http://www.raclub.org/

# The StarGazer

Newsletter of the Rappahannock Astronomy Club No. 4 Vol. 10 February–April 2022

## Processing Your Astrophotos with PixInsight

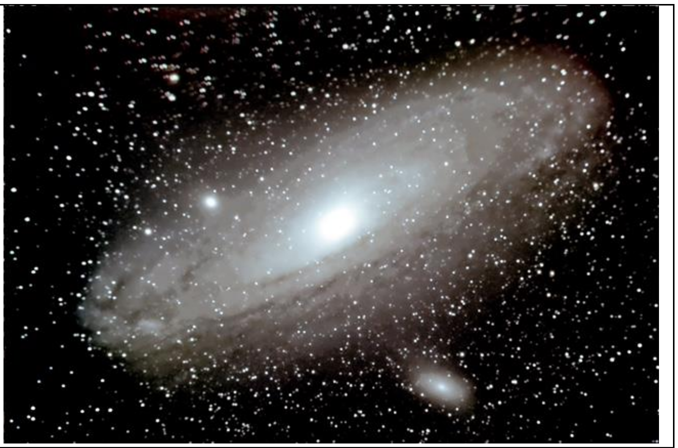
By Troy Major (with Linda Billard)

I recently started using a new program to process my pictures—PixInsight. According to the developer—Pleiades Astrophoto, which is based in Spain—PixInsight is an image processing platform specifically created for astrophotography. It is available natively for the FreeBSD, Linux, Mac OS X, and Windows operating systems. PixInsight is both an image processing environment and a development framework. The platform is a collaborative effort of astrophotographers and software developers that Pleiades Astrophoto claim pushes "…the boundaries of astronomical image processing with the most powerful toolset available." You can find available free downloads on the company's website.

At first, I found PixInsight a little overwhelming. I didn't have a clue where to even start, so I started watching YouTube videos on how and where to start. You can find links to several tutorials here. After a few practice runs processing old data, I couldn't believe the detail I was getting from the stacked pictures.

I had been using Photoshop Express and Lightroom. Although they're pretty good processing programs, they don't come close to PixInsight. A few things really sold me on it. The background modulation and background noise extraction, color calibration, histogram transformation, and intensity transformation are all excellent. Creating star masks was a little challenging; however, I'm still learning. There are about 75 or so programs within the platform that I haven't even opened yet. While it's a learning curve for sure, I've found that I can only do so much with my pictures using Photoshop Express and Lightroom. So far, I'm very impressed with PixInsight. The following examples show what I've been able to achieve with photos of three different targets using only the capabilities I've mastered so far.

Andromeda Galaxy—BEFORE (courtesy: Troy Major)



Andromeda Galaxy—AFTER (courtesy: Troy Major)

*(Continued on page 4)*

# How to Join RAC

RAC, located in the Fredericksburg, Virginia, area, is dedicated to the advancement of public interest in, and knowledge of, the science of astronomy. Members share a common interest in astronomy and related fields as well as a love of observing the night sky.

Membership is open to anyone interested in astronomy, regardless of his/her level of knowledge. Owning a telescope is not a requirement. All you need is a desire to expand your knowledge of astronomy. Most RAC members are from the Fredericksburg area, including, but not limited to, the City of Fredericksburg and the counties of Stafford, Spotsylvania, King George, and Orange. We also have several members who live outside Virginia and have joined to have the opportunity to use the Mark Slade Remote Observatory (MSRO)—one of the benefits of membership.

RAC offers you a great opportunity to learn more about the stars, get advice on equipment purchases, and participate in community events. We meet once a month and hold regular **star parties**. Our website, www.raclub.org is the best source of information on our events.

**Options for Dues Payment**

**RAC annual membership is $20 per family. Student membership is $7.50.** You can pay your dues in two ways. (For reference, the RAC membership year is January–December.) If you join anytime in the last quarter, your membership covers the upcoming year. Astro League dues run July to June.

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Website: www.raclub.org
Groups.io: Members-only group. When you join RAC, you will receive an invitation to join from the RAC President.

***RAC Officers***
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- **By Mail:** Make out a check to RAC Treasurer and send it to Matthew Scott, RAC Treasurer, PO Box 752, Fredericksburg, VA, 22404-0752. Both new and renewing members should also print out the membership application here, fill it out, and return it with their payment to keep our records up to date.
- ***By PayPal***: You can also pay your dues online. Simply go here, scroll down, and select the appropriate membership type from the dropdown box and click *Pay Now*. You do not need to complete an application because the notification the club receives of your payment will contain all the additional info needed. NOTE: If you pay using PayPal, your actual charge (including the PayPal usage fee) will be: Single/Family $21.23, Student $8.28, Single/Family & AL $29.00, Student & AL $16.05.

| Upcoming Events* | |
|---|---|
| Star Party, Caledon State Park | May 30 |
| Star Party, Caledon State Park | June 4 |
| Star Party, Caledon State Park | July 30 |

| Recent Events Completed | |
|---|---|
| Star Party, Caledon State Park | April 2 |
| Star Party, Caledon State Park | April 30 |

*Our Caledon star parties are now public again! However, please check the website raclub.org for updates. To attend a RAC meeting via Zoom, email president@raclub.org for an invitation.

## President's Corner

Dear Members,

RAC's business meetings are now at 8 o'clock rather than 7 o'clock. Presentations will still begin at 7 o'clock and will be announced in advance. Zoom sessions will begin at 7 o'clock even if there isn't a presentation so that members can chat and socialize before the business meeting.

I send Zoom meeting invitations to all RAC members via BCC eMail. Non-members may also participate by sending me a request at president@raclub.org. The invitation will specify the meeting time and whether there is a presentation.

Club meetings are far more interesting when they begin with a presentation. In the past, members have given the presentations. Please consider giving a presentation on a topic that interests you. It can be something that you like or something that you don't like. Perhaps some of you can dust off and update a presentation you gave years ago that many of our new members haven't seen.

May God bless you with transparent skies and excellent seeing.

Glenn Faini
President

## Did You Know?

by Scott Busby

Herschel discovered a small disk moving among the stars in Gemini on March 13, 1781. Initially, there was some uncertainty about whether it was a comet or a planet, but when Finnish Swedish astronomer Anders John Lexell, working in Russia, calculated a circular orbit, the new discovery was clearly a planet. By 1783, Herschel concurred. Herschel's proposed name, "Georgium Sidus" (George's Star) was rejected by astronomers outside Britain, and Johann Bode suggested instead "Uranus," pointing out that just as Saturn was the father of Jupiter, Uranus was the father of Saturn. After the existence of the latest planet was confirmed, earlier reports and observations were found in the record by Hipparchos in 128 BCE; by the British Astronomer Royal, John Flammsteed, who observed it at least six times by 1690; and by the French astronomer Pierre Limonnier, who observed it at least twelve times between 1750 and 1769.

**Source**: *Gerard P. Kuiper and the Rise of Modern Planetary Science,* Derek W. G. Sears, The University of Arizona Press, 2019.

## *Processing Your Astrophotos with PixInsight (Continued from page 1)*

Sombrero Galaxy—BEFORE (courtesy: Troy Major)

Sombrero Galaxy—AFTER (courtesy: Troy Major)

Flame and Horsehead Nebulae—BEFORE (courtesy: Troy Major)

Flame and Horsehead Nebulae—AFTER (courtesy: Troy Major)

## Astronomy Math—The Next Level (TNL)

By Scott Busby

In our solar system, planets orbit about the Sun in ellipses with the Sun at one focus (Kepler's first law). If you draw a radius vector between the Sun and a planet, that line will sweep out equal areas in equal times. (This is Kepler's second law.) When a planet moves close to the Sun, the vector is short ,causing it to sweep out a given area as it moves out a comparatively large angle. When a planet is farthest from the Sun, the radius vector is long, and it will have to move through a smaller angle to sweep out the same area.

Kepler's second law describes the way a planet speeds up and slows down when approaching or moving away from the Sun. If you suddenly increased the planet's velocity at some point in its orbit, you would be throwing it away from the Sun. It would be moving at steadily decreasing velocity, come to a halt, and then start falling toward the Sun again. The farthest point from the Sun that a planet moves is a point where the planet's velocity has steadily decreased and then suddenly increases. This is the planet's maximum distance from the Sun (aphelion).

As the planet continues in its orbit, it increases its velocity, and when it is closest to the Sun (perihelion), its orbital velocity is maximum. The greater the velocity at the perihelion distance, the more elongated the elliptical orbit. As velocity increases incrementally, the elongation of the ellipse also increases at greater and greater rates because as the aphelion recedes, the strength of the Sun's gravity weakens, and it can do less and less to prevent further recession.

At some particular velocity and given perihelion distance, the ellipse elongates to infinity—that is, becomes a parabola. A planet in a parabolic orbit will recede from the Sun never to return. This velocity is the called the *escape velocity*, and it can be determined for any given planet by multiplying the mean orbital velocity, as shown in the last newsletter, by the square root of 2; that is, by 1.414. The result is shown in the table at right.

| Planet | Escape Velocity (Miles Per Second) |
|---|---|
| Mercury | 42.1 |
| Venus | 30.7 |
| Earth | 26.2 |
| Mars | 21.2 |
| Jupiter | 11.6 |
| Saturn | 8.5 |
| Uranus | 5.9 |
| Neptune | 4.8 |
| Pluto | 4.1 |

If the Earth, for whatever reason, ever moved at 26.2 miles per second or more, it would leave the solar system forever. Rest easy, however, for it would take the invasion of an errant star to cause that apocalypse.

## Webinar Review: *Searching for Other Earths*

By Bart Billard

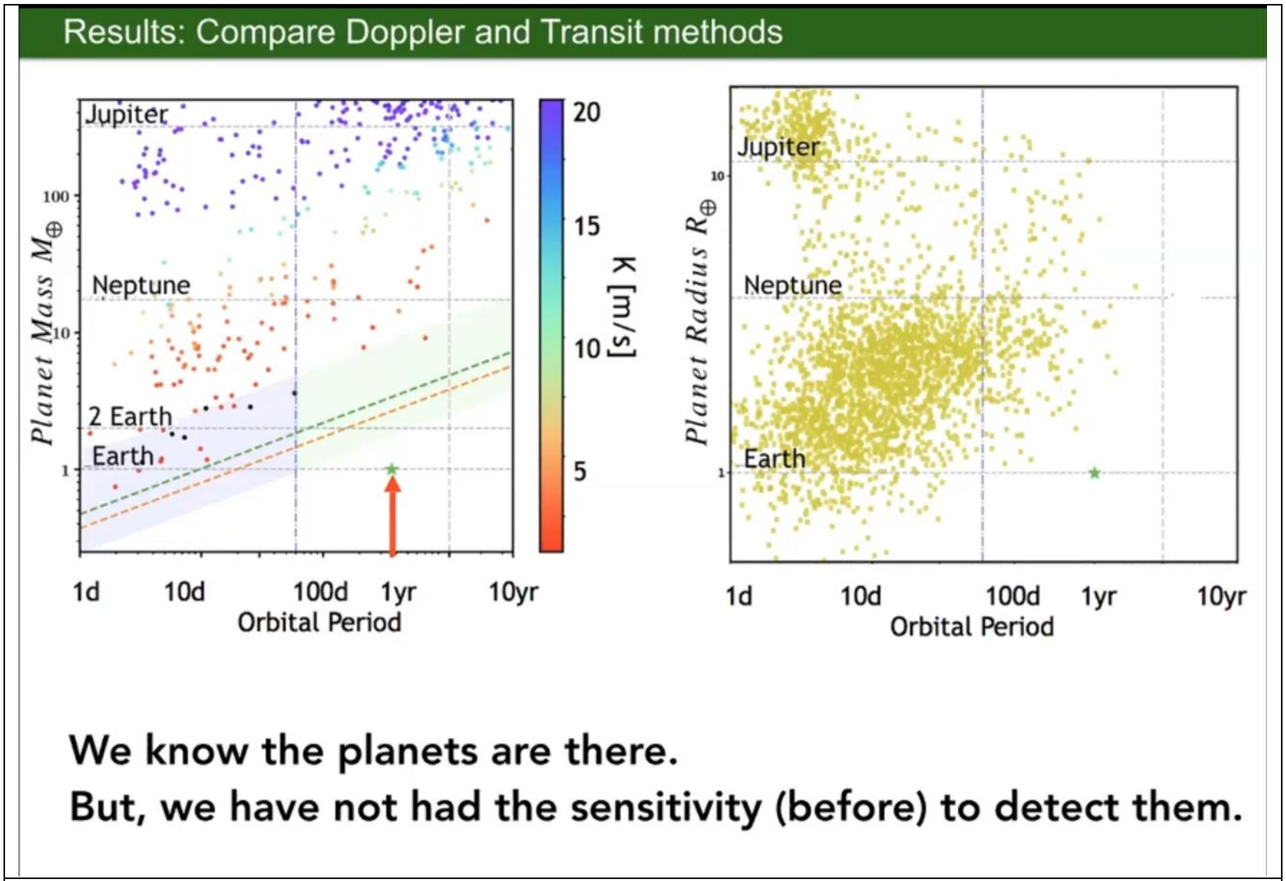
Because some recent RAC meetings have not included a presentation, my minutes have not been a source of as many items for *StarGazer*. Consequently, I decided to contribute to this issue by finding an online astronomy presentation that would interest *StarGazer* readers. I did not watch this one live but viewed the recording.

Yale Astronomy Professor Debra Fischer is a co-principal investigator of the team that developed EXPRES—the EXtreme PREcision Spectrograph—now operating at the Lowell Discovery Telescope (LDT). LDT, the fifth largest telescope in the continental United States, is located southeast of Flagstaff, Arizona. Fischer gave this lecture 2 years ago at the Yale Club of Chicago as a webinar rather than in person because of COVID. The recording is available here. EXPRES is the third instrument her team has built. The first (called CHIRON) is in Chile and the second in Lithuania.

Fischer's presentation focuses on the search for exoplanets, motivated by the question of whether life could exist outside our solar system. About 1990, the prevalence of planets orbiting other stars was widely doubted in the face of lack of evidence. The first discovery was 51 Peg in 1995. It was found using spectroscopy for Doppler shift measurements of radial velocity (motion toward or away from us during orbits) to find the "wobble" of a target star caused by a Jupiter-class planet in a very close orbit.

Over the next 20 years, the Doppler measurements improved such that some Earth-class planets in very close orbits of their stars could be detected. During that time, astronomers also developed the transit detection method. It detects a planet whose orbit passes in front of its star from our point of view, dimming the light briefly once during each orbital period.

In 2009, NASA launched the Kepler mission to use the transit detection method. It succeeded in detecting thousands of exoplanets. The statistical picture generated by the end of the Kepler mission indicated that *most stars have planets*. However, Professor Fischer showed graphs that illustrated that discovering truly Earthlike planets—those with low mass combined with periods on the order of a year—was still unlikely using either the Doppler or transit detection methods. The figure below is her slide showing the distributions of planets found with each method. In particular, you can see the transit method suffers because the farther a planet's orbit is from its star, the less likely that orbit will pass in front. Also, to capture transits, observation times must be much longer than the orbital period.



Results: Compare Doppler and Transit methods

We know the planets are there.
But, we have not had the sensitivity (before) to detect them.

Slide from Prof. Debra Fischer's webinar presentation *Searching for Other Earths*. The plot on the left shows the distribution of planets discovered by the Doppler method according to mass and orbital period. The one on the right shows the distribution for the transit method according to radius and period. Both have horizontal dashed lines added to indicate the equivalent size (mass or radius) of Jupiter, Neptune, and Earth. Prof. Fischer also added a blue star to each plot showing where Earth's size and orbital period falls. (Source: https://vimeo.com/421207358)

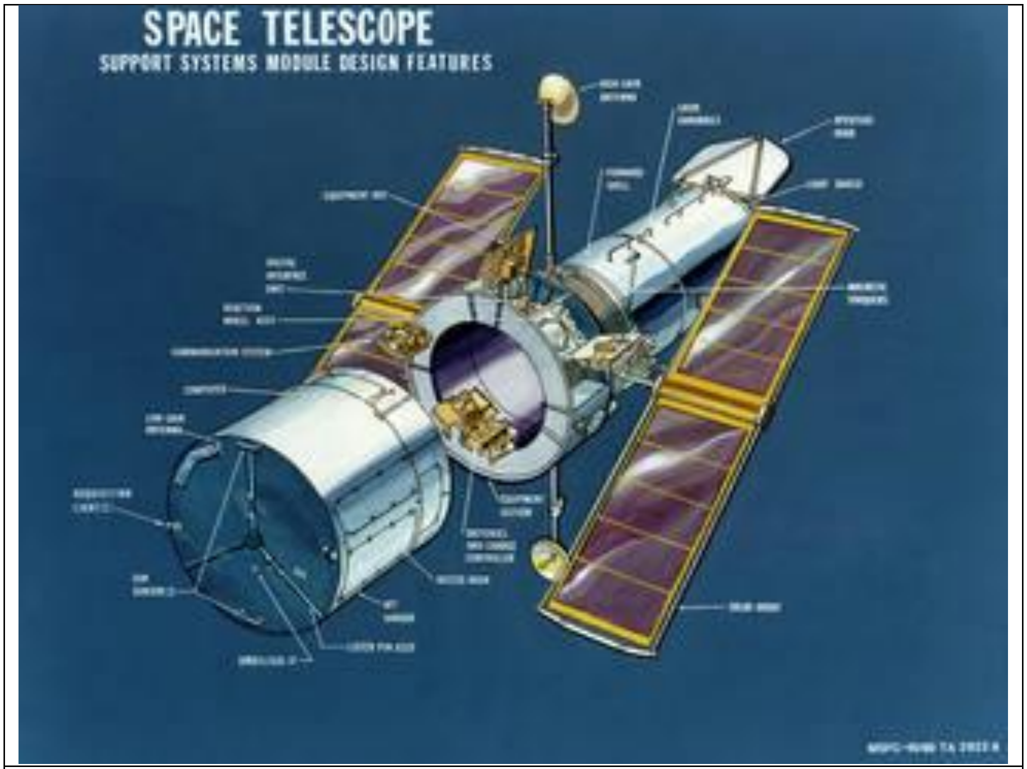
Fischer's team concluded that higher precision spectroscopy was needed to assess whether the radial velocity technique could overcome the velocity noise caused by turbulence in stars' atmospheres and improve sensitivity enough to detect true Earth analogs. Precision grew from approximately 10 m/s in 1995 to approximately 1 m/s a few years before this presentation. The goal for EXPRES is to improve precision to approximately 20 cm/s. The first year of data has shown marked improvement in sensitivity.

Prof. Fischer began her presentation by illustrating "your place in space and time" inspired by Carl Sagan, followed by a discussion of whether other stars have planets and how we know. Her presentation was interesting, and I don't think the technical content was excessive. If you look at the figure above and understand how it supports the idea that these search methods have worked better for larger planets and/or shorter orbit periods, you will enjoy viewing the entire presentation.

# A Short History of Hubble: Big Bang, Big Bucks, Big Screw-Up, Big Comeback

By Linda Billard

Did you know that April 24 of this year was the 32nd anniversary of the launch of the Hubble Space Telescope (HST)? In its years of service, Hubble has taken more than 1.5 million (that's million!) observations, which have become the basis of more than 20,000 publications. These publications have addressed subjects as close to us as the Moon and as distant as remote galaxies. But, according to *APS News*, the life of HST has been the rollercoaster ride that is "big science"—large, collaborative, high-dollar projects funded by government. A comment attributed to a *New York Times* writer in the 1990s pointed out that for science to make news at that time, "It has to involve big bang, big bucks, big screw-up, or big comeback…Hubble, of course, had them all."



This concept drawing from 1980 shows the original design features of Hubble and its Support Systems Module, which includes the communication equipment, pointing and control systems, and computer. Credits: NASA

**Big Bang, Big Bucks.** Whose idea was HST anyway? In 1946, astrophysicist Lyman Spitzer first outlined how a space-based telescope would avoid the turbulence of the Earth's atmosphere to better capture wavelengths outside the visible spectrum. One of the most important contributors to bringing this idea to fruition was Nancy Grace Roman, now referred to as "the mother of Hubble." Acclaimed in a time (1959) when there were few female astronomers, Dr. Roman became NASA's first chief of astronomy. She is credited with creating an atmosphere of collegiality between her agency and academia. In 1971, she convened a steering committee of NASA engineers and U.S. astronomers to design a space telescope that NASA could deploy. Her lobbying and congressional testimony about the value of such a project initially failed, but she did not give up. In 1977, Congress finally funded the "Large Telescope Project." The design featured a 7.8-foot, 1,825-pound primary mirror, as well as a wide-field camera, a high-resolution spectrograph, and a high-speed photometer.

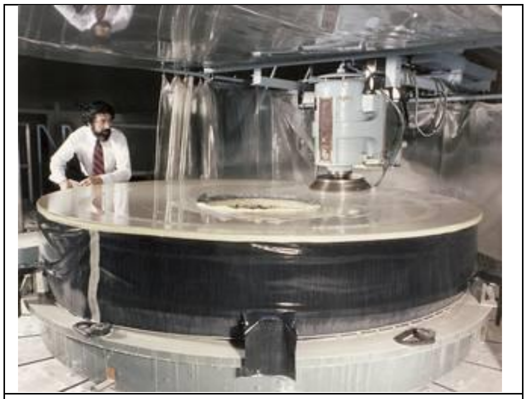
The launch date was delayed from 1983 to 1986 as a result of engineering challenges and delayed again to

**Update on the JWST:** In early April, the last of the James Webb Space Telescope's (JWST) scientific instruments reached operating temperature, which, for the Mid-Infrared Instrument (MIRI), is a whopping –447 degrees Fahrenheit! The low temperature is necessary because all of Webb's instruments detect infrared light—wavelengths longer than those that human eyes can see. Distant galaxies, stars hidden in cocoons of dust, and planets outside our solar system all emit infrared light. However, so do other warm objects, including Webb's own electronics and optics hardware. Cooling down the four instruments' detectors and the surrounding hardware suppresses those extraneous infrared emissions. MIRI detects longer infrared wavelengths than the other three instruments, which means it needs to be even colder. The entire process was heavily rehearsed and tested. Unlike Hubble, there is no option to send a service team of astronauts to fix problems. All problems must be addressed remotely or not at all.

1990 owing to the Challenger disaster. However, the setbacks didn’t end there.

**Big Screw-Up**. When the first-light HST images arrived, they were blurry and out of focus—certainly not what was expected of such a sophisticated and expensive instrument. The primary mirror had been ground too flat by 2 microns. The storm of criticism when this problem reached the media made the program the butt of late night TV show jokes and an unpleasant congressional hearing about who was at fault.

**Big Comeback.** Fortunately, two clever fixes averted total disaster, not only for HST but for NASA. Before the problem was discovered, work had begun on a second-generation camera that was to be installed in a future servicing mission. Corrective optics were added to this camera, and the COSTAR device was developed to refocus the light coming from the existing mirror so it would be properly focused when it reached the other HST instruments. The replacement camera and COSTAR device were installed in an 11-day mission, with a record five spacewalks. This risky mission was a success—the first images from the updated HST were perfect.



Hubble Space Telescope's primary mirror being ground at the Perkin-Elmer Corporation's large optics fabrication facility in 1979—more than a decade before its very small but very significant flaw was discovered.

At launch, the life expectancy of Hubble was 15 years. Now—2 years past twice that age—HST is expected to continue working until at least the 2030s, when it will be brought back to Earth. Although any piece of machinery this old will have aging parts, NASA has no more servicing missions scheduled. However, a dedicated team of engineers and scientists works to keep Hubble operating. For example, engineers have found a way to allow the telescope to operate with only one gyro by using other types of sensors on the spacecraft to make up for gyros that have failed. This and other innovations designed to extend the lifetime of Hubble’s equipment will keep the telescope exploring for at least another 10 years.

## Building a Permanent Outdoor Pier

By Troy Major

At the end of March, I completed a new outdoor pier for my telescope. First, I formed up a 3-ft x 3-ft x 8-inch frame. I put rebar in and set 4-1/2-inch anchor bolts in the concrete after attaching them to a plywood template of the bottom of a hollow parking lot post. The post is made from ¼-inch thick steel, which is more than strong enough to carry anything I can mount on it. My pier extension fit down into the pole perfectly, so there was no need for welding. I drilled and tapped a ¼-inch bolt to tighten the extension after I got it set to due north at Polaris. I then mounted my atlas eq-g mount and my lx 90 10-inch Meade telescope on it. I balanced the setup, and it works great. As soon as I get the time, I’ll build a roll-off roof—I already have the tracks and materials. In the meantime, I keep everything covered with a big piece of rubber with a tie down tarp over it.

# Image of the Quarter: Sun Animation

By Scott Busby

Note: This is our second video "image of the quarter." Click on the link below and read Scott's description. This link will download the video onto your local machine, so you need to open it with your video player.
**Link to video:** Ha-Sun occultation

**Description from Scott:**

I combined a stacked white-light image of Sol with a stacked hydrogen-alpha (Ha) filter image and then built an animated gif of a transition between the two images. I took the white-light image with the TOA150 refractor with a ZWO ASI 1600mm camera. I took the Ha image with a Coronado 60mm Ha scope piggy-backed on the 150. Both scopes were mounted on a Losmandy G11 in solar tracking mode.