Sky WAA tch

The Newsletter-Journal of Westchester Amateur Astronomers

September 2021

Necessity is the Mother of Invention

In June, Alex Mold found the full Moon too bright to view directly in his telescope. Lacking a dense enough filter, he projected the image onto the shiny top of an eyepiece dust cap and captured it with a cell phone.

WAA September Meeting

Friday, September 10 at 7:30 pm

On-line via Zoom

Members' Night

WAA members will present brief talks on topics of interest. Trips, observations, imaging, new equipment, or anything else of interest to fellow WAA'ers. It's one of our most popular events.

Members interested in making a presentation should contact Pat Mahon at waa-programs@westchesterastronomers.org.

Pre-lecture socializing with fellow WAA members and guests begins at 7:15 pm!

The Zoom link will be emailed to members and is on the WAA website.

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

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Call the WAA Hotline 1-877-456-5778 (toll free) for announcements, weather cancellations, or questions. Watch your email Inbox, Facebook or Twitter for real time updates. Also, don't forget to visit the WAA website.

Also in this Issue

WAA October Meeting

Friday, October 8 at 7:30 pm

On-line via Zoom

New Horizons and the Solar System's 3rd Zone

Will Grundy, PhD
Planetary Scientist, Lowell Observatory
Co-Investigator, New Horizons mission

Live meetings may resume in January 2022, depending on whether pandemic-related restrictions are still in effect at Pace University.

Starway to Heaven Star Party

Ward Pound Ridge Reservation, Cross River, NY

September 4 (Rain/cloud date September 11)

Free & open to the public. Bring your own telescope or view through members' instruments. Pandemic precautions will still be in effect. Vaccinate and mask!

Date	Sunset	Naut Twi ends	Astron Twi ends	Moon Rises	Moon Sets
9/4/21	19:21	20:26	21:01	04:30	N/A
9/11/21	19:10	20:14	20:48	N/A	21:55

New Members

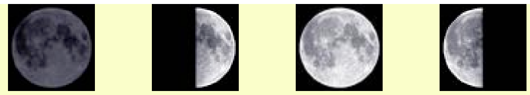
Paolo Georgeo	**Yonkers**
Chetan Karande	**Briarcliff Manor**
Mickey Mayo	**Long Island City**

Renewing Members

Keith Fliszary	**Bronxville**
Joe Geller	**Hartsdale**
Kim Hord	**Dobbs Ferry**
Joan Indusi	**Ossining**
Penny Kelly	**Wappingers Falls**
Mark Korsten	**Hastings on Hudson**
Gene Lewis	**Katonah**
Christopher Plourde	**New Rochelle**
Alan Struth	**Irvington**
Ihor Szkolar	**White Plains**
Roger Woolcott	**Brewster**

ALMANAC For [month]

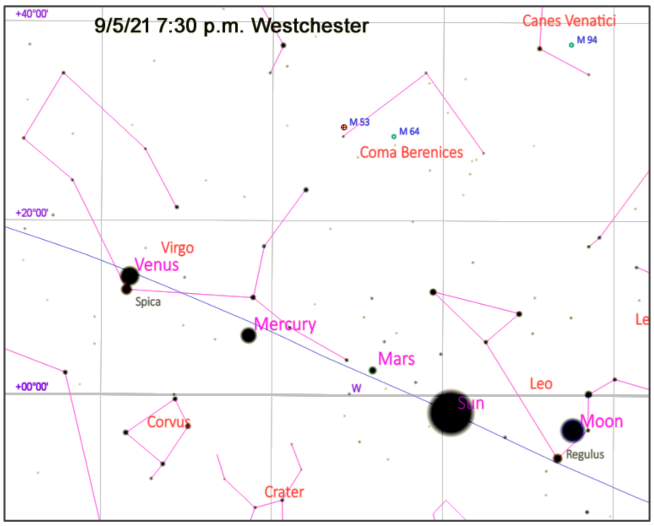
Bob Kelly, WAA VP for Field Events



New 9/6 | 1Q 9/13 | Full 9/20 | 3Q 9/28

Venus Crouches Low in the West

Venus ushers Spica out of the evening sky, passing 1½ degrees north of the star in Virgo on the 5th. It's separated from the Sun by 41 degrees but still low in the west because the ecliptic is at such an oblique angle at this time of year. Get a better view of Spica with binoculars.



Venus and the crescent Moon make a nice pair on the 9th and 10th.

Venus' setting time actually moves half-an-hour earlier in September, even though it moves farther east of the Sun in our sky. Venus doesn't get enough distance to exceed the rapidly changing time of sunset, since we are at the Equinox. Venus heading toward its aphelion in early October doesn't help either. Venus brightens to magnitude -4.1 and appears larger in a telescope, but its phase decreases to half-lit. The best time to see the planet's phase is as soon as you can find Venus in twilight.

Mercury Plays Limbo

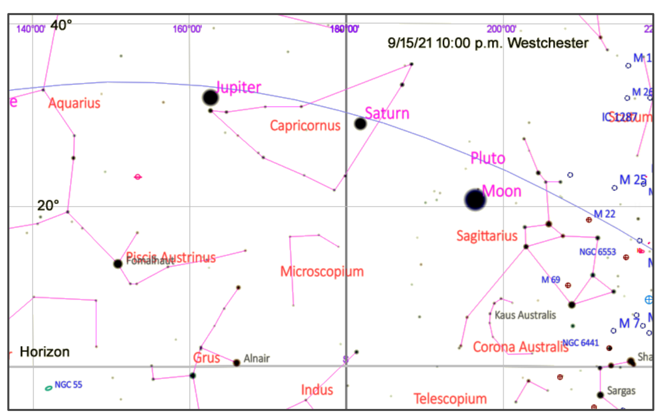
Mercury's greatest elongation is 27 degrees following the Sun on the 14th, before it heads back toward inferior conjunction in early October. Not a very easy-time to-view Mercury—compare it to Venus' larger elongation—but it's also very low in the sky. If you can catch Mercury, check three degrees to the upper right for slightly fainter Spica around the 21st and 22nd. Use a telescope to watch Mercury's waning phase from three-quarters full to one-quarter during the month.

Mars is Missing

Mars finally gets too deep into the solar glare to be easily seen. Conjunction with the Sun in October makes communication with our Martian probes more difficult. Aphelion was in July, so at least Mars is moving a bit closer toward the Sun in its orbit, helping probes that rely on solar panels for energy. The combination of aphelion and being on the other side of the Sun from us makes Mars look very small, only 3.5 arc-seconds wide, actually slightly smaller than Uranus.

Prime Time for Large Planets

Jupiter and Saturn become conveniently placed evening objects. They are a bit low in the southeastern sky after sunset for those of us with trees filling our southern exposure. Now a month after closest approach, they are easily viewable even with a small telescope. Spend some time observing the Great Red Spot and Jupiter's four dancing moons. Saturn's satellite Titan dances back and forth every 8 days. It isn't as bright as Jupiter's big four, but it's notable in most telescopes. Iapetus brightens up, although not as much as Titan's magnitude +9.4, as it moves well out to the west of Saturn, farther out than Titan, getting to its farthest and brightest point at magnitude +10.5 around the 18th.



Comet Tale

An old friend of mine, Comet 6P/d'Arrest, makes its perihelion in September, as it does every 6½ years nowadays. I remember picking out this fuzzball with binoculars during several close approaches back in the latter part of the last century. Its diffuse glow and low altitude at sunset will make it very tough viewing this time, even at a maximum brightness, perhaps magnitude +10, later in the year.

Outer Planets Parade

Neptune is at opposition to the Sun on the 14th, at mag +7.8. It's well up in Aquarius, with a disc 2.5" in diameter. Minor planet Pallas is nearby, about ten degrees over in Pisces at magnitude +8.4.

Uranus rises two hours later in the evening at magnitude +5.7 in Aries. Its disc is 3.6" in diameter. Both Uranus and Neptune are a pleasing aqua blue in a good telescope.

iPhone/Android Trick

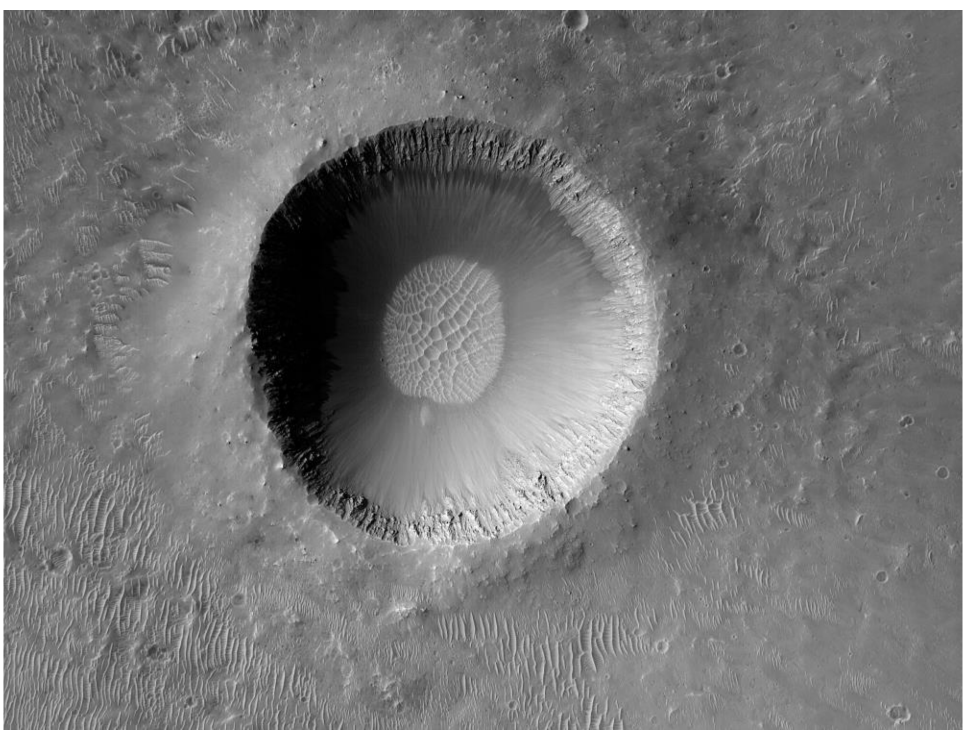
If you have one of those apps that show you a live map of the stars look for Vega when it first appears after sunset. It's now almost exactly overhead. Then, flip the phone (or tablet) so points in the opposite direction, *i.e.* toward the ground directly below you. Get under the phone and you should see Sirius winking at you. Vega and Sirius are almost directly opposite each other in our sky. I'm still working out when they would next be our pole stars. When Vega will be the pole star for the northern sky 11,000 years from now, Sirius should simultaneously be the southern pole star, right? What a pair that would be! But the alignment is not exact, so sources don't list Sirius as the southern pole star until the year 60,000-something. You can view Vega and Sirius in opposition in January during the 6 p.m. local-time hour. They will be across from each other, Vega low in the northeast and Sirius low in the southwest, but not exactly opposite.

Sighting Earth's Extraterrestrials

The International Space Station is visible in the pre-dawn sky through the 14th, then in the post-dusk sky for the rest of the month. Vanguard 1 was the second American and fourth worldwide satellite to be launched into orbit. It's the oldest satellite still orbiting the Earth. It's only a half-foot wide, so it's not very visible, ranging from magnitude +10 to +14.

Lunar, Solar and Terrestrial Line-Ups

The equinox is at 3:21 p.m. on September 22nd. Lunar perigee and apogee are two days before first quarter and last quarter Moon phases, respectively. ■



Your Editor needed to fill some white space, so why not this elegant image of a crater in Meridiani Planum on Mars. It was acquired by the Mars HiRISE camera aboard the Mars Reconaissance Orbiter.

The HiRISE camera is operated by the Lunar and Planetary Laboratory of the University of Arizona. An enormous number of images, including 3D anaglyphs and stereo pairs, are on the HiRISE web site, https://hirise.lpl.arizona.edu/.

See page 24 for an anaglyph image.

Member Profile: Charlie Wiecha

Home town: Hastings on Hudson, NY

Family: Carol Ehler (Spouse), Matt Wiecha (son, living in Brooklyn)

How did you get interested in astronomy? I received a Tasco 50-mm tabletop telescope as Christmas gift when I was about 12 years old. I saw the rings of Saturn and was hooked forever! I graduated to a 60-mm scope at a subsequent Christmas and recall using it for a well-timed occultation of the Pleiades that very same crisp winter night. I eventually majored in Physics/Astronomy at Cornell and worked for a while in Jim Elliot's lab (he discovered the rings of Uranus) doing programming on a Data General minicomputer (the paper tape backup tells you how long ago that was).

Do you recall the first time you looked through a telescope? What did you see? As above, the idea that (1) a planet could be seen by naked eye from the Earth was astounding, and then (2) details like the rings of Saturn could be so clearly seen was just unbelievable.

What's your favorite object(s) to view? Deep sky galaxies, e.g. M51, NGC 891, the Antennae; planetary nebulas. Somehow I'm not drawn to open clusters ☹.

What kind of equipment do you have? Too many scopes! My main gear is an AGOptical 10-inch "Harmer-Wynne" optical design, which is similar to a Dall-Kirkheim (parabolic primary, spherical secondary and corrector lenses). It's on a Paramount MyT mount. It lives on a pier on my back deck. I only have a zone of about 30 degrees visibility due to overhead trees, so I have to be patient year-round to wait for objects to appear in my sliver of sky. My travel scope is Lunt 100-mm Solar modular refractor with hydrogen-alpha filters that snap out to allow night-time observing. I use a Rainbow 150 strain-gauge (harmonic drive) mount on the road. I image with a ZWO ASI6200 monochrome camera with filters.

What kind of equipment would you like to get that you don't have? No more right now!

Have you taken any trips or vacations dedicated to astronomy? Tell us about them. I used to travel to New Mexico Skies in Cloudcroft to escape light pollution when I was observing with a large dob but more recently I have gone the imaging route to be able to have fun closer to home!

Are there areas of current astronomical research that particularly interest you? I recently joined AAS as an Amateur Affiliate after they acquired *Sky & Telescope*, to be able to follow their conferences. I'm also a member of their Historical Astronomy section. I love the S&T historical articles too. LIGO and other gravitational wave observing is an interest and a few years back I tried to learn general relativity to better follow that—I stopped after convincing myself that I had developed at least some "intuition" about to the tensor math ☺

Do you have any favorite personal astronomical experiences you'd like to relate? I have encountered a number of coyotes while trying to observe from a neighbor's garden and also I think at least once at Taghkanic State Park – if anyone else has seen or heard them there please let me know! I just jumped back into my car to escape.

What do you do (or did you do, if retired) in "real life"? I'm a Software Engineer/Manager at IBM. Like most of my Physics cohort from Cornell we have gone on in software, law, or other non-physics areas.

Have you read any books about astronomy that you'd like to recommend? The "Annals of the Deep Sky" series from the now-defunct Willmann-Bell publisher is really outstanding…the first six or seven of the series are out but it's not clear how or even if the remainder will get published.

How did you get involved in WAA? Chatting with folks at NEAF and then observing at Ward Pound Ridge.

What WAA activities do you participate in? Zoom meetings mostly so far.

Besides your interest in astronomy, what other avocations do you have? As I near partial retirement I'm hoping to spend some time teaching machine learning/AI in developing countries. I've also mentored a few students from Hastings High School on similar projects for the Westchester Science & Engineering Fair and have been a judge there for several years.

Another Movie Telescope

Burt Lancaster as a straight-laced Presbyterian minister in a New England town during the Revolutionary War in *The Devil's Disciple*, a 1959 movie based on George Bernard Shaw's 1897 play. The film co-stars Kirk Douglas as a rebellious ne'er-do-well and Laurence Olivier as General John Burgoyne. It was directed by Guy Hamilton, who later went on to direct four James Bond movies.

We enjoyed the stars' performances, especially Olivier, one of the greatest actors of all time. The telescope has nothing to do with the plot.

Deep Sky Object of the Month: Messier 110

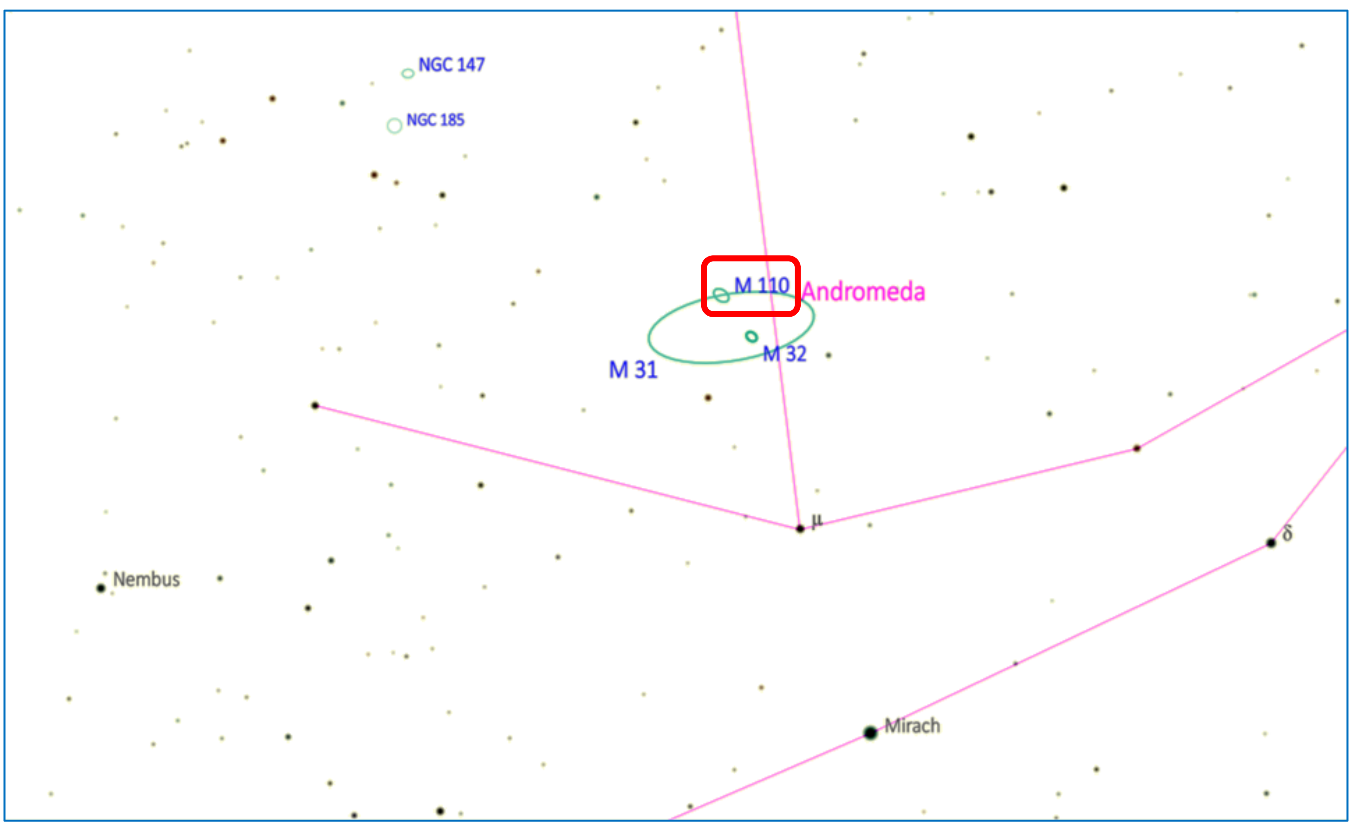
Messier 110	
Constellation	Andromeda
Object type	Dwarf elliptical galaxy
Right Ascension J2000	00h 40m 22s
Declination J2000	41° 41′ 07″
Magnitude	8.92
Size	21.9′ x 11.0′
Distance	2.9 million light years
NGC designation	205

While taking an obligatory look at Messier 31, be sure to examine its satellites, M32 and M110. Charles Messier's original catalog (1781) had 103 objects; the last seven were added afterwards based on evidence that he had indeed observed them. Messier saw M110 in 1773 and drew it in his depiction of M31, but it didn't get assigned a catalog number until 1967, when Kenneth Glyn Jones added it.

Walter Baade resolved its stars using the 100-inch Hooker telescope at Mt. Wilson. It has a mass of between 3.6 and 15 billion suns. It has been disrupted by interactions with M31, and may not have a black hole at its center.

Visibility for Messier 110			
10:00 pm EDT	9/1/21	9/15/21	9/30/21
Altitude	37° 27′	46° 55′	57° 28′
Azimuth	63° 33′	68° 53′	74° 07′

It is sometimes considered a "dwarf spheroidal" rather than a "dwarf elliptical" galaxy. If your telescope has a field of view of one degree (or more) you can fit M110, M32 and the bright core of M31 in the eyepiece at the same time.



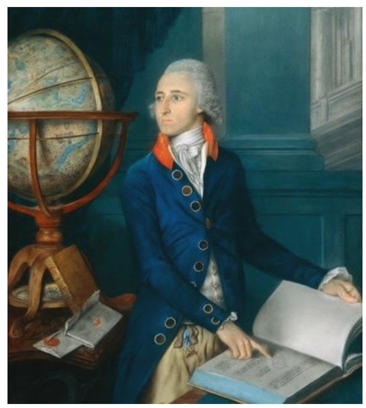
Measuring Starlight: Magnitudes, Film and Filters **Larry Faltz**

The system we use to rate and compare the brightness of stars is credited to Hipparchus, the Greek astronomer who lived in the second century B.C. Often hailed as the greatest astronomer of ancient times, he invented trigonometry and used it to make accurate models of the motions of the Sun and Moon, enabling precise eclipse predictions. He discovered the precession of the equinoxes and may have invented the astrolabe. The only complete work of his to survive from antiquity is a commentary on Aratus' *Phaenomena* and Eratosthenes' *Catasterismi,* which are descriptions of the constellations (Eratosthenes includes the mythology behind the celestial figures). We know of his achievements because they were reported in detail by contemporary astronomers and mathematicians. Of the 1,025 stars listed by Claudius Ptolemy in the *Almagest*, the positions of about 850 were determined by Hipparchus, whose star catalog was completed about 275 years earlier, in 129 BC. His positions were accurate to about half a degree. He is credited with the six-level ranking of naked-eye stellar magnitudes that we use today, although absolute proof of priority doesn't exist.

Hipparchean magnitudes range from 1, brightest, to 6, dimmest. The system seemed perfectly reasonable until that fateful night in 1609 when Galileo pointed his telescope at the Milky Way, noting in the *Sidereal Messenger* that

> Viewed with a telescope they [faint naked-eye stars] appear of a shape similar to that which they present to the naked eye, but sufficiently enlarged so that a star of the fifth or sixth magnitude seems to equal the Dog Star, largest of all the fixed stars. Now, in addition to stars of the sixth magnitude, a host of other stars are perceived through the telescope which escape the naked eye; these are so numerous as almost to surpass belief. One may, in fact, see more of them than all the stars included among the first six magnitudes. The largest of these, which we may call stars of the seventh magnitude, or the first magnitude of invisible stars, appear through the telescope as larger and brighter than stars of the second magnitude when the latter are viewed with the naked eye.

As telescopic astronomy took hold in the 17th and 18th centuries, astronomers began to make a more rigorous study of stellar brightness. This was particular important after the discovery of variable stars. Omicron Ceti (Mira) was noted to be variable in 1638 by the Frisian (northern Dutch) astronomer Johannes Phocylides Holwarda. Algol's variability was noted in 1669 by Geminiano Montanari. Although both stars are binary, Mira's variability comes from internal pulsations of the larger star, while Algol, the "Demon Star" (the "eye" of Medusa in the constellation Perseus) is an eclipsing binary, as shown by John Goodricke in 1784. Studying variable stars was an important pursuit of astronomy into the 19th century, and persists today in the AAVSO, which has over 1,000 members. As astronomy matured into an exact science, stellar magnitudes had to be standardized, turned from a guess into a measurement.



John Goodricke, FRS (1764-1786)

In one of the greatest losses to science in all of history, the brilliant and perceptive Goodricke died at the age of 21, four days after being inducted into the Royal Society. Both his deafness and his death would, today, have been prevented by antibiotics.

Experienced observers came to agree that magnitude 1 stars seemed to be about 100 times brighter than magnitude 6 stars. This suggested a logarithmic scale: each step would be the fifth root of 100, a system proposed by the English astronomer Norman R. Pogson in 1856. This like equal temperament, the way an octave is divided on the piano, where the scale factor is the 12th root of two. One of the earliest proponents of equal temperament was the Florentine composer Vincenzo Galilei, father of Galileo. Other logarithmic scales are the Richter scale for earthquakes and the decibel scale for loudness.

Since there are only five intervals in the scale, a magnitude 1 star is $\sqrt[5]{100}=2.512$ times brighter than a magnitude 2 star, which in turn is $\sqrt[5]{100}=2.512$ times brighter than a magnitude 3 star, etc. A magnitude 1 star is $(\sqrt[5]{100})^2$ brighter than a magnitude 3 star ($2.512^2=6.310$). And for magnitude 1 versus magnitude 6, it's $(\sqrt[5]{100})^5$ which is the 100-fold difference we started with. Once Galileo opened the heavens and observation of stars became more systematic, the scale was extended in either direction. Some objects have negative magnitudes: Sirius is -1.46 and Venus gets to -4.6 at its brightest. A so called "supermoon" can be as bright as -12.74 and the Sun is magnitude -26.74. On the other side of the scale, Hubble can see objects as faint as +31 magnitude and the James Webb telescope will (we hope) see down to +34. There is of course no real faintness limit: I calculate that a 60-watt incandescent lightbulb viewed at 10 parsecs will shine at magnitude +249.2!

The ancients thought that stars were equidistant from us, very far away but fixed to the inside of the celestial sphere according to Aristotle's model. He was primarily interested in planetary motion and didn't say much about the reason that the "fixed stars" vary in brightness. It wasn't until Friedrich Bessel measured the parallax of 61 Cygni in 1836 that the dimensions of the celestial sphere could begin to be envisioned and a possible explanation for magnitude differences suggested.

An object's brightness ("intensity") falls off proportional to the square of its distance ($1/r^2$). A 60 watt light bulb 100 feet away is as bright as a 240 watt light bulb 200 feet away. How does that relate to stellar magnitude?

Let's say a first magnitude star is 20 light years away. It would be a quarter as bright if it was 40 light years distant, but what would its magnitude be? The equation we need is

$$m_B - m_A = 2.5 \times log_{10}\left(\frac{d_B}{d_A}\right)^2$$

where d is the distance and A the nearer position. At double the distance, $(d_B/d_A)^2$ is 4, log(4)=0.60, and 2.5x0.6=1.5. Since m_A = +1, m_B must be +2.5, so a magnitude 1 star would shine at magnitude +2.5 at double the distance. A magnitude +3 star would shine at magnitude +4.5. You can plug in numbers for other distances. This measurement is an *apparent magnitude*, because we don't know anything about the star except how bright it seems to us.

We can standardize magnitudes to begin compare intrinsic brightness of stars by "moving" every star we are interested in to the exact same distance from us, then use observed the apparent magnitude to calculate an *absolute magnitude*. Are we looking at a 60-watt light bulb or one of 240 watts?

By convention, we magically move the star to a position exactly ten parsecs (32.6 light years) from us. We know the star's actual distance from parallax measurements.[1] Now what would its magnitude be?

The formula we need is

$$M = m - (5 \times \log(d)) + 5$$

where M is the absolute magnitude, m the star's observed (apparent) magnitude and d the star's actual distance in parsecs. This formula for absolute magnitude M can easily be derived from the first equation. I will spare you the details but I suggest that you try it yourself, since it's simple algebra and uses the fundamental logarithmic relations $\log(x^n)=n\log(x)$ and $\log(a/b)=\log(a)-\log(b)$. These formulas have been slumbering in your brain since high school, perhaps never expecting to be used again. Wake them up! Substitute the absolute magnitude M for m_A and note that d_A=10 (parsecs). As your math teacher said so often, "Watch your signs!"

As an example of absolute magnitudes, let's do the calculation with two stars close in apparent magnitude: Algol (β Persei) and Denebola (β Leonis).

Star	m	d (pc)	M
Algol	2.09	28.33	-0.18
Denebola	2.14	11.04	+1.92

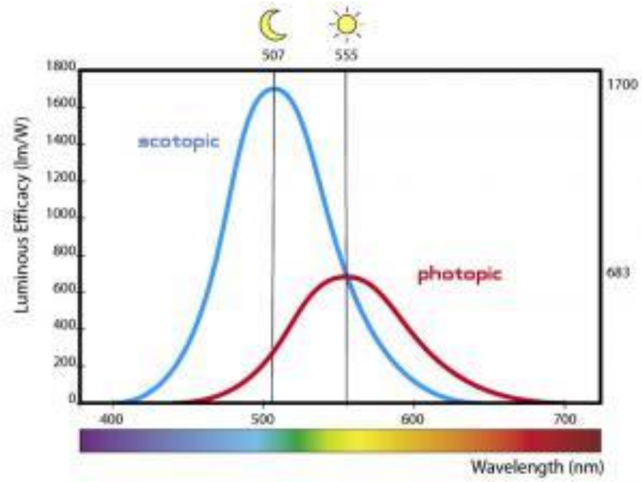
This means that Algol is inherently "brighter" than Denebola, at least in the visible range, although we know nothing yet about how that brightness comes about. We don't know any astrophysics yet. We're just looking at the stars, with the additional knowledge that we've been told how far away they are.[2]

These magnitudes are "visual magnitudes," brightness as perceived by our eyes. The eye's sensitivity across the visible spectrum is different for photopic (daylight) vision, for which we primarily use the cones in our retina, than it is for scotopic (night) vision, for which we use our rods. Rod sensitivity increases with

[1] The absolute magnitude can be directly determined if the star is a Cepheid variable, but that wasn't known until 1912 through the work of Henrietta Swan Leavitt.

[2] For distant stars, the effect of intervening dust ("interstellar reddening") needs to be taken into account.

dark adaptation to a maximum after about 20-30 minutes. The maximum sensitivity of scotopic vision is at 507 nm (blue-green) while that of photopic vision is at 555 nm (yellow).



Spectral response of the human eye

Until the end of the 19th century, astronomers could only measure magnitudes with their eyes. According to J.B. Sigwick's venerable 1955 tome *Amateur Astronomer's Handbook*, the human eye can be trained to estimate the brightness difference between two sources to within 0.1 magnitude. Presumably, though, those stars need to be fairly close to each other, likely in the same telescopic field. Even so, there are many factors that make apparent magnitudes hard to reproduce visually. There are a few clever visual ways of trying to objectify the measurement. Extinction photometers of various types used an opto-mechanical device, generally an aperture reducer, a silvered optical wedge or a polarizing filter, to reduce the brightness of a star until it could no longer be seen, an obviously subjective and poorly reproducible end-point, but perhaps better that a straight guess. It's similar to a hearing test, where you're supposed to acknowledge when you can't hear the tone anymore. Comparison with a known reference star, preferably close by, is still required. Errors can be reduced with multiple determinations and averaging. Once electronic photometers were available, reproducibility was improved, although these devices also have some inherent variances, as do all measuring devices.

The earliest objective measurements used film. Astrophotographers in the 19th century noticed that the size of a star on the photographic emulsion seemed to be proportional to its brightness, which is caused by "halation," light bouncing around in the layers of the film between the backing and the emulsion. Faint stars might also be calibrated by making images of different durations and seeing on which image the star first becomes detectable. However, this wasn't an entirely linear process.

All types of emulsions, from the earliest Daguerrotypes until mass-produced camera film in the early 1900's, were much more sensitive towards the blue end of the spectrum. The black-and-white rendering of flesh tones and other colors was sometimes a little strange. In addition, the sensitivity of film of any type varies non-linearly to some extent with the length of the exposure, a phenomenon called "reciprocity failure." This variation is also not linear across the spectrum. This is an obvious problem for long-exposure film astrophotography.

Frederick Charles Luther Wratten was a pioneer in the development of photographic emulsions. His British firm Wratten & Wainwright was the first to offer commercially prepared plates; before that, photographers had to make their own emulsions and plates. Kenneth Mees joined the firm in 1906, and shortly thereafter invented a panchromatic emulsion with a broader spectral sensitivity. Mees then developed dyed gelatin filters to manipulate the intensity of the spectrum of the light falling on the plates. These filters got "Wratten numbers" that are still in use today. In 1912, Wratten sold his business to Eastman Kodak, and Mees moved to Rochester, NY to found Eastman Kodak's research arm.

Filters have a useful role in visual observing. Almost all amateur astronomers purchase a set of filters for planetary use early in their engagement the hobby. The Orion starter filter set, for example, consists of #15 yellow, #25 red, #58 green, and #80A blue, while the Celestron starter set consists of #12 deep yellow, #21 orange, #80A blue, and a neutral density filter with 50% transmission, useful for a bright Moon (although the author prefers a variable density polarizer for this purpose). The color filter I use the most is #21 orange to bring out surface features on Mars. Using it made for maximum enjoyment of the October 2020 close approach of the red planet. There are many filter guides on the web or in books. A useful one is on AgenaAstro's web site at https://is.gd/aafilters.

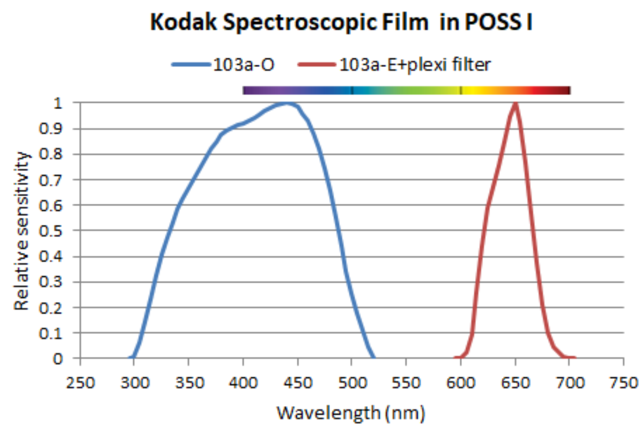
A set of dyed color filters is needed for "LRGB" imaging with a monochrome camera. These filters are not the same as Wratten filters in similar colors.

There are many ways of making colored filters, as distinguished from narrowband filters. Originally, a thin piece of gelatin was simply placed across the camera lens. Later the dyed gelatin was protected by sandwiching it between clear glass layers. Nowadays, gelatin is dispensed with and the chemical dyes stain the glass directly, although gelatins are still used for theater lighting. For narrow-band imaging, the filters are coated to transmit only specific spectral lines, rather than dyed, a topic for another time.

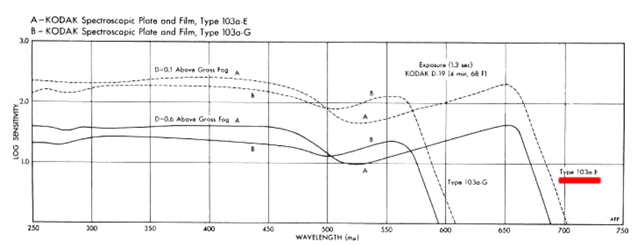
If you've ever done black-and-white photography, you know how valuable these filters can be. You can darken the sky dramatically and lighten foliage with a red filter, or balance flesh tones nicely with a mild yellow filter for portraits. Back in my film photography days, I liked to shoot landscapes with Konica 750 infrared film and a Wratten 25 (red) filter.

Near Owen's Lake, California, 11 a.m. Fuji 670III medium format camera, Konica 750 Infrared film, #25 filter. (LF)

The first major all-sky photographic imaging survey was the Palomar Sky Survey (POSS I), a 1950s project sponsored by National Geographic. Images were obtained with the 48-inch Schmidt telescope on Mt. Palomar. Each field was imaged consecutively with a blue-sensitive plate and a red-sensitive plate. The spectra of these two emulsions had essentially zero overlap. The red-sensitive film, Kodak 103a-E, needed a "plexi" filter[3] to remove blue wavelengths, but the blue-sensitive 103a-O had zero sensitivity above 520 nm.



Sensitivity of Kodak 103a-O (left) and 103a-E (right) film as used in POSS I. A "plexi" filter is used for the 103a-E exposures to suppress blue wavelengths. Data taken from the reference.[4]



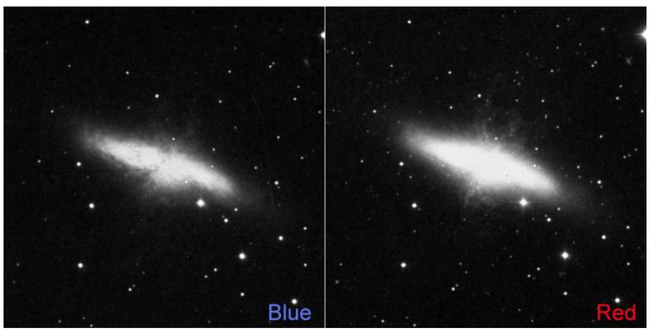
The spectral response of Kodak 103a-E and 103a-G (a blue-sensitive film similar to 103a-O but not used in POSS). From the publication *Kodak Plates and Films*, kindly supplied by Todd N from CloudyNights.com.

The POSS I and II (a later survey with different film and filters) can be found on the Space Telescope Science Institute's web site at https://is.gd/POSSI. Another excellent source for detailed images, primarily from digital detectors across the electromagnetic spectrum, is the Aladin portal at the Centre de Données astronomiques de Strasbourg, http://cds.u-strasbg.fr/.

[3] Plexiglass (acrylic sheets) can be formulated with superior UV-filtering properties, very useful for protecting artwork that is exposed to sunlight or fluorescent bulbs.
[4] http://gsss.stsci.edu/SkySurveys/Surveys.htm

How objects differ in the blue and red images of POSS I can be seen in the following two examples.

NGC 7331



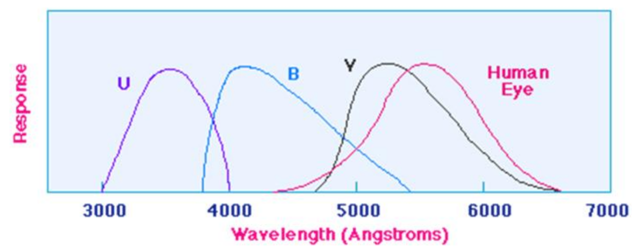
Messier 82

Clearly one of the problems in film photography is a limited dynamic range. In the era of CCD and CMOS cameras, we have come to expect vast detail. Film does not respond linearly to photon intensity, as mentioned earlier. Each film has a particular "characteristic curve" that is dependent on exposure and processing. The great black-and-white photographers of an earlier era, Steichen, Adams, Strand and Weston for example, used all sorts of tricks to take advantage of the film's characteristic curve to achieve the contrast and tone that they wanted. It was a mysterious art.

The study of spectral lines on the famous Harvard Observatory plates resulted in classification of stars using the OBAFGKM sequence, as told by Dava Sobel in *The Glass Universe*. These plates were black-and-white images. A bequest from the widow of Westchester's Henry Draper, MD, the first person to image a spectrum of a star, financed the acquisition of the images and paid the meager salaries of the staff. The nearly invisible spectral features were teased out by the all-female "computers" under the supervision of Harvard Observatory director Edward Pickering. The work was meticulous and at times mind- and eye-numbing.

In 1890, the first catalogue of 10,351 stars was published, most of them classified by Williamina Fleming, who functioned as the "house mother" of the computers. A short time later, Antonia Maury[5] and Pickering published additional spectra. In 1901, Annie Jump Cannon established the classification sequence we use today. She supervised the main editions of the catalog, which were published between 1918 and 1936, containing a total of 272,150 stars.

In 1953 H. L. Johnson and W. W. Morgan published in the *Astrophysical Journal*[6] their photometric observations through colored filters of almost 300 stars across the range of spectral classes. They used ultraviolet, blue and yellow ("visual") filters in front of a highly-calibrated photometer on telescopes at the McDonald Observatory in Texas. This work established the UBV photometric system.



The spectral sensitivity of U,B and V filters, and human photopic vision. The curve for scotopic vision, more appropriate for visual observing of the night sky, is closer to the V curve.

Photometry using filters means that we don't have to do spectroscopic analysis to determine star colors and by extension surface temperatures. With measurements in three different spectral bands, we can derive a "color index." The most common calculation for the color index is B-V. A class A0 star was chosen to be the calibration standard. But even stars in that class have slight color differences due to chemical variations, intervening dust and other factors, as can be seen in the table below.

[5] See a photo of Ms. Maury at the 6" Clark telescope at the Draper residence in Hastings in the January 2021 SkyWAAtch, page 16.

[6] Johnson, H.L., Morgan, W.W., Fundamental Stellar Photometry For Standards of Spectral Type On The Revised System of The Yerkes Spectral Atlas, *Astrophysical Journal*, 117: 313 (1953) http://articles.adsabs.harvard.edu/pdf/1953ApJ...117..313J

Star	Class	U	B	V	B-V (Color index)
γ Aqr	A0V	3.65	3.791	3.834	-0.043
γ Oph	A0V	3.83	3.8	3.75	+0.05
RX-Her	A0V	N/A	7.35	7.29	+0.06
ρ-Hya	A0V	N/A	4.309	4.337	-0.028

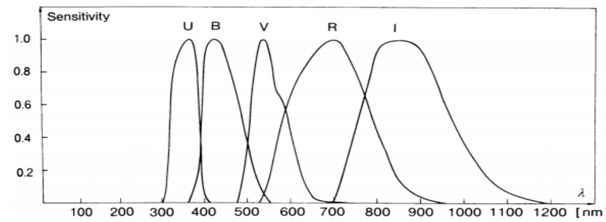
The A0V star Vega was chosen to be the color neutral standard, with the difference between the magnitudes in each filter assigned a value of zero. For Vega, the U, B and V magnitudes are all 0.3, so the differences B-V, U-B and U-V are all zero (always bluer filter minus redder filter). The color index ranges from -0.4 for the bluest stars to +2.0 for the reddest stars. The Sun's B-V color index is +0.65. At the far UV end of the U filter, the Earth's atmosphere reduces transparency to zero, limiting the amount of a star's output that reaches the filter even if the star has a massive ultraviolet flux in those wavelengths.

Betelgeuse and Rigel are often taken as paradigms of cool (red) and hot (blue) stars, and here is the data:

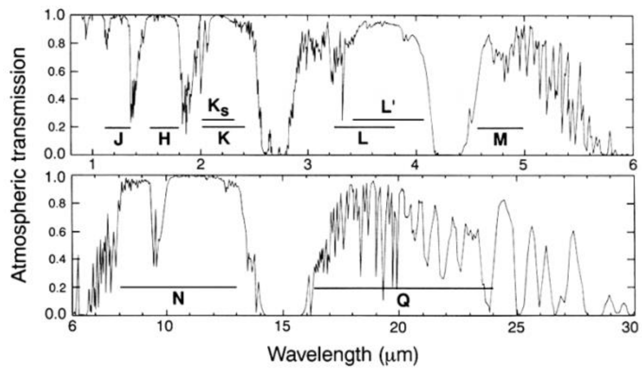
Star	Class	U	B	V	B-V (Color index)
Betelgeuse	M1	4.38	2.27	0.42	1.85
Rigel	B8	-0.56	-0.1	0.13	-0.23

As observatories grew larger and perched themselves at higher and drier elevations, infrared-absorbing water vapor was attenuated. To measure and compare astronomical objects (not just stars) in the infrared, new standards were required. First, the UBV system was extended into the very-near infrared by South African astronomer Alan Cousins, who added R and I filters on the red end of the UBV system to make UBVRI. Since then, over 200 photometric systems[7] have been developed, generally for specific research interests with large telescopes that require comparisons at specific wavelengths.[8] This is a business for a few high-end specialty-filter manufacturers.[9]

The Earth's atmosphere is transparent to some, but not all, of the infrared wavelengths because of the high concentration of absorbing molecules such as water and carbon dioxide. The energy of specific infrared wavelengths matches the vibrational energy of the various atmospheric molecules (vibrations of atomic bonds in molecules are quantized and thus can have spectra lines, just like those resulting from energy differences in electron orbitals of individual atoms).



Spectral ranges of UBVRI filters



Transmission of infrared wavelengths from 1 micron to 30 microns, with the most commonly used IR filter bandpasses noted.

Several filter systems have been developed for photometry and imaging in the farther infrared. The most commonly used ones go from J to Q, with transmission from the near infrared at just over 1,000 nm (1 micron) to about 24,000 nm. After that the atmosphere no longer cooperates until we get to the microwave and radio bands. Infrared filters are specially coated, like narrow-band filters in the visual range.

UBVRI filters are not the same as RGB filters. For amateurs, they are available in 1.25" or 2" mounted in threaded cells. They are expensive and lately very hard to get. If you are doing stellar photometry, you are probably a member of the American Association of Variable Star Observers. AAVSO's *Guide to CCD Photometry*[10] says that if an observer wants to use a filter (you don't have to), use the Johnson V filter, followed by Johnson B, Cousins I, Cousins R and Johnson U, in that order. Of course you must report the filter used when you post your observations. ■

7 See https://is.gd/asiago for a comprehensive list

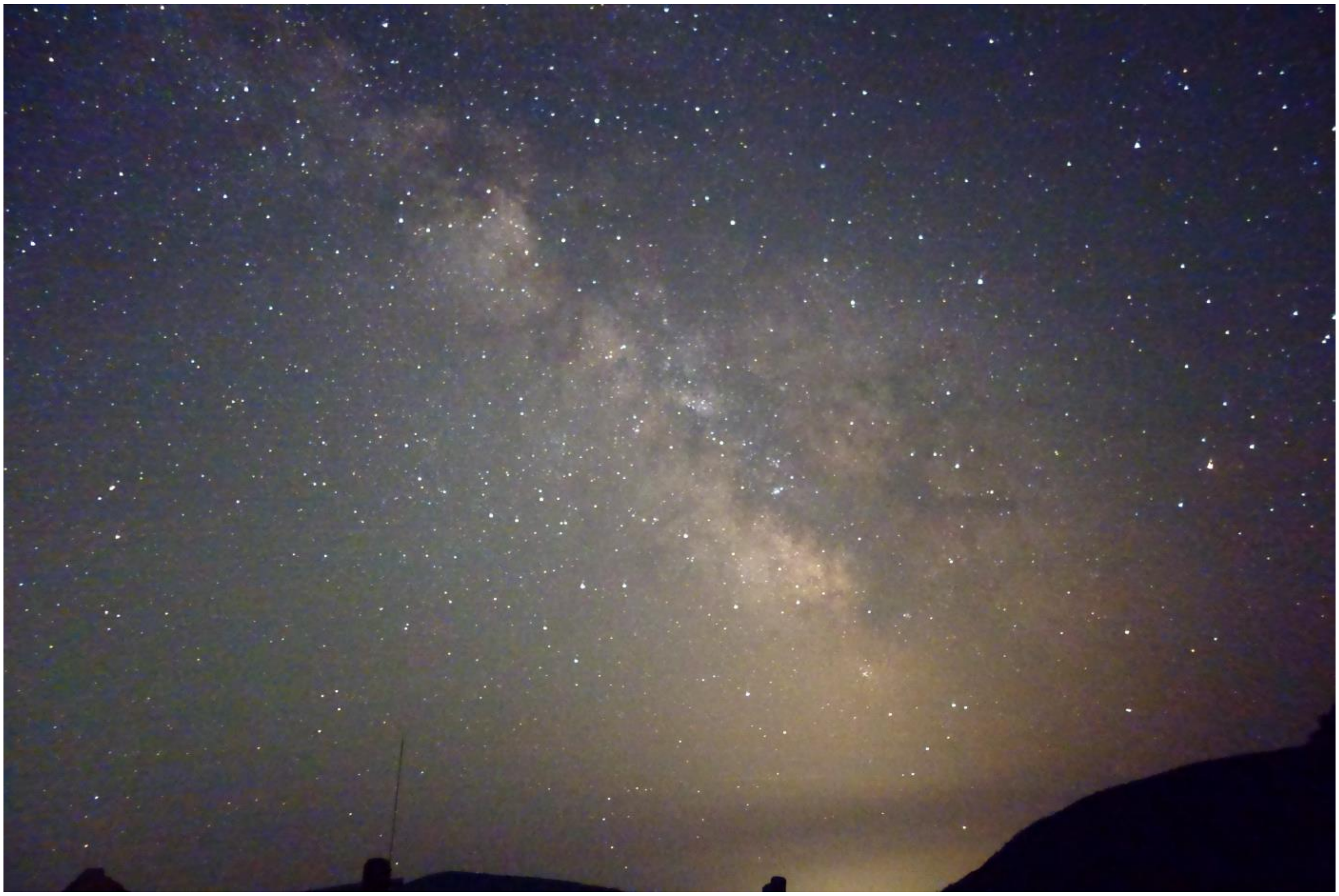
8 To see spectra of the filter systems used at some of the major observatories, go to https://speclite.readthedocs.io/en/latest/filters.html

9 See for example Astrodon (https://is.gd/astuvbri), Andover Corporation (https://is.gd/andfilt) and Asahi Spectra (https://is.gd/asahspec)

10 https://is.gd/aavsoccd

Images by Members

Milky Way from Camp Hale, Colorado, July 9, 2021 by Larry Faltz

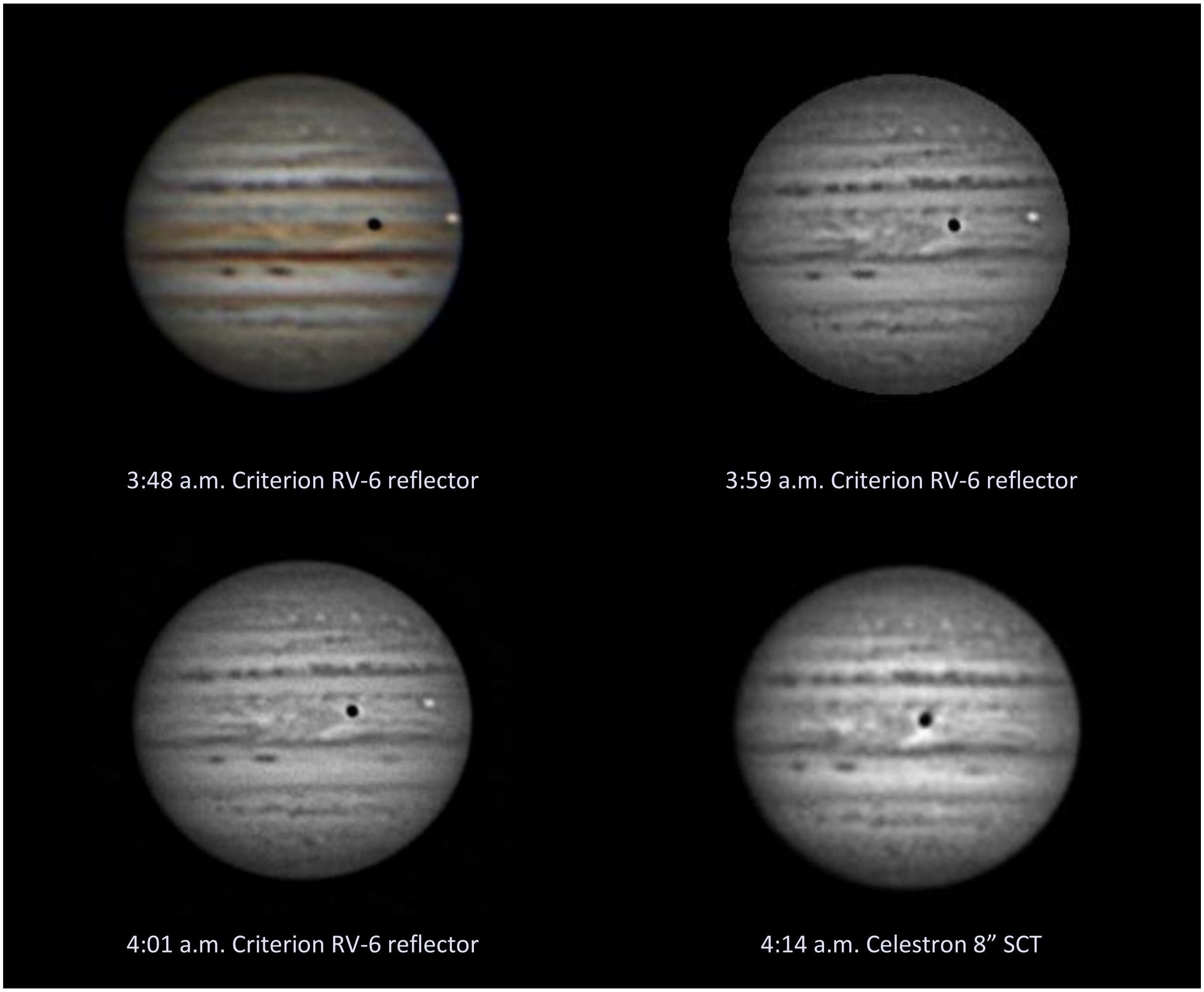


My favorite dark-sky site is Camp Hale, Colorado. At 9,350 feet elevation, it's located near Colorado's Tennessee Pass, some 15 miles north of Leadville, the highest-elevation metropolitan area in the US, if you can call a former mining town of 2,500 people a metropolis. Camp Hale usually boasts seventh magnitude skies, with SQMs around 21.85 and the Milky Way casting a distinct shadow. This year, smoke from western fires took away at least a magnitude, and the light dome from Leadville was more evident than usual as photons reflected off soot in the atmosphere. The Milky Way, while quite distinct, was not the bright white lacteal torrent we were used to. The North American Nebula was still visible with the naked eye near Deneb, but it wasn't as bright and demarcated as we had come to expect from prior visits to the site. My 80 mm f/5 travel scope showed M81 as a homogenous disk, but nothing of the structure that can usually be glimpsed even with this aperture.

Without a tracking mount, I was only able to make a snapshot of the Milky Way in Sagittarius. Scorpio is on the lower right. The brightest star near the right edge is Antares; the smudge of globular cluster M4 can be seen to its right if you enlarge the image. The Sagittarius teapot is distinct just below the Milky Way. Messier 7, Ptolemy's Cluster, is the smudge to its right. The image was made with a 20.2-megapixel Sony DSC-RX100 camera, which has a fine Zeiss f/1.8 lens. ISO 6400, 20 seconds, f/1.8, focal length 28 mm (35-mm equivalent).

The smoke worsened, and although we were in Colorado, Utah and Idaho for another 10 days, we only observed the Moon, and then just once. The morning and afternoon Sun was a pale disc and normally sharp distant mountains were shrouded in haze. The Earth's surface was essentially invisible from the airplane at 33,000 feet once we cleared western Wyoming on our afternoon flight from Salt Lake City on July 20th. Landing in New York at 9 p.m., we beheld a deep orange 8-day old Moon, magnitude perhaps -7 when it should have been -11.8.

John Paladini's Jupiter

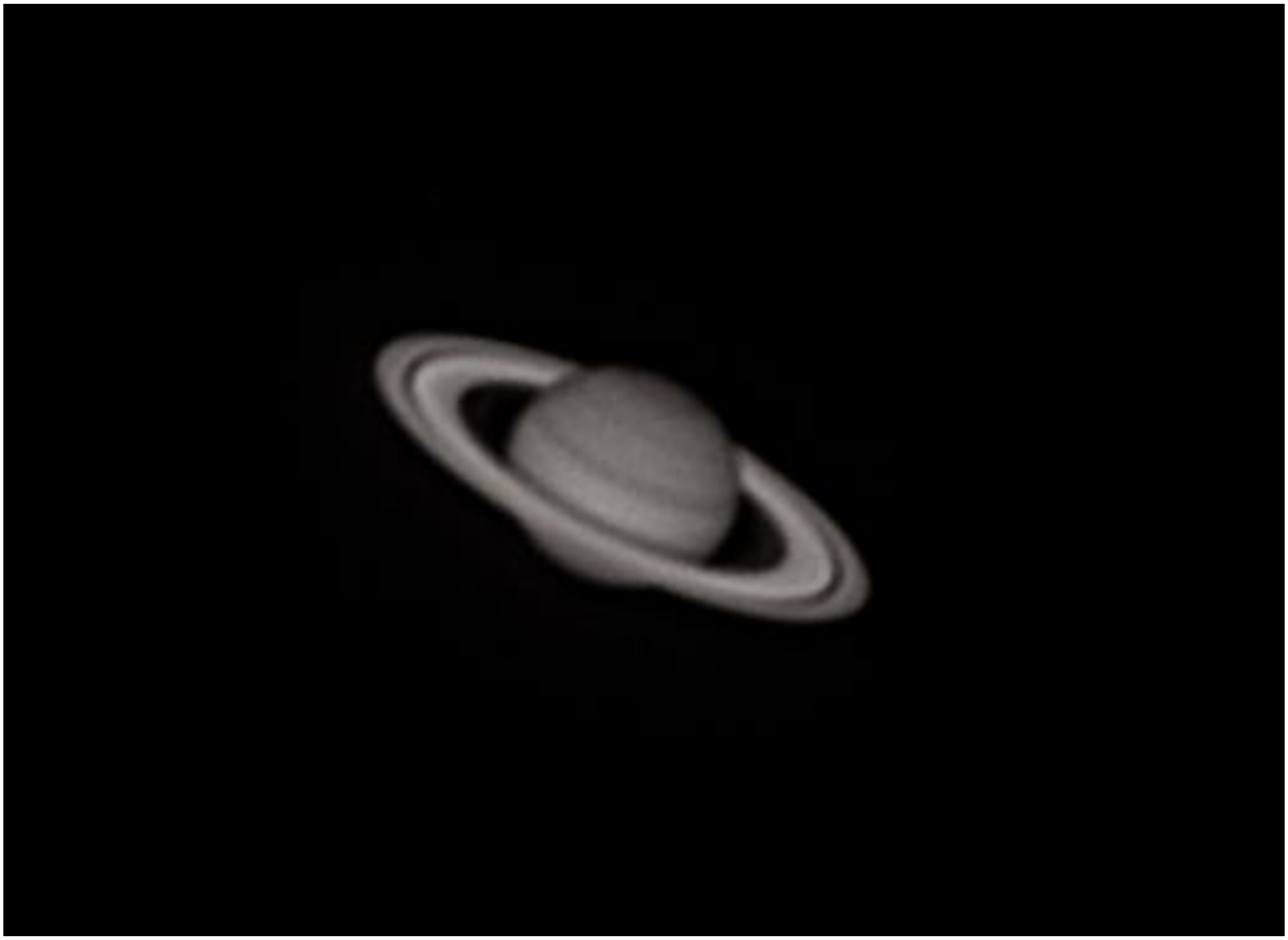


John Paladini imaged a shadow transit of Io across the face of Jupiter in the wee hours of July 28 from Mahopac. He used a venerable Criterion RV-6 six-inch f/8 reflector for the first three images (with 2.5X Televue Barlow), and then switched to an 8-inch Celestron Schmidt-Cassegrain for the final image. The color image was made with an ASI120MC camera, while the monochrome images were made with an ASI120MM camera and red filter. The bright disk of Io is easily seen in the first three images, along with the very distinct shadow.

Here are the shadow transits visible from our area (at night) in September. The dates are calendar dates, not necessarily "night of…." dates. Events that cross midnight are listed for the date that the transit starts.

Date	Start-End	Moon	Date	Start-End	Moon
9/1	00:23-05:00	Callisto	9/13	02:47-03:56	Ganymede
9/3	01:41-03:59	Io	9/17	18:39-23:12	Callisto
9/4	20:10-22:28	Io	9/18	00:00-01:34	Io
9/5	19:01-21:52	Europa	9/20	00:12-03:02	Europa
9/5	22:45-02:32	Ganymede	9/21	18:29-20:47	Io
9/10	03:36-05:54	Io	9/26	01:56-04:14	Io
9/11	22:05-00:23	Io	9/27	02:48-05:38	Europa
9/12	21:37-00:27	Europa	9/27	20:25-22:43	Io

John Paladini's Saturn

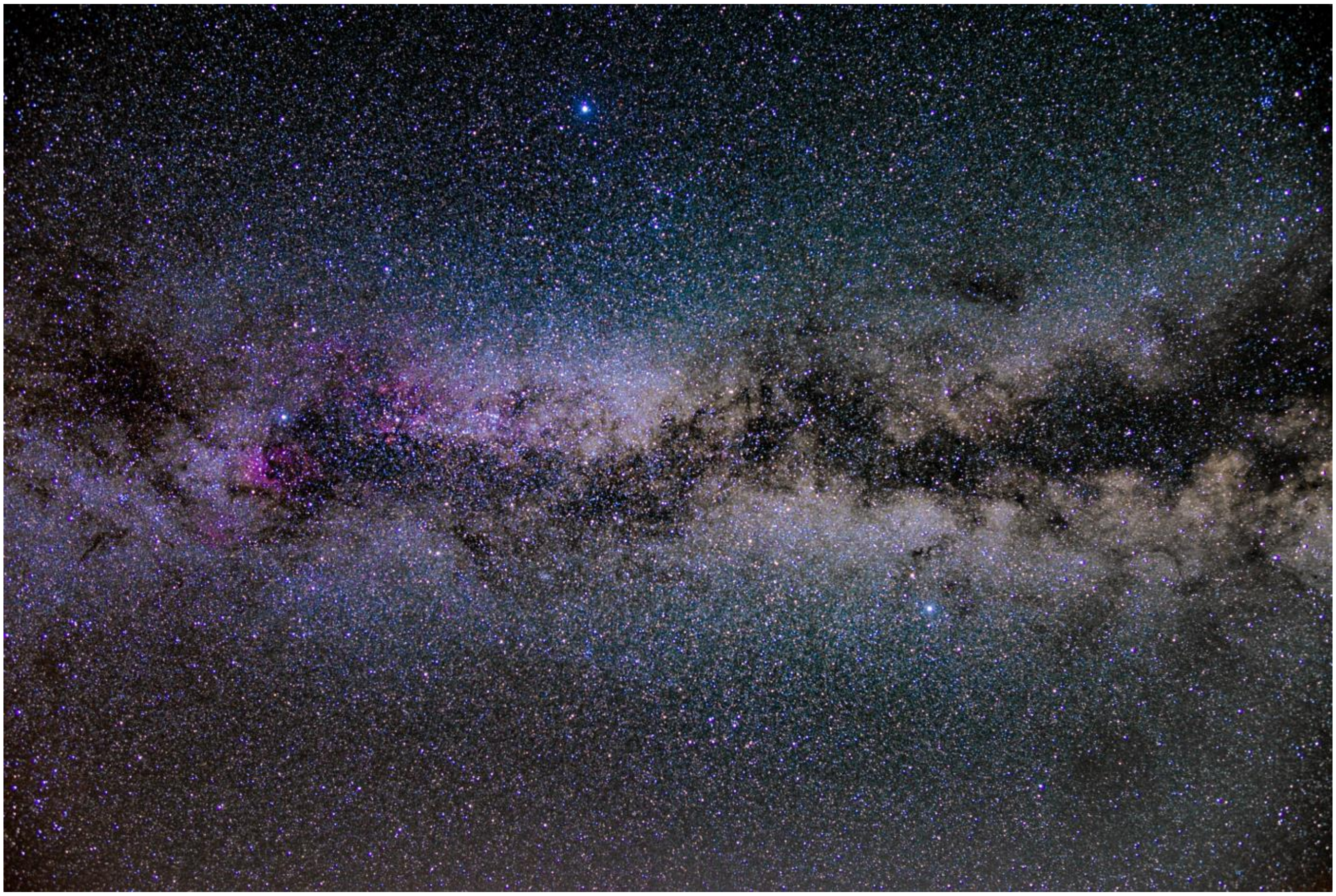


Again working with the Criterion RV-6 and an ASI-290MM camera with red filter, John captured Saturn on July 31.

There was a time when the 6-inch f/8 reflector was the amateur astronomy telescope design. They were often home-made. Large-mirrored Dobsonian telescopes were not available until the late 1980's, and Celestron SCT's were expensive. With suburban areas still having relatively dark skies, this size and format (1200 mm focal length) performed admirably for both planetary and deep sky observing, as John ably demonstrates with his images of Jupiter and Saturn. Fifty years ago, your editor lusted after the Criterion RV-6, which came with a German equatorial mount that had a 110-volt RA drive. At $199 in 1972, it was way beyond my meager intern's salary. Read about it at http://www.company7.com/library/criterion_rv6.html.

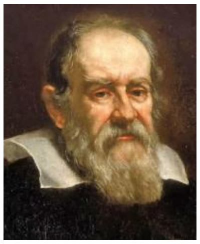
John commented, "Lately have been into this RV6 scope. It has real quick cool down. I guess the open tube on the bottom has an advantage." Incomplete cooling of the closed SCT tube coupled with the SCT's larger secondary, which reduces contrast in surface details, accounts for the rougher image and the disappearance of Io's disk in the SCT image of Jupiter on the previous page. SCTs and Maksutovs take a long time to come to thermal equilibrium, much less of a problem for open Newtonians.

The Summer Triangle by Dave Parmet



Taken in the dark skies of Cherry Springs, Pennsylvania, July 31. Dave used a Nikon D810 DSLR on a Sky-Watcher Star Adventurer mount. ISO 1600, 24mm lens at ƒ/5.0, 180 seconds. Twenty light frames and five darks stacked in Starry Sky Stacker and processed in Adobe Light Room Classic and Photoshop.

The North American Nebula is clearly visible on the left, just below and left of Deneb.



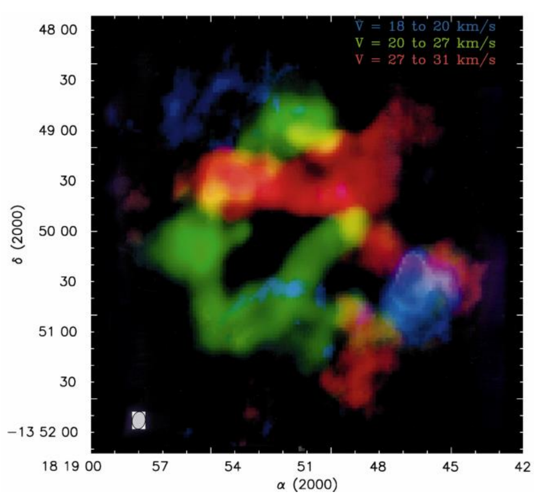
I have observed the nature and the material of the Milky Way. With the aid of the telescope this has been scrutinized so directly and with such ocular certainty that all the disputes which have vexed philosophers through so many ages have been resolved, and we are at last freed from wordy debates about it. The galaxy is, in fact, nothing but a congeries of innumerable stars grouped together in clusters. Upon whatever part of it the telescope is directed, a vast crowd of stars is immediately presented to view. Many of them are rather large and quite bright, while the number of smaller ones is quite beyond calculation.

But it is not only in the Milky Way that whitish clouds are seen; several patches of similar aspect shine with faint light here and there throughout the aether, and if the telescope is turned upon any of these it confronts us with a tight mass of stars. And what is even more remarkable, the stars which have been called “nebulous” by every astronomer up to this time turn out to be groups of very small stars arranged in a wonderful manner. Although each star separately escapes our sight on account of its smallness or the immense distance from us, the mingling of their rays gives rise to that gleam which was formerly believed to be some denser part of the aether that was capable of reflecting rays from stars or from the Sun.

Galileo Galilei, *The Sidereal Messenger*, March 1610

Messier 16 by Steve Bellavia

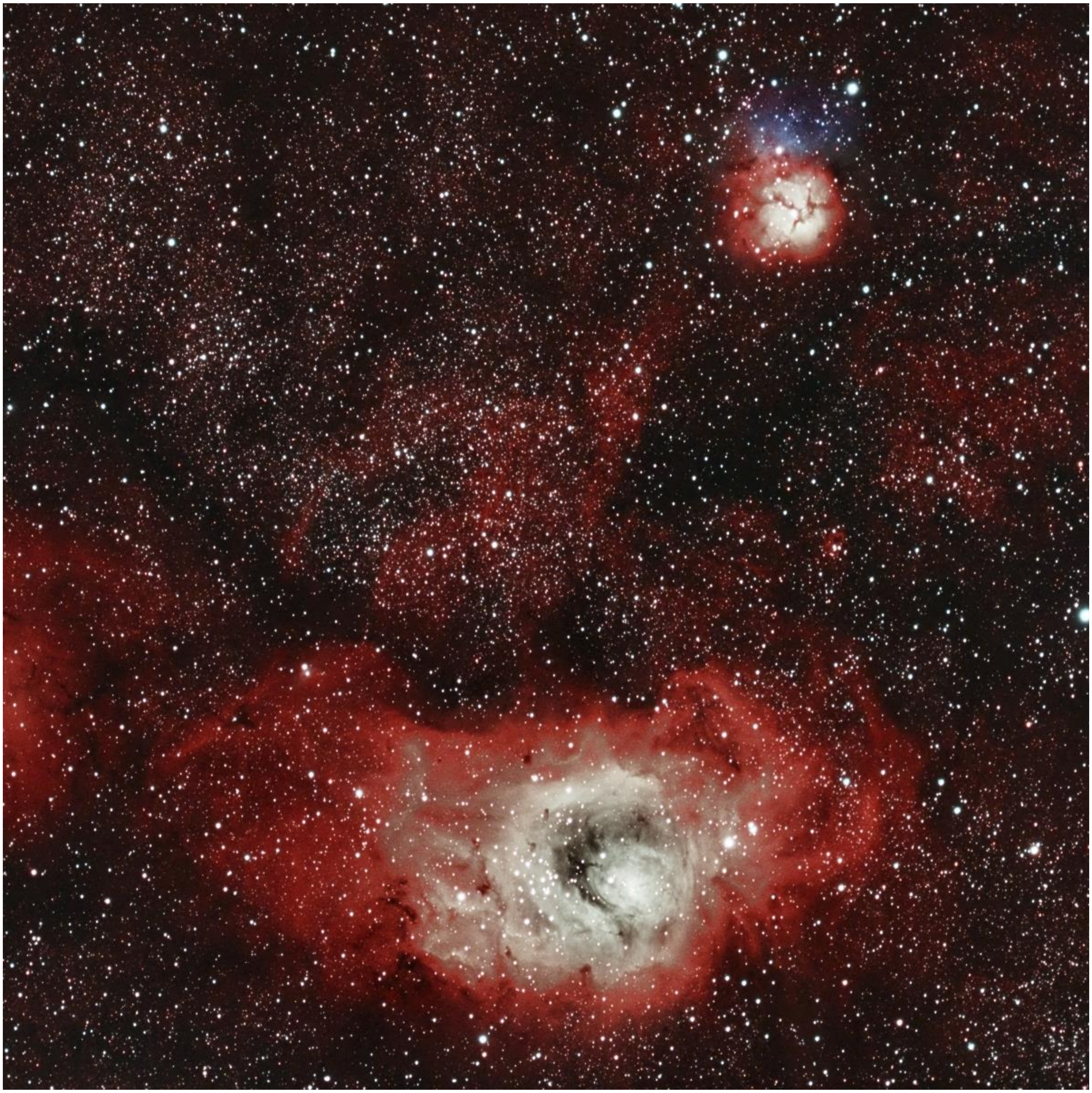
Made famous by the iconic Hubble image, the “Pillars of Creation” are in the center in this image of the Eagle Nebula, Messier 16, in the constellation Serpens. The nebulosity is very hard to see with a small scope, especially in our light-polluted skies, although the open cluster associated with it is easy. In Messier’s day, the dark skies in Paris allowed him to glimpse “a mass of small stars, mixed with a faint light” with his 3- to 4-inch telescopes. Technical data for Steve’s image is at https://www.astrobin.com/z7anhe/.



The largest of the pillars is about four light years in length. Within its dust and hydrogen gas are EGGs ("Evaporating Gaseous Globules") in which stars are forming. About 8,100 stars have been identified in the cluster. The brightest, HD 168076, is a binary of two large, hot, luminous O stars, with a mass of 80 $M_\odot$ and a visual magnitude of 8.24. Messier 16 is very young, about 1-2 million years old. It is 5,700 light years distant, in the Sagittarius Arm of the Milky Way.

Gas within the nebula is moving in different directions and rates, as can be seen in this image from “Molecular Clouds in the Eagle Nebula” by Mark Pound, *Astrophysical Journal* 493: L113-116, 1998. There are three kinematically distinct molecular (primarily CO) clouds in this region. The integrated intensity map of each cloud is coded according to its centroid velocity of 18 km s^{-1} (blue), 24 km s^{-1} (green; these are the Pillars), and 28 km s^{-1} (red). There has been a suggestion that the gas and dust has been disturbed by supernovas or magnetic fields.

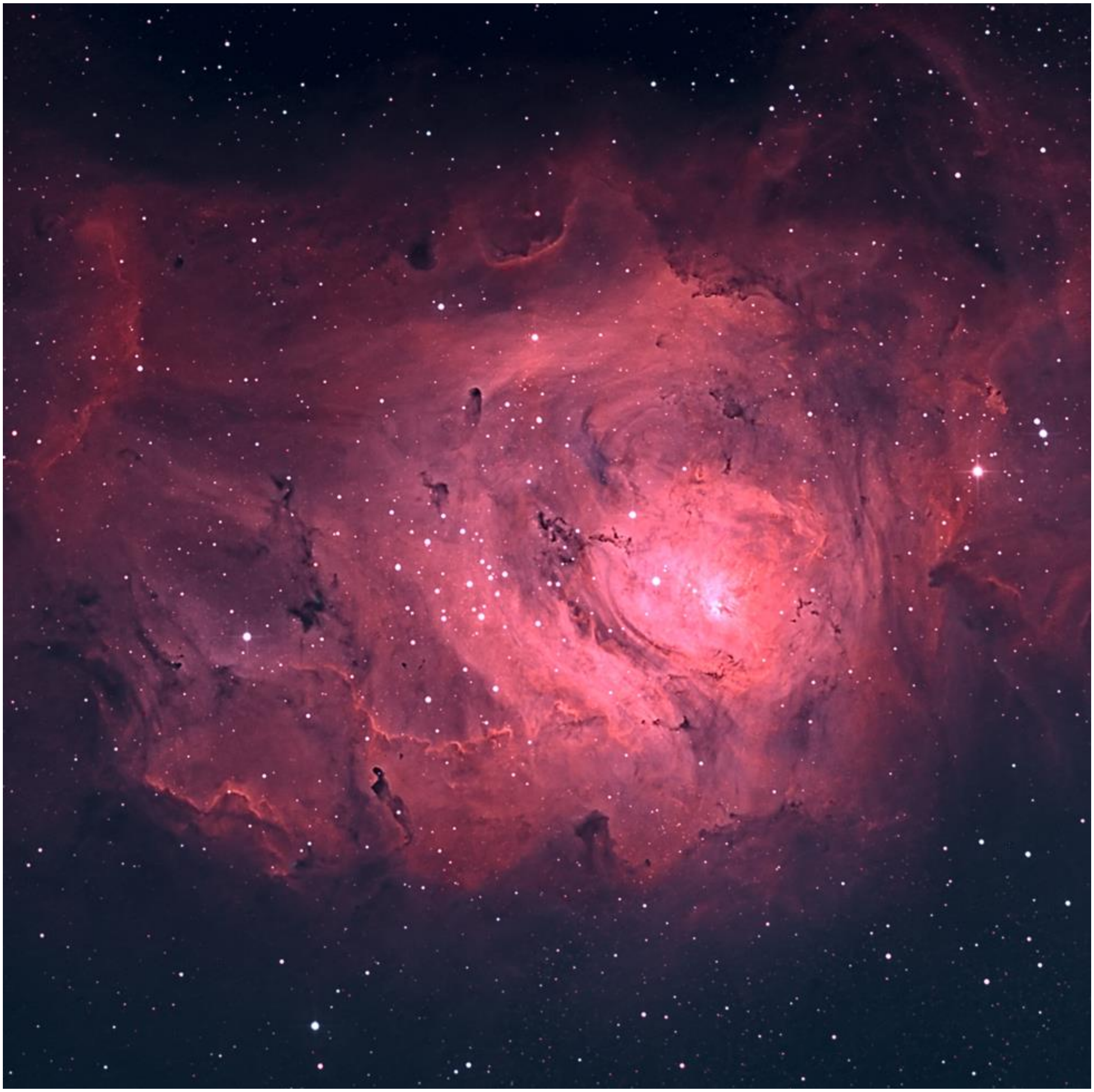
Lagoon and Trifid by Leandro Bento



Leandro obtained this image in the summer of 2020 with a William Optics Redcat 51, iOptron Skyguider tracker, and ZWO ASI 533MC Pro color camera. Processed in Pixinsight. Darks, flats and bias taken. Thirty-seven light frames were used for a total of 111 minutes of exposure. Gain 100, -10°C sensor temp.

The nebulosity surrounding the young cluster in M8 is easy to detect visually, especially if you are not looking over city lights. A mild-to-moderate light-pollution reduction filter will increase the contrast and make the nebula more dramatic. It is an HII region with active star formation, about 5,200 light years distant in the direction of the center of the Milky Way. Just 1½ degrees to the north, the Trifid Nebula, M20, shines in hydrogen alpha light and has blue reflection nebula on its north side. It too is a site of active star formation. It’s a little closer to our solar system, perhaps 4,100 light years distant.

Lagoon Alone by Rick Bria



Using the 14-inch telescope and narrowband filters at the Mary Aloysia Hardey Observatory in Greenwich, Rick captured the core of the Lagoon nebula, stressing the large amount of ionized hydrogen in this region. Even though he used an OIII filter for much of the exposure, there's not much oxygen in the nebula and so the red hydrogen signal dominates. This intense fluorescence at 656.28 nanometers is due to excitation of the high concentration (in cosmic terms) of hydrogen atoms by the hot young stars in the Lagoon's open cluster (officially NGC 6530). At least one of the stars in this cluster is less than two million years old, and most aren't that much older. Star formation is continuing in this area of the galaxy.

The densest parts of the nebula have a concentration of about 10^6 particles per cubic centimeter, just 10^{-14} the concentration of air at the Earth's surface.

NGC 4535 and Companions by Steve Bellavia

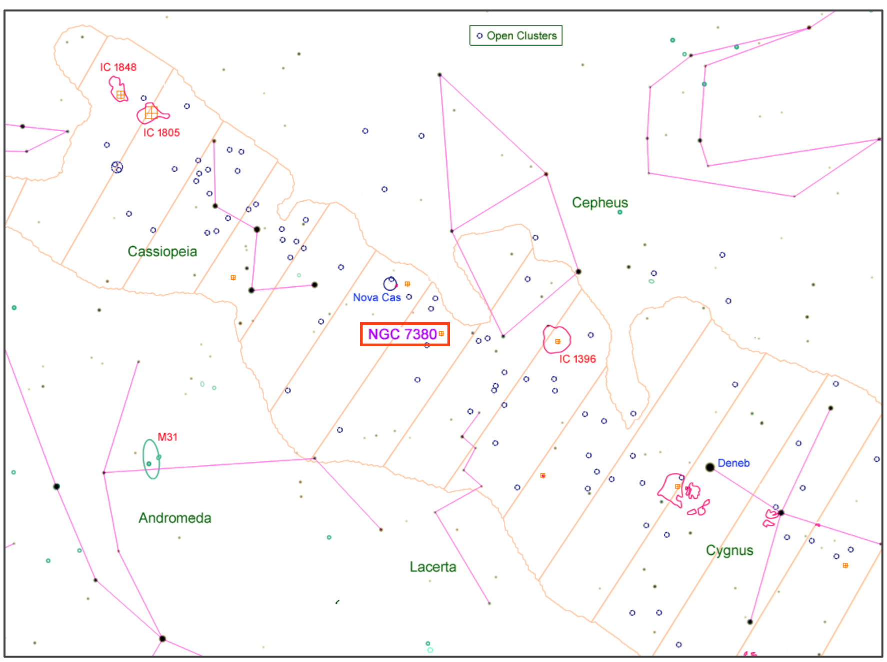
NGC 4535 is a beautiful 10.73-magnitude (Vmag) near-face-on spiral galaxy 52.2 million light years distant (as determined by observation of its Cepheid variables by the HST). It's accompanied by a gaggle of distant galaxies listed in the 2MASX, ECO, LEDA and SDSS surveys. Their magnitudes are measured with filter systems other than UBV (see page 13). These galaxies all have a "g" magnitude listed. The g transmission peak is at 520 nm, similar to the V filter peak at 532 nm. Enlarge the page to see these objects.

Steve made this image at Cherry Springs, PA in early May using two telescopes: a 6-inch Celestron SCT and a TS-Optics Photoline 115-mm F7 triplet apo.

In the 1950s, when amateur astronomy was a visual hobby and telescopes were not very big, amateur Leslie Copeland called NGC 4535 the "Lost Galaxy." It gets a listing in Burnham's *Celestial Handbook* ("fine S-shaped spiral, delicate arms"), and is mentioned, but not described, by Stephen James O'Meara in *Hidden Treasures*. It's not cited at all by Sue French (*Deep Sky Wonders*) or Phil Harrington (*Cosmic Challenge*).

	Galaxy	Red Shift		Galaxy	Red Shift
---	**NGC 4535** U=14.967, B=11.1, g=13.44, r=12.663	0.006551	D	**SDSS J123447.15+080946.9** g=17.355, r=16.898	0.05439
A	**2MASX J12340759+0810067** g=16.697, r=16.273, J=14.319	0.10222	E	**LEDA 1342835** g=16.719, J=13.866, H=13.011	0.08451
B	**2MASX J12341068+0814467** g=25.116, J=14.785, K=13.141	0.10143	F	**SDSS J123446.98+081510.7** g=16.511, r=15.591, z=14.869	0.08451
C	**ECO 12412** u=16.697, g=15.552	0.024828	G	**Z 42-153** B=15.2, g=15.058, H=12.276	0.03789

NGC 7380 by Gary Miller



Just 90 minutes of exposure (30 x three minute subs) through an Explore Scientific 127-mm triplet carbon-fiber tube scope, Optolong-l-Extreme filter and ASI2600mcPro camera (plus flats and darks) yielded this view of the so-called Wizard Nebula in Cepheus. It's a young (3-11 million years) HII region, powered by the double-star DH Cephei, not clearly visible on this image. The components of DH are both very large (A=25-34 $M_{\odot}$, B=16-34 $M_{\odot}$) hot O stars, with surface temperatures of about 44,000 K. The nebula itself is 8,500 light years from us. It sits in the northern Milky Way, among the many open clusters and HII regions in Cassiopeia, Cepheus, Lacerta and Cygnus.

Research Highlight of the Month

Burke, CJ, Shen, Y, Blaes, O, *et. al,* A characteristic optical variability time scale in astrophysical accretion disks, *Science* 2021; 373: 789-792 (August 13, 2021)

A supermassive black hole (SMBH) on the order of millions to billions of solar masses lies at the center of most, if not all, large galaxies. SMBH masses can be determined by a number of clever methods. For nearby galaxies, notably our own, velocity of stars close to the SMBH can yield the mass directly (see the discussion of how Newton's equations can be used to make this determination, page 11 of the May 2021 SkyWAAtch). The overall rotational velocity of the mass of stars in a galaxy correlates roughly with SMBH mass when individual stars cannot be resolved.

Supermassive black holes at the centers of galaxies are surrounded by accretion disks, matter orbiting the black hole at high velocity and, because of viscosity, high temperature. The energy output of these disks can be prodigious, radiating in optical, ultraviolet and X-ray wavelengths. These "active galactic nuclei" are Seyfert galaxies or quasars. In some black holes, such as Sgr A* in the Milky Way, the amount of matter and energy in the discs isn't very large, and the SMBHs are said to be "quiescent." The accretion disks are surrounded by a torus of cooler dust many light years distant. Interactions within the roiling, viscous accretion disk varies the energy output over time. For some active galactic nuclei, the differential time between radiation spikes in the accretion disk and re-radiation at lower wavelengths from heating of the more distant dust torus can be correlated with the SMBH mass, a technique known as "reverberation mapping." The galaxy needs to be relatively edge-on for this technique to be effective. There are some other rough ways of estimating SMBH mass, including measuring the luminosity of the galactic core when it has particular structural parameters.

The temporal variation of optical radiation from accretion disks is statistical in nature, and can be described by probability functions. Burke *et. al.* used historical light curves to examine the relationship between SMBH mass, previously determined by other techniques, and these variations. They looked at data on 67 SMBHs in active galactic nuclei to determine the "damping time" of the radiation, and found that it correlated with the SMBH mass. They also examined the gas surrounding stellar-mass black holes and even white dwarf stars, which through their substantial gravity also are surrounded by accretion disks. This suggests that the relationship between mass and radiation flux is a general property of highly gravitational objects and can be used directly to determine their masses. A galaxy's orientation is no longer narrowly constrained to make this measurement.

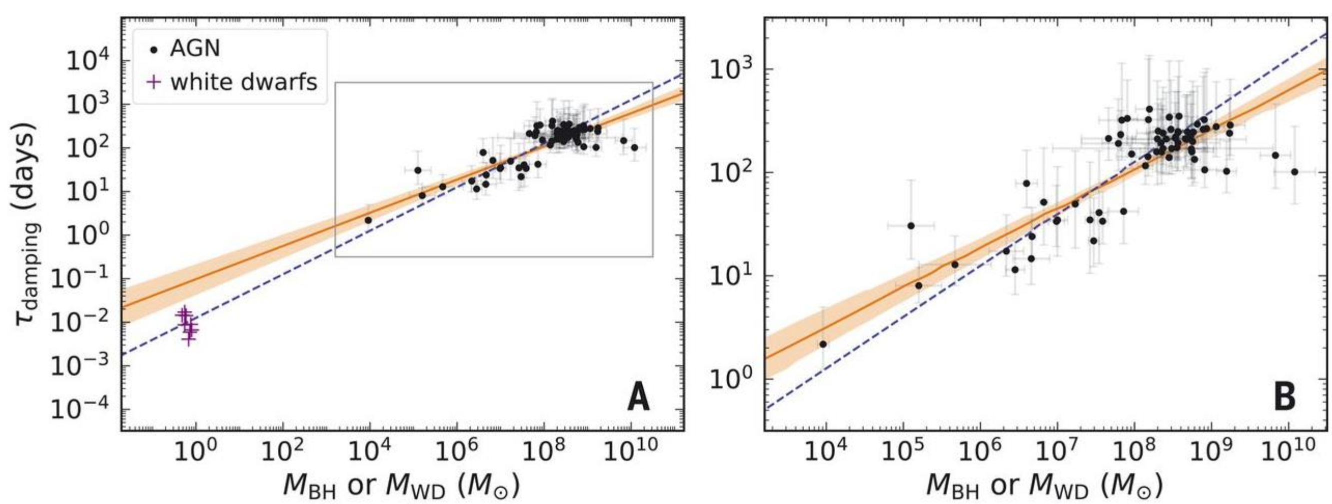


Fig. 1 from Burke et. al. Optical variability damping time scale as a function of accretor mass. (A) Rest frame damping time scale measured from AGN light curves as a function of SMBH mass for AGNs (black circles). The orange line and shaded band are the best-fitting model and 1σ uncertainty for the AGN sample, respectively. Purple crosses show equivalent measurements for white dwarfs All error bars are 1σ. (B) Magnified view of the region within the gray box in (A).

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. Just point it at two stars and you're good to go.	$750	David Parmet david@parmet.net
Nexus DSC Digital Setting Circles	Connects to encoders on your mount (you provide) for accurate push-to object finding. Contains many astronomical catalogues. See https://www.astrodevices.com/Products/NexusDSC/index.html.	$100	Peter Rothstein peterrothstein01@gmail.com
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
ExploreScientific 127-mm refractor	Air-spaced ED APO f/7.5 triplet OTA with tube rings, 2" diagonal, Orion focus extender. Like new condition; rarely used. See https://is.gd/es127gb for more information.	$1000	Greg Borrelly gregborrelly@gmail.com
ExploreScientific 40-mm eyepiece	68° field of view. Argon-purged, waterproof, 2" eyepiece. New in original packaging, only used once. Lists for $389.	$340	Greg Borrelly gregborrelly@gmail.com

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.

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

Use your **anaglyph (3D) glasses** (red/blue) to view this "enigmatic channel" in Syrtis Major, imaged by Mars HiRISE on August 3, 2021.