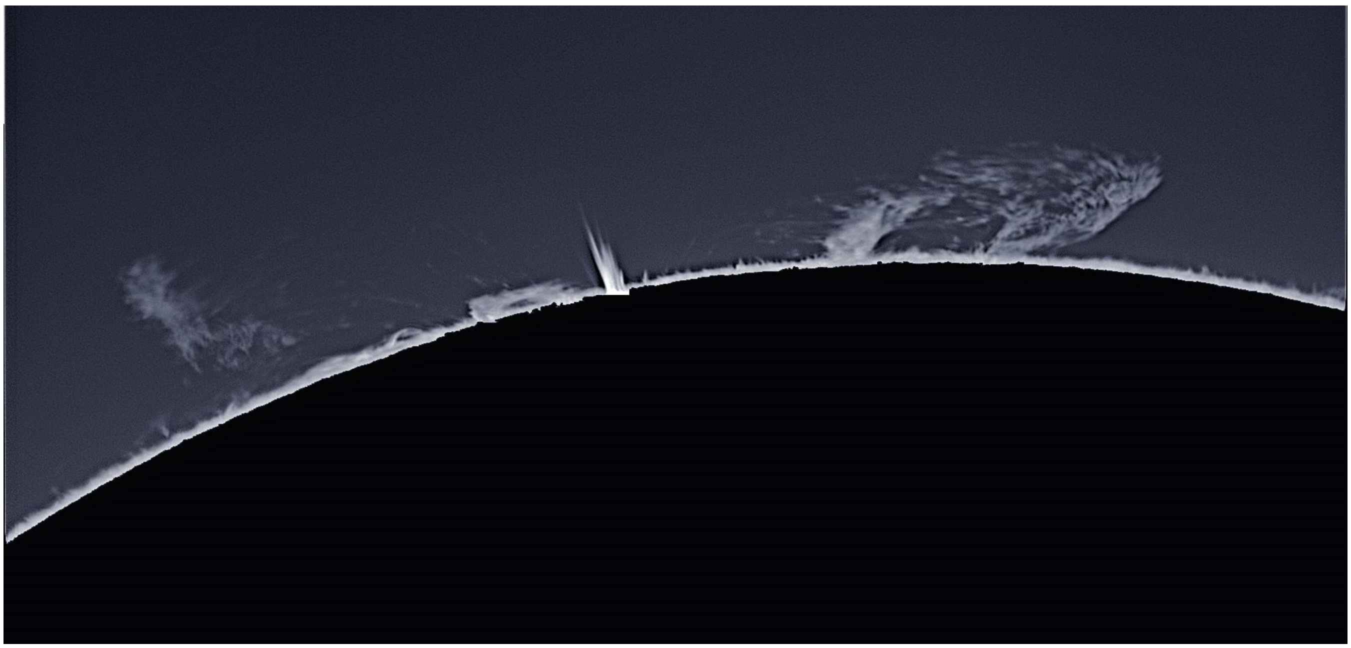
SkyWAAtch

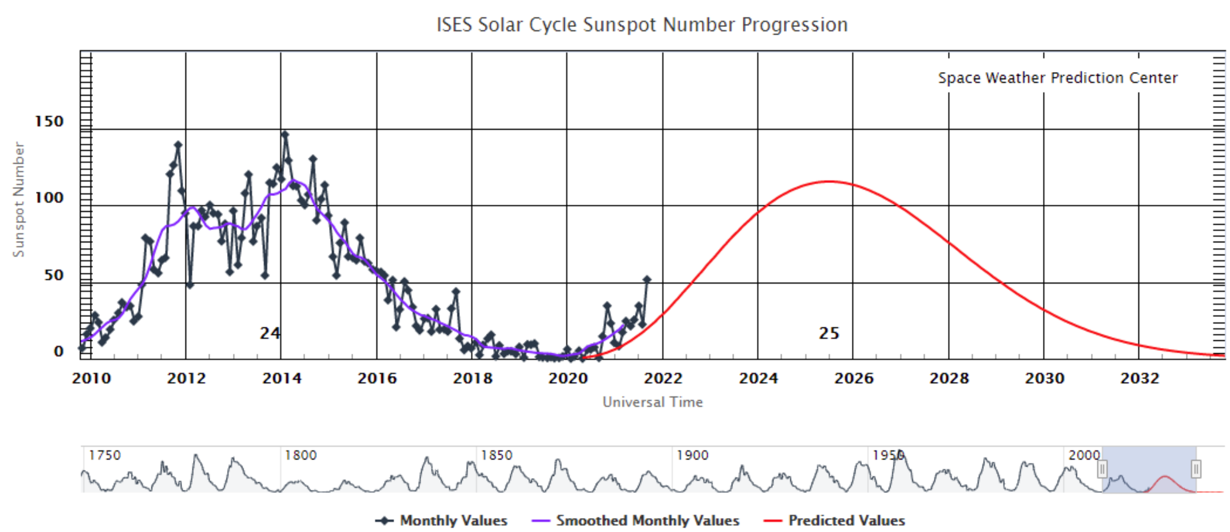
The Newsletter-Journal of Westchester Amateur Astronomers

November 2021



The Sun Gets Busier by John Paladini

Three-inch Edmund f/15 telescope, Daystar Quark Combo hydrogen-alpha Chromosphere filter, ZWO ASI290MM camera. The Chromosphere device has 4.3X telecentric Barlow built in.



This graph as of 10/24/21. Get the latest at https://www.swpc.noaa.gov/products/solar-cycle-progression.

WAA November Meeting

Friday, November 12 at 7:30 pm

On-line via Zoom

Magnetic Anomalies on the Moon

Dany Waller
Graduate Student, Johns Hopkins University Applied Physics Laboratory

Swirls are a unique class of lunar features. They occur across all types of terrain on the Moon and are associated with strong magnetic anomalies. Although the Moon does not currently have an active magnetic field like Earth, it may have had one in the past. The current magnetic anomalies may be left over from that time. Magnetic fields can provide radiation protection from the solar wind, influencing physical and chemical properties of lunar soil.

Pre-lecture socializing with fellow WAA members and guests begins at 7:15 pm! The Zoom link is on www.westchesterastronomers.org.

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

Editor: Larry Faltz
Assistant Editor: Scott Levine
Almanac Editor: Bob Kelly
Editor Emeritus: Tom Boustead

Also In This Issue

WAA DecemberMeeting

Friday, December 10 at 7:30 pm

On-line via Zoom

Single-Photon Technologies for Ground-based Gamma-ray Astronomy

Massimo Capasso, Ph.D.
Columbia University & Veritas Array

The December meeting is the official Annual Meeting of Westchester Amateur Astronomers, Inc. We will formally elect new officers, but the election will actually be virtual. Members will receive a ballot via email around December 1.

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

Starway to Heaven

Ward Pound Ridge Reservation, Cross River, NY

The next official star party will be in March 2022. Members may observe at WPRR with prior notification to the park. The phone number is on the ID card that you received with the email acknowledgment when you joined or renewed your membership in WAA. If you need a copy, email waa-membership@westchesterastronomers.org.

New Members

Rashmi Jain	Ossining
Laura Kovacs	Rye
Joe Lisle	White Plains
Kathy Ortiz	Port Chester
Bruce Rights	New Providence

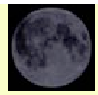
Renewing Members

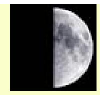
Paul Andrews	Patterson
Patricia Frasier & Myrna Morales	New York
Tim Holden	White Plains
Hugh Osborn	New Rochelle
James Peale	Bronxville

Westchester Amateur Astronomers

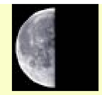
ALMANAC for November 2021

Bob Kelly, WAA VP for Field Events


New
11/4


1Q
11/11


Full
11/19


3Q
11/27

In November, the Moon gets involved in practically everything. Let's start with the sublime lunar eclipse and end with the ridiculously hard-to-see lunar occultation of Mercury.

An Almost Total Lunar Eclipse

On the early morning of the 19th, the full Moon has an almost total lunar eclipse, with the maximum eclipse at 4:02 a.m. EST. The Moon will be 97.4% covered by the darkest shadow. It would be even less covered if the Moon wasn't near its apogee for this month (its farthest distance from the Earth). The Moon edges into the umbra at 2:18 a.m. and leaves just after moonset at 6:58 a.m. The partially eclipsed Moon might make for some great photos with foreground objects before Moonset. The eclipse will be visible across the entire USA in case you are traveling on that date. Since the Moon will be in Taurus, see if the Hyades and Pleiades clusters become more visible near the time of maximum eclipse.

Closer Moon

November's lunar perigee occurs on the 5th, 25 hours after new Moon. Remember the coastal flood advisories we had for a week after new Moon in October? A steady easterly wind increased the likelihood of higher-than-normal tides. In November, the Moon is even closer at new Moon, so be aware if you are near the coast.

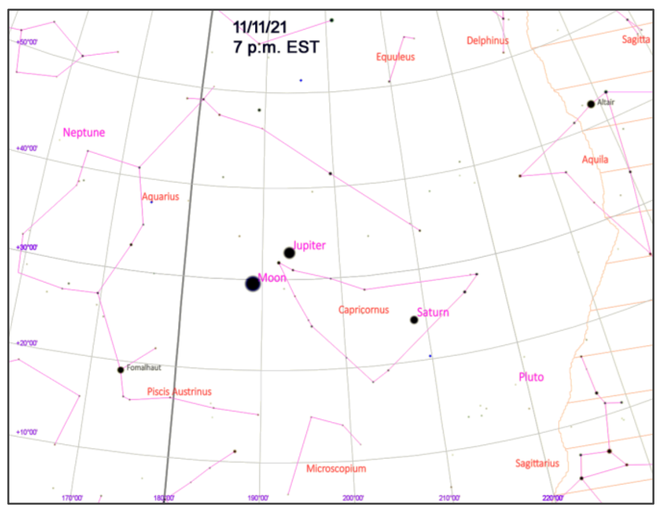
Uranus All Night

Uranus' opposition occurs on the 5th, with a maximum magnitude of +5.6. It will be visible to the unaided eye in a very dark sky. Get an atlas or a Uranus finder chart to spy which of those faint dots is the sideways planet. The rest of us can use the same charts to try to catch it with binoculars and compare with the other dim stars around it. It will be in Aries, not far from the action in Taurus, and visible all night. It's definitely a blue disk in a telescope, some 3.7 arcseconds across. Compare to Neptune, in Aquarius, rising earlier in the night and positioned 50 degrees to the west. It's one-third smaller, just 2.5 arcseconds and magnitude 7.9.

TimeandDate.com has a cool widget[1] that shows the relative sizes of the planets as seen from Earth. Just click on "size in the sky" to watch the app rank the planets by apparent size. How much optical aid will you need to see that Neptune is a disk?

Jupiter and Saturn Shine

The Moon Saturn and Jupiter visits on the 10th and 11th. Jupiter's at quadrature. That's 90 degrees from the Sun. Since we are looking at bit sideways at Jupiter, the shadows of its bright moons fall farthest from their positions from an Earthlings' point of view. One good example occurs on the evening of the 23rd, when the shadows of Calisto and Ganymede, Jupiter's two largest moons, appear on Jupiter's cloud tops in the evening from 6:52 to 9:39 p.m About 7 p.m., the Great Red Spot will be centered on the planet, with a satellite shadow nearby. Times can drift a little, so check the latest app results.



Find Saturn's brightest moon, 9th magnitude Titan. While you are looking, check for 11th magnitude Iapetus brightening as it passes south of Saturn on the 18th.

Inner Planets on the Morning and Evening Shifts

Mercury makes its superior conjunction with the Sun (behind the Sun from Earth's point of view) on the 29th. Before that, magnitude -1 Mercury passes +1.7

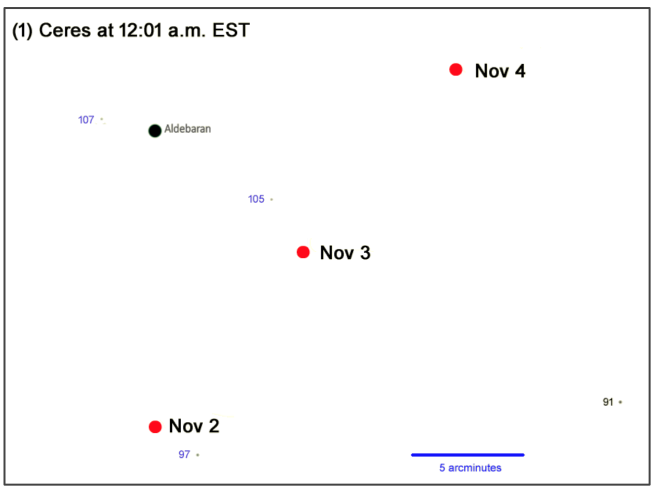
[1] https://www.timeanddate.com/astronomy/planets/distance

Mars on the 10th. Its phase increases and it gets brighter despite getting farther away from us. The slim Moon points to Mercury on the 3rd.

Venus is also having it both ways, getting larger in viewing size and slimmer in phase. It's sliding along the evening's southwestern horizon as it heads back toward the Sun at an incredibly bright magnitude -4.5. The Moon comes by the 7th and 8th.

Crumbs

How do you know Ceres? As the first asteroid, or the closest dwarf planet? Either way, it comes to opposition in late November at magnitude +7.0. It's the largest object between Jupiter and Mars, but it's still a star-like point in a telescope. Ceres has Aldebaran as a red-light pointer to its location for the first week of November as it gets within 8 arc-minutes of the star.



Ceres and Aldebaran at 12:01 a.m. EDT 11/2-11/4/21. Magnitudes of closest nearby faint stars are to given to one decimal place with the decimal point omitted.

Second-largest asteroid Vesta might be visible at magnitude +7.6 as it moves though the Solar and Heliospheric Observatory's C3 viewer starting on the 11th.

NASA tells us that right now there are 1,113,527 known asteroids, with undoubtedly more to come.

The Leonid meteors, the dust from comet 55P/Tempel-Tuttle, will peak at less than 15 an hour during the morning of the 17th. Will the lunar eclipse allow a few leftover Leonids be seen on the morning of the 19th?

How soon will you see Comet C/2021 A1 (Leonard)? It may be as bright as fourth magnitude in late December. Now it's brightening though 12th magnitude in the gap between Ursa Major, Boötes and Leo.

Go Back in Time

Daylight time ends at 2 a.m. Sunday, November 7. We mere mortals get to experience the "Groundhog Day effect", at least for an hour as the clocks change from 2 a.m. to 1 a.m. that morning. A *Jeopardy!* contestant noted that their baby was born just before 2 a.m. on the date of the change, meaning that the infant was alive before the official time of her birth! Morning sunrise moves back from 7:32 to 6:33 a.m. at White Plains. Make the most before the morning darkness departs. It's a "limited time offer," as the Sun doesn't rise this late in our area (on local clock time) for the rest of the year. We'll have more dark time for astronomy after sunset, but the evening commute will be darker.

Mercury Hides in Daylight

The Moon occults Mercury during the mid-afternoon on the 3rd. Since the Sun is moving downward toward the horizon with the Moon and Mercury just 15 degrees ahead of it, it's going to be hard to block the Sun with a solid object and keep it there. I don't know if the Moon or Mercury will be easier to find in the daylight, given how slim the Moon will be. Don't try this observation unless you've practiced observations in daylight and have a really effective means of keeping sunlight off your optics. According to calculations, a 6-inch telescope will need a sun shade of at least 23 inches (see page 4 in the August 2021 SkyWAAtch for the calculation). *Caveat astrologus*.

The International Space Station is visible in the morning though the 11th and in the evenings starting on the 17th.

The Sun is getting more active as we finally are ramping up into solar cycle number 25. Scientists predicted a deep solar minimum between cycles 24 and 25, which happened with long stretches of days with zero sunspots in 2019 and 2020. Cycle 25 should reach its peak in 2025. See the cover of this month's SkyWAAtch for the Space Weather Prediction Center sunspot graph. ■

More Movie Telescopes

Although a hardly the mind-expanding experience of Melville's astonishing book, the 1954 movie *Moby Dick* is a well-done telling of the basic plot, Ahab's manic search for the white whale. The film was directed by John Huston, who co-wrote the screenplay with Ray Bradbury. Gregory Peck does a fine job as the borderline-psychotic Ahab. Several of Ahab's greatest lines were also given to Ricardo Montalban as Khan in *StarTrek II*, most notably the climactic "to the last I grapple with thee; from hell's heart I stab at thee; for hate's sake I spit my last breath at thee."

A small brass telescope is a prop in an early scene in *The Rock*, a 1996 thriller about a group of disaffected soldiers led by Ed Harris who threaten to launch VX gas on San Francisco from Alcatraz. They are opposed by the team of Nicholas Cage, as an FBI chemical weapons expert, and Sean Connery, as a British secret agent imprisoned by the US for decades without trial, because he knows too much, like who actually killed JFK. He's released because he's the only person ever to have escaped from Alcatraz and so knows all its secrets. Vanessa Marcil plays Cage's girlfriend.

At a tense moment near the climax of *The Rock*, a group of good-guy soldiers are surveying Alcatraz Island from the San Francisco waterfront. One of them has a high-power scope that is probably a Maksutov. We don't get to see the corrector plate well enough to confirm it.

Spoiler alert: The good guys win.

Deep Sky Object of the Month: Messier 38

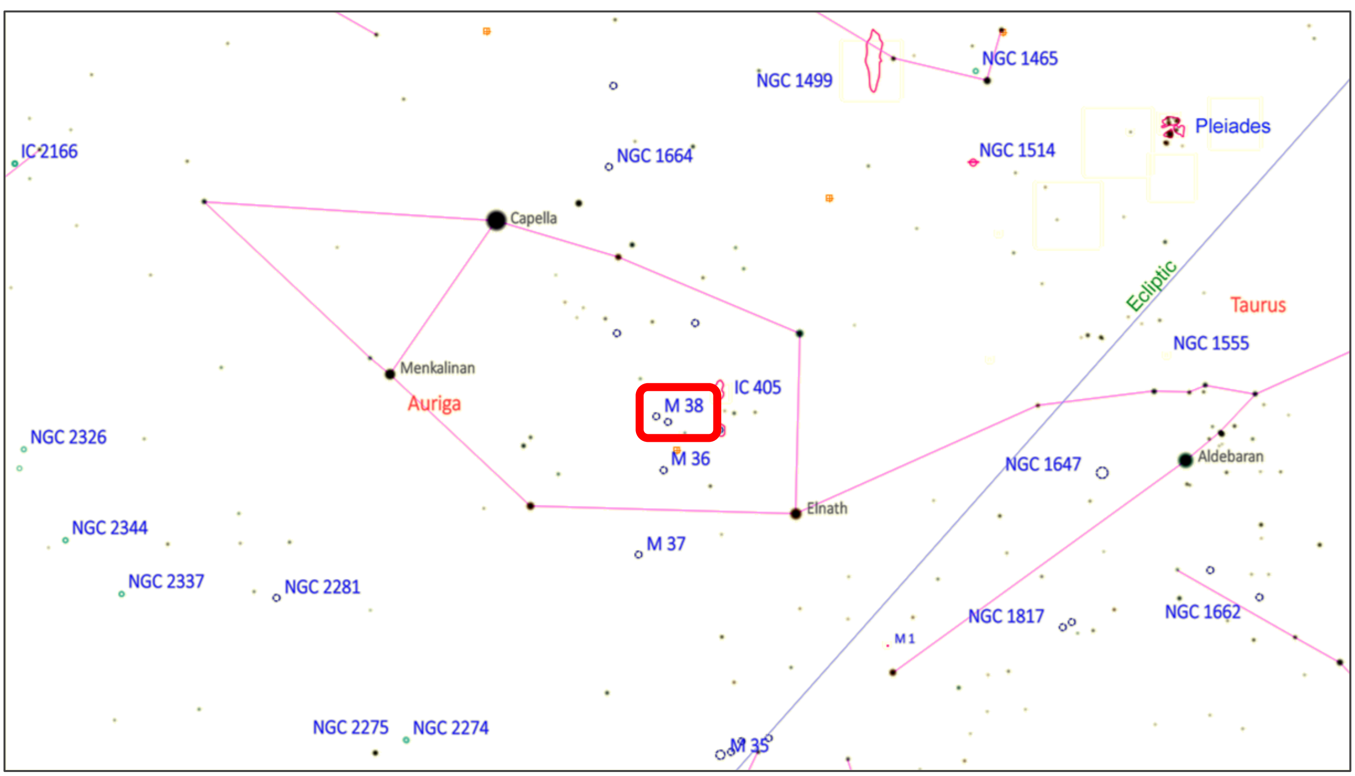
Messier 38	
Constellation	Auriga
Object type	Open Cluster
Right Ascension J2000	05h 28m 42.5s
Declination J2000	+35° 51m 18s
Magnitude	+6.69
Size	9.6’x9.6’
Distance	1,066 parsecs
NGC designation	NGC 1912

Known as the Starfish Cluster, M38 was one of the first open clusters to be recognized. It was seen by Giovanni Batista Hodiema in the early 1650s. Some observers see a cross, others the Greek letter π. Obviously some people see a starfish. *Chacun à son goût.*

The cluster contains about 100 stars. Its age is estimated to be about 290 million years. When you are in the area, take a look at neighboring open clusters M36 and M37. Just half a degree away from M38 is a somewhat fainter (magnitude +8.87) open cluster, NGC 1907. They make a nice pair in the right eyepiece/scope combination. The two clusters do not have a common origin, however.

Visibility for Messier 38			
10:00 p.m.	11/1/21	11/15/21	11/30/21
	EDT	EST	EST
Altitude	26° 24’	46° 51’	57° 50’
Azimuth	64° 12’	78° 13’	86° 02’

Astrophotographers will want to try for IC 405, the Flaming Star Nebula, and IC 410, impressive emission nebulas each less than three degrees away, possibly using very wide angle set-up or perhaps a good challenge for a mosaic. ■



Lifting the Veil — Robin Stuart

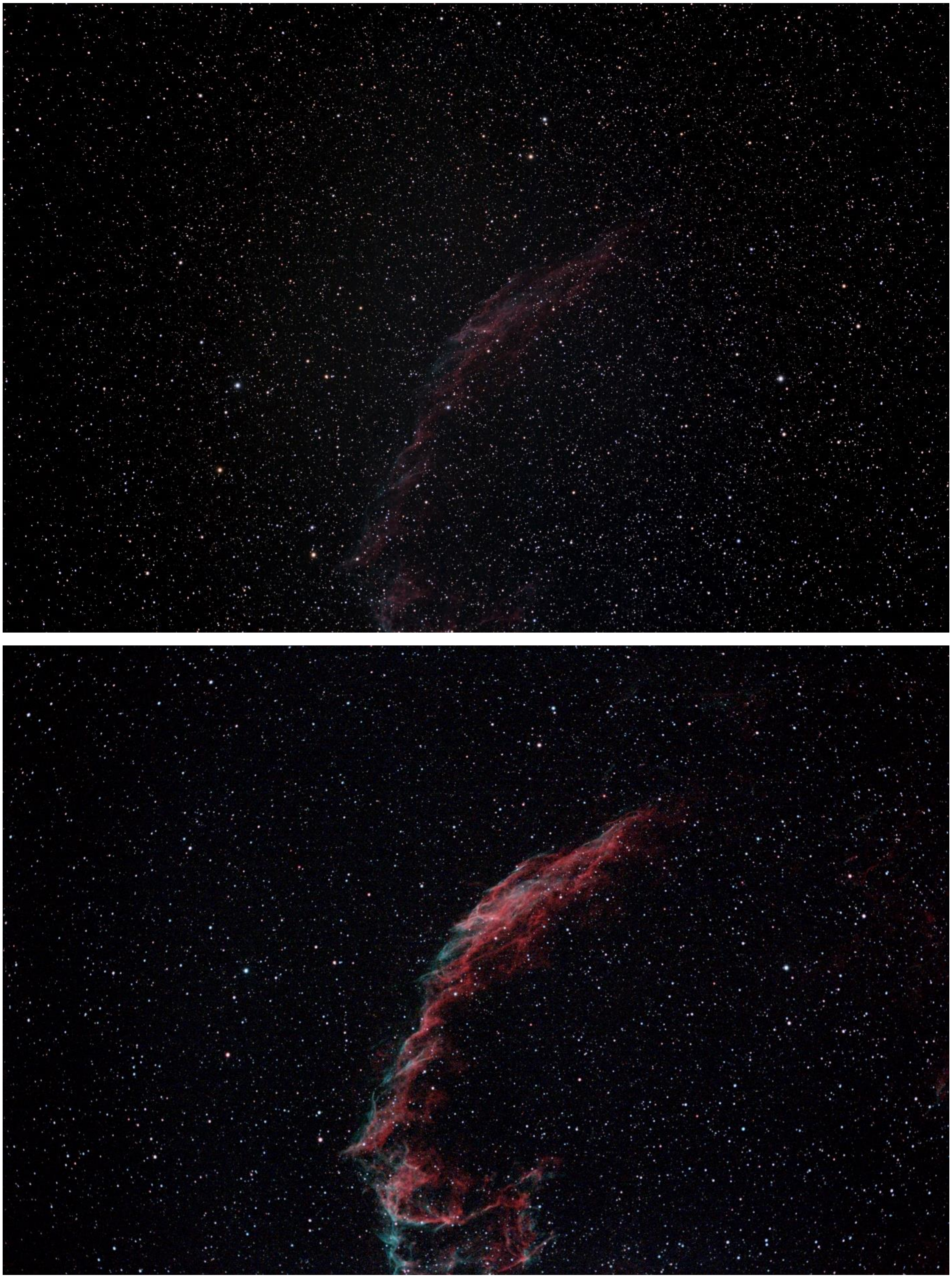
Under Bortle 3 skies: No filter, 6x300 seconds (total exposure 30 minutes)

An observing session at a truly dark location can be a breathtaking experience. The sky is an inky black and the familiar outlines of the constellations are lost among a host of other stars. Faint sporadic meteors delight as they streak across our gaze.

In early September I took my Televue NP127 to the Bortle 3 skies of northern Maine and was rewarded with several clear nights. I was interested in learning what was achievable under these conditions. The image above shows the Eastern Veil Nebula, C33 in the Caldwell Catalog and NGC 6992 & NGC 6995 in the New General Catalog. It is a 30-minute exposure taken at prime focus with a Canon 60Da DSLR at ISO1600 and constructed using ImagesPlus from six 5-minute subs that were dark and bias subtracted. Image set processing in ImagesPlus is normally a hands-free, automated procedure but in this case it ground to a halt at the alignment phase apparently stymied by the sheer number of stars that confronted the software.

For comparison, the images on the following page show 30-minute total exposures of the same target taken under the Bortle 6 skies of Valhalla, NY. The upper one was constructed from sixty 30-second subs. In this case the exposure time of the individual subframes is limited by the background brightness of the light-polluted suburban sky. The lower image is comprised of six 5-minute subs taken through a Radian Triad Ultra Quad-Band filter that transmits Hα, Hβ, OIII and SII wavelengths. It does a fine job of revealing the intricate emission features of this expanding supernova remnant while suppressing light pollution and, unavoidably, the background stars.

All three images were stretched with the same degree of Digital Development and taken together provide a lesson in the importance of the signal to noise ratio. [Not to mention the utility of filters and the value of packing your gear into the car and heading for the darkness.-Ed.] ■



Under Bortle 6 skies. Top: No filter 60x30 seconds (total exposure 30 minutes); Bottom: Radian Triad Ultra Quad-Band filter, 6x300 seconds (total exposure 30 minutes)

The History of Photoelectric Astronomy Larry Faltz

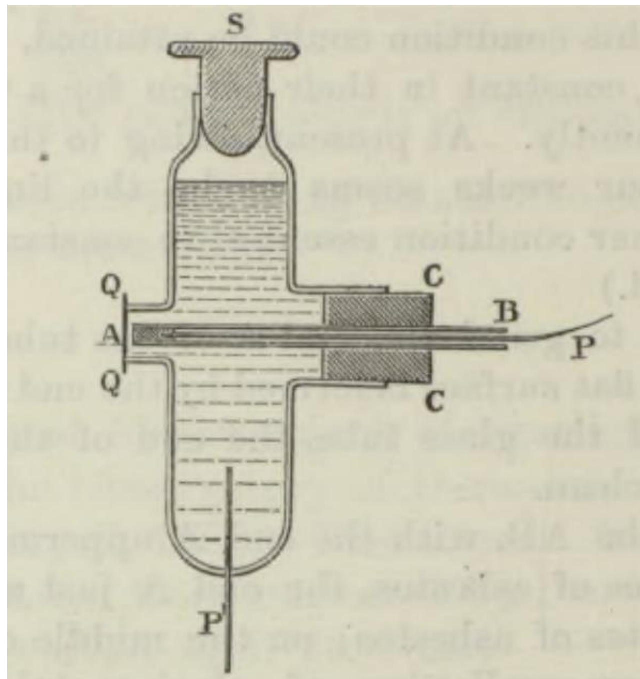
In September's SkyWAAtch, I described how filters are used to measure the color of a star. Using our eyes or guessing at the size of filtered star images on a photographic plate (whose low-light response suffers from reciprocity failure) just isn't good enough for truly scientific astronomy. We need to make objective, reproducible measurements of brightness with a sensitive device that responds linearly to the amount of light presented to it. Enter the electric photometer.

Electric photometers are based on the photoelectric effect, in which a photon with enough energy knocks electron off an atom on a metal surface. The flux of liberated electrons is proportional to the intensity of the light. The electrons are captured and counted by measuring the current.

The phenomenon of light causing certain metals to develop or transmit electric charges was investigated in the second half of the 19th century. The mechanism was a mystery until Max Planck's proposal in 1900 that light came in discrete packets. In 1905, Albert Einstein elaborated the quantum nature of light and, making theoretical sense out of experiments done by others, showed that the energy of the packets was related to the light's frequency by a constant ($e=hv$, where v [Greek nu] is the frequency and h is Planck's constant, $6.62607015 \times 10^{-34}$ Joule-seconds).[1] Einstein was awarded the Nobel Prize in 1921 for this work (not for special or general relativity). The higher the frequency, the shorter the wavelength and the greater the energy. Blue light photons have more energy than red light photons.

The photoelectric effect was harnessed for light measurement before it was completely understood. In the last quarter of the 19th century, several crude photometers were used to measure the intensity of sunlight.

Photoelectric measurement of stars, needing much more sensitivity than sunlight, was first achieved in 1895, when George M. Minchin, an Irish physicist, published his observation of Regulus, Procyon and Arcturus through "Mr. Wilson's 2-feet *(sic)* reflector" using a photovoltaic cell of his own invention.[2] His device consisted of a thin layer of selenium deposited on aluminum, in turn immersed in a glass cell filled with oenanthol, the common name of 1-heptanal ($CH_3(CH_2)_5CHO$).[3] While this is a "photosensitive" device, it is not a true "photoelectric cell," which by definition places a potential across the elements of the cell even if there are no photons (the "dark" state).



Minchin's selenium cell. The image of the star is focused on the quartz window QQ, with the selenium (A) right behind it. A small potential difference will form between P and P' when starlight-falls on A.

Minchin determined that "the intrinsic energy of Regulus = 3.6 X the intrinsic energy of Procyon." This

[1] Frequency v and wavelength λ are inversely related by the formula $v=c/\lambda$, where c is the speed of light in a vacuum, 299,792,458 meters per second.

[2] Minchin, G.M., The Electrical Measurement of Starlight. Observations Made at the Observatory of Daramona House, Co. Westmeath, in April, 1895. Preliminary Report, *Proceedings of the Royal Society of London*, 58: 142 (1895); https://is.gd/Minch1895.

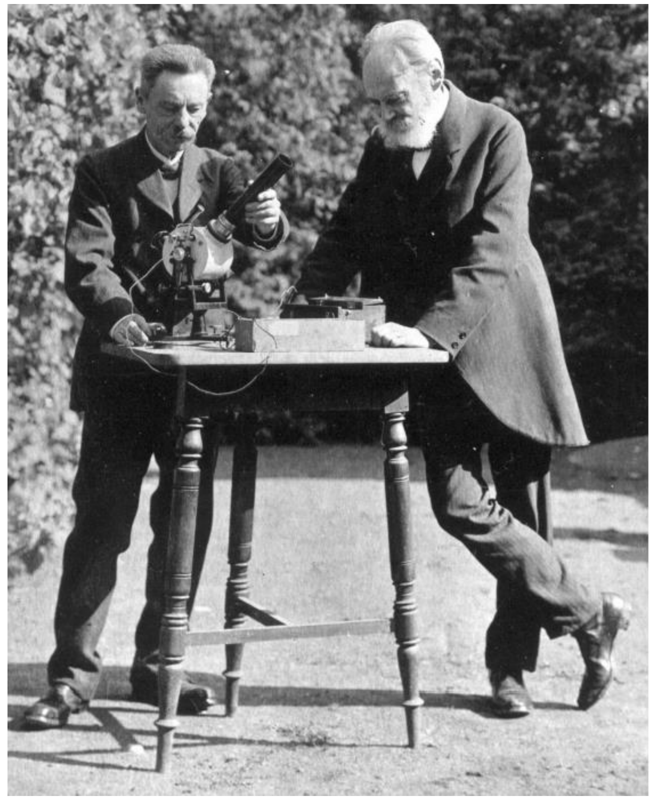
[3] 1-heptanal is a liquid at room temperature (boiling point 152.8 C, freezing point -43.3 C, at one atmosphere). It is derived from castor oil by distillation. It has a fruity odor. It's flammable and immiscible in water. Investigating this compound got me to pull my weighty, 2400-page *CRC Handbook of Chemistry and Physics* (56th edition) off the bookshelf for the first time in decades!

is at variance with the fact that Regulus is dimmer than Procyon, but that Minchin was able to get a signal at all is quite an achievement.

In 1906, Joel Stebbins, a young astronomer at the University of Illinois, saw a demonstration of a selenium cell at an exhibit in the university's physics department. Stebbins was amazed that a bell could be made to ring when a light was shined on the device. "Right then and there," Stebbins wrote, "I got the idea that if an ordinary light will ring a bell why would not the light from a star at the focus of a telescope produce a measurable electric current?" He quickly found Minchin's article and other reports that used similar devices to gauge the intensity of sunlight during partial phases of a solar eclipse. During the winter of 1906-7, with the selenium cell at the focus, he aimed the university's 12-inch telescope at the "brightest star in the sky," which happened that night to be Jupiter, not a star. Nothing happened, but he did get a reading when he pointed it at the nearly full Moon. Later that year, using a better cell, he was able to register a signal from Aldebaran. Further improvements in the selenium cells allowed him to measure the magnitude variation in Algol and shortly thereafter the minima of the variable star β Aurigae.[4]

The first photoelectric cell that was practical for astronomy had been developed by Julius Elster and Hans Geitel in 1904. An evacuated glass bulb housed a thin cathode made of a chemically active metal while the anode was simply a wire. The anode was maintained at a positive potential in order to collect the negative electrons released by light from the cathode. This was the fundamental design for increasingly sensitive and accurate light-sensing devices over the next 75 years.

Elster and Geitel were childhood friends who worked together doing research on a wide variety of topics, including electric phenomena in gases and liquids, instrumentation, materials science, meteorology, photoelectricity, photometry, and radioactivity. Their main interest was "atmospheric electricity." Their research was conducted privately: they were high school (*Gymnasium*) teachers their whole lives, turning down a number of university offers. Although nominated for the Nobel Prize on seven occasions between 1904 and 1912, they never won the award. One writer described them as the "Dioscuri of physics," a reference to Gemini, the heroic twins Castor and Pollux.

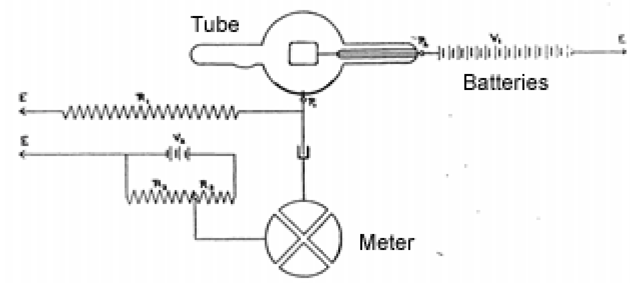


Julius Elster and Hans Geitel with an early photometer

In 1911, Swiss-born physicist Jakob Kunz, who had joined the University of Illinois in 1909, suggested to Stebbins that they should utilize an Elster-Geitel type of photoelectric cell rather than the selenium cell. While Stebbins was on sabbatical in Europe (where he visited German astronomer Paul Guthnick, who was also working with this device), W. F. Schulz and Kunz made the first photoelectric cell observations of stars.[5] Again using the university's 12-inch refractor at Urbana, they captured signals from Capella and Arcturus. They had to compensate for "dark current," which was temperature-dependent and thus less of a problem during winter observations. Schulz's conclusion was "These measurements seem to show that it is possible to use the photo-electric cell for astrophysical investigations."

[4] Stebbins, J. The Electrical Photometry of Stars, *Publications of the Astronomical Society of the Pacific*, 52: 235 (1940)

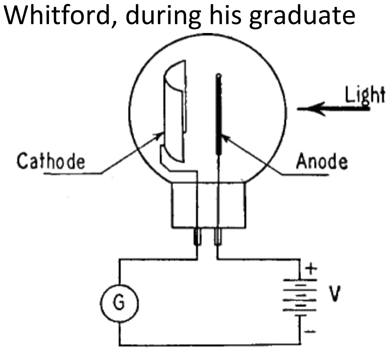
[5] Schulz, WF, The Use of the Photo-Electric Cell in Stellar Photometry, *Astrophysical Journal*, 38: 187 (1913) http://articles.adsabs.harvard.edu/pdf/1913ApJ....38..187S



Kunz and Schulz's apparatus

The first systematic studies with a photoelectric photometer were published between 1918 and 1921 by Guthnick. After plotting the light curve of the eponymous Cepheid variable δ Cephei with his photometer[6] he examined a large number of stars, comparing the instrument's response with and without a color filter.[7] The "color" of the star was the ratio of the measurements. His papers are published in the *Astronomische Nachrichten* and unfortunately my German is primitive, so I can't report more detail.

During the 1920s and 1930s, photoelectric tubes became more sensitive and efficient. One of the leaders in this effort was astronomer Albert E. Whitford, who obtained a PhD at the University of Wisconsin in 1932. At that time, the instrumentation was still very insensitive. General Electric had made a new tube, but it was too noisy. Whitford, during his graduate studies, realized that the noise was caused by leakage currents. The air around the tube was ionized by constant bombardment of secondary cosmic rays, a phenomenon that occurs everywhere on the surface of the Earth. He enclosed the amplifying tube in a vacuum, and that solved the problem. Moving to Mt. Wilson, Whitford improved the amplification circuits and was able to examine interstellar reddening of O and B-type stars in globular clusters. He worked on radar at MIT during World War II, and then returned to Wisconsin, eventually becoming Chair of Astronomy and director of the Washburn Observatory. He moved to California to become director of Lick Observatory in 1958. Whitford was president of the AAS from 1967-1970.



Basic design of a photoelectric tube

In 1940, Whitford, still a young astronomer, reviewed the status of electronic measurement of stars at the Symposium on the Photoelectric Cell in Astrophysical Research, held in Seattle at the meeting of the Astronomical Society of the Pacific.[8] In spite of his work with photomultipliers, he noted that

> However desirable in other respects a detector of radiation may be, its usefulness in astronomy will be limited unless it responds to exceedingly low intensities. The photographic plate is by this test still the best detector, because the procedure of extending the exposure until the blackening becomes perceptible is so simple and foolproof. The analogous requirement in measuring the light of a faint star with a photoelectric cell is to wait until a measurable electric charge has been released. Because of a multitude of technical difficulties, it has not been practical to extend the waiting period for the collection of charge much beyond one minute. With one-minute exposures at the focus of the 100-inch telescope the photoelectric cell has been used to measure stars of the 16th magnitude with fair accuracy. The limit of detection would have been perhaps two magnitudes fainter. If it became essential to measure stars down to the photographic limit by a photoelectric method, it seems possible that with sufficient patience it could be done.

Whitford made a prediction:

> In comparison with the photographic plate, the photoelectric cell possesses the limitation that it can give an indication on only one arbitrary area at a time. If the area is a very small one, such as a star image, the photoelectric cells does at least as well in a given time as the plate, but meanwhile the plate is able to record the position and intensity of myriads of other details. For this reason it seems unlikely that the photoelectric cell will ever be used to record stellar spectra.

Enter television. The first practical television-type video camera was invented by Vladimir Zworykin in

[6] Guthnick, P, Die Lichtkurve von δ Cephei nach lichtelektrischen Messungen, *Astronomische Nachrichten*, 208:.169 (1919) https://is.gd/Guth1919

[7] Guthnick, P. ; Hügeler, P., Beobachtungen der Helligkeit, des Farbenindex und des Spektrums der Nova Aqualie 3, *Astronomische Nachrichten*, 210: 345 (1920) https://is.gd/Guth1920

[8] Whitford, A.E., Advantages and Limitations of the Photoelectric Cell in Astronomy, *Publications of the Astronomical Society of the Pacific*, 52: 244 (1940) http://cdsads.u-strasbg.fr/pdf/1940PASP...52..244W.

1923. It was called the ionoscope. Improvements in the 1930s were insufficient to make them a potential option to film. Whitford's view was:

> The mosaic cathode used in television iconoscopes, though it does permit light from the whole image to be continuously effective, offers little hope as a substitute for the photographic plate. From what has been said it will be seen that even if the mosaic had a resolving power equal to that of the photographic plate, and each element were (*sic*) as efficient as the best photoelectric cell and its associated amplifier, the performance could perhaps equal but not excel the photographic plate. In practice there are inevitable large losses in efficiency, and the performance of the plate is far superior, not to mention its greater convenience.

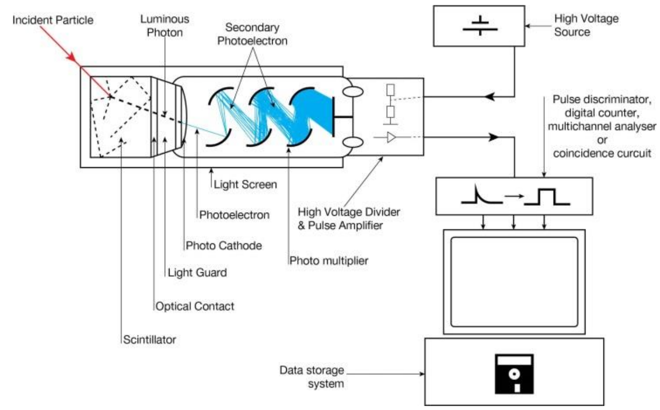
Whitford noted that

> Present-day [1940] photoelectric surfaces are inefficient; they require about 100 incident photons for each electrons emitted. But it is worth remarking that the photographic plate requires about an equal number of photons to produce developable plate grain.

This quantum efficiency of 1% is an order of magnitude lower than the human eye, which has a maximally dark-adapted scotopic QE of perhaps 10%,[9] while the QE of the CMOS cameras we use today is often over 80%. The CCD in the Dark Energy Survey Camera on the 4-meter Victor Blanco telescope at Cerro Tololo in Chile has a QE of >90% at 900 nm.

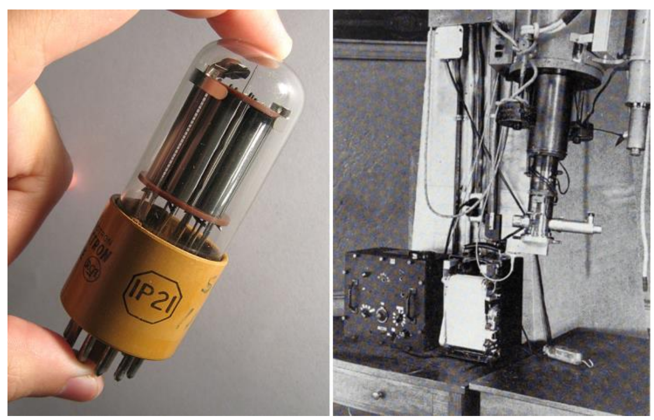
Photometry can take two forms: direct detection of light from the telescope and photometric scanning of photographic plates. After making exposures with different films and filters, back-lit plates could be scanned with a photocell moved mechanically to ultimately cover the plate, creating a quantitative map of the image.

Progress in electronics during and after World War II eventually led to more sensitive and stable photomultiplier tubes, sensitivity amplified by a cascade of secondary electrons inside the detector tube. Many observatories built and operated detectors using photomultiplier tubes made by RCA, GE and others, adapting them directly to the telescope.



A photomultiplier tube and detector circuit

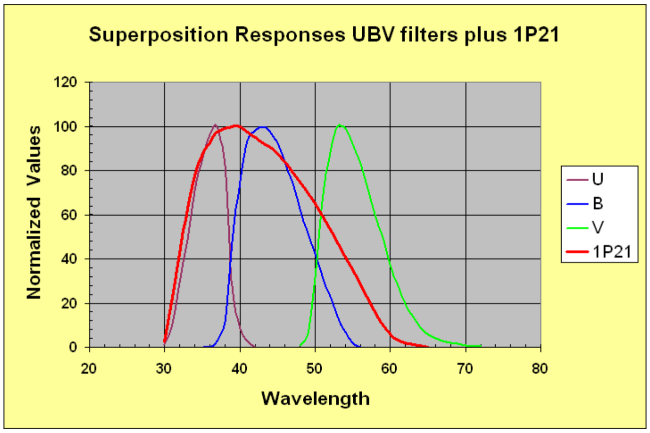
As mentioned the September article, in 1953 H. L. Johnson and W. W. Morgan published photometric observations through colored filters of almost 300 stars in a variety of spectral classes. They used ultraviolet, blue and yellow ("visual") filters in front of a highly-calibrated photometer with an RCA 1P21 photomultiplier tube. This work established the UBV photometric system, the first of what turns out to be a large number of such systems, employing a range of well-characterized filters.



Left: The RCA 1P21 photomultiplier tube used in Johnson and Morgan's detector. Right: A 1P21 photometer on the 12-inch telescope at Lick Observatory (1949).

The RCA 1P21 tube had 9-stages of internal amplification. The light sensitive material was cesium-antimony. The potential difference between the anode and cathode was 1250 volts. Its maximum spectral response was in the higher-energy violet at 4000 ± 500 Å. It had barely enough sensitivity towards the red end of the spectrum to be useful, but it was the best device available at the time. Johnson and Morgan reduced noise by packing the tube in dry ice during their observations.

[9] Rods in the human retina can respond chemically to a single photon, but conscious perception of light does not occur until a larger number of photons are incident on the retina, due to "post-retinal processing" in the nervous system.

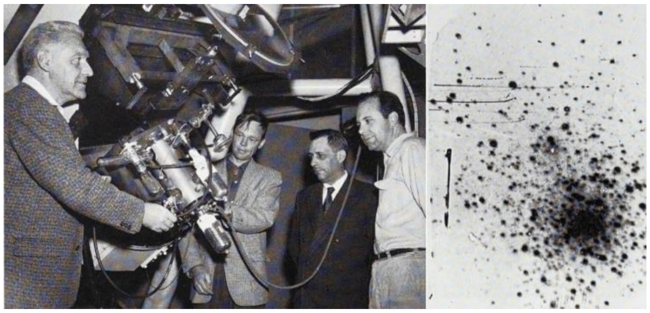


RCA 1P21 spectral response (red) compared to the UBV filters.

Experiments in spectroscopy with photocells started in the 1930s and rapidly accelerated after the war. The photomultiplier was attached to a spectroscope and the angle of the grating (or prism) was slowly changed to cover all of the wavelengths.

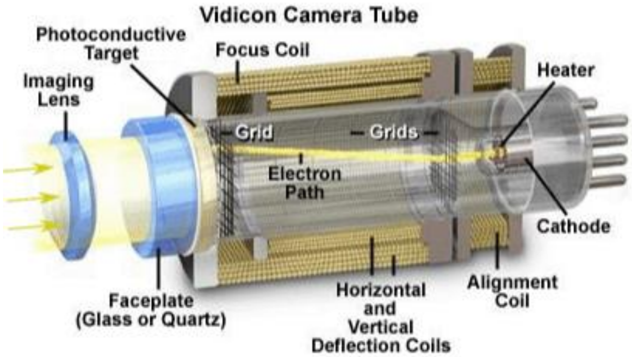
Photomultiplier-based detectors clearly have significant limitations: their quantum efficiency is relatively poor, they are bulky, they need a lot of power and voltage, and they generate heat. They are of course limited to single stars or small patches of the sky.

The 1950s saw progress in the field of video detectors, resulting primarily from the growth of broadcast television. French engineer André Lallemand invented a video tube that was sensitive enough to record stars. The bulky device required high voltage and a vacuum. It made its image by firing electrons on an electron-sensitive plate. To develop it into a visual image, the tube had to be destroyed, clearly a disincentive to wide-spread adoption. Nevertheless the device was used at observatories in France and eventually at Lick. In an image of M13, stars of V magnitude 17.5 could be reached in 25 minutes.

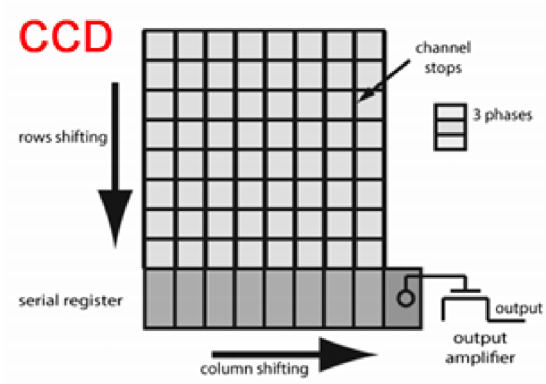


(L) Lallemand camera at Lick in 1959. The inventor, André Lallemand, is second from right.(R) an image of M13 through this device.

The vidicon tube in the late 1960s, developed by Westinghouse, was the most useful of the video devices. Fifteen-hundred-line vidicons were used on the Voyager spacecraft. An 8-position filter wheel sat in front of the tube. It took 48 seconds to read out the 800x800 images, which were stored on a videotape before being transmitted to Earth. A vidicon-based camera was an early proposal for the Hubble Space Telescope. The arrival of the CCD made vidicons obsolete. Videotapes are obsolete now as well.



The first mention of the charge-coupled device (CCD) was a 1970 technical report from Bell Labs by Willard Boyle and George Smith. They had been working on metal-oxide semiconductors (MOS). They found that light falling on the device created a proportional electric charge. A two-dimensional array of MOS capacitors accumulates charges when exposed at the focal plane of a lens. The charges in each row are read out sequentially from a register at one end of the array and converted into voltages. These analog signals are converted later to digital format. The rows are shifted towards the register and read out again, until the entire array has been emptied. The image can then be reconstituted from the stored signal.



The first CCD capable of recording an image was made by Fairchild in 1973, a 100x100 pixel array.

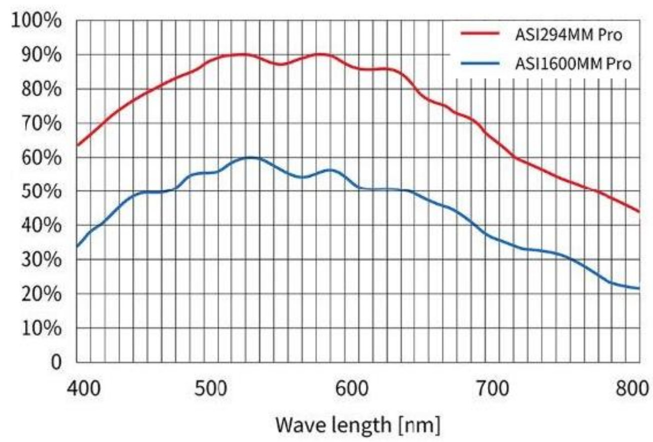
Texas Instruments built a 400x400 CCD for the Jet Propulsion Laboratory. These were first used for astronomy in 1975 at Kitt Peak by Roger Lynds, and shortly thereafter for spectroscopy by Bev Oke at Palomar with the 200-inch Hale telescope. The first satellite with a CCD detector was the KH-11 Kennen spy satellite in 1976. It had an 800x800 array. The image recorded by the CCD was transmitted to Earth and printed on film with an early laser printer.

CMOS sensors (complementary metal-oxide semiconductors) are arrays of field-effect transistors (MOSFETs). They are manufactured with the same photolithography techniques as microprocessors. They differ from CCDs in that each pixel converts its charge to a voltage (rather than using sequential registers). Because the processing is "parallel," the image readout is faster than a CCD. CMOS sensors were initially difficult to engineer, but advances in technology in the late 1990s made them more reliable and cheaper to produce than CCDs. They are inherently noisier than CCDs but use less power, making them desirable for battery-operated consumer cameras and for field work by amateur astronomers.

Although a few manufacturers still make high-end CCD cameras for the astro-imaging market, most cameras now used by amateurs have CMOS sensors, with CCDs generally reserved for high-end, large-format, cooled monochrome cameras.

CCDs are still the preferred sensor for professional observatory cameras. The 3.2 *giga*pixel CCD camera on the Vera Rubin Telescope has 0.2 arc-second resolution and a 9.6 square-degree field. It will employ the *ugrizy* photometric system, similar but not identical to UVBRI, for enhanced discrimination in the near-infrared.[10]

While photometers or modern CCD or CMOS chips can take the guessing out of magnitude measurements, they need to be calibrated with filters to account for variations in sensitivity across the spectrum and among devices. Spectral response curves of modern sensors vary much less than film, but astronomical photometry is now an exact science and so calibrations must be exquisitely accurate.



Quantum efficiency and spectral response of two recent CMOS cameras. The sensor in the ASI294 is the Sony IMX294 (4144x2822 pixels, 4.63 µ) and the ASI160MM, with the older Panasonic MN34230 sensor (4656x3520 pixels, 2.8µ).

Albert Whitford, who died in 2002 at age 96, was able to see the progress from film and photoelectric cells to CCDs. In a biographical note in 1982, he wrote,

> I have been no more than a witness to the final part of the photoelectric revolution: the advent of the so-called panoramic detectors that have extended the advantages of high quantum efficiency and linear response to thousands (or as many as a hundred thousand) of picture elements simultaneously viewed in the focal-plane image delivered by the telescope or spectrograph. Observers no longer have to reckon with the long exposure times required by sequential viewing of one element at a time. I salute those responsible for devices such as image-intensifier tubes, including schemes for recording and storing in the proper specially labeled bins the flashes on their output screens; for silicon target vidicons; and finally for charge-controlled (*sic*) devices (CCDs). Though the number of simultaneously recorded channels will undoubtedly increase, contemporary techniques have come very close to the ultimate of capturing all the photon information in the radiation incident on each picture element. [11]

Professional astronomers of the past would be amazed that amateurs now have multi-megapixel cameras, many with over 80% QE, weighing little more than a large eyepiece and costing a few hundred dollars. It's been a remarkable trip from Minchin's first selenium tube in 1895. ■

[10] https://speclite.readthedocs.io/en/latest/filters.html

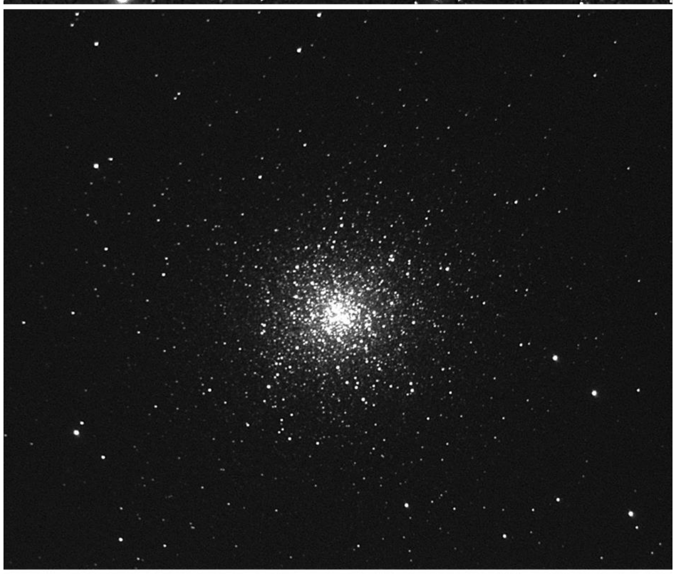
[11] Whitford, A.E., A Half Century of Astronomy, *Annual Rev. Astron. Astrophys.*, 24: 1 (1986) https://is.gd/whit86

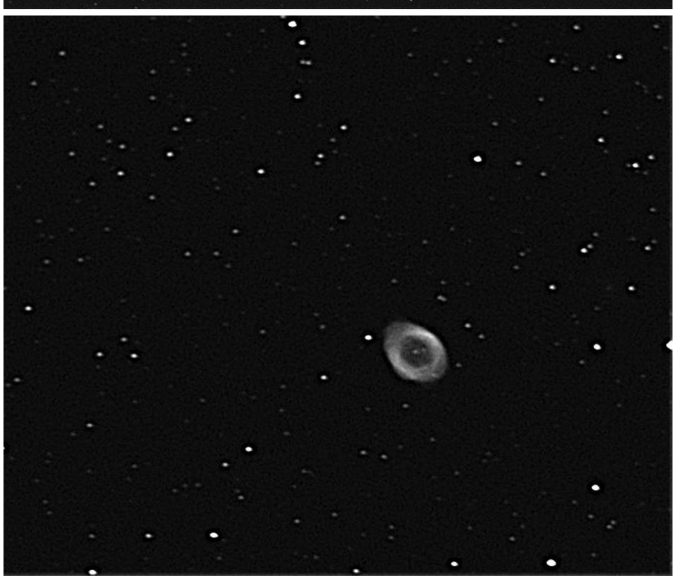
Images by Members

North American Nebula by Leandro Bento

Leandro's fine image was taken obtained and Ward Pound Ridge Reservation with his usual tiny but powerful set-up: William Optics Redcat 51-mm f/4.9 telescope, ZWO ASI533MC Pro camera, Optolong L-Enhance filter, all on an iOptron Skyguider tracker. The image was made on September 3. Fifty frames at 180 sec each, gain 100, camera cooled to-10° C. Darks, flats and bias frames were also taken.

"It's a Floor Wax! It's a Dessert Topping!" by John Paladini





John Paladini wanted to see how well a ZWO ASI290MM camera would work on deep sky objects, in this case the Dumbbell Nebula (M27), the Hercules Cluster (M13) and the Ring Nebula (M57). He chose among his many telescopes a 5.5 inch f/3.64 Celestron "Comet Catcher," a Schmidt-Newtonian made in the early 1980's in anticipation of the return of Halley's Comet. The scope was equatorially mounted.

The Schmidt part of a Schmidt-Newtonian is the combination of a fast spherical mirror (usually f/2) with a figured corrector plate, just like in a Schmidt-Cassegrain. The Newtonian part is that the image is brought out by a flat diagonal behind the center of the corrector plate to the side of the upper end of the telescope like a Newtonian reflector, rather than to the back of the tube through a hole in the mirror like an SCT. These telescopes are rare and highly sought-after for imaging because of their fast speed (low focal ratio) and excellent correction. There are also a few fast Maksutov-Newtonians around, with a different corrector plate design but same overall geometry .

The 290MM is positioned as a monochrome solar, lunar and planetary imager, primarily because its relatively small 1936x1096 sensor is designed for very fast read-out. It is capable of 170 frames per second at full resolution, even faster for a smaller "region of interest," just what you would want to make an AVI of a planet in a short time. But there's no inherent reason that the camera can't be used for longer exposures. Since it's not cooled, very long exposures will be noisier than those from a cooled deep-sky imager. John stacked ten 10-second frames for these images.

So it is evident that with a fast telescope "planetary" cameras might be usable for simple deep sky imaging. The dual function reminds us of the Saturday Night Live *faux* commercial for "Shimmer, the Non-Dairy Floor Wax," with Chevy Chase, Dan Aykroyd and Gilda Radner, which aired on January 10, 1976 and sticks hilariously in the memory of those of us a certain age.

LF

Shadow Transit of Europa by Rick Bria

Nights with a full moon are bad for taking pictures of the night sky. The Moon acts like a bright light that swamps objects like galaxies, nebulae, and star clusters. So, clear nights when the Moon is near full are good for telescope maintenance.

September 20 was perfect for the routine tasks of tuning the instruments. I completed lubricating, adjusting and calibrating the scopes at the Mary Aloysius Hardey Observatory at about 2:30 a.m. Before leaving, I thought I'd take a look at Jupiter. To my surprise, Jupiter's moon Europa was casting a shadow on Jupiter. Ganymede was nicely positioned to the left. Earth's atmosphere was extraordinarily steady and the view was VERY NICE.

Although Jupiter was low in the southwestern sky, I decided to try to shoot a video with the Televue 85-mm refractor that's piggybacked on the observatory's 14-inch PlaneWave. A ZWO ASI290MC camera made a 90-second video though a 2X Barlow. This image is a stack of 130 frames. Europa and Ganymede are labeled and Europa's shadow is an obvious black spot near Jupiter's equator. Several brown cloud bands, white cloud zones, and white ovals can be seen on Jupiter. Jupiter's Red Spot was on the other side of the planet. It would have been perfect were it visible at this time.

Had I planned on shooting a video of Jupiter, I would have done so earlier when Jupiter was higher in the sky and due south. Still, I'm glad I decided to take a chance before heading home for some sleep.

Rick Bria ■

Soap Bubble and Crescent by Steve Bellavia

Embedded in the Milky Way in Cygnus are a whole bunch of interesting objects. Last month we presented Steve's image of the Cocoon Nebula. Some 20 degrees west of the Cocoon, not far from Sadr (Gamma Cygni), the star at the center of the "Northern Cross" asterism that is often applied to the Swan, lies the fairly bright Crescent Nebula, NGC 6888, and the much more subtle Soap Bubble, PN G75.5+1.7 (use index marks to find it). The Soap Bubble is not a visual object. It was discovered by Pasadena amateur astronomer Dave Jurasevich in 2007 on an image he made with a 160-mm refractor and a SBIG STL-11000M camera. His equipment was housed in a small dome at the Mt. Wilson Observatory, one of several sites and instruments that he uses for observing and imaging (see his web site www.starimager.com). The Soap Bubble is a planetary nebula and should not be confused with the more frequently imaged Bubble Nebula, NGC 7635 in Cassiopeia, which is a structure within an HII region spherically cleared by intense stellar winds from a Wolf-Rayet star.

The detail on the left shows the perfectly spherical shell of ionized gas that gives the Soap Bubble its name. In the wide-field image above, the bright star on the left is P Cygni, a blue supergiant of V magnitude 4.82.

Hydrogen-alpha and OIII filters are required to Image the Soap Bubble. Steve's annotated images with technical information are available at https://www.astrobin.com/1k5s7g/0/ (full frame) and https://www.astrobin.com/1k5s7g/B/ (detail).

Charlied Gibson was on Grand Bahama Island to catch the waning Moon's crescent and Earthshine just before dawn on August 6, 2021. Cell phone image.

The nearly full Moon rises above thepink Belt of Venus and, below it, the deep blue of the Earth's shadow. Mamaroneck Harbor, April 6, 2020. Larry Faltz Canon T3i DSLR.

Research Highlight of the Month

Cambioni, S, Delbo, M, Poggiali, G, *et. al.*, Fine-regolith production on asteroids controlled by rock porosity, *Nature* 598: 49-52, 7 October 2021

Abstract:

Spacecraft missions have observed regolith blankets of unconsolidated subcentimetre particles on stony asteroids. Telescopic data have suggested the presence of regolith blankets also on carbonaceous asteroids, including (101955) Bennu and (162173) Ryugu. However, despite observations of processes that are capable of comminuting boulders into unconsolidated materials, such as meteoroid bombardment and thermal cracking, Bennu and Ryugu lack extensive areas covered in subcentimetre particles. Here we report an inverse correlation between the local abundance of subcentimetre particles and the porosity of rocks on Bennu. We interpret this finding to mean that accumulation of unconsolidated subcentimetre particles is frustrated where the rocks are highly porous, which appears to be most of the surface. The highly porous rocks are compressed rather than fragmented by meteoroid impacts, consistent with laboratory experiments, and thermal cracking proceeds more slowly than in denser rocks. We infer that regolith blankets are uncommon on carbonaceous asteroids, which are the most numerous type of asteroid. By contrast, these terrains should be common on stony asteroids, which have less porous rocks and are the second-most populous group by composition. The higher porosity of carbonaceous asteroid materials may have aided in their compaction and cementation to form breccias, which dominate the carbonaceous chondrite meteorites.

Although visibly covered in rocks of many sizes, asteroid surfaces might be expected to have a regolith, a high proportion of very small (centimeter -sized) rocks. Their surfaces are constantly bombarded by cosmic rays, solar particles and micrometeoroids, and they react to thermal changes during their orbits and rotation. These effects should scour larger rocks and break them down, like on the Moon. Data on the thermal properties of Bennu's surface obtained with Osiris-Rex's Thermal Emission Spectrometer showed that the rocks are porous, making them relatively resistant to fragmentation (you can't break a sponge with a hammer). This suggests that chondrite asteroids are not likely to have much of a regolith, while stony asteroids like Itokawa will be covered with finer particles. Osiris-REx grabbed a sample from the surface of Bennu (see February 2021 SkyWAAtch, p. 8), and will bring it back to Earth in 2023. This will allow astrogeologists to directly test the rocks' properties.

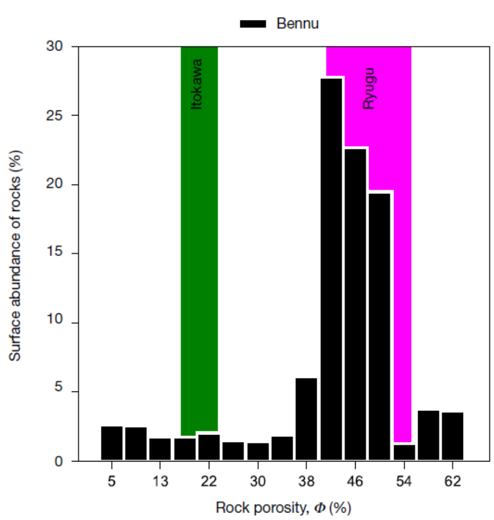


Fig 2: The porosities of most of Bennu's and Ryugu's rocks are much higher than that of Itokawa's rocks. About 70% of the rocks on Bennu are as porous as those on Ryugu, but only about 5% of Bennu's rocks have porosity similar to those of Itokawa.

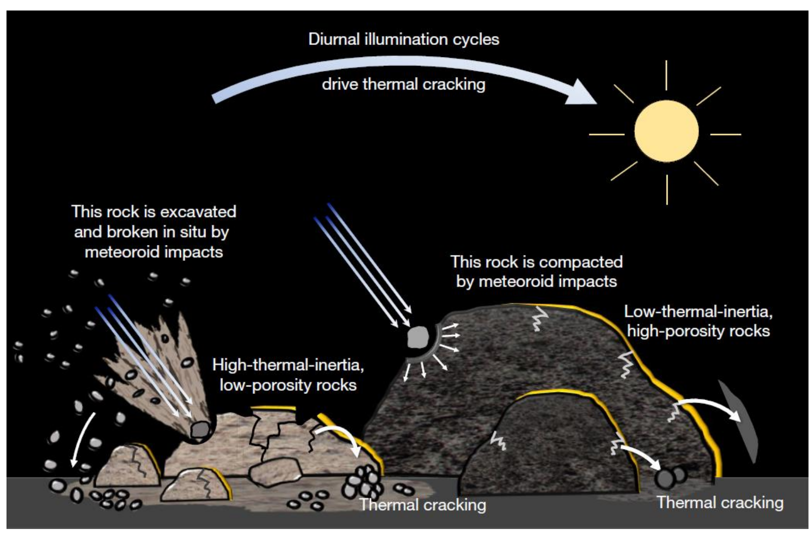


Fig 3: Fine-regolith production is frustrated in the presence of high-porosity rocks. On asteroids, rocks with higher porosity are compacted by meteoroid impacts rather than excavated. Thermal stresses in a more porous rock are weaker in magnitude than in a denser rock, which means that the former could be less prone to producing fine regolith than is the latter.

Member & Club Equipment for Sale

Item	Description	Asking price	Name/Email
Celestron CPC 800	8-inch f/10 SCT, complete with tripod, Telrad finder, dew shield and power supply. Like new. Updated to latest firmware. Align on two stars and you're good to go.	$750	David Parmet david@parmet.net
Bausch & Lomb 5-inch f/8 objective lens	Large-format/aerial camera lens in cell. Cleaned and reconditioned by John Paladini. Diaphragm removed. Weight 10 lbs. Mounted on a wooden board, can be removed. See images at https://is.gd/WAABL. Use in a telescope or camera project. Donated to WAA.	$25	WAA ads@westchesterastronomers.org
ADM R100 Tube Rings	Pair of 100 mm adjustable rings with large Delrin-tipped thumb screws. Fits tubes 70-90 mm. You supply the dovetail. Like new condition, no scratches. See them on the ADS site at https://tinyurl.com/ADM-R100. List $80.	$50	Larry Faltz lfaltzmd@gmail.com
75-mm Tube Rings	Pair of 75-mm inside diameter rings with 3-point nylon centering screws. Can accommodate tubes between 40 and 75 mm. On fine slotted 200 mm dovetail bar. Great for finder, guide scope, small camera lens. Photo https://is.gd/75mmrings.	$50	Larry Faltz lfaltzmd@gmail.com
NEW LISTING Celestron X-Cel 5-mm eyepiece	60-degree field, 6 elements, fully coated. Retractable rubber eye guard. Excellent condition, unmarked. Lists at $99.95. Donated to WAA.	$40	WAA ads@westchesterastronomers.org
NEW LISTING Laser Collimator	Orion LaserMate Deluxe II Telescope Laser Collimator (for Newtonian reflectors). Donated to WAA. It works. Uses CR2032 battery. Manual and instruction video on line on Orion's web site.	$35	WAA ads@westchesterastronomers.org
NEW LISTING Meade ETX-70	70 mm f/5 refractor on go-to mount (non-GPS) in original box with documentation. This telescope was unused for many years. Recently donated to WAA. Excellent condition. We cleaned the battery contacts and verified that it works. It's a noisy little guy on a lightweight aluminum tripod. There's a nice tripod bag but the accessory tray is missing. Fully set up the instrument weighs less than 9 lbs. Includes 1.25" 25- and 9-mm Meade Plossl eyepieces, built-in diagonal and fully-capable hand control with 1200 objects. Runs on 8 AA batteries only. May be useful as a travel scope or for a capable young person beginning the hobby.	$70	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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