SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

February 2024

Messier 87 by Arthur Miller

The giant elliptical galaxy M87 in the Virgo cluster is surrounded by 12,000 globular clusters, many of which can be seen here as bright points encircling the galaxy's halo. The two galaxies at 8 o'clock are sometimes mistaken for M87's famous jet, which on close inspection can be resolved in this image (see page 19). The distance to M87 is 16.4 Mpc; LEDA 139919, the closer of the two small galaxies, is 126 Mpc away while the redder UGC 7652 is 360 Mpc distant. Also seen are NGC 4486A (8.9 Mpc) on the left and IC 3443 (25.5 Mpc), left top. Celestron 11-inch SCT, from Quail Creek, Arizona. The field of view is 20.2x13.7 arcminutes.

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

WAA February Meeting

Friday, February 9 at 7:30 pm

The Vera Rubin Observatory Camera and LuSEE-Night

Steve Bellavia
Brookhaven National Laboratory

Two of the most recent projects at the Brookhaven National Laboratory are the camera for the Vera Rubin Telescope (formerly called the Large Synoptic Survey Telescope) and the LuSEE-Night lunar radio telescope. Steve will discuss the design and construction of these instruments and describe their scientific goals.

Steve is an amateur astronomer, astrophotographer and telescope maker. He's been at Brookhaven National Laboratory since 1992 and is the principal mechanical engineer for the Vera Rubin camera, the largest and most sophisticated astronomy camera ever built. He is an assistant adjunct professor of astronomy and physics at Suffolk County Community College and the Astronomy Education and Outreach Coordinator at the Custer Institute and Observatory in Southold, New York.

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

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

WAA March Meeting

Friday, March 8 at 7:30 pm

Galactic Archeology

Allyson Sheffield, Ph.D.
LaGuardia Community College & American Museum of Natural History

Starway to Heaven

Ward Pound Ridge Reservation

First 2024 star party March 9, weather permitting.

New Members

Robert Blake	Bedford
Ron Gillespie	Tarrytown
Alexander Profaci	Irvington
Michael Rozenblat	Yonkers
Jim Whittock	New Rochelle

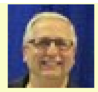
Renewing Members

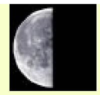
Christopher Abbamont	Goldens Bridge
Jim Carroll	Peekskill
Byron Collie	Croton on Hudson
Joseph Depietro	Mamaroneck
Larry and Elyse Faltz	Larchmont
Patricia Gelardo & Frank Antinarella	Mamaroneck
Jonathan Gold	Newcastle
Susan Light	Chappaqua
Richard Link	Ardsley
John Markowitz	Ossining
Geoffrey McFadden	Stamford, CT
Una O'Malley Petrino	Yorktown Heights
Arlene Persampieri	Mamaroneck
Richard Rubin	Somers
Srikanth Srinivasan	Mount Kisco

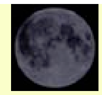
Also In This Issue

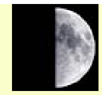
ALMANAC For Feb 2024

Bob Kelly, WAA VP of Field Events


Bob Kelly


3Q Feb 2


New Feb 9


1Q Feb 16


Full Feb 24

Venus and **Mars** get friendly in the morning sky. Last month, Mercury failed in its attempt to climb the ladder to Venus' perch. Now, it's Mars' turn. On the 22nd, you can celebrate Mars reaching Venus' altitude when it passes about a Moon's width from Venus. Venus is slowly sinking in the southeastern sky, rising after the start of morning twilight after the 7th. It's still the brightest object in the sky (except for the Sun and Moon) at magnitude -3.9. It's getting smaller in angular size and is a pudgy gibbous disk in a telescope. Mars is tiny, one-third of Venus' 12 arc second diameter, and dim at magnitude +1.3. Mars seems in no hurry to get separation from the Sun. It won't rise before the start of morning twilight until mid-May. Venus won't be up in a dark sky again until October.

Mercury starts the month rising 50 minutes before sunrise, still getting brighter as it swings toward us, increasing from magnitude -0.3 at the start of the month. It was easy to find in mid-January halfway down from Venus at the start of twilight, but now it's sinking into the solar glare.

Mercury and Saturn are in conjunction with the Sun on the 28th. Look for them in the SOHO C3 viewer at https://soho.nascom.nasa.gov/data/realtime-images.html. Mercury and Saturn pass each other on the 28th, their shared conjunction day.

See https://sungrazer.nrl.navy.mil/transits_2024 for dates when objects are visible in the C3 solar telescope, including Comet C/2023 A3 (Tsuchinshan-ATLAS) in October. See the image on page 4.

Jupiter is still high in the evening's southern sky at sunset, setting about midnight in early February. Jupiter's colors are best seen during late twilight as the planet's brightness (magnitude -2.3) can overwhelm the eye with the large light-gathering capability of our telescopes.

Saturn sets by the end of astronomical twilight by the end of the first full week in February. It will be hard to spot **Iapetus** west of Saturn, brightest and furthest out from Saturn on the 17th. Saturn's ring looks narrower, its tilt decreasing through 7 degrees this month, heading toward a minimum in July.

Want to compare the color of **Uranus** and **Neptune**? Look early - Neptune is getting pretty low in the evening sky. It will set before the end of twilight after the 24th. Uranus is still up there in Aries, following an hour behind Jupiter.

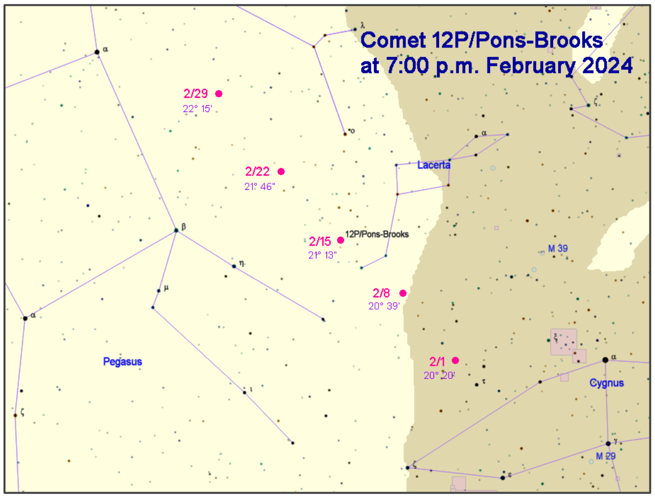
Orion is highest in our skies right after the end of evening twilight this month, making it a great time to view the Orion Nebula and neighboring **Pleiades** and **Hyades** clusters. **Sirius**, the brightest star in the sky at magnitude -1.6, follows Orion, a bit lower in the sky. Sirius is 'only' 8.6 light years away from Earth. We often say that's why it's so bright in our sky, but Sirius is no slacker as far as its intrinsic brightness. It's not Rigel or Deneb, who have absolute magnitudes of -6.9, but Sirius, at absolute magnitude +1.5, is more luminous than any of the 50 stars nearest our Sun.

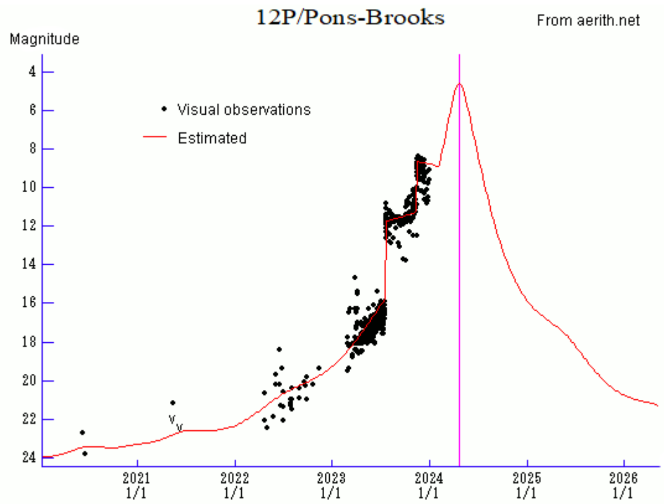
The **Moon** is closest to Earth on the 10th, twenty hours after new Moon. Watch out for larger-than-normal tide ranges then, and a few days afterward. Conversely, the full Moon on the 24th is the smallest of 2024.

For an update on what comets might be our best bets to see in 2024, compare the latest from Guy Ottewell's site https://www.universalworkshop.com/2024/01/12/comets-of-2024/#more-17092 with the summary for 2024 in the January issue. Updated information is also available at http://www.aerith.net/comet/weekly/current.html. **Comet 12P/Pons-Brooks** may reach 7th magnitude or brighter in the west-northwestern sky after evening twilight later this month. Map for February on page 4.

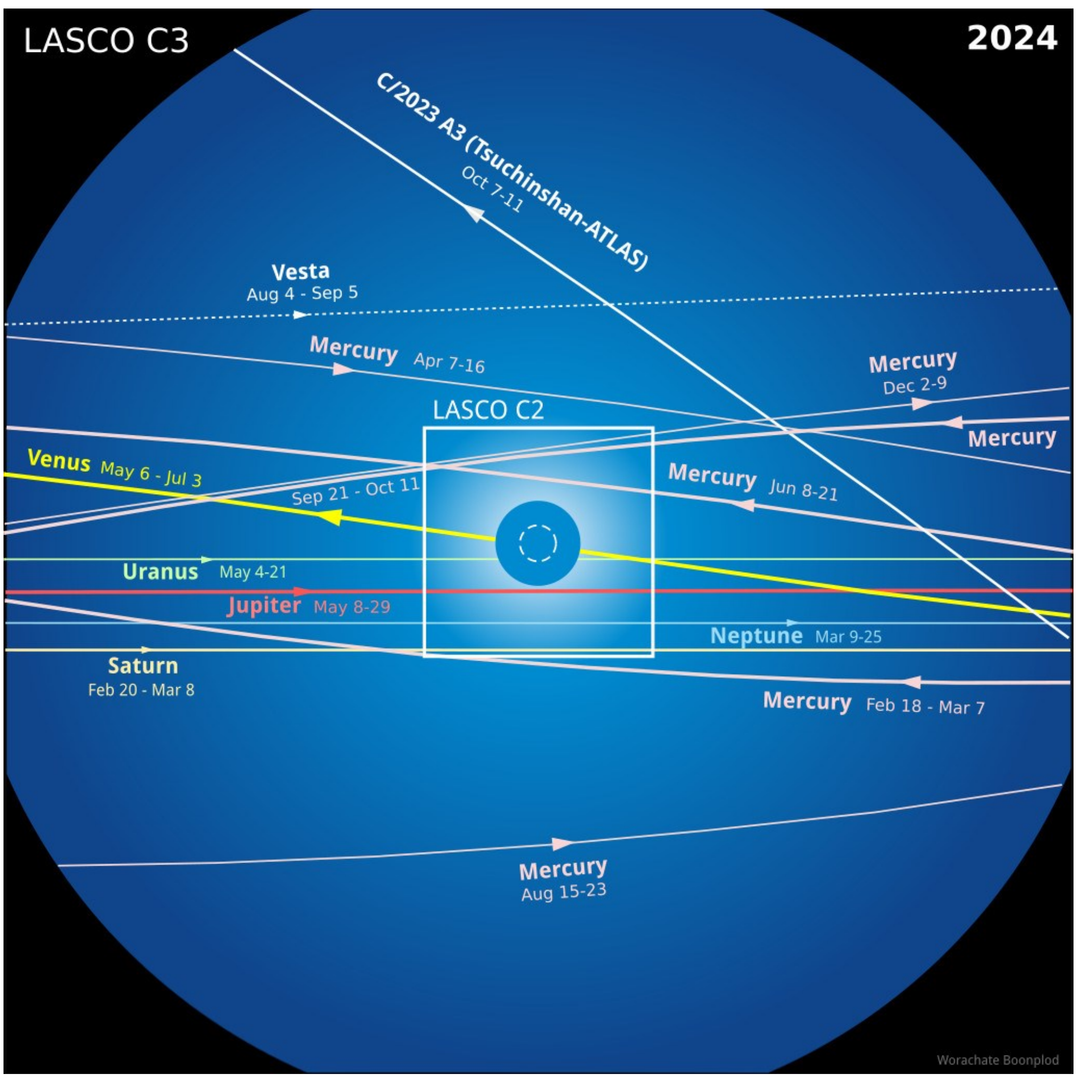
Satellite sightings visible to the unaided eye include the **International Space Station** in the evenings through the 4th. It can be viewed in the morning sky from the 13th onward. China's **Tiangong** can be seen in the mornings from the 3rd through the 18th and in the evening beginning on the 26th. Check https://heavens-above.com for updates as orbits can change with time.

Comet 12P/Pons-Brooks in February 2024





Planets and a Comet Visible in 2024 in the Solar and Heliographic Observatory LASCO C3 Camera



The Seven Sisters

Eva Andersen, WAA VP-Membership & Chief Confections Officer

The first WAA star party of 2021 was held that year on March 13th and it was a very memorable one at that.

My husband Erik and I were at the entrance to the Meadow parking area of Ward Pound Ridge Reservation in Pound Ridge, NY, managing the attendees according to the Covid protocols set forth by Westchester County and New York State. Adults had to be vaccinated and everyone needed to complete a Covid tracking form and be one of only fifty in the lot. Attendees were asked to wear a mask and maintain social distancing while telescope owners cleaned their lenses with 95% alcohol wipes after each observer.

I checked the vaccination cards, we both helped complete the paperwork and Erik kept track of everyone who went in and out of the lot.

Despite temperatures being in the low 40's and high 30's a surprising number of individuals, families and groups came to our event. People were eager to escape the confines of isolation and quarantine and the "remote" world that dominated their lives.

We rarely have fifty people at our monthly observing sessions but on this evening, in addition to our regular club members who set up telescopes, we knew there would be approximately 75 Boy Scouts and Cub Scouts camping adjacent to our observing site. They had made prior arrangements to attend the star party. The scouts agreed to stagger their arrivals to help us prevent overcrowding.

We had a long line of cars, vans and blazing headlights waiting to get into the lot. While it was great to see so many enthusiastic star gazers, it was a challenge keeping track of everyone. The park ranger made a few visits on a golf cart to make sure we were following the rules and attentively watched as we checked cards, collected forms, maintained an accurate headcount and kept track of the "clean" vs the "used" pencils.

Fortunately, we had a lot of telescopes that evening. Bob Kelly was delivering one of his five-star laser-guided constellation talks near a group of star-struck scouts who were focused, attentive and asking thoughtful questions, when yet another van full of passengers pulled up to the checkpoint. I still recall my mini-panic attack at thinking "where exactly are we going to put more people?" The lot was had reached its limit.

Luckily, by the time the paperwork was done, many of the scouts had hiked to their tents and our new arrivals were on the ground.

Seven women in dark blue and white habits with veils cheerfully announced they were the "Seven Sisters coming to see the Seven Sisters."

They explained that they drove up from their convent in Yonkers. One of the attendees, Sr. Mary Margaret Hope, had been an astronomer before entering religious life. The day of our observing session coincided with her "feast day," a special day of commemoration where the life of a specific saint or event is remembered and celebrated. Her wish was to see the *Seven Sisters*, also known as the *Pleiades* open star cluster, which is best observed in the winter sky near the shoulder of Taurus the

Bull. The Messier catalog lists this exceptionally beautiful object as M45. The Pleiades contains over 1,000 stars loosely bound by gravity, but it is visually dominated by a handful of its brightest members. This formation has been observed since ancient times and has no known discoverer. Under dark skies, dark-adapted observers with excellent eyesight report seeing up to 14 stars in this cluster, but most observers see only 6 stars in the Pleiades. There are legends in most cultures about the seventh "lost" sister. The Greeks who named the Pleiades sometimes considered Merope to be the "lost sister." Unlike her siblings she married a mortal, Sysiphus, the guy who had to push the rock up the hill for eternity. The loyal Merope stayed with him in Hades.

The Seven Sisters from Yonkers absolutely crushed it on 3/13/21!

In addition to the Pleiades the sisters had a front-row seat for the Hyades, Taurus, Orion, Gemini, Auriga, Canis Major, several Messier objects, dozens of Boy Scouts, many amateurs astronomers happy to make their acquaintances, a few nice meteors, and Mars.

Their wool attire kept them cozy while their cheerful and spirited enthusiasm added something very special to an already exceptional evening full of heavenly wonder and earthly camaraderie.

For more on the Pleiades, see the February 2021 SkyWAAtch, p. 15.

The Seven Sisters, left to right: Sr. Caroline Caritas, Sr. Mercy Marie, Sr. Mary Margaret Hope (the astronomer), Sr. Annunciata Maria, Sr. Benedicta, Sr. Elizabeth Grace, and Sr. Martha Maria Guadalupe. The telescope is Eva Andersen's Televue NP101.

Eva's recipe for the official WAA cookie is on page 13 of the November 2020 SkyWAAtch.

Deep Sky Object of the Month: The Trapezium

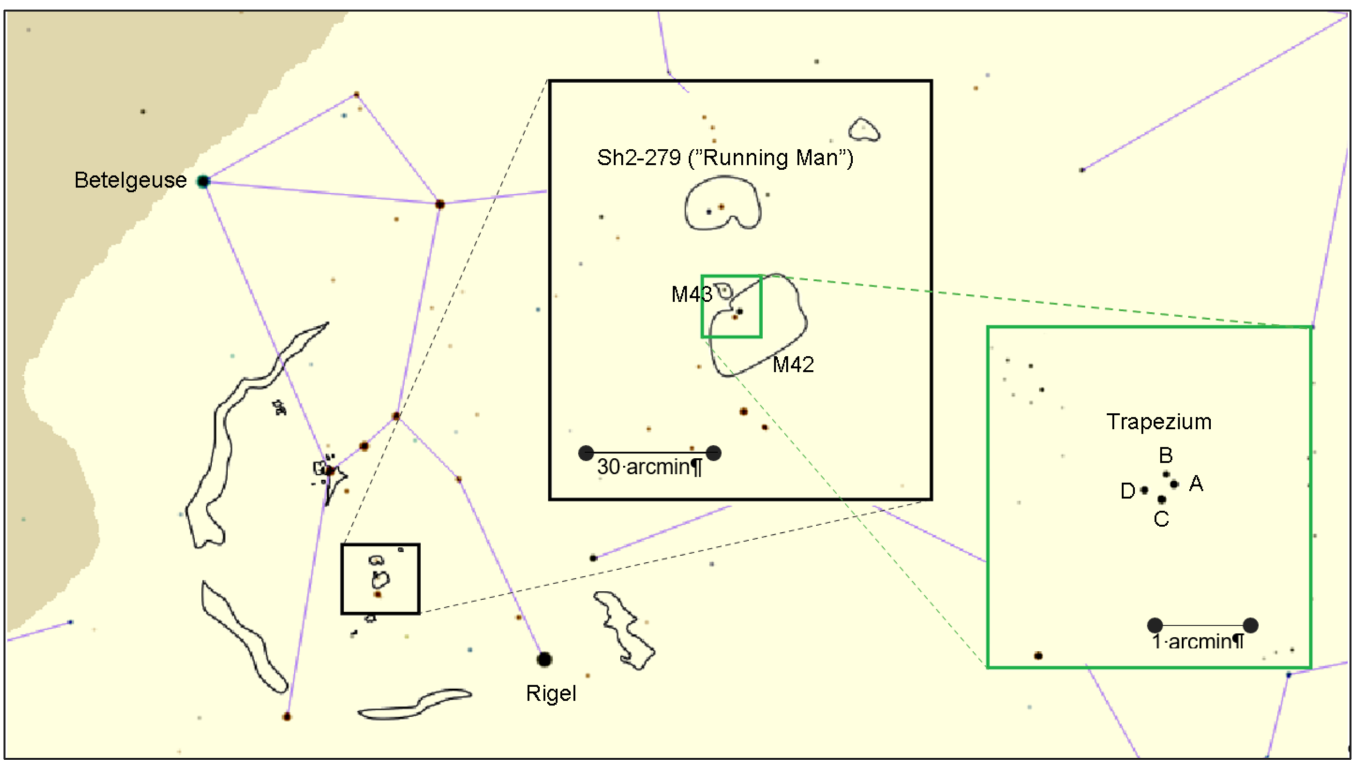
The Trapezium	
Constellation	Orion
Object type	Open Cluster/Asterism
Right Ascension J2000	05h 35m 15s
Declination J2000	-05° 22’ 23”
Magnitude	4.0
Size	47 arcseconds
Distance	1,344 ± 20 light years
NGC designation	Within Messier 42
Discovery	Galileo Galilei 1617

The four stars that make up the Trapezium (Galileo only saw three) are the brightest of a cluster of perhaps 2,000 young, hot stars within the Orion Nebula. O and B stars with masses of 15-30 $M_{\odot}$, their intense radiation powers the Orion Nebula. The four members of the Trapezium are within 1.5 light years of each other. Components A (the brightest, also known as θ_1 Orionis) and B are eclipsing binaries. The main star of θ_1 Orionis has a luminosity 250,000 times that of the Sun. There has been a suggestion that a 100 solar mass black hole lives within the larger Trapezium cluster, accounting for high velocity dispersion among its members. Star formation continues to occur within Messier 42.

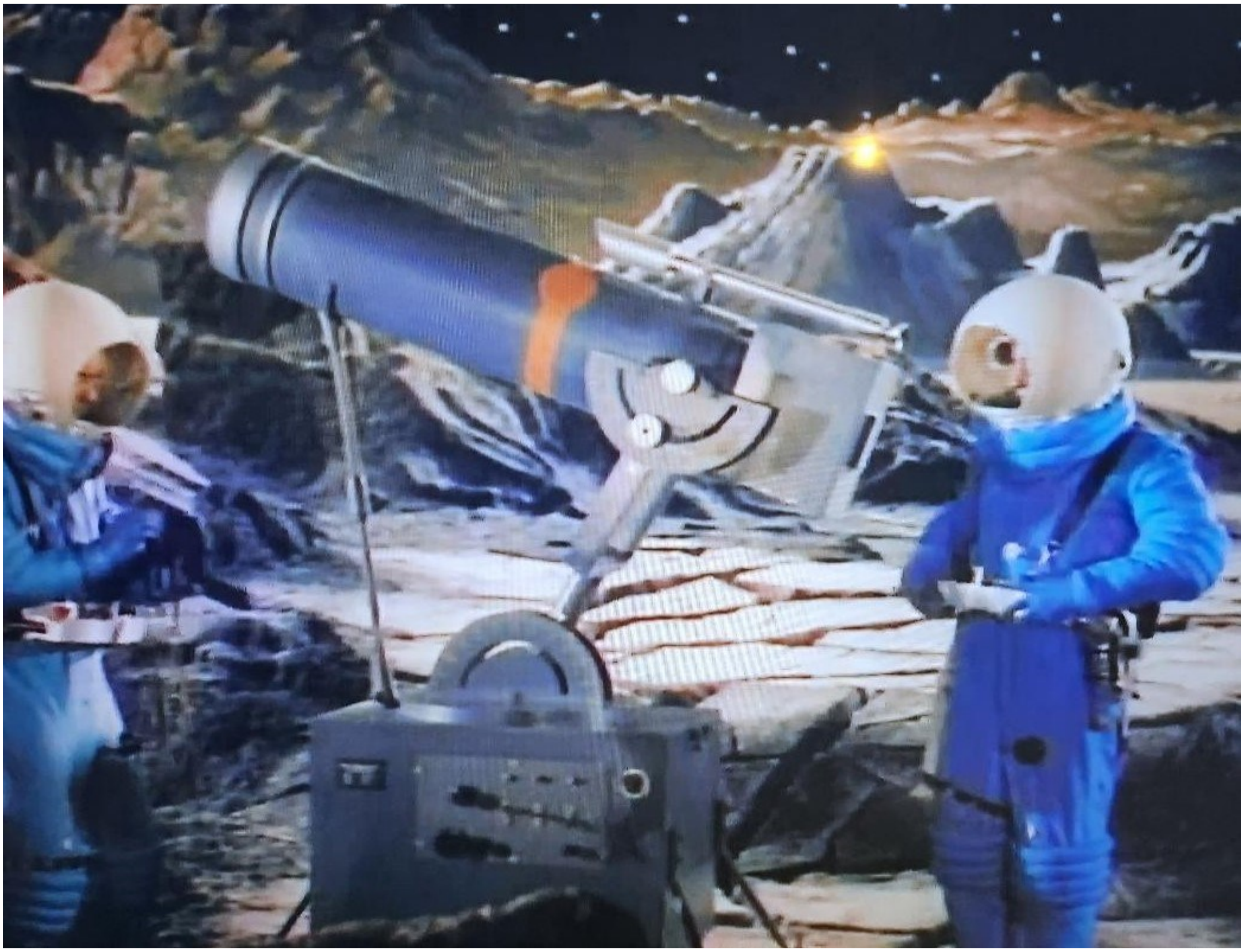
Visibility for the Trapezium			
10 p.m. EST	2/1/24	2/15/24	2/29/24
Altitude	40° 12’	34° 31’	26° 51’
Azimuth	205° 16’	221° 02’	234° 19’

One of the most difficult challenges in astrophotography is to make an image of Messier 42 that shows detail throughout the nebula but doesn’t wash out the Trapezium. It requires multiple exposure durations, masking and computer manipulation.

Fly thorough the Orion Nebula in a NASA video at https://www.youtube.com/watch?v=fkWrjrdT3Zg.



Another Movie Telescope



George Pal's *Destination Moon* (1950) was the first movie to address the actual scientific and engineering problems of space flight. It anticipated some historical and even current aspects of the space program. In the film, the US space program is competing with an unnamed non-Western power, which in 1950 would have clearly meant the Soviet Union. At the beginning of the film, government funding is cut after a rocket failure, so the rocketeers have to raise money privately from wealthy, patriotic industrialists who can supply the needed funds and materials, in a sense foreshadowing the current commercial space environment. The rocket has an atomic propulsion system, which engenders public opposition over safety concerns, analogous to sporadic outbursts of public objections to US space missions carrying radiothermal generators (the first ones were on Pioneer 10 and 11) although the RTGs were used to supply electrical power and not propulsion.

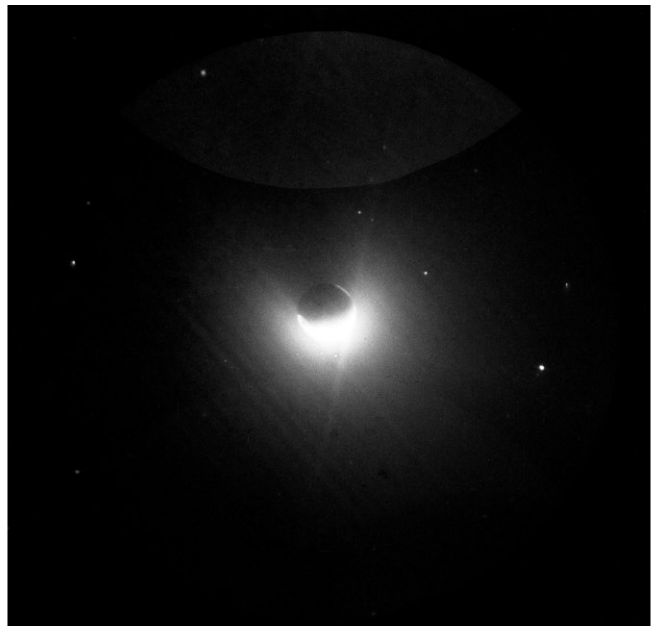
The corporate benefactors (and the film's audience) are given a basic education on the science of spaceflight in a cartoon hosted by Woody Woodpecker. Woody's creator, Charles Lantz, was one of George Pal's closest friends.

Science fiction writer Robert A. Heinlein, whose novel *Rocket Ship Galileo* was partially adapted for the film, also wrote some of the screenplay. Pal's movie featured backdrops by Chesley Bonestell, who later did the background art for Pal's 1951 film *When Worlds Collide* (see the November 2022 SkyWAAtch, p. 5). The *Destination Moon* backdrops were exhibited at the Metropolitan Museum of Art's 2019 show "Apollo's Muse," which presented visual representations of the Moon from Galileo's time to the present.

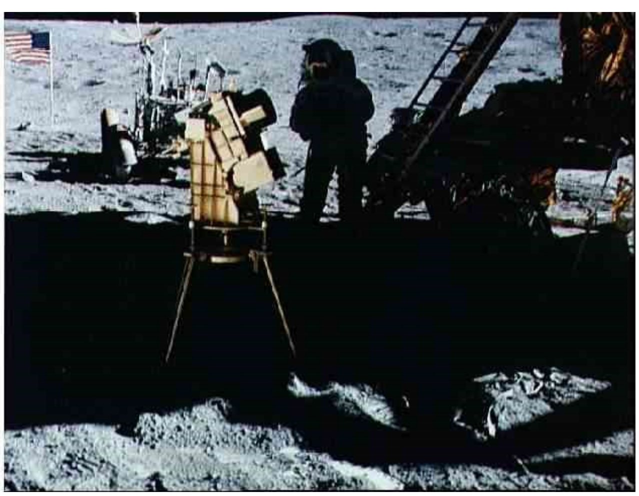
In *Destination Moon*, the astronauts set up a telescope that looks like an astrograph with a film plate holder on the back. This presaged an actual lunar telescope, an ultraviolet instrument brought to the lunar surface on Apollo 16. The Far Ultraviolet Camera/Spectrograph, a 75-mm f/1.0 Schmidt, was designed by physicist-engineer George Carruthers at the US Naval Research Laboratory after NASA, in response to the success of Apollo 11, solicited scientific experiments that could be done on the lunar surface. Ultraviolet radiation is absorbed by the Earth's atmosphere, and so it made sense to investigate the UV band from Luna's vacuum.

Astronauts John Young and Charles Duke used the gold-plated instrument to capture (on film) 178 images of distant star clouds, nebulae, and the Earth's outer atmosphere. In 2013, the Chinese Chang'e 3 lander placed a CCD-equipped robotic 50-mm f/3.75 Ritchey-Chretien UV telescope on the lunar far side. ■

George Carruthers (right) and NRL project manager William Conway (left) with the Far Ultraviolet Camera/Spectrograph (USNO)

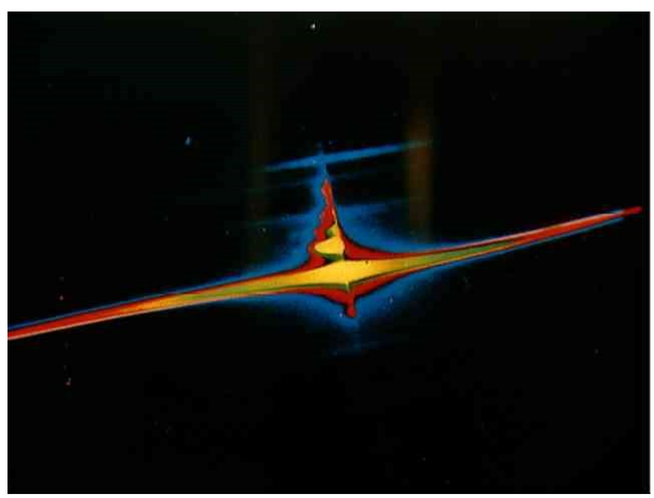


An image of Earth with the Far UV camera (NASA)



The Far UV Camera/Spectrograph on the Moon (NASA)

Thanks to John Paladini for submitting this movie telescope.



False-color UV spectrum of the Earth's upper atmosphere from the camera's spectrograph. The lump-like condition is caused by gases such as oxygen, nitrogen, and helium. The spectral dispersion is 10 angstroms per millimeter. (NASA)

WAA Members Picnic 2023, Sunday September 17, 2023
Croton Point Park, Croton-on-Hudson, NY

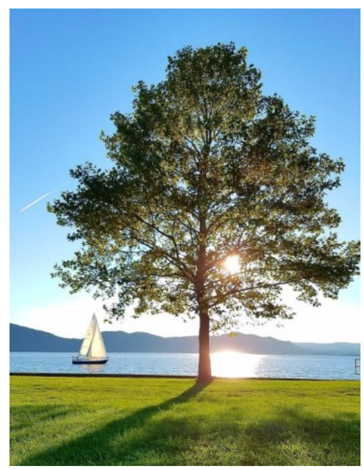
Eva Andersen

Our annual 2023 Members Picnic was held in mid-September after severe weather cancelled our planned June 17th event. Due to a slow start (good charcoal but bad lighter fluid) the first course never progressed beyond macaroni salad and Milky Way bars but those fine delicacies sustained the 50 attendees, including member canines Hamilton and Clyde, during the prolonged social hour until the hot food was ready. Several rounds of competitive "Black Hole" were played, old friends caught up, new acquaintances were made and the Trivia Contest was expanded to add new categories including Sports, Music and Science. AND you could double your points with a good Black Hole toss. It was SO MUCH FUN to see other members in the daylight and **FANTASTIC** to have so many families and kids energize our event.







SAVE THE DATE!

The **2024** WAA Annual Members Picnic will be held on

SATURDAY JULY 20, 2024, from 12 p.m. to 4 p.m.

Croton Point Park, Pavilion 1   Croton on Hudson, NY 10520

More information to follow

Eva Andersen VP Membership /Cookies/Picnic

The Large Scale Structure of the Universe: Superclusters and Beyond

Larry Faltz

By the late 1970s it was clear that many, if not most, galaxies were members of clusters, as we related last month (January 2024 SkyWAAtch, p. 14). Theorists thought that the size, distribution and content of the clusters could yield insights into galaxy formation and dynamics of the early universe. The eminent Russian nuclear physicist and cosmologist Yakov Zel'dovich, who in 1964 suggested that accretion discs around black holes powered quasars (proposed independently that same year by Edwin Salpeter), believed in a "top-down" theory: the first structures in the universe were massive galaxy conglomerations that broke down into smaller clusters of galaxies. This was not the view in the West. Cosmologists such as Jim Peebles and Gerard de Vaucouleurs proposed that small galaxies were the building blocks, agglomerating into clusters through the force of gravity as the universe aged. At the time, albeit on its last legs, the steady-state theory of the universe was still competing with Big Bang cosmology for acceptance. So any theory of galaxy clustering had to work in either setting.

Galaxy surveys done by Shapley and Ames, Abell and Zwicky were two-dimensional. While the shape (elliptical, spiral, lenticular), angular dimensions, brightness and position of brighter galaxies could be reasonably specified and some distances approximated (see "Determining Galactic Distances" in the March 2021 SkyWAAtch, p. 10), there were not enough detailed spectra to provide really accurate distances, especially for fainter galaxies beyond those in the Local Group and Virgo Cluster.

The search for structure was aided by advances in technology. It wouldn't be bigger telescopes that gathered new data, but better sensors. The photographic plate gave way to the photomultiplier tube, which in turn was replaced by the charge-coupled device (CCD) (see "The History of Photoelectric Astronomy" in the November 2021 SkyWAAtch, p. 9).

It took several hours for Edwin Hubble to record a galaxy spectrum on a photographic plate with the 100-inch Hooker telescope at Mt. Wilson. By the 1980s, the same spectra could be obtained in a few minutes with a 60-inch telescope and a photomultiplier detector. With multi-object fiberoptic spectrometers and CCDs arriving in the 1980s, the acquisition rate was multiplied by as much as 400. Hubble discovered the expansion of the universe in 1929 with the spectra of just 46 galaxies. In 1956 there were about 600 galaxies whose redshifts had been measured. In 1976 there were 2,700, in 1980 5,000 and by 1989 more than 30,000 galactic redshifts were cataloged.[1] Redshifts could also be determined by observing the 21-cm hydrogen line with radio astronomy; it too would be redshifted proportional to a galaxy's distance, at least for spiral galaxies that contained large amounts of gas. The variance in measured radial velocity, the speed at which galaxies are receding, or sometimes approaching, was reduced by a factor of more than ten. Radial velocities are now known for millions of objects, with accuracies of a fraction of a percent.

The "Hubble flow" increases the overall size of the universe. On average, galaxy clusters are moving away from each other at somewhere between 67 and 75 kilometers per second per Megaparsec because of the expansion of space. The Hubble flow is not stronger than gravity on local levels. Galaxies within clusters have "peculiar motion" that depending on their local gravity environment. If galaxies in our local cluster are approaching us, their light is blue shifted. Andromeda is the best example of "peculiar motion." It's coming at us at a speed of 300 km/s (redshift z= -0.001). Peculiar motion is not necessarily along the line of sight, but redshift can only be measured on that axis.

Within galaxy clusters, slight differences in redshift among the members could indicate differential motion around a common gravitational center, or the effect of a nearby mass density outside of the cluster. Determining these flows can help astronomers define the structure of space at the largest scales.

Are galaxy clusters just so many raisins in the universe's raisin bread, or are they linked in some more complex structure? The "Copernican Principle" says that there is a dimension at which space can be

References are at the end of the article.

considered homogeneous and isotropic, that is, local variances of mass and energy become irrelevant statistically. If you know that every chocolate chip cookie in the box is the same size and has the same number of same-sized chips, does it matter exactly how chips are arranged within each cookie if your unit of scale is “chocolate chip cookie”?

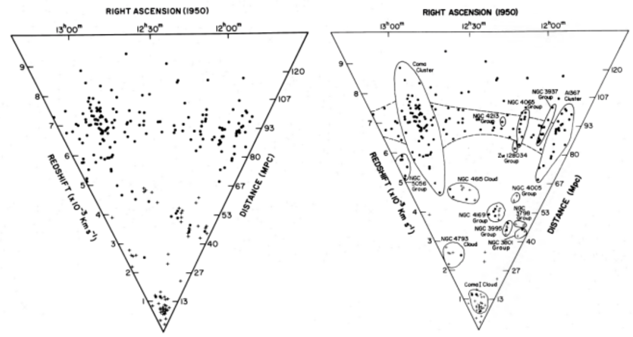
The universe is homogeneous and isotropic at some scale. As the universe expanded after the Big Bang and differentiated into discrete objects, from fundamental particles to atoms to molecules to stars to galaxies to galaxy clusters, that scale increased. In 1961, Gerard de Vaucouleurs suggested that,

> if clusters are the largest organized agglomerations of matter in the universe, the large-scale distribution of matter can be considered as already statistically uniform and isotropic in volumes of space of the order of 10 Mpc^3, since typical cluster diameters are of the order of 1 to 2 Mpc.
>
> If on the other hand, the largest recognizable agglomerations of matter are superclusters with typical diameters of the order of 20 or 30 Mpc, the presumed uniform and isotropic large-scale distribution will not emerge until volumes of space of the order of 100 Mpc^3 are considered. If so, considerable nonuniformity and anisotropy will prevail in regions of radius less than 50 Mpc, as indeed is actually observed.[2]

If the Copernican Principle is true, we should be able to discover the current dimension at which any one bite of the universe is equivalent, in terms of average physical characteristics, to any other bite. The dimension of this Copernican unit should be consistent with cosmological theory, the current case being “Lambda-CDM” (ΛCDM).

In the 1970s, several groups began to map galaxy clusters in small sections of the sky in three dimensions. It was only when Tifft and Gregory looked at the Coma cluster and made a visual map of all the galaxies did it become evident that their distribution was not uniform at a scale even larger than de Vaucouleurs had suggested 15 years earlier.

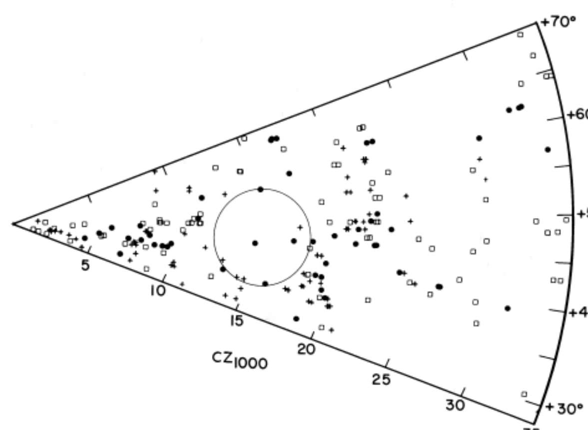
They published the first “cone diagram,” showing the galaxies in the Coma cluster arranged not just by position but by recession velocity, which correlates with distance. A large area devoid of galaxies was evident between recession velocities of 2000 and 4000 km/s (equivalent to redshift 0.007-0.013, and a distance of 30-56 Mpc).[3] The angular diameter of their survey was too small to capture the complete void.



Coma-A1367 map[4]

Two years later, their wider survey of the area showed that the Coma cluster and the Abell 1367 cluster are connected by a bridge of galaxies forming the back of the large void, now shown completely. They were able to identify other clusters in the region as well. The bridge between the Coma Cluster and A1367 was dubbed the “Great Wall.”

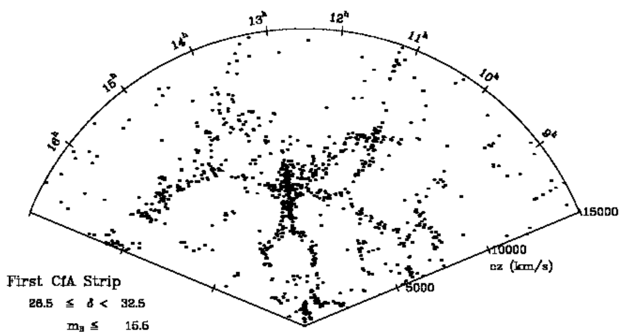
In 1983, a survey of three small fields in the direction of the north galactic pole (which is located in Coma Berenices) suggested another large void. This was confirmed with spectra from the Kitt Peak 1.3-meter telescope. The center of the void is at a recession velocity of 15,000 km/s (red shift ~0.05, distance 214 Mpc). Its volume is a million cubic Megaparsecs.



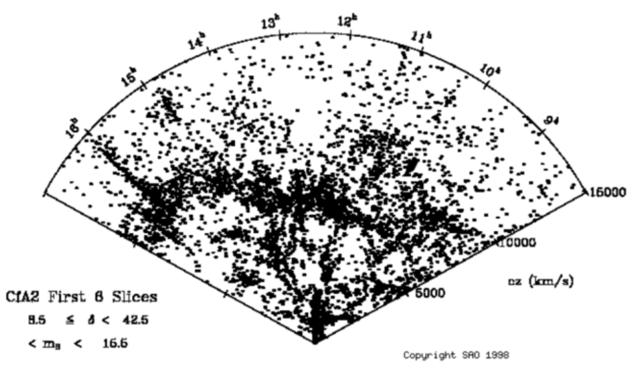
The Boötes Void[5]

The Center for Astrophysics (CfA) Redshift Survey was initiated in 1977 with the goal of measuring the redshift of galaxies brighter than magnitude 14.5, using the 1.5-meter telescope at what was then Smithsonian Mount Hopkins Observatory, now the Fred Whipple Observatory, on Mt. Hopkins, south of Tucson. In 1983, results for 2401 galaxies were published. With the universe now being viewed in three dimensions, relationships among galaxy clusters becomes clearer.

A second survey commenced in 1985 and ran for ten years. A total of 18,000 galaxies were included. Showing the galaxies in proper three-dimensional perspective is difficult, cone diagrams with different thicknesses not giving a clear 3D picture. At the time there were no on-line rotatable graphics. The cone diagrams show galaxies in a wedge of right ascension, the wedge having a “thickness” of some value of declination. Only a limited declination can be covered in this projection. But the structure becomes clearer if wedges are superimposed. There are groups, walls and voids. Layering on the slices shows the structure more clearly, if not perfectly.

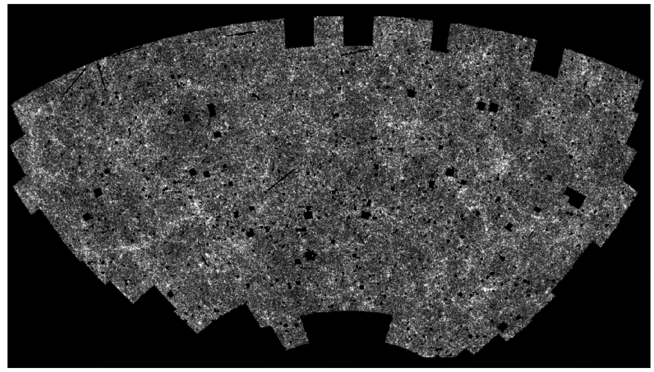


CfA survey, galaxies between 26.5 and 32.5 declination (a thin wedge). The homunculus is the Coma cluster.



CfA survey, galaxies between 8.5 and 42.5 declination (a thick wedge). With a larger volume of space, the Great Wall is more clearly demonstrated.

Another survey that showed a web-like structure, albeit not a redshift survey, was the clever APM Galaxy Survey. The team from Oxford and Cambridge universities scanned 185 plates from the UK Schmidt survey with an automatic plate scanner, netting over 2 million galaxies between magnitudes 17.0 and 20.5 in 4500-square degrees of sky, about 10% of the heavenly sphere. A web-like structure was evident in spite of the absence of distance data. The primary purpose of this effort was to contribute to what was becoming the Standard Model of Cosmology (ΛCDM) through measurements of cosmic density.



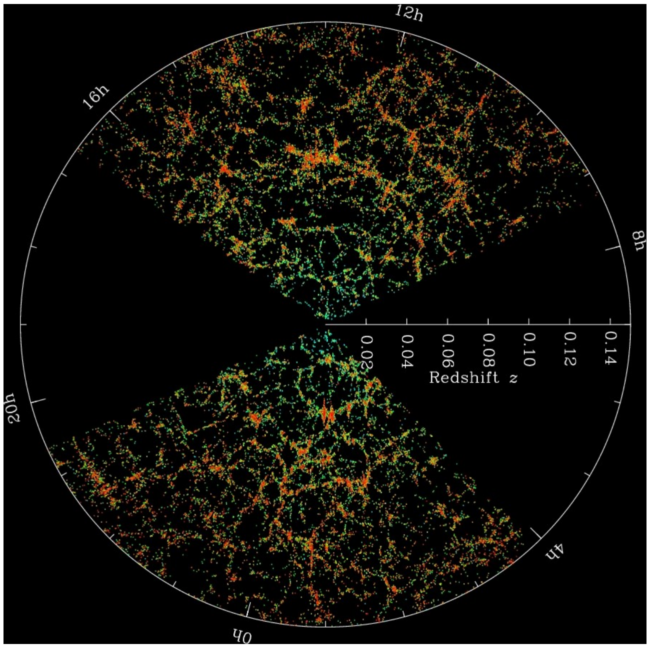
The APM Survey Map[6], Holes in the web are where bright stars prevented evaluation of the galaxies.

After the CfA survey, other redshift surveys gave more structural information about the universe at even greater scales. The Las Campanas Redshift Survey catalogued 26,418 southern hemisphere galaxies to redshift 0.2, showing filaments and voids. The 2dF survey, made with the 4-meter Anglo-Australian telescope, delivered high-quality spectra of 221,414 galaxies and further demonstrated the web-like structure of the cosmos. Filaments, sheets and voids abound.

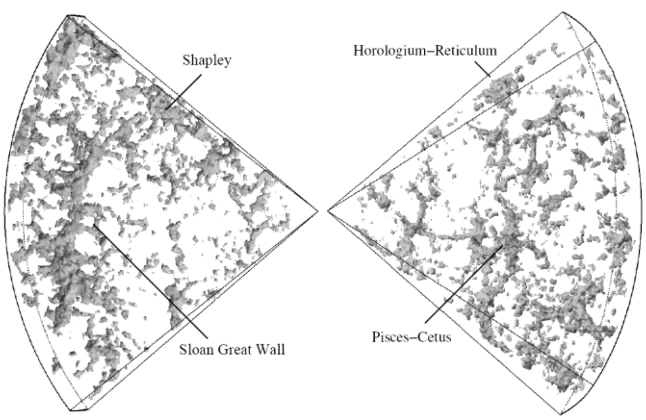
2dF galaxy survey, showing galaxies out to z=0.2

Commencing in 2000, the Sloan Digital Sky Survey has to date imaged a billion objects and made 400,000 spectra. Its 2.5-meter telescope sees a swath of the northern hemisphere from its perch on Apache Point, NM. There are spectra for some galaxies as distant as z=0.7 and quasars to z=5, and a few quasars at z=6 have been detected. The Sloan survey identified the

Sloan Great Wall, 2-3 times larger than the Great Wall, and estimated to be 1/60th the diameter of the entire visible universe. It is at a redshift of 0.1.

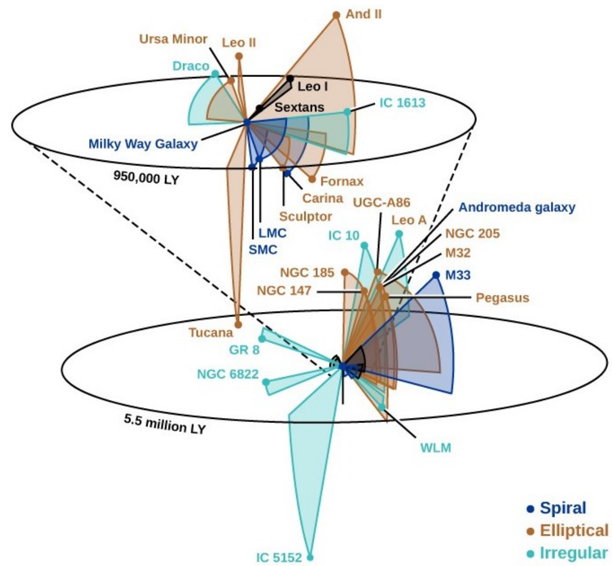


Large scale structure in the northern equatorial slice of the SDSS main galaxy redshift sample. The slice is 2.5 degrees thick, and galaxies are color-coded by g-r magnitudes. (SDSS Legacy Survey)



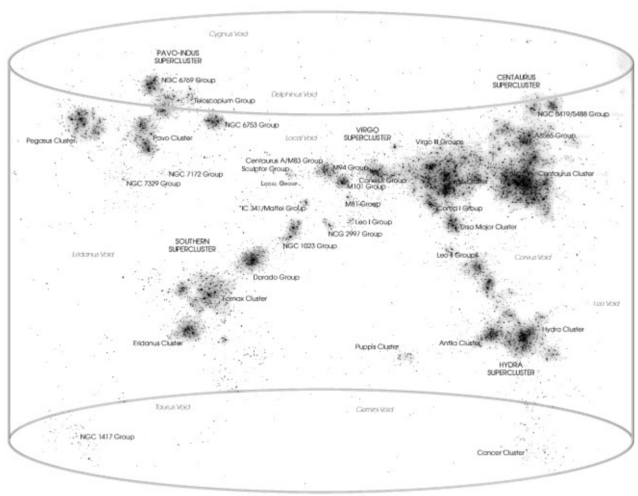
The Sloan Great Wall in a more 3D view (W. Schaap, Kapteyn Institute, U. Groningen, 2dF survey)

These surveys have shown that galaxies are arranged not just in clusters but in knots, strings and walls surrounding voids. In the voids, the density of matter is reduced by a factor of at least ten. There are a few galaxies floating around in the voids. Astronomers living on a planet in those lonely places would need very large telescopes to appreciate that the universe consisted of anything but their own galaxy. No Andromeda Nebula, Whirlpool or Pinwheel for them.



Map of the Local Group (Lumen Learning)

The Milky Way galaxy is part of the Local Group, which in turn is a member of the Virgo Supercluster, one of a dozen or so superclusters in our immediate cosmic neighborhood. All of these structures are now combined into the giant Laniakea supercluster, which contains 100,000 galaxies over 160 Megaparsecs, with a total mass of 10^{17} Mʘ. The name Laniakea means "immense heaven" in Hawaiian.



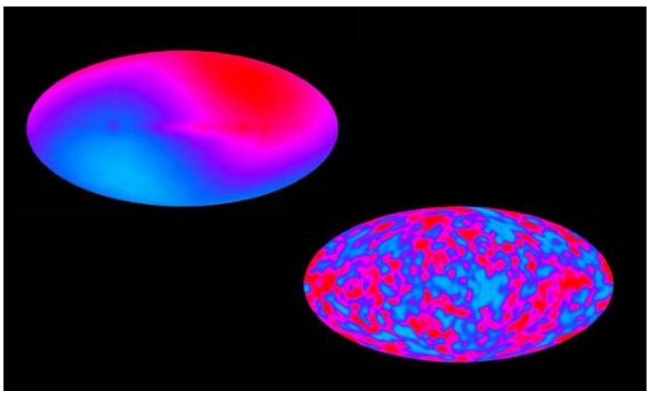
The Laniakea Supercluster (A. Colvin; original image inverted and made grayscale for clarity)

We don't really have clean definitions for groups, clusters and superclusters; maybe Laniakea should be called an "ultracluster." It has five major components.

- The Virgo Supercluster, which includes the Milky Way and the Local Group

- The Hydra–Centaurus Supercluster
- The Great Attractor, Laniakea's central gravitational point, in the direction of the southern Milky Way constellation Norma
- The Antlia Wall, known as the Hydra Supercluster
- The Centaurus Supercluster
- The Pavo–Indus Supercluster
- The Southern Supercluster, including the Fornax Cluster, Dorado and Eridanus clouds.

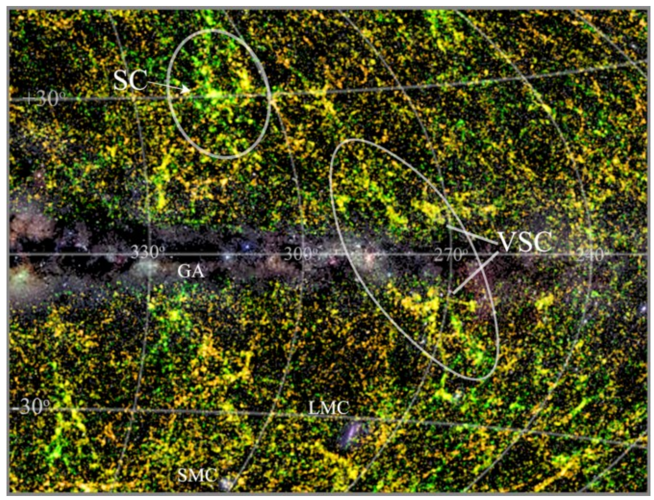
The Great Attractor is a galaxy cluster of immense proportions that is pulling the Milky Way and most of Laniakea towards it. We can't see it because it is behind the center of the Milky Way. The first evidence that we are moving in that direction came from early studies of the Cosmic Microwave Background.



Initial COBE microwave image (L), and final image (R) corrected for motion and with Milky Way removed, showing the 10^{-5} K temperature variation in the CMB (COBE)

When we view the CMB on a COBE, WMAP or Planck all-sky map, we are shown a surface with a near-homogeneous temperature of 2.725 K with only minuscule variations (amplified for clarity). But those lovely oval pictures had to be corrected for the larger bulk temperature variance caused by movement of the Milky Way, indeed the entire Virgo Supercluster, in the direction of the Great Attractor. The CMB microwaves are blueshifted in front of us and redshifted behind, and these velocities have to be subtracted to get the true picture of the CMB. This motion was first detected in 1977 by George Smoot. In the 1970s he flew a dipole antenna on a U-2 spy plane at 19.6 km (64,400 feet) above the Earth, measuring the microwave signal at 33 Ghz in opposite directions of the sky. He detected a difference that translated into a temperature variance of ±0.0035 K, compared to the thermal variance from the Big Bang itself of ±0.00001 K as was later shown by whole-sky satellite measurements. Smoot calculated a differential velocity of 390±60 km/sec towards the general area of Centaurus. He didn't have to worry about the velocity of the U-2 fouling up the data: the plane is subsonic with a top speed of 0.22 km/s. Smoot won the 2006 Nobel Prize for the Cosmic Background Explorer (COBE), which between 1989 and 1993 mapped the CMB over the entire sky. The modern value, from COBE, and the later WMAP and Planck spacecraft, is 613 km/s.

Beyond Great Attractor lies the Shapley Supercluster, the largest concentration of mass in the "nearby" universe. It consists of 76,000 galaxies at an average distance of 200 Mpc (z=0.046). It was named for Harlow Shapley by the APM Galaxy Survey team to acknowledge his pioneering efforts in the 1930s.



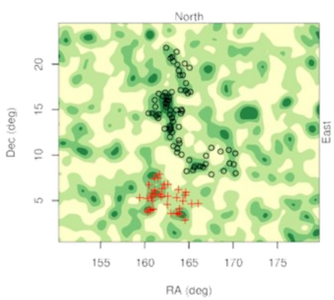
VSC: Vela Supercluster; SC: Shapely Supercluster; GA: Great Attractor; GA: Milky Way galaxy. (Thomas Jarrett, UCT & Max Planck Institute)

There is another large supercluster beyond Shapley. Using the 10-meter South African Large Telescope, Renée C. Kraan-Korteweg and her colleagues obtained redshifts of 4,500 of galaxies near the galactic plane at a distance of 18,000 km/s (z=0.062, 260 Mpc) in the constellation Vela. Follow-up spectroscopy with the Anglo-Australian Telescope confirmed that these clusters are embedded in a gigantic overdensity across about 20° × 20°◦ of the sky, dubbed the Vela Supercluster. The full extent of this concentration of matter will require surveys that can penetrate the Zone of Avoidance, such as H1 line surveys that are proposed for the MeerKAT radio telescope array in South Africa.

Surrounding Laniakea are the Hercules Supercluster, Coma Supercluster, and Perseus–Pisces Supercluster. There may be even larger and more distant formations in the universe. These megastructures are found on maps of quasars or gamma ray bursts. They arise in areas that must be dense with galaxies, but whether they are coherent structures in the early universe or just fortuitous groupings of random detections is still being evaluated.

Structure	Red-shift	# of objects	Size
Clowes-Campusano LQG	1.28	34	630 Mpc
U1.11 LQG	1.11	38	780 Mpc
Giant Arc (LQG)	0.8	25	1 Gpc
Huge-LQG	1.17	73	1240 x 500 Mpc
Big Ring (LQG)[7]	0.8	22	1.3 Gpc
Giant GRB Ring	0.8	9	1.72 Gpc
Hercules–Corona Borealis Great Wall (GRBs)	1.6-2.1	19	3 Gpc x 2.2 Gpc

The largest structures challenge the current ΛCDM model, which predicts that the universe will be homogeneous at a scale of about 370 Mpc (1.2 billion LY). Nothing should be bigger. But astronomers continue to find larger structures, and at earlier cosmic epochs.



Huge LQG (black circles) and Clowes-Campusano LQG (red crosses) (Roger Clowes)

Gravitational masses surrounding galaxies and clusters influence their trajectories. Using statistical techniques as well as corrections to galaxy velocity vectors and gravitational mass potentials with Wiener filters, a form of deconvolution,[8] Pomarède, Courtois and Tully have produced the "Cosmic V-Web,"[9] a map of gravitational and velocity gradients and the movements of galaxy clusters that define the filaments, walls and voids. The Cosmic V-Web describes a region more than one billion light years in diameter with the Milky Way at the center. The knots, filaments, walls and voids that make up the cosmic web are delimited not by matter but by the gravitational "shear" at each point in space. Tully's group has been able to determine whether a given location is in a collapsing knot (a gravitationally bound galaxy cluster), is moving towards a filament, is in a sheet or in a void. The process is complex but the visual representation is elegant and instructive. Global and local flows show the influences of concentrations of mass, tidal effects and even accelerations and decelerations. The movements can be categorized because the laws of gravitation are so well known.

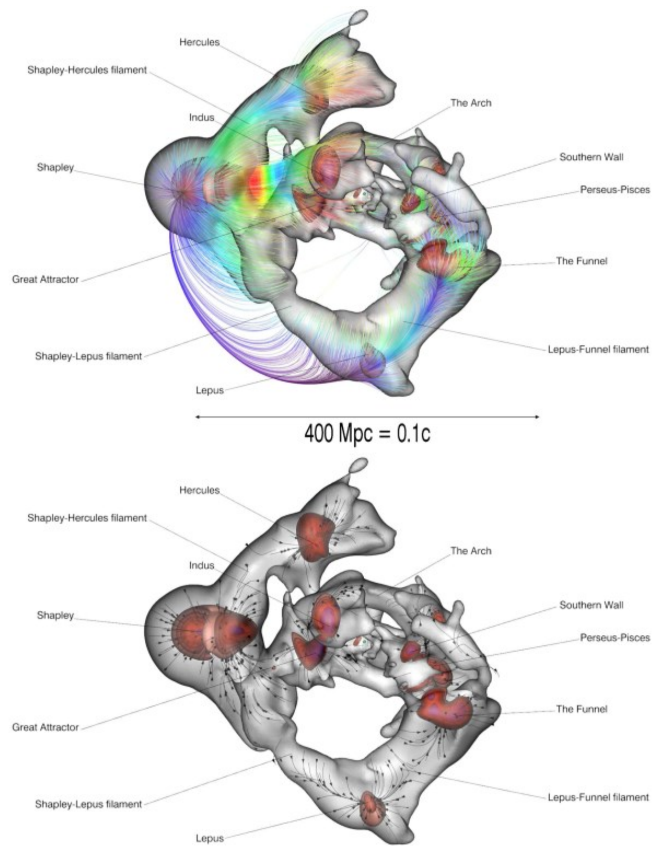
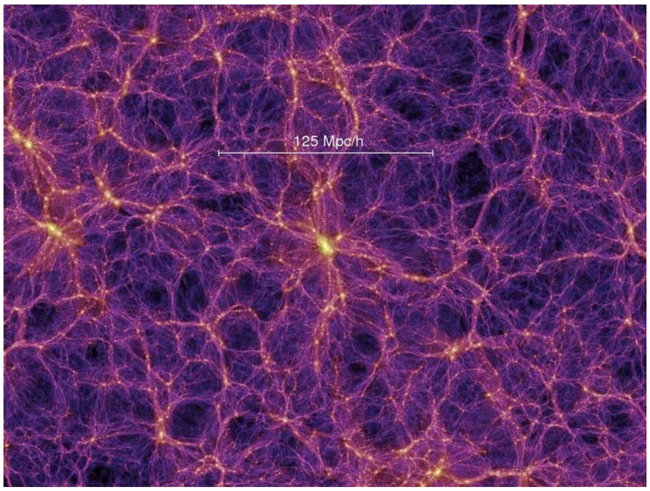


Fig 2 from Pomarède et. al. Cosmic V-web. Surfaces of knots, in red, are embedded within filaments, in gray. The top panel illustrates large-scale flow patterns from selected seed positions terminating in the Shapley Concentration. Motions accelerate toward knots (redder tones) and are retarded beyond knots (bluer tones). The bottom panel shows local flows toward local basins of attraction. There are frequently divergent points along filaments, with local velocities at adjacent positions in opposite directions.

In our region of the universe, all the bulk flows are directed towards the Shapely Concentration. Local flows respond to smaller and closer mass concentrations. To show how matter is moving, the authors have made a spectacular narrated video that explains the findings of the V-Web model. https://vimeo.com/206210825. A less technical explanation is on a fine video from the journal *Nature* at http://tinyurl.com/yc7ccukr.

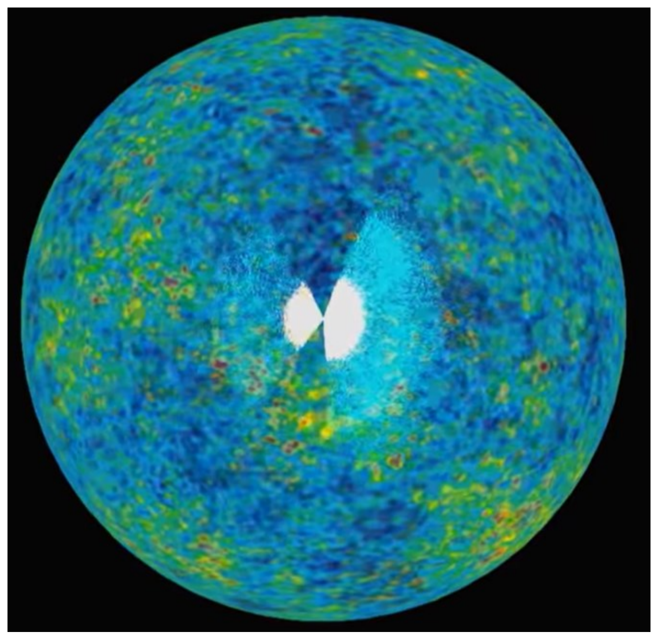
We are still able to map the only local part of our universe. A billion parsecs is just over one hundredth of the diameter of the universe at the current time. The age of the universe is given as 13.787±0.020 billion years but that doesn't mean that the universe is 13.787 billion light years across. It has been expanding ever since the Big Bang. If you could freeze time, take a ruler and measure the diameter of the observable universe, it would be 93 billion light-years across (28.5 Gigaparsecs). This is the "comoving distance."



A cosmic web simulation (Millennium Simulation Project, Max Planck Institute)

We've ignored dark matter up to now. Suffice it to say that the sponge-like mass of galaxy clusters, knots, sheets and walls is dominated by dark matter, while the voids contain much less dark matter. Dark matter undergoes gravitational contraction more efficiently than baryonic matter because it does not respond to non-gravitational forces (thermal, magnetic, electrostatic). The cosmic web is really the dark matter web, gravity taking regular matter along as a passenger and letting the other three forces go to work within its confines.

The Cosmic V-Web is a construct based on 8,000 galaxies. The European Space Agency's Euclid telescope, launched on July 1, 2023 and now operational at the L2 Lagrange point, has a 600-megapixel camera, a near-infrared spectrometer and a photometer. It will image, measure and obtain spectra on millions of galaxies out to a redshift of 2.0, a 10 billion year look-back in time and a comoving distance of almost 18 gigaparsecs. Euclid will capture vast numbers of gravitational lenses, allowing a better picture of dark matter distribution. It will surely increase the number of identified voids, now 6,000, and see filaments and walls with better definition and to a farther distance. From the measurements, not only will a better picture of the cosmic web emerge, but the parameters of the ΛCDM model will be refined, or perhaps the new data will overturn ΛCDM in favor of a new cosmological theory. ■



The SDSS galaxy map placed *in situ* within the Cosmic Microwave Background (NASA/Adler Planetarium)

[1] Geller, M, Huchra, J, Mapping the Universe, *Science* 246: 897-903 (1989).
[2] DeVaucouleurs, G, Recent Studies of Clusters and Superclusters, *Astronomical Journal*, 66:629-632, 1961.
[3] Tifft, WG, Gregory, SA, Direct Observations of the Large-Scale Distribution of Galaxies, *Astrophysical Journal*, 205: 696-708 (1976)
[4] Gregory, SA, Thompson, LA, The Coma/A1367 Supercluster and Its Environs, *Astrophysical Journal*, 222:784-799 (1978)
[5] Kirshner, R. et al., A Survey of the Boötes Void, *Astrophysical Journal* 314: 493-506 (1987)
[6] Maddox, SJ, et. al, Galaxy correlations on large scales, *Mon. Not. R. Astr. Soc.* 242: 43-47 (1990)
[7] The Big Ring was reported at the AAS Meeting in New Orleans on Jan. 12, 2024
[8] For more on deconvolution, see the September 2023 SkyWAAtch, p. 16.
[9] Pomarède, et. al., The Cosmic V-Web, *Astrophysical Journal*, 845:1-10 (2017)

Images by Members

The Jet of Messier 87

I was thrilled to find in **Arthur Miller's** cover image of Messier 87 the famous plasma jet that is generated by the rapidly spinning accretion disk around the galaxy's immense supermassive black hole. If you enlarge the cover image you can see it within the galaxy's glow, pointing at about 5 o'clock. Below is a contrast-enhanced view of the central portion of the galaxy from Arthur's image.

To prove that this was not some kind of artefact, I downloaded images of the central part of M87 from a range of terrestrial and space research telescopes that can be displayed on the Aladin sky atlas (Centre de Données astronomiques de Strasbourg [CDS] https://cds.u-strasbg.fr/). I rotated them 90 degrees clockwise to match the orientation of Arthur's image, confirming the alignment by the position of the two small galaxies on M87's southwestern edge. As you can see, the feature is in the same place in each image, proving that it is indeed the jet.

Arthur's image, central portion, contrast-enhanced with Photoshop

The jet was first discovered at radio wavelengths. Electrons are moving at relativistic velocity in the magnetic field generated by the spinning black hole and its accretion disk. As they spiral in the field, they emit synchrotron radiation in the radio band. The hot matter in the jets emits copious X-rays and ultraviolet light. The total energy of the electrons in the jet is estimated to be 5.1×10^{56} ergs, comparable to the total output of the entire Milky Way in one second, but still below supernovas, gamma ray bursts, binary black hole mergers and binary neutron star mergers. Unlike those blasts the M87 jet is a continuous phenomenon.

The Editor

Images of M87 as displayed in CDS

Messier 106 by Bill Caspe

This image was made over several nights in 2021 and 2022, but the data was processed just recently to make the final picture. Planewave 17" f/6.8 CDK telescope, FLI-PL6303 CCD with 9 micron pixels, twelve hours of 600 second subs in LRGB with Astrodon filters, remote imaging from New Mexico Skies (Bortle 2).

Messier 106 is a somewhat distorted spiral galaxy in Canes Venatici, magnitude 8.3, distance 22 million light years. It's slightly wider than half a full moon, measuring 18.6x7.2 arcminutes. The outer arms can be detected visually in a medium-sized telescope. A large companion, NGC 4217 is beyond the left edge of the image.

There are an extraordinary number of faint objects down to magnitude 20 on Bill's image, including some of the galaxy's globular clusters, other galaxies and distant quasars. To show the rich population of objects in the field, we labeled many of them on an inverse image that you can see at http://tinyurl.com/5e68kcdy. The objects were identified using Aladin, the portal to the CDS search engine referenced on page 19. Many very small galaxies that are evident on the enlarged image are are not identified in any catalog hosted by CDS.

Left: detail from the on-line image: SDSS J121933.77+472956.6, quasar with red shift z=2.0754, giving a look-back time of 10.522 billion light years. This is the largest red shift of any object identified to date in a WAA member image in *SkyWAAtch* (prior record-holder, Twin Quasar, z=1.416).

Right: detail of spiral galaxies NGC 4232 (top) and NGC 4231.

Two Galaxies with Vaonis Vespera by Jordan Solomon

Sombrero Galaxy M104 in Virgo. FOV 89.3 x 47.3 arcminutes. Imaged at Cherry Springs, PA

Whirlpool Galaxy M51 in Canes Venatici FOV 91.1 x 49.0 arcminutes. Imaged at Ward Pound Ridge Reservation.

The Andromeda Nebula by Manish Jadhav

Our biggest neighbor, the barred spiral galaxy Messier 31 (NGC 224) is 2.5 million light years distant. Its mass is 1.5 ± 0.5 x 10^{12} M⊙. It probably has a trillion stars. It is probably not much more massive than the Milky Way (and might even be slightly less, the jury is still out), but it is larger at 152,000 light years across, versus about 90,000 for the MW. Its brightest companions are M32 (left) and M110 (lower right). M32 was a larger galaxy that interacted with M31 and much of its disk was stripped off. M110 is also interacting with M31. A very large halo of metal-rich stars surrounds M31, originating from its interaction with these and about 18 other dwarf galaxies in the system. M31 has about 460 globular clusters. (See "Exploring the Great Nebula in Andromeda" by Robin Stuart in the January 2023 SkyWAAtch.)

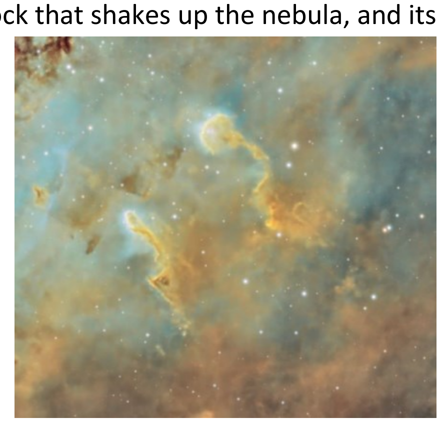
At magnitude 3.44, Messier 31 is a naked eye object even in moderately light-polluted skies and is the most distant object that can be seen with the naked eye. It is easy to find in the autumn sky. There is no reference to it in ancient Greek or Roman astronomy texts. It appears for the first time in al-Sufi's *Book of the Fixed Stars* (964 CE, 353 AH), described as a "small cloud." One might have thought that Hipparchos, who catalogued 850 stars down to magnitude 6 in 129 BC, would have seen a magnitude 3.44 object, but apparently he didn't, since it's missing in Ptolemy's *Almagest* (150 AD), which utilized Hipparchos' catalog for the majority of its star entries.

Manish made this image in Ossining, challenged by an inauspiciously placed LED streetlamp (a common problem for local astrophotographers wanting to image from their homes). He used a Stellarvue SV125-Access f/7.8 apochromatic doublet refractor on a new iOptron HEM27 harmonic drive mount and a Canon RP mirrorless camera. Twenty 3-minute subs were stacked and processed in Siri. The field is 2.09 x 1.39 degrees. Manish's picture shows the power of imaging to counter the curse of light pollution.

IC 405 and IC 410 in Auriga by Justin Accetturi

For his first submission to SkyWAAtch, new WAA member Justin Accetturi made this impressive image at Ward Pound Ridge Reservation in the fall of 2023 with a William Optics GT 81-mm f/5.9 APO refractor and ASI290MM camera. A total of 11 hours of with OIII, SII and Hα filters and 1.5 hours with RGB filters for the stars. The field is 2.79 x 1.88 degrees.

IC 405, on the left, is known as the Flaming Star Nebula (SH 2-229, Caldwell 31). It is about 2,500 light years distant. Its energizing star, AE Aurigae (the brightest star within the nebula), is a magnitude 5.96 O9.5V irregular variable with a mass 23 times that of the Sun and a surface temperature of 33,000 Kelvin. It has a substantial proper motion, which has led to speculation that it was ejected from the core of the Orion Nebula, possibly in the Trapezium (see page 7). As it passes through IC 405, it creates a bow shock that shakes up the nebula, and its radiation excites the gas to fluoresce primarily at the Hα wavelength.



IC 410, on the upper right, is sometimes called the Tadpoles Nebula because of the similarity of its internal structure to those amphibian larvae (see detail of Justin's image on the right). Within it is NGC 1893, a young open cluster with as many as 4,600 young stars and protostars.

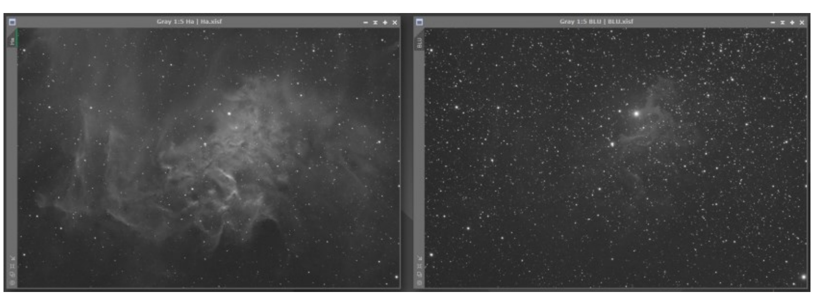
IC 405 was found on a photographic plate made on the night of February 6, 1892 at Lick Observatory by John Schaeberle, reported in the March 1892 issue of *Publications of the Astronomical Society of the Pacific*. IC 410 was a photographic discovery of Max Wolf. He exposed plates on September 25 and 30 and announced his discovery of a "new extensive nebula" (neuer ausgedehnter Nebelflecke) in the November 1892 *Astronomische Nachrichten.*

A Different Take on IC 405 by Steve Bellavia

Creative choices abound in the world of astrophotography. Steve focused on IC 405 rather than the wide field with IC 410. He wrote:

> I wasn't expecting it to be clear last night (January 11). but it was, for a little while. So I squeezed in an "experiment" to capture IC 405, The Flaming Star Nebula.
>
> My thinking was that it is mostly an emission nebula (H-alpha) but does have a small blue reflection region, which to me makes the blue part of the "flame." It can be difficult to capture and highlight. So I only used two filters: narrowband (4.5 nm) H-alpha and broadband (100 nm) blue: So instead of an H-O-O palette, this is an H-B-B or actually, H-HB-B. Other filters might help with the star colors, but for a short capture session, I think I accomplished what I wanted to do.

To illustrate the process, he even sent us the monochrome subs (left Hα, right OIII). Steve's choices brought out the wisp of blue reflection and made the stars (particularly AE Aurigae) more prominent. The technical details of the image are posted online at https://www.astrobin.com/mesziu/.



Justin's and Steve's images are two complementary and beautiful approaches to recording this fascinating object. Anyway, our choice is not Cezanne OR Monet, it's Cezanne AND Monet.

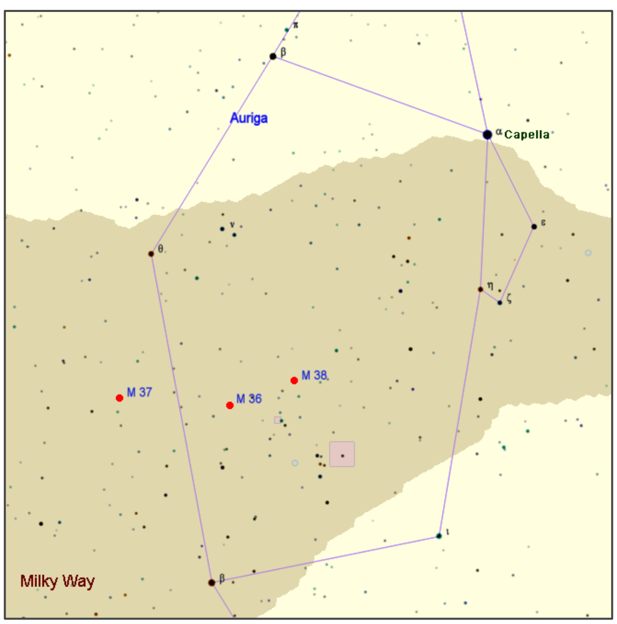
The Three Bright Open Clusters in Auriga by Rick Bria

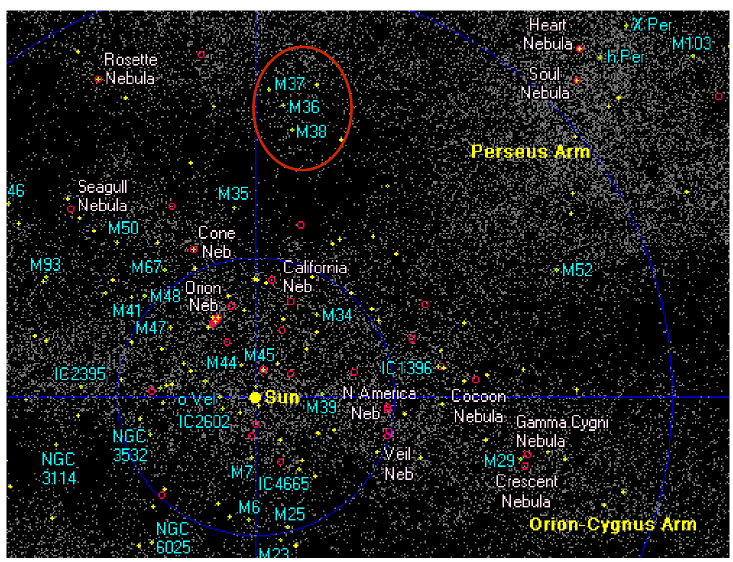
These three open clusters in Auriga, Messier 35, 36 and 37, are wonderful objects for telescopic or even binocular viewing, and M37 is bright enough for naked-eye observation in a dark sky. Rick made these images with the CDK-14 telescope at the May Aloysia Hardey Observatory at the Sacred Heart School in Greenwich. We thought they deserve full width on the page for your viewing pleasure.

Messier 36 (NGC 1960), magnitude 6.3, is 10 arcminutes wide. It contains many young blue stars, primarily class B, as nicely shown in Rick's image. Many of the stars have a rapid rotation rate and show, as a result, broad spectral lines. This is similar to the Pleiades. The 25.1 million year-old cluster is about 4,300 light years distant. It's been called the Pinwheel Cluster although few use that terminology today.

All three open clusters in Auriga were noticed by Giovanni Batista Hodierna around 1650.

Messier 37 (NGC 2099) is the brightest of the three clusters at magnitude 5.6. It's also the most condensed. Burnham calls is "superb." It's older than M36, with an age estimated to be somewhere around 400 million years. There are 500 members, with at least a dozen red giants. Distance 4,400 light years.



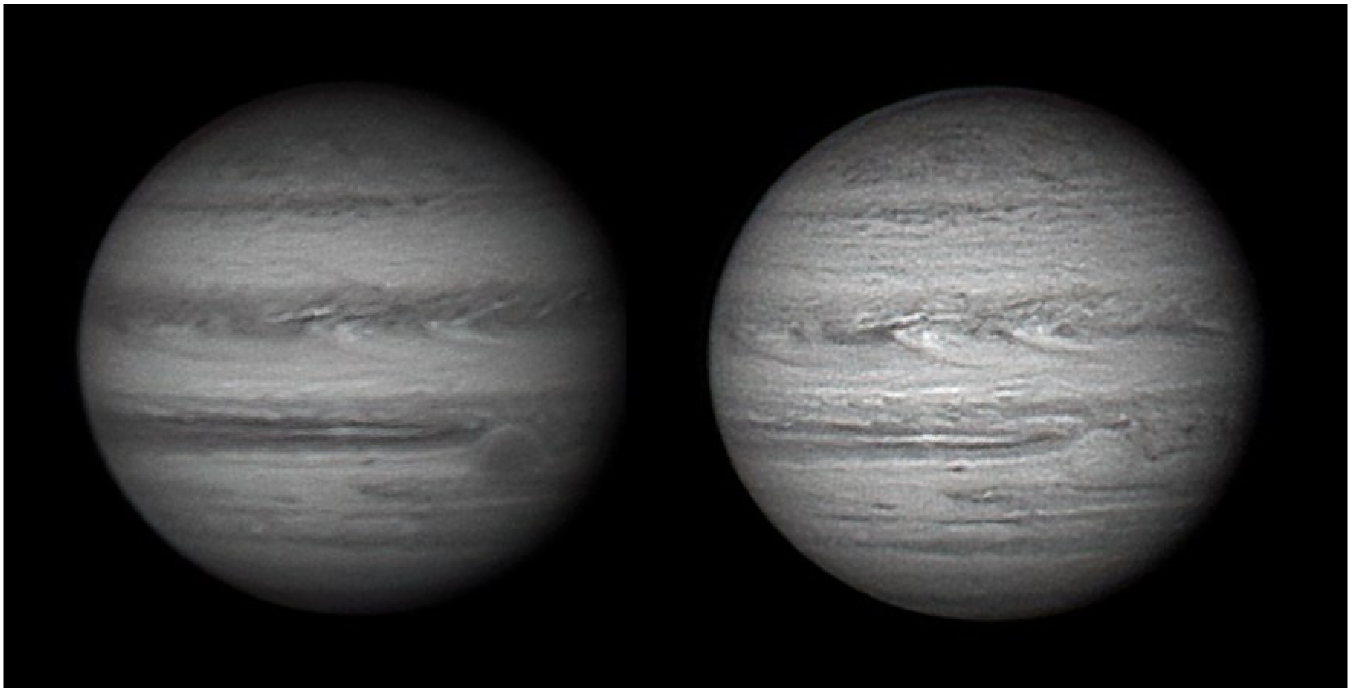


Top-down view of the clusters' location in the Milky Way. The galactic center is down. From Atlas of the Universe, Richard Powell.

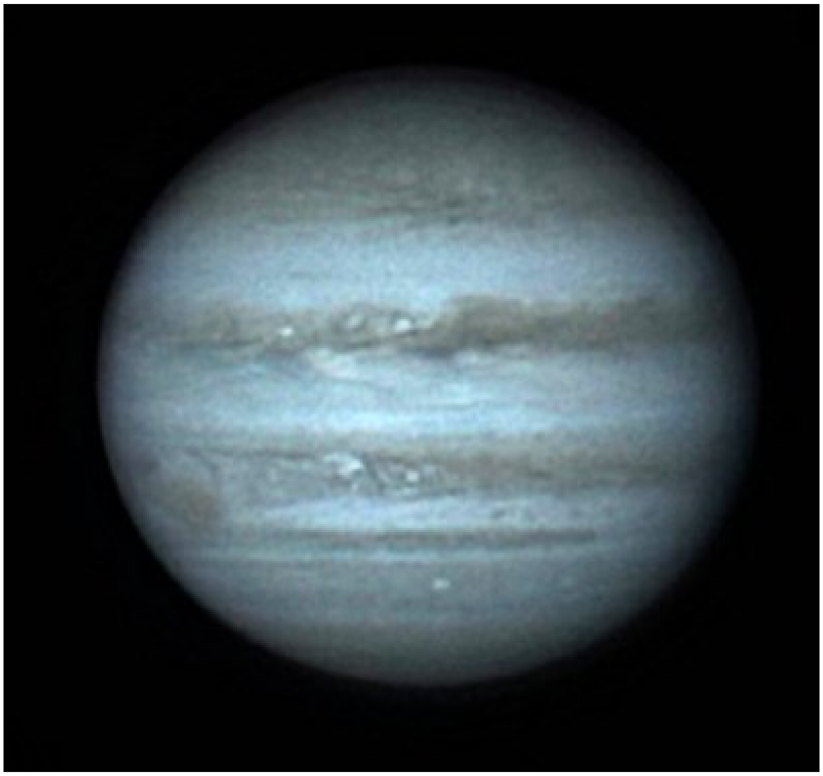
Messier 38 (NGC 1912) shines at magnitude 6.4. It spans 15 arcminutes. It is 4,200 lightyears distant and about 200 million years old. Sometimes called the Starfish Cluster, many observers have seen a cross or the Greek letter *pi*. We just see a pretty scattering of stars, around 100 in the cluster.

Half a degree south of M38, out of the field of this image, lies the smaller, fainter (mag 8.87) and older (500 million years) open cluster NGC 1907, with about 30 members. This cluster is also in the Perseus arm of the Milky Way. Thomas William Webb's *Celestial Objects for Common Telescopes*, published in 1859, was the go-to handbook for amateur astronomers well into the 20th century. Webb describes M38 as "A noble cluster arranged as an oblique cross…. Larger stars dot it prettily with open doubles. Glorious neighborhood." It's not surprising that Webb, a clergyman and son of a clergyman, saw a cross in these stars.

Jupiter's Red Spit in Visible Light and Infrared by John Paladini



Using a 10-inch Meade SCT and a monochrome ASI290MM camera, John made these images of the "King of the Planets" on Christmas evening. The image on the left is without a filter; on the right an IR-pass filter was used. This filter does not transmit any visible wavelengths. The Red Spot appears very light, rather than the dark hue we expect from its red color. A blue filter is excellent for visual observation of the Red Spot because it darkens the feature.



John also sent in this color image, made on December 7 with a 7-inch Maksutov telescope and an AsI290MC color planetary camera. The Red Spot is just rounding the planet's limb.

Editor's note:

Nearly seventy years ago in the third grade at PS 96 in the Bronx I was "Jupiter, King of the Planets" in a play about the solar system. My classmate Dava Sobel was the Sun, called in the play "the Lonely Star" because it is so far away from other stars. Dava writes about the play at the beginning of her book *The Planets* but leaves out this tidbit: On my cue, I stepped forward and declaimed "I am Jupiter, King of the Planets!" Then my mind went blank and I forgot the next line. It was a failure I still recall with embarrassment. While it cemented my decision not to become a thespian, at least it didn't ruin my interest in astronomy.

Research Highlight of the Month

Zeichner, S, et. al (70 authors), Polycyclic aromatic hydrocarbons in samples of Ryugu formed in the interstellar medium, *Science* 382: 1411-1415 (22 December 2023)

Carbon is the backbone element of life. It is made by stars primarily through the CNO cycle (see the June 2021 SkyWAAtch, p. 10). In space, carbon is often found in molecular clouds and dust, some of it in the form of complex organic compounds including amino acids. Evidence from spectroscopy and the analysis of meteorites has revealed the presence of polycyclic aromatic hydrocarbons, that have been invoked as possible sources of carbon for the development of life on Earth. Several astrophysical environments are potential sites of PAH synthesis, the exact mechanisms dependent on temperature, pressure, radiation environment and local elemental concentrations. PAHs could also form within a parent body, so-called "secondary processing," often in the presence of water. On Earth, PAHs can be formed by combustion. In sufficient concentrations, such as found in cigarette smoke, they are carcinogenic. Mid-infrared spectroscopy suggests that PAHs contain up to 20% of the carbon atoms in the interstellar medium, with a concentration of about 10^{-7} times that of hydrogen, which is actually not that insubstantial.

The authors extracted PAHs from samples brought back from the asteroid Ryugu by the Hayabusa2 spacecraft, as well as samples from the Murchison meteorite. A total of 5.4 grams of material was returned by Hayabusa, of which 52 milligrams was used for this analysis. The advantage of the Ryugu material is that it has not been exposed to any terrestrial contamination. The ratio of ^{13}C to ^{12}C in naphthalene and fluoranthene were higher than would be expected if these PAHs formed in a hot circumstellar environment but were consistent with formation in the interstellar medium. The ^{13}C content of phenanthrene and anthracene was consistent with formation in the higher-temperature environment.

The authors propose that at least some of the PAHs in Ryugu (and in Murchison) formed prior to the condensation of the solar nebula, and thus predate the formation of the solar system.

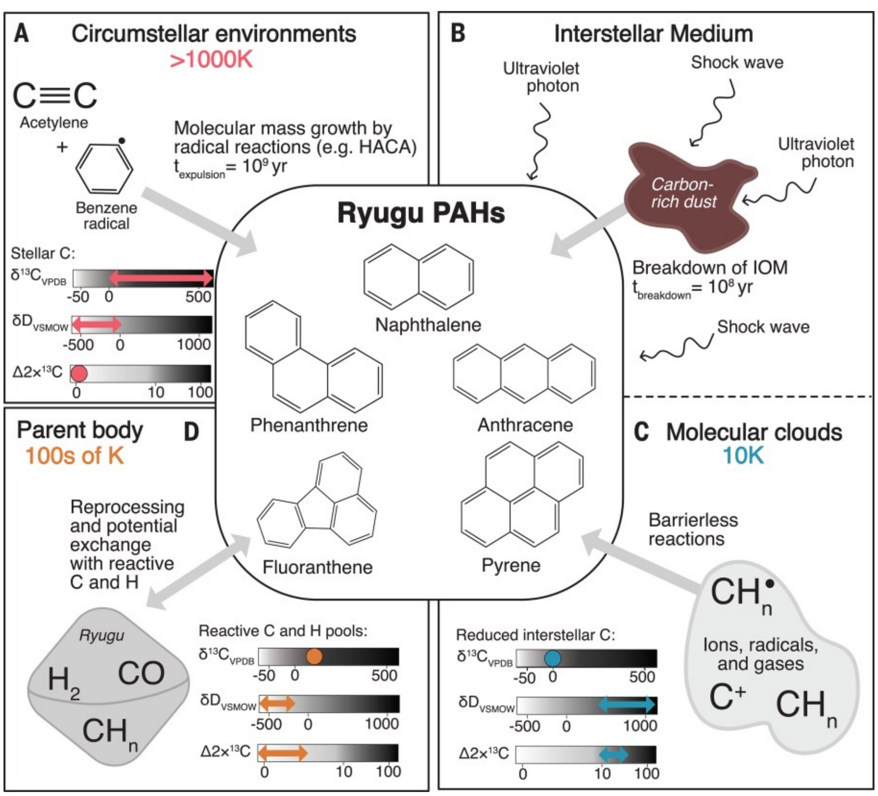


Fig. 1 from Zeichner et. al, showing potential pathways for PAH production.

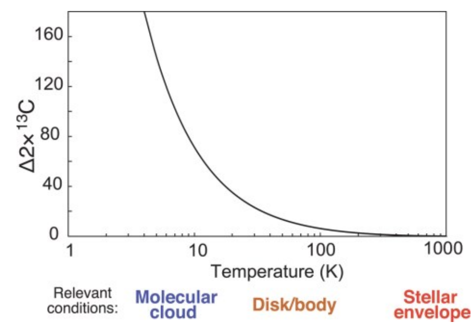


Figure 2 showing predicted 13C values from the model used.

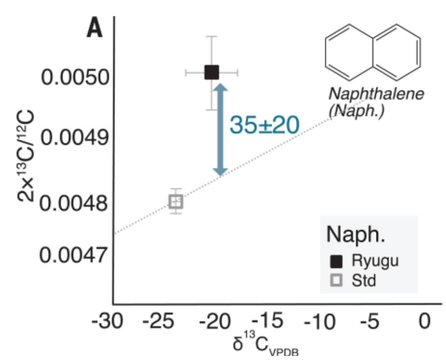


Figure 3A showing results for naphthalene.

Member & Club Equipment for Sale

Item	Description	Asking price	Name/Email
Celestron Nexstar 5SE	Mint condition white Celestron 5-inch f/10 (1250-mm) Schmidt-Cassegrain. Go-to alt-azimuth, single fork arm. Only used a couple of times. Complete with hand control, tripod, finder, eyepiece, diagonal. Picture here. Celestron lists this instrument for $799. Weight 17.8 lbs complete, including tripod. Runs on 8 AA batteries or external 12-volts. A fantastic telescope for lunar, planetary and bright DSO observing.	$400	Heather Morris heathermorris4381@gmail.com
Celestron StarSense auto-alignment	Automatically aligns a Celestron computerized telescope to the night sky. Includes finder camera, hand control (substitutes for the original HC), two mounting brackets, cables. Works with any computer controlled Celestron scope that has a hand control. Like new condition, in original box. Image here. Celestron's description and FAQ are here.	$300	Manish Jadhav manish.jadhav@gmail.com
NEW LISTING Celestron NexStar SLT 102-mm f/6.5 refractor	Go-to single-arm alt-az mount with Nexstar hand control. Tripod, Orion Sirius Plössl 20 & 7.5mm eyepieces, 3 color filters (#80A Blue, #12 Yellow & #25 Red), red dot finder, original manual. The fork arm outer case is damaged, and taped together, but it works.	$200	Bruce Rights brucerights@gmail.com
Orion 6-inch f/5 reflector on EQ mount	Little used, if at all. Solid EQ4-type non-go-to equatorial mount with an electric RA drive as well as slow-motion stalks. The setting circles are large and very readable, unlike most EQ mounts for scopes of this size. An image of the mount head is here. 9 and 25 mm Plössl eyepieces, polar alignment scope with reticle, Orion flashlight, finder, counterweights, gold-colored aluminum tripod (missing tripod tray, but you can make one easily enough). Good intro scope for a bright young person. A 6" f/5 OTA alone costs at least $300. Donated to WAA.	$150	WAA ads@westchesterastronomers.org
ADM R100 Tube Rings	Pair of 100 mm adjustable rings with large Delrin-tipped thumb screws. Fits tubes 70-90 mm. You supply dovetail bar. Like new condition, no scratches. See them on the ADS site at https://tinyurl.com/ADM-R100. List $89.	$40	Larry Faltz lfaltzmd@gmail.com
Tiltall photo/spotting scope tripod	TE Original Series solid aluminum tripod with 3-way head, center stalk. Very solid. 3-section legs. Height range 28.5"-74". Can carry up to 44 lbs. Folded length 29.6". Weighs 6 lbs. Carry bag. Image here. List $199.50. Donated to WAA.	$75	WAA ads@westchesterastronomers.org
RUBYLITH Screens	I have two 1/8" thick rubylith screens for placing over a laptop or tablet screen. Sizes are 14½x9" (for 17" diagonal 16:9 laptop) and 10½ x 7" for a tablet. Includes strong rubber retainers. I don't need them anymore. First come, first served.	Free	Larry Faltz lfaltzmd@gmail.com

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