Highlights of the September Sky…

- - - 2nd - - -
Full Moon
1:22 am EDT

- - - 5th - - -
PM: A waning gibbous Moon moves to within 0.7° (44′) of Mars.

- - - 9th - - -
DAWN: The Moon lies just above the Hyades cluster and below the Pleiades.

- - - 10th - - -
Last Quarter Moon
5:26 am EDT

- - - 14th - - -
DAWN: A slender waning crescent Moon is 5° to the left of Venus. The Beehive Cluster (M44) is 2.5° to the upper left of Venus.

- - - 15th - - -
DAWN: A very thin crescent Moon is 5.5° to the upper left of Regulus in Leo.

- - - 17th - - -
New Moon
7:00 am EDT

- - - 21st - - -
DUSK: A waxing crescent Moon occults Graffias (Beta Scorpii) - a double star - at 9:46 pm EDT.

- - - 23rd - - -
Equinox - Autumn begins at 9:31 am EDT.

- - - 23rd - - -
First Quarter Moon
9:55 pm EDT

- - - 24th - - -
DUSK: A waxing gibbous Moon, Jupiter, and Saturn form an arc 11° long.

- - 25th - - -
DUSK: The Moon, 3° to the lower left of Saturn, forms a scalene triangle with the ringed planet and Jupiter.

Prime Focus

A Publication of the Kalamazoo Astronomical Society

★ ★ ★ September 2020 ★ ★ ★

This Months KAS Events

General Meeting: Friday, September 11 @ 7:00 pm
Held Online via Zoom • See Page 10 for Details

Member Observing: Saturday, September 12 @ 8:00 pm
Jupiter, Saturn & Star Clusters • See Page 9 for Details

Board Meeting: Sunday, September 13 @ 5:00 pm
Held Online via Zoom • All Members Welcome to Attend

Member Observing: Saturday, September 26 @ 8:00 pm
Moon, Jupiter & Saturn • See Page 9 for Details

Inside the Newsletter. . .

Observations

by **Richard S. Bell**

Our pandemic-enforced summer hiatus is at long last over. Hopefully, the only way we'll have to cancel a KAS event from this point on is the old fashioned way - the weather goes to hell in a handbasket! In a way, I didn't mind the break from a general meeting in July. Instead of a Zoom meeting on July 10th, we held the first of 3 successful Owl Observatory Training Sessions that month. Plus, much of the attention around that time was on Comet NEOWISE. What was a total bummer was cancelling the 26th annual Perseid Potluck Picnic on August 8th. A 25-year streak of picnics brought to an end thanks to COVID-19. We did hold a Member-Only Observing Session that night instead, so that's some consolation I suppose.

Speaking of which, it'll be member-only sessions for the reminder of the season. KAS Board members didn't feel comfortable holding public sessions in September, so I made the decision to cancel the rest of the season. It is a real shame we'll have to wait until at least April 2021 to share the new Leonard James Ashby Telescope in Owl Observatory with the public. The good news is that the telescope will still be there. The safety of members and the public is more important. Attendance for the member-only gatherings has been sparse thus far, but that's to be expected. Some are unable or unwilling to take chances and - as I often remind myself - this is not an observing club.

Kalamazoo Public Schools made the decision to use remote learning until at least Thanksgiving. That means KAMSC will be off limits to us for the reminder of 2020. So, it'll be Zoom meetings for the foreseeable future. We do have a great speaker with an interesting topic for the meeting on September 11th. Chuck Allen is the current secretary and past -president of the Astronomical League. He is a recipient of both the G. R. Wright Award and the League's Master Outreach Award with over 400 public appearances. The title of his presentation is *Cosmic Horizons*. Please see the back page of the newsletter for full details.

The October and November meetings are set, but I'm racking my brain on what to do for December. That's always our annual meeting, featuring election of next year's KAS officers and at-large board members. We had planned to retool the Holiday Party, most likely a "Winter Solstice Dinner" at a local restaurant, but that will have to wait until next year now. Should we just find a guest speaker or try something else? I'm certainly open to suggestions.

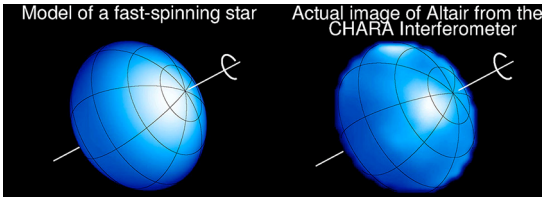
We'll start another season of Remote Viewing Sessions, featuring the KAS Remote Telescope, in November. We were planning to hold them online anyway and now we'll have to for sure. I'm also planning to do an online version of the *Introduction to Amateur Astronomy* lecture series. I'm trying to decide if I should keep it at five parts or break some of the presentations into separate parts. I'll be looking for feedback during the September meeting, but always welcome comments by email.

NASA Night Sky Notes...

Summer Triangle Corner: Altair

by **David Prosper**

Altair is the final stop on our trip around the Summer Triangle! The last star in the asterism to rise for Northern Hemisphere observers before summer begins, brilliant Altair is high overhead at sunset at the end of the season in September. Altair might be the most unusual of the three stars of the Triangle, due to its great speed: this star spins so rapidly that it appears "squished."



A very bright star, Altair has its own notable place in the mythologies of cultures around the world. As discussed in our previous edition, Altair represents the cowherd Niulang in the ancient Chinese tale of the "Cowherd and the Weaver Girl." Altair is the brightest star in the constellation of Aquila the Eagle; while described as part of an eagle by ancient peoples around the Mediterranean, it was also seen as part of an eagle by the Koori people in Australia! They saw the star itself as representing a wedge-tailed eagle, and two nearby stars as his wives, a pair of black swans. More recently one of the first home computers was named after the star: the Altair 8800.

Altair's rapid spinning was first detected in the 1960s. The close observations that followed tested the limits of technology available to astronomers, eventually resulting in direct images of the star's shape and surface by using a technique called interferometry, which combines the light from two or more instruments to produce a single image. Predictions about how the surface of a rapidly spinning massive star would appear held true to the observations; models predicted a squashed, almost "pumpkin-like" shape instead of a round sphere, along with a dimming effect along the widened equator, and the observations confirmed this! This equatorial dimming is due to a phenomenon called gravity darkening. Altair is wider at the equator than it is at the poles due to centrifugal force, resulting in the star's mass bulging outwards at the equator. This results in the denser poles of the star being hotter and brighter, and the less dense equator being cooler and therefore dimmer. This doesn't mean that the equator of Altair or other rapidly spinning stars are actually dark, but rather that the equator is dark in comparison to the poles; this is similar in a sense to sunspots. If you were to observe a sunspot on its own, it would appear blindingly bright, but it is cooler than the surrounding plasma in the Sun and so appears dark in contrast.

As summer winds down, you can still take a Trip Around the Summer Triangle with this activity from Night Sky Network. You can discover more about NASA's observations of Altair and other fast and furious stars at nasa.gov.

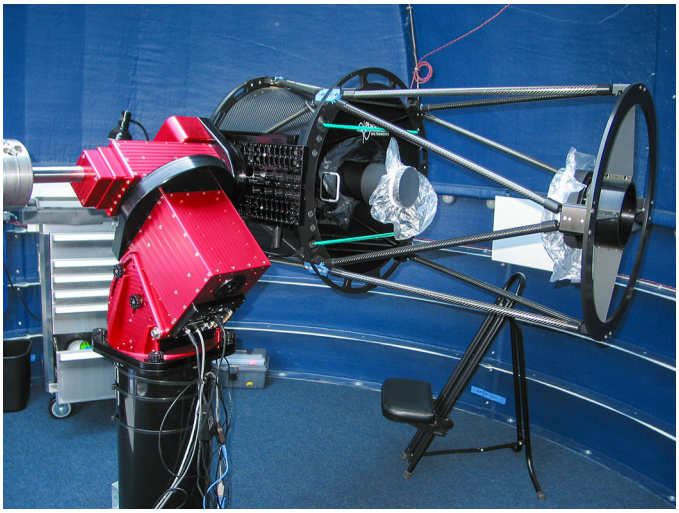
KAS Member Observatories

Part 2: Fred Dutton's Kalamazoo Observatory

Kalamazoo Observatory is housed in a Technical Innovations ProDome assembled in 2010 on the property where I live in Kalamazoo Township (visit KalObs.org for details). I chose a domed observatory over a roll-off roof unit in part because when open it affords greater protection against the elements and shuts out more stray light. Also, I had not a clue how to build a ROR observatory and secure it against strong winds!

The observatory contains a PlaneWave f/6.8 CDK 20-inch Astrograph OTA. The OTA is controlled by Software Bisque's Paramount ME (an older version of KAS's ME 2), which sits on a 10-inch aluminum pier from ATS. The OTA is equipped with a f/4.5 (0.66) focal reducer, which reduces the telescope's focal length from 3454 mm to 2280 mm thereby increasing the telescope's field of view. This in turn gives the square CCD array in my SBIG 1001E camera (24 micron pixels) a FOV of 37 arcminute side to side and 51 arcminute diagonally thereby increasing the number of reference stars available for accurate photometry and astrometry.

I originally used the observatory to generate photometric data on variable stars, which I reported to the American Association of Variable Star Observers (AAVSO) from 2010 until 2014. But I became increasingly interested in tracking asteroids in 2013, couldn't do justice to both, and reluctantly gave up variable star photometry. Tracking asteroids is challenging because, unlike variable stars, they shine only by reflected sunlight. Also, light pollution in Kalamazoo reduces the number of trackable asteroids to those whose magnitudes through a Johnson V filter are brighter than 18. Unlike stars, asteroids are constantly on the move. It's only because of their movement that they can be distinguished from stars. Astrometrica, a shareware program, is used to locate asteroids by blinking images and, when necessary, stacking images to enhance their signal-to-noise ratio. TheSkyX (Software Bisque) controls the observatory's dome, shutter, telescope and camera. MaxIm DL (Diffraction Limited) is used in conjunction with an Alnitak Flat-Man and camera to generate the Bias, Dark, and Flat-Field frames required for removing defects in the camera's images. The telescope's focus is controlled by a Hedrick Focuser (PlaneWave). ASCOM is used for plug and play control.



In 2014, I began running the observatory and its equipment remotely from my house located 250 feet due west. I used LogMeIn until it became too expensive and switched to RemotePC. A security camera and baby monitor are my eyes and ears telling me what is going on out there. Remote control is facilitated by a Web Power Switch 7, which contains eight switchable outlets and two always-on outlets. The switchable outlets turn on and off the computer, SBIG camera, observatory motor power, Paramount ME, Alnitak Flat-man, Hedrick Focuser, a lamp and the security camera. KAS members interested in tracking asteroids and other topics in astronomy can find some useful information on the Kalamazoo Observatory website or can email me.

Appearing as a brilliant rusty red beacon on a clear night, the planet Mars has attracted the attention of skywatchers for centuries - and rightly so. Of the eight planets to circle our star, Mars is the only one whose surface we can study through a telescope. Mercury huddles too close to the Sun, while Venus' hellish surface is enshrouded in a perpetual layer of clouds. The remaining worlds are all gas giants, with no surfaces to study at all. Mars is also the most earth-like of all the planets. Polar caps wax and wane with the seasons, puffy white clouds drift across the surface, and a roughly 24-hour day all remind us of home.

Orbits & Oppositions

Mars observers must be patient. While Jupiter and Saturn are always pleasing sights through a telescope, Mars is often too small to enjoy. The Red Planet may be our neighboring world, but it can have an angular diameter as small as 4″ when on the far end of its orbit. The best time to observe Mars is around opposition, when a planet is opposite the Sun in the sky as seen from Earth. Oppositions of Mars occur every 26 months, the interval needed for Mars to catch up to Earth (or more accurately, the time for Earth to lap Mars in its quicker and shorter orbit about the Sun). However, due to the elliptical nature of Mars' orbit, not all oppositions are created equal.

Next to Mercury, Mars has the most elliptical orbit of all the major planets. It has an eccentricity of 0.0934, meaning it deviates from a perfect circle by about 9%. This deviation makes its solar distance vary between 128 and 155 million miles. Thanks to this eccentricity, the separation between Earth and Mars during opposition can also vary dramatically over time. The most favorable Martian oppositions recur every 15 to 17 years. Known as *perihelic oppositions*, they occur, as one might assume, when Mars is at both opposition with Earth and at perihelion with the Sun at nearly the same time. At its peak, the angular diameter of Mars can "swell" to 25.1″ at a distance of about 35 million miles (or 0.38 Astronomical Units). During an *aphelic opposition*, the gap between Earth and Mars can be as much as 65 million miles. The Red Planet's angular size in this instance is a paltry 13.8".

The last perihelic opposition occurred in 2018 and the next will not take place until 2035. So, am I two years late (or 15 years too early) with an article about tips and techniques to view the Red Planet? Not at all. In fact, the coming observing season for Mars will be better – for us – than it was in 2018.

Observing Gear

Mars will be a pleasing sight with the unaided eye and binoculars this Fall. However, if you want to explore its rusty red surface in any detail, you're going to need a telescope. Just about any aperture or style telescope will do, but these are my *recommended* minimum apertures by telescope type:

- 4-inch Refractor
- 6-inch Reflector
- 5-inch to 8-inch Catadioptric

The refractor should preferably have an apochromatic lens to provide razor sharp views free of chromatic aberration. Achromatic refractors aren't quite as sharp and will show a secondary spectrum around the Red Planet, but you're pocket book won't take as large a hit. Any refractor should have a minimum focal ratio of f/6 or f/7 to provide sufficient magnification to reveal Mars' surface features.

Most Newtonian reflectors available for purchase are designed for deep sky viewing. They will have focal ratios between f/4 and f/5. Their secondary mirrors are fairly large so contrast will be sacrificed. A 6-inch f/8 Newtonian is a good compromise between planetary performance and portability. Larger apertures with high focal ratios are available, but their tube lengths make transporting them to suitable sites prohibitive.

With catadioptric telescopes, focal ratios are not a problem and their folded optical designs makes them highly portable. Even 5-inch Schmidt-Cassegrains have focal ratios of f/10. That secondary mirror will result in loss of contrast, but lower costs compared to apochromatic refractors and high portability make it a worthwhile compromise. One model of catadioptric telescopes, the Maksutov-Cassegrain, rival even

Just about any style telescope will due to observe Mars. The larger the aperture and longer the focal length the better. It is also recommended to have a sturdy mount with a drive that can compensate for Earth's rotation.

apochromatic refractors. Maks (as they're affectionately known) with apertures of 6 or 7-inches have focal ratios of f/12 or f/15. Loss of contrast is minimized thanks to small secondary mirrors and the color contrast is fantastic. Maks aren't as widely available at Schmidt-Cassegrains, but they're not difficult to track down. Manufacturers like Celestron, Orion, and Sky-Watcher have models 7-inches in aperture available. When no planets are visible, they're great for double star observing!

Any telescope you use should have a sturdy mount. The best optics in the world would be wasted if the mount can't minimize vibrations in less than a second or so. Non-tracking mounts like Dobsonians will do, but a clock-driven mount will allow you to focus on viewing Mars' features. If you don't have a telescope in the suggested aperture range then no need to worry. I had great success viewing Mars during the historic opposition of 2003 with a Tele Vue 70mm Pronto (a long discontinued semi-apochromat).

Most eyepieces in our collections feature ultra-wide fields-of-view for deep sky viewing. While these are suitable for viewing Mars, the generous fields they offer are overkill. There are specialized eyepieces available for planetary viewing. Tele Vue's DeLite eyepiece series still have a generous 62° apparent field-of-view, but offer fine planetary performance at a more affordable price than their high-end Nagler and Ethos eyepieces. Baader Planetarium offers the Hyperion eyepiece line. Focal lengths range from 5 to 24mm and have apparent fields of 68°. These eyepieces can even be reconfigured for afocal (eyepiece projection) imaging with DSLR cameras. Even more affordable are Orion's Edge-on series of planetary eyepieces. These range in size from 3 to 14.5mm and have 55° apparent fields. Both the Hyperion and

Any eyepiece in your current collection will help bring out detail on the Red Planet. However, there are more specialized eyepieces for planetary observing.

Colored or specialized Mars filters are an invaluable resource in helping to reveal the Red Planet's elusive surface features.

Edge-on eyepieces come in sets that will save you even more money.

Old school eyepiece designs like Orthoscopics and Plössls will also do well for planetary viewing. Orthoscopics are a little hard to come by these days, but Plössls are widely available and very affordable. Exact focal lengths are difficult to recommend. It depends on the telescope you use and the seeing conditions on any given night. It's best to have several focal lengths in your in collection.

A great way to increase your range of magnifications for viewing Mars is to add a Barlow lens to your collection. Barlows artificially increase (usually double) the focal length of an eyepiece with the use of a negative lens element. Most are more affordable than eyepieces, but there are higher-quality versions to match high quality eyepieces. Tele Vue's Powermates perform the same task as Barlow lenses, but use a positive lens element. This preserves the exit pupil of the eyepiece being used and is free of other aberrations some Barlows have. They are more expensive, of course, but still cheaper than high-end eyepieces.

Colored planetary filters are essential for the observation of surface detail that is often virtually invisible without filtration. Most are inexpensive and can be purchased in sets to save even more. While every colored filter does something for Mars, here's a breakdown of the best ones and the features they'll enhance:

- **#12 Yellow**: Increases contrast of maria and helps to spot clouds in the Martian atmosphere.
- **#21 Orange**: Sharpens boundaries between yellow-orange areas and blue-green regions on Mars,

Unlike observing deep sky objects, dark adaption is not a concern when viewing the planets. In fact, it's best to avoid it. Keep the color sensitive portion of your eyes active to enjoy Mars' wealth of hues.

resulting in a darkening of edge-detail in the maria.

- **#23A Light Red**: Useful for the outlining of the Martian polar ice caps, maria, and dust storms. Probably the most commonly used filter for Mars.
- **#56 Light Green**: Excellent for the observation of polar ice caps as well as yellow-tinted dust storms.

A minus violet filter is recommended for observer's that want to view Mars in its natural light with an achromatic refractor. The minus violet filter will mask the secondary spectrum inherit in the optical design. Baader Planetarium's version is called the "Contrast Booster Filter" and costs about $90. There are even specialized filters just for Mars now available. Tele Vue used to offer the Bandmate Mars Filters Type A & B, but they have been since discontinued. You could probably find them on the used market. Orion has the 1.25-inch Mars Observation Eyepiece Filter for about $40. Their Mars filter transmits violet/blue and orange/red wavelengths where detail is rich, while blocking overbearing yellow/green wavelengths. Polar ice caps appear more sharply defined, while differences in landscape shading are nicely resolved. Polar hazes and cloud cover also become visible.

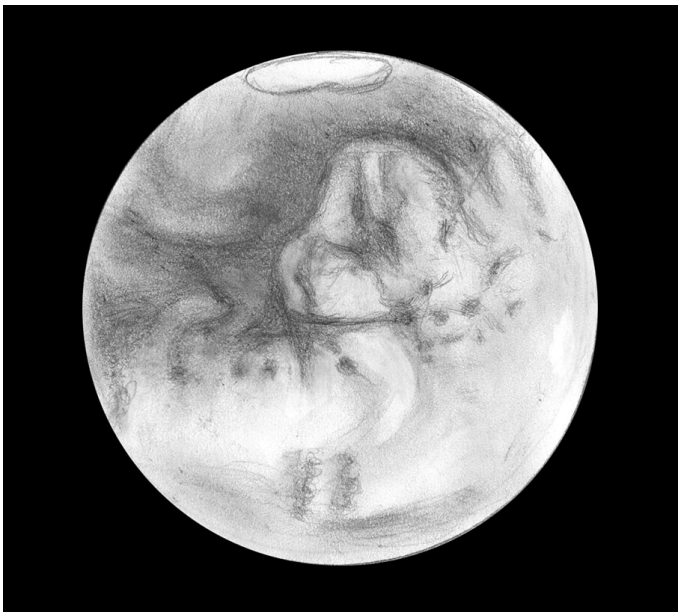
Finally, when viewing Mars through the eyepiece, it helps to know what you're looking at! In fact, it makes the experience much more enjoyable. Desktop planetarium programs like TheSkyX and Starry Night will show you which features are currently facing Earth, but their fancy graphics don't match what Mars looks like in the eyepiece. *Sky & Telescope* has a handy app on their website dubbed "Mars Profiler." Starting the app shows Mars' current face, but you can enter various dates and times (using Universal time, just add 4 hours during daylight time and 5 for standard time). Look for the central-meridian longitude and then you can use the handy-dandy Mars Map I assembled for the 2018 opposition while out in the field (using a map from the Association of Lunar & Planetary Observers). My favorite program for Mars viewing is called Meridian. It hasn't been updated for 8 years, but runs fine on Windows 10. After downloading and installing the program, you must enter your language preference, date format, latitude, and time zone every time (which is kind of irritating). Select Mars from the planet menu. The graphics may not be fancy, but that's the point. It's a realistic view of Mars through a telescope.

Observing Tips

Aside from overcast skies, the greatest menace for Mars observers is atmospheric seeing. However, even heat escaping your telescope can distort your view of the Red Planet. So, make sure you set up your telescope early enough for it to reach thermal equilibrium. To guarantee peak performance, be sure to also collimate your telescope as accurately as possible. The advantage of refractors is that they require infrequent collimation – in some cases never. The only exception is if your refractor takes a good bump. Some models can be collimated by the user, but others must be returned to the manufacturer. Newtonians can be collimated while you wait for the sky to darken thanks to Cheshire eyepieces and laser collimators. Collimating systems are available for Schmidt-Cassegrains, but most people align their optics on a star. Maksutov-Cassegrains share the same advantage as refractors, in that they require infrequent collimation.

Many amateur astronomers go to great lengths to seek out dark skies for observing faint fuzzies. The advantage of planetary observing is that it's largely unaffected by light pollution. In fact, when observing Mars (or any other planet) don't worry about dark adaption at all! Now, don't go thinking you can observe in a supermarket parking lot (the seeing would be terrible), but any city park with an unobstructed view would do nicely. Your eyes become less sensitive to color as they adapt to dark conditions. Planets like Mars have a plethora of colors! Feel free to even use a white flashlight when checking out your KAS Mars Map. I know, it feels weird to say that!

Observe Mars at its zenith, when it's due south and at its



Take the time to sketch Mars at the eyepiece. Nothing is better for training your eye to reveal surface detail.

highest altitude for the night. This is easy to determine with any desktop planetarium software. On the night of opposition, October 13th at 1:36 am EDT, Mars will be 53° above the southern horizon in the constellation Pisces and 22.3″ in angular diameter. Compare that to the perihelic opposition in 2018, when Mars reached a maximum altitude of only 22° on July 29th. This is why this year's opposition is better than 2018. Mars may have been 2″ bigger, but that extra 31° in altitude makes a world of difference for the stability of Mars in the eyepiece. If you're planning a trip to more southernly latitudes in October, then pack a telescope. The further south you go, the higher Mars gets.

Michigan weather can be unreliable (to say the least), so don't fret if it's cloudy on the night of opposition. In fact, Mars will be 20″ or larger between September 9th and November 2nd. Comfort is also very important when viewing through the eyepiece. There are many observing chairs available for purchase and many clever designs for ones you can build yourself. The more comfortable you are, the more relaxed you are. This will help you focus, because when you're at the eyepiece you need to be patient and stare at Mars intently. The seeing will distort Mars much of the time, but there are those brief moments of stability when features pop into view. You'll miss them if you're standing and swaying around. So, sit down, relax, be patient, and enjoy the view. The longer you look, the more you will see.

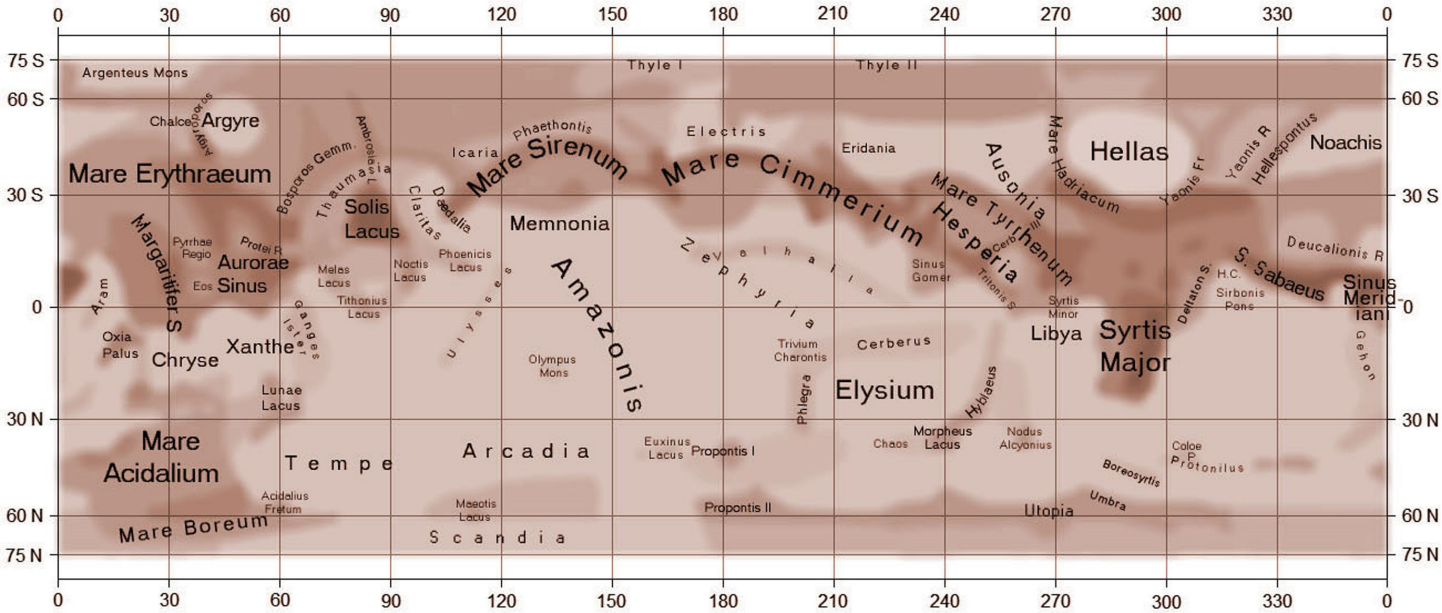
Finally, sketch Mars at the eyepiece. Nothing focuses your attention better than taking the time to draw what you see. Use a graphite pencil and smudge stick to emulate the mottling on the Martian surface. And remember, you can use a white flashlight to see what you're doing!

Top Sights to See

South Polar Cap. Mars' South Polar Cap is at a higher elevation than the North Polar Cap, thus it is cold enough for the water ice to be permanently covered by a layer of frozen carbon dioxide (dry ice). It's less than half the diameter of the northern cap and will be tilted by about 10° in our direction. The northern cap will be tilted out of view, but you should be able to spot the north polar hood. That's a cloud zone that develops over the polar caps during late summer and persist through the winter, and sometimes into early spring. It is composed of water ice clouds.

Syrtis Major. This prominent V-shaped feature was discovered by the famous Dutch scientist Christiaan Huygens on November 29, 1659. He used it to determine that Mars had a roughly 24-hour day like Earth. First known as the Hourglass Sea, it was renamed Syrtis Major Planum by noted Mars observer Giovanni Schiaparelli in 1877. The orbiting Mars Global Surveyor spacecraft discovered that it was a low-relief shield volcano. Its dark color comes from basaltic volcanic rock and a relative lack of dust.

Hellas. Mars is too distant to observe impact craters...with one notable exception. Hellas Planitia formed during the Late Heavy Bombardment period of the solar system about 4.1 to 3.8 billion years ago. It is the 3rd or 4th largest impact crater in the solar system and the largest impact crater visible from Earth. It is 1,400 miles in diameter and 23,465 feet deep. That makes it a little hard to miss, even from Earth!



Solis Lacus. The Latin to English translation for this prominent Martian feature is "Lake of the Sun." It is also known as the "Eye of Mars." Several features help form the entire eye, but Solis Lacus itself is the dark pupil in the center.

Conclusion

There you have it! Your guide to observing Mars during the Fall of 2020. A global dust storm spoiled the 2018 opposition, so let's hope the Martian skies remain clear this Fall. Take advantage now. Do not wait until 2035! May your skies be steady and clear.

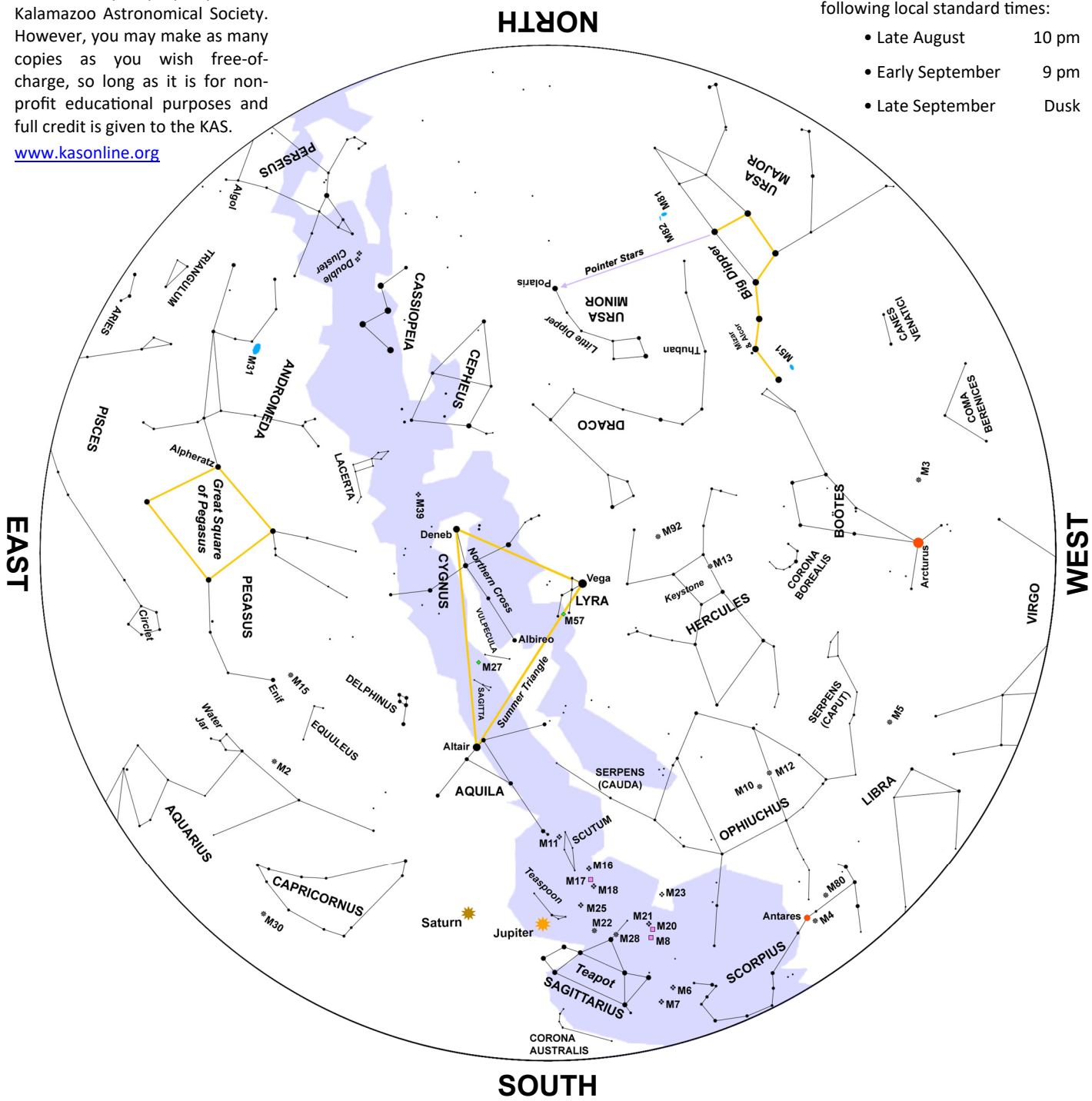
— September Night Sky —

This star map is property of the Kalamazoo Astronomical Society. However, you may make as many copies as you wish free-of-charge, so long as it is for non-profit educational purposes and full credit is given to the KAS.

www.kasonline.org

This map represents the sky at the following local standard times:

- Late August 10 pm
- Early September 9 pm
- Late September Dusk



Mars, heading for its opposition next month, has a very close encounter with a waxing crescent Moon on the night of September 5th/6th. At their closest, just after midnight on the 6th, they'll be 0.7° (44′) apart. The pair will look stunning in both binoculars and telescopes.

Early morning risers can catch the Moon, now appearing as a waning crescent, come within 5° of the brilliant morning star, Venus, on September 14th. Viewing with 7×50 binoculars, you might spot the Beehive Cluster (M44) about 2.5° to Venus' upper left.

The unilluminated portion of a waxing crescent Moon will occult (cover up) Graffias, a 2.5-magnitude star also known as Beta Scorpii, on September 21st. As an added bonus, Graffias is a double star so you'll be able to watch the stars disappear in quick succession. The occultation occurs at ~9:46 pm EDT. The Moon's altitude is only 6°, so you'll need a clear view of the southwestern horizon. The Moon sets before the stars reappear.

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CONTRIBUTE to Prime Focus

Share your passion for the cosmos with your fellow KAS members! Take us on a tour of the night sky or report on a memorable night under the stars. Review a book on amateur astronomy, astrophysics, space exploration, or even the latest gadget. There are limitless possibilities!

Deadline for articles is the 15th of every month. The quality of this newsletter depends on **YOU**!

Member-Only Observing Sessions

Join your fellow KAS members for a pleasant evening under the stars. To ensure the safety of all that attend, we ask everyone to adhere to the following guidelines:

- All attendees are required to wear a mask or other form of facial covering whenever in close proximity to others.
- Maintain at least 6 feet of physical distancing between other attendees whenever possible.
- Eyepieces and high-touch surfaces (such as focusers) will be sanitized after each use. Members bringing their own equipment are required to provide sanitizing wipes.
- If you have a cough or are feeling ill, please stay at home.

September 12th & 26th @ 8:00 pm

Kalamazoo Nature Center • 7000 N. Westnedge Ave.

General Meeting Preview

COSMIC HORIZONS

presented by **Chuck Allen**
Astronomical League Secretary

This program examines the three sets of horizons imposed by planetary curvature, human physiology, and the physical universe. First, Earth's horizon is discussed with attention given to horizon distance calculation, surface drop, and visibility of earth's curvature. Second, consideration is given to distance limitations imposed by human vision, both unaided and aided by binoculars and telescopes, and research into the smallest photon flux detectable by the human eye. Finally, the four horizons of our physical universe — the Hubble Distance, the cosmic particle horizon, the cosmic event horizon, and the future visibility horizon — are discussed in non-mathematical terms along with explanations of how accelerating expansion of the universe creates event horizons, how photons can reach us from regions receding from us faster than the speed of light, how the Hubble constant is not really a constant in time, and how the vast majority galaxies in the observable universe are now unreachable.

Friday, September 11 @ 7:00 pm

Held Online via Zoom

Kalamazoo Astronomical Society
c/o KAMSC
600 West Vine, Suite 400
Kalamazoo, MI 49008

STAMP