leverage the Church hierarchy's interpretive control.

We have to distinguish between the declaration of the belief in Copernicanism and mathematical methods that relied on a heliocentric construction. Even the Jesuit Clavius had a great deal of respect for Copernicus' system as a tool. One could reorient the Sun and the planets for the purposes of mathematical prediction without believing that they were *physically* occupying those positions. To the extent that it didn't challenge the truth of Scripture (since it was simply a hypothesis and not a thesis), it would be acceptable to continue to teach the methodology. Presumably, man could never understand God's actual design: that's reserved for the Almighty. We should recall Osiander's obsequious preface to Copernicus' *De Revolutionibus*, written without Copernicus' consent, making the argument that the placement of the orbits was entirely a theoretical exercise.

Bellarmine was professor of theology and rector at the Collegio Romano, the Jesuit university in Rome. Over time the Jesuits hardened their opposition to heliocentrism but did it quasi-scientifically. They were dedicated to the traditional interpretation of Scripture and obedience to Church authority, but they were also devoted to learning. They began to search for scientific (rather than just experiential or scriptural) evidence that could counter heliocentrism. Progress in physics and mechanics, some of it due to Galileo, could not be ignored, and Scripture had nothing to say about that. Among the explanations tendered in support of the heliocentric heresy was Kepler's idea that magnetism was the motive force for the planets. While he argued that it applied to a Sun-centered universe, Jesuit cosmologists argued the exact opposite.[11] Neither side could make a *demonstratio potissima*. Newton put an end to it all in 1687.

Galileo returned to Florence chastened but not suppressed. He continued to do research, invent instruments, write and confer with fellow Lynxes. He was buoyed by the election of the Florentine Maffeo Barberini, who he first met in 1611, as Pope Urban VIII in 1623. But this ultimately had dire consequences that we'll review next month. We'll present his two most important books on the construction of the heavens, *Il Saggiatore* (The Assayer) and the *Dialogo sopra i due massimi sistemi del mondo* (Dialogue Concerning the Two Chief World Systems) and see how and why they provoked his erstwhile friend Urban. We'll go to the Florentine suburb of Arcetri, where Galileo spent the last 11 years of his life. In the October SkyWAAtch we'll finish Galileo's story, stop by the beautiful church of Santa Croce to see his tomb, and visit the Arcetri Observatory, founded by Giovanni Battista Donati in 1872. Our Sky & Telescope tour concluded with an evening visit to the modern observatory of the University of Padua, located in the sub-alpine cheese-making region of Asiago. We'll throw in a Venetian tidbit that has an Arcetri connection, and a final surprise in Bologna. ■

Dondi's Astronomical Clock in Padua

[10] There is a significant difference between being required to "abandon" a belief (a passive act), and "abjuring" it (requiring active confession and rejection). Bellarmine's letter to Galileo was dated May 16, 1616. A copy was filed in Rome, to appear in 1633, contributing to Galileo's undoing.

[11] See "What Moves the Planets?" in the January 2020 SkyWAAtch

Images by Members

Molecular Clouds in Cepheus by Steve Bellavia

Steve writes, "It was a little scary when I looked at the subs on my laptop, since the individual images had almost nothing in them, even when stretched very hard. I was afraid I may be wasting two precious nights in the dark sky park that is so difficult for me to get to. Luckily, with approximately 8 hours of total integration of nearly 200 images, stacking revealed the wonders of this part of the sky."

LBN (Lynds Bright Nebula) 558 contains LDN (Lynds Dark Nebula) 1243 and 1251, faint molecular clouds about 1,000 light years away, in the constellation Cepheus. LDN 1251 is a star-forming region. Spectral and visible light observation of the obscuring interstellar clouds reveal energetic shocks and outflows associated with new-born stars, including the reddish glow from scattered Herbig-Haro objects

Distant galaxies are also in the image. To the left of LDN1251 is the spiral galaxy UGC 12160, approximately 84 million light years (MLY) away (triangulate the black markers). PGC 166755, also a spiral galaxy, is 100 MLY distant and near the top of LDN 1251 (triangulate the green arrows).

Telescope: William Optics 71 Star II f/4.9, 71-mm Petzval refractor, camera: ZWO ASI 294MM Pro, cooled to -10°C Subs: Baader Luminance UV-IR Cut filter, 127 x 90 seconds, Baader Red, 26 x 240 seconds, Baader Green, 24 x 240 seconds, Baader Blue, 22 x 240 seconds, all gain 100. 30 flat, 30 dark-flat Frames and 30 dark frames for each. Mount: Sky-Watcher EQ6-R Pro with EQMOD software. Guide Scope: Modified SvBony 30-mm, 210-mm FL, Guide camera: ZWO ASI 224MC.

See Steve's report of his trip to Cherry Springs on page 9.

Whale, Pup and Hockey Stick by Steve Bellavia

Steve writes, “I don't know why a whale is swimming around with a seal's pup. But what is more likely is that the astronomers misnamed it, as they are notorious for having naming issues (like a quarter vs. a full Moon, planetary nebulae, and let's not talk about Pluto).”

NGC 4631 (also known as the Whale Galaxy, or Caldwell 32) is an edge-on spiral galaxy in the constellation Canes Venatici. This galaxy's slightly distorted wedge shape gives it the appearance of a whale, hence its nickname. NGC 4631 has a nearby companion dwarf elliptical galaxy, NGC 4627, sometimes referred to as "the Pup" (even though a baby whale is a "calf"). NGC 4627 and NGC 4631 together were listed in Halton Arp’s *Atlas of Peculiar Galaxies* (1966) as an example of a "double galaxy" or a galaxy pair. They are part of the NGC 4631 Group, which also includes the interacting galaxies NGC 4656 and NGC 4657 (The "Hockey Stick" or "Crowbar"…the shaft is 4656 and the blade is 4657). The group’s total membership is uncertain, with estimates of from 5 to 27 galaxies. All the group members are about 30 million light years distant.

Telescope: TSO-115-mm Triplet f/7 refractor with TSO 3-inch, 0.79X reducer-flattener, 645-mm focal length. Camera: ZWO ASI 533MC Pro, cooled to -5°C. Subs: Astronomik L2 UV-IR cut, 40 x 300 seconds, gain 100 (total of 3.3 hours); 30 flat frames, 30 dark-flat frames and 30 dark frames. Mount: Sky-Watcher EQ6-R Pro using EQMOD software. Guide scope: The Bellavia Basic 50-mm, 370-mm FL, guide camera: ZWO ASI 290MC.

Cherry Springs State Park, PA, May 30-31, Transparency: 7/10; Seeing: 3/5. Temperature: Approximately 15°C.

Iris Nebula by Gary Miller

The Iris Nebula (Caldwell 4, NGC 7023) is a bright reflection nebula in the constellation Cepheus. NGC 7023 actually designates the open cluster within the nebula, while the nebula itself is LBN 487 (LBN for Lynds Catalog of Bright Nebulae, a 1965 list of objects found on plates of the National Geographic-Palomar Observatory Sky Atlas.) The gas is illuminated by radiation from the Herbig Ae/Be star SAO 19158, spectral class B2Ve. These stars are named after their discoverer, George Herbig, an astronomer at the University of Hawaii, who identified their unique properties in 1960. They are hot, young (less than 10 million years old) and are still undergoing gravitational contraction within their dusty nebulas. They weigh between two and eight solar masses. Herbig Ae/Be star emit a lot of radiation in the infrared, and display spectral lines of silicates, iron oxide, polycyclic aromatic hydrocarbons and crystalline water ice.

NGC 7023 lies 1,300 light-years away and the reflection nebula spans six light years. The faint brownish areas throughout the image are photoluminescence from interstellar dust. Lynds Bright Nebula LBN 468, along with LBN 475 and 483, are larger areas of interstellar HII regions that straddle the constellations Cepheus and Draco.

Gary made this image in late May from Ward Pound Ridge Reservation with his usual set-up, an Explore Scientific ES127ED triplet (carbon fiber tube), Losmandy GM811G mount, ZWO ASI2600MC Pro camera. Two hours 30 minutes of light frames, calibrated with flats only.

The Lagoon and Trifid Nebulas by Mauri Rosenthal

As described in the report of the June 25th star party (page 6), Mauri uses a highly portable system to record deep sky objects in urban environments. He relies on very short duration images that are stacked together in real time, adding detail and reducing noise. Short durations also allow the software to compensate for inaccuracies in pointing. As mentioned in the article, this image was made with a 55 mm aperture f/3.6 astrograph connected to a 16-megapixel ASI1600MC camera with a "four-thirds" chip like those in high-end mirrorless cameras.

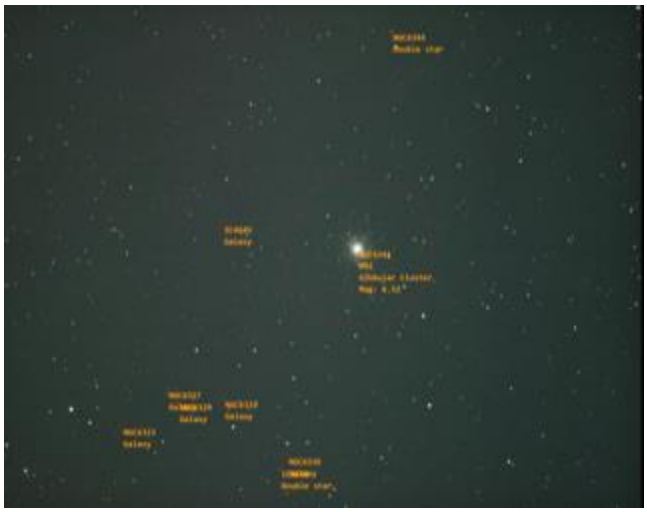
The editor asked Mauri to explain how he uses SharpCap (the Pro version with many valuable enhancements, not the free version, which is quite useful by itself). Here's his detailed response:

SharpCap currently does the following (list keeps expanding):

- Controls the camera (exposure length, gain, white balance settings, temperature, bit depth, file format, a few other things).

- Facilitates capture of dark frames and flat frames. I'm using an older dark frame – at the same settings (4-second or 8-second exposure, gain at 300, temperature -15° C). Flat frames are best taken fresh; on Saturday night I pointed the scope straight up; used my Kindle as a light source; and ran off new color flats).
- Runs LiveStacking:
  - Every four seconds new exposure comes off the camera.
  - The new exposure gets dark and flat adjusted (so it's now "calibrated").
  - The new exposure passes or fails two tests, one for focus (FWHM filter) and one for brightness (cloud filter). If it passes, then the new exposure gets averaged into the stack.
  - There is a sigma clipping control in the LiveStacking controls. As the frame is averaged in, outlier values are discarded (prior average value left alone). This is akin to the sigma clipping pixel rejection algorithms in stackers like DeepSkyStacker or PixInsight. The outlier controls can be cranked high or low; I aim for rejecting 0.1% of total pixels. So, I'm throwing away 16,000 data points (from the 16 megapixels in the camera). What are they? It depends, but the idea is that hot pixels and random noise get screened out more than good stuff (where good stuff would be detail so faint that incremental photons are only getting counted in a 4-second frame every 3rd or 4th frame). Here's the edge of my knowledge and technique *vis-a-vis* teasing out the faintest details, where the faintest details in images from my backyard in Edgemont are lost in light pollution more than at Pound Ridge. Even though it's very mathy, my approach is more art than science – I'm really not sure of what's best so I use it but usually at a very controlled level like 0.1%.
  - When six minutes of frames have passed and accumulated, I save and start the stack over. The files are saved as both 16-bit and 32-bit versions. The 32-bit files are 192 megabytes each, so I'm generating about 2 GB of data for every (successful) hour of imaging. That's how I filled my 10TB of hard drive space and now am using a desktop with 30TB of space (haven't filled it yet!).

- SharpCap also has nice plate-solving and mount control capabilities. In short, when it's working right, one click solves the frame and recenters the target. There's a cool annotation feature I just started to play with – I can do this in real time. Here's an example:



- SharpCap has a new, improved sequencing interface so I can have it save a 6-minute stack (or whatever length I want) then recenter on the target and repeat. This eliminates the one last thing about unguided imaging – namely a little bit of drift required manually recentering; now I can theoretically go to bed or do something else while it runs for hours on a target. This facilitated this little comet movie https://www.instagram.com/p/Ce1wGAaF4BO/.
- For live viewing/EAA etc., the screen stretch controls for the livestacks are pretty robust. Hence the image on my screen in the photo (page 6). I can zoom in, adjust the color balance and degree of stretch, and even add some sharpening and noise reduction. With a globular cluster for instance, a little bit of sharpening can get me the same view of M13 that I had at the star party via the Obsession eyepiece with a two-minute live stack, only with more color. With a 2.2" aperture!

By running PixInsight on the same laptop, I can do quality checks during a capture session

- Take a critical look at focus all around the frame – it's just easier to manipulate than the SharpCap screen
- Mess around with further adjustments, typically a background subtraction

- Confirm the positioning of the target in the frame and monitor how it's drifting over time by comparing multiple images to each other.

For plate solving SharpCap needs AstroTortilla, All Sky Plate Solver (ASPS) or ASTAP. I've has ASPS on my laptop for years. I just set up a new old laptop for this and tried ASTAP. It was easier to install and runs a little faster so I would start with it. You download the program (open source) and a big data package. Documentation is decent.

Once the capture session is complete, I transfer the gigabytes of images to my desktop and do the processing in PixInsight. The short version of this is that I do a visual quality inspection of the livestacks (at six minutes per stack, I'll have 10 for an hour and 20 for two hours, etc.) and then I treat them as if they are calibrated subframes. Typical steps would be select the usable frames; run ABE (background extraction) on the 32-bit stacks; register them; integrate them; run a drizzle integration; color adjust; stretch; starnet to separate the stars from nebulae; sharpen, denoise, and contrast adjust the nebula; sharpen and round up the stars; add them back together. At this point now I'm passing the image on to Topaz Denoise for best cosmetic noise adjustments, and ACDSee Gemstone for final tweaks on exposure, noise, sharpness, final crop, watermark. Easy-Peasy as they say!

If anyone thinks that high quality astrophotography is simply plugging in a camera and clicking a button, they are quite mistaken. Like any fine art, training is required. The tools are powerful and it takes time to master them. And the options are many, so a good bit of aesthetic judgment is required, and that too comes from practice. LF

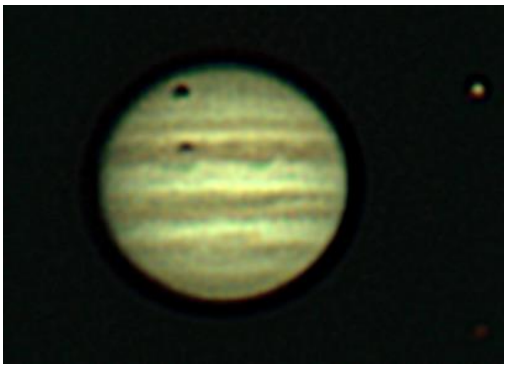
Shadow Transits of Jupiter in August 2022

Jupiter rises at 22:35 on August 1 and 20:33 on August 31, so it will be increasingly favorable for viewing as summer turns into autumn. It's always fun to see shadow transits. Even a small telescope will show the point-like shadow if the optics are good enough and the seeing is reasonable. Here are the transits that will be visible in Westchester when the planet is above 20 degrees elevation for at least part of the event.

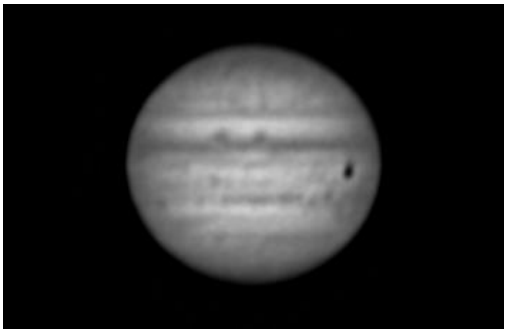
Date	Moon	Ingress	Egress	Altitude at Ingress	Altitude at Egress
8/7	Io	03:00	05:15	46°	49°
8/13	Europa	00:42	03:18	30°	49°
8/13 **Double**!	Io	23:23	01:38	19°	40°
	Ganymede	23:58	02:57	25°	49°
8/20	Europa	03:18	05:53	50°	39°
8/23	Io	01:18	03:32	42°	50°
8/30	Io	03:12	05:27	50°	36°
8/31	Io	21:41	23:55	12°	35°

The August 13 double shadow transit will last from 23:58 to 01:38 the next morning, with Jupiter at a reasonable altitude.

Try to observe and image away from heat sources (houses, streets) where thermals continue all night. Scopes should be at ambient temperature and Newtonians & SCTs should be well collimated.



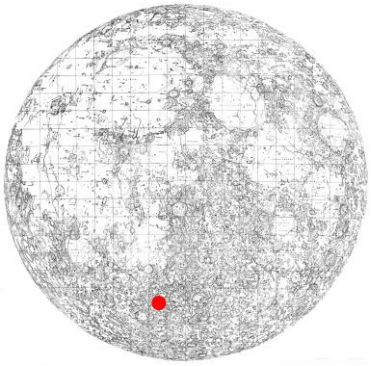
Double shadow transit of Io and Ganymede June 3, 2017. Ganymede is visible on the right edge; Io is transiting and can't be resolved. 8" SCT, NexImage 5 color camera. LF

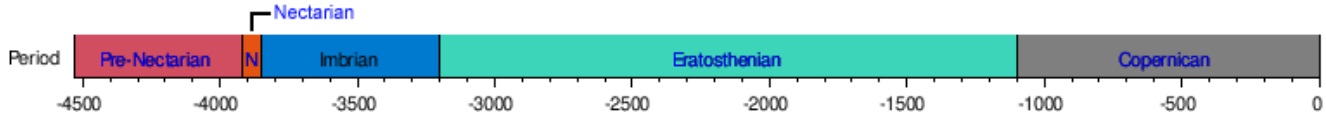


August 13, 2021: Io's shadow is just north of the Great Red Spot. The Moon itself is transiting just west of the shadow. 8" SCT + 2X Barlow, ASI290MM monochrome camera. LF

Tycho by Larry Faltz

One of the most recent impact craters on the Moon, Tycho is 53 miles in diameter and three miles deep. The impact happened 108 million years ago, as determined from analysis of material thought to be from its ray system brought back by Apollo 17. The rays, which can be traced across the Earth-facing lunar surface as far as 1500 km, consist of tiny, high-albedo fragments of lunar rock and impact glass. The high-albedo interior of the crater contains many of these particles. Over time, cosmic ray and solar wind impacts degrade the ejecta and the rays disappear. They are very visible when deposited on a low-albedo surface like the lava of a lunar maria. This accounts for the persistence of bright rays around Copernicus, a crater formed about 800 million years ago (although 800 million years is still "recent" and both Tycho and Copernicus are included in the "Copernican" lunar era, the most recent). Tycho's rays, being young, are still visible even over the high-albedo southern highlands. One reaches, and may even cross, the Mare Nectaris.





April 12, 2022, 9:30 p.m. Larchmont NY (my driveway). Seeing 4/10 (good for the suburbs, imaging over rooftops), transparency 8/10. Moon age 11.80 days, illumination 84.1%, Moon altitude 62 degrees. Orion Apex 127-mm Maksutov on iOptron Minitower, ASI290MM, best 25% of 4,000 frames stacked with Autostakkaert!3, wavelets with Registax 6.1.

Research Highlight of the Month

Anderson, CS, Carilli, C, Tozzi, P, et. al., The Spiderweb Proto-Cluster is Being Magnetized by its Central Radio Jet, arXiv:2207.03498v1, posted July 7, 2022. Accepted for publication in *Astrophysical Journal*

The star formation rate in the universe reached its peak around 10 billion years ago, in the era of quasars. These young galaxies contained supermassive black holes whose radio jets interacted with the surrounding environment to control the flow of gas. The jets could heat the gas to limit star formation, which depends on the gravitational contract of clouds of cool gas, or alternatively to enhance localized star formation by magnetic compression of gas clouds. Magnetic fields also affect the viscosity, pressure and thermal conductivity of the gas. The early universe was small and dense. Even the energy of the cosmic microwave background was higher (it scales as $(1+z)^4$), which in turn creates more inverse Compton scattering (interaction of CMB photons with relativistic electrons) and has impacts on gas temperature and pressure.

The authors used the Jansky Very Large Array to study the Spiderweb Galaxy, a z=2.156 galaxy with an active galactic nucleus some 10.6 billion light years distant. They mapped the magnetic fields along the jets emerging from the galaxy's supermassive black hole by measuring the Faraday rotation of polarized radio emissions.

The authors note "Our observations provide the most detailed ever maps of the magnetic field structure in a high redshift source. The emission-weighted, sky-projected magnetic field orientation (Fig. 2, panel c) is broadly aligned with the jet axis over the entire length of the system (∼ 70 kpc) where polarized emission is detected." The authors also note that "consistent picture emerges of a radio jet undergoing vigorous interaction with the surrounding gaseous environment, which is likely still in the process of falling into the system and equilibrating. The strong jet-gas interaction signatures may mean that the radio jet drives outflows observed in the system, rather than radiation pressure and winds from the central AGN." Many observational, structural and astrophysical details are given in the paper.

Spiderweb Galaxy (HST)

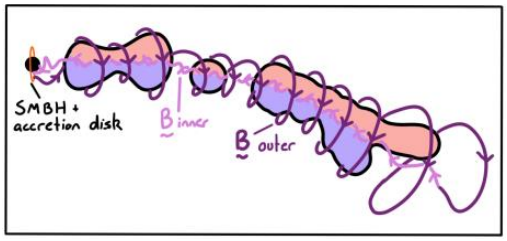


Fig 6: Model of the magnetic fields in the galaxy's jet

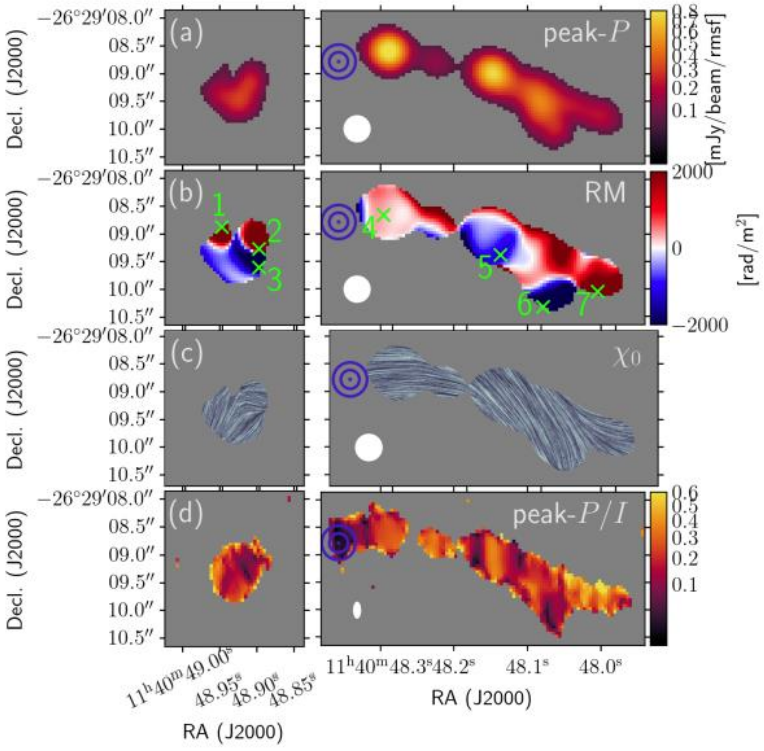


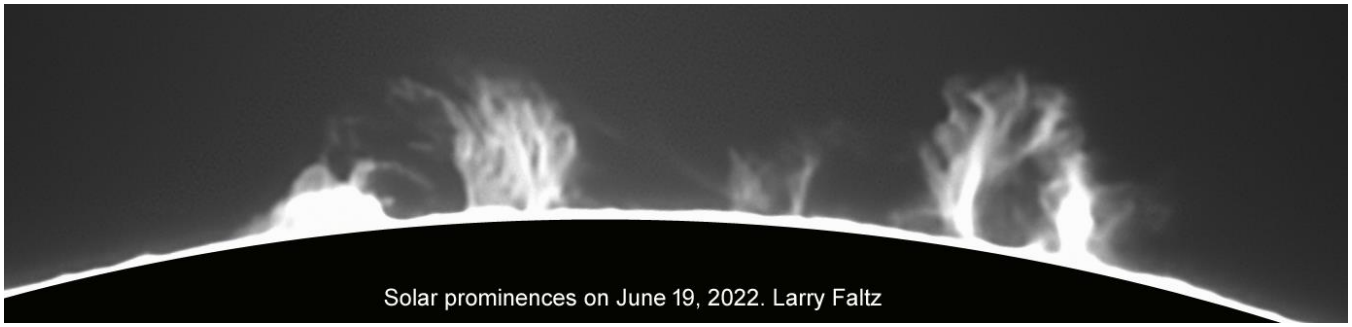
Fig 2: Radio and magnetic maps of the jet. The AGN core is located at the blue concentric circle marker

Member & Club Equipment for Sale

Item	Description	Asking price	Name/Email
Astronomy Books	From classic books on astronomy and astrophotography to bios and science classics. Selling all as one unit. See the titles at https://is.gd/cefbooks	$50	Mike Cefola meteormik@aol.com
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.	$110	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 Eyepiece Set	Like new condition. 4, 6, 9, 10, 15, 32-mm eyepieces, 2X Barlow, 6 colored planetary filters, Moon filter, in padded case. Donated to WAA	$125	WAA ads@westchesterastronomers.org
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
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

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!*



Solar prominences on June 19, 2022. Larry Faltz