AOH Newsletter

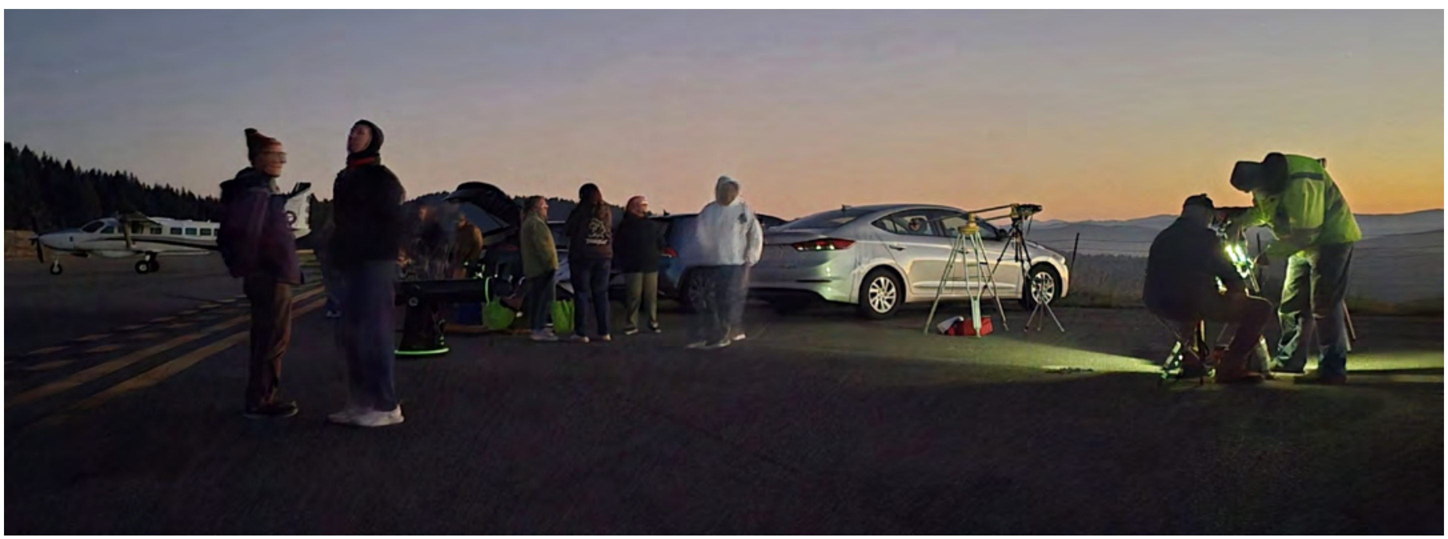
Winter 2026

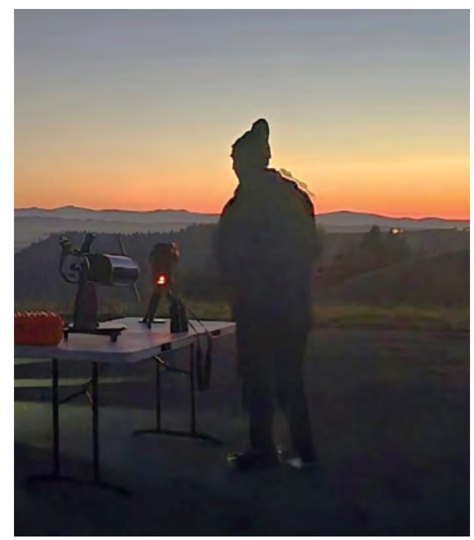
News and Notes

October at Kneeland

October brought clear skies for our regular monthly viewing session. The sky was cloudless and the weather was mild, with no wind. We had a nice crowd, a collection of scopes and binoculars, and two Seestars.

Right: Scopes of all sizes —Ken Yanosko.
Below: Setting up at dusk —Johnny Thomas.





Even the Solar System cooperated by sending us two comets. Comet A6 (Lemmon) was discovered in January and slowly brightened to magnitude 5.6 with a significant tail. Comet R2 (SWAN) was discovered in September and reached magnitude 6.0 with a definite greenish color.

Left: A6 (Lemmon) —Catrina Howatt. Right: R2 (SWAN) —Susan Coy.

A pair of emission nebulae. Left: NGC 6888 "The Crescent Nebula". Right: NGC 281 "The Pacman Nebula". —Catrina Howatt.

A half-dozen astronomers, standing still, in the dark, for a 30-second time exposure: Johann, Allison, Sana, Catrina, Brent, and Yoon. —Ken Yanosko.

College of the Redwoods Science Night

AOH returned to participate in the CR Science Night activities. We set up a roomful of displays and crafts for kids and grownups. We had a solar system model with planets scaled to a one-meter Sun, a gravity well, posters of deep-space objects, and our ever-popular planet masks. Outside we offered a telescopic view of the Moon.

Two "planets" orbiting the Sun, and Grace demonstrating a gravity well. —Catrina Howatt.

Mark explaining how telescopes work, and Johann and Allison demonstrating how telescopes work. —Grace Wheeler.

Outreach at Redway Elementary

Roger and Susan Coy gave two presentations at Redway Elementary School on the Sun and the Solar System, and set up a Seestar at recess for solar observing. They had about 350 students.

Roger at Redway. —Susan Coy.

Brent at Kneeland explaining the technology of the Newtonian telescope. —Catrina Howatt.

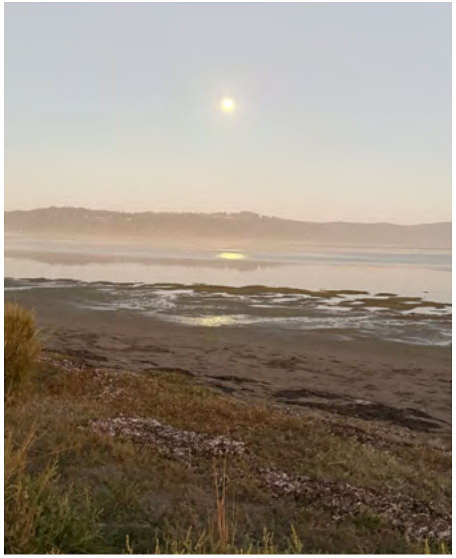
Outreach at Kneeland Elementary

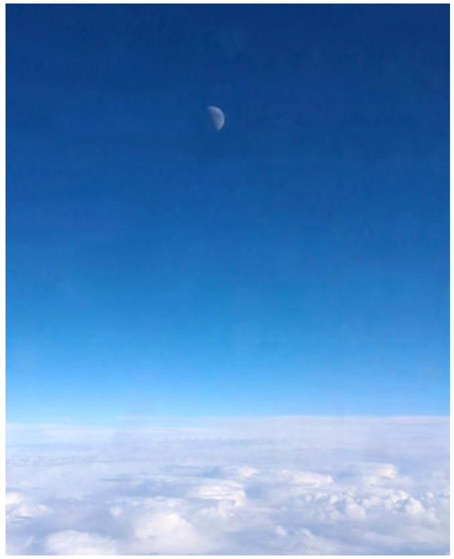
Brent, Catrina, Mark, Bernie, Allison and Johann represented AOH at the Kneeland Elementary Fall Festival/Trunk or Treat event. We had hoped to open the observatory for show and tell or to set up a scope to observe the afternoon Moon, but rain made both of these impossible. Instead a couple of tables were set up along the covered walkway. Brent was able to demonstrate the workings of the mini-Dob telescope. Mark gave a lesson on Meteorites and Meteorwrongs. And planet masks and NASA photos were handed out,

Allison, Johann, and Brent with handouts at Kneeland. —Catrina Howatt.

International Observe the Moon Night

We collected photos sent in to our "virtual" IOMN event. In addition, Mark set up a scope in McKinleyville for an in-person event.





Clockwise from above:

Ashley and Elizabeth were in Southern Humboldt. —Ashley Kreuger.

Ken was flying home, somewhere above Canada. —Ken Yanosko.

Youngest club member Ripley was helping Mark at Pierson Park in McKinleyville. —Rachel Wagenfuhr.

Annual AOH Pizza Party and General Membership Meeting and Board of Directors Meeting

The Club held its traditional November meetings at Round Table in Eureka. Minutes of the business meetings are online at https://www.astrohum.org/members_only/reports.php. The elections of Board members and officers were held; all current office-holders were re-elected for 2026.

President Brent presiding over the AOH business meetings. —Ken Yanosko

Arcata Library Display

The Arcata Library, which hosts three Starblast telescopes (tabletop Dobsonians) in their for-loan collection, has set up a display consisting of astronomy posters and handouts together with one of the telescopes. See the library catalog at https://humbc.na2.iiivega.com/search?query=telescope%20loan%20program to check on availability.

—Mark Wilson

November at Kneeland

November brought another clear Saturday night and a pretty good crown went up to Kneeland with telescopes, binoculars, and cameras on hand. The air was moist and it didn't take long for the temperature to drop below the dew point, but we held our own against the elements.

Visual observers setting up under the crescent Moon; astrophotographers Susan and Oliver getting ready to shoot. —Ken Yanosko.

Above: Part of the Veil Nebula in Cygnus. —Mark Wilson.
Below: Messier 39, The Pyramid Cluster in Cygnus and spiral galaxy Caldwell 30 in Pegasus. —Susan Coy.

Zoom

Our October Zoom meeting was attended by Allison and Johann, Brad, Brent, Chris, Greg, Ken, Mark, Mary, and Yoon. A good time was had by all.

Welcome Back, Greg

Former Board member Greg Deja, who moved away in 2019, has come back to Humboldt County. He expressed a desire to return to Club service, and since the Board is not at its maximum size as permitted by the bylaws, the Board voted to seat Greg on the Board for 2026.

AOH Telescope Workshop

AOH is planning a Telescope Workshop for community members (all those people who tell us they have a telescope at home in the closet but don't know how to use it). We've scheduled it for Saturday, January 31, from 1 to 3 pm at the Eureka Library. Look for a link to a flyer on our website, and let Ken (ken@astrohum.org) know if you are available to help out.

AOH Potluck

Save the date! We will have our annual potluck and astronomy lecture on Saturday February 21. Once again we will be at the Eureka Woman's Club, 1531 J St, in Eureka, Watch the website for details.

Albee Creek Star Parties

Save these dates, too! This summer we will have two Albee Creek Star Parties, on July 18 and August 15. More details will be forthcoming as the dates draw nearer.

Artemis Boarding Passes

NASA is issuing "boarding passes" for its upcoming Artemis II flight around the Moon, which is currently scheduled for an April 2026 liftoff. The pass doesn't get you a seat on board, but does get your name added to a "passenger list" to be carried on board the flight. You can register (for free) at https://www3.nasa.gov/send-your-name-with-artemis/. The deadline is January 21.

Online Astronomy Classes

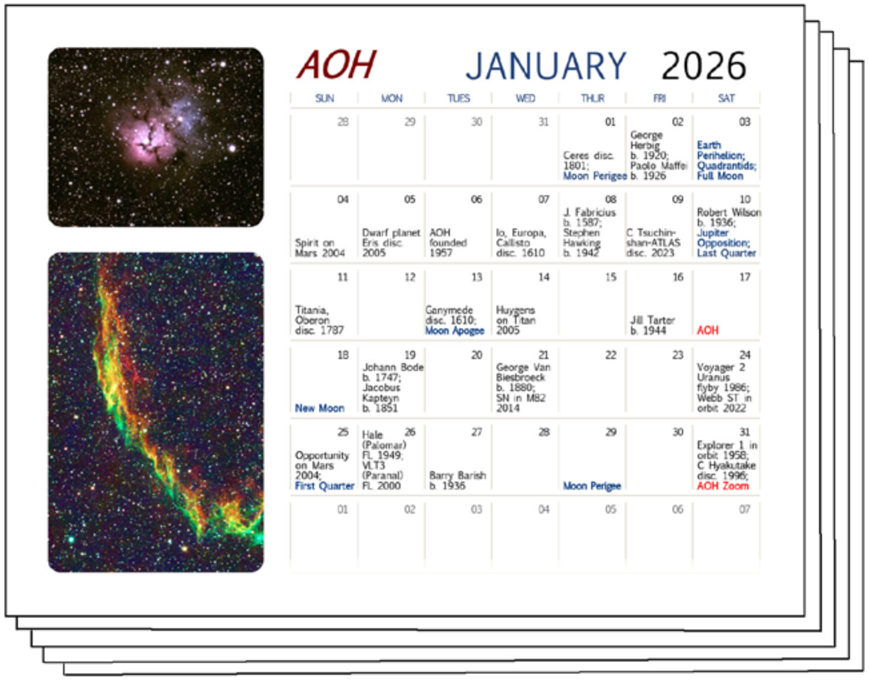
Our friends in Kalamazoo are once again offering a free online five-part "Introduction to Amateur Astronomy" lecture series in early 2026. The dates and topics are:

January 17th	Our Place Among the Infinities
January 31st	Discovering the Night Sky
February 14th	Binocular Basics
February 28th	Telescope Tutorial
March 14th	The Art of Astrophotography

All lectures are scheduled for 1–3 pm eastern time (that's 10 am–12 noon pacific). You can register at the Kalamazoo Astronomical Society's website at https://www.kasonline.org/amastro.html. This is an introductory-level program, and new or novice club members are especially welcomed.

AOH Calendar

The AOH Calendar is now available for club members to download from https://www.astrohum.org/members-only/calendar.php. It lists dates of scheduled AOH activities as well as current astronomical events and important historical events.



AOH JANUARY 2026

SUN	MON	TUES	WED	THUR	FRI	SAT
28	29	30	31	01 Ceres disc. 1801; Moon Perigee	02 George Herbig b. 1920; Paolo Maffei b. 1926	03 Earth Perihelion; Quadrantids; Full Moon
04 Spirit on Mars 2004	05 Dwarf planet Eris disc. 2005	06 AOH founded 1957	07 Io, Europa, Callisto disc. 1610	08 J. Fabricius b. 1587; Stephen Hawking b. 1942	09 C Tsuchinshan-ATLAS disc. 2023	10 Robert Wilson b. 1936; Jupiter Opposition; Last Quarter
11 Titania, Oberon disc. 1787	12	13 Ganymede disc. 1610; Moon Apogee	14 Huygens on Titan 2005	15	16 Jill Tarter b. 1944	17 AOH
18 New Moon	19 Johann Bode b. 1747; Jacobus Kapteyn b. 1851	20	21 George Van Biesbroeck b. 1880; SN in M82 2014	22	23	24 Voyager 2 Uranus flyby 1986; Webb ST in orbit 2022
25 Opportunity on Mars 2004; First Quarter	26 Hale (Palomar) FL 1949; VLT3 (Paranal) FL 2000	27 Barry Barish b. 1936	28	29 Moon Perigee	30	31 Explorer 1 in orbit 1958; C Hyakutake disc. 1996; AOH Zoom
01	02	03	04	05	06	07

Dues

Dues for 2026 are now due. It's $25 per family. Use the form at https://www.astrohum.org/membership.html. You can either pay online or mail in a check.

Thanks

Thanks to Allison, Ashley, Catrina, Grace, Johnny, Mark, Rachel, Susan C, and Susan F for your help putting together the Newsletter.

—*Ken*

The Winter Solstice

by Allison Waltberg

Happy solstice! 'Tis the season to be jolly, with a wide variety of winter solstice holidays all over the world to choose from. But what is a solstice, anyway? And why does everyone celebrate it?

Imagine you carefully tracked the direction of the sunrise each day over the course of the year by standing in the same spot every morning and marking where the sun first breaches the horizon every day. Over a full year, you'll see the *azimuth* of the sunrise (that is, its angle from north along the horizon, like a compass bearing) changing over the course of the year: it swings between the northeast in June and the southeast in December. When the sunrise is close to due east, the azimuth changes quickly from day to day, but as it approaches the extreme northernmost and southernmost points, the sunrise shifts less and less each day until it eventually stops and reverses direction. This is what gives the solstice its name, from the Latin *sol* (sun) and *stitium* (stoppage).

The changing sunrise azimuth isn't a mere astronomical curiosity, though—it's the whole reason that calendars exist, and literally the reason for the seasons! The time the sun takes to make a full trip and return to the same point is called a tropical year, and that period is the basis for the modern Gregorian calendar. Initially developed by the Catholic Church to correct for the Julian calendar's "drifting" spring equinox, its goal was to keep the equinox's date on or close to March 21, which would simplify their calculation of the date of Easter (which relies on moon phases relative to the equinox). Its 97 leap years per 400 years produce an average year length of 365.2425 days, a closer approximation to the fractional part of the mean tropical year than the Julian calendar's 365.25 days. It will drift out of sync much more slowly, so more than a thousand years from now in 3200 AD, the Gregorian calendar is estimated to be less than a day behind the sun.

Anyway, back to the winter solstice and what it means for people living in different places on Earth. On December 21, 2025, someone standing exactly on the Tropic of Capricorn, at latitude 23.4°S—perhaps near Alice Springs in the middle of the Australian Outback, or in the northern suburbs of São Paulo, Brazil—will be observing their summer solstice and longest day of the year. The sun will cross the zenith (directly overhead) around midday, resulting in their latitude's one and only "zero shadow day" of the year.

Meanwhile, Santa's employees at the North Pole are frantically finishing their last-minute Christmas preparations in the dark. They're midway through the silent night that lasts half the year: the sun set back in September, and it won't rise again till March. The solstice is their midnight clear, as dark as it ever gets. (Luckily, Rudolph's red-flashlight nose won't ruin their night vision!) Beginning today, the sun will start its gradual 3-month-long spiral toward its annual sunrise.

For most of the earth's population, neither extreme is true; the sun's daily arc is simply at its farthest south in the sky today. It rises in the southeast and sets in the southwest, and at local solar noon, it's at its southernmost point along the meridian. Here in the temperate northern latitudes, it means the sun stays low in the southern sky even at midday, giving us our shortest day and longest night of the year. Shorter days mean less heat from the sun, which is what makes the weather outside so frightful.

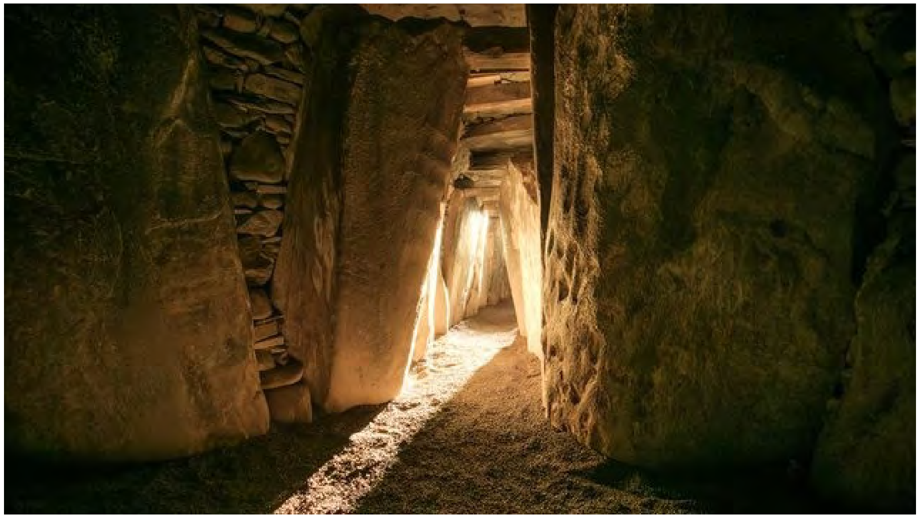


Figure 1. Newgrange. Source: National Museum of Ireland (https://www.museum.ie/en-ie/collections-research/irish-antiquities-division-collections/irish-antiquities-articles/the-winter-solstice-at-newgrange).

Figure 2. Karnak. Source: Explore Luxor (https://exploreluxor.org/winter-solstice-sunrise-at-the-karnak-temple/)

Because it's the turning point in the year when the days stop getting shorter and start getting longer, the solstice held great significance for ancient people. To cultures all around the world, sunrise on the winter solstice represented the rebirth of the sun and the return of joy to the world. The date was celebrated with festivals and rituals centering on the local sun deity.

Some cultures built monuments that precisely align with the sunrise on the winter solstice to ensure the date was properly marked. Two of these that are still standing are Newgrange, a Neolithic burial mound in Ireland older than both Stonehenge and the Pyramids, and Karnak, a sprawling complex of ancient Egyptian temples in the modern city of Luxor (historically called Thebes).

Newgrange (Figure 1) is a huge mound with a 19-meter-long stone passageway to a chamber with a carved altar. Just above the entrance is a window called a "roofbox" just large enough to allow sunlight to enter. The passageway is oriented southeast to northwest such that on the winter solstice, the sunrise shines through the roofbox and decks the halls all the way back to the burial chamber.

Karnak (Figure 2) is filled with courtyards, shrines, columns and obelisks, and huge stone gates called pylons, lining a straight central pathway more than a third of a mile long. The pylons and pathway are aligned to allow sunlight to travel its entire length at sunrise on the winter solstice.

If you were to look at these locations on Google Maps' satellite view, the first thing you might notice is that their northwest-southeast axes are at different angles. Their sunrise angles are different because they're at different latitudes. This is what I think is particularly cool: when ancient cultures thousands of years ago built these enormous structures, they likely had to determine the required angle by directly observing the sun shining in the east. I

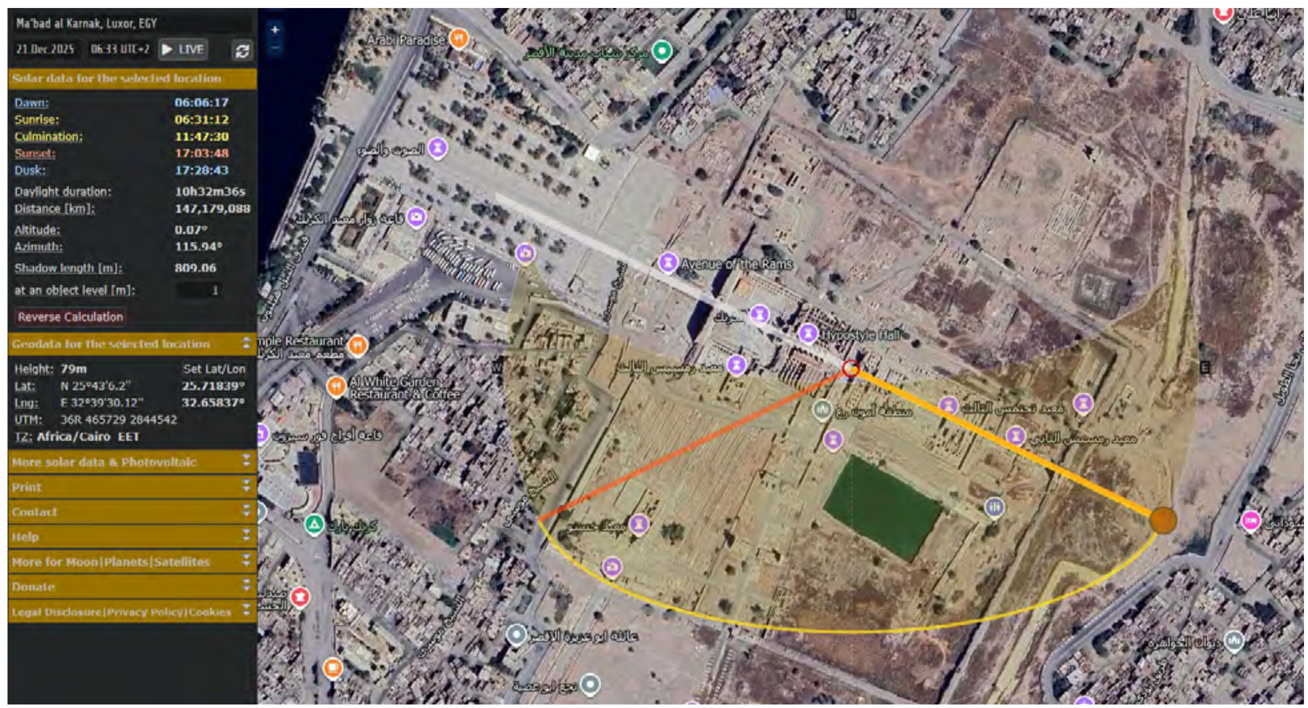


Figure 3 (above, right). Satellite view of Newgrange, with the direction of sunrise on 21 Dec 2025 superimposed. Source: https://www.suncalc.org.

Figure 4 (below, right). Satellite view of Karnak Temple, with the direction of sunrise on 21 Dec 2025 superimposed. Source: https://www.suncalc.org.

imagine this involved waking up before dawn, freezing in the frosty air, and moving big rocks around. I much prefer staying warm and sleeping in, so thousands of years later, we can conspire to do some math by the fire!

The azimuth (α) of an astronomical object is a trigonometric function of the object's declination (δ) and the observer's latitude (ϕ): $\alpha = \arccos(\sin(\delta)/\cos(\phi))$. At the winter solstice, the sun's declination is at its maximum southerly extent δ=-23.4°, meaning the only variable is the latitude. Applying this formula to our locations we get the following.

Up in Ireland, Newgrange (Figure 3) is at latitude ϕ=53.7° which works out to an azimuth angle of α = 131°.

Meanwhile, almost 3,000 miles southeast in Egypt, Karnak (Figure 4) has latitude ϕ=25.7° and α = 116°.

But there's no place like home for the solstice! Are there any "monuments" aligned with the winter solstice sunrise here in Humboldt?

Eureka is at latitude ϕ=40.8°, so our sunrise azimuth is α = 121.6°. I explored the map and found a pretty close match to that angle: almost a mile of 101 South between McKinleyville and Arcata, just north of the bridge over the Mad River (Figure 5).

If you'd like to channel your Neolithic sun-worshiping ancestors in a new old-fashioned way, you could arrange to be driving that particular stretch of highway around 7:40 in the morning on December 21. If the sky is clear (never a safe bet around here), at the moment of sunrise your car will be perfectly aligned to fill with sunlight and blind you.

On second thought, maybe that's not a great idea. Be careful out there, and have yourselves a merry little solstice!

Figure 5. There's no place like home.
Source: https://www.suncalc.org.

Allison Waltberg celebrates the solstice at home in Kneeland and participates in AOH outreach events all over Humboldt.

Saturn Observations Fall 2025: Transits, Opposition, and Disappearing Rings

by Grace Wheeler

Titan Transits

The 2025 Titan transit season came to an end in the fall with three notable transits on September 3, September 19, and October 5. These were transits where both Titan and its shadow were transiting the disk together. The October 5th transit would be the last shadow transit visible in North America until 2038.

On September 3, the shadow was transiting just below the north polar region (Fig.1). Titan was above Saturn, and the orbital path brought it to the limb of the north pole where a fraction of the moon transited the Saturnian disk in a partial transit (Fig.1C). A simulation of Titan's partial transit is shown in Winjupos, a planetary ephemeris program (Fig.1D). A time-lapse of the transit is shown here: https://youtu.be/76eXAY8wVSk.

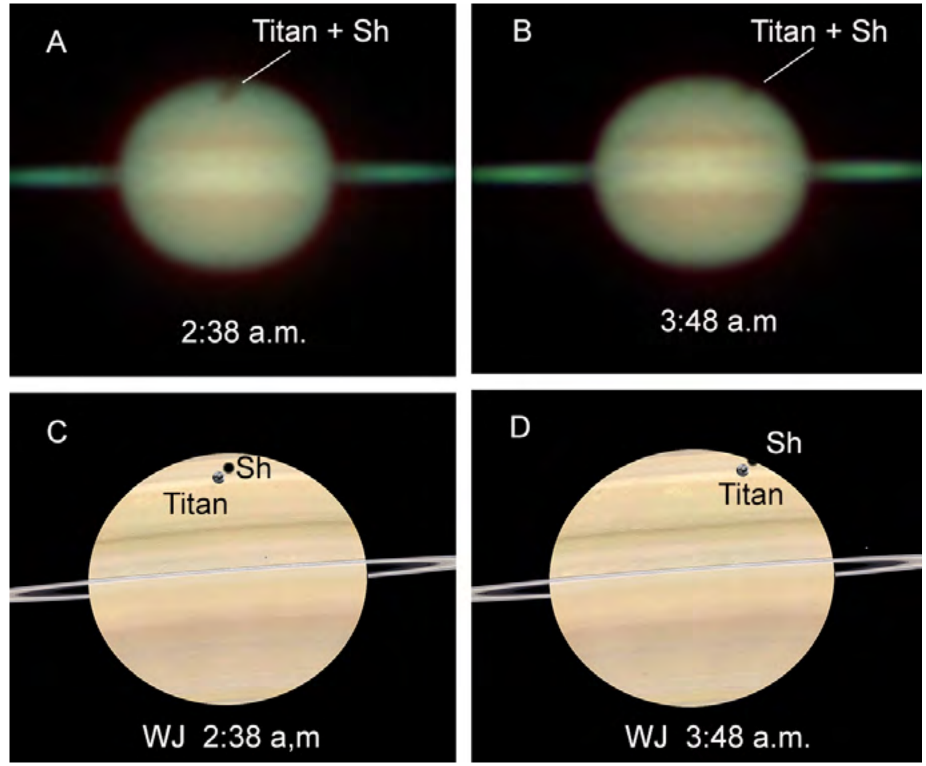


Figure 2. The transit of the moon Titan and its shadow (Sh) on the Saturnian disk on September 20, 2925. The top images (A, B) were taken with a 6-inch F/12 refractor telescope. Corresponding images were generated in Winjupos (C, D). Image credit: Jenny Cartie, Winjupos.

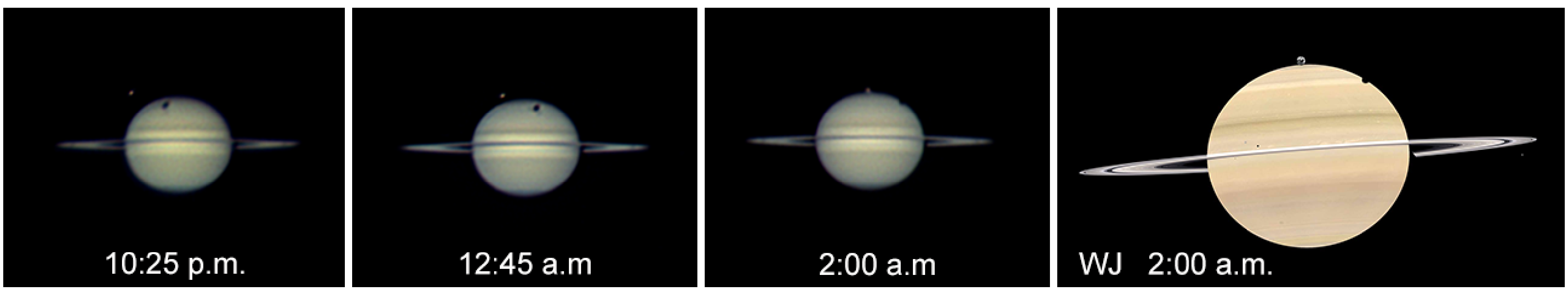


Figure 1. Shadow Transit/Partial Transit of Titan starting on 9/3/2025. The figure shows the shadow transit of Titan in the northern hemisphere, and transit of the moon Titan at the north pole. (C) shows the partial transit of Titan at 2:00 a.m. (D) is a simulation of the partial shadow transit in Winjupos (WJ). Image Credit: GDW; Winjupos.

The September 19 transit occurred about three days before opposition. This was the transit that I was most interested in, as both Titan and its shadow were transiting the disk simultaneously. I was unable to view the transit because of the rain in Humboldt County. Fortunately, the transit was livestreamed by the Kopernik Observatory in New York state: https://www.youtube.com/watch?v=tr02aZVvnxY. Staff astronomer Jenny Cartie started the broadcast at 12:30 a.m. EDT when Titan and its shadow were halfway through their transits in the north polar region (Fig. 2A). We followed the progress of the transits until it ended at 3:48 a.m. (Fig. 2B). During the broadcast, enhanced images of the transiting Titan and its shadow were shared on the screen. Unfortunately, Titan and its shadow were not well resolved. To clarify the event, the program Winjupos was used to simulate the transit of Titan and its shadow (Fig 2C, D).

A time-lapse of the transit from the Kopernik Observatory can be seen at https://youtu.be/vt1nWyRXVaM?si=b6wLUrmxhE4f5zEq. A time-lapse of the transit as seen with a 12-inch Dob, in which both Titan and its shadow are resolved, is at https://app.astrobin.com/i/h4wxke/.

For the October 5th transit (Fig. 3), the moon Titan was seen transiting the disk in the northern hemisphere. Titan's shadow, which had been transiting the disk during the previous observations, was now grazing the edge of the north pole in a partial transit. Because of technical difficulties, the capture of the transit was incomplete: only the last two hours of the event was recorded. A time-lapse of the transit from 10 p.m. to 12 a.m. can be seen at https://youtu.be/Z02GO65MMMQ?si=wTHHDsjIVyZN6eL6.

Saturn at Opposition

During the Saturnian opposition, the Sun, Earth, and Saturn are aligned in a straight line, and Saturn is at its peak brightness and largest size for the current apparition. Saturn was observed on September 15, six days before its opposition on September 21. Saturn near opposition appeared to have brighter rings (Fig. 4B) when compared its appearance on August 19 (Fig. 4A). Despite the inclination of the rings being less (-2 degrees) than that on August 19th (-2.95 degrees), the greater direct sunlight received at opposition made the rings brighter.

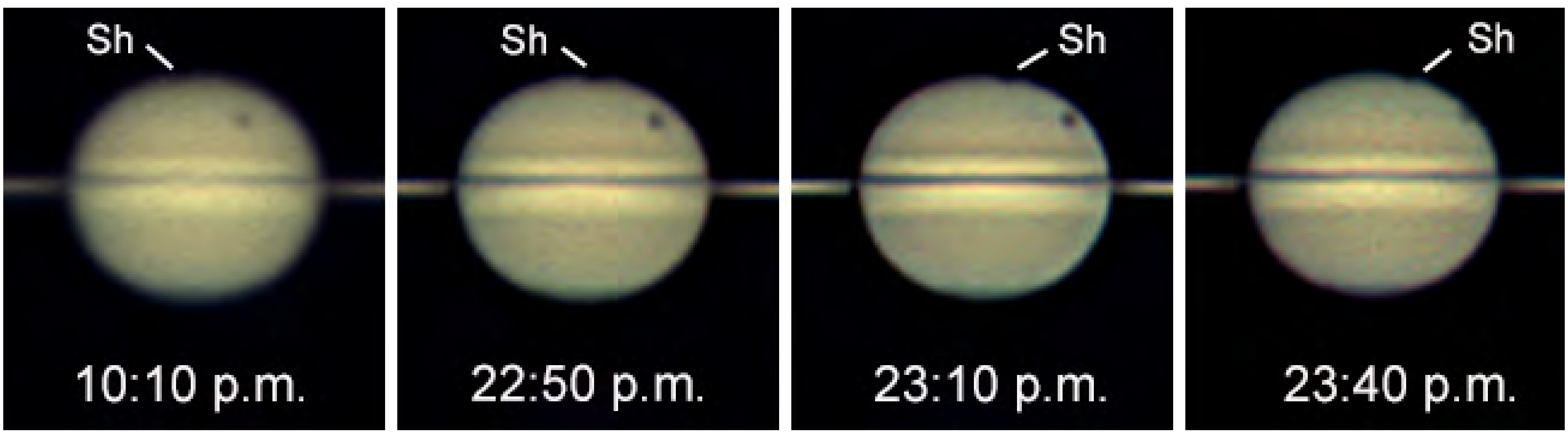
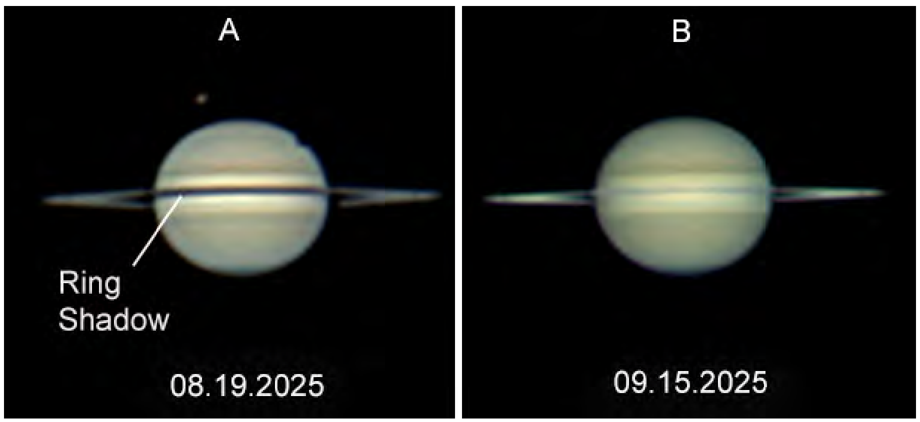


Figure 3. Transit of Titan and its shadow (Sh) on October 5, 2025. Titan is shown transiting the northern hemisphere of the Saturnian disk. Titan's shadow transit is seen as a shallow depression migrating on the northern limb of the disk. Image credit: GDW.

The opposition surge in the brightness of the rings is due to the Seeliger effect, which posits that at opposition, the sun's rays illuminate the rings more uniformly and from one direction. The rings temporarily become more luminous as sunlight is efficiently reflected and scattered by the particles, thereby minimizing the shadows they cast on one another. Another striking difference observed was the reduction of the ring shadow on the equator. This is due to less shadow being cast by the rings and by the direct illumination of the globe. As Saturn moved away from opposition, the rings dimmed and the ring shadow on equator returned. This was observed on October 21, about 30 days after opposition (Fig. 4C). In this case, the dimness of the rings is also exacerbated by the decreased ring inclination (-0.84) resulting in less reflected light. (Note: Saturn is at opposition in Figure 2.)



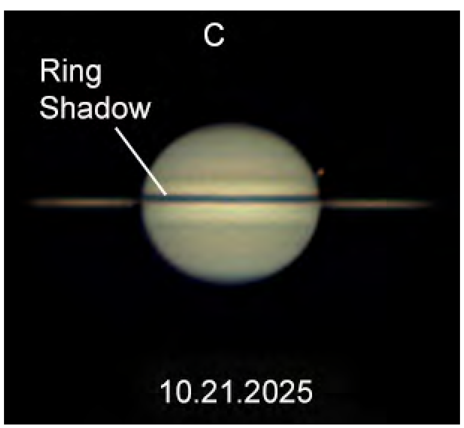


Figure 4. Observation of Saturn before, during, and after opposition. (A) Saturn on August 19, or 33 days before opposition. The ring inclination was -2.95 degrees. (B) Saturn on September 15, or 6 days before opposition. The ring inclination was -2 degrees. (C) Saturn on October 21, or 30 days after opposition. The ring inclination was -0.84 degrees. Note: (C) was taken at the end of a Titan transit on 10/21/2025; Titan can be seen off of the western limb. Image Credit: GDW.

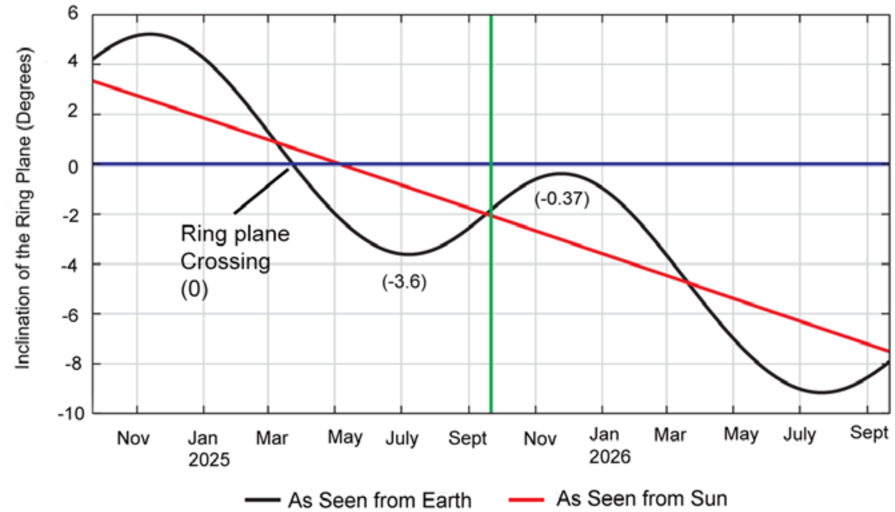


Figure 5. The inclination of Saturn's rings from November 2024 to September 2026. Positive values show that the north face of the rings is pointed towards the Earth or Sun. Negative values show that the south face of the rings is pointed towards the Earth or Sun. Original graph is found here: https://in-the-sky.org/news.php?id=20250921_12_100. Image credit: Dominic Ford (copyright holder) with modifications by GDW.

Saturn's Disappearing Rings

The finale of my Saturn observations ended with the disappearance of Saturn's rings in late November. I previously wrote about the March 23rd ring plane crossing in the Fall 2025 Newsletter. At the ring plane crossing, Earth aligns with the ring plane of Saturn, and the rings are seen as edge-on with an inclination of zero degrees (Fig. 5). At this angle, very little sunlight is reflected by the horizontal surface of the rings. The darkness and thinness of the rings made them invisible.

After March 23rd, the inclination of the rings increased and peaked on July 7th when the angle was -3.7 degrees. Even though the rings were still considerably dim, this small increase in ring inclination allowed more sunlight to be reflected which made the

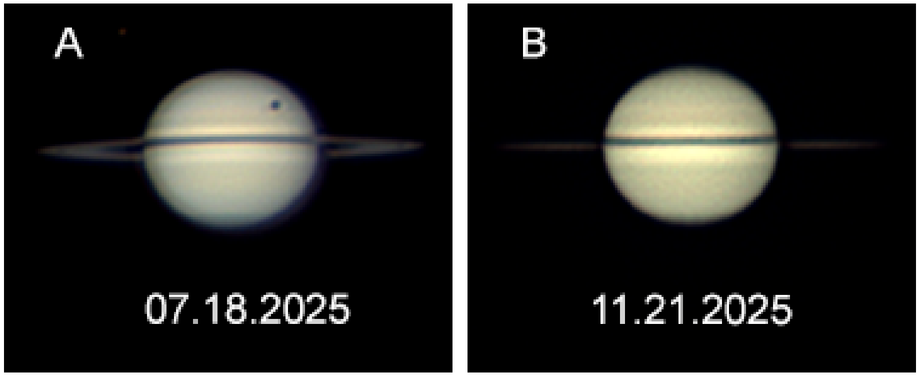


Figure 6. A comparison of the brightness of the rings on July 17 and November 21. (A) The rings on July 17 had an inclination of -3.6 degrees. (B) The rings on November 21 are nearly edge-on and have an inclination of -0.37 degrees. Image credit: GDW.

rings more visible (Fig. 6A). After July 7th, the ring angle started to narrow, and the rings gradually became edge-on. On November 23, there was an "incomplete" ring plane crossing. Because Saturn and Earth were not perfectly aligned for the crossing, the inclination narrowed to -0.37 degrees (Fig. 5). However, from our vantage point, the rings appeared to be edge-on and nearly invisible (Fig. 6B). After November 23, the ring inclination will continue to increase; the rings will become brighter and more open as Saturn transitions from fall into winter. The next time we will see the edge-on rings will be in 2039 when Saturn enters the spring equinox.

References

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Grace Wheeler is an AOH member who writes about the wonders of the astronomical universe.

Active Region 4274 and the Red Aurora of November 11

by Grace Wheeler

I had been watching AR 4274 since it rotated into view in early November. Since mid-October, prior to its Earth-facing arrival, it had been blasting off solar flares and producing coronal mass ejections (CMEs) on the far side of the Sun. When it finally appeared on the limb on November 4, it made a splash by erupting an X1.8 solar flare. That CME would miss the Earth, but it was an auspicious sign that this sunspot region might actually live up to the social media hype surrounding it since late October. AR 4274 would unleash three more X-flares in rapid succession: an X1.7 (Nov. 9), X1.2 (Nov. 10), and a massive X5.1 (Nov. 11). Because the sunspot region was located near the center of the solar disk at the time of the eruptions, any CMEs would certainly be Earth-directed. NOAA issued geomagnetic storm warnings almost immediately, predicting G2/G3 storms on November 11 from the two smaller flares, and a G4 storm on November 12 from the X5.1 flare.

The Red Aurora

I was not expecting to see an aurora on either date because the forecast in Humboldt County was for mostly cloudy skies on November 11 and rain on November 12. As predicted, the CMEs from the two smaller flares arrived in the late afternoon of November 11. The initial geomagnetic storm was rated a G3 (moderate) at 5:45 p.m. PST. It quickly intensified to a G4 an hour later. When I received the alert for a G4, I decided to drive to Kneeland

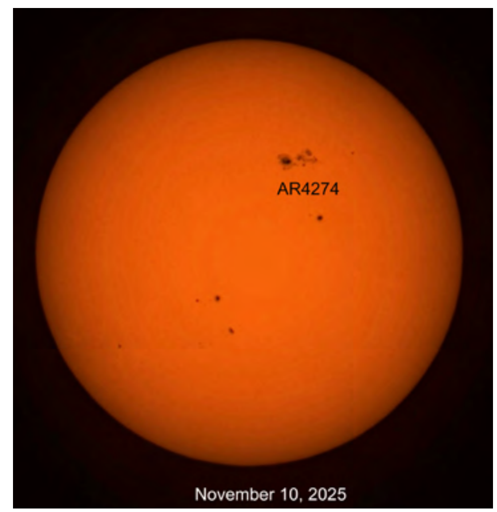

Figure 1. Sunspot Region AR4274 on November 10, 2025. Image Credit: GDW.

where the cloud layer was broken (as viewed on Barry Ridge Cam). I'm glad that I followed my hunch; by the time I arrived at the Kneeland airport, it was only partly cloudy, and stars were visible overhead and to the northeast. I noticed immediately the reddish haze that was visible to the unaided eye, and how the aurora extended high into the sky. I observed for about 90 minutes, taking pictures and noting the direction of the display (Figs. 2,3,4).

The G4 storm of November 11 lasted for several hours, and auroras were seen in Alaska, throughout the continental U.S., and as far south as central Mexico. It was dubbed the "Red Aurora" because of the intense red color in the auroral display. This was the third strongest storm of Solar Cycle 25.

One of the reasons why the CMEs from X1.2 and X1.7 solar flares were able to generate such a strong storm can be attributed to the value of the Bz component of their solar winds. Bz measures the north-south direction of the magnetic field within the solar winds. For the solar winds to be geoeffective (capable of causing a significant geomagnetic storm), its magnetic field must be pointed southward (negative). This southward magnetic field allows the solar wind's field lines to connect with the Earth's northward magnetic field (positive). This connection known as magnetic reconnection, allows solar wind particles to gain entry through the north and south polar regions. In the case of November 11, the magnitude of the negative Bz component of the solar winds was substantial, and it stayed negative for several hours. This allowed for the continuous funneling of solar wind particles into the atmosphere, extended the northern auroral oval southward, and ultimately created the massive auroral display that could be seen at low latitudes.

The November 12 Geomagnetic Storm

The CME from the X5.1 arrived on the afternoon of November 12 and there were expectations that this would also generate a G4 level storm. At one point, NOAA even mentioned the possibility of a G5. However, the Bz value of the incoming solar wind was northward (positive), which made it unlikely that the field lines of the solar wind would connect with the Earth's northward (positive) magnetic field. In other words, the solar wind particles would be prevented from entering the poles, and the possibilities of a G4 aurora diminished. Eventually the Bz did turn southward, but it was

Figure 2. A view of the aurora looking north at the Kneeland Airport runway. The aurora was bright and appeared to extend to a high altitude.

Figure 3. A view of the aurora to the northeast. I was able to capture green part of the aurora that is near the horizon.

Figure 4. A view of the aurora to the east. The image was taken at 8:50 p.m. when the azimuth of the Pleiades was 90 degrees. The red color might be from a SAR arc.

not enough to produce a G4 level storm. The much-anticipated G4 storm was downgraded to G3. The G3 storm still produced auroras in the northern tier states, and there were some brief substorms at mid-northern latitudes.

SAR Arcs and the Red Aurora

During the November 11 aurora, I was struck by the intense redness of the sky which prompted me to search for signs of a SAR (Stable Aurora Red) arc. I saw my first SAR arc during the G4 auroral event of October 10, 2024. The arc was a striking deep red plume of light (as viewed through a cell phone camera) that was oriented in an east-west direction. While both auroras and SAR arcs are caused by strong geomagnetic storms, their formation processes differ. In the case of the aurora, energized particles from the sun interact with atmospheric gas molecules, mostly oxygen and nitrogen, and cause the molecules to emit light in a multitude of hues. With SAR arcs, strong geomagnetic activity heats up the ring current system, a donut-like structure that encircles the equator and is part of the Earth's magnetosphere. The heat from the ring current dissipates into the upper atmosphere where it excites oxygen molecules to emit red light at 6300 angstroms. More about the ring current system can be found here: https://spaceweatherarchive.com/2023/11/08/earths-ring-current-system-just-sprang-a-leak/.

Figure 5. An image of SAR arc captured on November 11 between 11 p.m. and 12 a.m. The star Deneb in the constellation Cygnus is labeled. The direction is about 330 degrees (N/NW). The location is Shasta Lake, Ca. Image Credit: Amber Whitley.

Because of the deep red color of the November 11 aurora, and the appearance of the red haze overhead, I thought a SAR arc might be involved. However, the cloudy conditions in Humboldt County precluded me from seeing any clear evidence of a SAR arc. (I did pick up a wall of red color to the east in Fig. 5).

Fortunately, I was able to find images of SAR arcs posted on the California Aurora Chaser Facebook group. The images were taken in central part of Northern California which had clear skies on the evening of November 11 and early morning of November 12. I hope in the coming months, there will be more pictures posted showing the spatial relationship between the aurora and the SAR arc.

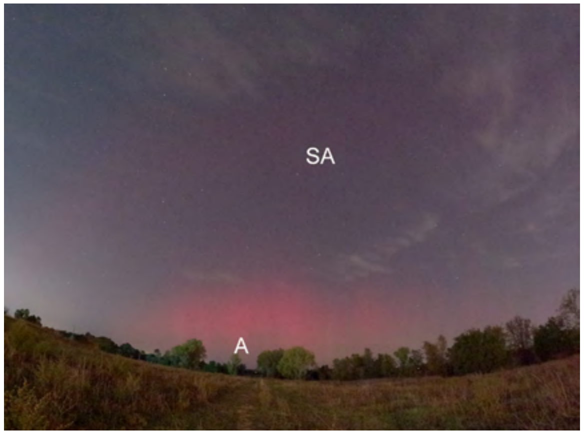

Figure 6. Image of an aurora (A) with the SAR arc (SA) overhead. This was a single frame taken from a GoPro time-lapse on November 12, 2025 from 12:00 to 1:30 a.m. The location was Lincoln, Ca. Image credit: Roy Cotterill.

Acknowledgment: I am grateful to Amber Whitley and Roy Cotterill for allowing me to use their images of the SAR arc for this article. I want to especially acknowledge Amber for sending me images of the October 2024 SAR arc, and Roy for sending me the original video.

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Grace Wheeler is an AOH wonder who writes about the members of the astronomical universe.

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A Guide to Cosmic Temperatures

by Francis Reddy

Japan's XRISM (X-ray Imaging and Spectroscopy Mission, pronounced "crism") observatory provides an unprecedented view into some of the hottest places in the universe. And it does so using an instrument that's actually colder than the frostiest cosmic location now known.

XRISM's Resolve instrument lets astronomers peer into the make-up of cosmic X-ray sources to a degree that hasn't been possible before. They anticipate many new insights about the hottest objects in the universe, which include exploding stars, black holes and galaxies powered by them, and clusters of galaxies.

This infographic illustrates the enormous range of cosmic temperatures. At the bottom of the scale is absolute zero Kelvin, or 459.67 degrees below zero Fahrenheit (minus 273.15 Celsius).

The detector for XRISM's Resolve instrument is just a few hundredths of a degree warmer than this. It's 20 times chillier than the Boomerang Nebula the coldest-known natural environment and about 50 times colder than the temperature of deep space, which is warmed only by the oldest light in the universe, the cosmic microwave background.

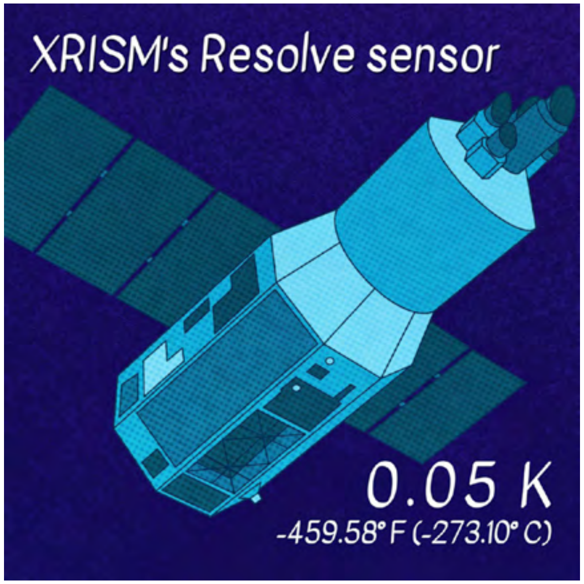
The instrument, a collaboration between NASA and JAXA (Japan Aerospace Exploration Agency), must be kept so cold because it works by measuring the tiny temperature increase created when X-rays strike its detector. This information builds up a picture of how bright the source is in various X-ray energies the equivalent of colors of visible light and lets astronomers identify chemical elements by their unique X-ray fingerprints, called spectra.

With other instruments, we're only capable of seeing these fingerprints in a comparatively blurry way. Resolve effectively gives X-ray astrophysics a spectrometer with a magnifying glass

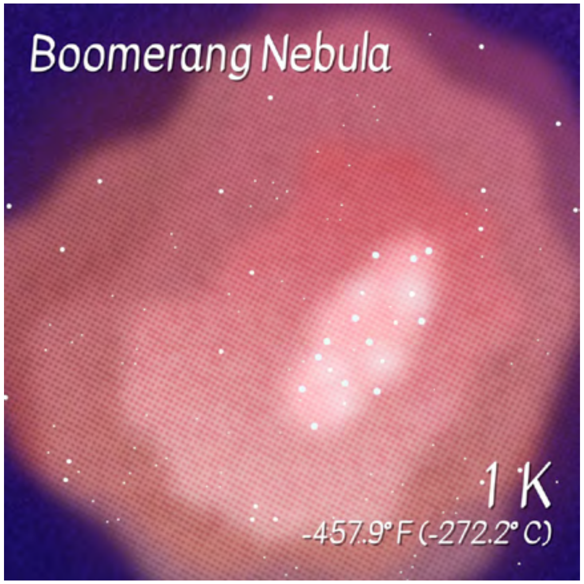
XRISM's other instrument, called Xtend, developed by JAXA and Japanese universities, is an X-ray imager that performs simultaneous observations with Resolve, providing complementary information. Both instruments rely on two identical X-ray Mirror Assemblies developed at Goddard.

XRISM is a collaborative mission between JAXA and NASA, with participation by ESA (European Space Agency). NASA's contribution includes science participation from the Canadian Space Agency.

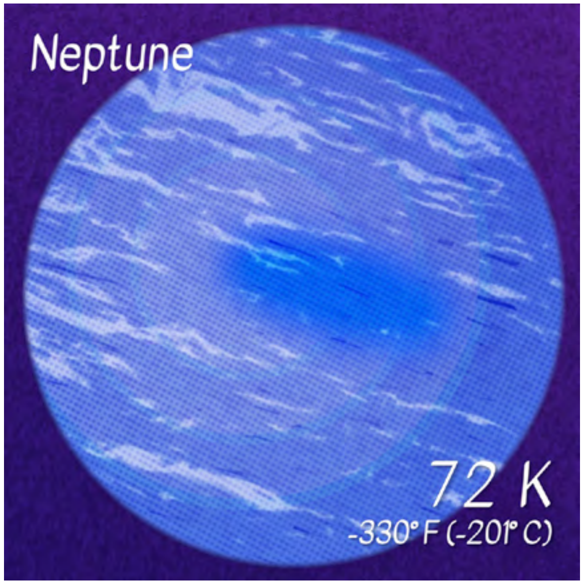
Francis Reddy is Senior Science Writer on contract to the Astrophysics Science Division at NASA's Goddard Space Flight Center in Maryland.



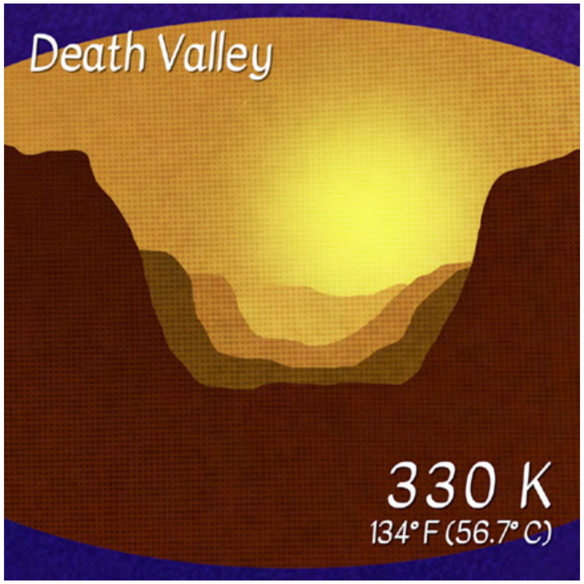
Just slightly warmer than absolute zero is the Resolve sensor inside XRISM, pronounced "crism," short for the X-ray Imaging and Spectroscopy Mission. This is an international collaboration led by JAXA (Japan Aerospace Exploration Agency) with NASA and ESA (European Space Agency). Resolve operates at one twentieth of a degree above 0 K. Why? To measure the heat from individual X-rays striking its 36 pixels!



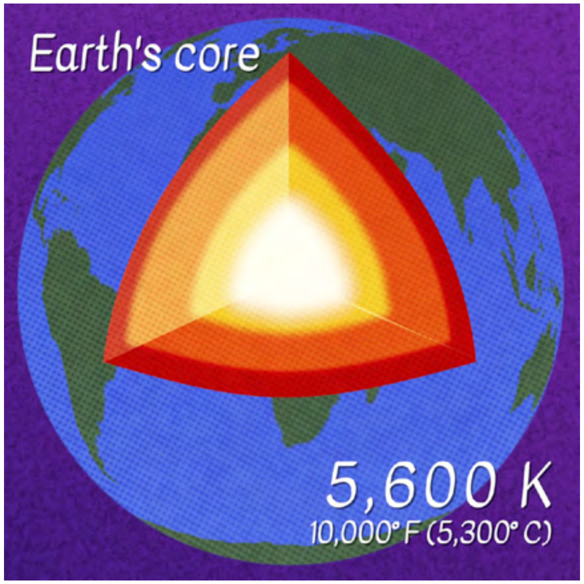
The Boomerang Nebula is the coldest known region in the cosmos at just 1 K on the Kelvin temperature scale that astronomers use This cloud of dust and gas left over from a Sun-like star is about 5,000 light-years from Earth.



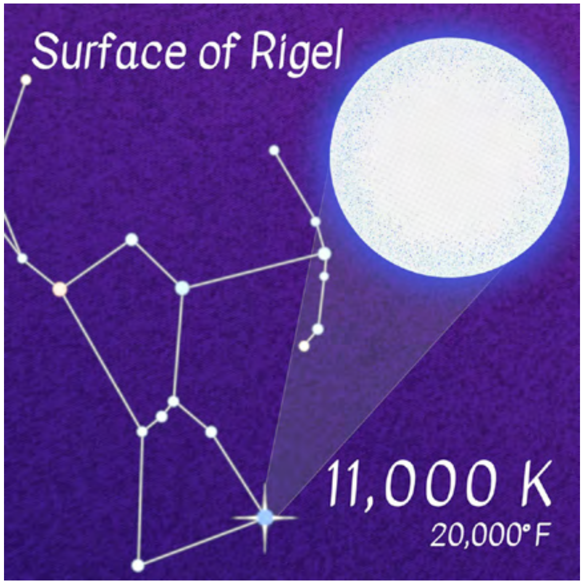
Icy gas giant Neptune is the coldest major planet in our Solar System. It has an average temperature of 72 K at the height in its atmosphere where the pressure is equivalent to sea level on Earth.



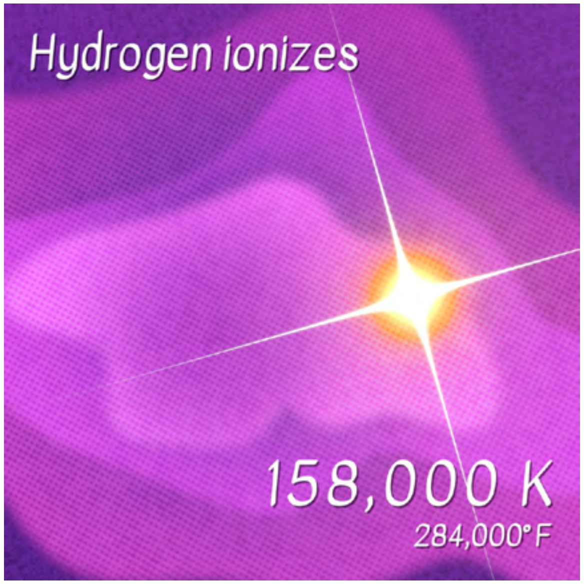
Bringing things closer to home, according to NOAA, Death Valley set the world's surface air temperature record on July 10, 1913. This record of 330 K has yet to be broken — but recent heat waves have come close.



Earth's inner core is a solid sphere made of iron and nickel that's about 760 miles (1,220 kilometers) in radius. It reaches temperatures up to 5,600 K.



We might assume stars would be much hotter than our planet, but the surface of Rigel is only about twice the temperature of Earth's core at 11,000 K. Rigel is a young, blue star in the constellation Orion.

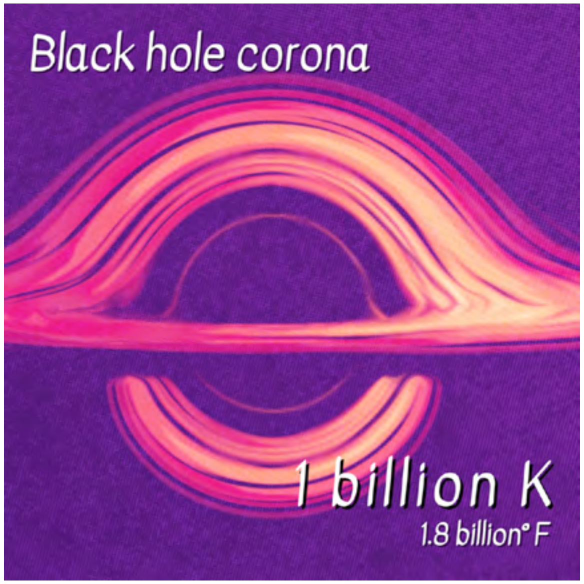


The electrons in hydrogen, can be stripped away from their atoms in a process called ionization at a temperature around 158,000 K. When these electrons join back up with ionized atoms, light is produced.

Our Sun's surface is about 5,800 K (10,000°F or 5,500°C), but the outermost layer of the solar atmosphere, called the corona, can reach millions of kelvins. Why? Solar scientists have been trying to figure this out for years.

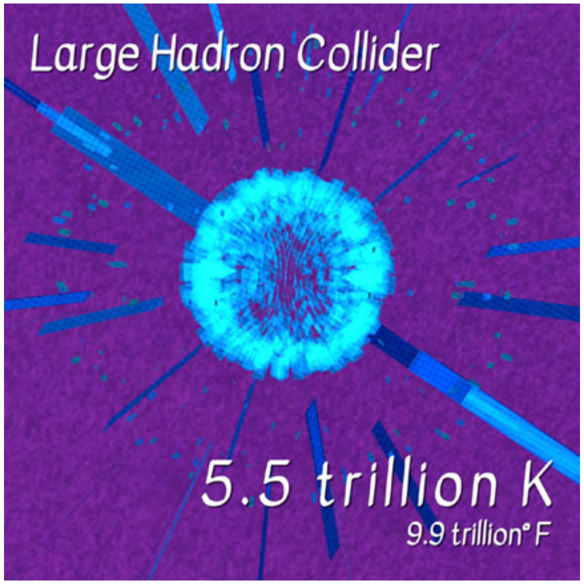
Located about 240 million light-years away, the Perseus galaxy cluster contains thousands of galaxies. It's surrounded by a vast cloud of gas heated up to tens of millions of kelvins that glows in X-ray light.

When massive stars — ones with eight times the mass of our Sun or more — run out of fuel, they put on a show. On their way to becoming black holes or neutron stars, these stars shed their outer layers in a supernova explosion.



When stuff gets too close to a black hole, it can become part of an orbiting debris disk This hot environment, which can reach temperatures of a billion kelvins, helps us study black holes even though they don't emit light themselves.

Just one second after the big bang, our tiny, baby universe consisted of an extremely hot — around 10 billion K — "soup" of light and particles. It had to cool for a few minutes before the first elements could form.



Scientists use the Large Hadron Collider at CERN to smash teensy particles together at superspeeds. In 2012, they generated a plasma that was over 5 trillion K, setting a world record for the highest human-made temperature.

This article is distributed by the [NASA Night Sky Network](), a coalition of hundreds of astronomy clubs across the US dedicated to astronomy outreach.

Looking Beyond the Stars

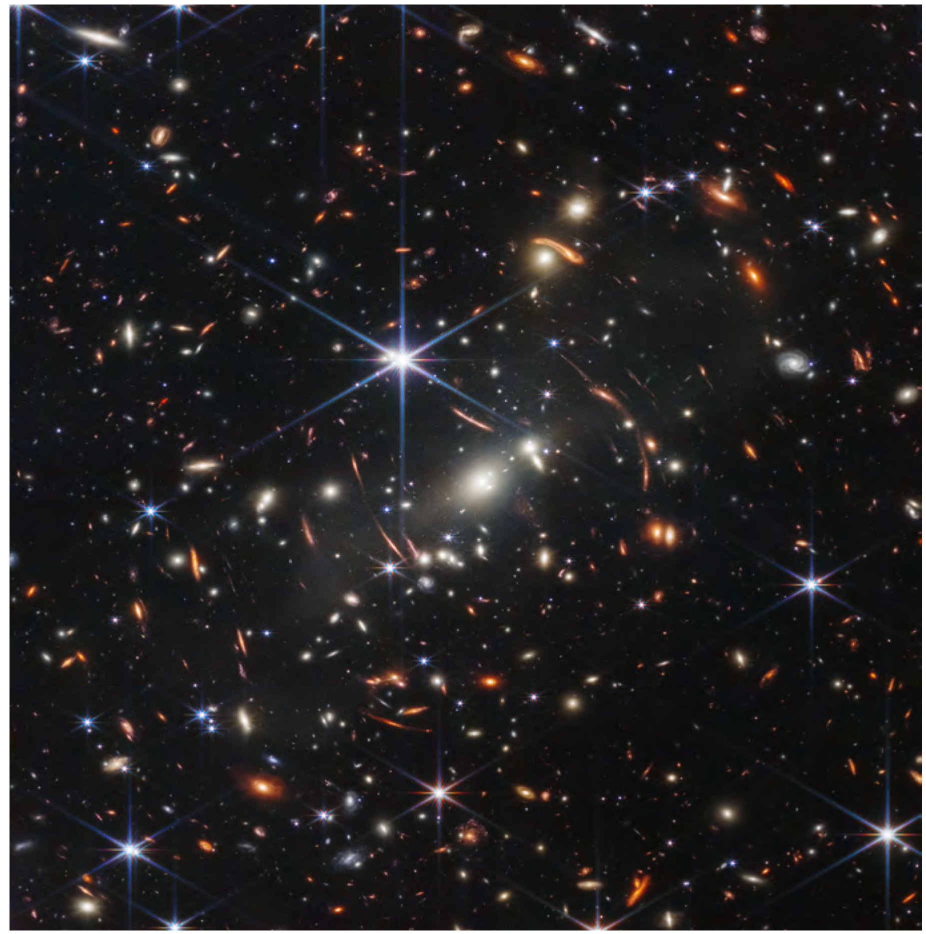
by Brian Kruse

Looking up in awe at the night sky, the stars and planets pop out as bright points against a dark background. All of the stars that we see are nearby, within our own Milky Way Galaxy. And while the amount of stars visible from a dark sky location seems immense, the actual number is measurable only in the thousands. But what lies between the stars and why can't we see it? Both the Hubble telescope and the James Webb Space Telescope (Webb) have revealed that what appears as a dark background, even in our backyard telescopes, is populated with as many galaxies as there are stars in the Milky Way.

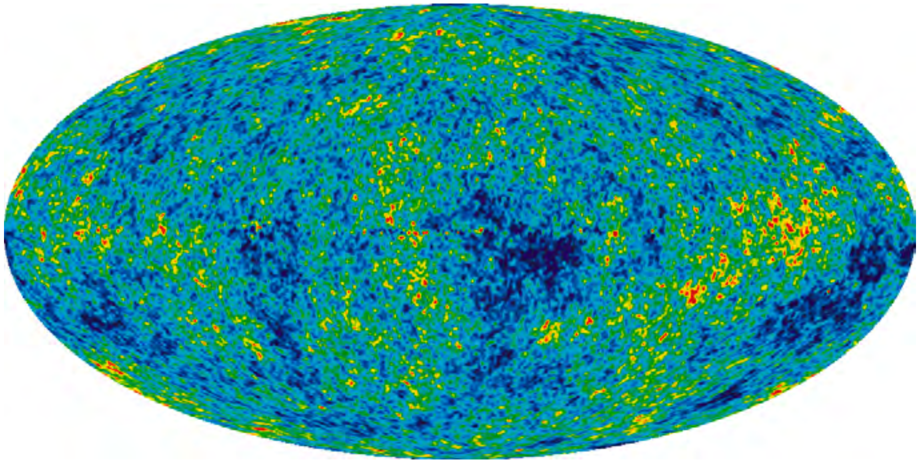
So, why is the night sky dark and not blazing with the light of all those distant galaxies? Much like looking into a dense forest where every line of sight has a tree, every direction we look in the sky has billions of stars with no vacant spots. Many philosophers and astronomers have considered this paradox. However, it has taken the name of Heinrich Wilhelm Olbers, an early 19th century German astronomer. Basically, Olbers Paradox asks why the night sky is dark if the Universe is infinitely old and static – there should be stars everywhere. The observable phenomenon of a dark sky leads us directly into the debate about the very nature of the Universe – is it eternal and static, or is it dynamic and evolving?

It was not until the 1960s with the discovery of the Cosmic Microwave Background that the debate was finally settled, though various lines of evidence for an evolving universe had built up over the previous half century. The equations of Einstein's General Theory of Relativity suggested a dynamic universe, not eternal and unchanging as previously thought. Edwin Hubble used the cosmic distance ladder discovered by Henrietta Swan Leavitt to show that distant galaxies are moving away from us – and the greater the distance, the faster they're moving away. Along with other evidence, this led to the recognition of an evolving Universe.

The paradox has since been resolved, now that we understand that the Universe has a finite age and size, with the speed of light having a definite value. Here's what's happening – due to the expansion of



NASA's James Webb Space Telescope has produced the deepest and sharpest infrared image of the distant universe to date. Known as Webb's First Deep Field, this image of galaxy cluster SMACS 0723 is overflowing with detail. This slice of the vast universe is approximately the size of a grain of sand held at arm's length by someone on the ground. (Image Credit: NASA, ESA, CSA, STScI) https://bit.ly/webbdeep



The oldest light in the universe, called the cosmic microwave background, as observed by the Planck space telescope is shown in the oval sky map. The cosmic microwave background was imprinted on the sky when the universe was just 380,000 years old. It shows tiny temperature fluctuations that correspond to regions of slightly different densities, representing the seeds of all future structure: the stars and galaxies of today. (Image credit: ESA and the Planck Collaboration - D. Ducros) https://go.nasa.gov/3qC4G5q

the Universe, the light from the oldest, most distant galaxies is shifted towards the longer wavelengths of the electromagnetic spectrum. So the farther an object is from us, the redder it appears. The Webb telescope is designed to detect light from distant objects in infrared light, beyond the visible spectrum. Other telescopes detect light at still longer wavelengths, where it is stretched into the radio and microwave portions of the spectrum. The farther back we look, the more things are shifted out of the visible, past the infrared, and all the way into the microwave wavelengths. If our eyes could see microwaves, we would behold a sky blazing with the light of the hot, young Universe – the Cosmic Microwave Background.

The next time you look up at the stars at night, turn your attention to the darkness between the stars, and ponder how you are seeing the result of a dynamic, evolving Universe.

Brian Kruse is the recently retired Director of the Teacher Learning Center at the Astronomical Society of the Pacific.

What Was the First Thing Scientists Discovered? A Historian Makes the Case for Babylonian Astronomy

by James Byrne

What was the first thing scientists discovered?
— Jacob, age 9, Santiago, Panama

All societies have had ways of understanding nature based on their experiences of it. For example, farmers need to understand the seasons and weather to know when to plant and harvest their crops. Hunters need to understand the lives of animals to know how to hunt them.

This kind of understanding of the natural world isn't quite the same as science though. Science typically refers to knowledge that's more

Ancient Babylonians looked to the skies to predict what would happen. mikroman6/Moment via Getty Images organized and formal than that. It's not just an explanation, but a system that uses observations and experiments to build theories that are recorded, passed on to others and built on.

With that idea in mind, as a historian of science, my best answer to the question of what the first scientists discovered is Babylonian astronomy.

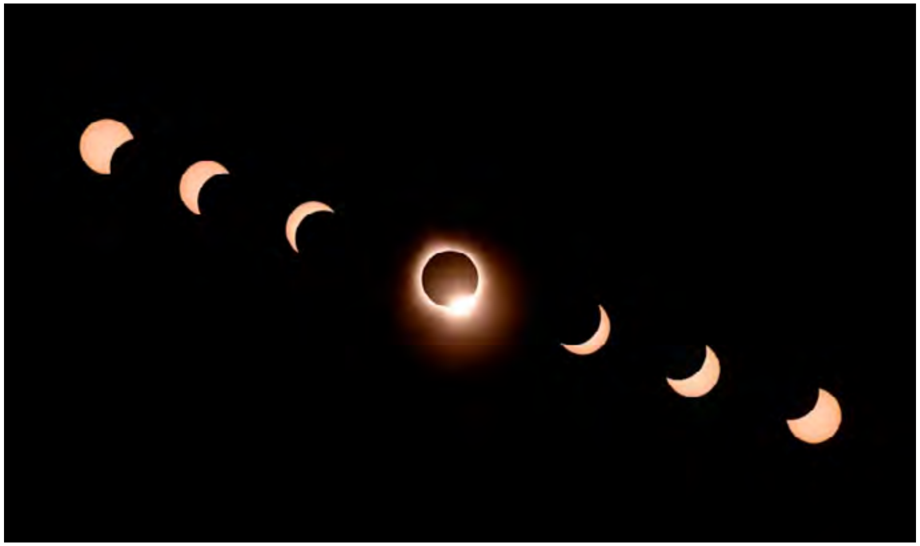
The Babylonians lived from about 2,500 to 4,000 years ago in the area that's now Iraq. What makes Babylonian astronomy stand out as being especially scientific is the careful, organized way in which Babylonian scribes—their keepers of knowledge—observed, recorded and eventually mathematically predicted the ways that the Sun, Moon, stars and planets move in the skies.

Babylonian astronomy was uniquely scientific

Before clocks, observing the sky was how people knew the time. During the day you can see the Sun, and at night you can see the stars. Many calendars are based on the skies too. A month is about how long it takes the Moon to go through its phases. A year is one full revolution of the Earth around the Sun.

But keeping track of time wasn't the only way the Babylonians used astronomy. Like today's world, Babylonia could be both predictable and chaotic. The weather changed with the seasons; crops were planted and harvested; festivals were celebrated; people were born, aged and died, all predictably. But a bad harvest might cause high prices for grains and starvation; a king might die young, causing political upheaval; a disease might kill thousands, all unpredictably.

The stars and planets can seem like that, too. The stars are always in the same places in relation to one another, so you can identify constellations, and those constellations rise and set at regular times over the course of a year. But the planets move around—they're not always in the same places, and sometimes they even seem to stop and move backward in their paths. Sometimes even more spectacular events occur, such as eclipses.



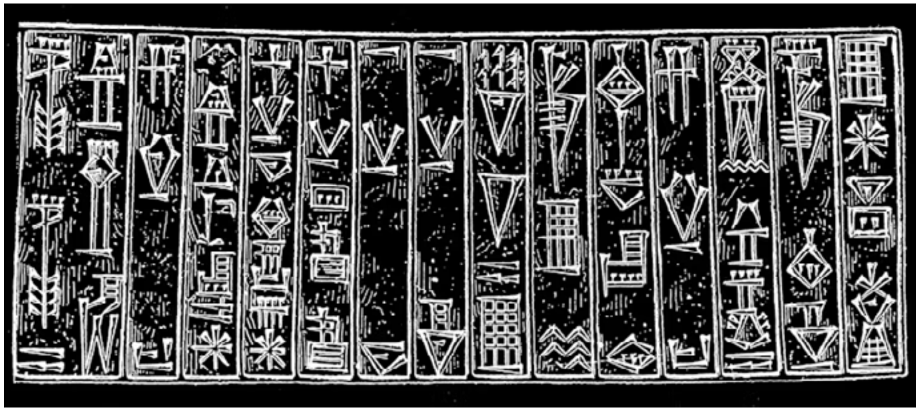
An eclipse might have seemed like a powerful omen of something that would happen next. Josh Edelson/AFP via Getty Images

For the Babylonians, those ideas were linked. They saw changes in the motions of the planets or rare events such as eclipses as signs—omens—about what was going to happen on Earth. For example, they might think the shadow of the Earth moving over the Moon in a certain way during a lunar eclipse meant that a flood would also happen.

The scribes kept a book called Enūma Anu Enlil listing omens and their meanings. So if the seemingly changing motions of the heavens could be predicted, maybe earthly events could be, too. This led the scribes to study astronomy.

How Babylonian astronomy worked

The foundation of Babylonian astronomy was kept in a book called MUL.APIN, meaning "The Plough Star," the name of a constellation. It recorded the positions of the stars, when in the year they would first be visible, the paths of the Sun and Moon, the periods when the planets would be visible in the night sky, and other fundamental astronomical knowledge.



Babylonian scribes used cuneiform to write down records of all kinds. mikroman6/Moment via Getty Images

Later, Babylonian scribes began to keep their Astronomical Diaries, which contained detailed records of the positions of the Moon and planets along with events on Earth such as the weather and the price of grain. In other words, they recorded their observations of both astronomical omens and the events they might have predicted. This kind of careful observation and record-keeping is a major part of science. The Astronomical Diaries were kept for over 700 years, making them maybe the longest-running scientific project ever.

The records in the Astronomical Diaries helped Babylonian scribes take another scientific step: predicting astronomical events. One part of this was computing what the Babylonians called goal-years: the number of years it took for a planet to return to the same place on the same day. For example, they computed that the period for Venus was eight Babylonian years. So if Venus was somewhere on a particular day, it would be in the same place on the same day eight years later.

By around the fourth century B.C.E., the scribes developed this knowledge into a system of mathematically predicting astronomical events. They made tables called ephemerides that showed when these events would happen in the future. So Babylonian scribes succeeded in their project: They made the motions of the Sun, Moon and planets predictable.

Babylonian astronomy and you

MUL.APIN, the Astronomical Diaries, the ephemerides and all of Babylonian astronomy had a major impact on later astronomers, one that continues to today. Greek astronomers used Babylonian observations to make geometric models of planetary motions, part of the long path toward modern astronomy. The ephemerides were the ancestors of astronomical tables, which still exist. For example, NASA has a table of eclipses online that goes to the year 3000.

We tell time using the Babylonian system. Catherine McQueen/ Moment via Getty Images

But the most familiar thing that comes from Babylonian astronomy is how we tell time. The Babylonians didn't use a decimal system with units of 10 like we do. Instead, they used a sexagesimal system, with units of 60. Babylonian observations were so important that later people kept Babylonian units for astronomy, even though they used a base 10 system for other things.

So if you've ever wondered why an hour has 60 minutes, and a minute has 60 seconds, it's because we've kept that way of measuring from Babylonian astronomy. Whenever you tell the time, you're using some of the very oldest science.

James Byrne is Assistant Teaching Professor in the Herbst Program for Engineering, Ethics & Society, University of Colorado Boulder.

Remo Nortsa
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