SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

January 2024

The Crescent Nebula, NGC 6888 by David Parmet

The Crescent Nebula resides in Cygnus amidst a sea of nebulosity. David made this image in Cherry Springs, Pennsylvania, in September 2023. WO RedCat 51-mm, ASI533 MC Pro.

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

WAA January Meeting

Friday, January 12 at 7:30 pm

Astronomy Education's Changing Perspective

Marc Taylor
Manager, Planetarium and Science Programs, Hudson River Museum

In the past, astronomy education was largely about mathematics, observing techniques, and perhaps theological interpretations of those observations. Over the past 75 years, astronomy education has democratized and become more widely available to all ages, backgrounds, and interests, and can now take us to other worlds and other times. But there has been another change, very recent, permeating the sciences and science education as well -- and this newest turn is not really about astronomy at all...

Also In This Issue

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

WAA February Meeting

Friday, February 9 at 7:30 pm

The Vera Rubin Observatory and LuSEE Night

Steve Bellavia
Brookhaven National Laboratory

Starway to Heaven Star Parties

Star parties at the Meadow Parking Lot, Ward Pound Ridge Reservation resume in March. See page 4.

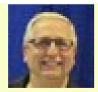
New Members

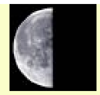
Abigail Blatte	Scarsdale
Cabiria Jacobsen Dougherty	Pleasantville

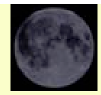
Renewing Members

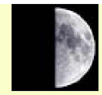
Janis Biermann	Yonkers
Richard Bronstein	Bedford
Tom & Lisa Cohn	Bedford Corners
Donna Divon	Hastings on Hudson
William & Edward Duncumb	Tunbridge Wells, Kent, UK
Eileen Fanfarillo	Irvington
Marc R. Favreau	Greenwich, CT
Patricia Frasier & Myrna Morales	New York
Timmy Froessel	Brewster
John Higbee	Ophelia, VA
Tony Irvin	Beyton, Suffolk, UK
Josh Knight	Mohegan Lake
The Maida Family	Portchester
John Pasquale	Bedford
Olivier Prache	Pleasantville
Bob Quigley	Eastchester
Robert Rehrey	Yonkers
Mauri Rosenthal	Scarsdale
William Rothman	Bronxville
David & Lisa Sadowsky	Larchmont
William Sawicki	Bronx
Robert Sour	Bedford
Jonathan Suarez	Port Chester
Kathleen Thrane	Greenwich, CT
Woody Umanoff	Mount Kisco
Cathleen Walker	Greenwich, CT
Charles Wiecha	Hastings on Hudson

ALMANAC For January 2024
Bob Kelly, WAA VP of Field Events


Bob Kelly


3Q 1/3


New 1/11

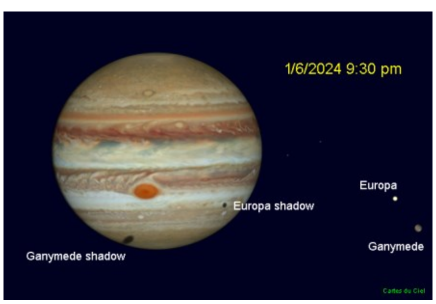

1Q 1/17


Full 1/25

Those people in the northern hemisphere will do anything to mitigate those cold winters! Our closest approach to the **Sun** for 2024 occurs on January 2nd at 7:39 p.m. EST. Only 3,106,444 miles closer to the Sun than our farthest day on July 5th. Just 3.3 percent closer. Not much help.

While you are out there celebrating the perihelion, look high in the southern sky for a bright dot inviting you to investigate it further. **Jupiter** transits the southern meridian at the end of twilight this month. A little bit of twilight can make it easier for me to pick out Jupiter's bands. Then take a look to the southwest for a moderately bright dot that looks steadier than the surrounding stars. That will be **Saturn**, which sets by 9 p.m. on the 2nd and just before 7:30 p.m. at the end of January. Get your sights on the two giant planets while we still have them. They'll be gone until next fall.

Jupiter's moons do their traditional dance, darting from side to side of Jupiter's disk. **Io** is the closest to Jupiter, switching sides almost every night. **Callisto** is the farthest out of the big four, switching sides from week to week. Look for the **Great Red Spot**, which is shrinking a bit, but is still a good object to see in a 60mm or larger scope, for the two hours when it's near Jupiter's central meridian during Jupiter's speedy 9 hour 56 minute rotation period. A double shadow transit crosses the planet's disk on the evening of the 6th. From 9:19 to 9:57 p.m. the shadows of **Ganymede** and **Europa** will be visible on Jupiter's cloud bands.



Saturn's rings are still the star of the solar system, according to our guests at star parties and everyone who sees them for the first time. Saturn looks only one-third the apparent size of Jupiter, so more magnification helps for a good view of its moons and rings. Ring tilt decreases to 7.1 degrees by the end of January, so they look thinner than last year. Thanks to the fabled low density of Saturn, if you could stand on the Saturnian clouds, you would weigh only six percent more than on Earth. Our weight on Neptune is the most, after Jupiter, the only major planets where we'd weight more than on terra firma.

We miss **Mars**. After a long run of being visible to us Earthlings, it passed through solar conjunction on November 18th and is finally exiting the solar glare in the morning sky. Our Mars-based spacecraft have resumed communications with Earth, as the Sun's magnetic field can corrupt data and mess up commands sent to the spacecraft.

Mercury makes a run at visiting **Venus** in the morning sky but doesn't make it to Venus' elevation even at greatest elongation on the 12th. Our innermost planet sinks slowly, making a very close pass at Mars in twilight on the 27th. If you can get a telescope on the pair, low in the sky before Sunrise, it's fun to compare the size and shape of the two planets. Mars takes the handoff and heads to a conjunction with Venus in late February.

The **Quadrantids** meteor shower has the highest hourly rate of Earth's meteor showers. The peak is so short that most of them are not seen by observers. This year's peak is the morning of the 4th. Keep the last quarter Moon out of your eyes and you'll have a chance to see a dozen or so an hour.

The **International Space Station** is visible in the dawn sky through the 6th. It shows up in the evening sky starting on the 12th. China's Tiangong station is visible in the evening from the 7th through the 23rd.

Vesta will be passing close to **Zeta Tauri**, a magnitude 3 star at the tip of the southern horn of Taurus the Bull, on the 9th and 10th. The **Crab Nebula** (M1) is a degree to the north of this meeting.

The **Moon** will cover up 1st magnitude star **Antares** on the 9th, but it'll be during the daytime. That will be hard to see, even in a telescope. Disappearance will be about 9:40 a.m. EST, with Antares reappearing about 10:52.

Star Parties 2024

In the past, we scheduled one Saturday star party a month with a "make-up" date for bad weather on the following Saturday. Some members, and the public, were unaware of whether the make-up session would be held. At our November Board meeting, we decided to no longer qualify the star parties as "regular" or "make-up," but to schedule an observing event every Saturday (March-Nov) with a favorable lunar phase. The odds of two consecutive clear Saturdays are low in our area, but we think we should maximize our observing opportunities. We will send emails and update the club telephone hot line (877-456-5778) as needed.

Date	Sunset	Moon Illumination	Moon status	Moon
March 9	5:57 pm	1%	New	No Moon
March 30*	7:19 PM	68%	Waning	Rises at 1:11 am Sunday
April 6**	7:28 pm	6%	New	No Moon
April 13	7:36 pm	27%	Waxing	Sets at 1:45 am Sunday
April 27	7:48 PM	82%	Waning	Rises at 11:54 pm
May 4	7:59 pm	16%	Waning	N/A
May 11	8:06 pm	14%	Waxing	Sets at 12:29 am
June 1	8:25 pm	28%	Waning	Rises at 2:48 am
June 8	8:30 pm	5%	Waxing	Sets at 11:43 pm
June 29	8:35 pm	42%	Waning	Rises at 1:17 am
July 6	8:33 pm	0.7%	New	Sets at 9:36 pm
July 27	8:17 PM	51%	Waning	Rises at 11:47 pm
August 3	8:10 pm	1%	New	N/A
August 10	8:00 pm	31%	Waxing	Sets at 10:42 pm
August 31	7:28 pm	6%	Waning	N/A
September 7	7:16 pm	18%	Waxing	Sets at 9:08 pm
September 28	6:39 pm	13%	Waning	N/A
October 5	6:28 pm	11%	Waxing	Sets 7:38 pm
October 26	5:55 pm	25%	Waning	Rises at 2:33 am
November 2	5:46 pm	3%	Waxing	Sets at 6:10 pm
November 23	4:28 pm	41%	Waning	Rises at 12:24 am
November 30	4:25 pm	0%	New	N/A

Notes:
* The following day, March 31, is Easter Sunday.
** Monday, April 8, is the total solar eclipse. Many WAA members may be traveling to see the event. We will decide in March whether there is enough interest in having a star party on April 6.

Lecture Dates in 2024

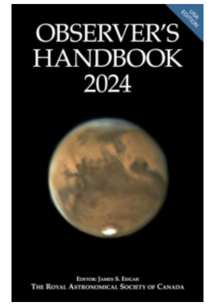
January 12
February 9
March 8
April 12
May 10
June 14
September 13
October 18
November 8
December 13

These are all the second Friday of the month, *except for October* because Yom Kippur begins on the evening of Friday, October 11. There are no meetings in July or August (come to the star parties).

All meetings will be live at Pace University and via Zoom.

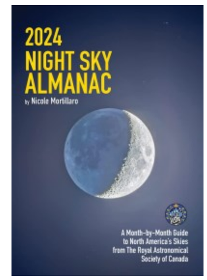
Free and open to the public. Invite your friends!

Resources for Sky Watchers for 2024 Bob Kelly

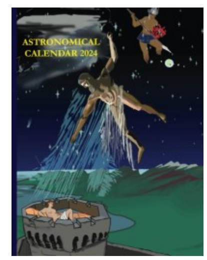


Many amateur astronomers want to plan ahead for observing, imaging or even travel. There are quite a few annual publications that serve our hobby.

My favorite source is the Royal Astronomical Society of Canada's USA edition of their *Observer's Handbook*. It has a month-by-month listing of astronomical happenings, with textbook level explanations and predictions for major astronomical events. Mine arrived December 14th. Compare postage when directly ordering from Canada versus ordering from a company in the United States. They also publish a *2024 Night Sky Almanac*, which is organized by month. It's available earlier in the year before, in late summer, well before the Observer's Handbook arrives. https://www.rasc.ca/.



Astronomical Calendar 2024 by Guy Ottewell is a wonderful source of essential data and has many graphics. It's available in hard copy or pdf from his web site. https://www.universal-workshop.com/astronomical-calendar-2024/



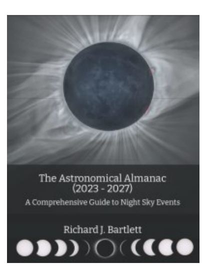
The United States Naval Observatory (and the UK Nautical Almanac Office) *Astronomical Phenomena for 2024* is a useful source of basic solar and lunar data and a summary of planetary events for the year. The print edition is published several years in advance and, for some reason, they are hard to find. The pdf version is published by the Brits on New Year's Day so people won't print and sell bootleg copies in advance. At last check, their web site was off-line for 'essential maintenance'. The 2027 hard copy may be out in mid-2024.

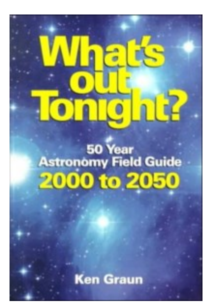
This year, I ordered the *Stargazer' Almanac 2024*, A Monthly Guide to the Stars and Planets. I'm not a big fan of almanac calendars, despite Carol's belief that I have every calendar in existence. They often don't have enough events on the pages. This one, from Floris Books, is a foot and a half wide and, opened, two feet high. They give views of the night sky facing north and south with a ribbon calendar of moon phases and altitude of Moon transits for the month in between. The page includes Sun, Moon and planet data for the month. I like the "How to use this Guide" page which includes "What is not on the charts" covering the few major events that don't fit the monthly format. The data and maps on the calendar pages are for 52 degrees north, since the calendar is produced in the United Kingdom.

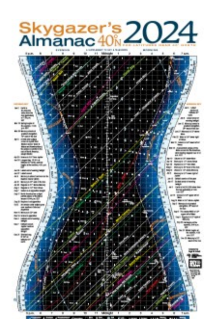
Sky & Telescope and *Astronomy* magazines are good month-to-month sources of information, observations and inspiration. S&T has increased their coverage about deep-sky and now, near-sky observing, covering a vast range of astronomical expertise. The January S&T includes the annual graphical almanac of nighttime events, which I hang in my computer room.

BBC's *Sky at Night* has good articles, and data, for observing from a British Isles (so looking at the sky from further north) perspective.

Multi-year sources of astronomical data include *What's Out Tonight: 50 Year Astronomy Field Guide: 2000 to 2050* and Richard J. Bartlett's *The Astronomical Almanac (2023 - 2027): A Comprehensive Guide to Night Sky Events*. They will keep you updated on month-to-month and week-to-week status (respectively) of the bright planets and the moon. Available on Amazon, but take care to make sure you find the latest edition of these reference documents. ■







Astronomical Highlights for 2024 — Bob Kelly

(All times Eastern Time – Daylight time runs from March 10 through November 3.)

Eclipses

March 25 (Sunday)
Faint penumbral eclipse of the Moon.

The Sun is only partially blocked by the Earth for this eclipse, shows up as a faint shadow on the Moon. Would be a brilliant 'diamond ring' partial eclipse as seen from the Moon. Begins 12:51 a.m., maximum at 3:13 a.m., ends 5:25 a.m.

April 8 (Monday)
Total eclipse of the Sun

The path of totality makes landfall in Mexico, tracks northeast from Texas through western New York State to Newfoundland.

In Westchester County, 90 percent of the area of the Sun will be covered by the Moon at maximum eclipse at 3:25 p.m. Tree leaves, interlaced hands and other pinhole projectors will make many fine images of a crescent Sun. The partial eclipse starts at 2:10 p.m. and ends at 4:36 p.m.

September 17/18 (Tuesday/Wednesday)
Partial eclipse of the Moon

Only 3 percent of the Moon will be covered by the shadow of the Earth, maximum at 10:44 p.m. The partial eclipse lasts from 10:12 p.m. to 11:17 p.m. The fainter penumbral stage starts at 8:41 p.m. and ends at 12:48 a.m.

October 2 (Wednesday)
Annular eclipse of the Sun

The eclipse will occur in the South Pacific and extreme southern South America. No part of it will be seen in the United States, except a partial eclipse in Hawaii.

Full Moons

The nearest (Moon closest to Earth) full Moons of 2024 are September 18 and October 17. The nearest new Moon is on March 10th.

Lunar Occultations

The only time in 2024 the Moon covers up a major planet or a 1st magnitude or brighter star during nighttime, is just before sunrise on November 17th when Spica will be occulted.

The Planets

Mercury

Greatest elongations in the morning sky: January 12, May 9, September 5*, December 25. In the evening sky: March 24*, July 21, November 15.

*The RASC Observer's Handbook rates these apparitions the best in 2024.

Venus

Visible in the morning sky through March and the evening sky starting in July. In conjunction with the Sun on June 4th when it is occulted by the Sun. Never reaches greatest elongation from the Sun in 2024. Shows gibbous phase all year. Venus is better placed in the sky for observers in the Southern Hemisphere.

Mars

The Red Planet comes back into the morning sky in January. It never makes it much into the evening sky as it doesn't rise before midnight until late September. Gets larger all year in advance of the next opposition in January 2025.

Jupiter

An evening object, high in the sky, through early May. Back in the morning sky in June. Reaches opposition, closest to us and up all night, in December.

Saturn

An evening object, low in the southwest, until mid-February. Visible in the morning sky starting in April. Closest to us September 8. A wonderful evening object for the rest of the year. Saturn's rings appear narrower this year, with a minimum in July.

Uranus and Neptune

We are closest to Uranus and Neptune in November and September, respectively. Uranus and Jupiter are visible about a moon-width apart in evening twilight on April 20.

Comets

It's always tricky to predict how good comets will be, and sometimes a new bright comet will appear.

Here's the latest ideas from http://www.aerith.net/comet/weekly/current.html and data from http://astro.vanbuitenen.nl .

12P/Pons-Brooks is a Halley-type comet last seen in 1954. Low in our skies near perihelion April 21. It may reach magnitude 5 or brighter, dimming to magnitude 6 at closest approach to Earth June 2. So far, it's had outbursts to as bright as magnitude 9 on its incoming trip.

144P/Kushida might reach magnitude 8 in January and February as it passes between Taurus and Orion. Perihelion on January 25 is outside Earth's orbit.

C/2023 A3 (Tsuchinshan-ATLAS) will reach perihelion in September, perhaps as bright as magnitude 0. We'll see if it'll be bright in a dark sky at some point.

207P/NEAT (2024) comes within 3 million miles from Earth on March 5, after its January 31 perihelion. Not expected to get brighter than magnitude 15, despite its close approach.

13P/Olbers (2024) will be low in our skies at maximum magnitude 7 in June and July.

62P/Tsuchinshan reached perihelion on Christmas Day. It'll be fading through magnitude 8 as it comes closest to Earth (at 117 million miles away on January 29.

Meteor Showers

Most of this years' better meteor showers will be affected by the Moon, but the **Perseids** should give a good show. The shower will peak on August 12 at 13 to 16 UT with the first-quarter Moon setting at 11:34 p.m. on the 12th and 12:10 a.m. EDT on the 13th, so the sky will be dark in the early morning hours, the best time to view meteors. The Perseids will show a decent number of meteors for a week or more before and after the peak.

The **Eta-Aquarids**, are bits of comet 1P/Halley, will peak on May 5 in a moonless sky until Luna's sliver crescent rises just before sunrise.

The other major showers, Quandrantids, Lyrids, Leonids, Orionids and Geminids are all crippled by the Moon in 2024.

A very good source of detailed information about meteor showers is the International Meteor Organization 2024 Meteor Shower Calendar, edited by Jürgen Rendtel, which can be found at https://www.meteorastronomie.ch/images/cal2024_e.pdf.

Northeast Astronomy Forum (NEAF)

NEAF will be held on Saturday, April 20 and Sunday April 21 at the Rockland Community College in Suffern. WAA will again have a booth at the show.

WAA Officers for 2024

At the Annual Meeting in December, following individuals were elected by the membership:

President: Jordan Webber
Senior Vice President: Olivier Prache
Secretary: Tim Holden
Treasurer: Paul Alimena
Vice President, Membership: Eva Andersen
Vice President, Field Events: Bob Kelly
Vice President, Programs: Pat Mahon
Vice President, Newsletter: Larry Faltz
Vice President, Communications: Mike Lomsky

The Board appoints an Advisory Board, which this year will include Mike Cefola, Darryl Ciucci, Eli Goldfine, Charlie Gibson, Jeffrey Jacobs, Frank Jones, Josh Knight, Matt Leone, Hans Minnich, Bill Newell, Satya Nitta, David Parmet, Dede Raver, Karen Seiter.

If you're interested in joining the Advisory Board, send an email to waa-president@westchesterastronomers.org.

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

Get Ready for the Total Solar Eclipse — Larry Faltz

The big astronomical event in 2024, barring a super comet, gigantic meteor impact, Carrington-level solar storm, nearby supernova or the arrival of aliens, is the total solar eclipse on Monday, April 8. The path will cross from Mexico to Texas and then across the US through New York, New England and Newfoundland before heading out to sea. There won't be another solar eclipse over the United States until August 23, 2044. Totality will be about 4½ minutes in duration in Texas, decreasing to 3½ minutes in northern New York. Local interest in the eclipse is rising, and WAA has been asked by some local organizations for presentations and partial-phase viewing events for people who won't be able to get to the eclipse path, or whose interest will be roused too late.

The weather in April is very unpredictable, with a good deal of spring cloudiness (April showers and all that) with better prospects the further south you go although even in Texas the chance of cloudiness is around 50%. It's already late to make travel plans for flights to Texas and to find hotels near the path. Many WAA members have already looked at observing venues in western New York or the Adirondacks. Staying in Westchester means seeing a 90.8% partial eclipse, which is nice but nothing like totality. Most eclipse enthusiasts have experienced one or more cloud-outs (mine was in 1991 in Hawaii) and you simply can't allow yourself to get too upset about it. We even had an eclipse wiped out by Covid travel restrictions. We had signed on several years in advance for the Sky & Telescope trip to the December 14, 2020 eclipse across Chile and Argentina, only to find the countries closed for travel because of the pandemic and so the trip was canceled. Of course, the sky was perfectly clear over what would have been our observing site. Clouds I can accept, but viruses?

Jay Anderson's Eclipsophile site[1] has path information and extended discussions about local weather patterns, as well as useful information about another spectacular Sun-related phenomenon, the aurora. Xavier Jubiez's site[2] has a lot of information about past and future eclipses. Specifically for the 2024 eclipse, the page at https://is.gd/xj2024 has weather and satellite images of past April 8ths. The site also features an interactive Google map that will give you eclipse contact times for any place you pick, whether in the path or not. It's at https://is.gd/xj2024map.

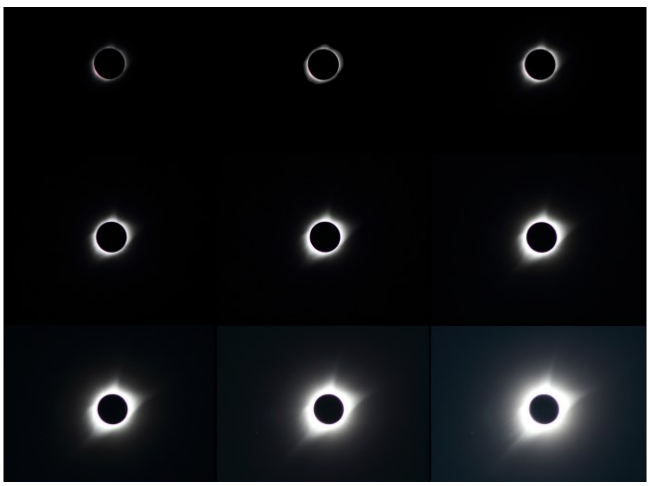
Make sure you arrange for certified eclipse glasses if you don't have a pair already. They tend to go quickly. If you want to take images, you will need a proper solar filter in front of your camera lens or

[1] https://eclipsophile.com/2024tse/

[2] http://xjubier.free.fr/en/index_en.html

telescope (although you don't need a filter during totality itself). These become difficult to find in the run up to the eclipse.

The general recommendation from experienced eclipse chasers is not to spend precious totality time taking photographs. Dedicate as much of your attention as possible to looking at the eclipsed Sun and the wonderful corona. If you must image, find a way to do it relatively automatically, using any one of a variety of apps and/or devices. In 2017 I was able to work the shutter speed dial on my tripod-mounted DSLR without taking my eyes off the Sun. I focused during the partial phase (with mylar filter), then removed the filter at totality, blindly rotating the speed dial one stop at a time and clicking away with a remote shutter release.



My eclipse photos on August 21, 2017. SDLR with APS-C sensor, ISO 200, 300-mm lens at f/8. 1/800 to 1/3 second exposures.

The solar disc moves ½ Sun diameter per minute. If the field of view is wide enough, you won't have to reposition the camera or use a tracking mount for the 20 or 30 seconds you might need for a full sequence of shutter speeds (keep the aperture around f/8 where most lenses are sharpest). The size of the Sun's disc on the sensor in millimeters is the lens focal length divided by 108; know your sensor size (full frame 36x24 mm, APS-C 25.1×16.7 mm) and account for the spread of the corona. With a 300-mm lens, an APS-C sensor is 5.3 Sun diameters wide. More advanced techniques are needed to bring out the corona's inner structure.

Absolutely **do not play music during totality**. All that noise is distracting and destroys the majesty of the event. Even Bach or Mozart would interfere, and that's telling you something about the splendor of totality. It needs no accompaniment. Stop any "playlists" at least 10 minutes before second contact.

Eyes are the best sensors for a total eclipse. There will be broadcasts of totality in April, but video is a frustrating way to experience it. We had planned to see the October 2023 annular eclipse in Albuquerque, but life intruded and we were unable to make the trip. So we watched two different streaming broadcasts, one from NASA (with telescopes in Utah, New Mexico and Texas) and another produced by the Exploratorium, the San Francisco science museum, who had set up scopes (including a 90-mm Hα scope) in the remote and beautiful Valley of the Gods in southeastern Utah, a place that we had been to on several occasions in the 1990s. The broadcasts were fun (the Exploratorium highlighted local Navaho sky beliefs) but of course it's not like being in the path. The amateur astronomer in Kerrville, Texas who provided the video feed via a Celestron Nexstar 6 with a mylar filter and DSLR didn't adjust the exposure properly, so annularity was a bit overexposed.

Watching the annular eclipse broadcast on October 14, 2023. Blah.

If my Hawaii recollection remains accurate, totality under a cloud is still better than watching on TV. Even if the event is clouded out, there is a camaraderie that can't be erased by disappointment. Perhaps it's just "misery loves company." But whatever the outcome, "nothing ventured, nothing gained." Even if the chance of seeing totality is less than 20%, remember that if you don't put yourself in the path, the chances are zero.

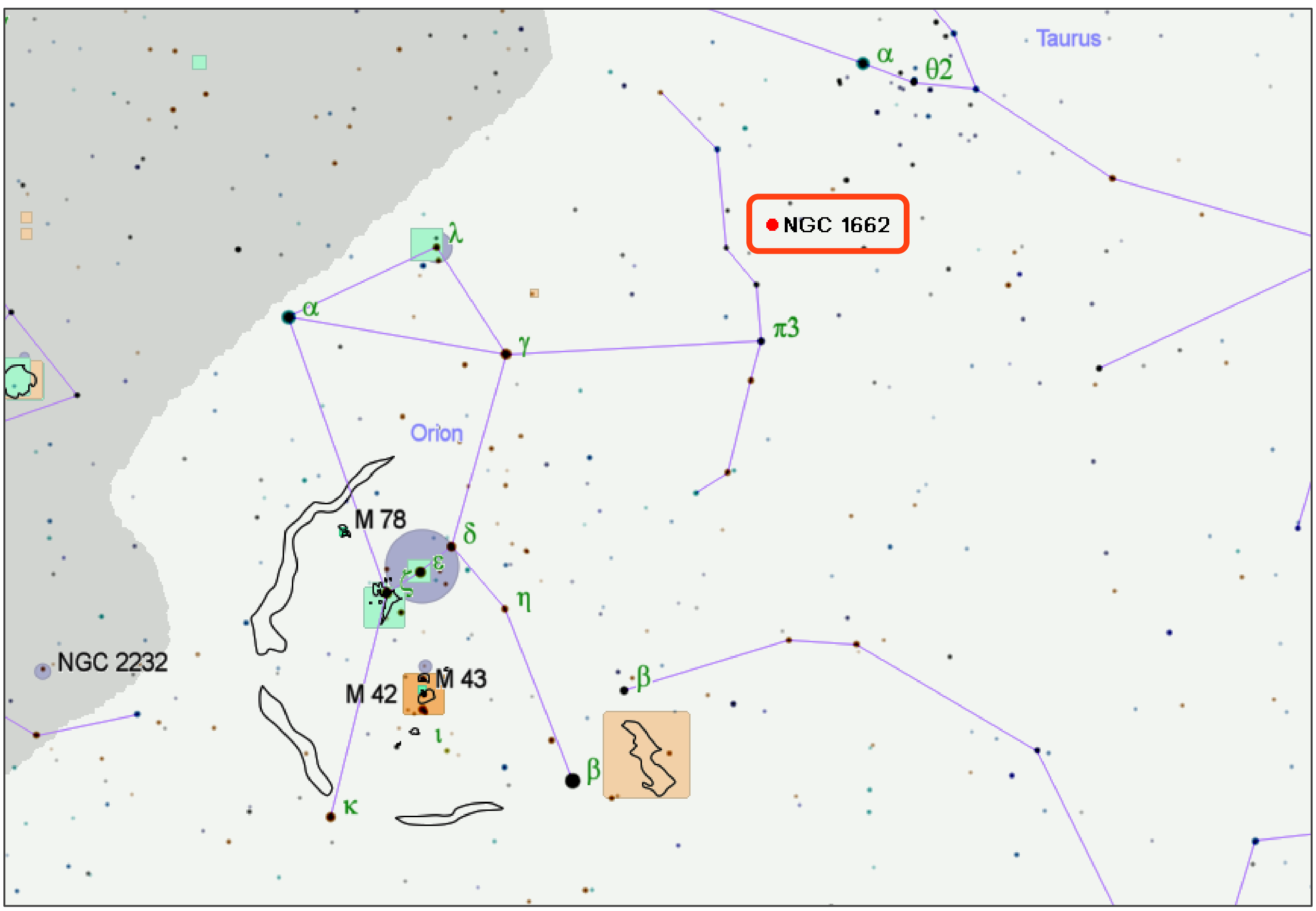
Look at the special October 2017 SkyWAAtch to read club members' eclipse experiences of the 2017 eclipse. The weather that day was remarkably good across the path. Let's hope for the same on April 8, 2024. ■

Deep Sky Object of the Month: NGC 1662

NGC 1662	
Constellation	Orion
Object type	Open cluster
Right Ascension J2000	04h 48m 27.0s
Declination J2000	+10° 56′ 12″
Magnitude	6.4
Size	20 arcminutes
Distance	1,425 light years
Other designations	Collinder 55
Discovery	W. Herschel 1784 (VII 1)

NGC 1662 is small cluster just in front of Orion's shield. The arrangement of stars was likened by California amateur astronomer Russel Sipe to a face-on view of a Klingon battle cruiser, as noted in Sue French's *Deep Sky Wonders*. The cluster contains about 30 stars when viewed with a 10-inch reflector. It's one of many small clusters that are typical members of the Milky Way family.

Visibility for NGC 1662			
22:00 EST	1/1/24	1/15/24	1/31/24
Altitude	60° 04′	57° 40′	50° 19′
Azimuth	180° 08′	206° 05′	229° 28′



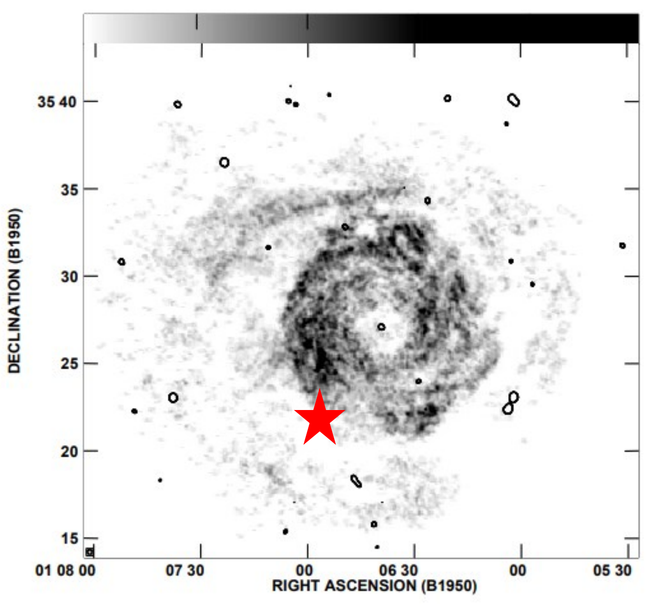
More on NGC 404, the "Ghost of Mirach" Larry Faltz

After choosing NGC 404 for last month's DSO of the Month, I wanted to see whether I could capture it from my light-drenched Larchmont driveway with a 105-mm triplet refractor and ASI533 MC Pro camera. On October 11, I grabbed one 60-second frame, in true EAA style. The magnitude 2.07, class M star Mirach (β-Andromedae) is very overexposed but retains its reddish hue. Just seven arcminutes away is the galaxy, whose magnitude as listed in various sources ranges from 10.3 to 11.2.

NGC 404 is the faint object in the center. The bright blob is Mirach. The field is 32.3x26.3 arcminutes. (LF)

NGC 404 has some very interesting characteristics besides its challenging location. It is an S0 dwarf lenticular galaxy, intermediate in structure between an elliptical and a spiral galaxy. It's a "field galaxy," lying just outside the local group, but apparently not gravitationally bound to it. It is less massive but more luminous than the Small Magellanic Cloud. Thought to be a typical example of an early-type galaxy, it seemed fairly ordinary until it was looked at with the Jansky Very Large Array in 1996.

The galaxy is surrounded by two enormous rings of neutral hydrogen, so large that the outer one reaches well beyond Mirach on the celestial sphere. The galaxy itself fits in hole of the denser inner ring.



Integrated neutral hydrogen map of NGC 404. Continuum sources over 5 σ (0.75 mJy) are superposed on the emission-line map. I superimposed the location of Mirach (red star). Fig. 3 from Del Rio, MD, Brinks, E, Cepa, J, High Resolution HI Observations of the Galaxy NGC 404: a dwarf S0 with abundant Interstellar gas, *The Astronomical Journal*, 2004; 128:89–102. https://is.gd/N404gas

NGC 404 may have been a spiral galaxy that merged with one or more dwarf galaxies a billion years ago, transforming it into a lenticular. Star formation is still occurring in the core of NGC 404, which would be somewhat anomalous for a lenticular galaxy, but there is probably residual cool gas from the merger. Low-level star formation occurs in the outer hydrogen rings as well.

Some red giant stars in NGC 404 have been resolved, permitting distance measurement using the "tip of the red giant branch" method (see "Determining Galactic Distances" in the March 2021 SkyWAAtch, p. 10). The value of 10 million light years is consistent with earlier, presumably less reliable methods of distance determination. In this case, they were right.

The nucleus features emission lines due to hot dust, a nuclear star cluster (like the Milky Way), and what appears to be an intermediate mass black hole of perhaps 450,000 solar masses. (Seth, AC, et. al., The NGC 404 Nucleus: Star Cluster and Possible Intermediate-Mass Black Hole, *Astrophysical Journal* 2010; 714:713-732. https://is.gd/n404nucleus). ■

Another Movie Telescope

Among the comedic riffs on James Bond movies in the 1960s were the two Derek Flint films with James Coburn (we featured *In Like Flint* in the October 2023 SkyWAAtch, page 9) and four films with Dean Martin as secret agent Matt Helm, *The Silencers* (1955), *Murderer's Row* (1966), *The Ambushers* (1967) and *The Wrecking Crew* (1968). Just as in the Flint films (and the James Bond films) there is a secret organization dedicated to mayhem and destruction, in the case of the Helm movies the Bureau of International Government and Order ("BIG O", playing on the nickname of the great 1960s basketball player Oscar Robertson). BIG-O is countered by a do-gooder spy organization, ICE (Intelligence Counter Espionage). There's often an army of beautiful women (in bikinis and with big hair) who work for the bad guys in these films, in this case the Slaygirls.

In the Helm films, Dean Martin basically plays himself, a crooning, womanizing and unserious boozer. There are lots of self-referential jokes and the usual ridiculous forms of jeopardy from which Helm always escapes against impossible odds. Martin, whose main entertainment skill was as a crooner, even gets to sing a song. There's always a nice, beautiful girl requiring rescue, in this case Ann-Margaret. I would imagine that a millennial, not having lived through the original James Bond phenomenon of the 1960s and the many contemporary movie and TV responses to it (foremost among them on TV are *Get Smart*, *The Man from UNCLE*, *I Spy*, *Mission Impossible* and our favorite *The Avengers* with Diana Rigg in a leather catsuit, driving a Lotus Elan*)* would have a very tough time sitting through a film like this. As an actor, Dean Martin is hardly Connery or even Coburn.

In this scene from *Murderer's Row*, Karl Malden, the head of BIG O, and his assistant Camilla Sparv are spying on Helm from a balcony on the French Riviera. Just like Lee J. Cobb, who appeared in *In Like Flint*, Malden had been nominated for an Oscar for his role in *On the Waterfront*, but he too must have needed the money 12 years later to be in this campy, inconsequential effort.

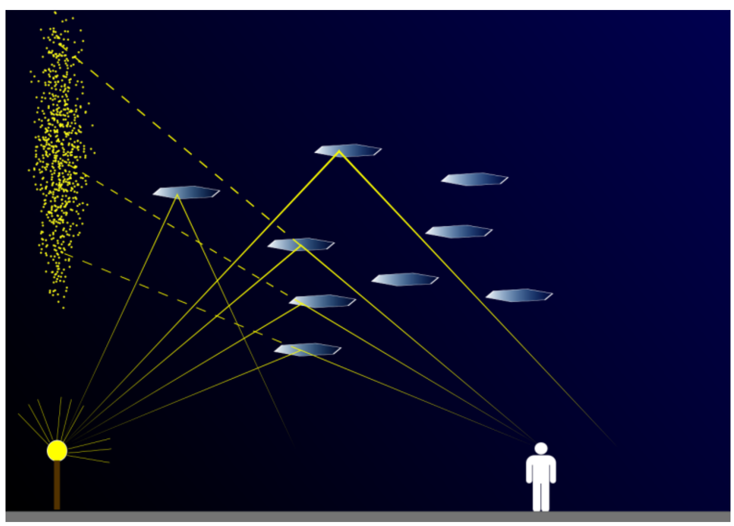
The scope is a 60-mm refractor and we think there's no erecting prism on it, so Sparv would be seeing everything upside down. Most of us place the focuser knobs below the eyepiece, but here the tube is rotated 180 degrees so the focuser knobs are at the top. There's no law against that, though. ■

Sun Pillar

Robin Stuart

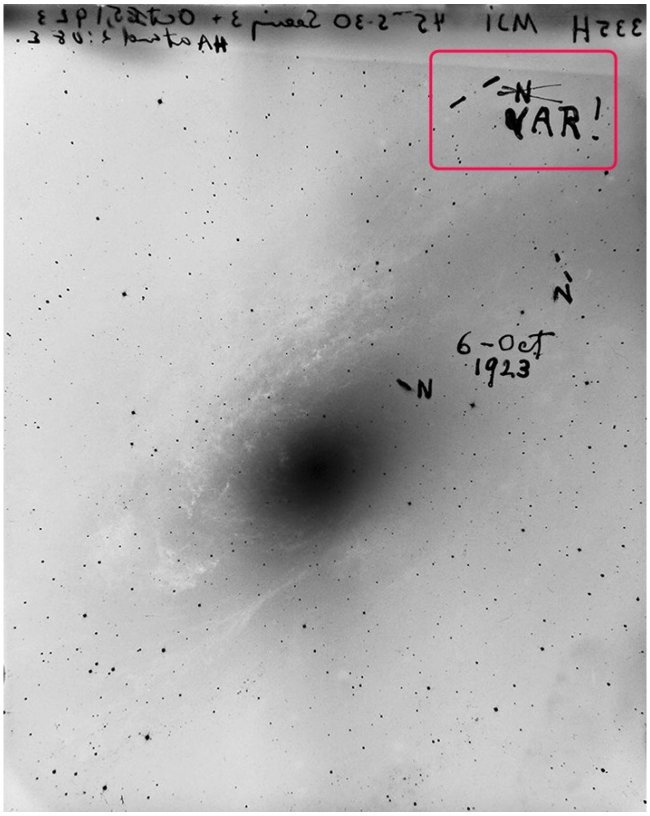
Just before dawn on 2 November, I noticed a faint Sun pillar rising above the mountains of the Bigelow Preserve in Eustis, Maine. Over a period of about four minutes, it brightened as it marched steadily down the ridge line from left to right. The picture was taken with my phone at 7:31 EDT, moments before the Sun itself emerged.

A Sun pillar betrays the presence of tiny, flat ice crystals in the air with their broad side oriented roughly horizontally. Light from the Sun is reflected from the underside of these crystals back to the observer, giving the appearance of a vertical shaft of light. Sun pillars are just one of a wide range of atmospheric ice crystal displays that can be observed when conditions are right. For insight and information on these phenomena it is hard to do better than Robert Greenler's book *Rainbows, Halos and Glories* (Cambridge University Press, 1990, still in print).



How a Sun pillar works (By V1adis1av - Own work, CC BY-SA 4.0)

Large-Scale Structure of the Universe: Galaxy Groups Larry Faltz



The VAR! Plate (Carnegie Observatories)

It's just been in the last century that we have had any scientifically validated conception of the vast size of the observable universe. This past October was the 100th anniversary of Hubble's identification of a star that he famously marked as VAR! on a photographic plate of the Andromeda Nebula (M31) exposed on the night of October 5-6, 1923. After measuring the star's brightness on previous Mt. Wilson plates, Hubble was able to construct a brightness curve and determine that the star was a Cepheid variable, from which he could derive its absolute magnitude. From that he could calculate its distance, which he determined to be an unheard-of 275,000 parsecs (900,000 light years, now known to be an underestimation). This was larger than any previous proposals for the distance to the spiral nebulas, the most recent of which had been by Lick Observatory's Heber Curtis. In 1917, he found a nova in M31. It was much fainter than expected, leading him to write,

> If we assume equality of absolute magnitude for galactic and spiral novae, then the latter, being apparently 10 magnitudes fainter, are of the order of 100 times as far away as the former. That is, the spirals containing the novae are far outside our stellar system.[1]

Harvard's Harlow Shapley, who had calculated the distance to globular clusters and was able to estimate the size of the Milky Way, did not think M31 or other "spiral nebulae" were external to our galaxy. In the "Great Debate" with Curtis in 1920, Shapley took the position that the spirals were within the Milky Way, whose diameter he had calculated to be about 300,000 light years (92,000 parsecs), an overestimation of the actual diameter by a factor of three.

In February 1924 Hubble wrote a letter to Shapley informing him that he had found two Cepheids in M31, providing a rough light curve of the VAR! star, which he identified as M31-V1. Cecilia Payne (later Payne-Gaposchkin, the discoverer of the composition of the Sun and the first female Harvard astronomy PhD) was in Shapley's office when he read the letter. Shapley showed her the document, commenting "Here is the letter that has destroyed my universe."[2]

Hubble eventually found 12 Cepheids in M31 and 22 in M33. He reported his discoveries at a meeting of the American Association for the Advancement of Science on January 1, 1925 in Washington, DC. He split a $1,000 young-investigator prize with a biologist studying protozoa in the digestive tract of termites. His paper was published that spring.[3]

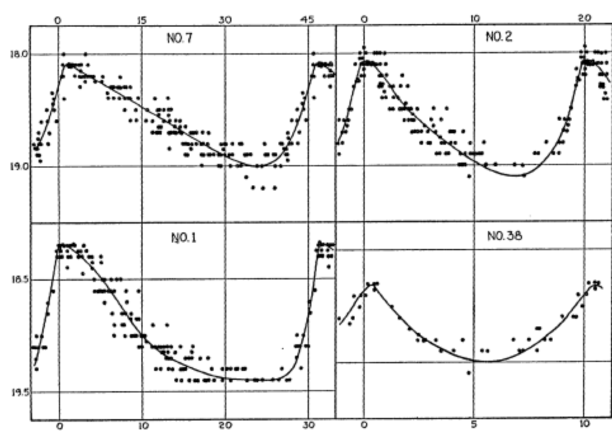


FIG. 1.—Light-curves of four Cepheids in M 31; ordinates, photographic magnitudes; abscissae, days.

Light curves of some M31 Cepheids, from Hubble's 1929 paper. The Var! star M31-V1 is the lower left tracing.

In 1929, in a more extensive paper on the nature of M31 as a complete star system, Hubble published the light curves of some of the variables.[4] That same year he reported his most famous finding: that the galaxies were receding from us at a rate proportional to their distance.[5]

In the 1920s, Shapley was studying the brightness, size and distance of nebulae (by which both he and we mean galaxies, which didn't become the common appellation for several years) and their distribution in the sky, using plates made with the Bruce telescope, a 24-inch telescope built by Alvan Clark & Sons. It was located from 1890 to 1927 at Harvard's Arequipa Station observatory near the Peruvian volcano El Misti, before being moved to South Africa, where it was in service until 1950. The optics, plateholder and other parts now reside in the Collection of Historical Scientific Instruments at Harvard.

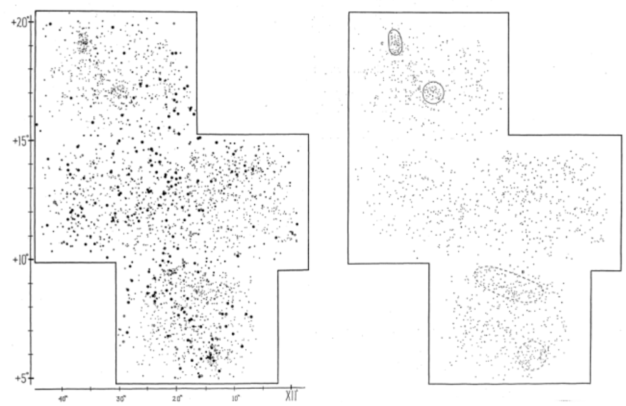
The Arequipa Station in Peru, around 1905-1910 (Harvard Library)

In 1926, Shapley published a paper with Adelaide Ames, who was his first graduate student, characterizing 103 "nebulae" in the Coma-Virgo cluster of galaxies, remarking,

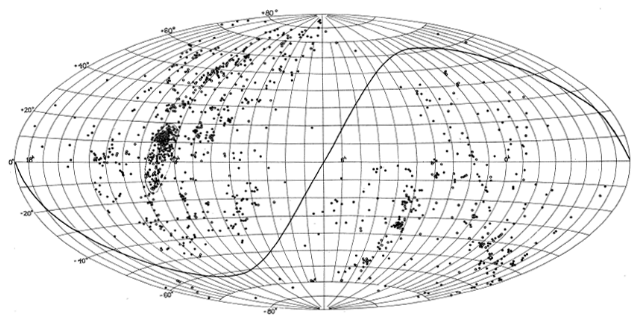
> The present communication embodies a brief report on investigations of a cluster or cloud of a hundred bright nebulae of the spiral family. WIth the interpretation of spirals as stellar organizations, of the nature if not of quite the dimensions of our own Galaxy, this work becomes a study of a higher system of stellar systems—a research, one might say, on a cloud of galaxies. The distance to the center of the cloud is probably of the order of ten million light years. Its diameter is about one-fifth of its distance from the Sun. Fairly accurate integrated magnitudes are obtained for all the spirals of the group; and color indices of some reliability are also found. The colors bear on the uniformity of nebular constitution and with even more directness, perhaps, on the question of the scattering of light in space.

Shapley and Ames went on to characterize 2,775 galaxies in the Coma-Virgo region down to magnitude 18, found on four plates from the Bruce telescope.

When they plotted the fainter (i.e. likely to be more distant) galaxies, they appeared to define several distinct groups, which led them to conclude that "the systematic deviation from uniform space distribution is glaring."[6]



Shapley & Ames (1929). (L) Fig 2, all galaxies, dot size proportional to magnitude; (R) Fig 7, galaxies with mag <17; approximate boundaries shown for four probable groups.



Whole sky map of the Shapley Ames catalog of galaxies (1932). The line shows the center of the "zone of avoidance," the part of the sky occupied by the Milky Way,

In 1932, Shapley and Ames published a catalog[7] of galaxies brighter than 13th magnitude, all but 13 having been previously listed in the NGC and IC catalogs. They were able to classify the shapes of the galaxies (701 spiral, 217 spheroidal, 29 irregular, 78 not determined). Looking at the distribution of objects in space, they note,

> We compute that within three megaparsecs all objects of average luminosity are included in the catalog. There is on the average one galaxy for each cube 4x10^5 parsecs.

> Although…there is no general concentration of nebulae toward our own system, there are many more than the average number within $4x10^5$ parsecs, thus lending support to the supergalaxy [i.e. cluster-*Ed*.] hypothesis.

How much more work Shapley and Ames could have done together will never be known. Ames, who was Cecelia Payne-Gaposchkin's closest friend at Harvard, drowned in a canoe accident while on vacation in July 1932. She was 32.

In 1933, Fritz Zwicky, using spectra made with the Mt. Wilson 100-inch telescope, published a paper on the redshift and rotation rates of galaxies and clusters of galaxies.[8] In his introduction, he noted that,

> By and large, the extragalactic nebulae are distributed uniformly over the sky and, as has been demonstrated, are also distributed uniformly in space. They occur as single individuals or group themselves into clusters.

He noted that the clusters, which contained "100 to 1000 individuals," are,

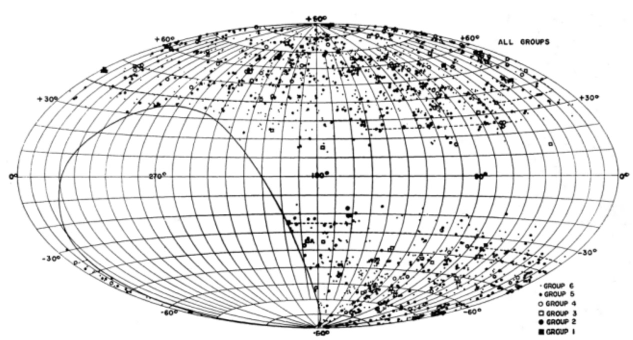
> likely that such an apparent accumulation of nebulae is also a real accumulation in space, and therefore all these nebulae are located at approximately the same distance.

He estimated their masses in two ways: by extrapolating the mass-to-light ratio of galaxies whose distances were known from Cepheids, and by using spectroscopy to determine the velocity dispersion by line-broadening. The spectral lines from parts of the galaxy rotating towards us are blue shifted while those on the opposite side, rotating away from us, are red shifted. The effect is to broaden the emission lines from the galaxy's stars or gas. Assuming the galaxy clusters were in dynamic equilibrium, Zwicky applied the virial theorem, which relates the kinetic energy of a system (reflected in the radial velocities of its stars) to its gravitational potential energy and thus its mass.

Zwicky found that the rotation rate of the Coma cluster as a whole was some 350 times higher than expected (shortly revised to 400 after more observations) and he inferred the existence of dark matter.

In a 1937 expansion of his analysis, Zwicky noted that, "It would rather follow that practically all nebulae must be thought of as being grouped in clusters."

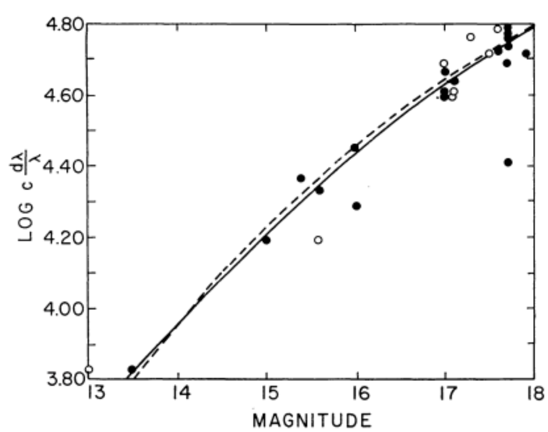
Examination of new, more sensitive photographic plates revealed new galaxy groups. For example, in 1951 Carl Seyfert reported "an exceedingly compact group of six galaxies" in Serpens, of which the brightest member was NGC 6027. However, a more general appreciation of the distribution of galaxies and galaxy clusters would come from the National Geographic Society-Palomar Observatory Sky Survey (POSS), which imaged the entire northern sky and some of the southern down to -36° declination, using the 48-inch Schmidt telescope on Mt. Palomar and blue and red-sensitive Kodak plate film, one plate of each type each showing a 6 square degree field. The survey achieved a limiting magnitude of +22.



Whole sky map of Abell Galaxy Clusters[10]

In 1958, George Abell, then still a graduate student at Caltech working on galaxy clusters for his PhD thesis, used the red-sensitive plates to compile a catalog of 2,712 clusters of galaxies with red shifts between 0.02 and 0.2.[9] Not all of the clusters had previously measured red shifts, but he was able to show that the magnitude of the tenth brightest galaxy in each cluster could be used to estimate the cluster's distance.

Abell found that the magnitude of the 10th brightest galaxy in the cluster was correlated with the red shift, which he could then estimate for those clusters that did not have actual red shift distance measurements.



Magnitude vs. red shift of the 10th brightest galaxy. Dotted line is preliminary data; the solid line is Abell's final determination.[9]

Abell did this work before there was automatic plate-scanning. He patiently scrutinized the plates with a 3.5X magnifier, recording the estimated magnitude and position of each galaxy, down to magnitude 18. He set an arbitrary but consistent criterion for cluster "richness," counting the number galaxies that were not more than two magnitudes fainter than the third-brightest member. He came up with this table:

Richness Group	Numbers of galaxies in the group	Number of clusters found
0	30-49	Not counted
1	50-79	1224
2	80-129	383
3	130-199	68
4	200-299	6
5	≥ 300	1

He also required the cluster to pass a "compactness" test, with 50 or more of the members within 1.72/*z* arcminutes (*z* being the red shift), now called the "Abell radius." (The requirement for 50 members explains why he did not tabulate clusters of richness group 0.) This parameter turns out to give an average cluster diameter of 2-3 megaparsecs regardless of absolute distance from us. Abell also concluded that there was "evidence that suggests the existence of second-order clusters, that is, clusters of clusters of galaxies." The Abell catalog was later extended into the southern hemisphere.

In 1961, Abell addressed new findings by Geoffrey and Margaret Burbridge and by Gerard de Vaucouleurs that the mass-light ratios of some galaxy clusters seemed to be inconsistent with their being gravitationally stable structures.[10] He reviewed the evidence for "second order clustering" that he had mentioned in 1958. This is a larger grouping at the lower limit of what we now might begin to call "superclusters." Abell concluded that,

> Available evidence appears to be quite conclusive for the existence of second-order clusters with diameters of the order of 50 megaparsecs. Whether these super-clusters are dynamically stable systems, however, is not established at present. If they are gravitationally stable, we can expect internal root-mean-square velocity dispersions of the order of 1-3x10^3 km/sec, and possibly superimposed upon this a velocity spread due to the general expansion of the universe. If the apparent superclusters are not stable systems, on the other hand, they must represent the regions in space where cluster formation has occurred, and may reflect something of the distribution of the primordial pre-galaxian (*sic*) material.

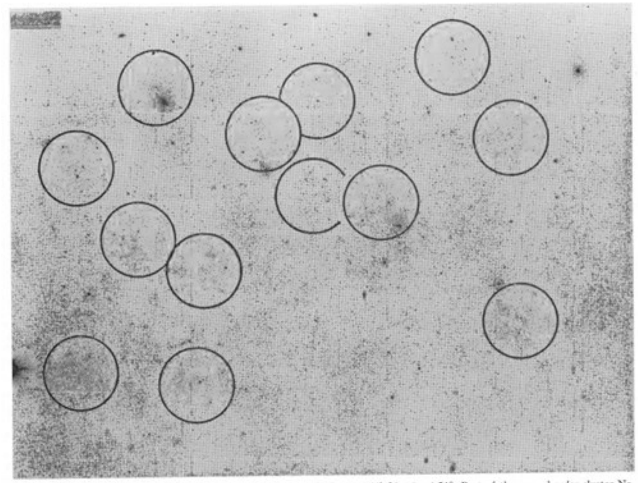


FIG. 5. A portion of the red print of the Palomar Sky Atlas field at $\alpha=11^h 24^m$, $\delta=+54°$. Part of the second-order cluster No. 4 (Table II) appears on the photograph. (Scale: 1 mm=99".) Copyright, National Geographic Society—Palomar Observatory Sky Survey.

A POSS plate as shown in Abell's 1961 paper

Fritz Zwicky compiled his own catalog of 29,418 galaxies and 9,134 galaxy clusters in the 1960s. His analysis[11] concluded that,

> the irregularities and often numerous local condensations within the latter two categories cannot be interpreted as evidence for any tendency toward either subclustering, second-order clustering, superclustering, or the formation of clusters of clusters of galaxies as has been advocated by various authors.

Alas, and perhaps surprisingly, the redoubtable Zwicky was proven wrong once the very largest scales of the universe were probed.

Using the Palomar plates, Paul Hickson compiled a list of 100 galaxy groups, each containing four or more galaxies within a 3 magnitude range, with an estimated mean surface brightness brighter than 26.0 mag/arcsec, and satisfying an "isolation criterion" that limits the size of the field.[12] Hickson studied these groups over the next two decades and in a 1997 review[13] noted that,

> Most compact groups contain a high fraction of galaxies having morphological or kinematical peculiarities, nuclear radio and infrared emission, and starburst or active galactic nuclei (AGN) activity. They contain large quantities of diffuse gas and are dynamically dominated by dark matter. They most likely form as subsystems within looser associations and evolve by gravitational processes. Strong galaxy interactions result and merging is expected to lead to the ultimate demise of the group.

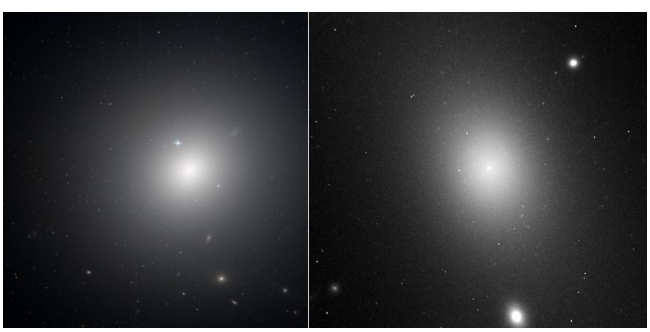
Hickson's groups, because they preferentially contain several bright galaxies, are frequently imaged by amateur astrophotographers.

Hickson 44 (Arthur Miller, WAA)

Continued scrutiny of galaxy clusters at higher resolution indicated that they were not simply larger or smaller aggregations of a similar range of galaxy types.

In 1970, Bautz and Morgan proposed a classification scheme for galaxy clusters, dividing them into 3 major groups depending on the morphology of galaxies within them.[14]

Type	Composition
I	Clusters containing a centrally located cD galaxy
II	Clusters whose brightest members are intermediate between cD galaxies and Virgo-type ellipticals
III	Clusters containing no outstanding galaxies' this category is divided into two groups: IIE or IIS depending on the absence of presence of giant spirals among the brighter members.

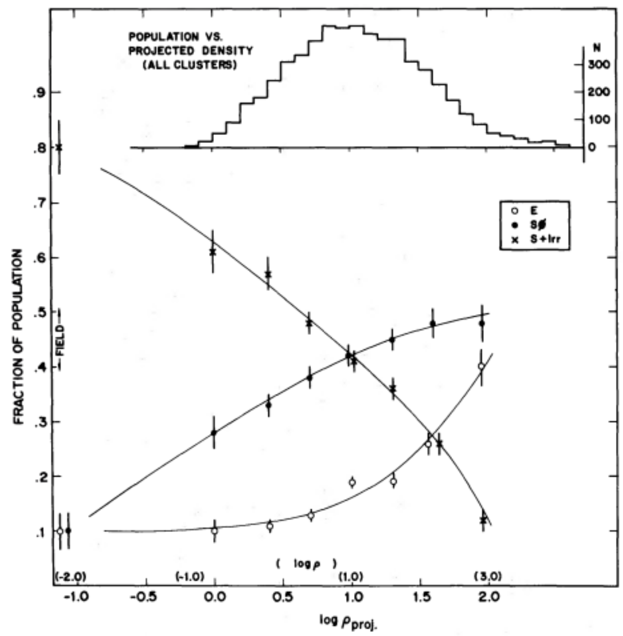


Two type cD galaxies: (L) NGC 1399, (R) IC 1101 (HST)

A cD galaxy is a type of giant elliptical galaxy with a large halo of stars. The famous Messier 87 is classified as a cD galaxy.

Variation in cluster size and composition was a major topic in the 1970s because it was thought to open a window into galaxy formation and the evolution of the universe, topics that had been amplified in the wake of the discovery of the cosmic microwave background radiation by Penzias and Wilson in 1965.

In 1980, Alan Dressler found that denser galaxy clusters were enriched in elliptical galaxies.[15]



Galaxy types vs. density (Dressler, 1980)

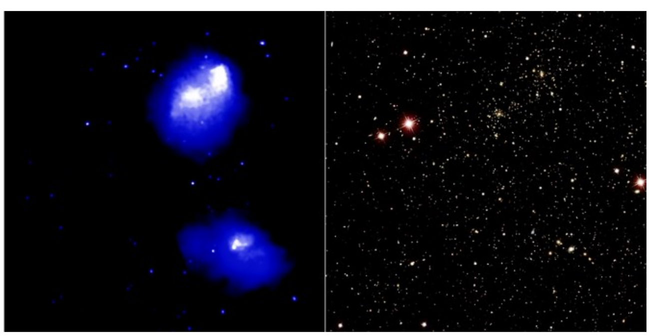
Dressler concludes that,

> It is suggested that the local density/morphological-type relation reflects the long time scale associated with the formation of the disk component of galaxies. If this time scale is comparable to or greater than several billion years, an increase in local galaxy density may slow or even halt the growth of the disk components. This could generally account for the large number of elliptical galaxies in very high density regions and the prevalence of spiral galaxies at very low densities.

With modern ground and space-based telescopes, a vast number of galaxies and clusters have been identified and characterized. The Dark Energy Survey, operating from Chile, catalogued 226 million galaxies in the 5,000 square degrees of the southern sky it examined from 2013 to 2019 with the Victor Blanco 4-meter telescope at Cerro Tololo, which was the subject of an article in the July 2017 SkyWAAtch.

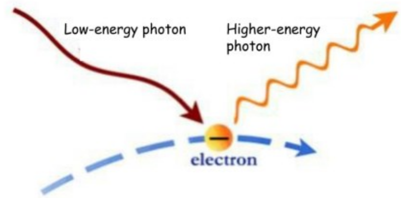
Galaxy clusters can be detected and their masses measured in ways other than scanning photographic (or later, CCD) images. The intra-cluster medium (ICM), the thin (10^{-3} particles per cubic centimeter) plasma between the galaxies, consists of very high energy protons, helium nuclei and electrons, with a small number of heavy ions created by stellar processes and supernovas. The heavier ions tend to concentrate near the center of the cluster. This plasma has a temperature of 10 million to 100 million Kelvin. Because of its high temperature, the ICM emits X-rays via bremsstrahlung radiation as the rapidly moving particles follow curved trajectories in the cluster's gravitational and magnetic fields or when passing near oppositely charged particles. With the advent of X-ray telescopes above the Earth's atmosphere (which blocks X-rays), these energetic photons can be detected. The temperature and density of the ICM can be measured, its pressure calculated, and because the cluster is in dynamic equilibrium, the virial theorem can be applied. The intra-cluster volume is large enough that the ICM accounts for three quarters of the baryonic mass of a galaxy cluster (and at most 20% of the total mass, recalling the large amount of [presumed] dark matter in a cluster).

The most recent X-ray catalog, as of this writing, is the RASS-MCMF catalog[16] of 8,465 X-ray selected galaxy clusters. The X-ray detections were made by the ROSAT satellite, which collected data from 1990 to 1999 and found over 150,000 objects.



Abell 1758. Showing two pairs of clusters of galaxies that are apparently in the process of merging.
(L) Chandra X-ray and (R) Optical images of the same field. (NASA)

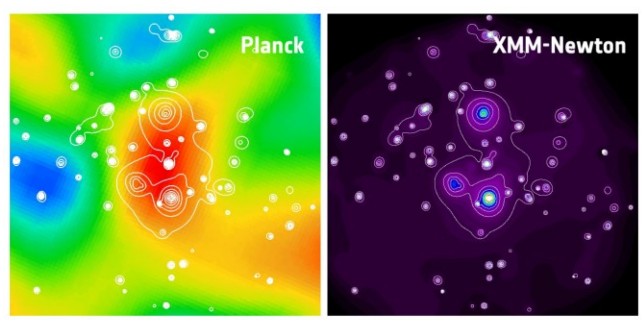
Another way to identify galaxy clusters is based on the interaction of photons and electrons. There are several ways that the two particles can interact and exchange energy, but the one that concerns us is Compton scattering. An energetic photon meeting a free electron transfers energy to the electron. The photon's trajectory changes and because it loses energy its wavelength increases. The opposite can happen: a low-energy, long wavelength photon can encounter a high energy electron, which transfers energy to the photon, shortening its wavelength and increasing its frequency. This is Inverse Compton scattering. The photons are supplied by the ubiquitous cosmic microwave background. It is calculated that all of space contains 411 CMB photons per cubic centimeter. These are in the form of microwaves, with a thermal spectrum at a temperature of 2.7 Kelvin (peak wavelength of about one millimeter). The energetic electrons are in the galaxy cluster's ICM.



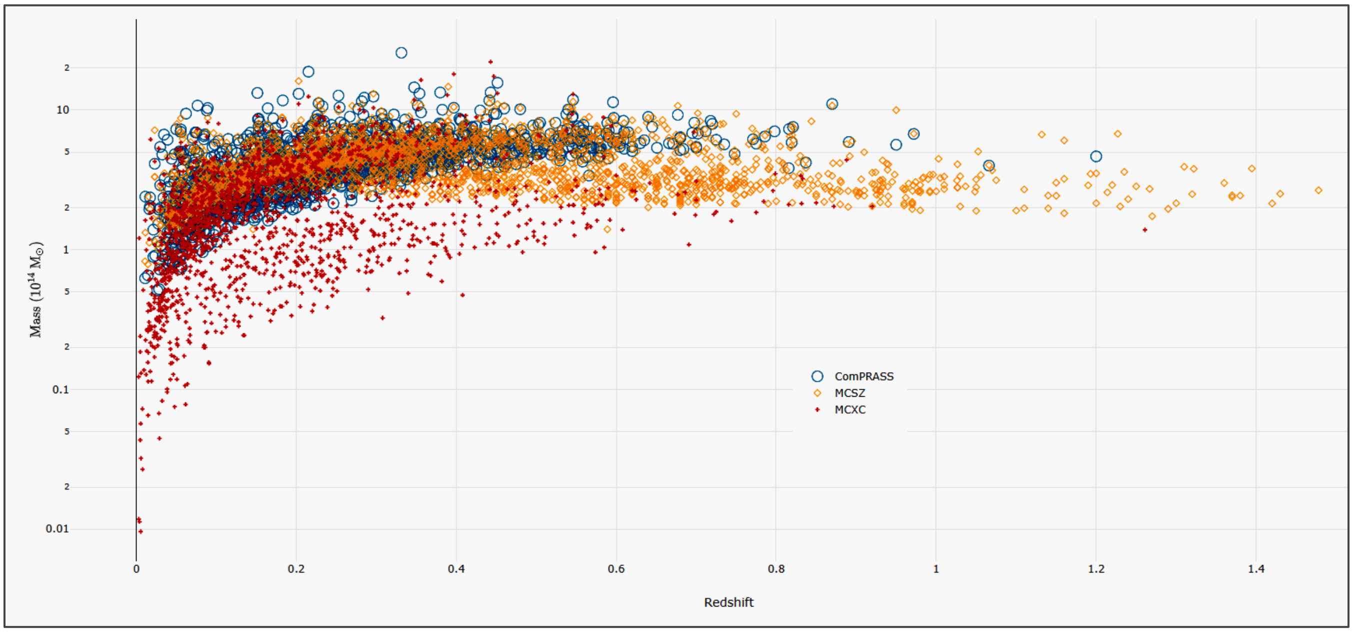
Inverse Compton scattering

The familiar all-sky map of the CMB has features on the order of a degree or so. The actual resolution of the CMB detectors on the Planck mission was 5 arcminutes. Earth-based CMB detectors like the now-retired Atacama Cosmology Telescope and the very much working South Pole Telescope have resolutions of 1 arcminute. The Atacama Large Millimeter/Submillimeter Array (ALMA) can resolve objects as small as 1 arcsecond, but its field of view is small and so it isn't used as a survey instrument.

As CMB photons pass through the hot gas in which galaxy clusters are embedded, some are scattered to higher energies. An anomalous bright spot will appear on the CMB background. This manifestation of Inverse Compton scattering is called the Sunyaev-Zel'dovich (SZ) effect, first proposed by Russian physicists Rashid Sunyaev and Yakov B. Zel'dovich, in 1970.



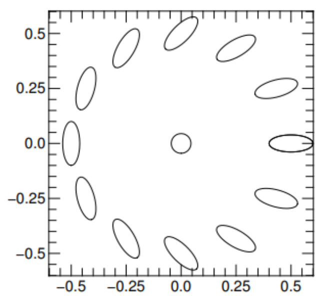
PLCK G214.6+37.0. This is the first supercluster to be discovered through its Sunyaev-Zel'dovich effect.



Mass vs. redshift from the M2C Catalog (https://www.galaxyclusterdb.eu/m2c/)

The M2C ("Most Massive Clusters across cosmic time") catalog contains masses for 5,072 galaxy clusters detected by either by X-ray or the SZ effect.

Galaxy cluster mass can also be derived from gravitational lensing. The Hubble Space Telescope and James Webb Space Telescope have given us impressive images of background galaxies distorted by massive foreground galaxy clusters as the light from the background galaxy is bent into multiple arcs and amplified by "strong gravitational lensing." Even when distorted arcs or "Einstein Rings" from a background galaxy are not present, a foreground cluster will cause a slight reorientation of multiple distant elliptical or spiral galaxies. This is "weak gravitational lensing," also known as "cosmic shear."[17] The effect is subtle; meticulous statistical analysis of shape and brightness of background objects is needed to find it. It is particularly valuable to detect the dark matter component of clusters, such as the famous Bullet Cluster, in which the gravitating masses of the two colliding clusters are clearly distinct from the hot X-ray emitting gas.



Cosmic shear. How background oval galaxies (all not at the same distance) could be distorted by a central foreground mass. Actual central masses are much less symmetrical.[17]

Bullet Cluster in Carina, 1E0657-56. X-ray image in red, mass distribution from lensing in blue. Optical by HST (NASA)

Cosmic shear is responsible for "E mode" polarization of the cosmic microwave background. This is not the long-desired, but yet to be found, "B-mode" polarization that would be proof of cosmic inflation.

Galaxy clusters, megaparsecs in diameter and with masses in the range of 10^{14}- 10^{15} M⊙, are the largest gravitationally bound structures in the universe, but there are larger cosmic objects. To reach the limit of the organization of the universe, we will have to look at superclusters and the origin and configuration of the cosmic web, the subject of a forthcoming article. ■

For the curious or possibly masochistic reader, here are the references cited, with links to the on-line papers. The older literature is quite readable. For the few articles that require a journal subscription to access, I've provided a link to the preprint.

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[4] Hubble, EP, A spiral nebula as a stellar system, Messier 31, *Astrophysical Journal*, 69: 103-158 (1929). https://articles.adsabs.harvard.edu/pdf/1929ApJ....69..103H

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[6] Shapley, H, Ames, A, The Coma-Virgo Galaxies, II. Distribution Charts and Frequency Curves, *Harvard College Observatory Bulletin No. 86*5, 1-13 (1929) https://articles.adsabs.harvard.edu/pdf/1929BHarO.865....1S

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[12] Hickson, Paul, Systematic Properties of Compact Groups of Galaxies, *Astrophysical Journal*, 255: 382-391 (1982) https://articles.adsabs.harvard.edu/pdf/1982ApJ...255..382H

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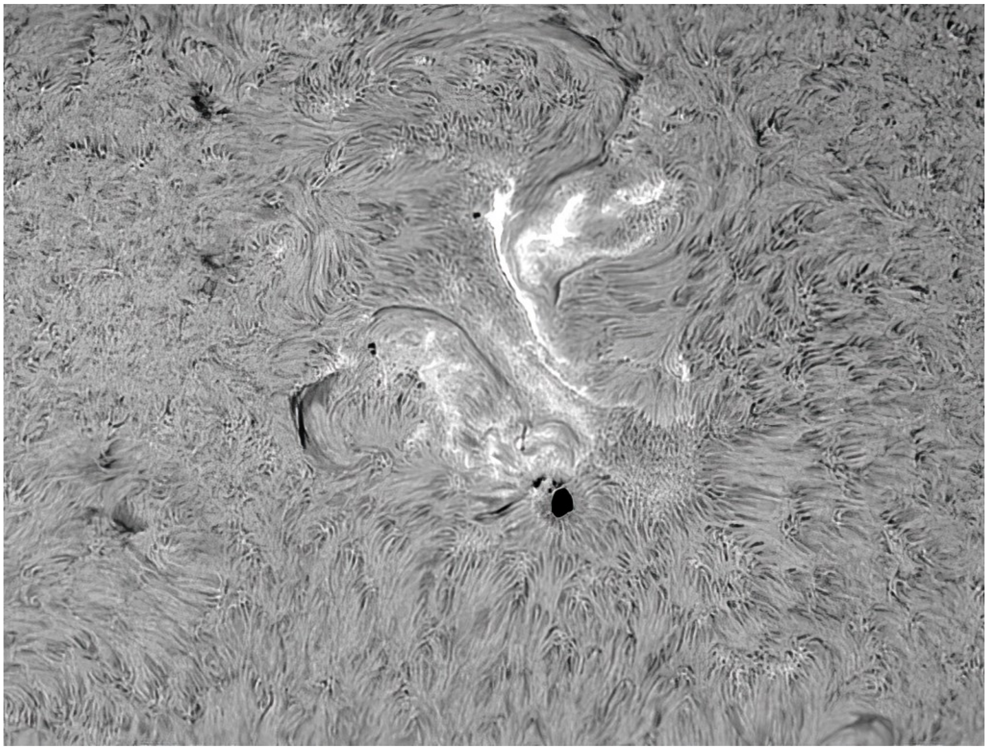
[16] Klein, M, et. al., RASS-MCMF: A full-sky X-ray selected galaxy cluster catalog, *Monthly Notices of the Royal Astronomical Society*, 526: 3757-3778 (2023). Preprint at https://arxiv.org/pdf/2305.20066.pdf

[17] Pello, R., et. al., Probing Distant Galaxies with Lensing Clusters, from *Extrasolar Planets to Cosmology: The VLT Opening Symposium*: Proceedings of the ESO Symposium Held at Antofagasta, Chile, 1-4 March 1999, ESO Astrophysics Symposia. Edited by J. Bergeron and A. Renzini. Springer-Verlag, 2000, p. 131. Preprint at https://arxiv.org/pdf/astro-ph/9905330.pdf

For those readers who want a rigorous but comprehensible exposition of the properties of galaxies and galaxy clusters, I recommend the college-level textbook *An Introduction to Galaxies and Cosmology* by Jones, Lambourne and Serjeant, 2nd edition, Cambridge University Press, 2015. It is extremely well organized and superbly illustrated. It has, by necessity, some mathematics, almost all of which is just algebra, although simply calculus (time derivatives) is needed for a few cosmological calculations. It also has many contextually appropriate questions with back-of-the-book answers, which makes the challenge that much more engaging and fun. ■

Images by Members

Imaging from my Larchmont Driveway by Larry Faltz



Close-up of the Sun's active region 3465 on June 18, 2023. I finally got around to stacking the video file and running it through im*ppg. I debated colorizing it, but I can never reproduce what I see in the eyepiece—all my attempts at colorization make the Sun look like the surface of a lemon and not the intense, biting orange-red sphere of a visual Hα image. So I kept the image monochrome. Lunt 60-mm single stack (0.7 Å bandpass) and ASI290MM camera.

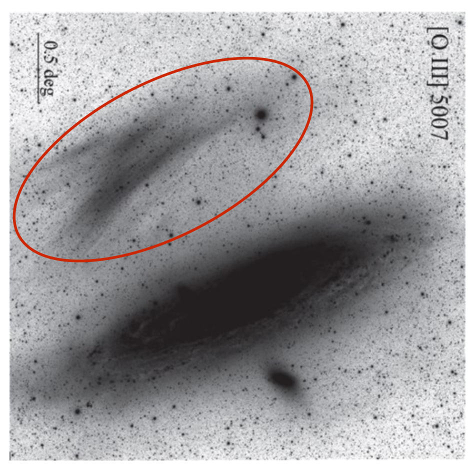
In spite of a nearby LED streetlamp and an SQM reading of just 18.3 (Bortle 7) I was able to make a fairly decent image of NGC 891 in Andromeda, also known as Caldwell 23 or the Silver Sliver Galaxy.

Stellarvue SVR-105, ASI533MC Pro, ZWO AM5 mount. 30x120 second light frames, 10 darks, 10 flats. Stacked with ASIStudio, processed with Siril and Topaz Denoise AI. The field is 35.1 x 29.7 arcminutes, about a 50% crop from the original.

Newly Discovered OIII region StDrSa-01 near Messier 31 by Steve Bellavia

In August 2022, Xavier Strottner, Marcel Drechsler, and Yann Sainty found a previously undetected arc of OIII emission next to the Andromeda Galaxy (M31). Their image, using 109 hours of data, won the Royal Observatory Greenwich's Astronomy Photographer of the Year contest in 2023 (see https://is.gd/ROG2023). Steve Bellavia managed to record the feature with 48 hours of data over 11 nights in eastern Long Island. The object is named Strottner-Drechsler-Sainty Object 1, or StDrSa-01. It's the faint bluish cloud left of center of the image. The nature of this object is unclear, but it may be a supernova remnant in our galaxy.

Technical information on Steve's image is at https://www.astrobin.com/te2lq4/E/. The discovery image is at https://www.astrobin.com/1d8ivk/H/, along with a lengthy explanation of the discoverers' image capture process and what it revealed about the galaxy and its environs.



This OIII image by the discoverers is rotated 90° to match the orientation in Steve's image. StDrSA-01 is indicated.

Barnard's Loop by Robin Stuart

The stars of Orion are an unmistakable sight in the winter skies. However, Orion is also home to a large complex of nebulosity dominated by a 10° diameter arc known as Barnard's Loop. It is only barely detectable to the visual observer under the best of conditions but part of it was seen by William Herschel. In 1890 W. H. Pickering noted it in photographs taken with a 2.6 inch f/3.3 portrait lens and in 1894 E. E. Barnard described capturing it with a 1½ inch f/2.4 "lantern lens."

The Orion OB1 association is a collection of hot, short-lived giant stars of spectral type O and B that includes the stars in the belt as well as those in the Great Nebula (M42) and M43. It has been estimated that 10-20 supernovas exploded in this region within the last 12 million years and Barnard's Loop is likely the aftermath of one of them. Sitting atop Orion's shoulders is the Lambda Orionis Ring (Sh2-264) sometimes called the Angelfish Nebula. It may also be a supernova remnant with the giant O type star, λ Orionis, lying at its center.

The image was made with Canon 50-mm lens stopped down to f/3.5 and attached to a ZWO ASI2600MC camera. The field of view is 17.3°x25.7°. The nebulosity was imaged using a Radian Quad band filter and is a stack of 10 600-second subframes (total). The stars were removed with the StarNet2 add-in in PixInsight. The stars are a stack of 62 60s subframes. Photometric color calibration was performed and the white balance weights obtained were then applied to the nebulosity before the two images were combined.

The Great Nebula (M42) stands out in the sword. The Horsehead Nebula is visible as a dark notch in the bright nebulosity below Alnitak (ζ Orionis), the star at the left-hand end of the belt. The Flame Nebula can be seen to its left. RS

Deer Lick Group by Olivier Prache

Olivier’s view of the NGC 7331 and its surrounding galaxies was made in Pleasantville in November over several nights, a total of eight hours of imaging with a 12½-inch Hyperion RC scope and ML16803 CCD camera.

We identified most of the faint galaxies in the image, which we uploaded to the WAA web site. See https://is.gd/Prache7331. The magnitudes of the galaxies in the negative image are given to one decimal place, with the decimal point omitted (for example, magnitude 15.4 is given as 154). This is a standard practice to avoid confusing the decimal point with a star.

The “Deer Lick Group” was named by the late amateur astronomer Tomm Lorenzin. The genesis of the name is given in the caption of Arthur Rotfeld’s image in the August 2023 SkyWAAtch, page 26.

Two Galaxies by Arthur Miller

NGC 4321, better known as Messier 100, a lovely spiral galaxy in Coma Berenices. One of the brightest members of the Virgo Cluster.

NGC 3198 is a barred spiral galaxy in Ursa Major

Celestron C11, 0.7X focal reducer.

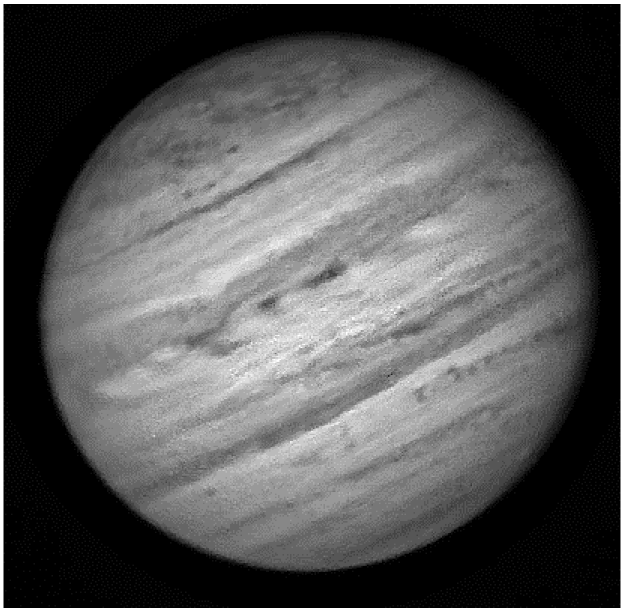
Imaged from Quail Creek, Arizona

Two Vaonis Vespera Images by Jordan Solomon

Messier 16, the Eagle Nebula, imaged at Cherry Springs, Pennsylvania

Helix Nebula, NGC 7293, imaged at Lake Taghkanic State Park, NY

Jupiter in the Infrared by John Paladini



John made this image with a 10-inch Meade Schmidt-Cassegrain and ASI290MM monochrome camera, using a filter that blocks all the wavelengths below 685 nanometers. Imaging in the infrared reduces the impact of suboptimal atmospheric seeing, enhancing detail. CMOS cameras are quite sensitive to infrared wavelengths. These IR bandpass filters look essentially opaque to visible light.

There's a lot of methane on Jupiter. Methane absorption is very strong at 890 nm; 90 percent of the incoming light is absorbed by methane gas.

Orion Rising over Orient Point by Steve Bellavia

While imaging StDrSa-01 (see page 23), Steve made a nightscape of Orion rising above the calm waters at Orient Point at the tip of eastern Long Island's North Fork.

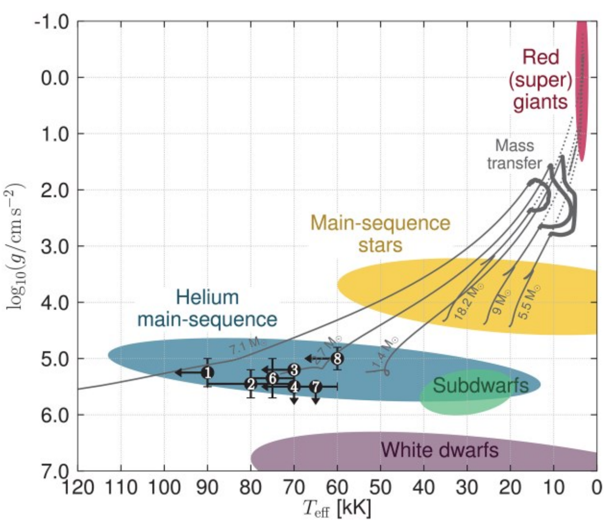
Research Highlight of the Month

Drout, MR, et. al., An observed population of intermediate-mass helium stars that have been stripped in binaries, *Science* 382: 1287-1291 (15 December 2023)

All stars begin their lives by fusing hydrogen into helium (see the June 2021 SkyWAAtch). High-mass stars (classes O and B, heavier than 8 solar masses (M⊙), burn through their hydrogen fuel quickly. When they begin to fuse helium at a hotter core temperature they become massively swollen. Their outer layers, made of cool unfused hydrogen, are tenuously held and can be expelled via intense stellar winds. Wolf-Rayet (WR) stars are the largest and hottest helium stars, with surface temperatures from 20-200,000K, masses as high as 315 M⊙ and helium emission lines in their spectra. Stars in the 8-25 M⊙ range have less intense solar winds but can lose their outer layers by interacting with binary companions. The “stripped” stars show helium absorption lines in their spectra because the outermost helium layer absorbs radiation coming from below. Helium stars continue to evolve and have their own temperature/luminosity zone on the Hertzsprung-Russel diagram. Progenitor stars that start out in the 8-25 M⊙ range, even though they’ve lost mass, should still be large, on the order of 2-8 M⊙.

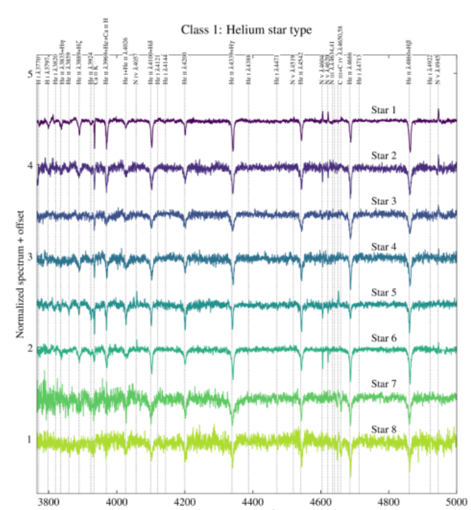
Helium stars in the 2-8 M⊙ range may be the precursors of neutron stars and/or hydrogen-deficient core-collapse supernovas (one third of all core-collapse SNs) and are sources of the ultraviolet radiation that might have contributed to the reionization of the interstellar medium in the early universe.

The only helium star in the 2-8 M⊙ mass rage identified to date is a “quasi-WR” star in the 9th-magnitude system HD 45166, 3° north of the Rosette Nebula in Monoceros. Helium stars in this mass range should be more ubiquitous. The authors identified 25 high-UV luminosity stars in the Large and Small Magellanic Clouds using data from NASA’s Swift ultraviolet satellite. The Magellanic Clouds were chosen because they contain a large number of massive stars at a known distance, with little intervening dust. They investigated the stars’ optical spectra with the Magellan Echellette spectrograph on the 6.5-m Magellan Baade telescope at Las Campanas Observatory in Chile. The authors compared actual spectra with models and found the stars had masses of 2-8 M⊙, a zone between subdwarf helium stars that are thought to result from binary mergers and massive (>20 M⊙) Wolf-Rayet stars. They proposed three categories of “stripped” stars with a binary companion. In class 1 (8 stars) the optical spectrum is dominated by the helium star, the companion being either a low mass main sequence star, another stripped star or even a neutron star. In class 2 (8 stars) the companion star is an intermediate mass main sequence star of approximately equal brightness and the spectrum shows features of both stars. In class 3 (9 stars) the companion star, probably a B-type main sequence star, dominates the spectrum, with the stripped star being revealed only by its ultraviolet emission. The stars had high temperatures (60-100,000 K) and high surface gravity, and 16 of the spectra showed clear binary motion. These are properties consistent with expectations for helium stars with initial masses in the 8-25 M⊙ range that are now in the 2-8 M⊙ mass rage. ■



←Left:
HR diagram showing intermediate-mass helium stars, which are hotter but less luminous than hydrogen-burning main sequence stars. The evolutionary paths are shown.

Right: →
Spectra of 8 the class 1 stars.



Member & Club Equipment for Sale

Item	Description	Asking price	Name/Email
Celestron Nexstar 5SE NEW LISTING	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 AVX Go-to Mount NEW LISTING	German equatorial mount and tripod with Celestron hand control. Polar scope, counterweights. upgraded with ADM dual saddle (a $200 part). 30 pound payload capacity. Excellent condition. Will work with StarSense, advertised below. New AVXs are almost $1200.	$650	Manish Jadhav manish.jadhav@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
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.	$50	Larry Faltz lfaltzmd@gmail.com
Tiltall photo/spotting scope tripod	TE Original Series solid aluminum tripod with 3-way head, center stalk. Very solid. 3-section legs. Height range 28.5"-74". Can carry up to 44 lbs. Folded length 29.6". Weighs 6 lbs. Carry bag. Image here. List $199.50. Donated to WAA.	$75	WAA ads@westchesterastronomers.org
RUBYLITH Screens	I have two 1/8" thick rubylith screens for placing over a laptop or tablet screen. Sizes are 14½x9" (for 17" diagonal 16:9 laptop) and 10½ x 7" for a tablet. Includes strong rubber retainers. I don't need them anymore. First come, first served.	Free	Larry Faltz lfaltzmd@gmail.com

Want to list something for sale in the next issue of the WAA newsletter? Send the description and asking price to waa-newsletter@westchesterastronomers.org. Member submissions only. Please offer only serious and useful astronomy equipment. WAA reserves the right not to list items we think are not of value to members.

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