NWASNEWS

Volume30 Issue 9

May 2024

Newsletter for the Wiltshire, Swindon, Bath Astronomical Societies

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American Eclipse

Hopefully some our members who attended the eclipse in America this April will be able to talk about their experiences

Wiltshire Astronomical Society is inviting you to a scheduled Zoom meeting.

7th May Meeting on Zoom (Hall not available)

Andy Burns is inviting you to a scheduled Zoom meeting.

Topic: Wiltshire AS Zoom Meeting

Time: May 7, 2024 07:45 PM London

No set speaker…

Join Zoom Meeting

https://us02web.zoom.us/j/83774956679?pwd=b3VZMzRXQUNSM1RJdWRXYjNKeGdBdz09

Meeting ID: 837 7495 6679

Passcode: 424854

Clear skies.

Andy Burns.

Imaging the tail end of the 19th April aurora while in the Northern inner circle of the Avebury Stone circle.
We are still getting peak aurora visible from Wiltshire indicating the highly active Sun cycle stage has been reached.

Photo: Andy Burns

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Wiltshire Society Page

Wiltshire Astronomical Society

Web site: www.wasnet.org.uk

Facebook members page: https://www.facebook.com/groups/wiltshire.astro.society/

Meetings 2023

HALL VENUE the Pavilion, Rusty Lane, Seend

Some Speakers have requested Zoom Meetings will be stay at home sessions.

Meet 7.45 for 8.00pm start

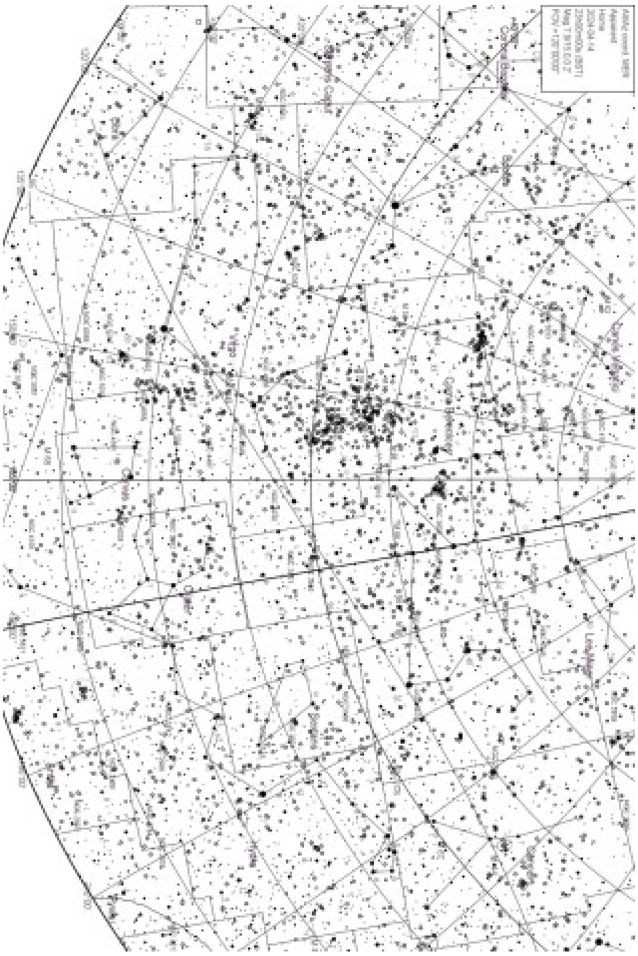
SEASON 2023/24

2024
May 7th Zoom meeting
June 4th:Hall Meeting, Rob Lucas Building a Garden observatory

Zoom meeting details for log on will be sent out and published the Sunday before the meeting.
AWAITING A SPEAKER SECRETARY FOR 23/24 SEASON

Speaker tonight:

The Spring Skies



Membership Meeting nights £1.00 for members £3 for visitors

Members can renew or new members sign up online via https://wasnet.org.uk/membership/ and also remind them they can pay in cash too on the door.

Wiltshire AS Contacts

Chairperson:

Outreach coordinator:

Newsletter/Publicity

Treasurer and Membership: Sam Franklin

Hall coordinator:

Live Meeting Supplies

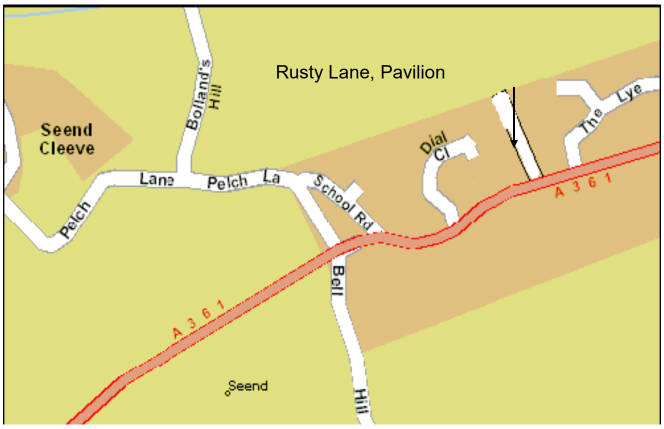
Speaker secretary

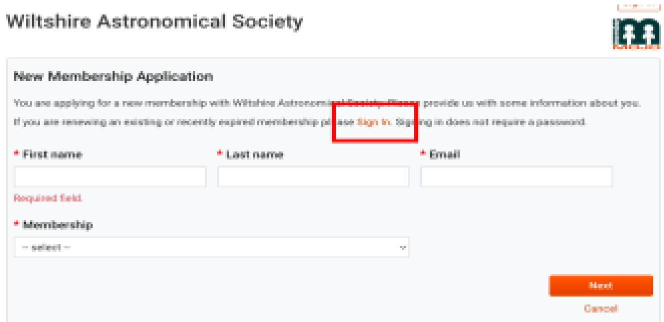
Zoom session coordinator

Observing Sessions coordinators: Chris Brooks, Jon Gale,

Web coordinator: Sam Franklin

Contact via the web site details.




Wiltshire Astronomical Society

New Membership Application

You are applying for a new membership with Wiltshire Astronomical Society. Please provide us with some information about you.
If you are renewing an existing or recently expired membership please Sign in. Signing in does not require a password.

* First name | * Last name | * Email

Required field.

* Membership

-- select --

Next

Cancel

Observing Sessions see back page

Spring is the season we look out of our Milky Way galaxy confining dust and material and get clearer views of the galaxies that lay outside our own. Thois brings the comparatively near string on clusters of the Virgo Coma Berenices super cluster and beyond.

Swindon's Own Astronomy Group

Physical meetings

The club meets in person once per month.

Online Meetings

Once per month to discuss equipment and techniques.

Friday, 17th May 2024:

Kate Earl: Magnetars – The Beauty behind the Beast

Kate Earl is a geologist-turned-science educator, who runs a small Bournemouth-based business called SkyHigh Astronomy, in addition to working for a company who runs mobile planetarium science shows in schools. She has a passion for astronomy, and endeavours to make astronomy more accessible to the public. She is the current chairperson for Wessex Astronomical Society

Magnetars are one of the strangest objects known to science. Formed in a supernova, the huge explosion that occurs when a giant star comes to the end of its life, these city-sized dead stars somehow end up with super-charged magnetic fields 1000 times stronger than their neutron star siblings.

Magnetars may hold the key to solving another cosmological mystery - they are possible progenitors of enigmatic Fast Radio Bursts (FRBs).

Ad-hoc viewing sessions

Regular stargazing evenings are organised near Swindon. The club runs a WhatsApp group to notify members in advance of viewing sessions, usually at short notice. Anyone can call a viewing. To join these events please visit our website.

Information about our evenings and viewing spots can be found below:

http://www.swindonstargazers.com/noticeboard/noticeboard06.htm

Meetings at Liddington Village Hall

Church Road, Liddington, SN4 0HB

7.30pm onwards

The hall has easy access from Junction 15 of the M4, a map and directions can be found at:

http://www.swindonstargazers.com/clubdiary/directions01.htm

Following Meeting Dates

Friday, 21 June 2024 @ 19:30

Mary McIntyre FRAS: Shadows in Space and the Stories they tell.

Friday, 20 September 2024 @ 19:30

Owen Brazell: Choosing an Eyepiece – it is half the telescope

Friday, 18 October 2024 @ 19:30

Prof Martin Hendry MBE - The Science of Star Wars

Friday, 18 October 2024 @ 19:30

Prof David Southwood CBE: How and why the Icy Moons of Jupiter became a goal for space exploration?

Website:
http://www.swindonstargazers.com

Chairman: Damian OHara
Email: swindonstargazers@duck.com

Secretary: Hilary Wilkey
Email: hilary@wilkey.org.uk
Address: 61 Northern Road
Swindon, SN2 1PD

BATH ASTRONOMERS

A friendly community of stargazers and enthusiastic astronomers who share experiences and know-how and offer an extensive outreach programme of public and young people's observing and activities. As a partner of Bath Preservation Trust and the Herschel Society, Bath Astronomers are the resident astronomers at the Herschel Museum of Astronomy. Bath Astronomers also operate a 5-metre mobile planetarium taking it to schools and community events to show off the night sky even when the clouds hide the starry sky.
Contact us using hello@bathastronomers.org.uk

Members:

Over 125 members enjoy free monthly talks, free access to the Herschel Museum, astronomy WhatsApp groups and free telescope loans. https://bathastronomers.org.uk/membership/ shows the benefits and annual subscription fees.

Next Gatherings:

Wednesday, **29th May 2024** – Talk by **Dr. Penny Wozniakiewicz**, University of Kent.

Wednesday, **26th June 2024** – Talk by **Pete Richardson**, Construction of a 20" telescope with science grade optics… in your garage.

Wednesday, **25th September 2024** – Talk by **Prof. Catherine Heymans**, Astronomer Royal for Scotland

Wednesday, **30th October 2024** – Talk by **Prof. Chris Lintott**, Gresham Professor of Astronomy. To be held at BRLSI.

Wednesday, **27th November 2024** – Talk by **Dr Meganne Christian**, UK Reserve Astronaut. To be held at BRLSI.

Wednesday, **11th December 2024** – Talk by **Meyrick Williams** on planetary weather.

Gatherings are held on the last Wednesday of each month at 7:30pm (excluding December, July, and August) and are of 90 minutes duration or so.

Venue for Gatherings:

Unless otherwise specified, meetings are held at the Herschel Museum of Astronomy, 19 New King Street, Bath, BA1 2BL.

The Team:

Chair: Simon Holbeche
Treasurer: Julia Matthews
Coordinators: Martin Farrell, Meyrick Williams, Prim Pike
Outreach Guru: Camilla Evans

Shared Stargazing:

Public stargazing is scheduled twice a month on Friday or Saturday evenings to promote astronomy in Bath and Somerset area. Locations vary to bring telescopes to local communities. Members' observing is conducted from the Monkton Combe Community Observatory using the Victorian refractor and more modern telescopes. We try to avoid school nights but will run member's sessions when the clouds look like they'll recede long enough to align a Goto telescope.

Public Solargazing is also scheduled when the weather permits with pop-up events at locations all over Bath to increase access. The society has a range of solar telescopes that are safe to share the Sun's surface with.

Outreach:

Bath Astronomers are very active providing stargazing, workshops and talks for the local community, schools, and young peoples' organisations. Planetarium shows, rocket launching, and night sky experiences. The offerings include the Discover Astronomy Loan Box, a flight case full of astronomy goodies for teachers and the classroom available for no charge.

Visit https://stem.bathastronomers.org.uk/ for more.

Video channel for BA adventures:
https://www.youtube.com/@bathastronomers

Web & Social Media links:

https://bathastronomers.org.uk
https://www.instagram.com/bathastronomers
https://bsky.app/profile/bathastronomers.org.uk
https://www.facebook.com/BathAstronomers
https://www.threads.net/@bathastronomers
https://mastodonapp.uk/@bathastronomers
https://twitter.com/bathastronomers

TSE 2024 Viewing Log

8th April 2024

Ruth and I travelled to San Antonio TX to join the Astro Trails Total Solar Eclipse 2024 USA Tour arriving 4th April.

We stayed in San Antonio for two days enjoying the San Antonio River Walk and visited The Alamo. The museum contains approx. 500 Alamo related items donated by Phil Collins of Genesis, apparently he is an Alamo enthusiast. Also, we found out the hard way that pizzas served in the restaurants are the diameter of car tyres, we made the mistake of ordering one each!

On Sunday 7th April we travelled to Waco as the eclipse viewing site was a horse ranch at Valley Mills near Waco.

It was an early start on Monday 8th April, eclipse day. However, there was heavy dense cloud. Watching the weather forecast at the hotel at breakfast prospects looked bleak for the Waco area, probably a “no show”. There was a band of cloud stretching from the south west to north east over Mexico and USA. This band of cloud was mostly over the umbral shadow track as well. Seeing the eclipse could all depend on whether the cloud moved north or south in any area.

On arrival at the ranch we were greeted by the hosts on horseback with Stars and Stripes flags.

At the viewing field it was a case of choosing a spot, grabbing haystacks for seating or lounging and avoiding the horse poo!

There was still a lot of cloud but also a few areas with glimpses of the blue sky, so perhaps the cloud was breaking up.

I planned to set up three cameras:

· A Canon SX50HS bridge camera with the focal length set at 600mm. This was to run one CHDK script to capture the partial phases before and after totality using a K&F Concept ND100000 filter. A second CHDK script for totality without the filter was to capture diamond rings, Baily’s Beads, prominences and the corona.

· A Canon 1300D DSLR fitted with a Rokinon 8mm fish eye lens, effective focal length 13mm, set at ISO 400, F5.6. Exposure times were automatic as the camera was in Aperture Priority mode, set to underexpose by two stops so as to not blow the corona etc. This was to capture the eclipse shadow from the south west to the north east. It was to capture images approx. five minutes before and after totality. An intervalometer fired the shutter once per second. It was orientated pointing slightly east of south to capture the shadow heading east.

· A Canon 1200D DSLR fitted with a Tamron 10-20mm. The lens was set at 10mm, effective focal length 16mm. The plan for this camera was to capture images of the eclipse partial and totality phases for a landscape wide angle composite.

o During the partial phases the camera was fitted with a K&F Concept ND100000 filter. In Manual Mode at ISO 100, F5.6 and exposures of 1/800, 1/400 and 1/200 with an intervalometer firing the shutter once per minute. These settings were to compensate for any cloud or limb darkening close to totality.

o At totality with the filter removed the setting was changed to Aperture Priority ISO 400, F5.6 and exposure compensation of 0, -1 and -2. The intervalometer was set to fire the shutter for 3 seconds and an interval of 1 second.

The first issue I found on setting up was the baseplate for the SX50HS tripod was missing, possibly becoming detached when packing! Fortunately, I had packed a sturdy table top tripod with a ball head in my carry-on luggage so I fixed it to SX50HS tripod with a few turns of electrical insulating tape which salvaged the situation.

The second issue was the altitude of the Sun at 61-66 degrees during the initial partial phase and totality. The field of view of the 1300D (APS-C) with the lens at 10mm focal length was 96 degrees horizontal by 73 degrees vertical, so there was only 7 degrees vertical to spare. Some test images in landscape with some foreground were not featuring the Sun so I had to change the plan from a landscape to a portrait composite. I realised later that the camera review screen does not show the full image and the Sun was there, but only just.

As the morning progressed the low thick cloud started to thin out, so it was possible to see a mixture of clear sky and high cirrus cloud. Predicted local times (UTC - 5, BST - 6), direction and altitude for our location were:

Event	Waco, Texas, USA
Coordinates	31° 37' 07.8" N, 97° 23' 50.1" W 208m
C1 – Start of the partial eclipse	12:20:17 (141.7°, 60.8°)
C2 – Start of totality	13:37:39 (183.9° 65.9°)
C3 – End of totality	13:42:02 (186.6°, 65.8°)
C4 – End of the partial eclipse	15:00:23 (225.6°, 58.3°)
Duration of totality	4m 22s

Umbra details 192.2 km, 0.737 km/s, 6.3 km from centreline

Before the start of the partial phase I was able to view the Sun thru my 8x30 Lunt Solar binoculars picking out sunspots AR3628 and AR3633. I captured a good image with the Canon SX50HS at 600mm at 11:58.

Ruth started recording the temperature as well. Although it did vary depending on cloud cover across the Sun.

At 12:05 I started the Canon 1200D composite image capture (now in portrait) taking an image every 5 minutes with the ND filter on.

First contact predicted at 12:20:17 was partially obscured by cloud. My first recorded image of the partial phase through cloud was 12:20:37 (camera clock). I was then able to take images of the partial phase at varying times (3-7minutes apart) dependent on cloud cover. So my image every 5 minutes plan did not work out, but they were on average every 5 minutes. At 13:18 I captured a cloud covered partial phase but then ran into issues with the SX50HS. The camera kept freezing and I had to cycle it off/on several times. I don’t know what the issue was, maybe overheating, the battery was fine.

Ignoring the SX50HS for the moment at 13:31 I started the Canon 1300D fish eye for capturing the transition and shadow from pre to post totality for a timelapse. At this stage the light was changing affecting shadows – so shadows of fingers looked more skeletal.

I had another attempt at getting the SX50HS up and running, but I was now past the planned start time of 13:36 for the close totality sequence and totality was rapidly approaching. This attempt was successful and with the ND filter removed the sequence started. However, I had built in a delay to imaging, there was no time to change this so I just let the camera run.

My golden rule for imaging Solar Eclipses is automate the process and let the cameras run while watching and enjoying totality. There is no time to fix issues anyway, if you try you miss the enjoyment of totality and you probably don't get the images either.

So I now concentrated on that and this is what I noticed:

- Quality of light harsher and shadow effect.
- • Temperature changes – being recorded
- • Animal behaviour – a few birds flew to roosts
- • Shadow Bands – one observer had a large white sheet and a video camera nearby – but they were disappointed as no shadow bands were visible. • Baily's Beads at 2nd contact.
- • The Diamond Ring at 2nd contact.
- • Corona and prominences detail visible during totality
- ◦ Planets that were visible: · Venus on the right of the Sun · Jupiter on the left of the Sun
- • No sign of Comet 12P Pons-Brooks
- • Baily's Beads at 3rd contact.
- • Diamond Ring at 3rd contact.

All the above was accompanied by lots of "screamin' and hollerin'"!!!!

So after 4 minutes and twenty two seconds totality finished, although it only felt like a few seconds had elapsed!

As it turned out the SX50HS missed the initial diamond ring but captured prominences, Baily's Beads and corona as planned. It also captured the final diamond ring although there was some flaring due to the high cloud. Meanwhile, the wide angle and fish eye had captured the images as well.

I was then able to capture the post totality partial phases on the SX50HS (now working) until fourth contact at 15:00:23.

So, by 15:01 it was all over and time to pack up. This included helping a nearby observer who used tie it's to fix wires and equipment in place only to find he did not have any means of removing them! My multi-tool came into use then cutting them away!

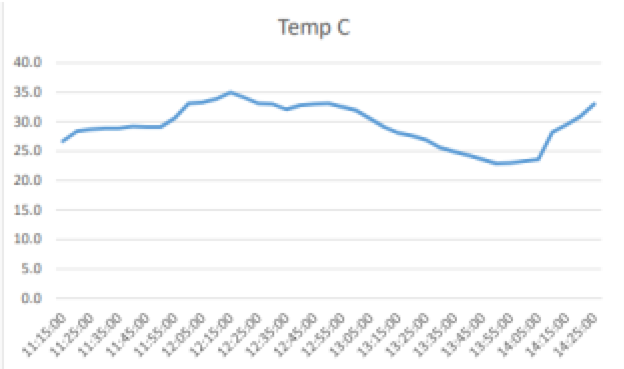
Our hosts gave us another horseback Stars and Stripes send off as we returned to Waco.

Back in Waco when we went to get something to eat it started to rain a little, then within seconds it turned into a torrential downpour that lasted a good hour as we ate our meal.

The following day it was very overcast and raining. We walked to a US Post Office a few blocks away to see if they had any special stamps to celebrate the eclipse but on asking I got a "What a dumb question!" look from the assistant, so no.

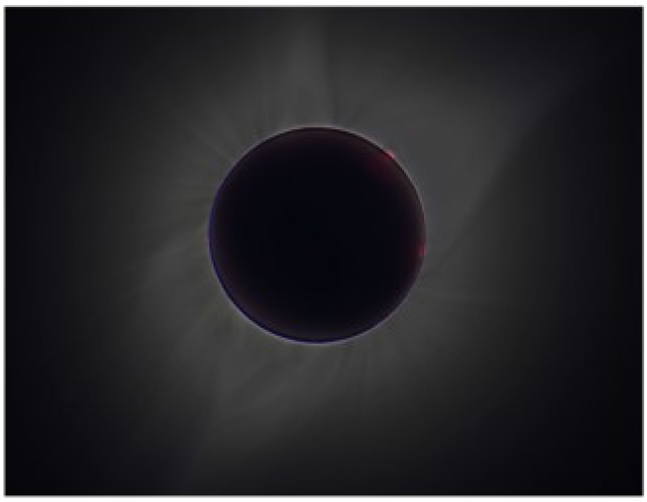
Our return to San Antonio was accompanied by extremely heavy torrential rain, lightning and thunder most of the way. Water was pouring from the flyovers onto roads below. If the eclipse had been one day later or the weather system arrived a day earlier it would have been impossible to see anything.

Here is the temperature chart compiled by Ruth. At 12:50 it was 33.1 C and the lowest recorded was 22.9 at 13:50, by 14:25 it was back at 33.0 C.

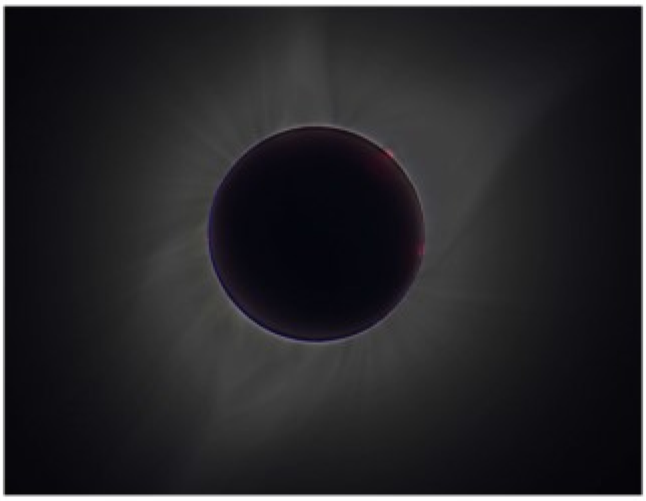


The most interesting aspect of a total eclipse for me is to see the difference in the corona streamers at different times of the solar cycle from minimum to maximum which we are currently experiencing. This is apparent comparing images I captured in 2017 (USA), 2019 (Argentina) and now in 2024.

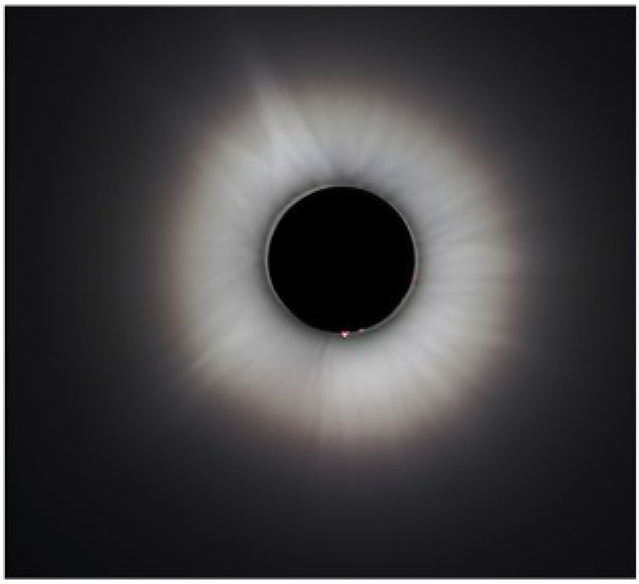
2017 Corona TSE USA (below)



2019 Corona TSE Argentina (below)

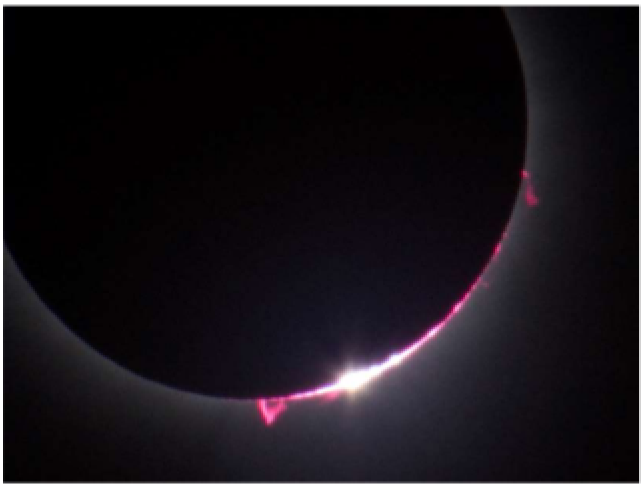


2024 Corona TSE USA (below)



Also, here are images of prominences, the wide field composite and the fish eye wide angle.

2024 Prominences TSE USA (below)



2024 Fish Eye TSE USA with Venus (below)

2024 Composite TSE USA with Venus (below)

As they say total solar eclipses are addictive so it is on to planning for 2026, which, hopefully, we will be able to travel to.

Clear Skies,

John and Ruth

E MAILS and MEMBERS VIEWING LOGS.

Peter Chappell also travelled out to the USA to view and image the eclipse

The sky before eclips above and the the sky during the eclipse.

PYJAMA VIEWING LOG 29th April 2024

Andy Burns

Camera still out taking star trail shot.

A wonderful early morning chance for a pyjama log.

15x80mm binoculars trawling the south and eastern skies. A little cloud hugging the the west.

In the handle of the plough and below easily splitting Mizar A and B then Leopold's star (thought to be planet of Mizar when first seen) and Alcor. The M51 and M101 (just), Down to Arcturus then Spica, but the latter was showing signs of a halo from atmospheric moisture.

Up overhead, coronae borealis, but no sign in my binoculars of the up coming nova.

Into Lyra, Eta Lyra double double. Not picking up the close in secondary binaries, but down to M57 ring nebula, just seeing...

Over to Brocchia's cluster (the coat hanger), M27 dumbbell nebula, and up to Albireo Beta Cygnus. Into the Milky Way and running up to M29 and M39 clusters..

Changing view to back of the house to run along the Milky Way to Cepheus and Cassiopeia, and plunder the garnet star, the clusters of M52, and Caroline's Rose before the halo became too strong.

Beginning to chill down and pain killers kicking in...

Star trail still running. The Moon should stay out of the shot because of vegetation.

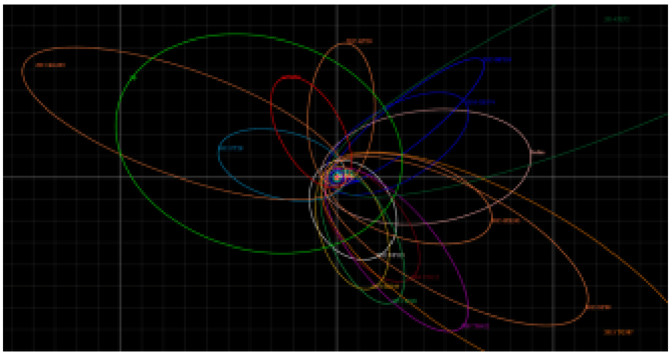
SPACE NEWS

New Evidence for Our Solar System's Ghost: Planet Nine

Does another undetected planet languish in our Solar System's distant reaches? Does it follow a distant orbit around the Sun in the murky realm of comets and other icy objects? For some researchers, the answer is "almost certainly."

The case for Planet Nine (P9) goes back at least as far as 2016. In that year, astronomers Mike Brown and Konstantin Batygin published evidence pointing to its existence. Along with colleagues, they've published other work supporting P9 since then.

There's lots of evidence for the existence of P9, but none of it has reached the threshold of definitive proof. The main evidence concerns the orbits of Extreme Trans-Neptunian Objects (ETNOs). They exhibit a peculiar clustering that indicates a massive object. P9 might be shepherding these objects along on their orbits.



This orbital diagram shows Planet Nine (lime green colour, labelled "P9") and several extreme trans-Neptunian objects. Each background square is 100 AU across. Image Credit: By Tomruen – Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=68955415

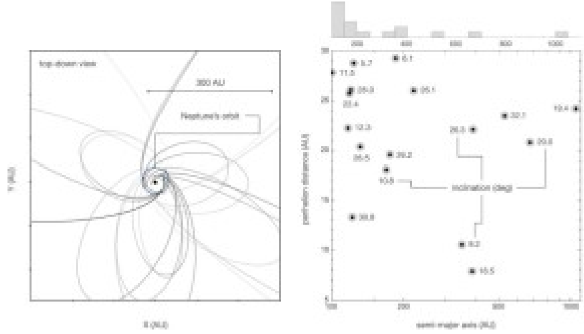
The names Brown and Batygin, both Caltech astronomers, come up often in regard to P9. Now, they've published another paper along with colleagues Alessandro Morbidelli and David Nesvorny, presenting more evidence supporting P9.

It's titled "Generation of Low-Inclination, Neptune-Crossing TNOs by Planet Nine." It's published in The Astrophysical Journal Letters.

"The solar system's distant reaches exhibit a wealth of anomalous dynamical structure, hinting at the presence of a yet-undetected, massive trans-Neptunian body—Planet Nine (P9)," the authors write. "Previous analyses have shown how orbital evolution induced by this object can explain the origins of a broad assortment of exotic orbits."

To dig deeper into the issue, Batygin, Brown, Morbidelli, and Nesvorny examined Trans-Neptunian Objects (TNOs) with more conventional orbits. They carried out N-body simulations of these objects that included everything from the tug of giant planets and the Galactic Tide to passing stars.

29 objects in the Minor Planet Database have well-characterized orbits with a > 100 au, inclinations < 40°, and q (perihelia) < 30 au. Of those 29, 17 have well-quantified orbits. The researchers focused their simulations on these 17.



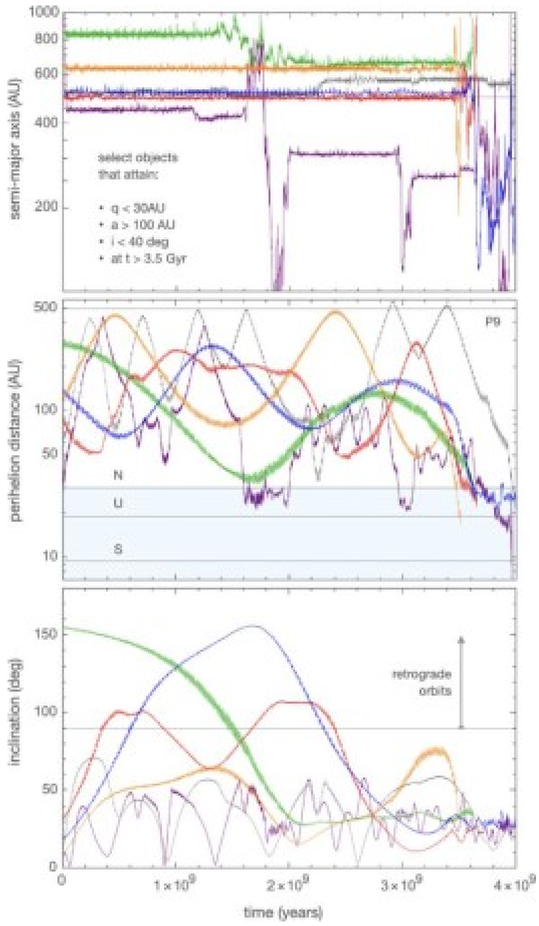
This figure from the research shows the 17 planets, their orbits, their perihelions, semi-major axes, and their inclinations. Image Credit: Batygin et al. 2024.

The researchers' goal was to analyze these objects' origins and determine if they could be used as a probe for P9. To accomplish this, they conducted two separate sets of simulations. One set with P9 in the Solar System and one set without.

The simulations began at *t*=300 million years, meaning 300 million years into the Solar System's existence. At that time, "intrinsic dynamical evolution in the outer solar system is still in its infancy," the authors explain, while enough time has passed for the Solar System's birth cluster of stars to disperse and for the giant planets to have largely concluded their migrations.

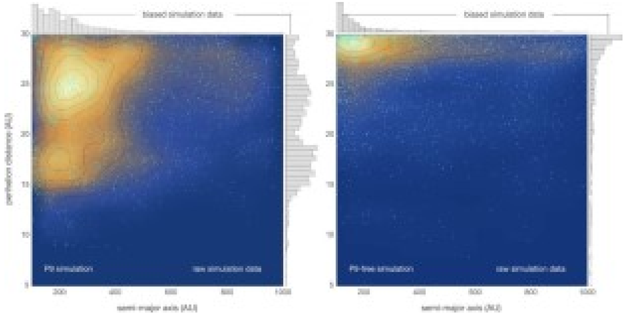
They ended up with about 2000 objects, or particles, in the simulation with perihelia greater than 30 au and semimajor axes between 100 and 5000 au. This ruled out all Neptune-crossing objects from the simulation's starting conditions. "Importantly, this choice of initial conditions is inherently linked with the assumed orbit of P9," they point out.

The figure below shows the evolution of some of the 2,000 objects in the simulations.



These panels show the evolution of selected particles within the calculations that attain nearly planar (i < 40°) Neptune-crossing orbits within the final 500 Myr of the integration. "Collectively, these examples indicate that P9-facilitated dynamics can naturally produce objects similar to those depicted in Figure 1" (the

previous figure), the researchers explain. The top, middle, and bottom panels depict the time series of the semimajor axis, perihelion distance, and inclination, respectively. The rate of chaotic diffusion greatly increases when particles attain Neptune-crossing trajectories. Image Credit: Batygin et al. 2024.
These are interesting results, but the researchers point out that they in no way prove the existence of P9. These orbits could be generated by other things like the Galactic Tide. In their next step, they examined their perihelion distribution.



This figure from the research shows the perihelion distance for particles in a simulation with P9 (left) and without P9 (right.) The P9-free simulation shows a "rapid decline in perihelion distribution with decreasing *q*, as Neptune's orbit forms a veritable dynamical barrier," the researchers explain. Image Credit: Batygin et al. 2024.
"Accounting for observational biases, our results reveal that the orbital architecture of this group of objects aligns closely with the predictions of the P9-inclusive model," the authors write. "In stark contrast, the P9-free scenario is statistically rejected at a ~5*?* confidence level."
The authors point out that something other than P9 could be causing the orbital unruliness. The star was born in a cluster, and cluster dynamics could've set these objects on their unusual orbits before the cluster dispersed. A number of Earth-mass rogue planets could also be responsible, influencing the outer Solar System's architecture for a few hundred million years before being removed somehow.
However, the authors chose their 17 TNOs for a reason. "Due to their low inclinations and perihelia, these objects experience rapid orbital chaos and have short dynamical lifetimes," the authors write. That means that whatever is driving these objects into these orbits is ongoing and not a relic from the past.
An important result of this work is that it results in falsifiable predictions. And we may not have to wait long for the results to be tested. "Excitingly, the dynamics described here, along with all other lines of evidence for P9, will soon face a rigorous test with the operational commencement of the VRO (Vera Rubin Observatory)," the authors write.

A drone's view of the Rubin Observatory under construction in 2023. The 8.4-meter is getting closer to completion and first light in 2025. The Observatory could provide answers to many outstanding issues, like the existence of Planet Nine. Image Credit: Rubin Observatory/NSF/AURA/A. Pizarro D
If P9 is real, what is it? It could be the core of a giant planet ejected during the Solar System's early days. It could be a rogue planet that drifted through interstellar space until being caught up in our Solar System's gravitational milieu. Or it could be a planet that formed on a distant orbit, and a passing star shepherded it into its eccentric orbit. If astronomers can confirm P9's existence, the next question will be, 'what is it?'
If you're interested at all in how science operates, the case of P9 is very instructive. Eureka moments are few and far between in modern astronomy. Evidence mounts incrementally, accompanied by discussion and counterpoint. Objections are raised and inconsistencies pointed out, then methods are refined and thinking advances. What began as one over-arching question is broken down into smaller, more easily-answered ones.
But the big question dominates for now and likely will for a while longer: Is there a Planet Nine?
Stay tuned.

China is Going Back to the Moon Again With Chang'e-6

On Friday, May 3rd, the sixth mission in the Chinese Lunar Exploration Program (*Chang'e-6*) launched from the Wenchang Spacecraft Launch Site in southern China. Shortly after, China announced that the spacecraft separated successfully from its Long March 5 Y8 rocket. The mission, consisting of an orbiter and lander element, is now on its way to the Moon and will arrive there in a few weeks. By June, the lander element will touch down on the far side of the Moon, where it will gather about 2 kg (4.4 lbs) of rock and soil samples for return to Earth.
The mission launched four years after its predecessor, Chang'e-5, became China's first sample-return mission to reach the Moon. It was also the first lunar sample return mission since the Soviet *Luna 24* mission landed in Mare Crisium (the Sea of Crisis) in 1976. Compared to its predecessor, the Chang'e-6 mission weighs an additional 100 kg (220 lbs), making it the heaviest probe launched by the Chinese space program. The surface elements also face lesser-known terrain on the far side of the Moon and require a relay satellite for communications.
Speaking of surface elements, the China Academy of Space Technology (CAST) has since released images showing how the mission also carries a rover element. This payload was not part of mission data disclosed by China before the flight. But as SpaceNews' Andrew Jones pointed out, the rover can be seen in the CAST images (see above) integrated onto the side of the lander.

"Little is known about the rover, but a mention of a Chang'e-6 rover is made in a post from the Shanghai Institute of Ceramics (SIC) under the Chinese Academy of Sciences (CAS)," he wrote. "It suggests the small vehicle carries an infrared imaging spectrometer." This rover is no doubt intended to assist the lander with investigating resources on the far side of the Moon. This is consistent with China's long-term plans for building the International Lunar Research Station (ILRS) around the southern polar region in collaboration with Roscosmos and other international patterns.

Similar to NASA's plans for the Lunar Gateway and Artemis Base Camp, this requires that building sites be selected near sources of water ice and building materials (silica and other minerals). Ge Ping, the deputy director of the Center of Lunar Exploration and Space Engineering (CLESE) with the China National Space Administration (CNSA), related the importance of the sample-return mission to CGTN (a state-owned media company) before the launch:

"The Aitken Basin is one of the three major terrains on the Moon and has significant scientific value. Finding and collecting samples from different regions and ages of the Moon is crucial for our understanding of it. These would further study of the moon's origin and its evolutionary history."
In addition, the Chang'e-6 orbiter carries four international payloads and satellites including a French radon detector contributed by the ESA. Known as the Detection of Outgassing Radon (DORN), this payload will study how lunar dust and other volatiles (especially water) are transferred be-

tween the lunar regolith and the lunar exosphere. Then there's the Italian INstrument for landing-Roving laser Retroreflector Investigations (INRRI), similar to those used by the *Schiaparelli* EDM module and *InSight* lander, that precisely measures distances from the lander to orbit.

The Chang'e-6 spacecraft stack shows a lunar rover attached to the mission lander. Credit: CAST

There's also the Swedish Negative Ions on Lunar Surface (NILS), an instrument that will detect and measure negative ions reflected by the lunar surface. Lastly, there's the Pakistani ICUBE-Q CubeSat developed by the Institute of Space Technology (IST) and Shanghai Jiao Tong University (SJTU), which will take images of the lunar surface using two optical cameras and measure the Moon's magnetic field. The data these instruments provide will reveal new information about the lunar environment that will inform plans for long-duration missions on the surface.

By 2026, the Chang'e-6 mission will be joined by Chang'e-7, including an orbiter, lander, rover, and a mini-hopping probe. The data provided by the program will assist China's plans to land taikonauts around the lunar south pole by 2030, followed by the completion of the ILRS by 2035.

What Can Early Earth Teach Us About the Search for Life?

Earth is the only life-supporting planet we know of, so it's tempting to use it as a standard in the search for life elsewhere. But the modern Earth can't serve as a basis for evaluating exoplanets and their potential to support life. Earth's atmosphere has changed radically over its 4.5 billion years.

A better way is to determine what biomarkers were present in Earth's atmosphere at different stages in its evolution and judge other planets on that basis.

That's what a group of researchers from the UK and the USA did. Their research is titled "The early Earth as an analogue for exoplanetary biogeochemistry," and it appears in Reviews in Mineralogy. The lead author is Eva E. Stüeken, a PhD student at the School of Earth & Environmental Sciences, University of St Andrews, UK.

When Earth formed about 4.5 billion years ago, its atmosphere was nothing like it is today. At that time, the atmosphere and oceans were anoxic. About 2.4 billion years ago, free oxygen began to accumulate in the atmosphere during the Great Oxygenation Event, one of the defining periods in Earth's history. But the oxygen came from life itself, meaning life was present when the Earth's atmosphere was much different.

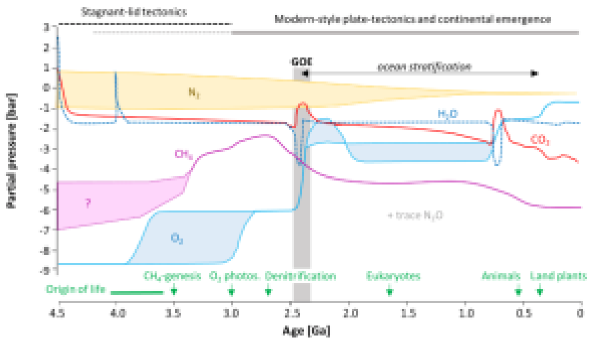
This isn't the only example of how Earth's atmosphere has changed over geological time. But it's an instructive one and shows why searching for life means more than just searching for an atmosphere like modern Earth's. If that's the way we conducted the search, we'd miss worlds where photosynthesis hadn't yet appeared.

In their research, the authors point out how Earth hosted a rich and evolving population of microbes under different atmospheric conditions for billions of years.

"For most of this time, Earth has been inhabited by a purely microbial biosphere albeit with seemingly increasing complexity over time," the authors write. "A rich record of this geobiological evolution over most of Earth's history thus provides insights into the remote detectability of microbial life under a variety of planetary conditions."

It's not just life that's changed over time. Plate tectonics have changed and may have been 'stagnant lid' tectonics for a long time. In stagnant lid tectonics, plates don't move horizontally. That can have consequences for atmospheric chemistry.

The main point is that Earth's atmosphere does not reflect the solar nebula the planet formed in. Multiple intertwined processes have changed the atmosphere over time. The search for life involves not only a better understanding of these processes, but how to identify what stage exoplanets might be in.



This figure from the research shows how the abundance of major gases in Earth's atmosphere has changed over time due to various factors. Image Credit: Stüeken et al. 2024.

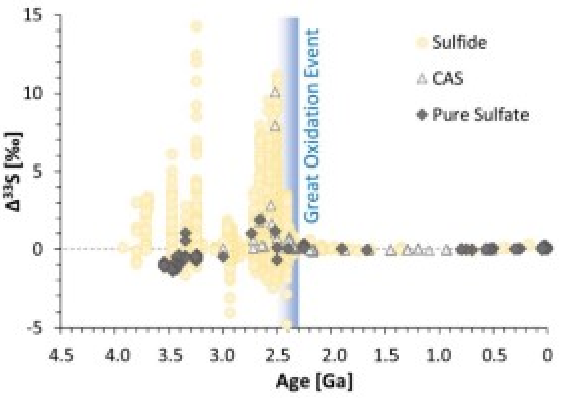
It's axiomatic that biological processes can have a dramatic effect on planetary atmospheres. "On the modern Earth, the atmospheric composition is very strongly controlled by life," the researchers write. "However, any potential atmospheric biosignature must be disentangled from a backdrop of abiotic (geological and astrophysical) processes that also contribute to planetary atmospheres and would be dominating on lifeless worlds and on planets with a very small biosphere."

The authors outline what they say are the most important lessons that the early Earth can teach us about the search for life.

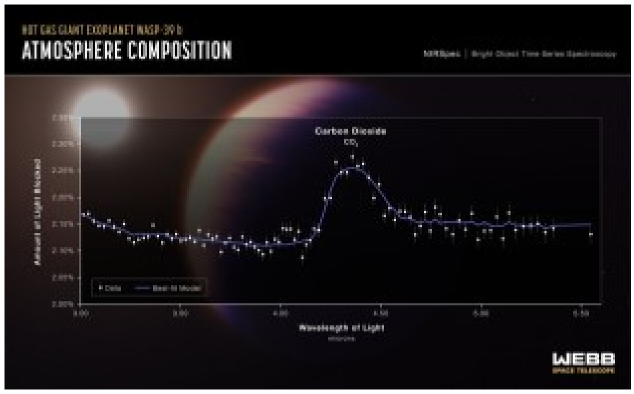
The first is that the Earth has actually had three different atmospheres throughout its long history. The first one came from the solar nebula and was lost soon after the planet formed. That's the primary atmosphere. The second one formed from outgassing from the planet's interior. The third one, Earth's modern atmosphere, is complex. It's a balancing act involving life, plate tectonics, volcanism, and even atmospheric escape. A better understanding of how Earth's atmosphere has changed over time gives researchers a better understanding of what they see in exoplanet atmospheres.

Earth's Hadean Eon is a bit of a mystery to us because geologic evidence from that time is scarce. During the Hadean, Earth had its primary atmosphere from the solar nebula. But it soon lost it and accumulated another one via outgassing

as the planet cooled. Credit: NASA
The second is that the further we look back in time, the more the rock record of Earth's early life is altered or destroyed. Our best evidence suggests life was present by 3.5 billion years ago, maybe even by 3.7 billion years ago. If that's the case, the first life may have existed on a world covered in oceans, with no continental land masses and only volcanic islands. If there had been abundant volcanic and geological activity between 3.5 and 3.7 billion years ago, there would've been large fluxes of CO2 and H2. Since these are substrates for methanogenesis, then methane may have been abundant in the atmosphere and detectable.
The third lesson the authors outline is that a planet can host oxygen-producing life for a long time before oxygen can be detected in an atmosphere. Scientists think that oxygenic photosynthesis appeared on Earth in the mid-Archean eon. The Archean spanned from 4 billion to 2.5 billion years ago, so mid-Archean is sometime around 3.25 billion years ago. But oxygen couldn't accumulate in the atmosphere until the Great Oxygenation Event about 2.4 billion years ago. Oxygen is a powerful biomarker, and if we find it in an exoplanet's atmosphere, it would be cause for excitement. But life on Earth was around for a long time before atmospheric oxygen would've been detectable.



Earth's history is written in chemical reactions. This figure from the research shows the percentage of sulphur isotope fractionation in sediments. The sulphur signature disappeared after the GOE because the oxygen in the atmosphere formed an ozone shield. That blocked UV radiation, which stopped sulphur dioxide photolysis. "Anoxic planets where O2 production never occurs are more likely to resemble the early Earth prior to the GOE," the authors explain. Image Credit: Stüeken et al. 2024.
The fourth lesson involves the appearance of horizontal plate tectonics and its effect on chemistry. "From the GOE onwards, the Earth looked tectonically similar to today," the authors write. The oceans were likely stratified into an anoxic layer and an oxygenated surface layer. However, hydrothermal activity constantly introduced ferrous iron into the oceans. That increased the sulphate levels in the seawater which reduced the methane in the atmosphere. Without that methane, Earth's biosphere would've been much less detectable. Complicated, huh?
"Planet Earth has evolved over the past 4.5 billion years from an entirely anoxic planet
with possibly a different tectonic regime to the oxygenated world with horizontal plate
tectonics that we know today," the authors explain. All that complex evolution allowed life to appear and to thrive, but it also makes detecting earlier biospheres on exoplanets more complicated.
We're at a huge disadvantage in the search for life on exoplanets. We can literally dig into Earth's ancient rock to try to untangle the long history of life on Earth and how the atmosphere evolved over billions of years. When it comes to exoplanets, all we have is telescopes. Increasingly powerful telescopes, but telescopes nonetheless. While we are beginning to explore our own Solar System, especially Mars and the tantalizing ocean moons orbiting the gas giants, other solar systems are beyond our physical reach.
"We must instead remotely recognize the presence of alien biospheres and characterize their biogeochemical cycles in planetary spectra obtained with large ground- and space-based telescopes," the authors write. "These telescopes can probe atmospheric composition by detecting absorption features associated with specific gases." Probing atmospheric gases is our most powerful approach right now, as the JWST shows.

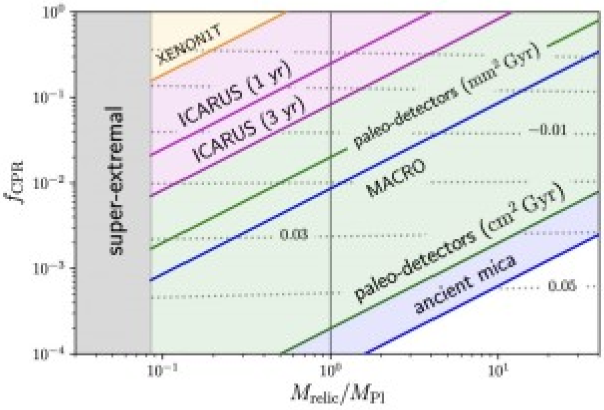


The JWST has made headlines for examining exoplanet atmospheres and identifying chemicals. A transmission spectrum of the hot gas giant exoplanet WASP-39 b, captured by Webb's Near-Infrared Spectrograph (NIRSpec) on July 10, 2022, revealed the first definitive evidence for carbon dioxide in the atmosphere of a planet outside the Solar System. Credit: NASA, ESA, CSA, and L. Hustak (STScI). Science: The JWST Transiting Exoplanet Community Early Release Science Team
But as scientists get better tools, they'll start to go beyond atmospheric chemistry. "We might also be able to recognize global-scale surface features, including light interaction with photosynthetic pigments and 'glint' arising from specular reflection of light by a liquid ocean."
Understanding what we're seeing in exoplanet atmospheres parallels our understanding of Earth's long history. Earth could be the key to our broadening and accelerating search for life.
"Unravelling the details of Earth's complex biogeochemical history and its relationship with remotely observable spectral signals is an important consideration for instrument design and our own search for life in the Universe," the authors write.

The Universe Could Be Filled With Ultralight Black Holes That Can't Die

It's that time again! Time for another model that will finally solve the mystery of dark matter. Or not, but it's worth a shot. Until we directly detect dark matter particles, or until some model conclusively removes dark matter from our astrophysical toolkit the best we can do is continue looking for solutions. This new work takes a look at that old theoretical chestnut, primordial black holes, but it has a few interesting twists.
Primordial black holes are hypothetical objects formed during the earliest moments of the Universe. According to the models they formed from micro-fluctuations in matter density and spacetime to become sandgrain-sized mountain-massed black holes. Although we've never detected primordial black holes, they have all the necessary properties of dark matter, such as not emitting light and the ability to cluster around galaxies. If they exist, they could explain most of dark matter. The downside is that most primordial black hole candidates have been ruled out by observation. For example, to account for dark matter there would have to be so many of these gravitational pipsqueaks that they would often pass in front of a star from our vantage point. This would create a microlensing flare we should regularly observe. Several sky surveys have looked for such an event to no avail, so PBH dark matter is not a popular idea these days.
This new work takes a slightly different approach. Rather than looking at typical primordial black holes, it considers ultralight black holes. These are on the small end of possible masses and are so tiny that Hawking radiation would come into play. The rate of Hawking decay is inversely proportional to the size of a black hole, so these ultralight black holes should radiate to their end of life on a short cosmic timescale.

Since we don't have a full model of quantum gravity, we don't know what would happen to ultralight black holes at the end, which is where this paper comes in.



Observational limits for primordial black holes. Credit: S. Profumo

As the author notes, basically there are three possible outcomes. The first is that the black hole radiates away completely. The black hole would end as a brief flash of high-energy particles. The second is that some mechanism prevents complete evaporation and the black hole reaches some kind of equilibrium state. The third option is similar to the second, but in this case, the equilibrium state causes the event horizon to disappear, leaving an exposed dense mass known as a naked singularity. The author also notes that for the latter two outcomes, the objects might have a net electric charge.

For the evaporating case, the biggest unknown would be the timescale of evaporation. If PBHs are initially tiny they would evaporate quickly and add to the reheating effect of the early cosmos. If they evaporate slowly, we should be able to see their deaths as a flash of gamma rays. Neither of these effects has been observed, but it is possible that detectors such as Fermi's Large Area Telescope might catch one in the act.

For the latter two options, the author argues that equilibrium would be reached around the Planck scale. The remnants would be proton sized but with much higher masses. Unfortunately, if these remnants are electrically neutral they would be impossible to detect. They wouldn't decay into other particles, nor would they be large enough to detect directly. This would match observation, but isn't a satisfying result. The model is essentially unprovable. If the particles do have a charge, then we might detect their presence in the next generation of neutrino detectors.

The main thing about this work is that primordial black holes aren't entirely ruled out by current observations. Until we have better data, this model joins the theoretical pile of many other possibilities.

Starlink on Mars? NASA Is Paying SpaceX to Look Into the Idea

NASA has given the go-ahead for SpaceX to work out a plan to adapt its Starlink broadband internet satellites for use in a Martian communication network.

The idea is one of a dozen proposals that have won NASA funding for concept studies that could end up supporting the space agency's strategy for bringing samples from Mars back to Earth for lab analysis. The proposals were submitted by nine companies — also including Blue Origin, Lockheed Martin, United Launch Alliance, Astrobotic, Firefly Aerospace, Impulse Space, Albedo Space and Redwire Space.

Awardees will be paid $200,000 to $300,000 for their reports, which are due in August. NASA says the studies could lead to future requests for proposals, but it's not yet making any commitment to follow up.

"We're in an exciting new era of space exploration, with rapid growth of commercial interest and capabilities," Eric Ianson, director of NASA's Mars Exploration Program, said in a news release. "Now is the right time for NASA to begin looking at how public-private partnerships could support science at Mars in the coming decades."

For years, SpaceX executives have been talking about using Starlink satellites in Martian orbit as part of billionaire founder Elon Musk's vision of making humanity a multiplanetary species. In 2020, SpaceX President Gwynne Shotwell told Time magazine that connectivity will be an essential part of the company's Mars settlement plan.

"Once we take people to Mars, they are going to need a capability to communicate," she said. "In fact, I think it will be even more critical to have a constellation like Starlink around Mars. And then, of course, you need to connect the two planets as well — so, we need to make sure we have robust telecom between Mars and back in Earth."

Musk delved into more detail during last October's International Astronautical Congress in Azerbaijan. "For Mars, you'd want a laser relay system, essentially," he said. "It depends on what bandwidth you're looking for. … Ultimately, we'd want terabit, maybe petabit-level data transfer between Earth and Mars." **Check out his comments on YouTube:**

Musk could capitalize on NASA's need to upgrade its communication relay system at the Red Planet, which relies on satellites that are up to 23 years old. The space agency's main focus for future Mars exploration is its multi-mission strategy to retrieve samples that have been cached by the Perseverance rover. Last month, NASA said it would rework that strategy to reduce costs, in part by taking advantage of innovations coming from private industry. The innovations that are now the focus of the Mars Exploration Commercial Services program could play prominent roles in the revised strategy.

Blue Origin, the space venture founded by Amazon billionaire Jeff Bezos, will look into adapting its Blue Ring transfer vehicle to host and deliver payloads heading for Mars. A separate study will focus on Blue Ring's potential use for next-generation relay services. In a posting to X / Twitter, Blue Origin said it was "excited to be part of NASA's studies around the future of Mars robotic science and the unique benefits our Blue Ring platform can provide by enabling large payload delivery, hosting, and next-gen relay services."

Here are the other companies on NASA's list, and the subjects of their studies:

Albedo Space: How to adapt an imaging satellite originally meant for low Earth orbit to provide Mars surface imaging.

Astrobotic Technology: How to modify a lunar-exploration spacecraft for large payload delivery and hosting services. Also, how to modify a lunar-exploration spacecraft for Mars surface imaging.

Firefly Aerospace: How to adapt a lunar-exploration spacecraft for small payload delivery and hosting services.

Impulse Space: How to adapt its Helios space tug to provide small payload delivery and hosting for Mars missions.

Lockheed Martin: How to adapt a lunar-exploration spacecraft for small payload delivery and hosting. Also, how to provide communication relay services for Mars with a spacecraft originally meant for use in the vicinity of Earth and the moon.

Redwire Space: How to modify a commercial imaging spacecraft originally meant for low Earth orbit to provide Mars surface-imaging services.

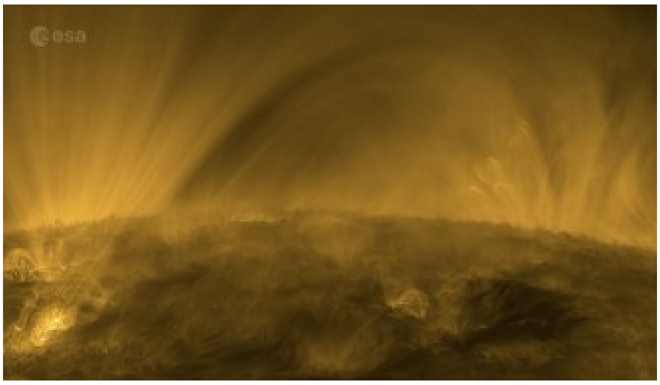
United Launch Alliance (through United Launch Ser-

vices): How to modify an Earth-vicinity cryogenic upper stage to provide large payload delivery and hosting services.

Solar Orbiter Takes a Mind-Boggling Video of the Sun

You've seen the Sun, but you've never seen the Sun like this. This single frame from a video captured by ESA's Solar Orbiter mission shows the Sun looking very …. fluffy! You can see feathery, hair-like structures made of plasma following magnetic field lines in the Sun's lower atmosphere as it transitions into the much hotter outer corona. The video was taken from about a third of the distance between the Earth and the Sun.
See the full video below, which shows unusual features on the Sun, including coronal moss, spicules, and coronal rain.
Solar Orbiter recorded this video on September 27, 2023 using its Extreme Ultraviolet Imager (EUI) instrument.

ESA said the brightest regions are around one million degrees Celsius, while cooler material looks darker, as it absorbs radiation.
So, just what is coronal moss? It's what gives the Sun its fluffy appearance here. These peculiar structures on the Sun resemble the moss we find on Earth, in that it appears like fine, lacy features. But on the Sun, they usually can be found around the center of sunspot groups, where magnetic conditions are strong and large coronal loops are forming. The moss is so hot, most instruments can't detect them. The moss spans two atmospheric layers, the chromosphere and corona.

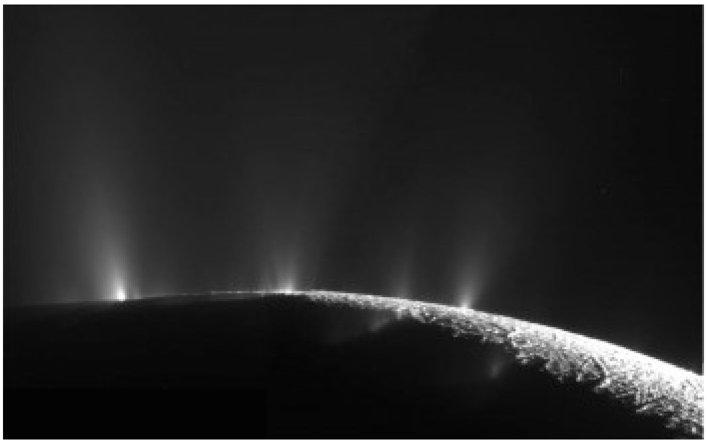


Features on the Sun's surface, as seen by Solar Orbiter. Credit: ESA & NASA/Solar Orbiter/EUI Team

Spicules, as their name implies, are tall spires of gas seen on the solar horizon that reach up from the Sun's chromosphere. These can reach up to a height of 10,000 km (6,000 miles).
At about 0:30 in the video, you'll see coronal rain. This material is cooler than the rest of the solar surface (probably less than 10,000 °C) versus the one million degrees C of the coronal loops. The rain is made of higher-density clumps of plasma that fall back towards the Sun under the influence of gravity.
Did you see the small eruption in the center of the field of view at about 0:20 seconds in the video? , with cooler material being lifted upwards before mostly falling back down. It's not small at all — this eruption is bigger than Earth!
Missions like Solar Orbiter, the Parker Solar Probe and the Solar Dynamics Observatory are giving us unprecedented views of the Sun, helping astronomers to learn more about the dynamic ball of gas that powers our entire Solar System.
Further reading: ESA

Enceladus's Fault Lines are Responsible for its Plumes

The Search for Life in our Solar System leads seekers to strange places. From our Earthbound viewpoint, an ice-covered moon orbiting a gas giant far from the Sun can seem like a strange place to search for life. But underneath all that ice sits a vast ocean. Despite the huge distance between the moon and the Sun and despite the thick ice cap, the water is warm.
Of course, we're talking about Enceladus, and its warm, salty ocean—so similar to Earth's in some respects—takes some of the strangeness away.
Enceladus is Saturn's sixth-largest moon, and the Cassini spacecraft observed it during its mission to the Saturn system. Scientists discovered that plumes of water originating from Enceladus' southern region are responsible for one of Saturn's rings. They also discovered that the water is salty. Any place we find warm, salty water attracts our immediate attention, even when it's covered by kilometres of ice and is 1.5 billion kilometres away from the life-giving Sun.
There's lots of talk about a future mission to Enceladus to explore the moon and its potentially life-supporting ocean in more detail. But until then, scientists are working with their current data, and using models and simulations to understand the moon better.
Enceladus' most defining surface features are its Tiger Stripes. They're four parallel, linear depressions on the moon's surface about 130 km long, 2 km wide, and 500 meters deep. They have higher temperatures than their surroundings, indicating that cryovolcanism is active. The stripes are the source of Enceladus' plumes.

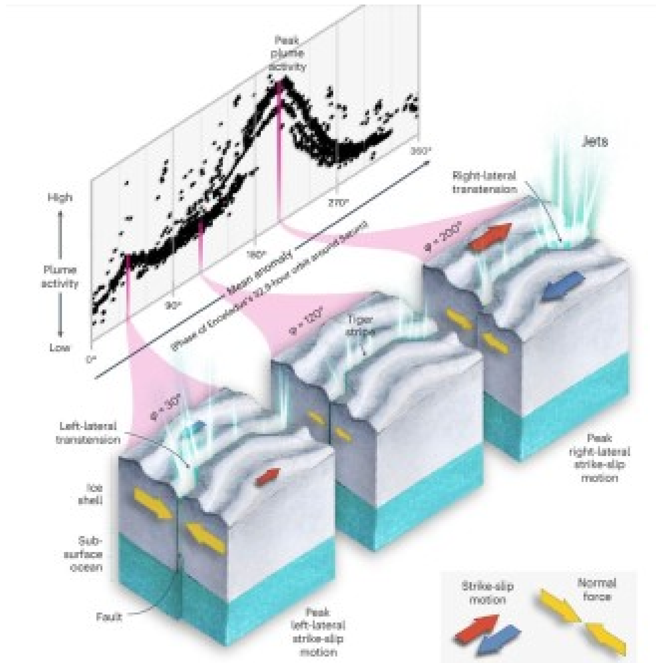


Geysers erupt from Enceladus' Tiger Stripes in this image from the Cassini spacecraft. Image Credit: By NASA/JPL/SSI – http://www.nasa.gov/mission_pages/cassini/multimedia/pia11688.html, Public Domain, https://commons.wikimedia.org/w/index.php?curid=15592605

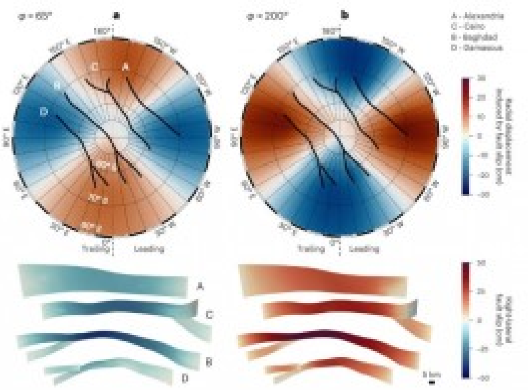
New research suggests that strike-slip faults at the moon's prominent Tiger Stripe features allow plumes of water from Enceladus to escape into space. It's published in Nature Geoscience and titled "Jet activity on Enceladus linked to tidally driven strike-slip motion along tiger stripes." The lead author is Alexander Berne, a doctoral candidate in Geophysics at the California Institute of Technology.

The plumes above the Tiger Stripes aren't stable and continuous. They wax and wane as the moon follows its 33-hour orbit around Saturn. Tidal heating keeps the moon's water in liquid form, and according to the researchers, the same tidal forces are responsible for the intermittent plumes. Theory shows that tidal forces open and close faults at the Tiger Stripes like an elevator door, and that turns the plumes on and off.
However, those theories can't accurately predict the timing of the plumes' peak brightness. They also show that tidal forcing alone doesn't provide enough energy to open and close the faults.
This research digs deeper into the question and provides an

answer. The authors say that rather than acting like an elevator door, strike-slip faults at the Tiger Stripes open and close to regulate plume activity. This is similar to what happens on Earth in places like the San Andreas Fault. It's a strike-slip fault where one side shears past the other, causing Earthquakes. The critical part of this is that strike-slip faults require less energy than the elevator opening and closing scenario.
Models are more effective as they're fed more detailed and accurate data. Berne and his co-researchers built a numerical model that simulates the strike-skip faults on Enceladus. They included friction, compressional forces and shear forces. The numerical model showed the faults acting in concert with the changing plumes. This strongly suggests that Enceladus' orbit and the tidal forces acting on the moon cause the strike-slip faults to open and close.



This illustration from the research explains how strike-slip faults are responsible for the plumes erupting from Enceladus' Tiger Stripes. As the moon orbits Saturn, tidal forces open and close the faults. Image Credit: Berne et al. 2024.
The Tiger Stripes have bent sections that pull apart under strain. Since they're bent, an opening appears as they slide. The plumes come from these openings.
The research team's work and previous research into the Tiger Stripes by NASA's Jet Propulsion Laboratory both support the idea that the plumes come from these strike-slip faults.
"We now appear to have both geologic and geophysical reasons to suspect that jet activity occurs at pull-aparts along Enceladus's tiger stripes," said lead author Berne.



This figure from the research shows the degree of displacement and slip at the Tiger Stripe faults at two different points in Enceladus' orbit. Image Credit: Berne et al. 2024.
Enceladus gets most of its attention because of its potential to support life. The plumes themselves aren't part of what life needs, but they're a window into the moon's potential habitability.

"For life to evolve, the conditions for habitability have to be right for a long time, not just an instant," said study co-author Mark Simons, Professor of Geophysics at Caltech. "On Enceladus, you need a long-lived ocean. Geophysical and geological observations can provide key constraints on the dynamics of the core and the crust as well as the extent to which these processes have been active over time."
There's a lot more work to be done to understand Enceladus. On Earth, satellites can monitor the movement at strike-slip faults and use it to better understand Earthquakes. Once we get a spacecraft to Enceladus, it could do the same.
"Detailed measurements of motion along the tiger stripes are needed to confirm the hypotheses laid out in our work," Berne says. "For instance, we now have the capacity to image fault slip, such as earthquakes, on Earth using radar measurements from satellites in orbit. Applying these methods at Enceladus should allow us to better understand the transport of material from the ocean to the surface, the thickness of the ice crust, and the long-term conditions which may enable life to form and evolve on Enceladus."
When we get a spacecraft to Enceladus, it can monitor the faults and jets over multiple orbits. That will allow researchers to test their predictions.
"These observations could provide key constraints on the mechanical nature of the crust, tidal controls on jet activity and the evolution of the south polar terrain," the authors conclude.

Insanely Detailed Webb Image of the Horsehead Nebula

Few space images are as iconic as those of the Horsehead Nebula. Its shape makes it instantly recognizable. Over the decades, a number of telescopes have captured its image, turning it into a sort of test case for a telescope's power.
The JWST has them all beat.
The Horsehead Nebula is about 1300 light-years away in Orion. It's part of the much larger Orion Molecular Cloud Complex. Horsehead is visible near the three stars in Orion's Belt in a zoomed-in image.

The Horsehead Nebula is visible in this image of Orion's Belt. It's in the lower left, extending horizontally, to the lower left of the belt star Alnitak. Image Credit: By Davide De Martin (http://www.skyfactory.org); Credit: Digitized Sky Survey, ESA/ESO/NASA FITS Liberator – https://www.spacetelescope.org/projects/fits_liberator/fitsimages/davidedemartin_12/ (direct link), Public Domain, https://commons.wikimedia.org/w/index.php?curid=1329999
The leading image shows JWST's view of the Horsehead Nebula alongside two other views. The Euclid image was captured in November 2023. Euclid features a wide-angle, 600-megapixel camera, and its primary job is to measure the redshift of galaxies and the Universe's expansion due to dark energy. It took Euclid about one hour to capture the image, showcasing the telescope's ability to gather highly detailed images quickly.
The Hubble captured its image in 2013 and was released as

the telescope's 23rd-anniversary featured image. The venerable Hubble does a good job of revealing structures hidden by dust. There's nothing left to say about the Hubble that hasn't been said already. It's the revered elder among telescopes, and if you feel no reverence towards it, its contribution to science, and the people responsible for it, you may have a bad case of ennui.

The third image is a new one from the JWST's NIRCam instrument. It's described as the sharpest image of the Horsehead ever taken. It shows a small part of the iconic nebula in detail we don't usually see. The JWST is so powerful it even shows background galaxies.

A zoom-in of the JWST image. The detail is incredible. Image Credit: ESA/Webb, CSA, K. Misselt, M. Zamani (ESA/Webb)

The Horsehead Nebula is the result of stellar erosion. The nebula itself was formed by a collapsing cloud of material, and a nearby hot star called Sigma Orionis illuminates the structure. The nebula is denser than its surrounding gas and has resisted the dissipative energy of the star, while the gas that used to surround it is long gone.

This definitely isn't the last we'll see of Horsehead. New, powerful telescopes coming online soon, like the Giant Magellan Telescope and the European Extremely Large Telescope will likely take a crack at the nebula. Prepare to be wowed.

There's no rush. According to astronomers, the Horsehead Nebula will eventually be eroded away, too, but not for another five million years or so.

Earth Had a Magnetosphere 3.7 Billion Years Ago

We go about our daily lives sheltered under an invisible magnetic field generated deep inside Earth. It forms the magnetosphere, a region dominated by the magnetic field. Without that planetary protection shield, we'd experience harmful cosmic radiation and charged particles from the Sun.

Has Earth always had this deflector shield? Probably so, and the evidence is in old rocks. A team of researchers at University of Oxford and MIT found the earliest evidence for its existence in stones found along the coast of Greenland in a region called the Isua Supercrustal Belt.

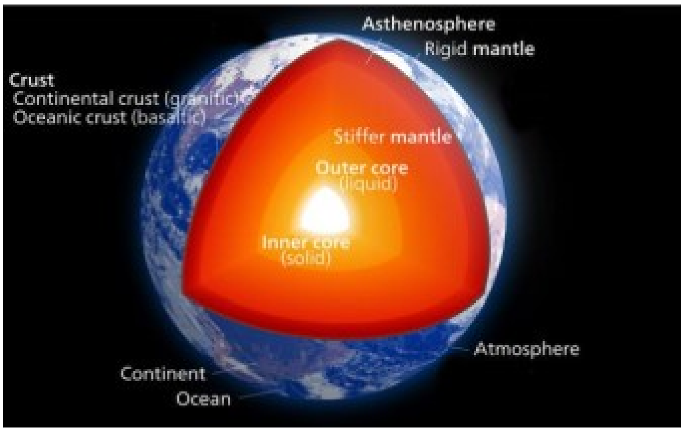
Geologists have long known that iron particles in rocks "entrain" a print of the magnetic field that was in place when they formed. So, the research team uncovered rocks that formed some 3.7 billion years ago. It's not an easy task, according to team lead Claire Nichols of the Department of Earth Sciences at Oxford. "Extracting reliable records from rocks this old is extremely challenging," Nichols pointed out. "It was really exciting to see primary magnetic signals begin to emerge when we analyzed these samples in the lab. This is a really important step forward as we try and determine the role of the ancient magnetic field when life on Earth was first emerging."

This 3.7-billion-year-old rock from Greenland. Entrained magnetic field fingerprints help scientists determine that our magnetosphere and magnetic field existed when this rock formed. Courtesy: Claire Nichols.

The team's samples recorded a magnetic field strength of 15 microteslas at the time they formed. Today, Earth's field strength is closer to 30 microteslas, so it's obvious that our magnetic field and magnetosphere have been there for billions of years. It's also clear that the field changes over time. The science team also found that early Earth's magnetosphere was amazingly similar to the one it has today.

Tracking Earth's Magnetosphere through Time

Our planet has a main dynamo at its heart. There are two cores—an inner one and an outer one. Motions in the core regions generate the magnetic field that defines our magnetosphere. Molten iron mixes and moves in the fluid outer core and the inner core solidifies. The two actions together create that dynamo. That's what's happening inside our planet today.



This cutaway of planet Earth shows the familiar exterior of air, water and land as well as the interior: from the mantle down to the outer and inner cores. Currents in hot, liquid iron-nickel in the outer core create our planet's protective but fluctuating magnetic field and magnetosphere. Credit: Kelvinsong / Wikipedia

However, when Earth was first forming some 4.5 billion years ago, that solid inner core didn't exist. Without the interaction we see today between the two parts of the core, it's hard to know how any early magnetic field existed. That's an open question among geologists and planetary scientists: how did it form and how was it sustained?

Another question relates to how much the planetary magnetic field has varied over time. Answering that one would help geologists understand just when the solid inner core formed.

It would also show how much heat has escaped our planet from deep inside over time. Heat escape drives plate tectonics, which uses large “plates” of rock to shift things around on the surface over hundreds of millions of years.
What Do the Rocks Tell Us?
Rocks have a long and complex history. They form as a molten mixture that solidifies, or in the case of sandstones, are laid down in layers that then harden. In the case of molten rocks, they have magnetic field fingerprints entrained at the time of formation. In measuring those fingerprints, geologists account for any heating that could “reset” the magnetic signatures over time. The Greenland rocks are relatively pristine, meaning they haven’t been significantly heated since they formed. That means their magnetic fingerprints haven’t changed since formation.

Lava cooling after an eruption. This rock has an entrained magnetic field fingerprint from the time it formed. Credit: kalapanaculturaltours.com

Rocks also get weathered by wind, temperature changes and erosion, but the Isuan samples seem to be relatively pristine, according to Benjamin Weiss of MIT. “Northern Isua has the oldest known well-preserved rocks on Earth,” Weiss said. “Not only have they not been significantly heated since 3.7 billion years ago but they have also been scraped clean by the Greenland ice sheet.”
Rocks Through Time
The rocks the team studied date back to the Archean Eon—the second-oldest geologic eon in Earth’s history. That period began about 4 billion years ago, and during that time Earth was largely an ocean world with a limited amount of continental surface. Since then, Earth’s surface has changed a great deal, destroying or burying rocks from earlier times. So, finding rocks that date back that far in time is a big deal.
The Isuan rocks are relatively unchanged since they formed, and bear proof of a magnetic field existing less than a billion years after the planet formed. That same early magnetic field could have played a role in the development of our planet’s atmosphere, by assisting in removing xenon gas. Other old rocks may well tell scientists more about the birth of the magnetic field. There are rocks in Canada, Australia and South Africa that could give unique insight into the formation of the field and its role in making Earth habitable for life.

For More Information

Researchers Find Oldest Undisputed Evidence of Earth’s Magnetic Field

Possible Eoarchean Records of the Geomagnetic Field Preserved in the Isua Supracrustal Belt, Southern West Greenland

First Light from Einstein Probe: A Supernova Remnant

Supernova remnant Puppis A

POSTED ONAPRIL 29, 2024 BY MARK THOMPSON

On 9 January 2024, the Einstein probe was launched, its mission to study the night sky in X-rays. The first image from the probe that explores the Universe in these energetic wavelengths has just been released. It shows Puppis A, the supernova remnant from a massive star that exploded 4,000 years ago. The image showed the expanding cloud of ejecta from the explosion but now, Einstein will continue to scan the skies for other X-ray events.
The Chinese and European probe was designed to revolutionise our understanding of the Universe in X-rays. Named after none other than Albert Einstein, it houses cutting edge technology that will enable the observation of black holes, neutron stars and other events and phenomena emitting X-ray radiation. To achieve this it has two science instruments on board; the Wide-field X-ray Telescope (WXT) to give large field views of the sky and the Follow-up X-ray Telescope (FXT) which homes in on objects of interest identified by WXT.
The Einstein probe has three main questions it hopes to address focusing on black holes, gravity waves and supernovae. The recent image just released shows the stunning Puppis A supernova remnant. Supernova are a common process that takes place at the end of a massive star’s life. A star like the Sun is fusing hydrogen in its core into helium. The process is known as thermonuclear fusion and it releases heat, light and an outward pressure known as the thermonuclear force. While a star is stable, the thermonuclear force balances the force of gravity which is trying to collapse the star.
Massive stars will continue fusing different elements in the core until an iron core remains. It’s not possible to fuse iron so the thermonuclear force ceases allowing gravity to win. the core collapses and the inward rushing material crashes down onto the core and rebounds into a massive explosion known as a supernova.
Puppis A is one such object that is thought to have exploded 4,000 years ago. It lies about 7,000 light years from us which means the light that the radiation detected by the Einstein probe left about 7,000 years ago.
In the image released from Einstein, the cloud like structure is all that remains of the star that went supernova. It is possible to see a bright dot at the centre of the cloud, this is the core of the star that remains, a neutron star.
The FXT image was accompanied by a spectrum to show the distribution of energy to help understand the elements present.
Source : Supernova remnant Puppis A imaged by Einstein Probe

Galaxies Evolved Surprisingly Quickly in the Early Universe

Anyone familiar with astronomy will know that galaxies come in a fairly limited range of shapes, typically; spiral, elliptical, barred-spiral and irregular. The barred-spiral galaxy has been known to be a feature of the modern

universe but a study from astronomers using the Hubble Space Telescope has recently challenged that view. Following on observations using the James Webb Space Telescope has found the bar feature in some spiral galaxies as early as 11 billion years ago suggesting galaxies evolved faster in the early Universe than previously expected.
Our own Galaxy, the Milky Way is a spiral galaxy with a central nucleus and spiral arms emanating out from the centre. Our Solar System lies about 25,000 light years from the centre. Look at the galaxies in the sky though and you will see a real mix but generally they fall under the four main categories. Edwin Hubble tried to bring some structure to the different shapes by developing his galaxy classification scheme to articulate not only the shape but also the sub categories within them.

This research published in Nature is the first direct confirmation that supermassive black holes are capable of shutting down galaxies
It has been known for some time that galaxies aren't static. They move and they evolve and change. Spiral galaxies for example, as they age, they often develop a bar feature. The bar joins up the spiral arms instead of a nucleus connecting them and it is believed they are temporary, forming when a build of gas creates a burst of star formation.
The existence of a bar in a spiral galaxy suggests that the galaxy is fairly stable. Understanding just how the bar feature forms is key to understanding the evolutionary process of the galaxy itself. All previous observations showed that the appearance of the bar significantly reduces from the nearby Universe to redshifts near a value of one. This tells us that the bar seemed to be a modern feature and not present in the early Universe.

The barred spiral galaxy NGC 1300. Credit: NASA, ESA, and The Hubble Heritage Team (STScI/AURA)
In a new paper by lead author Zoe A Le Conte, observations from the more sensitive James Webb Space Telescope report that galaxies to greater redshift are studied for bar features. Data is used from the Cosmic Evolution Early Release Science Survey and the observations from the Public Release Imaging for Extragalactic Research studies. Only the galaxies that also appear in the Cosmic Assembly Near Infra Red Deep Extragalactic Legacy Survey are used giving a sample of 368 face on galaxies.
The team visually searched through the 368 galaxy selection to classify and identify those with bars between redshifts 1 and 2 and then repeated the exercise for those between redshift 2 and 3. As expected, the fraction of bars reduced from around 17.8% between a red shift of 1 and 2 down to 13.8% at the greater red shift of 2 to 3.
The study revealed that JWST's infra-red sensitivity picked up twice as many barred-spiral galaxies than the HST's more blue sensitive imaging platform. Le Conte and her team conclude that the evolution of bars in spiral galaxies began to appear at a much earlier epoch, around 11 billion years ago.

A Cold Brown Dwarf is Belching Methane Into Space

Brown dwarfs span the line between planets and stars. By definition, a star must be massive enough for hydrogen fusion to occur within its core. This puts the minimum mass of a star around 80 Jupiters. Planets, even large gas giants like Jupiter, only produce heat through gravitational collapse or radioactive decay, which is true for worlds up to about 13 Jovian masses. Above that, deuterium can undergo fusion. Brown dwarfs lay between these two extremes. The smallest brown dwarfs resemble gas planets with surface temperatures similar to Jupiter. The largest brown dwarfs have surface temperatures around 3,000 K and look essentially like stars.
Because of this, it can be difficult to study brown dwarfs, particularly ones that don't orbit other stars. Without much reflected or emitted light, we can't easily analyze their spectra to determine their composition. Fortunately, some brown dwarfs do emit radio light thanks to their strong magnetic fields.
Planets such as Earth and Jupiter have strong magnetic fields, and this means they can trap ionized particles such as hydrogen. These charged particles then spiral along the magnetic field lines until they collide with the planet's upper atmosphere, generating glowing aurora. On Earth, we see them as the Northern Lights. For brown dwarfs, we can't see the visible light of their aurora, but we can detect their radio glow.
Recently a team looked at the auroral light from a brown dwarf known as W1935. It is a cold brown dwarf 47 light-years from Earth with a surface temperature of just 200 ° C. Within the spectra the team found light emissions from methane. While the presence of methane was expected in cold brown dwarfs, the fact that the methane emitted light was not. This means the atmosphere of W1935 likely has a thermal inversion, where the upper atmosphere is warmer than the lower layers.
This is true for the atmosphere of Earth but is driven by solar radiance. W1935 doesn't orbit a star, so how can its upper atmosphere get so warm? One possible explanation is that the brown dwarf has an undetected small companion. This companion could be ejecting material similar to the way Saturn's moon Enceleadus ejects water vapor. Once ionized in the vacuum of space, it would become trapped by the magnetic fields of W1935, eventually colliding with the brown dwarf's upper atmosphere and giving it a bit of thermal heating.
This discovery shows that even the smallest brown dwarfs defy easy classification. Though they resemble planets, they may have their own planetary system like a star.
Reference: Faherty, Jacqueline K., et al. "Methane emission from a cool brown dwarf." *Nature* 628.8008 (2024): 511-514.

Japan's Lunar Lander Survives its Third Lunar Night

Space travel and exploration was never going to be easy. Failures are sadly all too common but it's wonderful to see missions exceed expectations. The Japanese Space Agency's SLIM lunar lander was only supposed to survive a single day but it's survived three brutal, harsh lunar nights and is still going. The temperatures plummet to -170C at night and the lander was never designed to operate into the night. Even sat upside down on the surface

it's still sending back pictures and data.
The Japanese agency's lunar lander known as SLIM (Smart Lander for Investigating the Moon) began its lunar journey on 19 January 2024 when it touched down on the surface of the Moon. Its mission was to test the lunar landing technology and to collect data about the surface geology.

An artist's conception shows Japan's SLIM lander in its upended position on the lunar surface. (Credit: JAXA)
Unfortunately, soon after landing it became clear that the probe had landed at a strange angle, leaning forwards, resting on its face. The orientation of the solar panels was all wrong and it meant they could not generate as much electricity as expected allowing it to operate for a few hours just after dawn and just before sunset.
Of course it is important to note that a day on the Moon lasts many days compared to a day here on Earth and so, the first night for SLIM began on 31 January. Surprisingly, SLIM survived the first long night where temperatures to -170 degrees. SLIM was never designed to survive the cold harsh nights on the Moon so it was with some surprise that it powered back up successfully on the 15 February.
The operations team for SLIM were disbanded in March but to their surprise, after the second lunar night, a signal was received again. Surpassing everyones expectations it seems SLIM wasn't going to give up yet and still sending images. The lander was even picked up after its second night by cameras on board the Chandrayaan-2 orbiter as it flew over.
Just a few days ago on Wednesday 24 January, JAXA, the Japanese Aerospace Exploration Agency announced it had survived a third night on the freezing lunar surface. Using the plucky littler lander which measures just 1.5m x 1.5m x 2m, the agency hope to be able to learn more about the origin of the Moon by analysing the surface geology.
One of the fascinating elements to the mission was the pinpoint landing technology that was being tested. On descent, the lander would be able to recognise the craters using technology that has been developed by facial recognition systems. Using the data, it would be able to determine its location with pinpoint accuracy and perform a touch down with an accuracy of 100m. The landing was successfully accurate albeit slightly wobbly leaving the lander in a strange orientation.

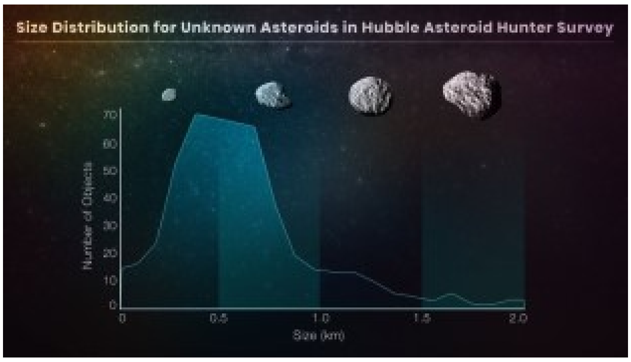
Hubble Has Accidentally Discovered Over a Thousand Asteroids

The venerable *Hubble Space Telescope* is like a gift that keeps on giving. Not only is it still making astronomical discoveries after more than thirty years in operation. It is also making discoveries by accident! Thanks to an international team of citizen scientists, with the help of astronomers from the European Space Agency (ESA) and some machine learning algorithms, a new sample of over one thousand asteroids has been identified in *Hubble*'s archival data. The methods used represent a new approach for finding objects in decades-old data that could be applied to other datasets as well.
The research team was led by Pablo García-Martín, a researcher with the Department of Theoretical Physics at the Autonomous University of Madrid (UAM). It included members from the ESA, NASA's Jet Propulsion Laboratory (JPL), the Astronomical Institute of the Romanian Academy, the University of Craiova, the Université Côte d'Azur, and Bastion Technologies. The paper that describes their findings, "*Hubble* Asteroid Hunter III. Physical properties of newly found asteroids," recently appeared in *Astronomy & Astrophysics.*

Ask any astronomers and they will tell you that asteroids are material left over from the formation of the Solar System ca. 4.5 billion years ago. These objects come in many shapes in sizes, ranging from peddle-sized rocks to planetoids. Observing these objects is challenging since they are faint and constantly in motion as they orbit the Sun. Because of its rapid geocentric orbit, Hubble can capture wandering asteroids thanks to the distinct curved trails they leave in Hubble exposures. As Hubble orbits Earth, its point of view changes while observing asteroids following their orbits.

Hubble image of the barred spiral galaxy UGC 12158, with streaks left by photobombing asteroids. Credit: NASA, ESA, P. G. Martín (AUM)/J. DePasquale (STScI)/ A. Filippenko (UC Berkeley)
Asteroids have also been known to "photobomb" images acquired by *Hubble* of distant cosmic objects like UGC 12158 (see image above). By knowing Hubble's position when it took exposures of asteroids and measuring the curvature of the streaks they leave, scientists can determine the asteroids' distances and estimate the shapes of their orbits. The ability to do this with large samples allows astronomers to test theories about Main Asteroid Belt formation and evolution. As Martin said in a recent ESA Hubble press release:
"We are getting deeper into seeing the smaller population of main-belt asteroids. We were surprised to see such a large number of candidate objects. There was some hint that this population existed, but now we are confirming it with a random asteroid population sample obtained using the whole Hubble archive. This is important for providing insights into the evolutionary models of our Solar System."
According to one widely accepted model, small asteroids are fragments of larger asteroids that have been colliding and grinding each other down over billions of years. A competing theory states that small bodies formed as they appear today billions of years ago and have not changed much since. However, astronomers can offer no plausible mechanism for why these smaller asteroids would not accumulate more dust from the circumstellar disk surrounding our Sun billions of years ago (from which the planets formed).
In addition, astronomers have known for some time that collisions would have left a certain signature that could be used to test the current Main Belt population. In 2019, astronomers from the European Science and Technology Centre (ESTEC) and the European Space Astronomy Center's Science Data Center (ESDC) came together with the world's largest and most popular citizen-science plat-

form (Zooniverse) and Google to launch the citizen-science project Hubble Asteroid Hunter (HAH) to identify asteroids in archival *Hubble* data.



This graph is based on Hubble Space Telescope archival data that were used to identify a largely unseen population of very small asteroids. Credit: NASA/ESA/P. G. Martín (AUM)/E. Wheatley (STScI)

The HAH team comprised 11,482 citizen-science volunteers who perused 37,000 Hubble images spanning 19 years. After providing nearly two million identifications, the team was given a training set for an automated algorithm to identify asteroids based on machine learning. This yielded 1,701 asteroid trails, with 1,031 corresponding to previously uncatalogued asteroids – about 400 of which were below 1 km (~1090 ft) in size. Said Martin:

"Asteroid positions change with time, and therefore you cannot find them just by entering coordinates, because they might not be there at different times. As astronomers we don't have time to go looking through all the asteroid images. So we got the idea to collaborate with more than 10,000 citizen-science volunteers to peruse the huge Hubble archives."

This pioneering approach may be effectively applied to datasets accumulated by other asteroid-hunting observatories, such as NASA's Spitzer Space Telescope and Stratospheric Observatory for Infrared Astronomy (SOFIA). Once the James Webb Space Telescope (JWST) has accumulated a large enough dataset, the same method could also be applied to its archival data. As a next step, the HAH project will examine the streaks of previously unknown asteroids to characterize their orbits, rotation periods, and other properties.

NASA Restores Communications with Voyager 1

The venerable Voyager 1 spacecraft is finally phoning home again. This is much to the relief of mission engineers, scientists, and Voyager fans around the world.

On November 14, 2023, the aging spacecraft began sending what amounted to a string of gibberish back to Earth. It appeared to be getting commands from Earth and seemed to be operating okay. It just wasn't returning any useful science and engineering data. The team engineers began diagnostic testing to figure out if the spacecraft's onboard computer was giving up the ghost. They also wanted to know if there was some other issue going on.

It wasn't completely surprising that Voyager 1 would have issues, after all. And, this isn't the first time Voyager 1 has sent back garbly data. It's been traversing space since its launch in 1977. Currently, the spacecraft is rushing away from the Solar System toward interstellar space. The spacecraft systems will eventually fail due to age and lack of power. But, people have always held out hope for them to last as long as possible. That's because Voyager 1 is probing unexplored regions of space.

What Happened to Voyager 1?

The diagnostic testing led the engineering team at NASA's Jet Propulsion Laboratory to look at old engineering documents and manuals for the onboard computers. Eventually, they found that the flight data subsystem (FDS) was having an issue. In the spacecraft's data handling pipeline, this system takes information from the instruments and packages it into a data stream for the long trip back to Earth.

It turns out that the FDS has a bit of a memory problem. The engineers found this out by poking at the computer—literally sending a "poke" command to Voyager 1. That prompted the FDS to disgorge a readout of its memory—including the software code and other code values. The readout showed that about 3 percent of the FDS memory is corrupted due to a single chip failing. That's just enough to keep the computer from doing its normal work of packaging science and engineering data. Unfortunately, engineers can't replace the chip. No repair is possible, so the technical team devised a workaround.

Fixing the Faulty Code and Chip

So, how did engineers reach across 24 billion kilometers of space to restore communication with Voyager 1? They focused on a specific part of the computer. The loss of the code on that failed chip made it impossible for the computer to do its job. So, they figured out a way to divide the code into sections and store them in various locations around the FDS. Then they had to make the sections work together to do their original job.

They started out by taking the code that packages engineering data and moving it to a safe spot in FDS. Then they sent some commands to the spacecraft for the FDS to do some tasks. That worked because, on April 20th, they heard back from the spacecraft with clear, intelligible data. Now, they just need to do the same thing with other bits of code so that the spacecraft can send back both engineering and science data.

The Voyager 1 flight team members celebrate in a conference room at NASA's Jet Propulsion Laboratory on April 20 after receiving confirmation that their repair to the spacecraft's FDS worked. Credit: NASA/JPL-Caltech

For now, at least, the science and engineering teams can check the spacecraft's health and its systems. Once they relocate the other bits of code and test them after being moved, they should be able to start receiving science data again. This could take several weeks to accomplish. They're communicating with a spacecraft that's 22.5 light-hours away, so having a lengthy diagnostic conversation with Voyager is going to take some time. This isn't the only problem engineers have had to contend with recently with Voyager 1. In October 2023, they worked to overcome a fuel flow problem affecting its thrusters.

Voyager 1 Into History

Voyager 1 was launched on a planetary flyby trajectory on September 5, 1977. It passed by Jupiter in March 1979 and Saturn in November 1980. The mission then morphed into an extended period of exploration and exited the heliopause in 2012. On its way out of the Solar System, the spacecraft also "looked back" at Earth. Now, it's exploring the interstellar medium but has not yet traversed the Oort Cloud, the outermost portion of the Solar

System.

This updated version of the iconic "Pale Blue Dot" image taken by the Voyager 1 spacecraft uses modern image-processing software and techniques to revisit the well-known Voyager view while attempting to respect the original data and intent of those who planned the images. Credit: NASA/JPL-Caltech

Several of Voyager 1's science instruments are shut down, including its ultraviolet spectrometer, the plasma subsystem, planetary radio astronomy instrument, and scan platform. In the not-too-distant future, more instruments will be powered down, along with the data tape recorder, the gyroscopes, and other systems will be off. Sometime in the next decade, the spacecraft won't have enough power to keep anything running, and that is when we'll finally lose contact with Voyager 1.

This will probably happen by the mid-2030s, and by that time, Voyager 1 will have been "in service" for around 55 years. Along with its twin, Voyager 2, this spacecraft opened up exploration of the outer solar system and interstellar space. They'll continue out to the stars, their last mission being as a calling card to any civilizations that might find them in the distant future.

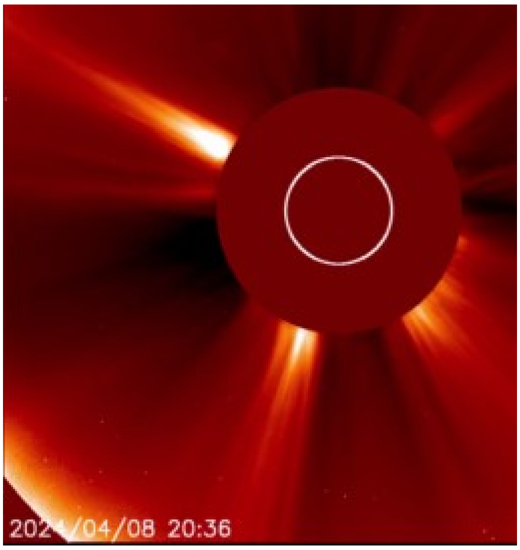
There Was a Doomed Comet Near the Sun During the Eclipse

A surprise appearance of a new comet made the April 8th total solar eclipse all the more memorable.

Any dedicated 'umbraphile' will tell you: no two eclipses are exactly the same. Weather, solar activity, and the just plain expeditionary nature of reaching and standing in the shadow of the Moon for those brief moments during totality assures a unique experience, every time out. The same can be said for catching a brief glimpse of what's going on near the Sun, from prominences and the pearly white corona to the configuration of bright planets… and just maybe, a new comet.

The Discovery

While many planned to try and spy periodic Comet 12P Pons-Brooks during totality, astronomer Karl Battams at the U.S. Naval Research Laboratory alerted us to another possibility. A new sungrazing comet, spotted just hours prior. The Kreutz family comet was seen by Worachate Boonplod in the field of view of the joint NASA/ESA Solar Heliospheric Observatory's (SOHO) LASCO C3 and C2 imagers. These are equipped with Sun-covering coronagraphs that allow it to see the near solar environment. The mission was launched over a quarter of a century ago in 1995. SOHO was deployed to the sunward L1 Earth-Sun Lagrange point nearly a million miles distant. SOHO has since proven itself to be a crucial workhorse in solar heliophysics.



Doomed SOHO-5008 (lower left). Credit: NASA/ESA/SOHO

The comet soon received the formal designation of SOHO-5008. That's right: SOHO has led to the discovery of over 5,000 comets in its career. Most of these discoveries were thanks to the efforts of dedicated online sleuths, scouring recent LASCO images.

At the time, the doom'd comet was a faint object, located only a few degrees from the Sun. The icy interloper was a tough target to nab during the fleeting minutes of totality, but at least two dedicated astrophotographers managed to catch it. Lin Zixuan saw it imaging from northern New Hampshire. Petr Horálek from the Institute of Physics in Opava Czechia (Czech Republic) was imaging from Mexico as he caught the object.

Like so many other sungrazers, the comet met its demise shortly after discovery (less than 12 hours, in fact), like a sundiving spaceship at a *Disaster Area* concert right out of Douglas Adam's *Hitchhiker's Guide to the Galaxy*.

A Brief History of Sungrazers

This sort of SOHO versus comet, versus eclipse discovery has only occurred twice: once in 2008 and again in 2020). SOHO wasn't designed per se to find comets, but its prolific nature as a comet hunter has become an essential part of the legacy of the mission. SOHO has defined whole new families of Kreutz, Marsden and Kracht sungrazing comets. And to think, prior to the mission, only sixteen sungrazing comets were even known of.

One similar case was the Great Comet of 1948, which was also discovered by stunned observers during a total solar eclipse. Another was C/1965 Ikeya-Seki, which went on to become one of the truly great comets of the 20th century. More recently, C/2011 W3 Lovejoy surprised everyone by surviving its perihelion passage 140,000 kilometers from the surface of the Sun. Just one year later, however, 2012 S1 ISON didn't.

It was a thrilling celestial spectacle, with an added treat.

Ice Deposits on Ceres Might Only Be a Few Thousand Years Old

The dwarf planet Ceres has some permanently dark craters that hold ice. Astronomers thought the ice was ancient when they were discovered, like in the moon's permanently shadowed regions. But something was puzzling. Why did some of these shadowed craters hold ice while others did not?

Ceres was first discovered in 1801 and was considered a planet. Later, it was thought to be the first asteroid ever discovered, since it's in the main asteroid belt. Since then, our expanding knowledge has changed its definition: we now know it as a dwarf planet.

Even though it was discovered over 200 years ago, it's only in the last couple of decades that we've gotten good looks at its surface features. NASA's Dawn mission is responsible for most of our knowledge of Ceres' surface, and it found what appeared to be ice in permanently shadowed regions (PSRs.)

New research shows that these PSRs are not actually permanent and that the ice they hold is not ancient. Instead, it's only a few thousand years old.

The new research is titled "History of Ceres's Cold Traps Based on Refined Shape Models," published in The Planetary Science Journal. The lead author is Norbert Schorghofer, a senior scientist at the Planetary Science Institute.

"The results suggest all of these ice deposits must have accumulated within the last 6,000 years or less."

Norbert Schorghofer, senior scientist, Planetary Science Institute.

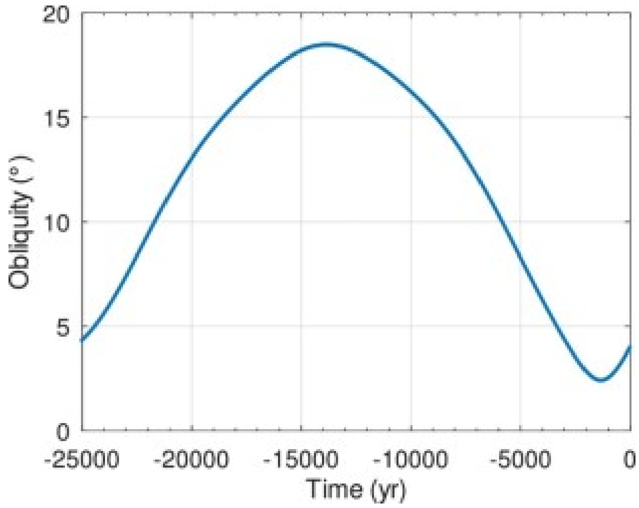
Dawn captured its first images of Ceres while approaching the dwarf planet in January 2015. At that time, it was close enough to capture images as good as Hubble's. Those images showed craters and a high-albedo site on the surface. Once captured by Ceres, Dawn followed a polar orbit with decreasing altitude. It eventually reached 375 km (233 mi) above the surface, allowing it to see the poles and surface in greater detail.

"For Ceres, the story started in 2016, when the Dawn spacecraft, which orbited around Ceres at the time, glimpsed into these permanently dark craters and saw bright ice deposits in some of them," Schorghofer said.

"The discovery back in 2016 posed a riddle: Many craters in the polar regions of Ceres remain shadowed all year – which on Ceres lasts 4.6 Earth years – and therefore remain frigidly cold, but only a few of them harbor ice deposits."

As scientists continued to study Ceres, they made another discovery: its massive Solar System neighbours make it wobble.

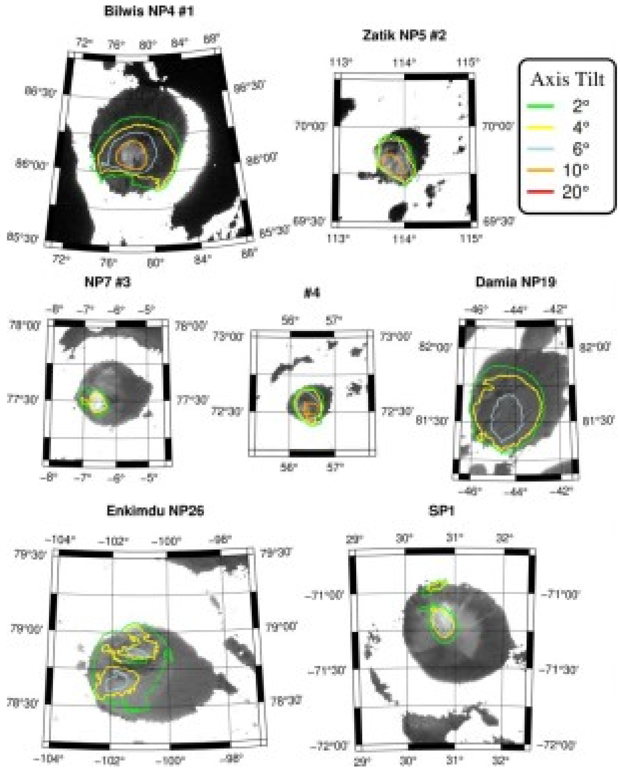
"Soon, another discovery provided a clue why: The rotation axis of Ceres oscillates back and forth every 24,000 years due to tides from the Sun and Jupiter. When the axis tilt is high and the seasons strong, only a few craters remain shadowed all year, and these are the craters that contain bright ice deposits," said lead author Schorghofer.



This figure from the research shows how Ceres' obliquity has changed over the last 25,000 years. As the obliquity varies, sunlight reaches some crater floors that were thought to be PSRs. Image Credit: Schorghofer et al. 2023.

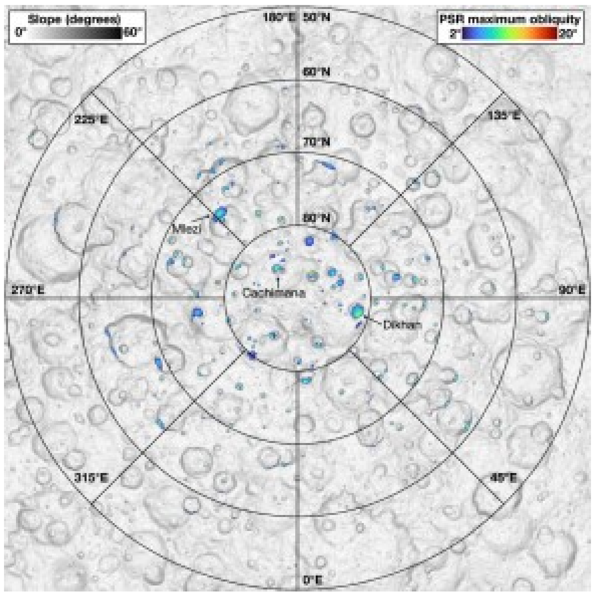
Researchers constructed digital elevation maps (DEMs) of the craters to uncover these facts. They wanted to find out how large and deep the shadows in the craters were, not just now but thousands of years ago. But that's difficult to do since portions of these craters were in deep shadow when Dawn visited. That made it difficult to see how deep the craters were.

Robert Gaskell, also from the Planetary Science Institute, took on the task. He developed a new technique to create more accurate maps of the craters with data from Dawn's sensitive Framing Cameras, contributed to the mission by Germany. With improved accuracy, these maps of the crater floors could be used in ray tracing to show sunlight penetrated the shadows as Ceres wobbled over thousands of years.



This figure from the study shows some of the DEMs the researchers developed for craters on Ceres. White regions represent sunlit areas, while the coloured contours represent PSRs for different axial tilts. Image Credit: Schorghofer et al. 2023.

The DEMs in the above image show that at 20 degrees obliquity, none of the craters are in permanent shadow. That means none of them have truly permanent PSRs. "A PSR starts to emerge in Bilwis crater at about 18°, and they emerge at lower obliquities at the other six study sites. This implies that the ice deposits are remarkably young," the researchers write in their paper.



This figure from the research shows PSRs in the north-polar region of Ceres. The colour scale shows how oblique each crater is. The research shows that 14,000 years ago, none of these were PSRs, and the ice they hold now is only 6,000 years old. Image Credit: Schorghofer et al. 2023.

About 14,000 years ago, Ceres reached its maximum axial tilt. At that time, no craters were PSRs. Any ice in these craters would've been sublimated into space. "That leaves only one plausible explanation: The ice deposits must have formed more recently than that. The results suggest all of these ice deposits must have accumulated within the last 6,000 years or less. Considering that Ceres is well over 4 billion years old, that is a remarkably young age," Schorghofer said.

So, where did the ice come from?

There must be some source if the ice is young and keeps reforming during maximum obliquity. The only plausible one is Ceres itself.

"Ceres is an ice-rich object, but almost none of this ice is exposed on the surface. The aforementioned polar craters and a few small patches outside the polar regions are the only ice exposures. However, ice is ubiquitous at shallow depths – as discovered by PSI scientist Tom Prettyman and his team back in 2017 – so even a small dry impactor could vaporize some of that ice." Schorghofer said. "A fragment of an asteroid may have collided with Ceres about 6,000 years ago, which created a temporary water atmosphere. Once a water atmosphere is generated, ice would condense in the cold polar craters, forming the bright deposits that we still see today. Alternatively, the ice deposits could have formed by avalanches of ice-rich material. This ice would then survive in only the cold shadowed craters. Either way, these events were very recent on an astronomical time scale."

There are other potential sources of water ice. Ceres has a very thin, transient water atmosphere. The water could come from cryovolcanic processes and then be trapped and frozen in shadowed regions.

Ceres also has a single cryovolcano: Ahuna Mons. It's at least a couple hundred million years old and long dormant. There are dozens of other dormant potential cryovolcanoes, too. But these likely aren't the water source.

There's ample water ice at shallow levels in Ceres. If the dwarf planet erodes over time, mass-wasting could expose and release water that freezes in the craters. "The few ice deposits that have been detected spectroscopically outside the polar regions are indeed often associated with landslides, and the sunlit portion of the ice deposit in Zatik crater is best explained by a recent mass wasting event," the authors explain.

Ceres has been through a lot. As an ancient protoplanet that's survived to this day, it holds important clues to the Solar System. Though its craters don't hold ancient ice like once thought, deeper study is revealing the dwarf planet's true nature.

"The ice deposits in the Cerean PSRs indicate an active water cycle; ice is either repeatedly captured and lost or frequently exposed, or both," the authors conclude.

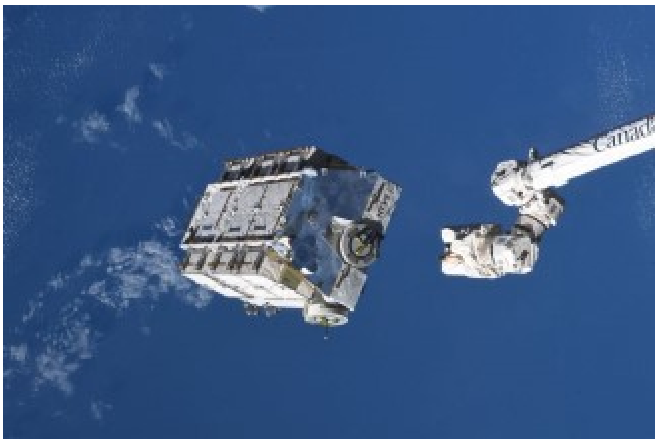
NASA Confirms that a Piece of its Battery Pack Smashed into a Florida Home

NASA is in the business of launching things into orbit. But what goes up must come down, and if whatever is coming down doesn't burn up in the atmosphere, it will strike Earth somewhere.

Even Florida isn't safe.

Careful consideration goes into releasing debris from the International Space Station. Its mass is measured and calculated so that it burns up during re-entry to Earth's atmosphere. But in March 2024, something didn't go as planned.

It all started in 2021 when astronauts replaced the ISS's nickel hydride batteries with lithium-ion batteries. It was part of a power system upgrade, and the expired batteries added up to about 2,630 kg (5,800 lbs.) On March 8th, 2021, ground controllers used the ISS's robotic arm to release a pallet full of the expired batteries into space, where orbital decay would eventually send them plummeting into Earth's atmosphere.



The Canadarm 2 robotic arm releases a pallet of spent batteries into space on March 8th, 2021. Image Credit: NASA

It was the most massive debris release from the ISS. According to calculations, it should have burned up when it entered the atmosphere on March 8th, 2024. But it didn't.

Alejandro Otero owns a home in Naples, Florida. He wasn't home on March 8th when there was a loud crash as something smashed into his roof. But his son was. "It was a tremendous sound. It almost hit my son," Otero told CNN affiliate WINK News in March. "He was two rooms over and heard it all."

"Something ripped through the house and then made a big hole in the floor and on the ceiling," Otero explained. "I'm super grateful that nobody got hurt."

This time, nobody got hurt. But NASA is taking the accident seriously.

Otero cooperated with NASA, and NASA examined the object at the Kennedy Space Center in Florida. They determined the debris was from a stanchion used to mount the old batteries on a special cargo pallet.

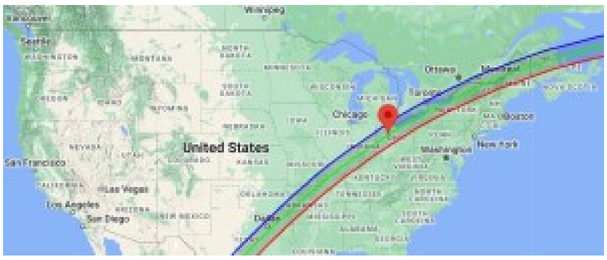
This image shows an intact stanchion and the recovered stanchion from the NASA flight support equipment used to mount International Space Station batteries on a cargo pallet. The stanchion survived re-entry through Earth's atmosphere on March 8, 2024, and impacted a home in Naples, Florida. Image Credit: NASA

The stanchion is made of the superalloy Inconel to understand extreme environments, including extreme heat. It weighs 725 grams (1.6 lbs.) It's about 10 cm (4 inches) in height and 4 cm (1.6 inches) in diameter.

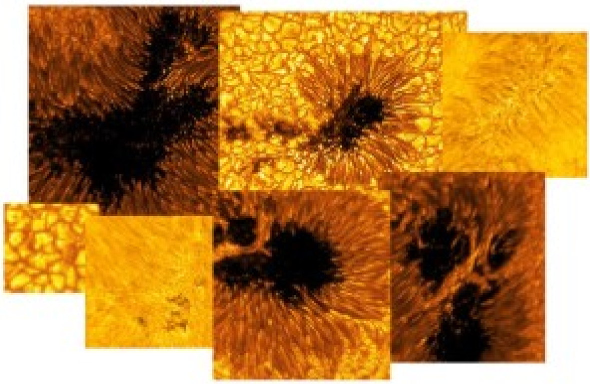
Even though it's a tiny object, it's the type of accident that NASA and the ISS are determined to avoid. "The International Space Station will perform a detailed investigation of the jettison and re-entry analysis to determine the cause of the debris survival and to update modelling and analysis, as needed," a NASA statement read.
Investigators want to know how the debris survived without burning up on re-entry. Engineers use models to understand how objects react to re-entry heat and break apart, and this event will refine those models. In fact, every time an object reaches the ground, the models are updated.
For Otero, this accident amounted to little more than a great story and an insurance claim. But the chunk of stanchion could've seriously injured someone or even killed someone.
In January 1997, Lottie Williams was walking through a park with friends in Tulsa, Oklahoma, in the early morning. They saw a huge fireball in the sky and felt a rush of excitement, thinking they were seeing a shooting star. "We were stunned, in awe," Williams told FoxNews.com. "It was beautiful."
Then, something struck her lightly on the shoulder before falling to the ground. It was like a piece of metallic fabric, and after reaching out to some authorities, she learned that it was part of a fuel tank from a Delta II rocket. She's the first person known to have been hit with space debris. Had it been something with more mass, who knows if Williams would've been injured or worse?
That's why NASA takes debris survival so seriously. The guilt of injuring or even killing someone would be overwhelming. A serious debris accident could also make things very uncomfortable going forward, as people can be fickle and not prone to critical thinking. NASA's already struggling with budget constraints; the organization doesn't need any nasty public relations to imperil its progress further.
Complicating matters is that the ESA warned that not all the battery debris would burn up. There wasn't much else they could do. Fluctuating atmospheric drag made it impossible to predict where debris would strike Earth.
Those who follow space know how complicated and unpredictable this is. And they likewise know how improbable an injury is. But there's always a non-zero chance of injury or death from space debris for someone going about their life here on the Earth's surface. If that ever happened, the scrutiny would be intense.
Is it statistical fear-mongering to consider space debris striking someone, injuring them, or worse? Probably. When we see a shooting star in the sky, it's safe to enjoy the spectacle without worry.
But maybe, just in case, out of an abundance of caution, Don't Look Up.

The Solar Eclipse Like We've Never Seen it Before

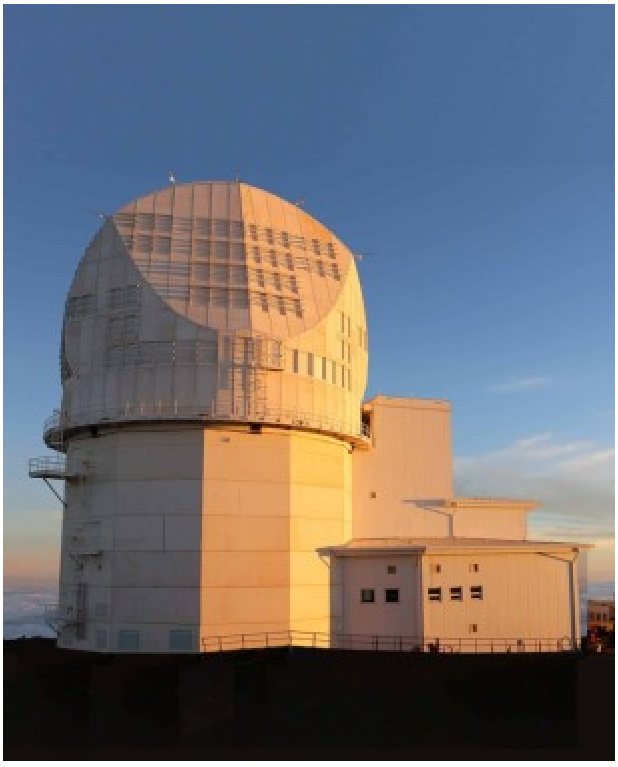
You had to be in the right part of North America to get a great view of the recent solar eclipse. But a particular telescope may have had the most unique view of all. Even though that telescope is in Hawaii and only experienced a partial eclipse, its images are interesting.



You had to be in the right part of North America to get a great view of the recent eclipse. Image Credit: DKIST/NSO/NSF/AURA
The Daniel K. Inouye Solar Telescope (DKIST) is at the Haleakala Observatory in Hawaii. With its four-meter mirror, it's the largest solar telescope in the world. It observes in visible to near-infrared light, and its sole target is the Sun. It can see features on the Sun's surface as small as 20 km (12 miles.) It began science operations in February 2022, and its primary objective is to study the Sun's magnetic fields.



This is a collage of solar images captured by the Inouye Solar Telescope. Images include sunspots and quiet regions of the Sun, known as convection cells. (Credit: NSF/AURA/NSO)
Though seeing conditions weren't perfect during the eclipse and the eclipse was only partial when viewed from Hawaii, the telescope still gathered enough data to create a movie of the Moon passing in front of the Sun. The bumps on the Moon's dark edge are lunar mountains.
via GIPHY
"The team's primary mission during Maui's partial eclipse was to acquire data that allows the characterization of the Inouye's optical system and instrumentation," shares National Solar Observatory scientist Dr. Friedrich Woeger.
The Moon plays a critical role in measuring the telescope's performance. Its edge is well-known and as a dark object in front of the Sun, it acts as a unique tool to measure the Inouye telescope's performance and to understand the data it collects. Since the telescope has to correct for Earth's turbulent atmosphere with adaptive optics, the Moon's known qualities help researchers work with the telescope's optical elements.



The Daniel Inouye Solar Telescope at the Haleakala Observatory on the Hawaiian island of Maui. Image Credit: DKIST/NSO

"With the Inouye's high order adaptive optics system operating, the blurring due to the Earth's atmosphere was greatly reduced, allowing for extremely high spatial resolution images of the moving lunar edge," said Woeger. "The appearance of the edge is not straight but serrated because of mountain ranges on the Moon!" This serrated dark edge covers the granular convection pattern that governs the "surface of the Sun."

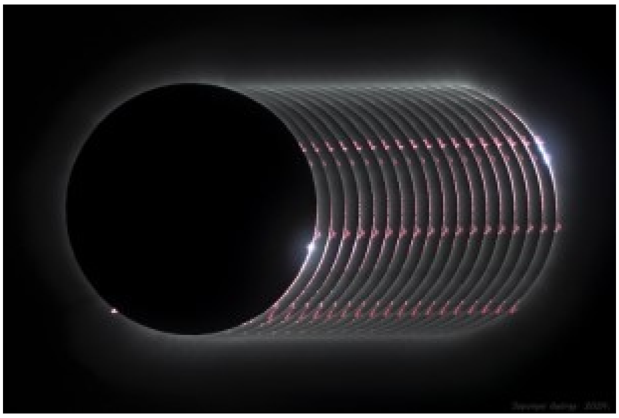
The Inouye Solar Telescope studies the Sun's magnetic fields, which drive space weather. What we see in the video is visually interesting, but there's a lot of data behind it. It'll take several months to analyze all of the data it gathered during the eclipse.

Amazing Amateur Images of April 8th's Total Solar Eclipse

The last total solar eclipse across the Mexico, the U.S. and Canada for a generation wows observers.

Did you see it? Last week's total solar eclipse did not disappoint, as viewers from the Pacific coast of Mexico, across the U.S. from Texas to Maine and through the Canadian Maritime provinces were treated to an unforgettable show. The weather threw us all a curve-ball one week out, as favored sites in Texas and Mexico fought to see the event through broken clouds, while areas along the northeastern track from New Hampshire and Maine onward were actually treated to clear skies.

Many eclipse chasers scrambled to reposition themselves at the last minute as totality approached. In northern Maine, it was amusing to see tiny Houlton, Maine become the epicenter of all things eclipse-based.



A composite of images snapped every five seconds during totality, showing off solar prominences. Credit: György Soponyai observing from Montreal, Canada.

Tales of a Total Solar Eclipse

We were also treated to some amazing images of the eclipse from Earth and space. NASA also had several efforts underway to chase the eclipse. Even now, we're still processing the experience. It takes time (and patience!) for astro-photos to make their way through the workflow. Here are some of the best images we've seen from the path of totality:

Tony Dunn had an amazing experience, watching the eclipse from Mazatlan, Mexico. "When totality hit, it didn't look real," Dunn told *Universe Today*. "It looked staged, like a movie studio. the lighting is something that can't be experienced outside a total solar eclipse."

Totality on April 8th, with prominences. Credit: Tony Dunn.

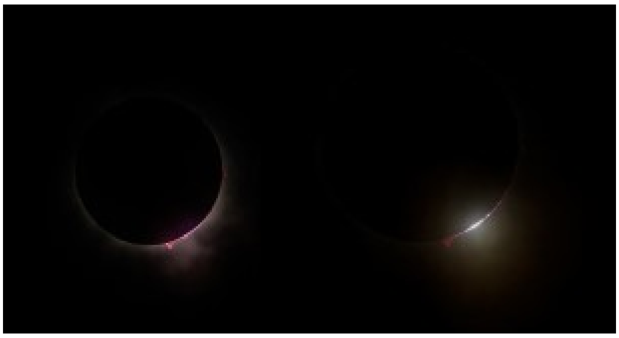
Dunn also caught an amazing sight, as the shadow of the Moon moved across the low cloud cover:

Black Hole Sun

Peter Forister caught the eclipse from central Indiana. "It was my second totality (after 2017 in South Carolina), so I knew what was coming," Forister told *Universe Today*. "But it was still as incredible and beautiful as anything I've ever seen in nature. The Sun and Moon seemed huge in my view—a massive black hole (like someone took a hole punch to the sky) surrounded by white and blue flames streaking out. Plus, there was great visibility of the planets and a few stars. The memory has been playing over and over in my head since it happened—and it's combined with feelings of awe and wonder at how beautiful our Universe and planet really are. The best kind of memory!"

Totality over Texas. Credit: Eliot Herman

Like many observers, Eliot Herman battled to see the eclipse through clouds. "As you know, we had really frustrating clouds," Herman told *Universe Today*. "I shot a few photos (in) which you can see the eclipse embedded in the clouds and then uncovered to show the best part. For me it almost seemed like a cosmic mocking, showing me what a great eclipse it was, and lifting the veil only at the end of the eclipse to show me what I missed…"



Totality and solar prominences seen through clouds. Credit: Eliot Herman

Totality Crosses Into Canada

Astrophotographer Andrew Symes also had a memorable view from Cornwall, Ontario. “While I’ve seen many beautiful photos and videos from many sources, they don’t match what those us there in person saw with our eyes,” Symes told *Universe Today*. “The sky around the Sun was not black but a deep, steely blue. The horizon was lighter–similar to what you’d see during a sunset or sunrise–but still very alien.”

“The eclipsed Sun looked, to me, like an incredibly advanced computer animation from the future! The Sun and corona were very crisp, and the Sun looked much larger in the sky than I’d expected. The eclipsed Sun had almost a three-dimensional quality… almost as if it were a dark, round button-like disk surrounded by a bright halo affixed to a deep blue/grey background. It was as if a ‘worm hole’ or black hole had somehow appeared in front of us. I’m sure my jaw dropped as it was truly a moment of utter amazement. I’m smiling as I type it now… and still awestruck as I recall it in my mind!”

An amazing eclipse. Credit: Andrew Symes.

Success for the Total Solar Eclipse in Aroostook County Maine

We were met with success (and clear skies) watching the total solar eclipse with family from our hometown of Mapleton, Maine. We were mostly just visually watching this one, though we did manage to nab a brief video of the experience.

What I was unprepared for was the switch from partial phases to totality. It was abrupt as expected, but there almost seemed to be brief but perceptible pause from day to twilight, as the corona seemed to ‘switch on.’ We all agreed later on that the steely blue sky was not quite night… but not quite twilight, either.

The elusive diamond ring, seen from Wappappello Lake, Missouri on April 8th. Credit: Chris Becke

When’s the next one? I often wonder how many watchers during a given eclipse were ‘bitten by the bug,’ and looking to chase the next one. Spain is set to see an eclipse a year for the next three years, starting in 2026:

Spain in August… be sure to stay cool and bring sunblock. Don’t miss the next total solar eclipse, and be thankful for our privileged vantage point in time and space.

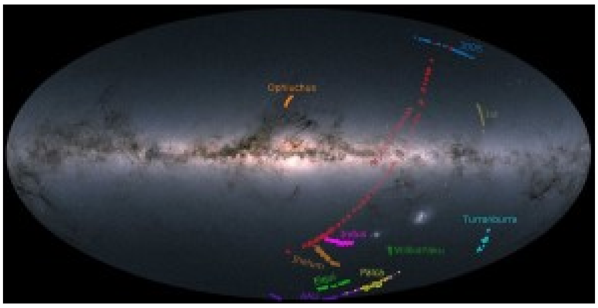
The Milky Way’s History is Written in Streams of Stars

The Milky Way is ancient and massive, a collection of hundreds of billions of stars, some dating back to the Universe’s early days. During its long life, it’s grown to these epic proportions through mergers with other, smaller galaxies. These mergers punctuate our galaxy’s history, and its story is written in the streams of stars left behind as evidence after a merger.

And it’s still happening today.

The Milky Way is currently digesting smaller galaxies that have come too close. The Large and Small Magellanic Clouds feel the effects as the Milky Way’s powerful gravity distorts them and siphons a stream of gas and stars from them to our galaxy. A similar thing is happening to the Sagittarius Dwarf Spheroidal Galaxy and globular clusters like Omega Centauri.

There’s a long list of these stellar streams in the Milky Way, though the original galaxies that spawned them are long gone, absorbed by the Milky Way. But the streams still tell the tale of ancient mergers and absorptions. They hold kinematic and chemical clues to the galaxies and clusters they spawned in.

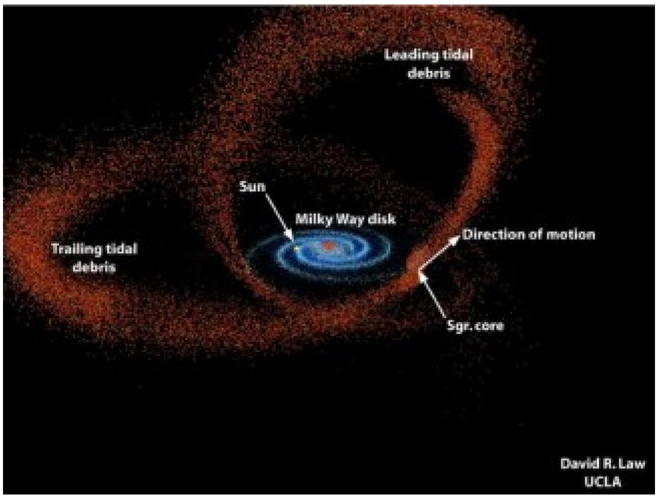


As astronomers get better tools to find and study these streams, they’re realizing the streams could tell them more than just the history of mergers. They’re like strings of pearls, and their shapes and other properties show how gravity has shaped them. But they also reveal something else important: how dark matter has shaped them. Since dark matter is so mysterious, any chance to learn something about it is a priority. As researchers examine the stellar streams, they’re finding signs of disturbances in them—including missing members—that aren’t explained by the Milky Way’s mass. They suspect that dark matter is the cause.

"If we find a pearl necklace with a few scattered pearls nearby, we can deduce that something may have come along and broken the string."

Soon, astronomers will have an enormously powerful tool to study these streams and dark matter's role in disturbing them: the Vera Rubin Observatory (VRO).

Astronomers have different methods of studying dark matter. Weak gravitational lensing is one of them, and it maps dark matter on the large scale of galaxy clusters. But stellar streams are at the opposite end of the scale. By mapping them and their irregularities and disturbances, astronomers can study dark matter at a much smaller scale.



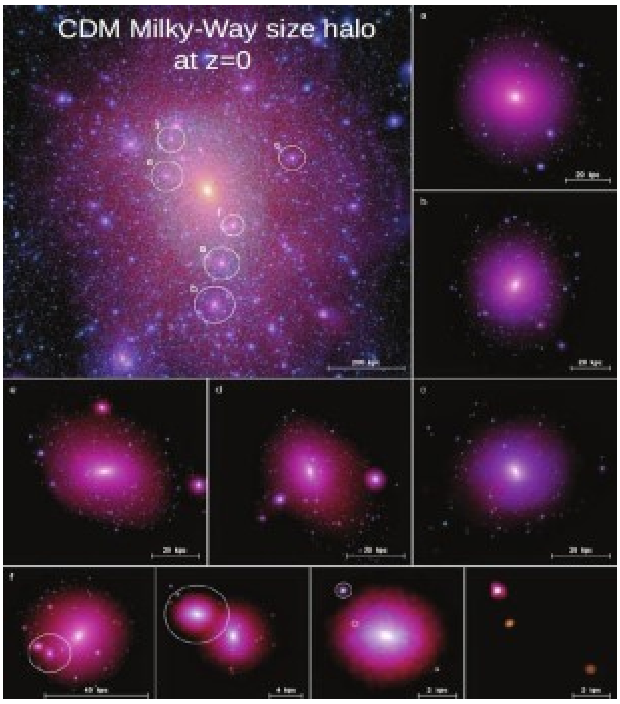
This image shows the core of the Sagittarius Dwarf Spheroidal Galaxy and its stellar streams as it's absorbed by the Milky Way. Image Credit: David Law/UCLA

The Rubin Observatory will complete its Legacy Survey of Space and Time (LSST) in a ten-year period. Alongside its time-domain astronomy objectives, the LSST will also study dark matter. The LSST Dark Energy Science Collaboration is aimed at dark matter and will use Rubin's power to advance the study of dark energy and dark matter like nothing before it. "LSST will go much further than any of its predecessors in its ability to measure the growth of structure and will provide a stringent test of theories of modi?ed-gravity," their website explains.

As we get closer and closer to the observatory's planned first light in January 2025, the growing excitement is palpable.

"I'm really excited about using stellar streams to learn about dark matter," said Nora Shipp, a postdoctoral fellow at Carnegie Mellon University and co-convener of the Dark Matter Working Group in the Rubin Observatory/LSST Dark Energy Science Collaboration. "With Rubin Observatory we'll be able to use stellar streams to figure out how dark matter is distributed in our galaxy from the largest scales down to very small scales."

Astronomers have ample evidence that a halo of dark matter envelops the Milky Way. Other galaxies are the same. These dark matter halos extend beyond a galaxy's visible disk and are considered basic units in the Universe's large-scale structure. These haloes may also contain sub-haloes, clumps of dark matter bound by gravity.



This image shows a simulated Milky Way-size CDM halo. The six circles show sub-haloes enlarged in separate boxes. Sub-haloes are also visible, and the bottom row shows several generations of sub-subhaloes contained within subhalo f. Image Credit: Zavala and Frenk 2019

These clumps are what astronomers think are leaving their marks on stellar streams. The dark matter clumps create kinks and gaps in the streams. The VRO has the power to see these irregularities on a small scale and over a ten-year span. "By observing stellar streams, we'll be able to take indirect measurements of the Milky Way's dark matter clumps down to masses lower than ever before, giving us really good constraints on the particle properties of dark matter," said Shipp.

The Lambda Cold Dark Matter (Lambda CDM) model is the standard model of Big Bang Cosmology. One of the Lambda CDM's key predictions says that many sub-galactic dark matter substructures should exist. Astronomers want to test that prediction by observing these structures' effect on stellar streams. The VRO will help them do that and will also help them find more of them and build a larger data set.

Stellar streams are difficult to detect. Their kinematics give them away, but sometimes, there are only a few dozen stars in the streams. This obscures them among the Milky Way's myriad stars. But the VRO will change that. The VRO will detect streams at much further distances. On the outskirts of the Milky Way, the streams have interacted with less matter, making them strong candidates for studying the effect of dark matter in isolation.

"Stellar streams are like strings of pearls, whose stars trace the path of the system's orbit and have a shared history," said Jaclyn Jensen, a PhD candidate at the University of Victoria. Jensen plans to use Rubin/LSST data for her research on the progenitors of stellar streams and their role in forming the Milky Way. "Using properties of these stars, we can determine information about their origins and what kind of interactions the stream may have experienced. If we find a pearl necklace with a few scattered pearls nearby, we can deduce that something may have come along and broken the string."

The VRO's powerful digital camera and its system of filters make this possible. Its ultraviolet filter, in particular, will help make more streams visible. Astronomers can distinguish stellar streams from all other stars by examining the blue-ultraviolet light at the end of the visible spectrum. They'll have thousands upon thousands of images to work with.

Rubin Observatory at twilight in May 2022. Among the observatory's many endeavours is the study of dark matter. Credit: Rubin Obs/NSF/AURA

In fact, the VRO will unleash a deluge of astronomical data that scientists and institutions have been preparing to handle. AI and machine learning will play a foundational role in managing all that data, which should contribute to finding even more stellar streams.

"Right now it's a labor-intensive process to pick out potential streams by eye—Rubin's large volume of data presents an exciting opportunity to think of new, more automated ways to identify streams."

Astronomers are still finding more stellar streams. Earlier this month, a paper in The Astrophysical Journal presented the discovery of another one. Researchers found it in Gaia's Data Release 3. It's likely associated with the merger of the Sequoia dwarf galaxy.

It seems certain that astronomers will keep finding more stellar streams. Their value as tracers of the Milky Way's history is considerable. But if scientists can use them to understand the distribution of dark matter on a small scale, they'll get more than they bargained for.

More Views of the 2024 Eclipse, from the Moon and Earth Orbit

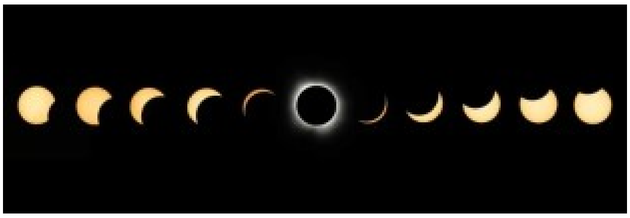
It's been just over a week since millions of people flocked to places across North America for a glimpse of moonshadow. The total solar eclipse of April 8th, 2024 was a spectacular sight for many on the ground. From space, however, it was even more impressive as Earth-observing satellites such as GOES-16 captured the sight of the shadow sweeping over Earth.

NASA even got a snap of the eclipse from the Moon, as taken by the Lunar Reconnaissance Orbiter Camera (LROC). Unlike most Earth-based photographers, however, LROC's view was a tricky one to get. The cameras are line scanners and their images get built up line-by-line. That process requires the spacecraft to slew to keep up with the action and build up a complete view. Amazingly, it took only 20 seconds to capture all the action.

NASA's Deep Space Climate Observatory got an amazing view from Earth orbit, capturing the entire eclipse as it passed over the continent. That observatory "lives" out at LaGrange Point 1, which enabled it to get a full view of Earth and the Moon's shadow.

Eclipse as Experience

For most viewers, the chase to see an eclipse meant driving (or flying) to somewhere along the path of totality to get the best view. That path stretched from the Pacific Ocean off the coast of Mexico up toward the northern Canadian provinces. That meant a wide swath of the U.S. experienced totality. Or course, the weather had to be good to see it all. In most places, that actually turned out reasonably well. Social media immediately came alive with images of the eclipse, people enjoying it, and others waiting vainly for a break in the clouds.



A composite of images taken during the total solar eclipse showing all the phases leading up to and after totality. NASA/Keegan Barber.

This writer was stationed off the coast of Mazatlán, Mexico, on a cruise ship with a group of amateur and professional astronomers. Although there were a few clouds, the view of the eclipsed Sun was nearly pristine. From the ship, everyone was able to watch the shadow approach, feel the temperature drop, and marvel at 4 minutes and 20 seconds of totality.

A projection of the partially eclipsed Sun on the stack of a cruise ship off the coast of Mazatlan. Image credit: Carolyn Collins Petersen.

In a few regions, however, people were only able to watch clouds get dark. And, for the majority of viewers outside of the path of totality, they could only get a partial view. Still, in many places, people went out to experience the event using eclipse glasses or pinhole projection methods to see those partial phases.

Eclipse from the Air

For those who could "fly the eclipse" it was an opportunity to take a jet plane along the path and prolong the experience. During the eclipse, flight-tracking apps showed a huge increase in traffic along the path. Several airlines had flights that tracked the path, giving lucky passengers the view of a lifetime for a short period.

A pilot flying a WB-57 jet during the total solar eclipse on April 8, 2024. Credit: NASA/Mallory Yates

At least one NASA jet pilot captured a view as the aircraft passed through the shadow. In space, the astronauts aboard the International Space Station got a great shot of the umbra and penumbra passing over the maritime provinces of Canada.

A view of the eclipse shadow from the International Space Station. Courtesy NASA.

Future Eclipses

The 2024 eclipse across North America left many with a taste for more moonshadow experience. Unfortunately, that was the last one for this part of the world until 2045. That's when another one will sweep across the continent. Before that, however, there are other total solar eclipses, as well as lunar and annular events. The years 2026, 2027, and 2028 will feature totalities across parts of Europe, Egypt, and Australia. You can find out locations and dates for others at Mr. Eclipse, as well as NASA's own eclipse site. For each event, there'll be plenty of information about safe viewing, as well as "broadcasts" on social media for those outside of the paths of totality.

For More Information

2024 Eclipse as Seen From The Moon
The April 8 Total Solar Eclipse: Through the Eyes of NASA

The Milky Way's Role in Ancient Egyptian Mythology

Look through the names and origins of the constellations and you will soon realise that many cultures had a hand in their conceptualisation. Among them are the Egyptians who were fantastic astronomers. The movement of the sky played a vital role in ancient Egypt including the development of the 365 day year and the 24 hour day. Like many other cultures they say the Sun, Moon and planets as gods. Surprisingly though, the bright Milky Way seems not to have played a vital role. Some new research suggests that this may not be the case and it may have been a manifestation of the sky goddess Nut!

It's a fairly well accepted theory that the pyramids of Egypt were constructed in some way as a representation of or tribute to the sky. The Sun god Ra was often depicted sailing the Sun across the sky in a boat but the Milky Way was never seemed to be a big part, other than perhaps some consideration that the river Nile could represent it.

Nile River, Lake Nasser and the Red Sea, Egypt

Back in the days of ancient Egypt, light pollution really wasn't a thing. The Milky Way would have been far more prominent than for many stargazers today. A recent study by astrophysicists at the University of Portsmouth suggest that a lesser heard god by the name of Nut had something to do with it.

Hunt through Egyptian artwork and you will often see a star-filled woman arched over another person. The woman is Nut, the goddess of the sky and the other figure represents her brother, the god of Earth, Geb. Nut has a very specific job though, she protects the Earth from being flooded from waters of the void! Presumably this would be the void of space but of course back then we didn't have such a great understanding of the cosmos. She also swallowed the Sun as it sets, giving birth to it again in the morning.

Thankfully the Egyptians were fabulous at recording things and so there have been plenty of Egyptian texts to refer to. Running simulations from the evidence in the documents, the team (led by Dr Or Graur Associate Professor in Astrophysics) suggest that the Milky Way represented Nut's outstretched arms in the winter and her backbone in the summer. This suggestion aligns with the broad patterns in the Milky Way.

The arch of the Milky Way seen over Bisei Town in Japan. It prides itself on its dark skies, but faces scattered light pollution from other nearby municipalities. Courtesy DarkSky.Org.

Dr Graur went on to explain that their results revealed that Nut had far more of a functional role too. She was involved in the transition of deceased souls to the afterlife and had a connection with annual bird migrations. This is in line with many cultures like those in North and Central America believing the Milky Way was a road used by spirits or those in Finland and the Baltics who believed it was a path for birds.

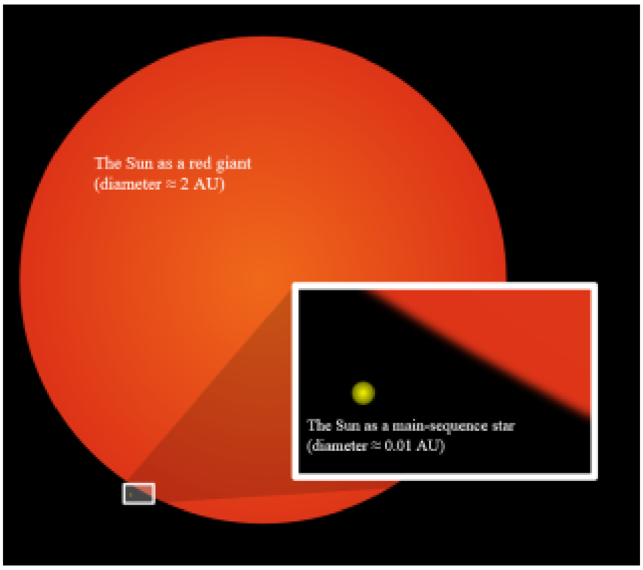
What Happens to Solar Systems When Stars Become White Dwarfs?

In a couple billion years, our Sun will be unrecognizable. It will swell up and become a red giant, then shrink again and become a white dwarf. The inner planets aren't expected to survive all the mayhem these transitions unleash, but what will happen to them? What will happen to the outer planets?

Right now, our Sun is about 4.6 billion years old. It's firmly in the main sequence now, meaning it's going about its business fusing hydrogen into helium and releasing energy. But even though it's about 330,000 times more massive than the Earth, and nearly all of that mass is hydrogen fuel, it will eventually run out.

In another five billion years or so, its vast reservoir of hydrogen will suffer depletion. As it burns through its hydrogen, the Sun will lose mass. As it loses mass, its gravity weakens and can no longer counteract the outward force driven by fusion. A star is a balancing act between the outward expansion of fusion and the inward force of gravity. Eventually, the Sun's billions-of-years-long balancing act will totter.

With weakened gravity, the Sun will begin to expand and become a red giant.

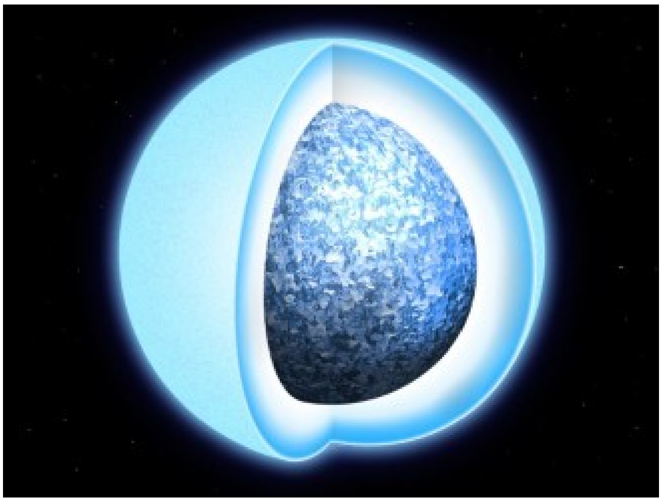


This illustration shows the current-day Sun at about 4.6 billion years old. In the future, the Sun will expand and become a red giant. Image Credit: By Oona Räisänen (User:Mysid), User:Mrsanitazier. – Vectorized in Inkscape by Mysid on a JPEG by Mrsanitazier (en:Image: Sun Red Giant2.jpg). CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=2585107

The Sun will almost certainly consume Mercury and Venus when it becomes a red giant. It will expand and become about 256 times larger than it is now. The inner two planets are too close, and there's no way they can escape the swelling star. Earth's fate is less certain. It may be swallowed by the giant Sun, or it may not. But even if it isn't consumed, it will lose its oceans and atmosphere and become uninhabitable.

The Sun will be a red giant for about one billion years. After that, it will undergo a series of more rapid changes, shrinking and expanding again. But the mayhem doesn't end there.

The Sun will pulse and shed its outer layers before being reduced to a tiny remnant of what it once was: a white dwarf.



An artist's impression of a white dwarf star. The material inside white dwarfs is tightly packed, making them extremely dense. Image credit: Mark Garlick / University of Warwick.

This will happen to the Sun, its ilk, and almost all stars that host planets. Even the long-lived red dwarfs (M-dwarfs) will eventually become white dwarfs, though their path is different.

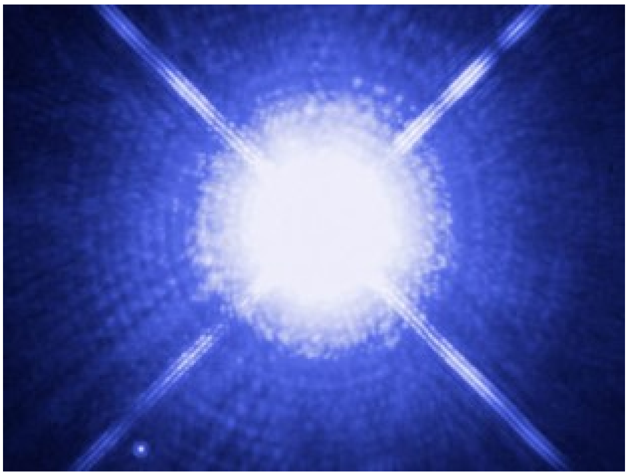
Astronomers know the fate of planets too close to the stars undergoing these tumultuous changes. But what happens to planets further away? To their moons? To asteroids and comets?

New research published in The Monthly Notices of the Royal Astronomical Society digs into the issue. The title is "Long-term variability in debris transiting white dwarfs," and the lead author is Dr. Amornrat Aungwerojwit of Naresuan University in Thailand.

"Practically all known planet hosts will evolve eventually into white dwarfs, and large parts of the various components of their planetary systems—planets, moons, asteroids, and comets—will survive that metamorphosis," the authors write.

There's lots of observational evidence for this. Astronomers have detected planetary debris polluting the photospheres of white dwarfs, and they've also found compact debris disks around white dwarfs. Those findings show that not everything survives the main sequence to red giant to white dwarf transition.

"Previous research had shown that when asteroids, moons and planets get close to white dwarfs, the huge gravity of these stars rips these small planetary bodies into smaller and smaller pieces," said lead author Aungwerojwit.



This Hubble Space Telescope shows Sirius, with its white dwarf companion Sirius B to the lower left. Sirius B is the closest white dwarf to the Sun. Credit: NASA, ESA, H. Bond (STScI) and M. Barstow (University of Leicester).

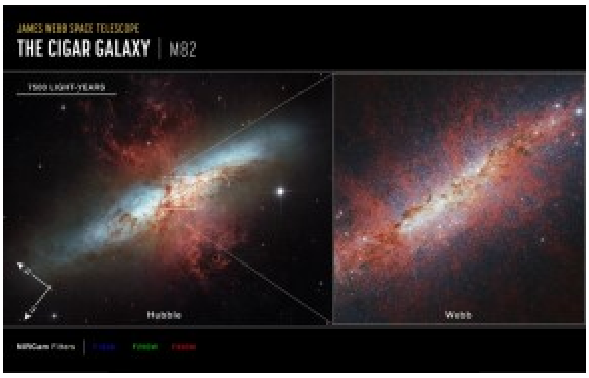
In this research, the authors observed three white dwarfs over the span of 17 years. They analyzed the changes in brightness that occurred. Each of the three stars behaved differently.
When planets orbit stars, their transits are orderly and predictable. Not so with debris. The fact that the three white dwarfs showed such disorderly transits means they're being orbited by debris. It also means the nature of that debris is changing.
"The unpredictable nature of these transits can drive astronomers crazy—one minute they are there, the next they are gone."
Professor Boris Gaensicke, University of Warwick
As small bodies like asteroids and moons are torn into small pieces, they collide with one another until nothing's left but dust. The dust forms clouds and disks that orbit and rotate around the white dwarfs.
Professor Boris Gaensicke of the University of Warwick is one of the study's co-authors. "The simple fact that we can detect the debris of asteroids, maybe moons or even planets whizzing around a white dwarf every couple of hours is quite mind-blowing, but our study shows that the behaviour of these systems can evolve rapidly, in a matter of a few years," Gaensicke said.
"While we think we are on the right path in our studies, the fate of these systems is far more complex than we could have ever imagined," added Gaensicke.

This artist's illustration shows the white dwarf WD J0914+1914 (Not part of this research.) A Neptune-sized planet orbits the white dwarf, and the white dwarf is drawing material away from the planet and forming a debris disk around the star. Image Credit: By ESO/M. Kornmesser – https://www.eso.org/public/images/eso1919a/, CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=84618722
During the 17 years of observations, all three white dwarfs showed variability.
The first white dwarf (ZTF J0328?1219) was steady and stable until a major catastrophic event around 2011. "This might suggest that the system underwent a large collisional event around 2011, resulting in the production of large amounts of dust occulting the white dwarf, which has since then gradually dispersed, though leaving sufficient material to account for the ongoing transit activity, which implies continued dust production," the researchers explain.
The second white dwarf (ZTF J0923+4236) dimmed irregularly every couple of months and displayed chaotic variability on the timescale of minutes. "These long-term changes may be the result of the ongoing disruption of a planetesimal or the collision between multiple fragments, both leading to a temporarily increased dust production," the authors explain in their paper.
The third star (WD 1145+017) showed large variations in numbers, shapes and depths of transits in 2015. This activity "concurs with a large increase in transit activity, followed by a subsequent gradual re-brightening," the authors explain, adding that "the overall trends seen in the brightness of WD?1145+017 are linked to varying amounts of transit activity."
But now all those transits are gone.
"The unpredictable nature of these transits can drive astronomers crazy—one minute they are there, the next they are gone," said Gaensicke. "And this points to the chaotic environment they are in."
But astronomers have also found planetesimals, planets, and giant planets around white dwarfs, indicating that the stars' transitions from main sequence to red giant don't destroy everything. The dust and debris that astronomers see around these white dwarfs might come from asteroids or from moons pulled free from their giant planets.
"For the rest of the Solar System, some of the asteroids located between Mars and Jupiter, and maybe some of the moons of Jupiter may get dislodged and travel close enough to the eventual white dwarf to undergo the shredding process we have investigated," said Professor Gaensicke.
When our Sun finally becomes a white dwarf, it will likely have debris around it. But the debris won't be from Earth. One way or another, the Sun will destroy Earth during its red giant phase.
"Whether or not the Earth can just move out fast enough before the Sun can catch up and burn it is not clear, but [if it does] the Earth would [still] lose its atmosphere and ocean and not be a very nice place to live," explained Professor Gaensicke.

Webb Sees a Galaxy Awash in Star Formation

Since it began operations in July 2022, the *James Webb Space Telescope* (JWST) has fulfilled many scientific objectives. In addition to probing the depths of the Universe in search of galaxies that formed shortly after the Big Bang, it has also provided the clearest and most detailed images of nearby galaxies. In the process, *Webb* has provided new insight into the processes through which galaxies form and evolve over billions of years. This includes galaxies like Messier 82 (M82), a "starburst galaxy" located about 12 million light-years away in the constellation Ursa Major.

Also known as the "Cigar Galaxy" because of its distinctive shape, M82 is a rather compact galaxy with a very high star formation rate. Roughly five times that of the Milky Way, this is why the core region of M82 is over 100 times as bright as the Milky Way's. Combined with the gas and dust that naturally obscures visible light, this makes examining M82's core region difficult. Using the extreme sensitivity of *Webb*'s Near-Infrared Camera (NIRCam), a team led by the University of Maryland observed the central region of this starburst galaxy to examine the physical conditions that give rise to new stars.
The team was led by Alberto Bollato, an astronomy professor at the University of Maryland and a researcher with the Joint Space-Science Institute (JSSI). He was joined by researchers from NASA's Jet Propulsion Laboratory, NASA Ames, the European Space Agency (ESA), the Space Telescope Science Institute (STScI), the ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D), the Max-Planck-Institut für Astronomie (MPIA), National Radio Astronomy Observatory (NRAO), the Infrared Processing and Analysis Center (IPAC-Caltech) and multiple universities, institutes, and observatories. Their findings are described in a paper accepted for publication in *The Astrophysical Journal.*



Annotated image of the starburst galaxy Messier 82 captured by Hubble (left) and Webb's NIRCam (right). Credit: NASA/ESA/CSA/STScI/Alberto Bolatto (UMD)

Their observations were part of a Cycle 1 General Observations (GO) project – for which Bollato is the Principal Investigator (PI) – that used NIRCam data to examine the "prototypical starbursts" NGC 253 and M82 and their "cool" galactic winds. Such galaxies remain a source of fascination for astronomers because of what they can reveal about the birth of new stars in the early Universe. Starbursts are galaxies that experience rapid and efficient star formation, a phase that most galaxies went through during the early history of the Universe (ca. 10 billion years ago). Studying early galaxies in this phase is challenging due to the distances involved.

Fortunately, starburst galaxies like NGC 253 and M82 are relatively close to the Milky Way. While these galaxies have been observed before, Webb's extreme sensitivity in the near-infrared spectrum provided the most detailed look to date. Moreover, the NIRCam observations were made using an instrument mode that prevented the galaxy's intense brightness from overwhelming the instrument. The resulting images revealed details that have been historically obscured, such as dark brown tendrils of heavy dust that contained concentrations of iron (visible in the image as green specks).

These consist largely of supernova remnants, while small patches of red are clouds of molecular hydrogen lit up by young stars nearby. Said Rebecca Levy, second author of the study at the University of Arizona in Tucson, in a NASA press release, "This image shows the power of Webb. Every single white dot in this image is either a star or a star cluster. We can start to distinguish all of these tiny point sources, which enables us to acquire an accurate count of all the star clusters in this galaxy."

Another key detail captured in the images is the "galactic wind" rushing out from the core, which was visible at longer infrared wavelengths. This wind is caused by the rapid rate of star formation and subsequent supernovae and has a significant influence on the surrounding environment. Studying this wind was a major objective of the project (GO 1701), which aimed to investigate how these winds interact with cold and hot material. By a central region of M82, the team was able to examine where the wind originates and the impact it has on surrounding material.

The Cigar Galaxy (M82), a starburst galaxy with high star production. Credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA)

The team was surprised by the way *Webb*'s NIRCam was able to trace the structure of the galactic wind via emission spectra from very small dust grains known as polycyclic aromatic hydrocarbons (PAHs) – a chemical produced when coal, wood, gasoline, and tobacco are burned. These emissions highlighted the galactic wind's fine structure, which appeared as red filaments flowing from above and below the galaxy's disk. Another surprise was the structure of the PAH emission, which was similar to that of the hot ionized gas in the wind. As Bollato explained:

"M82 has garnered a variety of observations over the years because it can be considered as the prototypical starburst galaxy. Both NASA's Spitzer and Hubble space telescopes have observed this target. With Webb's size and resolution, we can look at this star-forming galaxy and see all of this beautiful, new detail. It was unexpected to see the PAH emission resemble ionized gas. PAHs are not supposed to live very long when exposed to such a strong radiation field, so perhaps they are being replenished all the time. It challenges our theories and shows us that further investigation is required."

The team hopes to further investigate the questions these findings raise using Webb data, which will include spectroscopic observations made using the Near-infrared Spectrograph (NIRSpec) and large-scale images of the galaxy and wind. This data will help astronomers obtain accurate ages for the star clusters and determine how long each phase of star formation lasts in starburst galaxies. As always, this information could shed light on how similar phases took place in the early Universe, helping shape galaxies like ours. As Bollato summarized:

"Webb's observation of M82, a target closer to us, is a reminder that the telescope excels at studying galaxies at all distances. In addition to looking at young, high-redshift galaxies, we can look at targets closer to home to gather insight into the processes that are happening here – events that also occurred in the early universe."

A New Map Shows the Universe's Dark Energy May Be Evolving

At the Kitt Peak National Observatory in Arizona, an instrument with 5,000 tiny robotic eyes scans the night sky. Every 20 minutes, the instrument and the telescope it's attached to observe a new set of 5,000 galaxies. The instrument is called DESI—Dark Energy Survey Instrument—and once it's completed its five-year mission, it'll create the largest 3D map of the Universe ever created. But scientists are getting access to DESI's first data release and it suggests that dark energy may be evolving.

DESI is the most powerful multi-object survey spectrograph in the world, according to their website. It's gathering the spectra for tens of millions of galaxies and quasars. The goal is a 3D map of the Universe that extends out to 11 billion light-years. That map will help explain how dark energy has driven the Universe's expansion.

DESI began in 2021 and is a five-year mission. The first year of data has been released, and scientists with the project say that DESI has successfully measured the expansion of the Universe over the last 11 billion years with extreme precision.

"The DESI team has set a new standard for studies of large-scale structure in the Universe."

Pat McCarthy, NOIRLab Director

DESI collects light from 5,000 objects at once with its 5,000 robotic eyes. It observes a new set of 5,000 objects every 20 minutes, which means it observes 100,000 objects—galaxies and quasars—each night, given the right observing conditions.

This image shows Stu Harris working on assembling the focal plane for the Dark Energy Spectroscopic Instrument (DESI) at Lawrence Berkeley National Laboratory in 2017 in Berkeley, Calif. Ten petals, each containing 500 robotic positioners that are used to gather light from targeted galaxies, form the complete focal plane. DESI is attached to the 4-meter Mayall Telescope at Kitt Peak National Observatory. Image Credit: DESI/NSF NOIRlab

DESI's data creates a map of the large-scale structure of the Universe. The map will help scientists unravel the history of the Universe's expansion and the role dark energy plays. We don't know what dark energy is, but we know some force is causing the Universe's expansion to accelerate.

"The DESI instrument has transformed the Mayall Telescope into the world's premier cosmic cartography machine," said Pat McCarthy, Director of NOIRLab, the organization behind DESI. "The DESI team has set a new standard for studies of large-scale structure in the Universe. These first-year data are only the beginning of DESI's quest to unravel the expansion history of the Universe, and they hint at the extraordinary science to come."

DESI measures dark energy by relying on baryonic acoustic oscillations (BAO.) Baryonic matter is "normal" matter: atoms and everything made of atoms. The acoustic oscillations are density fluctuations in normal matter that date back to the Universe's beginnings. BAO are the imprint of those fluctuations, or pressure waves, that moved through the Universe when it was all hot, dense plasma.

As the Universe cooled and expanded, the density waves froze their ripples in place, and where density was high, galaxies eventually formed. The ripple pattern of the BAO is visible in the DESI leading image. It shows strands of galaxies, or galaxy filaments, clustered together. They're separated by voids where density is much lower.

The deeper DESI looks, the fainter the galaxies are. They don't provide enough light to detect the BAO. That's where quasars come in. Quasars are extremely bright galaxy cores, and the light from distant quasars creates a shadow of the BAO pattern. As the light travels through space, it interacts with and gets absorbed by clouds of matter. That lets astronomers map dense pockets of matter, but it took over 450,000 quasars. That's the most quasars ever observed in a survey like this.

Because the BAO pattern is gathered in such detail and across such vast distances, it can act as a cosmic ruler. By combining the measurements of nearby galaxies and distant quasars, astronomers can measure the ripples across different periods of the Universe's history. That allows them to see how dark energy has stretched the scale over time. It's all aimed at understanding the expansion of the Universe.

In the Universe's first three billion years, radiation dominated it. The Cosmic Microwave Background is evidence of that. For the next several billion years, matter dominated the Universe. It was still expanding, but the expansion was slowing because of the gravitational force from matter. But since then, the expansion has accelerated again, and we give the name dark energy to the force behind that acceleration.

So far, DESI's data supports cosmologists' best model of the Universe. But there are some twists.

"We're incredibly proud of the data, which have produced world-leading cosmology results," said DESI director and LBNL scientist Michael Levi. "So far, we're seeing basic agreement with our best model of the Universe, but we're also seeing some potentially interesting differences that could indicate dark energy is evolving with time."

Levi is referring to Lambda Cold Dark Matter (Lambda CDM), also known as the standard model of Big Bang Cosmology. Lambda CDM includes cold dark matter—a weakly interacting type of matter—and dark energy. They both shape how the Universe expands but in opposite ways. Dark energy accelerates the expansion, and regular matter and dark matter slow it down. The Universe evolves based on the contributions from all three. The Lambda CDM does a good job of describing what other experiments and observations find. It also assumes that dark energy is constant and spread evenly throughout the Universe.

This data is just the first release, so confirmation of dark energy evolution must wait. By the time DESI has completed its five-year run, it will have mapped over three million quasars and 37 million galaxies. That massive trove of data should help scientists understand if dark energy is changing.

Whatever the eventual answer, the question is vital to understanding the Universe.

"This project is addressing some of the biggest questions in astronomy, like the nature of the mysterious dark energy that drives the expansion of the Universe," says Chris Davis, NSF program director for NOIRLab. "The exceptional and continuing results yielded by the NSF Mayall telescope with DOE DESI will undoubtedly drive cosmology research for many years to come."

DESI isn't the only effort to understand dark energy. The ESA's Euclid spacecraft is already taking its own measurements to help cosmologists answer their dark energy questions.

In a few years, DESI will have some more powerful allies in the quest to understand dark energy. The Vera Rubin Observatory and Nancy Grace Roman Space Telescope will both contribute to our understanding of the elusive dark energy. They'll perform surveys of their own, and by combining data from all three, cosmologists are poised to generate some long-sought answers.

But for now, scientists are celebrating DESI's first data release.

"We are delighted to see cosmology results from DESI's first year of operations," said Gina Rameika, associate director for High Energy Physics at the Department of Energy. "DESI continues to amaze us with its stellar performance and how it is shaping our understanding of dark energy in the Universe."

WHATS UP, MAY 24

Alt/Az coord. ARC
Apparent
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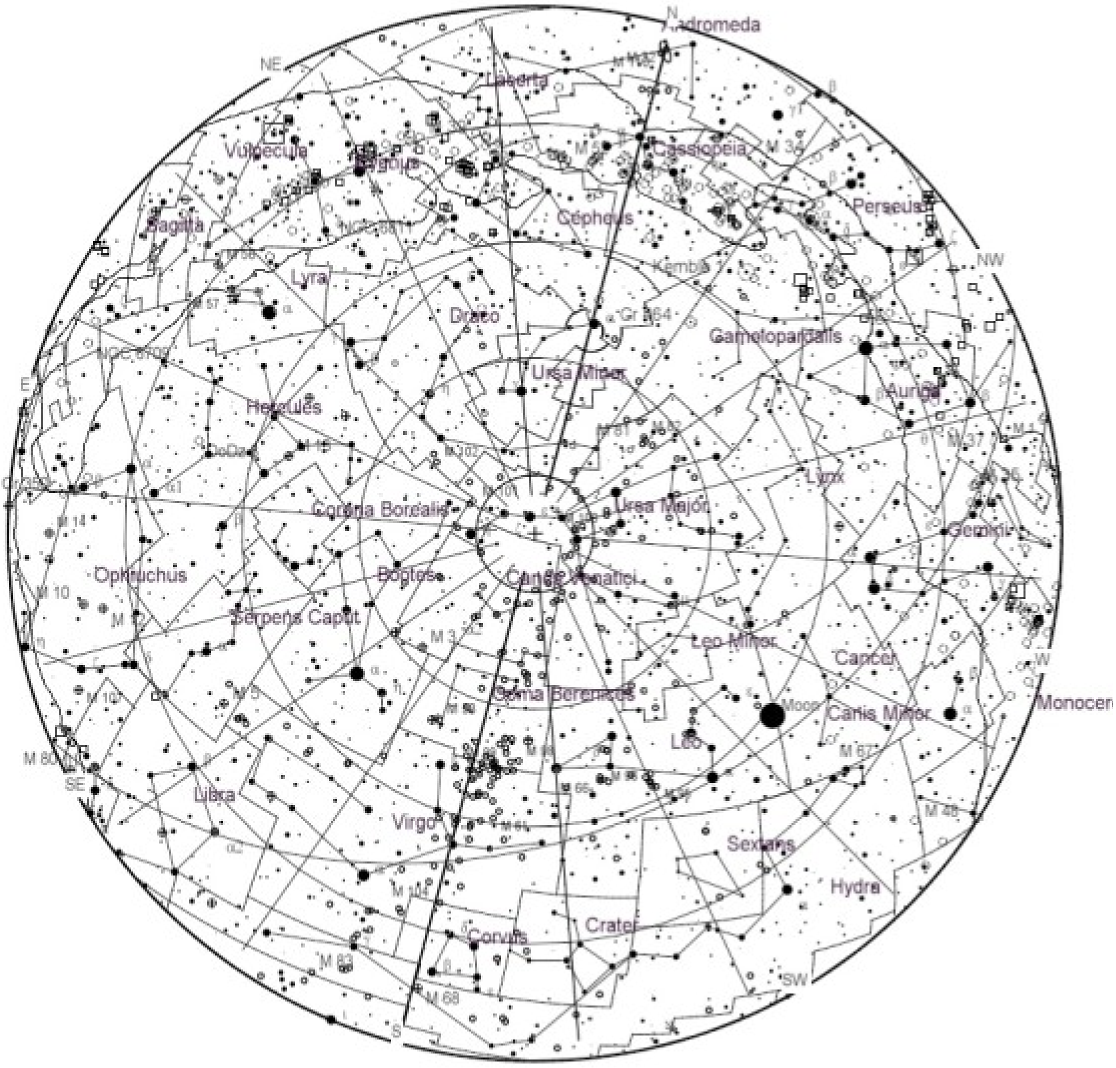


May 6, 7 - **Eta Aquarids Meteor Shower.** The Eta Aquarids is an above average shower, capable of producing up to 60 meteors per hour at its peak. Most of the activity is seen in the Southern Hemisphere. In the Northern Hemisphere, the rate can reach about 30 meteors per hour. It is produced by dust particles left behind by comet Halley, which has been observed since ancient times. The shower runs annually from April 19 to May 28. It peaks this year on the night of May 6 and the morning of the May 7. The nearly new moon means dark skies for what should be an excellent show this year. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Aquarius, but can appear anywhere in the sky.

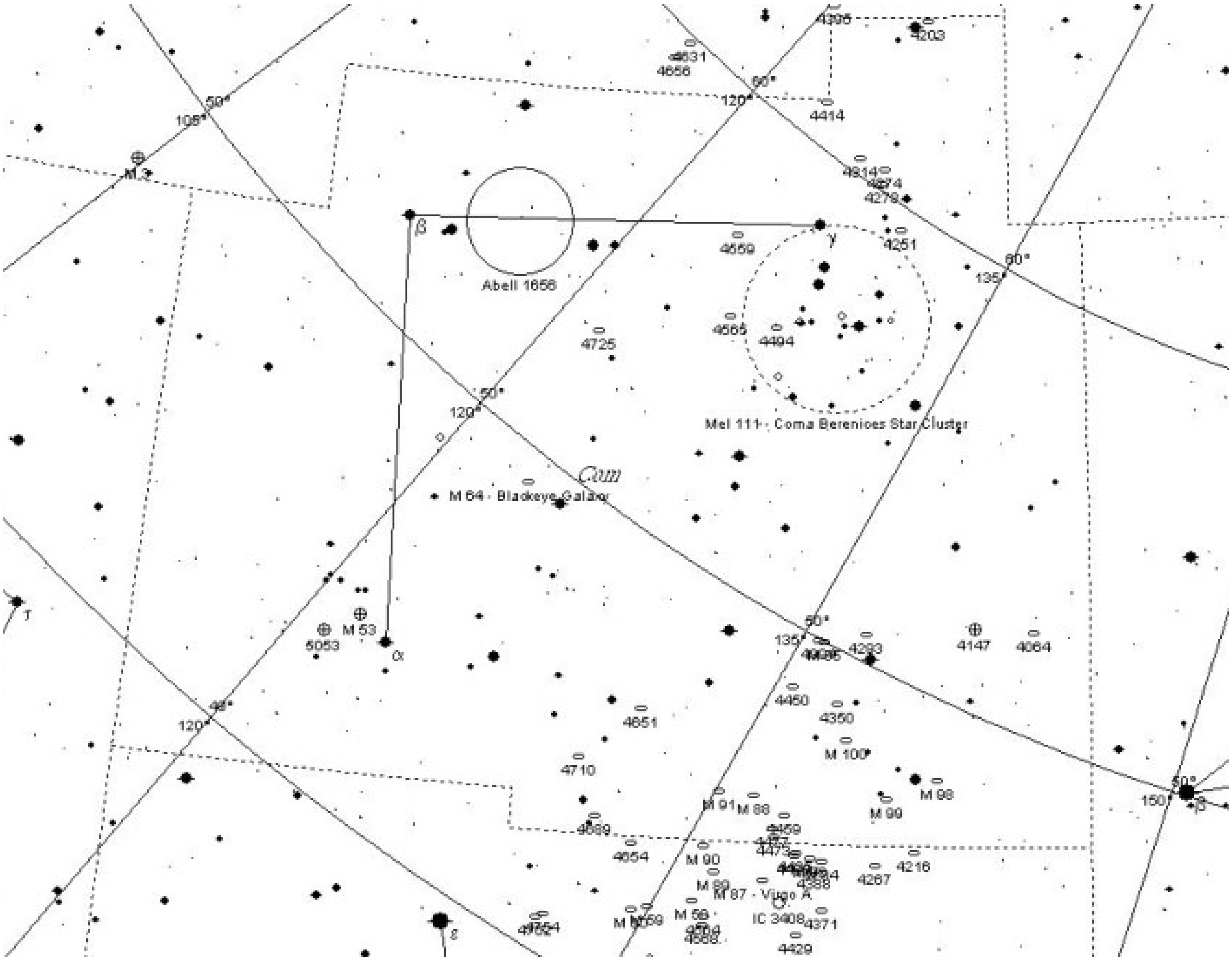
May 8 - **New Moon.** The Moon will located on the same side of the Earth as the Sun and will not be visible in the night sky. This phase occurs at 03:23 UTC. This is the best time of the month to observe faint objects such as galaxies and star clusters because there is no moonlight to interfere.

May 9 - **Mercury at Greatest Western Elongation.** The planet Mercury reaches greatest western elongation of 26.4 degrees from the Sun. This is the best time to view Mercury since it will be at its highest point above the horizon in the morning sky. Look for the planet low in the eastern sky just before sunrise.

May 23 - **Full Moon.** The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This phase occurs at 13:55 UTC. This full moon was known by early Native American tribes as the Flower Moon because this was the time of year when spring flowers appeared in abundance. This moon has also been known as the Corn Planting Moon and the Milk Moon.

June 6 - **New Moon.** The Moon will located on the same side of the Earth as the Sun and will not be visible in the night sky. This phase occurs at 12:39 UTC. This is the best time of the month to observe faint objects such as galaxies and star clusters because there is no moonlight to interfere

CONSTELLATION OF THE MONTH: COMA BERENICES



The Coma Berenices Constellation

In the 2nd century CE, Greek-Egyptian astronomer Claudius Ptolemaeus (aka. Ptolemy) compiled a list of all the then-known 48 constellations. This treatise, known as the *Almagest*, would be used by medieval European and Islamic scholars for over a thousand years to come, effectively becoming astrological and astronomical canon until the early Modern Age.

One of these is the constellation Coma Berenices, an ancient constellation located in the norther skies. In the *Almagest*, Ptolemy considered the asterism to be part of the constellation Leo. Today, it is one of the 88 constellations recognized by the International Astronomical Union, and is bordered by the constellations of Canes Venatici, Ursa Major, Leo, Virgo and Boötes.

Name and Meaning:

In mythology, it is easy to see why this dim collection of stars was once associated with Leo and considered to be the tuft of hair at the end of the Lion's tail. However, as the years passed, a charming legend grew around this sparkling group of stars. Since the time of Ptolemy, this grouping of stars was recognized and although he didn't list it as one of his 88 constellations, he did refer to is as "Berenice's Hair".

As legend would have it, the good Queen Berenice II of Egypt offered to sacrifice her beautiful long hair to Aphrodite for the safe return of her husband from battle. When she cut off her locks and placed it on the altar and returned the next day, her sacrifice was gone. To save his life, the court astronomer proclaimed Aphrodite had immortalized Berenice's gift in the stars… and thus the Lion lost his tail and the astronomer saved his hide!

History of Observation:

Like many of the 48 constellations recognized by Ptolemy, Coma Berenices traces it routes back to ancient Mesopotamia. To Babylonian astronomers, it was known as *Hegala*, which translated to "which is before it". However, the first recorded mention comes from Conon of Samos, the 3rd century BCE court astronomer to Ptolemy III Euergetes – the Greek-Egyptian king. It was named in honor of his consort, Berenice II, who is said to have cut off her long hair as a sacrifice to ensure the safety of the king.

The constellation was named "*bostrukhon Berenikes"* in Greek, which translates in Latin to "Coma Berenices" (or "Berenice's hair"). Though it was previously designated as its own constellation, Ptolemy considered it part of Leo in his 2nd century CE tract the *Almagest,* where he called it "Plokamos" (Greek for "braid"). The constellation was also recognized by many non-western cultures.

In Chinese astronomy, the stars making up Coma Berenices belonged to two different areas – the Supreme Palace Enclosure and the Azure Dragon of the East. Eighteen of the constellation's stars were in an area known as *Lang wei* ("seat of the general"). To Arabic astronomers, Coma Berenices was known as *Al-*

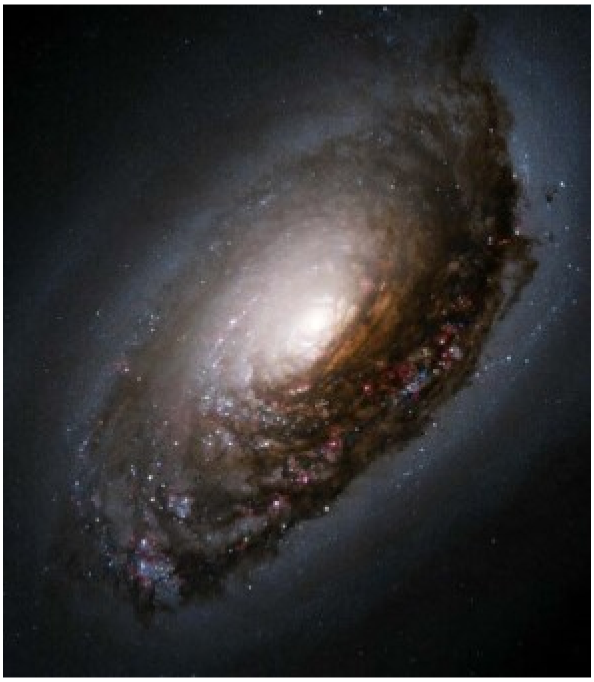
Du'aba, Al Dafira and *Al-Hulba*, forming the tuft of the constellation Leo (consistent with Ptolemy's designation).

By the 16th century, the constellation began to be featured on globes and maps produced by famed cartographers and astronomers. In 1602, Tycho Brahe recognized it as its own constellation and included it in his star catalogue. In the following year, it was included in Johann Bayer's famed celestial map, *Uranometria*. In 1920, it was included by the IAU in the list of the 88 modern constellations.

Notable Objects:

Despite being rather dim, Coma Berenices is significant because it contains the location of the North Galactic Pole. It is comprised of only 3 main stars, but contains 44 Bayer/Flamsteed designated members. Of its main stars, Alpha Comae Berenices (aka. Diadem) is the second-brightest in the constellation.

The name is derived from the Greek word *diádema*, which means "band" or "fillet", and represents the gem in Queen Berenice's crown. It is sometimes known by its other traditional name, *Al-Zafirah*, which is Arabic for "the braid". It is a binary star composed of two main sequence F5V stars that are at a distance of 63 light years from Earth.



The Black Eye Galaxy (Messier 64). Credit: NASA/The Hubble Heritage Team (AURA, STScI)

It's brightest star, Beta Comae Berenices, is located 29.78 light years from Earth and is a main sequence dwarf that is similar to our Sun (though larger and brighter). It's third major star, Gamma Comae Berenices, is a giant star belonging to the spectral class K1II and located about 170 light years from Earth.

Coma Berenices is also home to several Deep Sky Objects, which include spiral galaxy Messier 64. Also known as the Black Eye Galaxy (Sleeping Beauty Galaxy and Evil Eye Galaxy), this galaxy is located approximately 24 million light years from Earth. This galaxy has a bright nucleus and a dark band of dust in front of it, hence the nicknames.

Then there is the Needle Galaxy, which lies directly above the North Galactic Pole and was discovered by Sir William Herschel in 1785. It is one of the most famous galaxies in the sky that can be viewed edge-on. It lies at a distance of about 42.7 million light years from Earth and is believed to be a barred spiral galaxy from its appearance.

Coma Berenices is also home to two prominent galaxy clusters. These includes the Coma Cluster, which is made up of about 1000 large galaxies and 30,000 smaller ones that are located between 230 and 300 million light years from Earth. South of the Coma Cluster is the northern part of the Virgo Cluster, which is located roughly 60 million light years from Earth.

The globular cluster Messier 53 (NGC 5024), located in the Coma Berenices constellation. Credit: NASA (Wikisky)

Other Messier Objects include M53, a globular cluster located approximately 58,000 light years away; Messier 100, a grand design spiral galaxy that is one of the brightest members of the Virgo cluster (located 55 million light years away); and Messier 88 and 99 – a spiral galaxy and unbarred spiral galaxy that are 47 million and 50.2 million light years distant, respectively.

Finding Coma Berenices:

Coma Berenices is best visible at latitudes between +90° and -70° during culmination in the month of May. There is one meteor shower associated with the constellation of Coma Berenices – the Coma Berenicid Meteor shower which peaks on or near January 18 of each year. Its fall rate is very slow – only one or two per hour on average, but these are among the fastest meteors known with speeds of up to 65 kilometers per second!

For both binoculars and telescopes, Coma Berenices is a wonderland of objects to be enjoyed. Turn your attention first to the brightest of all its stars – Beta Coma Berenices. Positioned about 30 light years from Earth and very similar to our own Sun, Beta is one of the few stars for which we have a measured solar activity period – 16.6 years – and may have a secondary activity cycle of 9.6 years.

Now look at slightly dimmer Alpha. Its name is Diadem – the Crown. Here we have a binary star of equal magnitudes located about 65 light years from our solar system, but it's seen nearly "edge-on" from the Earth. This means the two stars appear to move back-and-forth in a straight line with a maximum separation of only 0.7 arcsec and will require a large aperture telescope with good resolving power to pull them apart. If you do manage, you're separating two components that are about the distance of Saturn from the Sun!

Another interesting aspect about singular stars in Coma Berenices is that there are over 200 variable stars in the constellation. While most of them are very obscure and don't go through radical changes, there is one called FK Comae Berenices which is a prototype of its class. It is believed that the variability of FK Com stars is caused by large, cool spots on the rotating surfaces of the stars – mega sunspots! If you'd like to keep track of a variable star that has notable changes, try FS Comae Berenices (RA 13 3 56 Dec +22 53 2). It is a semi-regular variable that varies between 5.3m and 6.1 magnitude over a period of 58 days.

For your eyes, binoculars or a rich field telescope, be sure to take in the massive open cluster Melotte 111. This spangly cloud of stars is usually the asterism we refer to as the "Queen's Hair" and the area is fascinating in binoculars. Covering almost 5 full degrees of sky, it's larger than most binocular fields, but wasn't recognized as a true physical stellar association until studied by R.J. Trumpler in 1938.

Located about 288 light years from our Earth, Melotte 111 is neither approaching nor receding… unusual – but true. At around 400 million years old, you won't find any stars dimmer than 10.5 magnitude here. Why? Chances are the cluster's low mass couldn't prevent them from escaping long ago…

Now turn your attention towards rich globular cluster, Messier 53. Achievable in both binoculars and small telescopes, M53 is easily found about a degree northwest Alpha Comae. At 60,000 light years away from the galactic center, it's one of the furthest globular clusters away from where it should be. It was first discovered by Johann Bode in 1755, and once you glimpse its compact core you'll be anxious to try to resolve it.

The Needle Galaxy (NGC 4565). Credit: ESO

With a large telescope, you'll notice about a degree further to the east another globular cluster – NGC 5053 – which is also about the same physical distance away. If you study this pair, you'll notice a distinct difference in concentrations. The two are very much physically related to one another, yet the densities are radically different!

Staying with binoculars and small telescopes, try your hand at Messier 64 – the "Blackeye Galaxy". You'll find it located about one degree east/northeast of 35 Comae. While it will be nothing more than a hazy patch in binoculars, smaller telescopes will easily reveal the signature dustlane that makes M64 resemble its nickname. It is one of the brightest spiral galaxies visible from the Milky Way and the dark dust lane was first described by Sir William Herschel who compared it to a "Black Eye."

Now put your telescope on Messier 100 – a beautiful example of a grand-design spiral galaxy, and one of the brightest galaxies in the Virgo Cluster. This one is very much like our own Milky Way galaxy and tilted face-on, so we may examine the spiral galaxy structure. Look for two well resolved spiral arms where young, hot and massive stars formed recently from density perturbations caused by interactions with neighboring galaxies. Under good observing conditions, inner spiral structure can even be seen!

Try lenticular galaxy Messier 85. In larger telescopes you will also see it accompanied by small barred spiral NGC 4394 as well. Both galaxies are receding at about 700 km/sec, and they may form a physical galaxy pair. How about Messier 88? It's also one of the brighter spiral galaxies in the Virgo galaxy cluster and in a larger telescope it looks very similar to the Andromeda galaxy – only smaller.

How about barred spiral galaxy M91? It's one of the faintest of the Messier Catalog Objects. Although it is difficult in a smaller telescope, its central bar is very strong in larger aperture. Care to try Messier 98? It is a grand edge-on galaxy and may or may not be a true member of the Virgo group. Perhaps spiral galaxy Messier 99 is more to your liking… It's also another beautiful face-on presentation with grand spiral arms and a sweeping design that will keep you at the eyepiece all night!

There are other myriad open clusters and just as many galaxies waiting to be explored in Coma Berenices! It's a fine region. Grab a good star chart and put a pot of coffee on to brew. Comb the Queen's Hair for every last star. She's worth it.

We have written many interesting articles about the constellation here at Universe Today. Here is What Are The Constellations?, What Is The Zodiac?, and Zodiac Signs And Their Dates.

Be sure to check out The Messier Catalog while you're at it!

For more information, check out the IAUs list of Constellations, and the Students for the Exploration and Development of Space page on Canes Venatici and Constellation Families.

Source:

- *Constellation Guide – Coma Berenices*
- *Wikipedia – Coma Berenices*
- *SEDS – Coma Berenices*

ISS PASSES For May 2024

from Heavens Above website maintained by Chris Peat.

Date	Brightn	Start	Highest point	End						
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
06 May	-1.0	01:11:52	11°	E	01:11:52	11°	E	01:12:06	10°	E
06 May	-3.9	02:44:42	50°	W	02:45:28	87°	N	02:48:49	10°	E
06 May	-3.9	04:18:51	10°	W	04:22:10	71°	SSW	04:25:29	10°	ESE
07 May	-3.2	01:57:01	49°	E	01:57:01	49°	E	01:59:33	10°	E
07 May	-3.9	03:29:51	12°	W	03:32:55	85°	SSW	03:36:15	10°	ESE
08 May	-1.5	01:09:21	17°	E	01:09:21	17°	E	01:10:16	10°	E
08 May	-3.9	02:42:10	31°	W	02:43:38	87°	N	02:46:59	10°	E
08 May	-3.5	04:17:01	10°	W	04:20:13	44°	SSW	04:23:24	10°	SE
09 May	-3.8	01:54:31	76°	ENE	01:54:31	76°	ENE	01:57:39	10°	E
09 May	-3.8	03:27:41	10°	W	03:30:58	59°	SSW	03:34:15	10°	ESE
10 May	-1.9	01:07:01	22°	E	01:07:01	22°	E	01:08:19	10°	E
10 May	-4.0	02:39:51	25°	W	02:41:40	75°	SSW	02:45:00	10°	ESE
10 May	-2.7	04:15:15	10°	W	04:18:02	25°	SSW	04:20:49	10°	SSE
10 May	-3.0	22:36:12	10°	SSW	22:39:10	29°	SSE	22:40:15	24°	ESE
11 May	-1.8	00:12:16	10°	WSW	00:20:09	4°	E	00:13:25	20°	WSW
11 May	-3.3	01:53:05	51°	ESE	01:53:05	51°	ESE	01:55:40	10°	E
11 May	-3.2	03:26:02	12°	W	03:28:49	35°	SSW	03:31:53	10°	SE
11 May	-2.5	21:47:23	10°	SSW	21:49:57	21°	SE	21:52:33	10°	E
11 May	-3.9	23:22:56	10°	WSW	23:26:15	68°	SSE	23:28:57	15°	E
12 May	-2.9	00:59:35	10°	W	01:01:52	40°	W	01:01:52	40°	W
12 May	-1.4	02:42:18	13°	SE	02:42:18	13°	SE	02:42:45	10°	SE
12 May	-1.9	04:15:29	13°	SW	04:15:37	13°	SW	04:17:11	10°	SSW
12 May	-3.7	22:33:38	10°	SW	22:36:54	52°	SSE	22:40:10	10°	E
13 May	-3.8	00:10:10	10°	W	00:13:31	85°	N	00:14:46	36°	E
13 May	-1.5	01:46:53	10°	W	01:47:37	16°	W	01:47:37	16°	W
13 May	-3.2	21:44:27	10°	SW	21:47:33	38°	SSE	21:50:42	10°	E
13 May	-3.9	23:20:44	10°	W	23:24:05	90°	SSW	23:27:09	12°	E
14 May	-3.3	00:57:27	10°	W	00:59:58	48°	W	00:59:58	48°	W
14 May	-3.9	22:31:18	10°	WSW	22:34:39	79°	SSE	22:37:59	10°	E
15 May	-3.9	00:08:00	10°	W	00:11:20	90°	W	00:12:11	48°	E
15 May	-1.2	01:44:44	10°	W	01:45:00	12°	W	01:45:00	12°	W
15 May	-3.8	21:41:54	10°	WSW	21:45:12	63°	SSE	21:48:31	10°	E
15 May	-3.8	23:18:30	10°	W	23:21:51	85°	N	23:24:21	17°	E
16 May	-2.5	00:55:13	10°	W	00:57:09	30°	W	00:57:09	30°	W
16 May	-3.8	22:29:00	10°	W	22:32:21	86°	N	22:35:42	10°	E
17 May	-3.9	00:05:42	10°	W	00:09:02	69°	SSW	00:09:16	65°	SSE
17 May	-3.8	21:39:29	10°	W	21:42:50	87°	S	21:46:10	10°	E
17 May	-3.9	23:16:11	10°	W	23:19:32	83°	SSW	23:21:22	25°	ESE
18 May	-1.7	00:52:59	10°	W	00:54:10	18°	W	00:54:10	18°	W
18 May	-3.8	22:26:38	10°	W	22:29:59	88°	N	22:33:20	10°	E
19 May	-3.2	00:03:21	10°	W	00:06:15	41°	SW	00:06:15	41°	SW
19 May	-3.7	21:37:04	10°	W	21:40:25	85°	N	21:43:45	10°	E
19 May	-3.7	23:13:45	10°	W	23:17:03	57°	SSW	23:18:19	32°	SE
20 May	-1.1	00:51:03	10°	W	00:51:08	10°	WSW	00:51:08	10°	WSW
20 May	-3.8	22:24:10	10°	W	22:27:30	73°	SSW	22:30:24	13°	ESE
21 May	-2.2	00:01:06	10°	W	00:03:12	22°	SW	00:03:12	22°	SW
21 May	-2.9	23:11:19	10°	W	23:14:22	33°	SSW	23:15:16	28°	S
22 May	-3.3	22:21:36	10°	W	22:24:50	46°	SSW	22:27:20	15°	SE

END IMAGES, AND OBSERVING

Composite of the American eclipse of April 24 by John Dartnell.

See the article from page 5

Wiltshire Astronomical Society Public Observing Dates for the 2023-2024 Season.

The observing site is normally in the Picnic Area beside the Red Lion Pub car park, in Lacock but can change, so sign up for email confirmation at https://wasnet.org.uk/observing/

The WAS Observing team have provided at least two opportunities for observing evenings each month. If the first is cancelled due to weather then we have normally have a second chance the following week. A reminder email is sent out on the Tuesday before the day and a 'Go, No-Go' email sent by 16:00 on the observing day which based on various weather Apps and looking out of the window at work.

Opportunity	Day	Date	Month	set-up	Observe	Moon Phase and Rise/Set Times			Suggested Observing Targets
First	Friday	03rd	May	20:30	21:00	Cres	Rising	4:30	The nights are short and the rise of Vega, Deneb and Altair, mark the rise of the summer triangle and the final few weeks of the Wiltshire Astronomical Societies observing season.
Second	Friday	10th	May	20:30	21:00	Cres	Setting	23:45	

Always feel free to contact the observing team for advice on what to see in the night sky.
Also if members want to see a particular event the observing team can look into setting up ad-hoc sessions where possible.

Wiltshire Astronomical Society Observing Team

OUTREACH

See emails for a proposal by Dave Buckle to take donations at outreach observing sessions for Starlight Children's Foundation