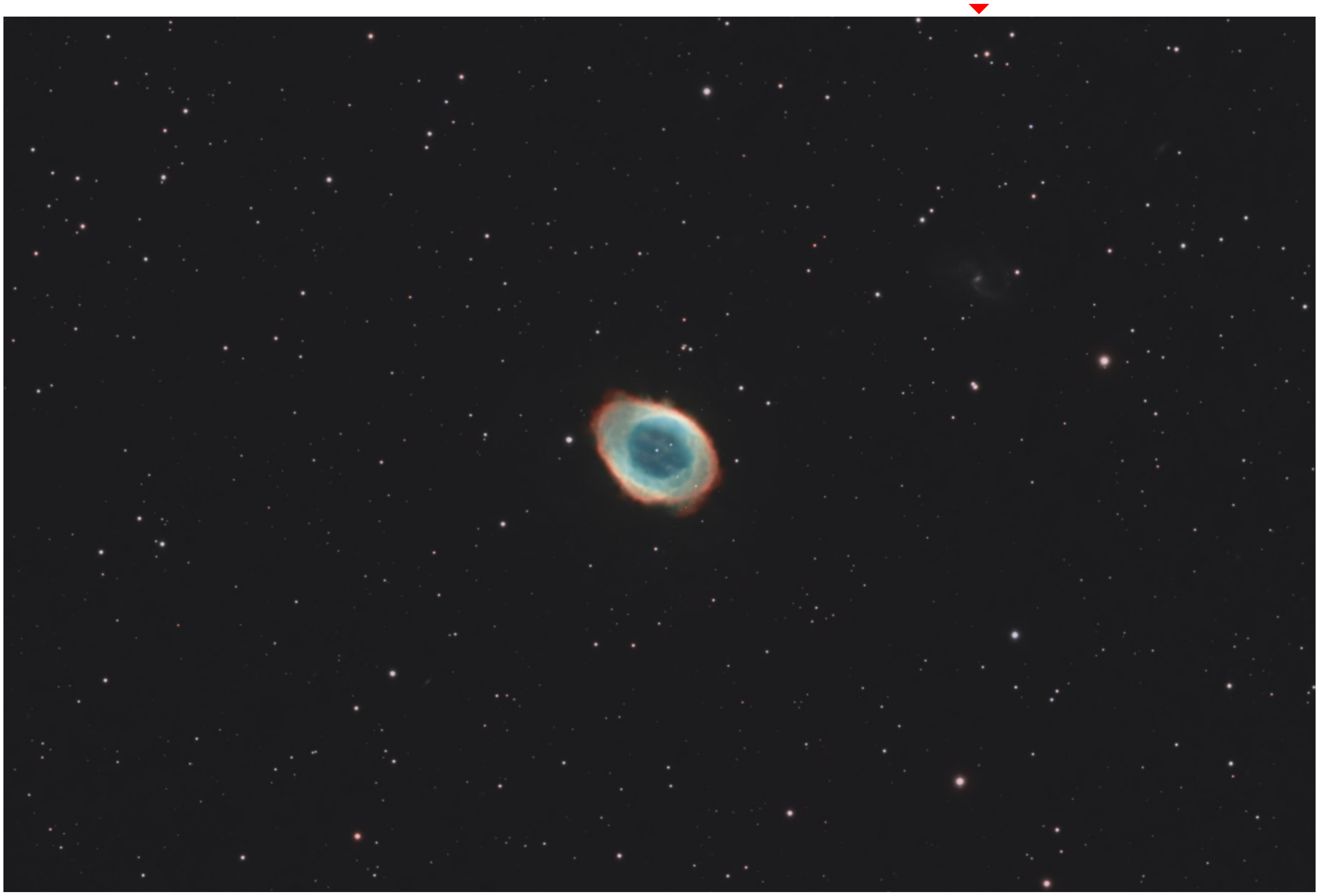
SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

August 2024



Messier 57 by Steve Bellavia

The Ring Nebula is one of the highlights of the summer sky and always a crowd-pleaser at star parties. Steve was testing out his new Explore Scientific 152mm Maksutov-Cassegrain telescope (see his report on NEAF in the May 2024 SkyWAAtch, p. 10) with an Astro-Physics CCDT67 Telecompressor. Steve notes "M57 is between the trees at my house this time of year and it was a good target for the tests." The image was made with a total of 3 hours of exposure with an ASI 533MC Pro camera and Baader UHC-S and UV/IR block filters. The 15th magnitude white dwarf central star is clearly seen. Triangulate the red markers to find the 14.0 magnitude spiral galaxy IC 1296, just 4 arcminutes from the Ring Nebula in the 14.8 x 9.84 arcminute field. Full technical information is at https://www.astrobin.com/no482r/.

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 September Meeting

Friday, September 13 at 7:30 pm

Live or on-line via Zoom

Members' Night

WAA members

A club tradition. WAA members will present short talks on a wide range of topics of interest to fellow members.

Members interested in presenting a talk should contact Pat Mahon, VP for Programs, via email at waa-programs@westchesterastronomers.org.

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

Also In This Issue

WAA October Meeting

Friday, October 18 at 7:30 pm

Live or on-line via Zoom

Monster Black Holes at the Edge of the Universe

Zoltan Haiman, PhD
Department of Astronomy, Columbia University

Starway to Heaven

Ward Pound Ridge Reservation, Cross River, NY

Saturday, August 3, 10 and 31 Weather permitting. Use your judgment, check the phone 1-877-456-5778 if you're not sure.

New Members

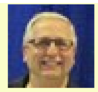
Courtney Cameron	Mount Vernon
Jon Corrado	Ridgewood
Terry Jackson	New York
Charbel Kaed	Hastings on Hudson
Deshmukh Kartik	Hartsdale
Jennifer Kovalskaya	Mt. Kisco
Mark Maiello	Ossining

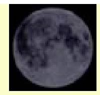
Renewing Members

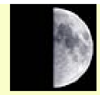
Justin Accetturi	Scarsdale
Jason Alderman	Pelham
Liv Andersen	Westport
Richard Austin	Milford
Eric and Katherine Baumgartner	Redding
Anthony Bonaviso	New Rochelle
Brian Carroll	Ossining
Michael & Ann Cefola	Commack
Federico Duay	Briarcliff Manor
Eva Gao	Millwood
Joe Geller	Hartsdale
Charlie Gibson	Scarsdale
Jimmy Gondek and Jennifer Jukich	Jefferson Valley
Kim Hord	Dobbs Ferry
Glen & Patricia Lalli	White Plains
Arumugam Manoharan	Yonkers
Alexander Mold	East Orange
Scott Nammacher	Athens
Ayumi Noda	Elmsford
Una O'Malley Petrino	Yorktown Heights
Alfred J. Padilla	Armonk
James Peale	Bronxville
Lydia Maria Petrosino	Bronxville
Peter Rothstein	Hastings on Hudson
Robin Schwartz	Riverdale
Maryellen Sinclair	Cross River
Jordan Solomon	Pleasantville
Ihor Szkolar	White Plains
Jordan Webber	Rye Brook
Alan Young	Tarrytown

ALMANAC For August 2024

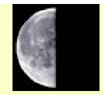
Bob Kelly, WAA VP of Field Events


Bob Kelly


New Aug 4


1Q Aug 12


Full Aug 19


3Q Aug 26

What does 'bimonthly' mean? Every other month? Or twice a month? Webster's includes both meanings. Mercury does one kind of bimonthly, with two views in August. The speedy planet starts this month in the evening sky and zips over to visit the planetary zoo in the morning sky by the end of the month.

Planets Low in the Evening Sky

For how many days in early August can you see Mercury, low in the western sky right after sunset? Mercury gets larger, and closer to Earth, but as its phase decreases, it's more of a crescent and dimmer. By the 19th, it's in conjunction with the Sun.

Venus is slow to get up in our skies, as if drowsy from a long summer's nap. The brilliant planet, at magnitude -3.8, starts on August 1st at nine degrees above the horizon at sunset, and only rises to 11 degrees on the 31st. If you can catch it, Venus looks almost fully lit, but tiny at only 10 arc seconds wide.

Starting on the 1st, Mercury gets level with Venus as Mercury leaves the evening sky. They are closest on the 7th. On the 5th, right after sunset, the Moon's thin 1½-day sliver comes by, passing close to Venus while she is keeping company with first-magnitude Regulus. Mercury stands off to the lower left; at magnitude +1.6. This scene will be hard to pick up, even in binoculars.

Morning Planet Parade

Saturn continues to lead the way in the morning sky, getting ready for its all-night appearance when it reaches opposition on September 7th/8th. The rings are almost edge-on. With the glare from the rings reduced, it's a great time to find some of Saturn's fainter moons. Also, catch Saturn's shadow on the rings before it gets too close to opposition to be seen.

Mars comes down to meet Jupiter as the giant planet rises higher in the sky. They cozy up from the 13th through the 15th in the horns of Taurus the Bull, rising together about 12:55 a.m. EDT. They are quite different in size and color, and three magnitudes difference in brightness. Jupiter's rise time moves from 2 a.m. EDT to midnight during the month.

The shadows of Jupiter's moons appear on the face of the planet on the mornings of the 7th, 14th and 21st. Check an almanac or a Jupiter's Moons app for the exact times for our location.

Perseid Meteor Shower

Warm temperatures and a dark sky offset the annoyances of bugs, making the Perseids one of the best meteor showers. The peak number of meteors passing through Earth's atmosphere occurs at midnight on the night of the 12th, but shower members can be seen any time in August. The first quarter Moon sets at 11:03 p.m. on the 12th, so we'll have dark skies as our location rotates into the radiant. The shower spigot can rain down over 50 visible meteors an hour in dark skies. Even the evening hours can have lots of meteors, the brightest visible despite the lurking Moon. It's easy to block its light, since it doesn't get higher than 30 degrees above the horizon that evening. The Perseids are chips off the old block from Comet 109P/Swift-Tuttle, which last came by in 1992 and won't be back until 2126.

Comets

Stay tuned for news about Comet C/2023 A3 Tsuchinshan-ATLAS, which may be breaking up. It's not reaching its expected brightness, so it may not be the super comet predicted for this fall.

Crewed Satellites

The ISS won't be seen from our area for much of the month. In the last third of the month, it will be visible in the pre-dawn sky. China's Tiangong station has overflights during and after dusk for the first third of August, with a long gap before being able to be sighted in the dawn sky as August ends.

More Dark!

The time of end of evening's astronomical twilight moves from 10 p.m. to just after 8 p.m. this month. By the end of August, we are treated to almost eight hours of true darkness, not counting the light pollution. Get your scopes out!

Another Movie Telescope: *Bowfinger*

LA's Griffith Observatory has been in almost as many films as the Eiffel Tower it seems (OK, maybe not). It appears near the end of Steve Martin's wonderfully crafted and extremely funny *Bowfinger* (1999), directed by Frank Oz (we honor him as the voice of Miss Piggy, Fozzie Bear, Animal, Cookie Monster, and of course Yoda). The film stars Martin, Eddie Murphy (in 2 roles), Heather Graham and Terence Stamp. Near the climax of the film, Murphy and Graham climb into the dome of the Griffith's 12-inch Zeiss refractor, the most looked-through telescope in the world.

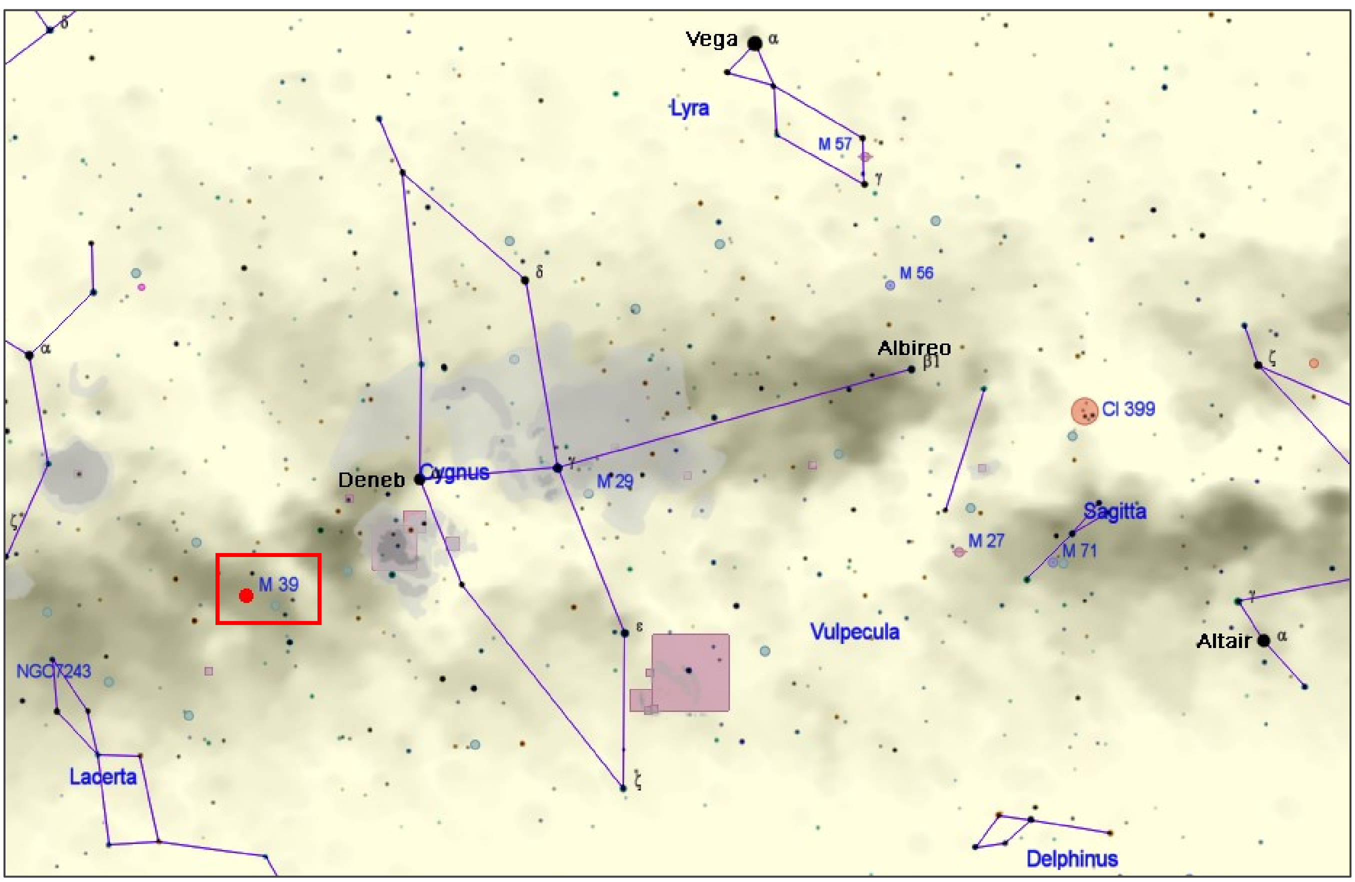
Deep Sky Object of the Month: Messier 39

Messier 39	
Constellation	Cygnus
Object type	Open Cluster
Right Ascension J2000	21h 31m 48.3s
Declination J2000	+48° 26’ 17”
Magnitude	4.6
Size	29 arcminutes
Distance	1,011 light years
NGC designation	7092
Discovery	Guillaume Le Gentil, 1749

Some observers are not impressed with Messier 39. Stephen James O’Meara (in *The Messier Objects*) calls it “large” and “very poor,” but he praises the “diamond blue purity” beauty of its brightest members. It’s indeed large, the size of the full Moon, but it only has about 30 members, so poor in number but not in quality. It’s nine degrees east-northeast of Deneb, smack-dab in the middle of the Milky Way, so sometimes it’s hard to pick out in spite of the brightness of its members. It’s visible with the naked eye in very dark skies (even Le Gentil noted that) and is a very good binocular object.

Visibility for Messier 39			
2200 EDT	8/1	8/15	8/31
Altitude	50° 51’	59° 55’	70° 18’
Azimuth	59° 53’	61° 39’	59° 29’

Next time you are looking at the wonders of the Summer Triangle, take a look at M39 with a low power, wide-field eyepiece.



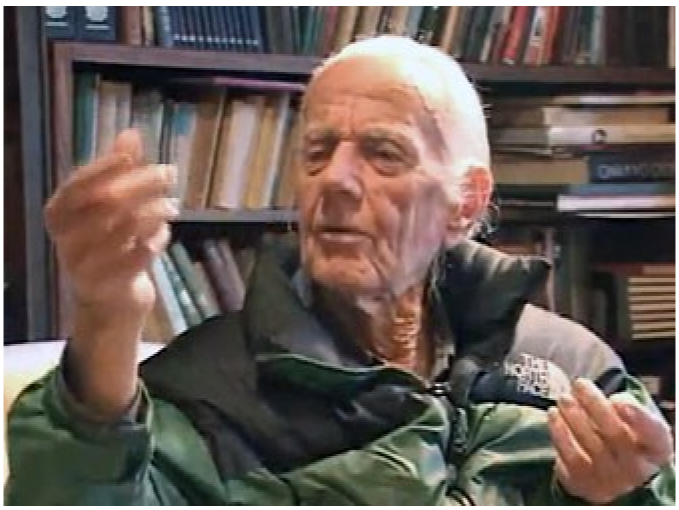
The Man Behind the Dobsonian Telescope

Ann Cefola

Meeting John Dobson

Michael and I met John Dobson (1915-2014) two decades ago at a day-long Westchester Amateur Astronomers event followed by a star party that night. Longtime WAA members Jen and Jimmy Gondek, who had been hosting him, asked if we could take him home in the free time before the star party.

Soon we were driving on the Cross County Parkway with Dobson, revered inventor of the namesake telescope, in our back seat.



Then in his late 80s, Dobson was an iconic figure—sporting clean jeans, white running shoes, and his trademark gray ponytail. Years of yoga had made him agile and quick. His high crackly voice sounded more like your Aunt Mildred than the genius he was. And he never stopped talking—so relentlessly excited was he about the wonders of the universe.

The Myth Behind the Man

Dobson, it was rumored, had been a physicist on the Manhattan Project. He became a Vedanta monk and spent 23 years isolated in a California monastery studying the spiritual meaning of physics. His attention was drawn to the stars and how he could make the universe more accessible to people. He felt that seeing the night sky would expand our personal understanding of existence.

In secret, he began to build what is known today as the Dobsonian telescope. He smuggled it out of the monastery at night, set it up on a sidewalk, and showed the planets to delighted passers-by. Finally, after going AWOL one too many times, he was kicked out of the monastery. That was the beginning of the San Francisco Sidewalk Astronomers, now a worldwide organization that continues his original mission.

Relativity and Our Cat

When we arrived at our apartment building, Michael dropped Dobson and me off so he could find parking. Dobson shared a history that had a conspiratorial ring: Did I know that Einstein's wife first formulated the theory of relativity in a footnote while typing Einstein's paper? Now he had my attention. We sat on the couch in our living room, where he stroked our black and white cat, and declared that its glossy fur originated from the same compounds as those found on the Moon.

All Dobson wanted was some orange juice, which Michael scrambled to find. I was sure ours was spoiled but was too embarrassed to say so before our guest. Michael gave Dobson a small cup of the bitter sludge which the former monk sipped and declared, "Delightful!" I was more speechless at that than at Einstein's wife discovering relativity.

Relentless Riddles

As we drove to the star party, Dobson pounded us with riddles: What has seeds but no flower? What has a flower but no seeds? What is on the back of the Moon? "Think!" he urged, "It's right in front of you!" Driving on I-684, I went blank. Dobson pointed to the windshield; it was glass. I was starting to understand why the Gondeks, uncharacteristically stressed, had earlier pleaded, "Can you guys *please* take him?"

Once at the star party, he was on home ground—surrounded by many versions of his telescope and relishing his impresario role. He had never claimed any patent on his invention although astronomy companies have profited from it. From the start, he had eagerly shared how amateur astronomers could easily build one with basically two mirrors, a large cardboard cylinder and Lazy Susan base.

Big Bang…Maybe Not

The next day I had a Dobsonian headache. Exhausted, I felt like he had performed some Vulcan mind-meld on me. However, I investigated his scientific insights, and the Internet confirmed the facts, if not conclusions, behind each one. I also agreed with his take on the Big Bang, "You can't have something from nothing." Instead, he suggested an outward movement to the edges of the universe that infinitely rebounds to its center.

"One of the problems of human knowledge," he liked to say, "is that the world which we see from the surface of this planet on a sunny day bears almost no resemblance to the Universe at large."

His quest to advance amateur telescope-making and viewing addressed this most human concern. And he did acknowledge his unceasing chatter, predicting his mouth would continue long after he was gone. In a way it does: every time we look through a Dob, we rejoice in the renegade telescope maker who insisted we experience a more accurate view of the universe.

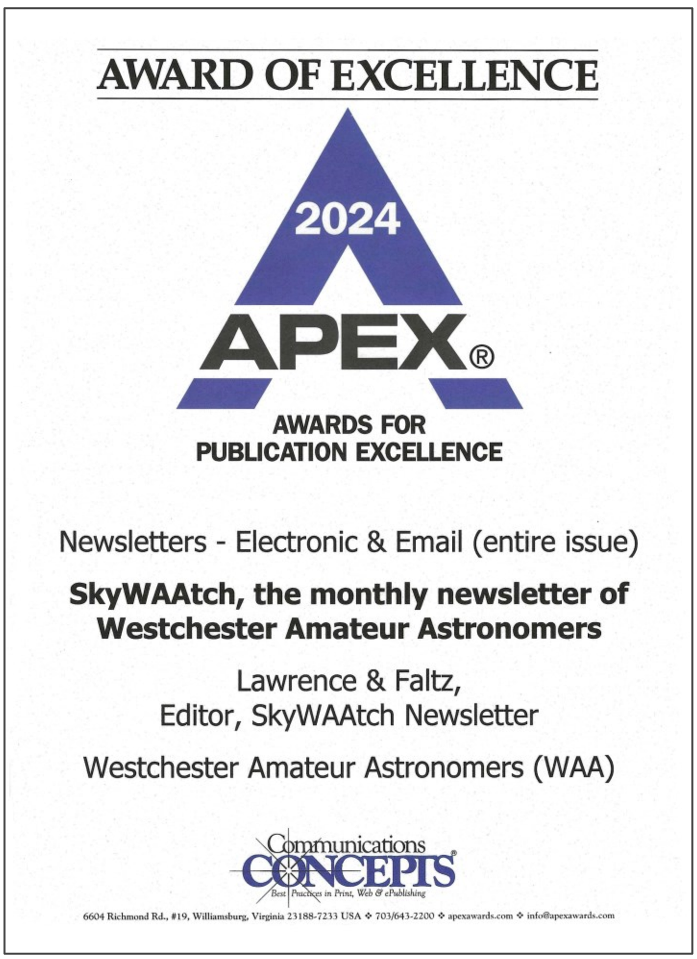
Editor's Note:

Among other Dobsoniana, in 2005 WAA member Jeffrey Jacobs wrote, produced and directed the documentary A Sidewalk Astronomer *about Dobson. More information can be found at https://en.wikipedia.org/wiki/A_Sidewalk_Astronomer.*

SkyWAAtch wins another Apex Award for Publication Excellence

For the fourth year in a row, SkyWAAtch has won an Award of Excellence from Communications Concepts. The annual competition got 1,100 entries this year from a vast range of organizations in the US and other countries.

SkyWAAtch is the only amateur astronomy publication to be recognized. This year, there were no other astronomy organizations, amateur or professional, who were cited in any of the 100 categories, which include print media of various types, electronic publications and web sites, as well as categories for writing excellence and design. Entries can be made in more than one category, but since a fee is required for each entry, we frugally chose to place SkyWAAtch in a single category, "Newsletters—Electronic & Email."



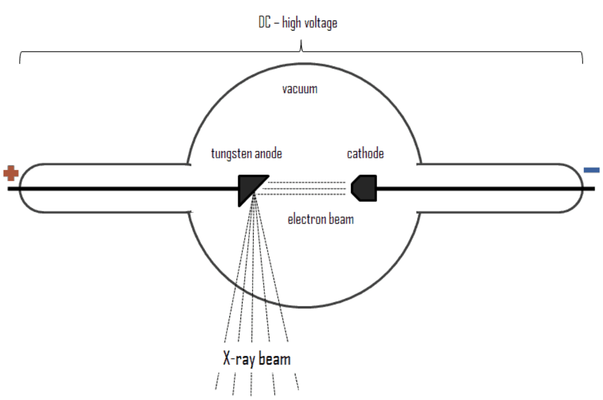
The rules allow us to submit four issues from 2023. I made sure to select those that had contributions by other WAA members, including Robin Stuart, Rick Bria, Steve Bellavia, David Parmet and Eli Goldfine, and of course the wonderful monthly almanac by Bob Kelly. The superb images by so many talented WA astrophotographers certainly impressed the judges. And support by Elyse Faltz, who caught many typos and a few formatting goofs, must have had an effect: you can't win if there are *misteaks*. ☺

There's a lot of excellent astronomy information out there: terrific web sites, email newsletters, fine magazines, professional and amateur YouTube channels. SkyWAAtch is a place where WAA members can show each other what captures their interest and enthusiasm in the hobby, in space science, and In our organization.

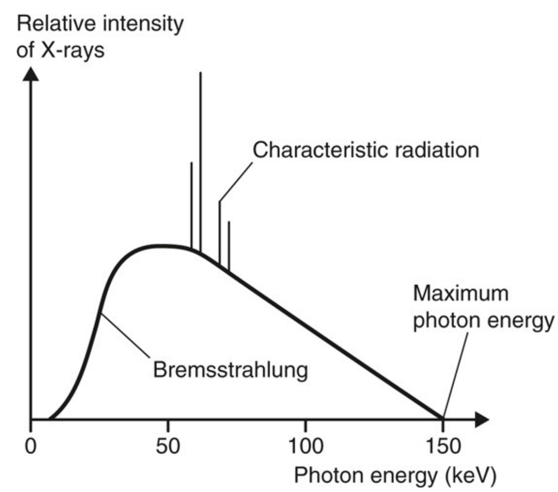
The Editor

X-ray Astronomy and Chandra's Troubles Larry Faltz

We've all had X-rays. A broken bone in the playground, a cough and a fever, a bad back. My first experience with X-radiation was an odd but common one in the early 1950s for kids growing up in the Bronx. A couple of times a year, as I grew and needed new shoes, my mother would take me to Alexander's department store on the Grand Concourse and Fordham Road. Once you tried on your new shoes you would step into a little box to have your feet fluoroscoped to check the fit and see whether you needed an arch support. These machines made their appearance in the 1920s and were in use in shoe stores throughout the English-speaking world, Germany and Switzerland until after World War II when the dangers of radiation began to be recognized. The radiation doses were quite high: an examination lasting 20 seconds would expose a child's feet to 120 milliSieverts (mSv). For comparison, a chest X-ray provides just 0.1 mSv, since only a very short exposure is required; annual exposure in the US from all natural sources is 3.1 mSv.[1] Shielding of these machines was generally poor. The shoe salesmen must have had significant exposure, undoubtedly in excess of the recommended maximum daily workplace exposure of 50 mSv (intended for radiology and nuclear power workers). Although there were a few case reports of medical complications, there were no longitudinal risk studies of shoe salesmen. The machines were phased out in the 1960s, a victory for science coupled with common sense.



Medical (and shoe-fitting) X-rays are generated with a cathode-ray tube. A beam of high energy electrons in a vacuum strikes a tungsten anode. X-rays are emitted by two mechanisms. *Bremsstrahlung radiation* results when the negatively charged electrons curve around positive tungsten nuclei as they pass by. When a charged particle changes its path, it loses energy in the form of an emitted photon. This "braking" radiation has a broad wavelength range, to a maximum of the energy of the electron (because of the conservation of energy). X-rays can also be emitted when an electron collides with a tungsten atom, exciting it by kicking an inner electron up to a much higher energy level. When the atomic electron returns to its original energy, it emits a photon with a wavelength given by the familiar "Planck relation" $\mathcal{E}=hc/\lambda$. These are "characteristic X-rays" and are peaks on the broad *Bremsstrahlung background.*



X-rays can also be thermal. The peak wavelength is given by Wein's displacement law, $\lambda_{max} = b/T$, where b is Wien's displacement constant, 2.8977719 mm·K. The peak wavelength of a body at 5,000 K is 579 nm, in the yellow zone of the visual spectrum. A thermal source at 10 million Kelvin will have a peak wavelength of 0.2898 nanometers (289.8 picometers). The X-ray band is generally given as 10 picometers to 10 nanometers, corresponding to photon energies of 123.9 KeV to 0.12 keV (lower energies with longer wavelengths). The energy of a 5,000 K photon is just 2.4 eV (0.0024 keV) while the 298.8 picometer photon packs an energy of 4.16 keV. "Hard" X-rays are those with energies above 5-10 keV while lower

[1] One Sievert (1000 mSv) of exposure results in a 5.5% probability of eventually developing fatal cancer. There may be somewhat less of a risk if the exposure is confined to the extremities.

energy X-rays are “soft.” Whether hard or soft, all X-rays are “ionizing” and can do damage to biological tissues. The harder the X-ray, the greater the damage. Fortunately, the Earth’s atmosphere is an excellent barrier to X-rays from the Sun and other cosmic sources. X-rays can travel a few hundred feet in air, but they lose energy in the process. You do get a measurably higher dose of ionizing radiation in an airplane, but it’s not biologically significant. If it was, airplane fuselages would have to be made of lead, making planes too heavy to fly.

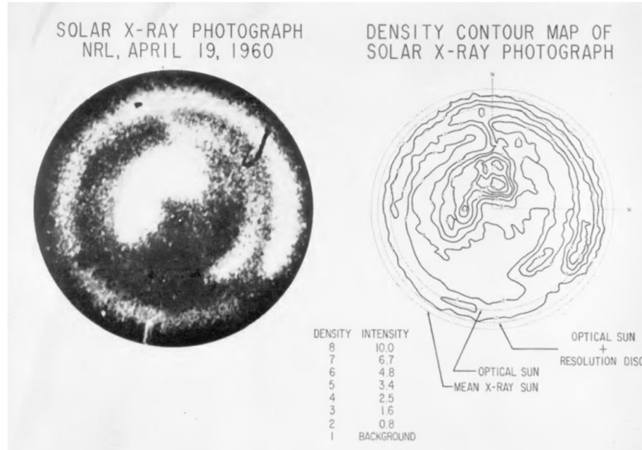
X-rays from the Sun

In the 19th century, the solar corona was thought to be made of gas and dust. It did not occur to solar observers that there could be a mechanism that could make the corona any hotter than the solar surface, which was determined by Joseph Stephan in 1879 to be around 5500 K using what is now known as the Stefan-Boltzmann law. This states that for a blackbody (a perfect emitter of radiation) the total energy radiated per unit surface area per unit time (M) is directly proportional to the fourth power of the temperature. The equation is simply

$$M = \sigma T^{-4}$$

where σ is the Stefan-Boltzmann constant, equal to 5.670374419×10^{-8} $W\cdot m^{-2}\cdot K^{-4}$. That the temperature of the corona was above a million Kelvin (heated by a mechanism still not fully explained) was first proposed by Walter Grotrian in 1939 and then Bengt Edlén in 1940. They mapped spectral lines at 530.3 nm and 637.4 nm to Fe^{+13} and Fe^{+9} respectively. To be so highly ionized, the iron must be in an extraordinarily hot environment.

X rays from the Sun were first detected by Thomas Burnight with a detector flown on a captured German V-2 rocket, launched from White Sands, New Mexico, in 1948. The first X-ray image of the Sun was made on April 19, 1960, using a pinhole camera on an Aerobee rocket.[2] The exposure was 286 seconds, the pointing maintained with 1 arcminute by a special device built at the University of Colorado. The peak altitude of the flight was 220 km.



First X-ray image of Sun, from ref. 2.

Detecting X-rays from Deep Space

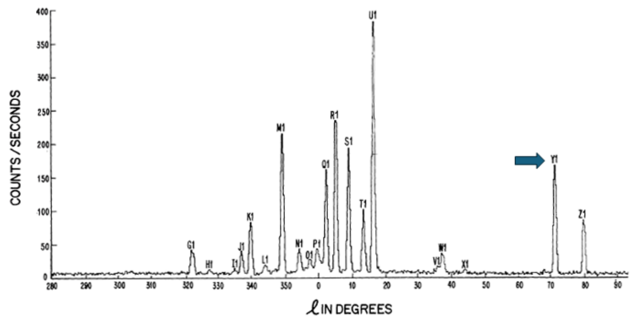
In 1962, a detector on an Aerobee rocket recorded X-rays from a source in deep space, dubbed Scorpius X-1. The project was led by Riccardo Giacconi (1931-2018), who was the force behind X-ray astronomy for the next four decades. Giacconi was responsible for the Uhuru, Einstein and Chandra X-ray satellites, and later was the first director of the Space Telescope Science Institute, which oversaw the Hubble Space Telescope. He also was Director General of the European Southern Observatory and was later president of Associated Universities, Inc., which during his tenure was responsible for the early years of the ALMA array. AUI currently runs the National Radio Astronomy Observatory. Giacconi won the Nobel Prize in 2002 for his X-ray work.

Uhuru, launched in 1970, was the first dedicated X-ray satellite. It gathered data for 3 years. Sensitive to X-rays in the 2–20 keV range, it could detect strong sources with a resolution of several arcminutes. It did not have collimating optics and did not make images. Instead, it simply reported the X-ray flux in the direction the detectors were pointing. Peaks of activity were correlated with known astronomical objects but some represented new objects unseen at visual wavelengths. Uhuru made the first X-ray all sky survey, detected 339 sources[3] and it discovered diffuse X-ray emission from galaxy clusters. About 15% of the

[2] Blake, R. L., Chubb, T. A., Friedman, H., Unzicker, A. E., Interpretation of X-Ray Photograph of the Sun. *Astrophysical Journal* 137: 3-15 (1963) https://articles.adsabs.harvard.edu/pdf/1963ApJ...137....3B

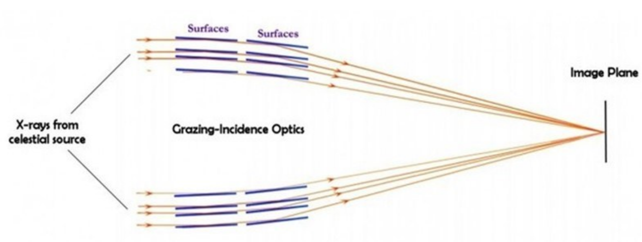
[3] Giacconi, R, Kellogg, E, Gorenstein, P, et. al., An X-Ray Scan of the Galactic Plane from UHURU, *Astrophysical Journal*, 165: L27-L35 (1971) https://articles.adsabs.harvard.edu/pdf/1971ApJ...165L..27G

detections had not been previously found at any wavelength.



An example of the data from Uhuru (part of Fig 4 from ref. 3). As an example, peak Y1 (arrow) is Cygnus X-1, the first black hole ever detected.

The first imaging X-ray satellite was Einstein, which was launched in 1979. As in all subsequent X-ray telescopes, Einstein focused X-rays using grazing-incidence mirrors. If directed directly at a surface, an X-ray will either pass through the material or scatter within it. However, if it encounters the surface at a very shallow angle, it will be reflected, like a stone skipping across a pond. Grazing mirrors for X-ray telescopes were invented in 1952 by German physicist Hans Wolter. He came up with three designs. The mirrors utilize a paraboloid element and either a hyperboloid or ellipsoid secondary. The various designs influence the focal length, field of view and field flatness. Material for the mirrors can be metal or glass, but if made of glass, a special coating is used to maximize X-ray reflectivity.



A Type I Wolter telescope (NuSTAR).

In a Type I Wolter design, the mirrors can be nested, which enhances sensitivity because more photons will arrive at the detector. ROSAT, a joint US-German-British satellite that gathered data from 1990 to 1999, used four pairs of thick nested mirrors coated with iridium. The NuSTAR telescope, observing the more energetic end of the X-ray spectrum, is also a Type I design. It uses 133 glass shells, each just 0.2 mm thick, coated with a multilayer platinum-based material. The Suzaku X-ray telescope, a project of the Japanese Space Agency and NASA's Goddard Space Flight Center, used 700 pairs of nested mirrors in a Type I design.

Grazing mirrors need to be figured to extraordinary tolerances to be effective. The mirrors for Chandra, also a 4-nested-mirror Type I design, were ground and polished by Raytheon in Danbury to a tolerance of a few atoms, the equivalent of polishing the Earth's surface to a deviation of just 78 inches. The Chandra mirrors are claimed to be the most precise mirrors ever figured.

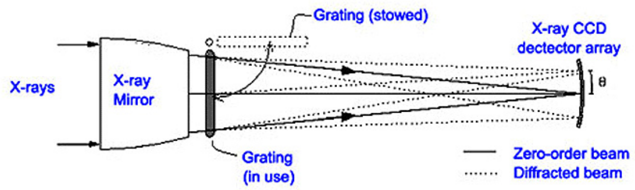
Since Einstein, a substantial number of X-ray instruments have been deployed. The full list of past and current X-ray instruments is available at https://en.wikipedia.org/wiki/List_of_space_telescopes#X-ray. Some telescopes, such as INTEGRAL, have both X-ray and gamma-ray sensitivity.

Detectors

After the earliest film experiments, proportional counters or scintillation detectors were used to register the radiation. The classic proportional counter is the Geiger counter. A high-energy photon passes through an inert gas in a cell across which is placed an applied voltage. The photon (X-ray or gamma ray) ionizes the gas along its track, setting off pulses which can be recorded. In scintillation counters, the photon passes through a transparent liquid or solid material, producing low-energy photons of visible light that are amplified by photomultiplier tubes or photodiodes. Modern imaging X-ray telescopes employ CCD detectors sensitive in the X-ray region of the spectrum. The basic mechanism is that the high-energy photon generates an electron (actually an electron-hole pair) in the silicon of the CCD by the photoelectric effect, which is then detected when the pixels of the CCD are read out. Functionally, this is just like any CCD or CMOS sensor in your camera or cell phone, with the substrates designed to be sensitive to appropriate X-ray wavelengths. These sensors have revolutionized medical imaging, making X-ray film obsolete.

Spectrometers

Transmission gratings made of metal or crystals can be inserted into the focused X-ray light cone to provide spectroscopy within the X-ray band.



Chandra grating geometry.

In Chandra, the gratings are made of strips of gold supported by plastic layers thinner than a soap bubble. X-ray spectroscopy allows astronomers to detect elements that are made in supernovas.

X-ray emission lines are usually given by their energies rather than their wavelengths or frequencies. See https://xdb.lbl.gov/Section1/Table_1-2.pdf for a listing.

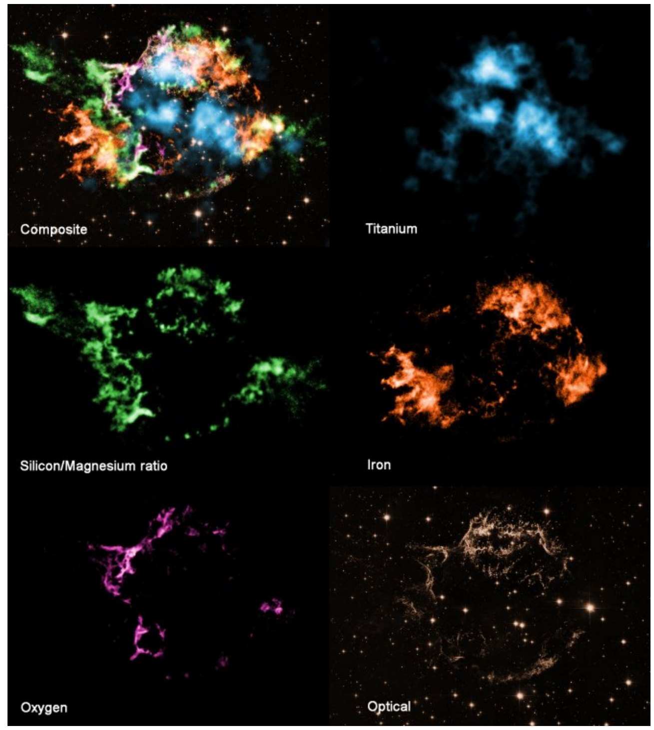
X-ray Sources

There are three primary sources of X-rays in the cosmos.

Friction in accretion disks around binary white dwarfs, neutron stars and black holes raises the temperature of the rapidly rotating, increasingly dense matter in the disk. For black holes, particularly the supermassive black holes at the center of galaxies, as the gas spirals inwards, gravitational potential energy is converted to increased velocity of the particles, and as much as 40% of its mass is converted to energy (as compared with just 0.7% for nuclear fusion). Much of the energy is radiated away in the X-ray band.

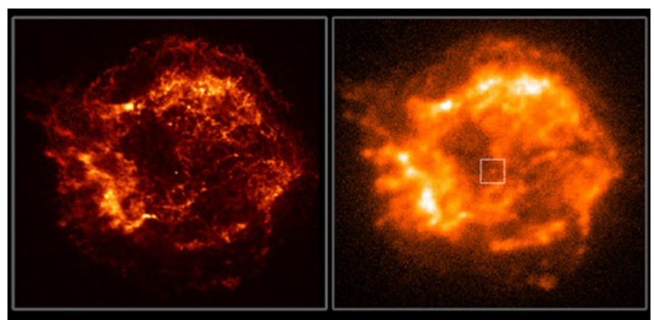
Another major source of X-rays is the baryonic intracluster medium (ICM). It is composed of ionized hydrogen and helium nuclei (with a smattering of other nuclei). Even though it is very thin (10^{-3} particles per cubic centimeter) 15% of a galaxy cluster's mass (and 75% of its baryonic mass) is in the form of the hot (10-100 million K), rarified gas concentrated in the center of the cluster. Recall that dark matter makes up 80% of the total matter in the cluster.

Supernova remnants are also potent X-ray sources. Shock waves from supernovas heat the ejecta from the star to temperatures that radiate X-rays. Using X-ray spectrometers, elements with characteristic spectral emission in the X-ray band can be localized, helping astronomers understand the dynamics of supernova explosions.



The Cassiopeia A supernova as seen by Chandra's imaging spectrometer. The upper left image is a composite.

More About Chandra



Images of Cassiopeia A: (L) Chandra, (R) ROSAT (NASA)

The Chandra X-Ray Observatory is one of NASA's four "Great Observatories," the three others being Hubble (launched 1990 and still operational, observing in UV, optical, near IR), Spitzer (2003-2020, infrared), and Compton (1991-2000, gamma rays). Chandra was launched in 1999 from the space shuttle Columbia. It had an expected five-year operational lifetime, which has obviously been exceeded, just like many other NASA instruments. Chandra has an effective aperture of 1.2 meters and a focal length of 10 meters. Its resolution of 0.5 arcseconds is more than 14 times finer than ROSAT. It has an unusual elliptical orbit, with perigee of 14,000 km and apogee of 134,000 km, more than halfway to the Moon. One orbit takes 63.4 hours.

Chandra's view of the Crab Nebula

According to the Chandra mission web site, these were Chandra's most important findings, as proposed by Project scientist Martin Weisskopf in 2011:

1. Deep field observations resolved the X-ray background and showed that it is dominated by accreting supermassive black holes including a large number of highly obscured black holes.

2. Images of clusters of galaxies established that energetic feedback by rotating supermassive black holes dramatically affects the evolution of intracluster gas and galaxies.

3. X-ray rings and jets around rotating neutron stars provide the most direct evidence of the transformation of rotational energy of these stars into jets and winds of high-energy particles.

4. X-ray and optical observations of the Bullet cluster of galaxies show the separation of dark and ordinary matter in a collision between galaxy clusters.

5. Observations of the rate at which massive galaxy clusters grow have provided confirmation that the expansion of the universe is accelerating, an effect attributed to the prevalence of dark energy, and have ruled out some alternatives to Einstein's General Theory of Relativity.

6. Observations of supernova remnants showed that supernova explosions are asymmetric and turbulent, requiring mixing of layers either during or prior to the explosions, and images of supernova shock waves provide evidence for acceleration of electrons to extremely high energies.

7. Detection of absorption by highly ionized oxygen atoms in X-ray spectra of a quasar behind the Sculptor wall of galaxies provided evidence for the Warm Hot Interstellar Medium thought to contain the missing baryons in the local universe.

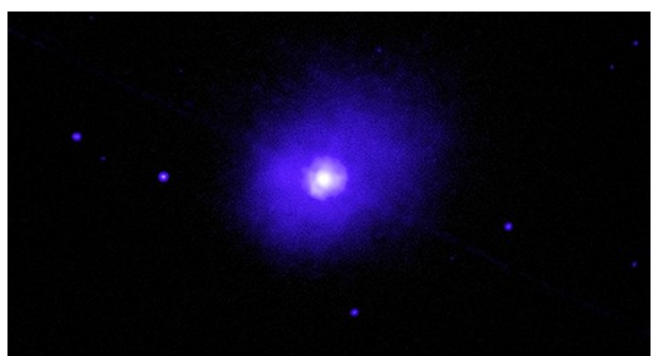
8. Chandra observations of spectrally soft X-ray sources in early-type galaxies led to the conclusion that mergers, rather than accretion-driven explosions, are responsible for the Type Ia supernovas in these galaxies.

9. A number of multi wavelength studies of star clusters have provided an unprecedented look at the co-evolution of young stars and their disks in a wide variety of conditions.

10. Chandra was used to discover and/or contribute to an understanding of the X-ray emission processes from comets, the moons, of Jupiter, the Io plasma torus, the atmospheres of Venus and Mars.

Chandra generates 400 publications per year. Over 2,000 students and 5,000 unique principal investigators have been involved over the lifetime of the mission. It continues to get far more requests for observing time than it can supply, evidence that it still has much to discover.

The El Gordo galaxy cluster. (L) Chandra X-ray image, (C) JWST infrared image (R) Composite image.



Quasar H1821+643 (Chandra X-ray band only)

Chandra in Trouble

Chandra has had occasional minor glitches over the years but continues to be a productive instrument. Program managers estimate it has at least ten more years of life left. There are no concrete plans for a replacement, certainly not in the immediate future. ESA's XMM-Newton can do X-ray spectroscopy but its resolution is a factor of 10 worse than Chandra. NuSTAR can reach higher energies, but its resolution is no better. eROSITA, a joint project of Germany and Russia launched in 2019, also resolves to only about 15 arcseconds. When Russia invaded Ukraine, the Germans imposed an embargo and discontinued co-operative ventures with Russia. The telescope was put in safe mode and stopped taking data.

The Chandra X-Ray Observatory is managed by the Harvard-Smithsonian Center for Astrophysics (CfA), which has been receiving about $70 million per year for operations and scientific studies. NASA's budget has been cut, and Chandra is facing an allocation of just $41 million for fiscal year 2025, which begins on October 1 this year, with further reductions to just $5 million By 2029. There is no way that CfA can continue to operate the telescope on this meager appropriation. The CfA's budget is already under stress. In May it shuttered the John G. Wolbach Library, one of the most comprehensive astronomy libraries in the world, shifting its operations to the main Harvard University library.

The budget cut was forced upon NASA because of the terms of the debt ceiling agreement enacted by Congress. NASA's budget was reduced by $1 billion from its $8.261 billion request. Unless money is found, CfA would immediately have to lay off half of the Chandra staff. Hubble too will feel the budgetary ax (see "Treble Hubble Trouble" on page 16 of this issue).

NASA justified the decision to shutter Chandra because of age-related changes in temperature management on the craft. NASA's position is that,

> The Chandra spacecraft has been degrading over its mission lifetime to the extent that several systems require active management to keep temperatures within acceptable ranges for spacecraft operations. This makes scheduling and the post processing of data more complex, increasing mission management costs beyond what NASA can currently afford.

With NASA committed to a return to the Moon and the enormous expense of human spaceflight, as compared to orbiting telescopes and robotic exploratory missions, it's not surprising that older missions, even if still somewhat functional, are on the chopping block.

Save Chandra?

Dr. Patrick Slane, Director of the Chandra X-ray Center disputed NASA's claim of compromised functionality. He wrote,

> Our teams have developed thermal models and processes to manage this situation and have done so with amazing success – experiencing little or no decrease in observing efficiency, which far exceeds the initial requirements for the mission. This is all managed through advanced planning. Schedules and command loads with thermally-balanced observing and maneuver parameters are developed in advance and sent for autonomous operation on the spacecraft. 'Active management' isn't done with Chandra, given that the Chandra Operations Control Center is only in contact with the spacecraft through one-hour communications every 8 hours. The thermal properties of the instruments (e.g., spectral response) are encoded into our analysis software and calibration database, so there is nothing about Chandra's evolving temperature behavior that makes "post processing of data more complex."

If Chandra shuts down, a replacement high-resolution X-ray telescope might not fly for 30 years. As CfA postdoctoral fellow Fabio Paccuci noted in an interview in the *Harvard Crimson*, "New grad students, new undergraduate students will not train on high-resolution X-ray data…. People that know how to do it will retire at some point…. This is not something that can be rebuilt in a few months."

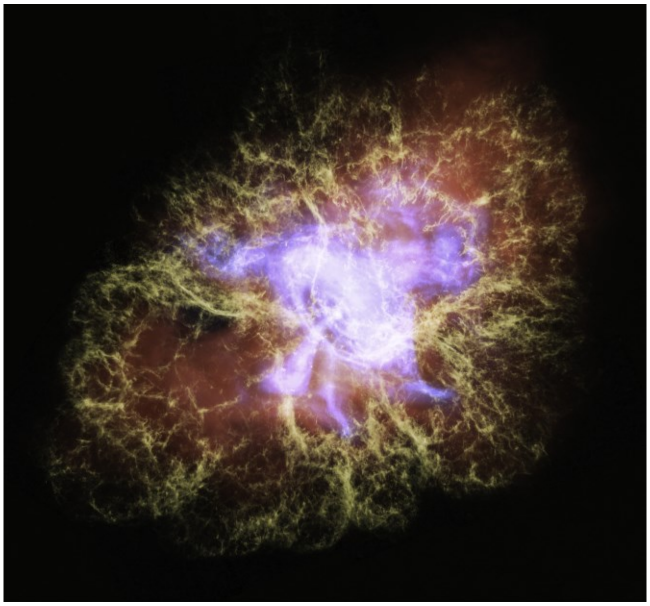
In March, a group of astronomers started a grass-roots campaign to save the telescope, Save Chandra. Their website, http://savechandra.org, provides information about the telescope and its impact on astronomy and education, as well as images and videos.

Slane's response to NASA may be true, but reason can't prevail by itself. There is only one possible way to preserve Chandra's funding, and that is for NASA to restore the cuts to Chandra's budget. Money would have to be pulled from other NASA ventures, upsetting astronomers on those projects. The current political mayhem in Congress makes it unlikely that there will be more appropriations for astronomical research any time soon.

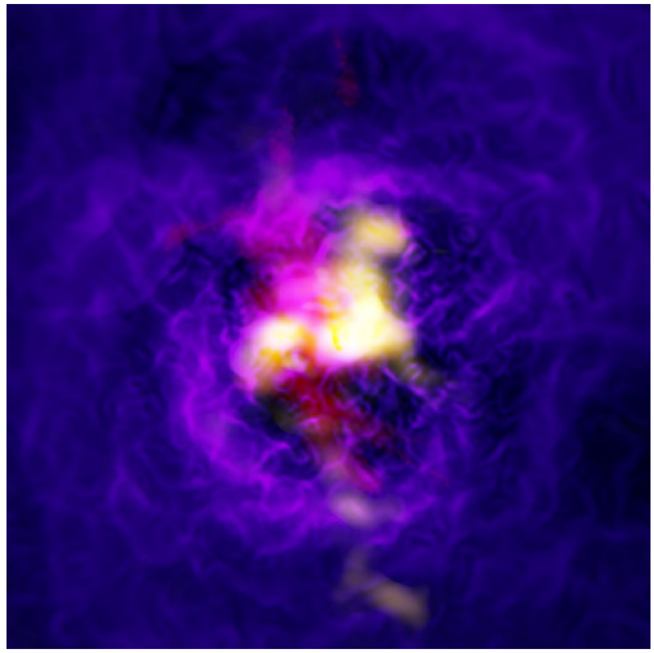
Nevertheless, you are encouraged to check out Save Chandra and consider participating in their advocacy, which, like all advocacy, primarily involves contacting your congressional representatives and pleading your case. ■

A Chandra Gallery

Here are a few of the Editor’s favorite Chandra images. Most are combined with data from other wavelengths, as noted. All the Chandra images, including composites and videos, are at https://chandra.harvard.edu/photo/.

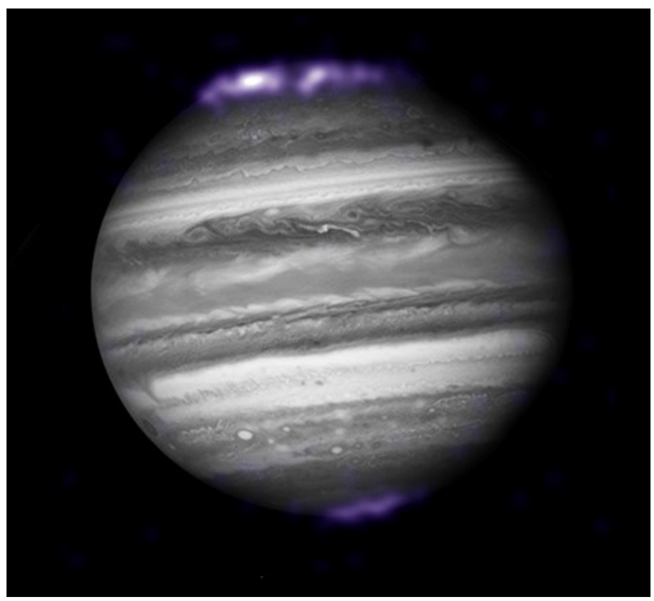


Crab Nebula (M1). Chandra (X-Ray blue), Hubble (visible, yellow), Spitzer (IR, red)

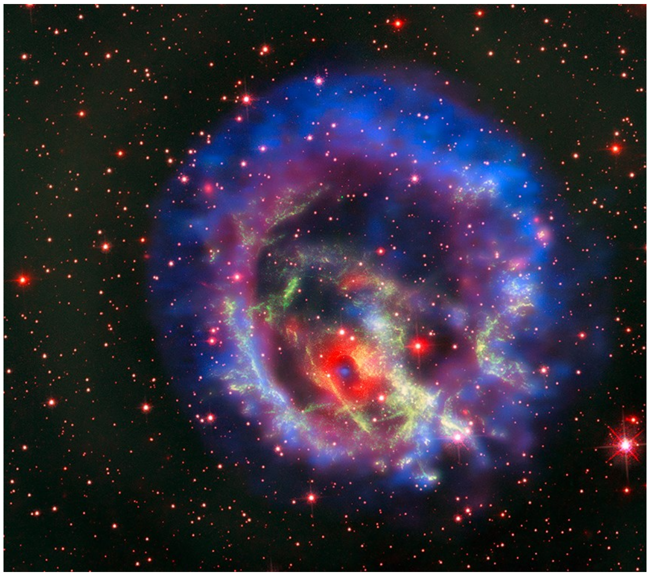


Abell 2597 galaxy cluster Chandra (X-ray purple), VLT (visible, red), ALMA (radio, yellow)

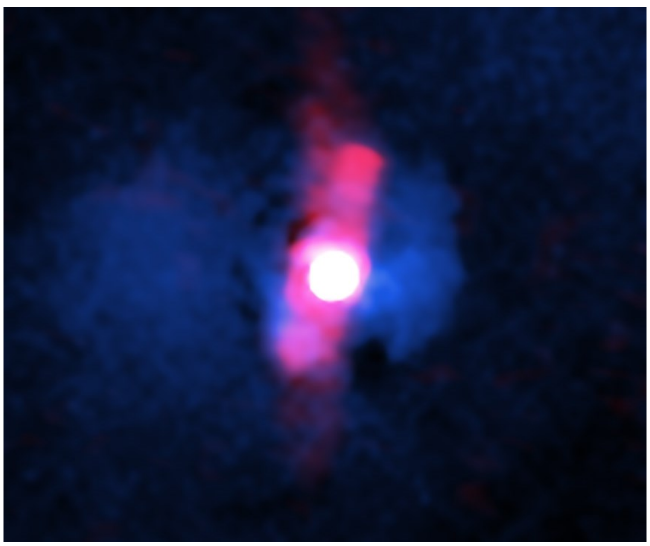
Planetary Nebulas. Chandra (X-ray, purple), Hubble (visible, RGB)



Auroras on Jupiter (Chandra X-ray purple), Hubble (visible B/W)

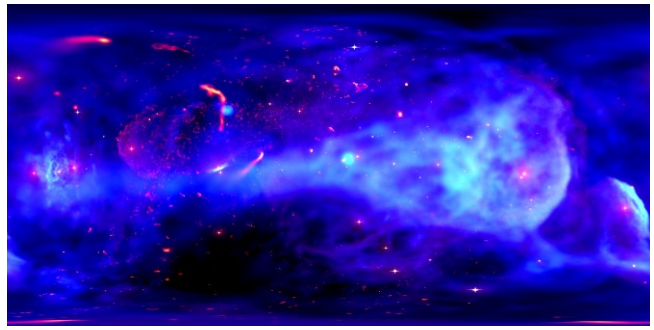


Supernova Remnant 1E 0102.2-7219 in the Small Magellanic Cloud. Chandra (X-ray, blue and purple), VLT (visible, red, green)



Quasar H1821+643, distance 3.4 billion LY. Chandra (X-ray, blue), Jansky Very Large Array (radio, red)

Core of NGC 253. Chandra (X-ray, pink a& white), Kitt Peak (H-alpha: orange), Spitzer (Infrared: red), La Silla (visible, cyan)



Center of the Milky Way. Chandra (X-ray. Hot gas blue, moderate temperature gas red, cool gas yellow)

Tycho's Supernova (1572) Remnant. Chandra (X-ray, red and blue), IXPE (X-ray, purple and white), Sloan DSS (visible, white, red, blue)

Manatee Nebula, SS 433. Chandra (X-ray, pink, blue, purple), WISE (IR, red), VLA (radio, green), The white dot in the middle of the nebula is a black hole; a jet is seen to its left.

Treble Hubble Trouble

Larry Faltz

Alas, we have to report another major astronomy research instrument in jeopardy. The Hubble Space Telescope has been productive since its launch in 1990. After its optics were corrected in 1993, it began to provide a seemingly never-ending flow of incredible images and scientific data for a vast number of astronomical discoveries. Because it was in low Earth orbit and designed to interface with the Space Shuttle, five repair and upgrade missions kept the instrument functioning nearly perfectly.

HST's pointing control is achieved with sensors and actuators. There are five types of sensors, each with its own function: Coarse Sun Sensors, Magnetic Sensing System, gyroscopes, Fixed Head Star Trackers, and Fine Guidance Sensors. The Sun sensors ensure that the HST is always pointed at least 50 degrees away from the Sun. Magnetic sensors interface with the Earth's magnetic field to make corrections. Gyroscopes measure the direction and rate that the telescope is turning. The Fixed Head Star Trackers match star positions to a map in HST's computer memory. The Fine Guidance System locks on to a star just like a guidescope used in amateur astrophotography.

At the last servicing mission in May 2009, all six gyroscopes were replaced. The gyros are among the most accurate ever manufactured. Their flex lead wires, thinner than a human hair, degrade over time. Computers can make adjustments but total failure eventually occurs. The telescope needs three gyros for routine operation, so three were in reserve.

Since 2009, four of the six gyros have failed, leaving only two healthy ones. While the Pointing Control System can work with two or even just one gyro, the efficiency of pointing is substantially reduced. HST has gone into safe mode several times in the last eight months because of the gyro problems, resulting in some temporary data interruptions.

NASA has decided to go with a one-gyro system, keeping one in reserve. In one-gyro mode, the telescope will be unable to track fast-moving objects, such as the Moon or asteroids. This is a minor inconvenience since these objects are rarely HST targets. A greater problem is that the star trackers won't be usable if they are blocked by the Earth, which would happen about half the time. This reduces the portion of the sky that Hubble can safely observe at any time from 82% to 40%. Although the Hubble will still be able to point to the entire sky over the course of a year, it may not be able to go to transient events like supernovas or gamma ray bursts quickly enough for optimal science. NASA claims the total productivity loss will be about 25%, with a 70% chance of HST being productive until 2035. The Nancy Grace Roman telescope, due to fly in 2027, is as sharp as HST in the visible and near IR but has no UV capability.

There are no plans to make another servicing mission. Without the Space Shuttle and its robotic arm, it's not clear how a SpaceX vehicle would be able to make repairs, even if NASA wanted it.

There is a second problem: atmospheric drag. Although Hubble orbits at a height of 320 miles, there are still enough gas molecules there to put a retarding force on the telescope. HST's orbit is also affected by pressure from solar particles, tidal effects and magnetic forces. The orbit is decaying and eventually Hubble will come crashing to the Earth's surface. It's possible that this will occur before 2035. NASA would like to make sure HST doesn't land on someone's head, so it will eventually have to actively de-orbit the telescope. A mission to postpone reentry by boosting the orbit with a SpaceX rocket was proposed by billionaire entrepreneur Jared Isaacman in response to a NASA request for proposals, but NASA has now deemed the plan too risky. NASA was concerned that volatiles could get on the mirror and affect its sensitivity, particularly in the ultraviolet. Better the devil you know than the one you don't.

And there's a third problem for the venerable telescope: Like Chandra, Hubble is facing budget cuts. The 2024 NASA budget drops the funding for Hubble from $98.3 million to $88.9 million for fiscal 2025, a 9.5% reduction. The impact is unclear. One possibility is for one or more instruments to be turned off. For example, why operate a near-IR camera when the JWST has IR capabilities with higher resolution? Whatever is decided, any reduction in funding will directly impact some salaries and research grants.

Compared to manned space flight, astronomy research isn't very expensive, but it's arcane, putting it at a disadvantage in the fight for public dollars. ■

Images by Members

The Leo Triplet by Robin Stuart

Robin writes:

Situated near the lion's hindquarters, the Leo Triplet is a popular springtime target for visual observers and astrophotographers alike. This interacting group of galaxies consists of NGC 3628 (top center), M 65 (lower right) and M 66. They lie at a distance of around 35 million light years. A close look reveals that the field is strewn with smaller, more distant, galaxies.

NGC 3628 holds particular interest. It was discovered by William Herschel in 1784 and at about 100,000 light-years across it is the largest member of the group. Its warped disk bears witness to gravitational interactions with the other members, as does the 300,000 light-year-long tidal tail emanating from it. The tail is shown in negative image (page 18) with key features indicated in red.

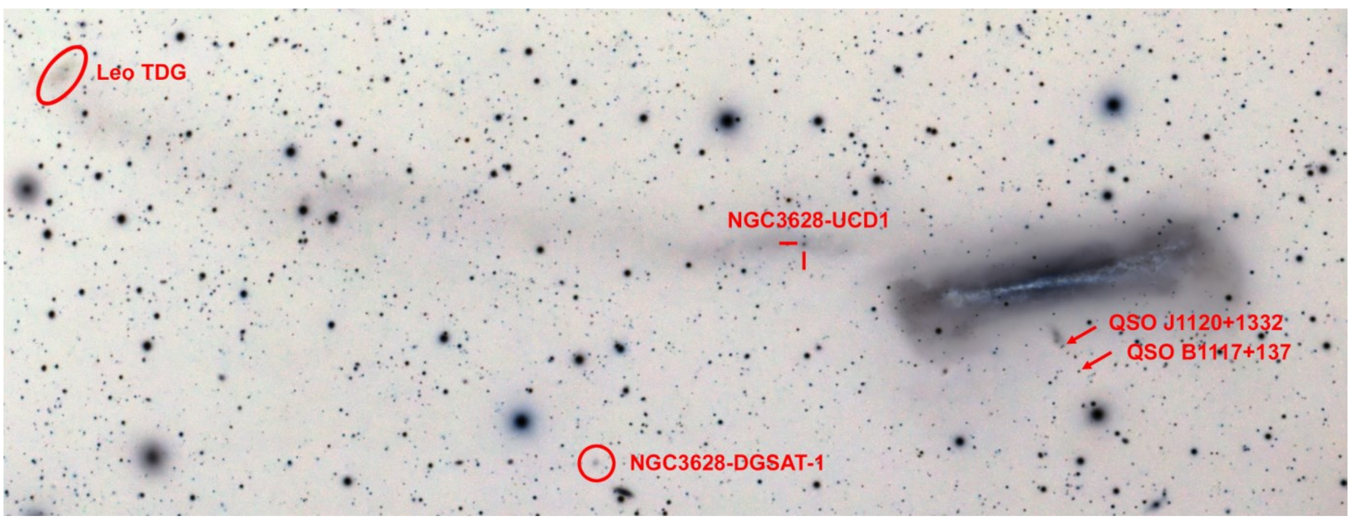
Embedded within the tail is the star cluster NGC 3628-UCG1 which is believed to be the nucleus of a tidally stripped infalling galaxy (Jennings et al. 2015). The designation UCG stands for ultra-compact galaxy. In size and luminosity this cluster is a close match to Milky Way's largest globular cluster, ω (Omega) Centauri, which itself has long been suspected of being the stripped remnant of an accreted dwarf galaxy.

At the far end of the tidal tail is the Leo Tidal Dwarf Galaxy (TDG) formed from the ejected debris. That structures could arise in this way was first suggested by Fritz Zwicky in 1956. Observations of neutral atomic hydrogen (HI) show the Leo TDG to be rotating independently of the tidal tail (Nikiel-Wroczyński et. al. 2014). It has an unusually high HI content and relatively little, if any, dark matter (DM). This tends to be the case in TDGs as the velocities of DM particles in the parent galaxy's halo are greater than the dwarf's escape velocity, leaving it with a preponderance of ordinary baryonic matter.

The low surface brightness (LSB) galaxy NGC3628-DGSAT-1 (circled) was discovered by the Dwarf Galaxy Survey with Amateur Telescopes (DGSAT) project that uses small telescopes to "probe LSB features around large galaxies and to increase the sample size of the dwarf satellite galaxies in the Local Volume." This discovery was made using a 10 hour exposure with a 0.36 m (14 inch) Ritchey-Chrétien telescope (Javanmardi et al. 2016).

A string of objects appears to emerge from the center of NGC 3628 below and at right angles to it. Two of those objects (arrowed) are the quasars QSO J1120+1332 and QSO B1117+137 with redshifts z = 0.993 and z = 2.15 respectively. Arp et al. (2002) note that the latter quasar appears at the tip of an x-ray filament, observed by the ROSAT satellite, emerging from an HI plume that is being outgassed by NGC 3628. The other quasar also appears embedded in the filament. Moreover they point out that there is an unusually high concentration of other quasars of various redshifts in close proximity to NGC 3628. Arp et al. argue that this indicates that the galaxy and quasars are related and the measured redshifts are not a result of the Universe's expansion but must have a non-cosmological origin. This, along with his rejection of the Big Bang Theory, were views that astronomer Halton Arp held until his death in 2013.

The image was made from 45 ten minute exposures for a total of 7½ hours over 3 nights in late March and early April 2024 from Eustis, Maine. The faint features described above can be visible in shorter exposures. A Televue NP127 refractor with a ZWO ASI2600MC camera cooled to -10° C was used.



References

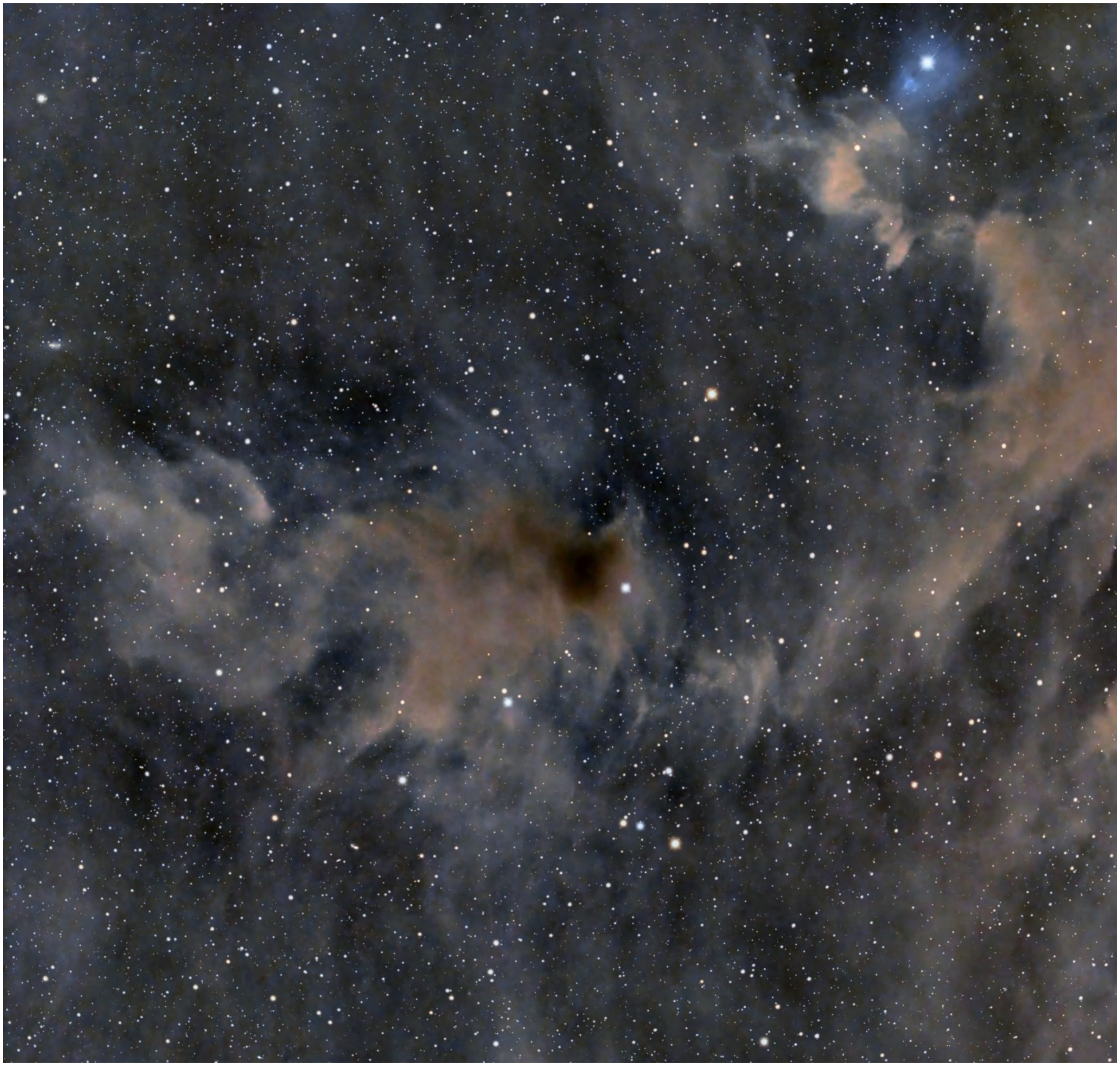
Arp, H. et al. (2002) NGC 3628: Ejection activity associated with quasars, *Astronomy & Astrophysics* 391 833 https://www.aanda.org/articles/aa/pdf/2002/33/aah3558.pdf

Javanmardi, B. et al. (2016) DGSAT: Dwarf Galaxy Survey with Amateur Telescopes, I. Discovery of low surface brightness systems around nearby spiral galaxies, *Astronomy & Astrophysics* 588, A89 https://www.aanda.org/articles/aa/pdf/2016/04/aa27745-15.pdf

Jennings, Z. G. et al. (2015) NGC 3628-UCD1: A Possible ω Cen Analog Embedded in a Stellar Stream, *Astrophysical Journal Letters* 812 L10 https://iopscience.iop.org/article/10.1088/2041-8205/812/1/L10/pdf

Nikiel-Wroczyński, et. al. (2014) Discovery of a Tidal Dwarf Galaxy in the Leo Triplet, *The Astrophysical Journal*, **786** 144 https://iopscience.iop.org/article/10.1088/0004-637X/786/2/144/pdf

Lynd's Dark Nebula (LDN) 134 by Steve Bellavia



Steve made this image using three hours of signal at his home in Long Island and three hours at Cherry Springs State Park in Pennsylvania. He noted that the raw frames from LI had an average of 500 stars while the Cherry Springs frames had twice as many, a consequence and a measure of light pollution. The field is 1.99 x 1.89 degrees. Technical details are at https://www.astrobin.com/ktigrj/.

LDN 134 is a molecular cloud in the constellation Libra. The Lynds Catalog of Dark Nebula was created by astronomer Beverly Turner Lynds when she was working at the National Radio Astronomy Observatory. She examined all 879 pairs of red and blue-sensitive plates of the Palomar Sky Survey (made with the 48" Schmidt telescope) for the presence of dark nebulas, rating them for opacity and tracing their outlines. There are 1802 entries. The paper is at https://articles.adsabs.harvard.edu/pdf/1962ApJS....7....1L. Unfortunately, there are several images of Palomar plates that didn't reproduce well when the article was scanned into the NASA/ADS library.

Messier 5 by Arthur Miller

The globular cluster Messier 5, in the constellation Serpens, was discovered on May 5, 1702 by Gottfried Kirch, a German astronomer and calendar-maker. In addition to M5, he is credited with the Wild Duck Cluster (Messier 11) and Comet C/1680 V1, the first comet discovered with a telescope. He also was the first to note that χ (Chi) Cygni was variable. Kirch was the first director of the Berlin Observatory. Messier's catalogue says *elle ne contient aucune étoiles* ("it does not contain any stars"); William Herschel was the first to resolve stars in M5.

Shining at magnitude 5.6, M5 is potentially a naked eye object in extremely dark skies. It spans 23 arcminutes, three-quarters the diameter of the full Moon. It is 24,500 light years distant. Its age can be estimated as 10.6 billion years from its metallicity ratio [Fe/H] of -1.12. Metallicity ratios (also called chemical abundance ratios) are compared to the Sun, which by convention has a metallicity ratio of 0, based on the formula

$$\left[\frac{Fe}{H}\right] = \left[\log_{10}\frac{N_{Fe}}{N_H}\right]_{Star} - \left[\log_{10}\frac{N_{Fe}}{N_H}\right]_{Sun}$$

where N is the number of iron and hydrogen atoms per unit of volume. This looks more complicated than it really is. Stars with ten times the metallicity of the Sun have a ratio of +1 while stars with one-tenth that of the Sun have a ratio of -1. Low metallicity stars are older than the Sun's 4.5 billion years, since they formed from gas clouds that had not yet become enriched with elements produced by stellar evolution and in supernova explosions. The iron content of the universe is presumed to be linearly increasing with time. Before the first stars, of course, there was no iron at all in the universe. Metallicity is determined by spectroscopy.

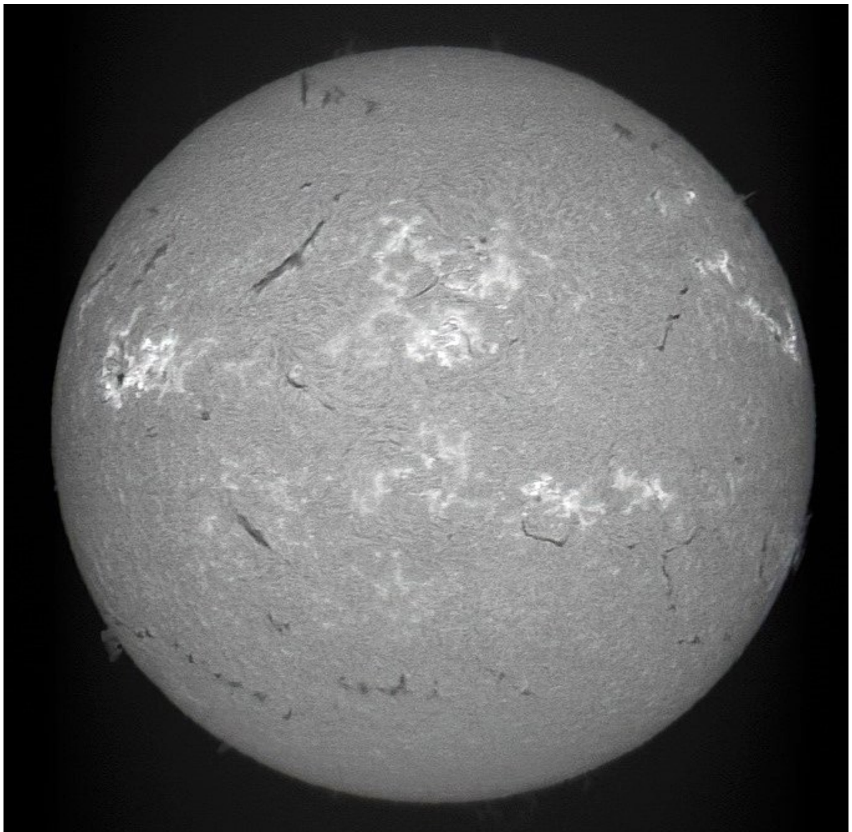
The Sun on July 1 via SeeStar by Arthur Miller

Among its many clever features, ZWO's SeeStar has a solar filter that can be placed in front of the optics, allowing acquisition of "white light" images of the Sun to show sunspots. The Seestar provides a field of 0.7° x 1.3°, with an imaging scale of 2.39 arcseconds per pixel from its 1936×1096 pixel IMX462 sensor (2.9 micron pixels). The field of view is perfect for whole Sun or whole Moon images.

Capturing finer details on the solar surface in white light can be challenging and requires high resolution, a combination of optics and sensor. Solar granules in the photosphere have diameters of around 1,500 km. Since the Sun's diameter of 1,391,400 km subtends 30 arcminutes (½ degree) in the sky, a typical granule will be less than two arcseconds in diameter, below the 2.4 arcsec resolution of the SeeStar. You can use the Field of View/Imaging function at the web site astronomy.tools to calculate the resolution of your system. For the new class of automatic scopes, use the chart at https://is.gd/scopecomp. In the Editor's experience, solar granules are best seen optically with a Herschel wedge on a high-quality refractor. Another critical factor in solar observing and imaging is seeing. The atmosphere is heated directly by the Sun and by reflection of solar energy from the Earth during the day, creating thermal cells that disrupt the image wavefront, reducing resolution. Seeing is best in the morning and on expanses of lawn. Get out early in the next few months to see and image the Sun as it reaches the peak of sunspot cycle 25.

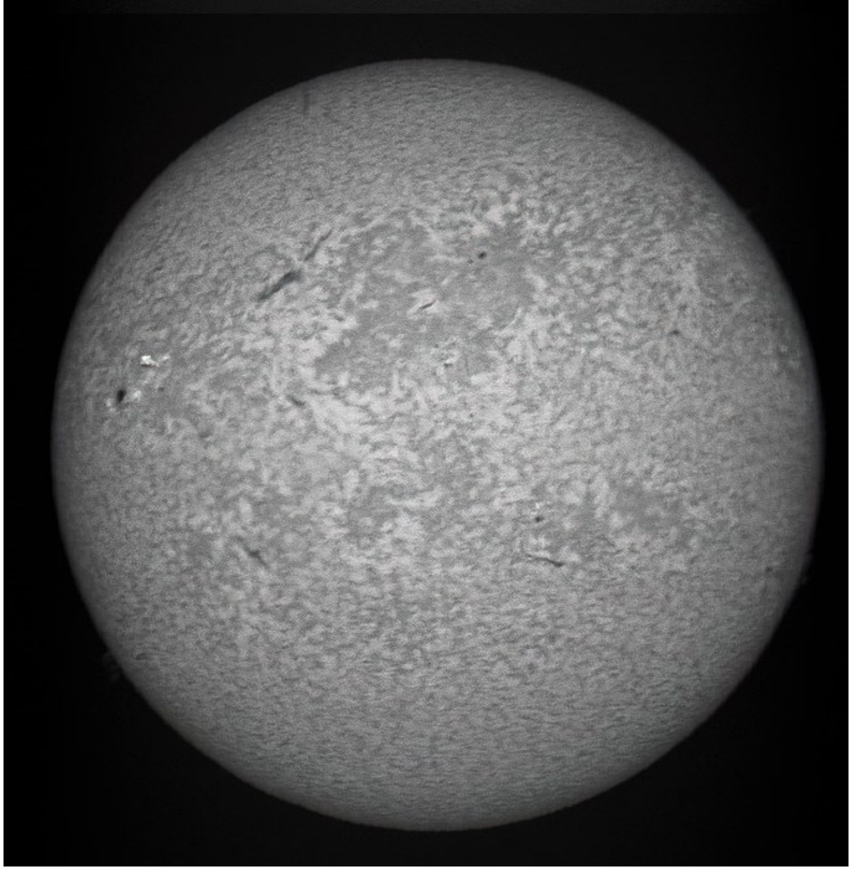
The Sun on July 14 via Spectroheliograph by John Paladini

John’s home-made spectroheliograph is capable of giving superb images at any visible wavelength.



Hydrogen-alpha
656.28 nanometers

The Hα emission arises in the Sun’s chromosphere, the layer above the photosphere, at a temperature of 6,000 K. The density of the chromosphere is 10^{-4} times that of the underlying photosphere and 10^{-8} times that of the Earth's atmosphere at sea level.



Hydrogen-beta
486.135 nanometers

The Hβ emission comes from a slightly higher and hotter part of the chromosphere, above the zone of Hα emission.

Detailed features in Hα and Hβ images are due to the Sun’s intense magnetic activity. See this month’s Research Highlight.

Research Highlight of the Month

Vasil, GM, et. al., The solar dynamo begins near the surface, *Nature* 529: 769-772 (2024)
Open access: https://www.nature.com/articles/s41586-024-07315-1

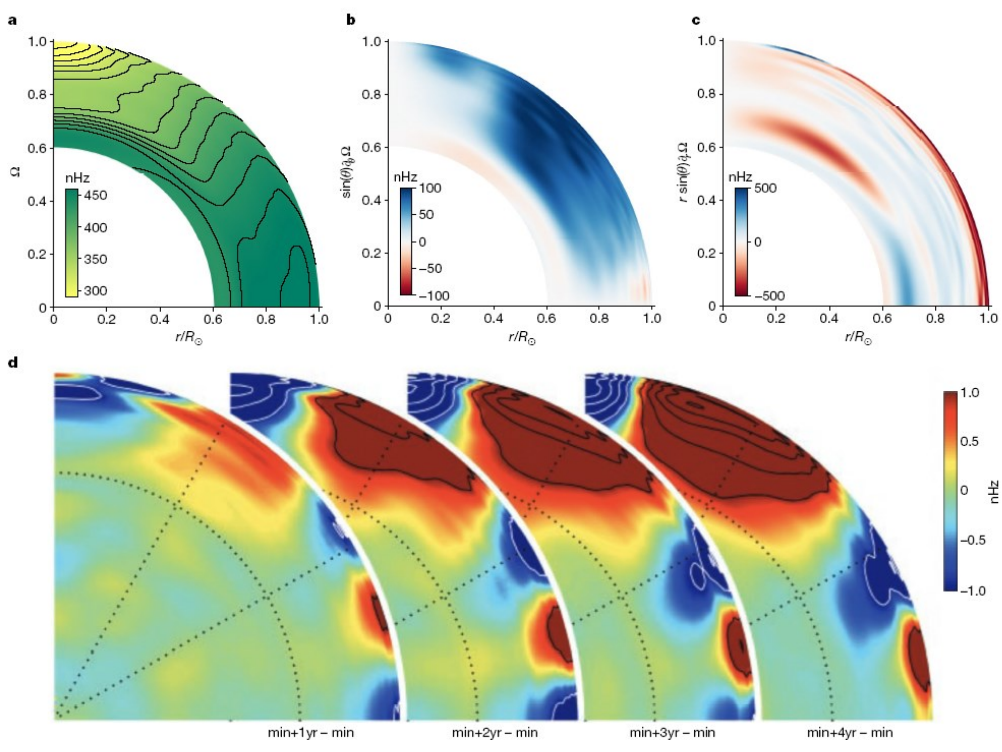
As Faraday showed almost 200 years ago, moving electric charges generate magnetic fields. Inside the Sun, vast numbers of protons and electrons circulate. Since the Sun is not solid, the rotation rate varies at different latitudes, provoking complex magnetic fields that in turn influence the trajectories of the particles and the flows of gas.

The Sun reverses its magnetic field every 11 years. The number of sunspots increases to a maximum (coming in the next few months) and then wanes to a minimum before the next cycle begins. At the beginning of the cycle, the sunspots are at high latitudes (towards both poles). As their numbers increase, they form closer and closer to the equator. Sunspots are regions in the photosphere where the magnetic field lines plunge into the surface, reducing up-flows of hot gas to form cooler areas.

The magnetic fields of the Sun are organized in two geometries: a poloidal field aligned along lines of longitude, and a toroidal field that is equatorial. It has been proposed that the driving mechanism for these fields actually occurs at the interface of the Sun's inner radiative zone, immediately above the hot core where fusion takes place, and the outer convective zone, where plumes of plasma circulate. This interface is located 0.7 solar radii from the center. The interface, just 0.04 solar radii thick, is called the tachocline.

The authors use recent helioseismology data and models of magnetic field interactions from accretion disk physics (the rapidly rotating accretion discs around black holes and neutron stars are highly magnetized) to suggest that the solar magnetic cycle is due to "magneto-rotational instability" (MRI), arising from a zone just below the photosphere that is affected by the rotational movement of plasma, and not the deeper tachocline. They propose that at the solar minimum the toroidal field is weak and the poloidal field is stronger. This creates the MRI, which provokes torsional oscillations and asymmetries in the subsurface fields that propagate as a travelling wave, strengthening the toroidal configuration and causing the cycle to progress. They test the model with computer simulations and suggest opportunities (via helioseismology) to provide support for this mechanism.

Fig. 1 from Vasil, et. al. Measured internal solar rotation profiles. **a**, Helioseisimic differential rotation profile using publicly available. **b**,**c**, Latitudinal and radial shear gradients, **d**, Helioseismic measurements of solar torsional oscillations. The red shows positive residual rotation rates and blue shows negative residual rotation rates. Each slice shows the rotational perturbations 1, 2, 3 and 4 years after the approximate solar minimum.



Member & Club Equipment for Sale

Item	Description	Asking price	Name/Email
NEW LISTING iOptron CEM25P equatorial go-to mount	A complete IOptron "center-balanced" equatorial mount. Includes Go2Nova 82408 hand control with >50,000 objects, counterweight, heavy-duty tripod, QHY PoleMaster for easy polar alignment (laptop required). Low periodic error. Payload 27 lbs (without counter-weight). Excellent condition. Although this model is dis-continued by iOptron, the current very similar mount lists for about $2,000 with the heavier duty tripod plus $269 for the PolemAster. An image is here. Details for the CEM25P are still available on iOptron's web site. Do-nated to WAA.	$500	WAA ads@westchesterastronomers.org
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 con-trol, tripod, finder, eyepiece, diagonal. Picture here. Celestron lists this instrument now for $939. Weight 17.8 lbs complete, including tripod. Runs on 8 AA batter-ies or external 12-volts. A fantastic telescope for lunar, planetary and bright DSO observing. A great deal!	$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.	$220	Manish Jadhav manish.jadhav@gmail.com
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.	$30	Larry Faltz lfaltzmd@gmail.com
Tiltall photo/spotting scope tripod	TE Original Series. Solid professional 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. Great for a spotting scope, camera. Donated to WAA.	$55	WAA ads@westchesterastronomers.org

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

Buying or selling items is at your own risk. WAA is not responsible for the satisfaction of the buyer or seller. Commercial listings are not accepted. Items must be the property of the member or WAA. WAA takes no responsibility for the condi-tion or value of the item, or for the accuracy of any description. We expect but cannot guarantee that descriptions are accurate. Items subject to prior sale. WAA is not a party to any sale unless the equipment belongs to WAA (and will be so identified). ***Prices are negotiable*** unless otherwise stated. Sales of WAA equipment are final. *Caveat emptor!*

WAA Members: Contribute to the Newsletter!

Send articles, photos, or observations to
waa-newsletter@westchesterastronomers.org

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Proofreader: Elyse Faltz