SkyWAAtch

The Newsletter of Westchester Amateur Astronomers

July 2024

The Dark Shark Nebula by Robin Stuart

The Dark Shark Nebula (LDN 1235) is a complex of dust and gas in the constellation of Cepheus, lying at a distance of 650 light years. The bluish-white areas behind the shark's head (vdB 150) and on its belly (vdB 149) are reflection nebulas caused by starlight illuminating the surrounding material. The shark's eye is the 6th magnitude star HD 211300, spectral class G8. The elegant spiral galaxy, PGC 67671, can be seen to the right of the frame.

This image is a total of 3 hours 20 minutes of exposure taken on the nights of September 29, November 2 and November 21, 2023, from Eustis, Maine through a Televue NP127 using a ZWO ASI2600MC camera. Nebulosity and stars were processed separately before being combined into the final image. For more excellent images from the very dark skies of Maine, visit Robin's web site, https://eustis-sky.com.

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).

There are no WAA meetings in July or August. Come to Starway to Heaven!

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.

WAA Club Picnic

The 2024 Members' Picnic will take place on **Saturday, July 20** from 12:00 noon-4:00 p.m. at Pavilion 1 in Croton Point Park in Croton-on-Hudson. Food, drinks, trivia contest and the camaraderie of WAA members and their families. Rain or shine!

See page 6 for more information.

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

Also In This Issue

WAA 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 Star Party

Meadow Picnic Area Parking Lot
Ward Pound Ridge Reservation,
Cross River, NY

Summer Schedule (weather permitting)

Saturday, July 6, 8:30 p.m.
Saturday, July 27, 8:15 p.m.
Saturday, August 3, 8:15 p.m.
Saturday August 10, 8:00 p.m.
Saturday, August 31, 7:30 p.m.

New Members

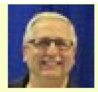
Katherine Clyne	Mount Vernon
Daphne Tsai	White Plains

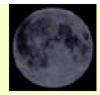
Renewing Members

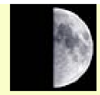
Pramod Agrawal	Bardonia
Linda Biderman	Plainview
Brian Blaufeux	Larchmont
Frank and Kathy Clemens	Larchmont
Emily Dean	Pelham
Joyce Dow	White Plains
Daniel Karpel	Mt. Kisco
Bob Kenison	Scarsdale
Marko Kokic	Pleasantville
Gene Lewis	Katonah
Patricia Mahon	Yonkers
Mark Mayo	White Plains
Charles Pevsner	Riverside
Anthony Sarro	Brooklyn
Richard Segal	Chappaqua
Francesca Varga	Pleasantville
Thomas Venditto	Somers

ALMANAC For July 2024

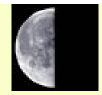
Bob Kelly, WAA VP of Field Events


Bob Kelly


New July 5


1Q July 13


Full July 21


3Q July 27

Opposition Dates

I love bright objects, so I want to be the leader of the Opposition Party! At opposition with the Earth, the planets appear largest and brightest for the year. I'd love that to happen more frequently, but typically, it's once every thirteen months, less frequently for Mars. As a result, Mars doesn't have an opposition this year. I'd love to change that, but even as leader of the party, I can't. Here's the data for upcoming oppositions of the planets beyond Earth from the Sun.

Object	Next Opposition	Distance at Opposition (million miles)	Magnitude at Opposition	Apparent Size at Opposition (arcseconds)
Saturn	2024 Sep 8	804	+0.8	19
Neptune	2024 Sep 20	2,684	+7.6	2
Uranus	2024 Nov 16	1,725	+6.0	4
Jupiter	2024 Dec 7	380	-2.3	48
Mars	2025 Jan 15	60	-1.4	14

At the time of opposition, the planets rise at sunset, so they start showing up in the evening sky for the months afterwards. Great for those of us who aren't morning people.

Jupiter Gets Spotted

Jupiter starts the month rising at the beginning of astronomical twilight, about two hours before sunrise. (Start setting your alarm for 3:30 a.m. Daylight Time if you want to watch Jupiter rise in the east-northeast.) See how long into twilight you can track the giant planet. By the end of July, it'll rise by 2 a.m.

At mid-month, Jupiter and its four brightest moons start doing interesting dances, with the moons casting their shadows on Jupiter while they stand off to the side of the planet, as if to see if it's safe to cross in front of Jupiter after shadows land. Check online resources, a Jupiter's moons app or the Royal Astronomy Society of Canada's almanac for the crossing times. Most of the crossings are going to be during daylight for us. That's not surprising, given we only get two to four hours of Jupiter before sunrise in July. If I've read the apps right, mark August 7th on your calendar for the best morning to see shadows and moons crossing Jupiter's disk.

Check the apps for the location of Jupiter's Great Red Spot, reported to be shrinking substantially but still around some 359 years after Giovanni Cassini first saw it. A telescope with at least a three-inch diameter objective should be able to show it.

Saturn Gets High

Saturn will be rising about midnight in early July. By the end of the month, Saturn will be highest in the sky by the beginning of morning twilight.

Getting your telescope on Saturn in a dark sky will provide good views of the planet and its brightest moons. Since the rings are now almost edge-on, the fainter moons are getting easier to pick out. For several days around the 19th, you might catch six Saturnian moons including Iapetus, then at its brightest, twice as far out as Titan, the brightest of Saturn's moons. See map on page 4.

Mars – Slowest Wins the Race?

Nope. Mars is just a slowpoke, sauntering low in the eastern sky before sunrise. The ruddy planet rises well before twilight starts. Marsrise gets earlier by less than an hour this month. Uranus uses Mars as a marker, passing about a Moon's width away on the 15th.

Mercury Hangs Out in the Evening

Catch Mercury early in the month, when it's brightest, at magnitude -0,6. Look low in the west-northwest during evening twilight. Mercury is highest in our skies around the 14th, with greatest elongation, 27 degrees from the Sun, on the 22nd. Look for the very thin Moon above Mercury on the 7th.

Come on, Venus!

Venus continues its leisurely slide out from the Sun's glare into the evening sky, stretching from 8 to 15 degrees from the Sun this month. Once you identify it in bright twilight (it's even lower than Mercury!) it'll be easier to catch this magnitude -3.9 beacon sitting just above the horizon. Mercury, faded to magnitude +0.7, slides by Venus, to its left, as it leaves the evening sky at the end of July.

Ceres in the Teapot

Dwarf planet Ceres, the largest member of the set of objects between Mars and Jupiter, comes to opposition on the 5th. Find it in the Milky Way in Sagittarius, low in the southern sky.

Sunspots

Massive sunspot groups have been seen on the Sun. The largest group is moving around to the other side of the Sun – we might see it again in mid-July. Some have seen them as a fuzzy patch in their eclipse glasses. Never use eclipse glasses in front of binoculars or a telescope…get a dedicated solar filter.

Comets

C/2023 A3 (Tsuchinshan-ATLAS) is low in the western sky after sunset. The much-ballyhooed comet of 2024 may be stuck at 10th magnitude. It's under the paws of Leo, getting lower in the evening sky and harder to see. It'll be visible again in October, when it is predicted to be much brighter. Comet 13P/Olbers is low in the northwest and reported to be at 7th magnitude but will fade this month.

Delta Aquarids?

The Delta Aquarids meteors are mostly visible from the southern hemisphere. A few per hour could be seen from our latitude near the peak date of the 30th. You might see a few early members of the Perseid meteor shower at the end of July.

Space Stations

Tiangong, China's space station, is forecast to be visible in the mornings from the 10th through the 21st and evenings for the rest of the month.

The International Space Station starts off the month visible in the morning sky. The ISS may be visible evenings and mornings from the 8th through the 14th. After that, the station should be visible in the evenings.

Earth Aphelion

We are farthest out from the Sun on July 5th at 1:06 a.m., 94.5 million miles away (94,510,539 center-to-center for those of you who are sticklers for exactitude).

Covered by the Moon

The first magnitude star Spica will be occulted by the Moon just after 11:20 p.m. EDT on the 13th. Spica will disappear behind the dark edge of the first quarter Moon.

Morning Panorama

In the last several days of July, the pre-dawn sky will have a great view of planets, the crescent Moon and the winter constellations.

Saturnian moons brighter than 15th magnitude.

Get Ready for a Recurrent Nova

T Coronae Borealis (T CrB) is a binary system of a white dwarf and a red giant. The white dwarf has a mass of 1.37 $M_{\odot}$, while the red giant has a mass of 1.12 $M_{\odot}$. They orbit each other every 228 days, separated by just 0.54 AU (50 million miles). The pair is 806 parsecs from us.

The dwarf's intense gravity strips hydrogen from the surface of the red giant. When the hydrogen concentration is high enough on the dwarf's surface, the pressure and heat of accretion triggers a thermonuclear explosion that brightens the star considerably.

After 80 years of quiescent behavior, the recurrent nova T CrB is due for an outburst. Astronomers predict it will brighten from its baseline magnitude of 10.6 to naked-eye visibility around magnitude 2.5 for a week or so.

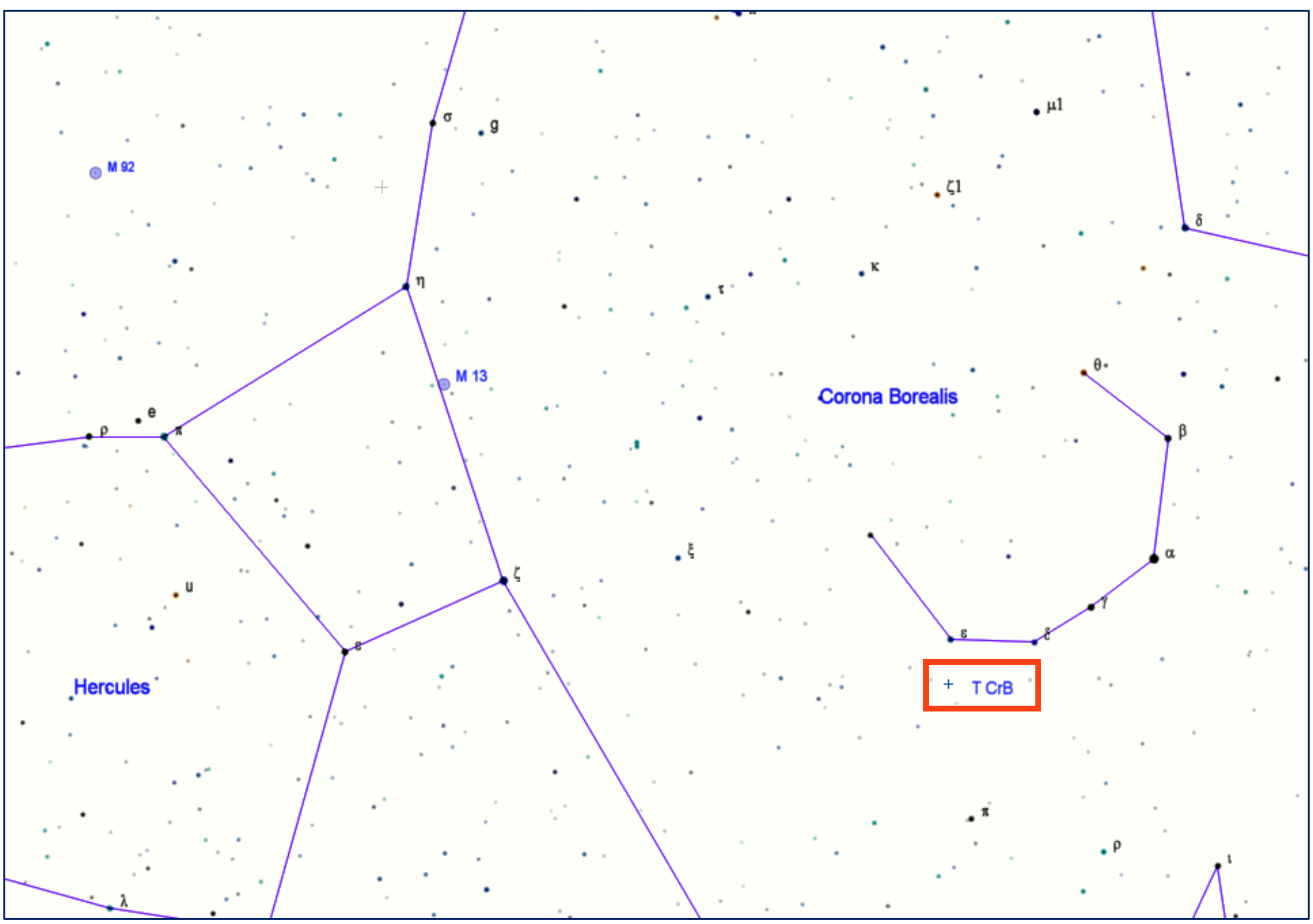
In 1866 T CrB reached magnitude 2.0, while in 1946 it brightened to magnitude 3.0. Although the exact date of the event cannot be accurately predicted, the range is between March 2024 and October 2026. As it hasn't exploded yet, you haven't missed anything, but it's a good time to start looking since Corona Borealis is overhead in the evenings this time of year, and easy to find next to Hercules.

There are currently just ten recurrent novas known to astronomers.

If you have Star Analyzer spectroscopy gratings and the appropriate software, you can capture the nova's spectrum. For an example, see Rick Bria's spectrum of Nova V3890 in the October 2019 SkyWAAtch, page 7.

For observers with go-to telescopes that can be programmed with user-defined objects (as almost all can), the coordinates of T CrB are (epoch J2000):

RA 15h 59m 30.1622s
Dec +25° 55′ 12.613″



WAA Members' Picnic

Saturday, July 20, 2024, 12 noon-4 p.m.

RSVP by MONDAY, JULY 15th

Eva Andersen: andefam55@gmail.com or text 845-803-4949
Please include number attending and any food allergies

Make your plans now to join us for the annual WAA Member Picnic at beautiful Croton Point Park. Spend a relaxing and fun afternoon catching up with old friends and making new acquaintances. *A benefit of your membership is our annual complimentary Member Picnic.* Our memberships are considered family memberships so feel free to bring family members or a guest.

The club will provide hotdogs, hamburgers, chicken, veggie dogs & burgers, salads, chips and non-alcoholic drinks. We supply condiments, plates, cups, utensils, napkins and dessert.

Bring your own beer and wine. We will provide coolers and ice for your beverages.

Hard liquor is not permitted on Park grounds.

Meet us in Pavilion 1 located at **1A Croton Point Avenue, Croton on Hudson, NY 10520**. The pavilion has capacity for 200 people and includes picnic tables and cooking grills. **This is a rain or shine event.**

Croton Point Park is a lovely 508-acre Westchester County Park located on the largest peninsula on the Hudson River. This Park is well-known to **bird watchers** so bring your binoculars! There are several **hiking** trails in the park. **Dogs** are permitted but must be leashed at all times. For more information, the park's web site is **https://parks.westchestergov.com/croton-point-park**

There is no cost for the picnic and no admission fee to enter Croton Point Park but there is a **parking fee.** $5 per car for Westchester Park Pass holders, $10 per car without Park Pass.

The Trivia contest will take place at 2 p.m.

As we consider the ongoing nature of Covid and the health and safety of our members and their families, we ask you not to attend if you have any illness symptoms the day of the picnic.

Another Movie Telescope: *Operation Fortune: Ruse de Guerre*

We found two telescopes in the clever and likeable super-spy action comedy *Operation Fortune: Ruse de Guerre*, directed by Guy Ritchie. The 2023 film stars Jason Statham, Aubrey Plaza, Josh Hartnett, Cary Elwes and Hugh Grant. Grant is a wealthy and suave arms dealer who is going to sell a stolen high-tech device to the highest bidder. It turns out that Grant's favorite movie actor is action hero Josh Hartnett, and Hartnett is humorously blackmailed into joining super-spy Statham's team so they can get in Grant's good graces and prevent the sale.

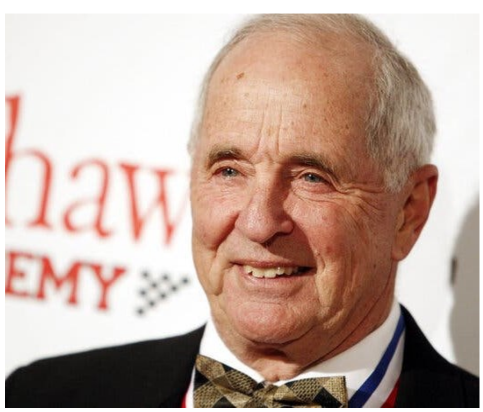
They first meet Grant on his yacht in Cannes, where he is hosting a benefit. From the team's hotel, Cary Elwes is examining the yacht through what looks like a 130-mm reflector. A small refactor sports a long 0.965" Barlow.

Ritchie has a unique approach to mixing crime, action and comedy in such films as *Lock, Stock and Two Smoking Barrels*, *Snatch*, *RocknRolla*, *The Gentlemen*, and *The Man from U.N.C.L.E.*, but he's also directed films as diverse as Disney's *Aladdin*, *King Arthur: Legend of the Sword*, and the two Sherlock Holmes movies with Robert Downey, Jr. His one truly immense bomb (although the Holmes movies were unacceptable to us true Holmesians) was the remake of *Swept Away*, starring his then-wife, Madonna.

Willliam Anders, Apollo 8 Commander

The astronomy and space-flight communities were saddened to learn of the death of Maj. Gen. William A. Anders in an airplane crash on June 7th in Puget Sound, northwest of Seattle. He was 90.

Anders was a member of the Apollo 8 crew, along with Frank Borman, who passed away in November 2023, and James Lovell, who is still with us at 96. Anders took what is probably the world's most famous photograph, "Earthrise," on Christmas Eve 1968. Apollo 8 was the first time humans left the Earth's gravity.

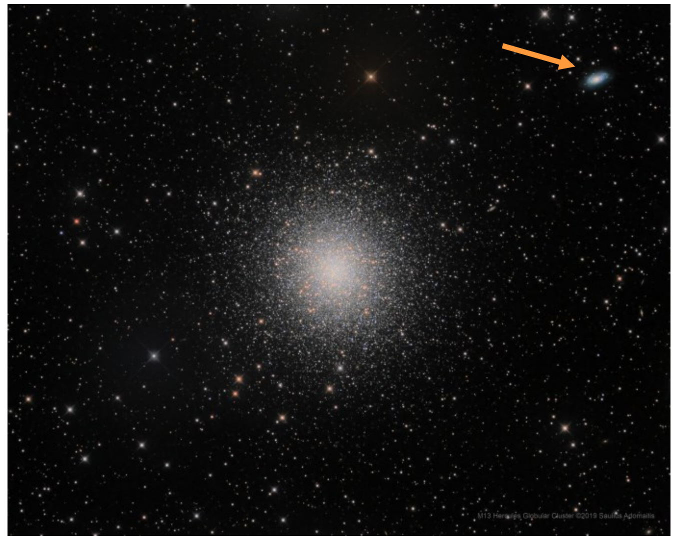


Left: Apollo 8 crew. (L to R) Frank Borman, William Anders, James Lovell. Right: Anders in 2009.

Only 5 Apollo astronauts who went to the Moon are still alive: Lovell (Apollo 13), Buzz Aldrin (11), David Scott (15), Charles Duke (16) and Harrison Schmitt (17). The latter 4 walked on the lunar surface.

Deep Sky Object of the Month: NGC 6207

NGC 6207	
Constellation	Hercules
Object type	Spiral Galaxy
Right Ascension J2000	16h 43m 03.7s
Declination J2000	+36° 49′ 57″
Magnitude	11.7
Size	3 x 1.2 arcminutes
Distance	30 million LY
Discovery	W. Herschel May 16, 1787

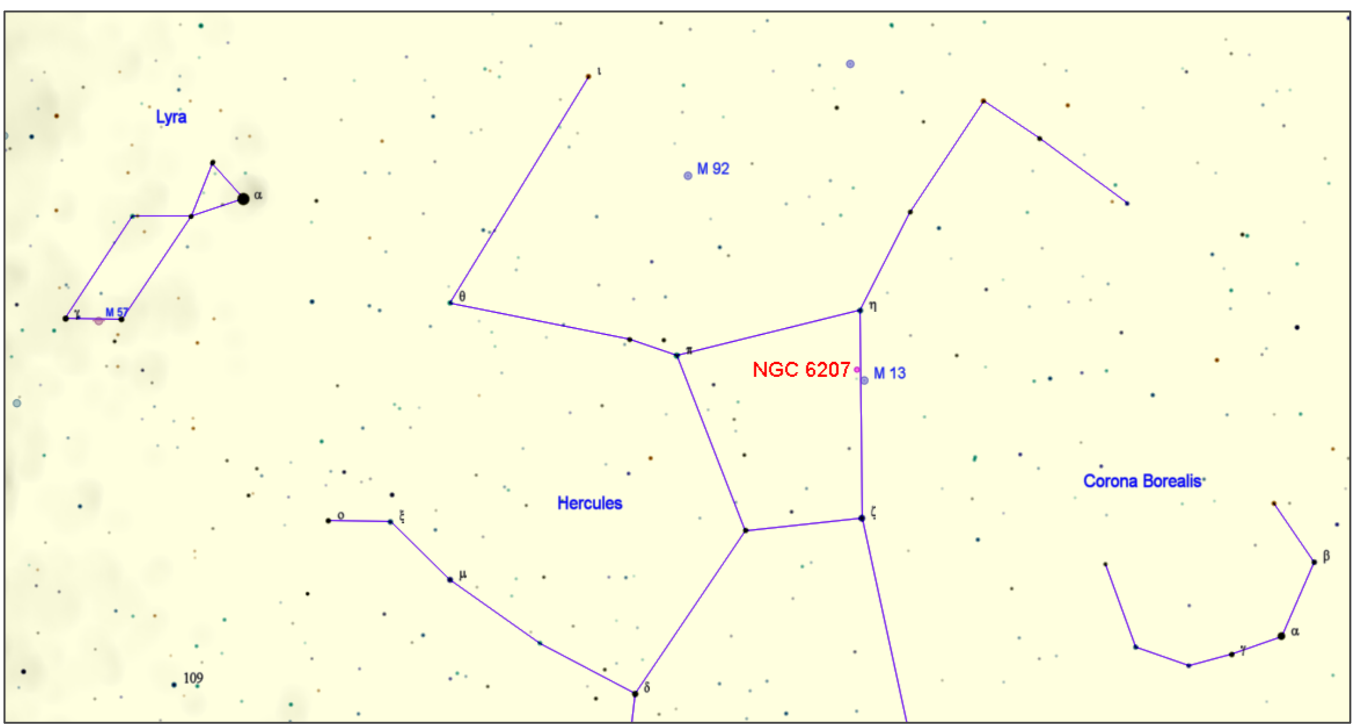


Almost everyone observes the giant globular cluster Messier 13 during a summer star party. Just half a degree to the northeast of M13 is a little gem, the spiral galaxy NGC 6207. At magnitude 11.7 it will be a challenge at Ward Pound Ridge, where sky darkness is a bit of an issue. The galaxy has reasonable surface brightness and I've seen it there with my 8-inch SCT when conditions were very good. Being small; it benefits from moderate to high magnification, maximal dark adaptation, averted vision and concentration.

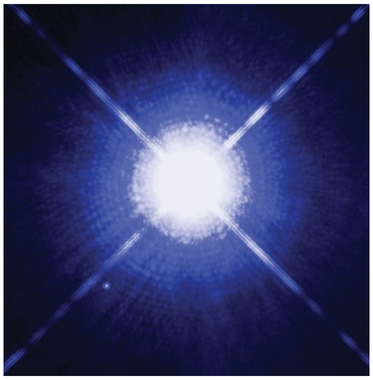
In *The Urban Astronomer's Guide*, Rod Mollise writes that "higher magnification increases the contrast between an object and the sky background."

Visibility for			
2200 EDT	7/1/24	7/15/24	7/31/24
Altitude	85° 31′	78° 17′	77° 06′
Azimuth	178° 20′	107° 53′	243° 48′

NGC 6207 will be high overhead in July, so it will be a challenge for Dobsonians. which are harder to position when searching for objects near the zenith. But NGC 6207 is so close to bright M13 (magnitude 5.8) that finding it shouldn't be difficult.



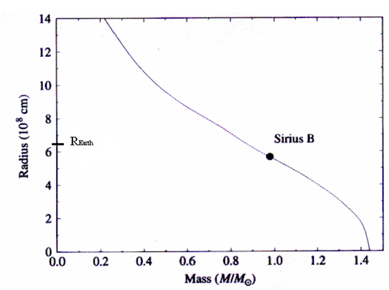
Erratum, kind of…White Dwarfs — The Editor



Sirius B is tha small star at 7 o'clock

Long-time WAA member Joe Geller pointed out that in the *Research Finding of the Month* in the May 2024 SkyWAAtch we made the nonsensical statement that "Ninety-seven percent of stars will end up as white dwarfs, stars the diameter of the Earth with masses greater than the Sun." Stars of course cannot gain mass as they age. We meant to say "Ninety-seven percent of stars will end up as white dwarfs. A white dwarf the mass of the Sun will shrink to the diameter of the Earth." A good example is Sirius B, whose mass is 1.018 ± 0.011 $M_\odot$ and whose radius is 0.9166 that of Earth. Close enough. The mean density of the Earth 5.513 gm/cm^3 and the Sun is 1.408 gm/cm^3, while that of Sirius B is 2.38x10^6 grams/cm^3.

It might seem logical then that stars with less mass than the Sun would contract to radii smaller than the Earth when they become white dwarfs, but it turns out that's not true. White dwarfs with masses less than the Sun are actually larger than the Earth. The lower the mass, the bigger the white dwarf's radius.



In a regular star, the gravity of the star's mass is balanced by energy produced by nuclear fusion to maintain hydrostatic equilibrium, but in a white dwarf fusion has stopped. Electron degeneracy pressure is the force that opposes contraction. In a normal star, the gas is "ideal" and electron energies follow Maxwell-Boltzmann statistics (we recall the ideal gas law *PV=nRT* from high school physics). The interior of a white dwarf is a plasma of nuclei (mostly protons) and electrons. The electrons are "degenerate" and follow Fermi-Dirac statistics, which are governed by quantum mechanics. No two electrons can be in the same state, a state being position and momentum (subject to the uncertainty principle), energy and spin (by convention either "up" or "down"). That's the Pauli Exclusion Principle. The lowest energy levels are occupied first; additional electrons must occupy higher energy levels. This creates the pressure that opposes gravitational collapse.

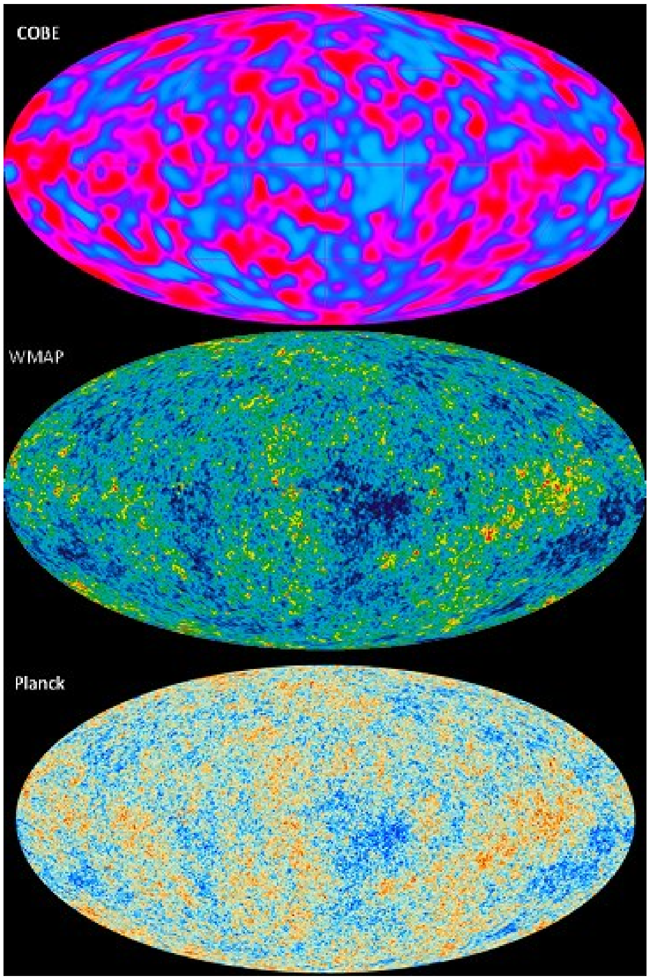
Degenerate matter is relatively compressible. The density of a high-mass white dwarf will be greater than that one with a low mass, which implies that the more massive star's radius will be smaller. The detailed physics and mathematics of the white dwarf mass-radius relation are complicated (see for example https://is.gd/whitedwarf for a "simple" treatment and https://is.gd/whitedwarf2 for a more complex one), but for our purposes the most important conclusion is that the radius scales in proportion to $M^{-1/3}$.

Once a white dwarf forms, its mass does not change. The vast majority of white dwarfs are in the range 0.6 ± 0.1 $M_\odot$. The most massive white dwarf known has a mass of 1.35 $M_\odot$. There are few very low mass white dwarfs because their progenitors, low-mass red dwarf stars, have lifetimes longer than the current age of the universe, and so have not yet had time to use up their fuel and evolve to white dwarfs.

At the very high energy levels that electrons in larger white dwarfs must occupy, their velocities approach light speed and special relativity has to be taken into account when calculating the electrons' equation of state (the relationship between density and pressure). This was the 20 year-old Subrahmanyan Chandrasekhar's great insight in 1930, made while sailing from India to Cambridge for graduate work.

At a certain mass, even electron degeneracy pressure can no longer support the mass of the white dwarf, and it will collapse. This happens at the Chandrasekhar Limit, 1.44 $M_\odot$. A type 1a supernova occurs when a white dwarf's mass has been increased by accretion from a close companion star. As mass is added, the radius of the white dwarf shrinks and its density increases, until the mass reaches the Chandrasekhar Limit. Then, kaboom! ■

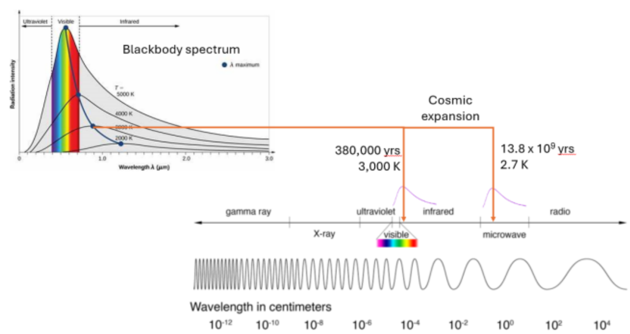
Another Big Astronomy Project in Trouble: CMB-S4 Larry Faltz



In the April 2024 SkyWAAtch, I wrote about the National Science Foundation's determination that it would not be able to fund both large telescopes in the U.S. Extremely Large Telescope (USELT) program. A decision as to which of the two competing instruments would receive funding (the Thirty Meter Telescope proposed for Mauna Kea or the Giant Magellan Telescope, already partly constructed in Chile) was to be made at an NSF meeting in late May. The NSF decided to "kick the can down the road" by appointing an "expert panel" charged with making a decision by the end of September. As of this writing (early June) the members of the panel have not yet been appointed. NSF Director Sethuraman Panchanathan promised it would include scientists as well as experts in construction, design, and risk assessment who are capable of "assessing the readiness of the project from all perspectives." Of course, there is still time for Elon Musk to jump in and assure the survival of both instruments, as we suggested in April.

As important as these telescopes are for astronomical research, another advanced project with clear and important scientific goals has been delayed, potentially for many years. The $800 million **CMB-S4**, which had been envisioned to commence operations in the early 2030s, has been indefinitely postponed, at least in its originally planned form. CMB-S4 is a ground-based experiment designed to map the cosmic microwave background (CMB) with far greater precision and resolution than has been achievable to date.

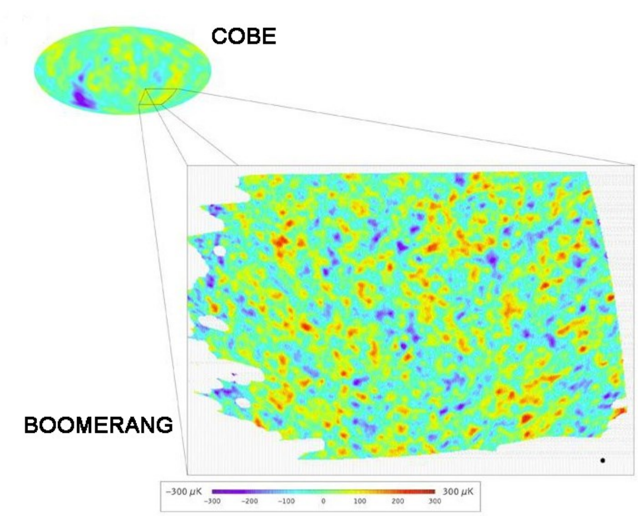
Following the discovery of the CMB by Penzias and Wilson in 1964, studies of the CMB were done with microwave telescopes in Chile and at the South Pole and multiple balloon-borne detectors, often launched from Antarctica. These instruments could only survey small areas of the sky. Three space-based all-sky detectors (COBE, WMAP and Planck) showed us with increasing detail how the CMB appeared throughout the entire sky, leading to a greater understanding of the conditions in the early universe and revealing the composition of matter and energy in the cosmos.



The CMB spectrum is redshifted from 3.000 K to 2.7 K

The CMB provides direct evidence for a highly energetic, dense, hot origin for the universe. CMB photons are distributed as a spectrum of blackbody (purely thermal) radiation with a temperature of 2.72548 ± 0.00057 K. The radiation was emitted 380,000 years after the universe began, after it had expanded and cooled to a temperature of about 3,000 K. Prior to that time, positively charged protons (and helium nuclei) and negatively charged electrons had been in the form of an ionized plasma, the particles interacting with and scattering photons. By 3,000 K neutral atoms had formed, with the electrons bound to nuclei. Photons were then free to travel through space. With further expansion of the universe their wavelengths were stretched, and they lost energy.[1] At the time the CMB was liberated, so to speak, had there been anyone around to see it the universe would appear as a dull red, with the bulk of the energy in the very near infrared but still with plenty of photons in the visible range. Think of a 3,000 K LED bulb. A 2.7 K blackbody radiates completely in the microwave spectrum.

The COBE satellite proved that the CMB spectrum was a perfect blackbody with very slight variations in the temperature above or below the average. Cooler areas were presumed to be slightly denser and would become the seeds of future stars and galaxies after a period which is referred to as the “dark ages.” The variations in temperature and density are consequences of quantum events much earlier in the universe’s history, most likely at the end of the proposed inflationary epoch that occurred around 10^{-32} seconds after the Big Bang. Even the most minuscule variations in temperature and density at that time would be propagated throughout cosmic history, affecting the rates of physical processes that ultimately gave rise to the very inhomogeneous (on local scales) universe we have today, with galaxies strung along filaments of dark matter, surrounding voids of much lower mass density.



Detectors on the Boomerang experiment, a balloon-borne detector launched from Antarctica in 1999, showed that the hot and cold spots on the CMB had an average separation of one degree on the sky.

These results were confirmed by WMAP and Planck, and are evidence that the universe is geometrically flat (that is, two parallel light beams, if unaffected by mass along their trajectories, will neither converge nor diverge, even at infinite distance). Had the angular separations of the temperature variations been larger or smaller than one degree, that would have been evidence for different spatial geometry, either closed (spherical) or open (saddle-shaped).

CMB measurements inform cosmological models, which describe the organization of matter and energy in the universe that ultimately controls its evolution. The most accepted cosmic model is ΛCDM (Lambda Cold Dark Matter) which proposes that a universe consisting (now) of 27% matter (four-fifths of it in the form of heavy, slowly moving dark matter particles that only interact by gravity), and 73% so-called dark energy (the lambda term), a property of space itself. Adding in data from Big Bang Nucleosynthesis (the process that resulted in the young universe containing 75% hydrogen and 25% helium by mass, with a smidge of deuterium and lithium but nothing else) and calculations about the matter density of the universe and its rate of expansion (the Hubble constant and its history), the age of the universe can be calculated to be 13.787 ± 0.020 billion years.

There is more to learn by studying the CMB, both about the conditions in the very early universe and about the evolution of cosmic structure over time. For example, CMB photons can interact with energetic electrons, getting a boost in energy. This is the Sunyaev–Zel’dovich effect. These interactions distort the spectrum in a detectable way (remember, the CMB is a blackbody spectrum, so it is not a single wavelength). The most potent source of these energetic electrons is in galaxy clusters, which contain a lot of extremely hot, ionized gas. Microwave telescopes in the Atacama region of Chile and at the South Pole have detected galaxy clusters in this manner. Distortion of the CMB by gravitational lensing has also been used to detect galaxy clusters. Those distortions can be used to model the expansion rate of the universe and thus assess the contribution and scale of dark energy. See p. 15 for examples.

New, more sophisticated CMB detectors with higher sensitivity and greater resolution will probe

[1] The relationship of energy (Ɛ) to wavelength (λ) is $\mathcal{E}=hc/\lambda$ where h is Planck’s constant and c is the speed of light.

important phenomena in the early universe and can address some of the (many) unresolved questions about particle physics. The range of issues that can be examined include setting the mass scale of neutrinos (the total mass of the three flavors of neutrinos, electron, muon and tau) and whether there are additional types of "sterile" neutrinos that interact even more weakly than the three neutrinos of the Standard Model. Evidence for the existence of other light "relic" particles that react too weakly to be produced in accelerators on Earth might also be revealed. These particles might be axions, hidden photons or gravitinos, among other esoterica. They would contribute to the energy density during the "radiation-dominated" era just after the Big Bang, influencing the evolution of baryons and photons. Their existence would be inferred by examining the appearance of the CMB on very small angular scales, which requires much higher resolution than current instruments can provide.

Perhaps the most important new discovery of a next-generation CMB program would be the existence of "B-mode" polarization in the CMB, which would be strong evidence for an inflationary epoch during which the volume of the universe increased by a factor of 10^{78} in less than 10^{-32} seconds. Gravitational waves generated by this event would polarize the CMB photons in a specific pattern.

South Pole Telescope (L) and BICEP3 (R)

It's not as if searches for polarization and other cosmological implications of the CMB haven't been active or productive in the last 25 years. Among the most notable experiments are a series of microwave telescopes at the Amundsen-Scott South Pole Station. BICEP, BICEP2, the Keck Array, BICEP3, and the BICEP Array are a sequence of five CMB telescopes that started observations in 2005 with BICEP. "BICEP" stands for Background Imaging of Cosmic Extragalactic Polarization. Each iteration increased sensitivity and resolution. The BICEP2 experiment announced the detection of B mode polarization in 2014, only to have the discovery retracted after it became clear from Planck data that the polarization was caused by dust in the Milky Way.[2] The BICEP Array was being installed at the Pole when Covid-19 forced operations to be suspended, and it is yet to be fully operational. Some other recent CMB observatories include:

- PolarBear (Polarization of Background Radiation) which uses the 3.5-meter Huan Tran Telescope in Chile, containing 1274 antenna-coupled TES bolometers observing at 150 GHz.
- The Atacama Cosmology Telescope (ACT), which had 3,072 detectors. Located, like PolarBear, on Cerro Toco not far from the 66 microwave telescopes of ALMA, it operated from 2007 to 2022.
- South Pole Telescope (SPT), a 10-meter instrument with 16,000 detectors. The SPT was a component of the Event Horizon Telescope that imaged supermassive black holes at the center of Messier 87 and the Milky Way.

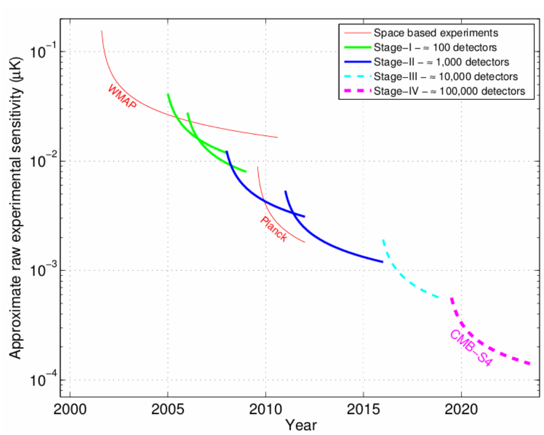
Microwave telescopes need to be high and dry to prevent attenuation of microwave radiation by water vapor in Earth's atmosphere. The "cameras" are actually bolometers, detectors that respond to microwave energy, converting heat to electric current. They need to operate at temperatures close to absolute zero.

Observatories on the Chajnantor Plateau and Cerro Toco in Chile. San Pedro de Atacama is 28 miles as the crow flies from the Simons Observatory, but the length of the drive is much, much longer and the altitude gain is almost 10,000 feet. (Google Earth).

[2] See "Pardon My Dust" in the April 2015 SkyWAAtch.

In April 2024, the Simons Observatory, funded privately by the late mathematician and hedge fund billionaire Jim Simons, began to take data in Chile using two of the three small (0.42 meter) telescopes on the site. Each telescope has 10,000 detectors. The Large Aperture telescope, a 6-meter instrument with a wider field feeding 30,000 detectors, will become operational next year.

It might be possible for the Simons Observatory to find B-mode polarization, but the larger astronomical community had proposed CMB-S4 in the mid-2010s as the grand project to achieve this goal. It is a larger and more ambitious endeavor, involving many participants (139 US and international institutions are listed as members). It includes Department of Energy funded entities in the physics community such as Lawrence Berkeley Laboratory, Argonne National Labs, SLAC and the National institutes of Standards and Technology.



Sensitivity of CMB instruments (CMB-S4 Science Book, 2016, which hoped that CMB-S4 might be operational by now).

S4 in CMB-S4 stands for “Stage 4.” Stage 1 searches were those that utilized about 100 detectors; Stage 2 instruments, such as BICEP2, utilized 1,000 detectors, while Stage 3 instruments like BICEP3 and ACT use around 10,000 detectors. The Simons Observatory instruments could be considered Stage 3½, since they have a total of 60,000 detectors. Stage 4 plans to utilize over half a million detectors. Newer detectors are more sensitive, more stable, more capable of precise polarimetry and faster than earlier devices. The Planck mission in space had 56 detectors working in 9 frequency bands, with an angular resolution of 5 arcminutes and a sensitivity of 5 μK. The half-million detectors used by CMB, cooled to 0.1 K, will have a resolution of 1 arcminute and a temperature sensitivity of 1 μK. Computer software and hardware capabilities have also advanced.

The CMB-S4 project, which put out its first Science Book in 2016 (https://arxiv.org/pdf/1610.02743), envisioned a larger number of both small and large aperture instruments and many more detectors than prior searches. It would use 12 telescopes, some in Chile and the rest in the South Pole, correlating the data whenever possible, although the main search for B-modes would be with the South Pole instruments because they can stare at a single area in the sky on a continuous basis.

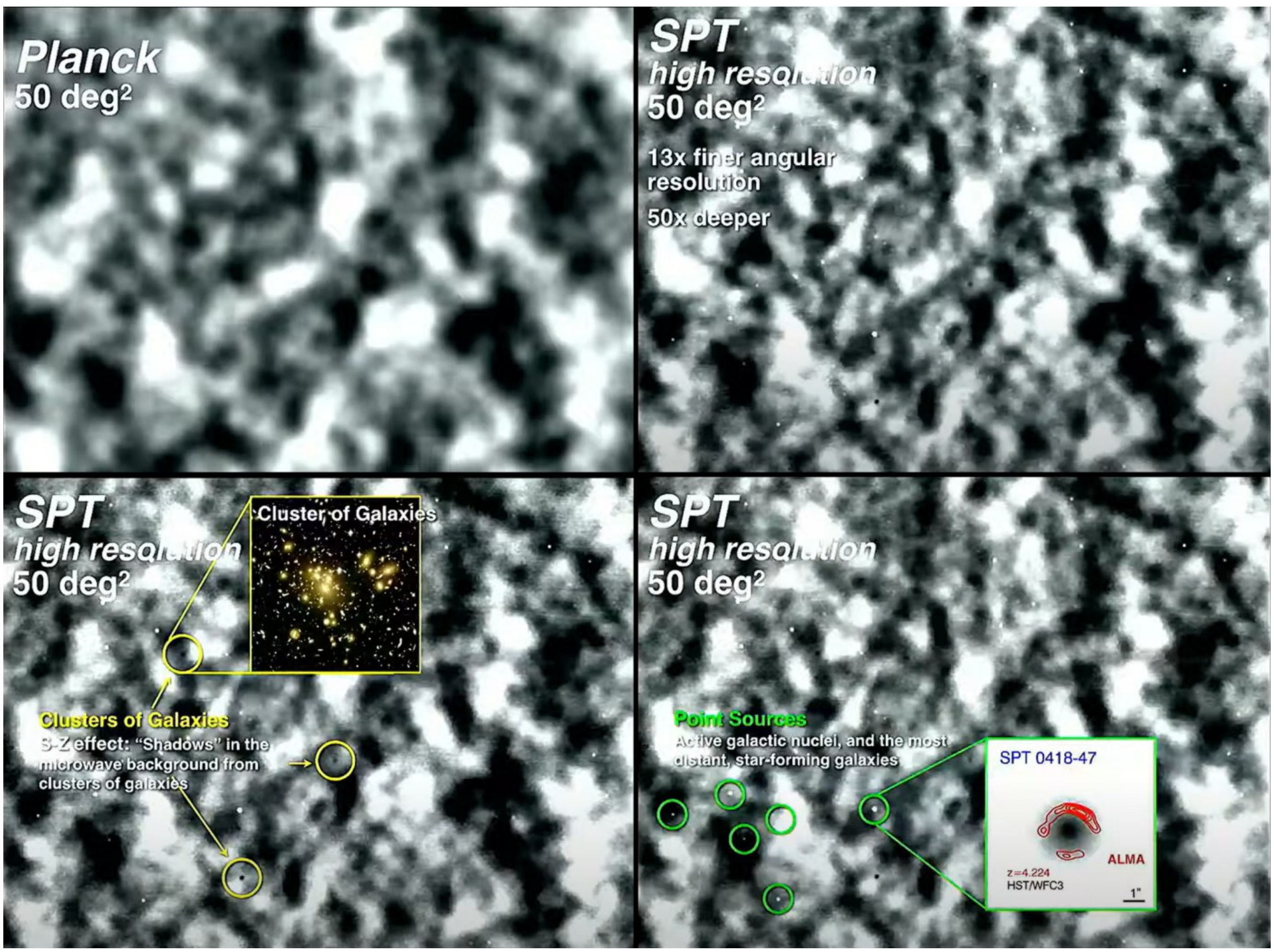
The CMB-S4 project was strongly supported in the 2020 Decadal Survey, which noted,

> Given technical and scientific progress over the past decades, ground-based studies of the CMB are poised to take a major step forward in the coming decade. The Cosmic Microwave Background Stage 4 (CMB-S4) observatory will leverage this progress and will have broad impact on both cosmology and astrophysics. Realizing the ultimate scientific potential of ground-based CMB observations will take an effort far beyond what can be achieved by independently scaling up existing experiments. CMB-S4 observatory, a joint effort of NSF and DOE, is the compelling and timely next leap for ground-based observations. It will conduct a 7-year ultra-deep survey of a few percent of the sky from the South Pole with a combination of large- and multiple small-aperture telescopes observing from 30–270 GHz. This will be done in parallel with a 7-year deep/wide survey of roughly half the sky with additional telescopes sited in the Atacama Desert in Chile. The Survey is also excited by the breadth of science, including time-domain and transient studies, and the potential engagement of a community well beyond traditional CMB cosmologists. To maximize the science, transient alerts and well-calibrated maps from all surveys will need to be made available to the entire community in a timely fashion, even if it requires some extra resources to do so.

Well, as Captain Jean-Luc Picard once said on the bridge of the Enterprise, “Wishing for something does not make it so.” Antarctica is a daunting environment for human activity. Facilities at the South Pole and the larger McMurdo Station, at the edge of the Ross Ice Shelf on the Antarctic coast, require a high level of upkeep to counter the impacts of extremely harsh conditions and the lengthy dark winter. The Covid-19 pandemic severely disrupted maintenance and delayed planned upgrades. More than half of the 2023-2024 research projects (in all scientific fields) were canceled. There is insufficient housing at McMurdo, which won't be corrected until 2026. There are additional concerns about the stability of some of the structures at the Polar Station, which rests on two miles of ice.

On April 1, the National Science Foundation announced that "there remains a significant backlog of funded projects that need logistics resources between 2024 and 2026 to achieve their research objectives…. NSF will therefore focus on supporting those projects already funded." This leaves out CMB-S4, and on May 7 the NSF announced that the project, which has been in the development stage for a decade, "would not proceed to the design stage in its current form." A major upgrade to the IceCube neutrino detector is also postponed.

Quite a few young astronomers and physicists have already been involved in the CMB-S4 project. This cancellation may have a significant impact on their careers. Project director Jim Strait, a physicist at Lawrence Berkeley National Laboratory, said his team is working on developing a new plan with Chile as the only site. There's plenty of room on the Chajnantor plateau for more telescopes. Although the sites are at high elevation (17,000 feet) they are much closer to civilization than Antarctica. But the scientific output of CMB-S4 might not be as revelatory as hoped without the South Pole site. ■



The value of increased resolution and sensitivity can be seen in this comparison of images of the same field from Planck (upper left) and the South Pole Telescope. The SPT resolution is great enough that galaxy clusters appear as shadows in the higher-temperature (bright) regions of the CMB due to the Sunyaev-Zel'dovich effect, while distant active galactic nuclei and quasars appear as bright spots due to gravitational lensing. Screen shots from a 2019 lecture on YouTube by Zeeshan Ahmed, a physicist at SLAC National Accelerator Laboratory in Palo Alto.

Images by Members

California Nebula by Steve Bellavia

NGC 1499 is a diffuse emission nebula in the constellation Perseus. Although listed as magnitude 5.0, it's not visible except under the darkest skies because its surface brightness is so low. A hydrogen beta filter is generally needed to get a decent visual sighting, and then only in the darkest skies after good dark adaptation with at least a moderate-size wide-field telescope, needed because the nebula is 2½ degrees in length. Sue French, in *Deep Sky Wonders*, reminds us that "a faint object in a moving field of view is often easier to spot than it is if the field is stationary," so jiggling the scope might help. Phil Harrington, in *Cosmic Challenge*, warns that NGC 1499 "is one of those targets that puts even the most experienced observers to the test."

On the other hand, it is a frequent subject for astrophotographers and is now within the range of the new generation of small automated imaging telescopes.

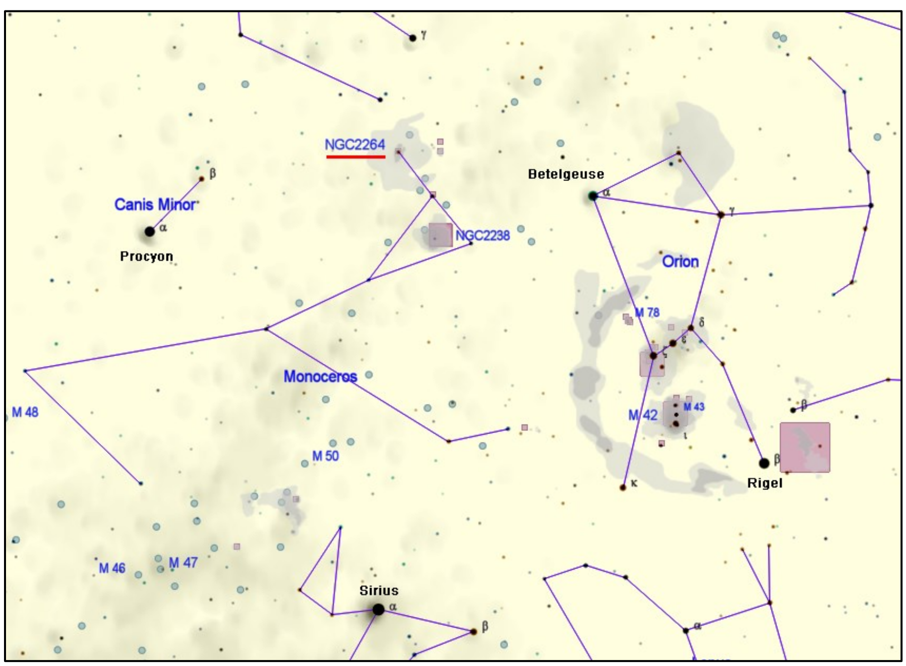
Steve made this image on December 15, 2023, with a 51-mm William Optic WhiteCat and ZWO ASI183MC Pro camera. He used a ZWO Duo-band filter. The hydrogen beta line is at 486 nanometers, not far from the oxygen III line at 500.7. Depending on the filter's bandwidth, at least some of the Hβ signal will come through.

The great observer Edward Emerson Barnard discovered the nebula visually with a 6-inch Cooke refractor in 1885 at the Vanderbilt Observatory in Tennessee. The nebula shines because its hydrogen is excited by the nearby magnitude 3.98 giant O7 star ξ (Xi) Persei, named Menkib by the Arabs. The name apparently means "shoulder," but it seems closer to the hero's right hip. It's the bright star below the nebula in Steve's image. The "shoulder" reference is to the star being on the "shoulder" of the Pleiades, 12 degrees to the south.

The field of view is 3.04 x 2.03 degrees. Technical data is at https://www.astrobin.com/oai84m/?nc=user.

Christmas Tree Nebula by Arthur Miller

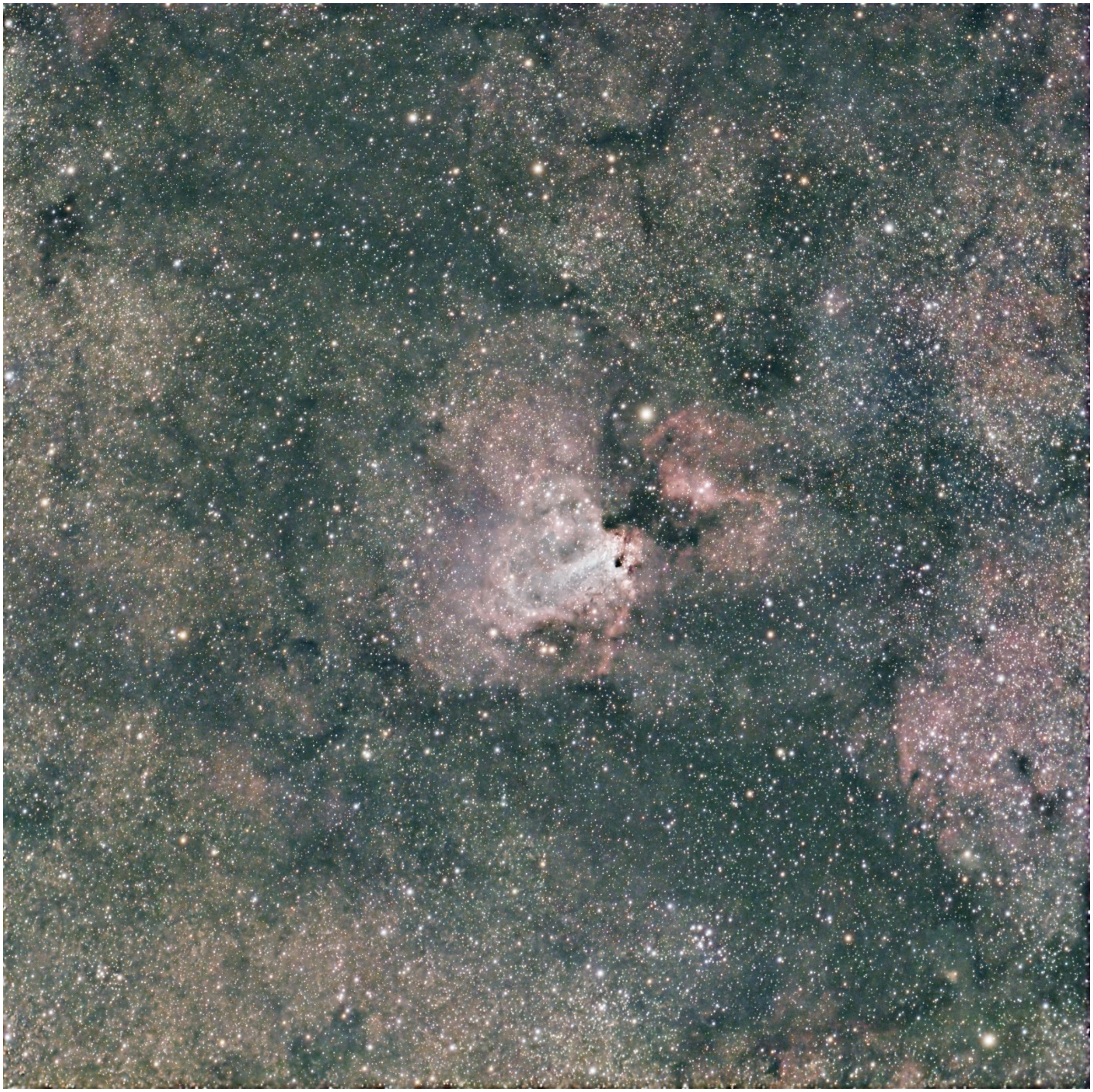
Arthur made this image at his winter home in Arizona. The field of view is 1.55 x 1.0 degrees field, with north up, NGC 2264, in Monoceros at a distance of around 2,700 light years, consists of the Christmas Tree emission nebula, Christmas Tree star cluster, the Cone Nebula, and the Fox Fur reflection nebula, the light patch embedded in the red emission nebula. The emission and reflection nebulas are energized by the intense radiation coming from magnitude 4.66 variable spectroscopic binary star S Monocerotis (class O7), which has a mass of 37 $M_{\odot}$ and a surface temperature of 37,500 K. Its luminosity is some 230,000 times that of the Sun. It's the bright star in the middle of the image.



The Cone Nebula, which is often imaged on its own, is a cloud of cold hydrogen and dust that overlies that portion of the Christmas Tree but it's very close to the bulk of the emission and not simply dust in the line of sight.

Arthur's close-up view of the Cone Nebula ran in the December 2023 SkyWAAtch, page 16.

Messier 17 (Swan Nebula) by David Parmet



David drove out to Cherry Springs State Park in Pennsylvania for a couple of clear nights of imaging during the last week of May. Here's a wide-angle shot of M17 through a Redcat 51, with an ASI533MC Pro on a Star Adventurer GTi mount, controlled with an ASIAir Plus. Seventeen 3- minute light subs, ten each dark, flat and bias subs. PixInsight.

The vast amount of hydrogen in this star-forming region in Sagittarius overwhelms the "swan" figure, which is usually easy to visualize even in a small telescope. The bright nebula also has been given the appellations Omega, Checkmark and Lobster. The field of view is 2.58 x 2.58 degrees.

Messier 20 (Trifid) and Messier 13 by Mike Virsinger

Former WAA President Mike Virsinger joined the SeeStar bandwagon and made these two images at his "first light" for the little scope. Mike and his wife Angela now live in Freeport, Long Island, and went to Parking Lot 2 at the west end of Jones Beach (the app identified the location as "Point Lookout," which is about half a mile to the west across Jones Inlet). Mike wrote, "It's unreal how easy. Power it up, connect the app, level, select a target, run the autofocus routine and click the shutter. It will automatically keep taking and stacking exposures until you tell it to stop. I was a bystander, watching the images integrate on my phone."

For those of us, your Editor included, who struggle with setup, collimation, alignment, focusing, lights, darks, biases, hardware and software, we offer the final lines of Percy Bysshe Shelley's *Prometheus Unbound* (1819):

To suffer woes which Hope thinks infinite;
To forgive wrongs darker than death or night;
To defy Power, which seems omnipotent;
To love, and bear; to hope till Hope creates
From its own wreck the thing it contemplates;
Neither to change, nor falter, nor repent;
This, like thy glory, Titan, is to be
Good, great and joyous, beautiful and free;
This is alone Life, Joy, Empire, and Victory.

Messier 51 by Justin Accetturi

Here's Justin's image of the beautiful Whirlpool Galaxy. The main galaxy is M51a, catalogued as NGC 5194. The smaller M51b is NGC 5195. It is spewing out stars from its gravitational interaction with M51a.

Your Editor was thinking of cropping the image until he saw the spiral galaxy along the left edge. It's IC 4263, a g-magnitude 14.77 class SBcd galaxy about 130 million light years distant, more than five times the distance of magnitude 8.4 Messier 51 (23.5 million light years).

The image was made over several nights at Ward Pound Ridge with a Celestron Edge 800 HD Schmidt-Cassegrain telescope and ASI294MM camera using Antlia LRGB and Ha filters. Red: 1 Hour 50 minutes, Blue: 2 hours, Green: 1 Hour 50 minutes, Luminance: 4 hours 46 minutes, Hα: 3 hours 49 minutes. The field is 42.3 x 26.2 arcminutes.

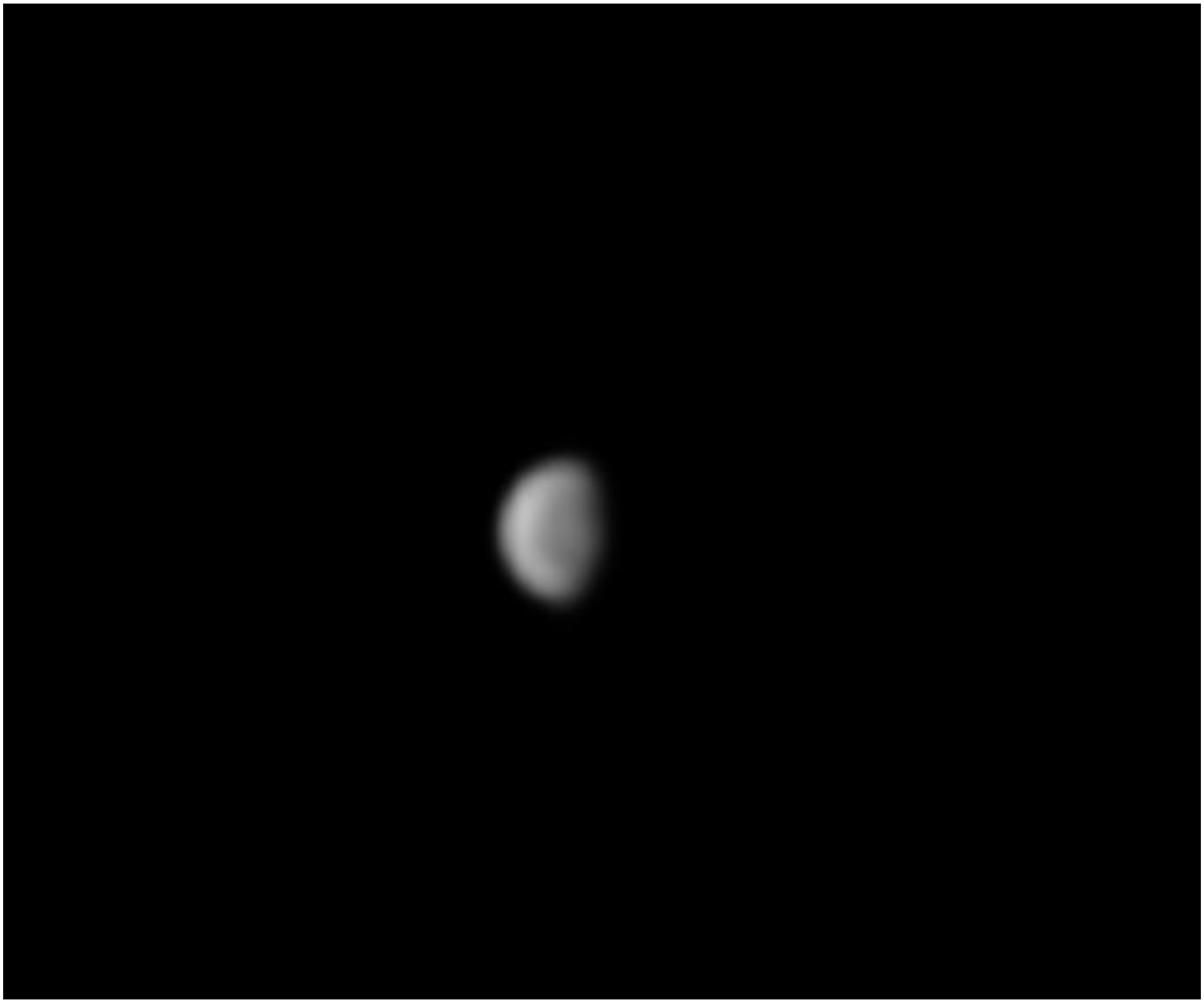
The red glow of hydrogen marks the site of new star formation. Tidal forces during galaxy mergers funnel relatively dispersed hydrogen gas clouds into high density, concentrated regions, resulting in star forming clusters and a cascade of new star formation.

The Whirlpool Galaxy was discovered on October 13, 1773 by Charles Messier, observing from Paris. His catalogue entry reads:

> Very faint nebula, without stars, near the eye of the Northern Greyhound [Cor Caroli in Canes Venatici], below the star Eta of 2nd magnitude of the tail of Ursa Major [Alkaid].… One cannot see this nebula without difficulties with an ordinary telescope of 3.5 foot [focal length]: Near it is a star of 8th magnitude…. It is double, each has a bright center, which are separated 4'35". The two "atmospheres" touch each other, the one is even fainter than the other. Re-observed several times.

For more on the observational history, dynamics and astrophysics of Messier 51, see "The Wonderful Whirlpool" in the June 2016 SkyWAAtch, page 4.

Gibbous Mercury by Steve Bellavia



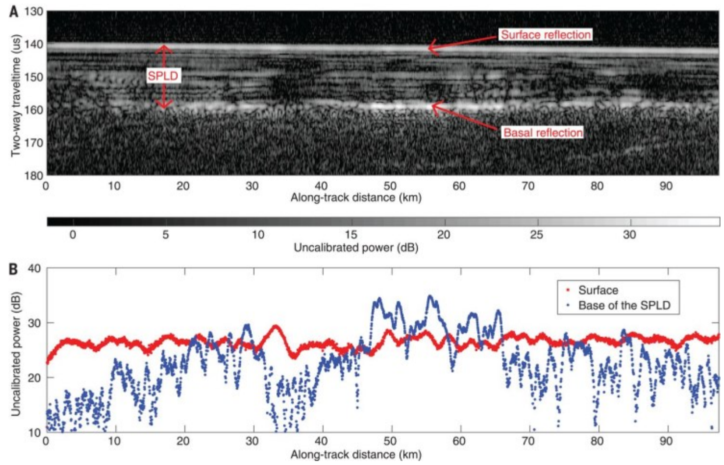
Steve made this image on May 29, 2024 at around noon with suboptimal seeing. At the time, Mercury was just 17° 36’ from the Sun, and 1.16 astronomical units from the Earth (107 million miles). The surface was 76% illuminated. Mercury’s angular diameter was just 5.8 arcseconds. It shined at -0.7 magnitude, which sounds like it’s bright, but consider that the Sun was close by at magnitude -26. The thick white band on the planet’s edge is probably artefact, a consequence of the processing of this difficult object, but very subtle albedo differences in the interior may be real. Steve believes it, your Editor is almost but not fully convinced. The gibbous phase is, of course, definitely real. Steve deserves credit for trying this demanding shot in the first place!

Mercury’s gibbous and crescent phases are rarely seen. Both Thomas Harriot and Galileo observed the planet in 1610. The German astronomer Simon Marius observed changes in its brightness as it orbited the Sun, guessing that it had phases, but he apparently did not actually visualize a gibbous or crescent phase. In 1639, Giovanni Zupi observed the phases telescopically. Your Editor has only seen Mercury in its gibbous phase once telescopically.

Steve used a TS Optics Photoline 115-mm f/7 refractor and ASI294MM Pro camera, with a Baader IR-pass 685-nm filter in the optical train.

Research Highlight of the Month

Lalich, DE, Hayes, AG, Poggiali, V, Small variations in ice composition and layer thickness explain bright reflections below Martian polar cap without liquid water, *Science Advances* DOI: 10.1126/science.aar7268 7 June 2024



Radar image of Mars South Polar Cap from Orosei, R. et. al., Radar evidence of subglacial liquid water on Mars. *Science* 361, 490–493 (2018).

Any finding of liquid water on Mars raises hopes that the planet has life. The South Polar Layered Deposit (SPLD) is a formation of nearly pure water ice and dust that can reach more than 3 km thick. Radar studies for the past two decades have probed the structure and composition of the SPLD, with the idea that it may provide clues to the climatological history of the Red Planet. In 2018, a group from Italy analyzed radar images of the SPLD, obtained by the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) on board the Mars Express, claiming that liquid water was trapped in layers below the surface. This would be analogous to the lakes of liquid water that exist below the Antarctic ice cap, such as Lake Vostok. Since the 2018 paper, additional data and simulations have attempted to define the exact nature of the radar reflections, for which liquid water was only one of a number of possible interpretations. The main caveat is that unlike on Earth, the Martian ice is presumably too cold to create or maintain meltwater.

The exact source of radar echoes is not an obvious call. It depends on composition and layer thickness. In this NASA-funded study by astronomers from the Cornell Center for Astrophysics and Planetary Science, the authors used “radar reflectivity simulations to show that the strong reflections can instead be caused by constructive interference between dusty ice layers that are more closely spaced than the radar resolution. Unlike previous hypotheses, interference does not require anomalous subsurface conditions or exotic materials to be present beneath the ice. In addition, interference between thin layers can explain the variable power of radar returns beneath the entire ice sheet and does not require different mechanisms to be responsible for reflections in different regions.” In other words, it is unlikely that there are lakes of liquid water under the South Polar cap. Surface radar instruments, which have yet to be landed on Mars’ polar caps, might improve resolution sufficiently to prove or disprove the original proposal by Orosei et. al.

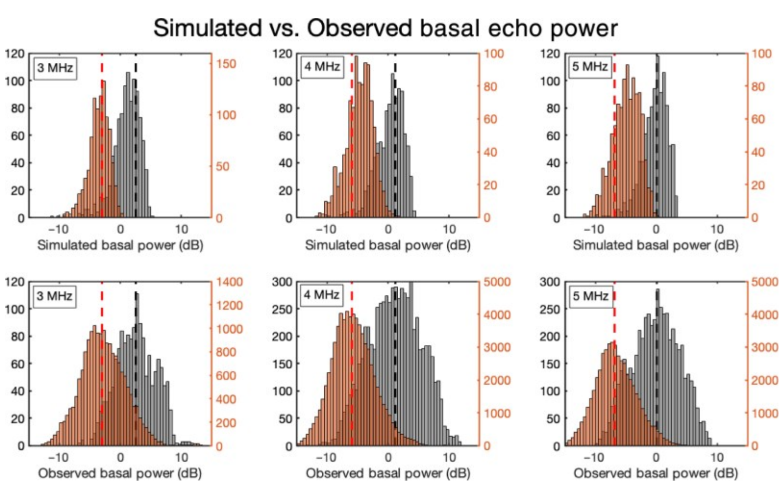


Fig. 3. Simulated and observed basal echo power distributions.
(**Top row**) Distribution of simulated MARSIS normalized basal echo power for a single starting scenario capturing the behavior both inside the bright area (gray histograms) and outside the bright area (red histograms). (**Bottom row**) Observed normalized basal echo power distributions both inside the initially defined bright area (2) (gray histograms) and the surrounding region (red histograms). Dotted lines indicate the median value of the observed power distributions.

Member & Club Equipment for Sale

Item	Description	Asking price	Name/Email
Celestron Nexstar 5SE	Mint condition white Celestron 5-inch f/10 (1250-mm) Schmidt-Cassegrain. Go-to alt-azimuth, single fork arm. Only used a couple of times. Complete with hand control, tripod, finder, eyepiece, diagonal. Picture here. Celestron lists this instrument for $799. Weight 17.8 lbs complete, including tripod. Runs on 8 AA batteries or external 12-volts. A fantastic telescope for lunar, planetary and bright DSO observing.	$400	Heather Morris heathermorris4381@gmail.com
Celestron StarSense auto-alignment	Automatically aligns a Celestron computerized telescope to the night sky. Includes finder camera, hand control (substitutes for the original HC), two mounting brackets, cables. Works with any computer controlled Celestron scope that has a hand control. Like new condition, in original box. Image here. Celestron's description and FAQ are here.	$220	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.	$125	WAA ads@westchesterastronomers.org
ADM R100 Tube Rings	Pair of 100 mm adjustable rings with large Delrin-tipped thumb screws. Fits tubes 70-90 mm. You supply dovetail bar. Like new condition, no scratches. See them on the ADS site at https://tinyurl.com/ADM-R100. List $89.	$40	Larry Faltz lfaltzmd@gmail.com
Tiltall photo/spotting scope tripod	TE Original Series. Solid 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.	$75	WAA ads@westchesterastronomers.org

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

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