NWASNEWS

Volume27 Issue 8

April 2022

Newsletter for the Wiltshire, Swindon, Beckington, Bath Astronomical Societies

The End of an Era (we hope).

It is not meant as a comment of some of the last talks by our speaker tonight, Pete Williamson FRAS. He announced his retirement from 'working astronomy' in March, but assures is this does not affect the Solarsphere summer of observing and music in mid Wales during August. This link between music and astronomers is part of what he touches on in tonights talk to the Wiltshire Society on Zoom.

I refer to this being our last on line Zoom evening, and I see our next meetings being in the hall so we can all get together and enjoy coffee, chatting and meeting up again.

Some speakers will still ask to be on Zoom rather than travel and I am looking at ways we can make these happen with speaker broadcasting and interacting with us on Zoom BUT they will not be oen on the internet, they will be hall meeting assemblies. Please do all you can to attend. One or two meetings we tried in the COVID lull were not well attended and we could not afford to bring speakers in on that basis.

Over to you as members.

I am delighted to note how the observing sessions are going. We had had a great run for four months, unfortunately I missed the last two, being on holiday for the March session and injections for the February meeting. If this enthusiasm is carried forward I am sure we will have no problems filling our hall meetings.

And back to our tonight's speaker and his topic, Herschel to Hawkwind. Astronomy and Music.

The image below includes so many of the William Herschel discoveries in the Virgo cluster of galaxies….

Topic: Wilts AS April Zoom Meeting

Time: Apr 5, 2022 07:45 PM London

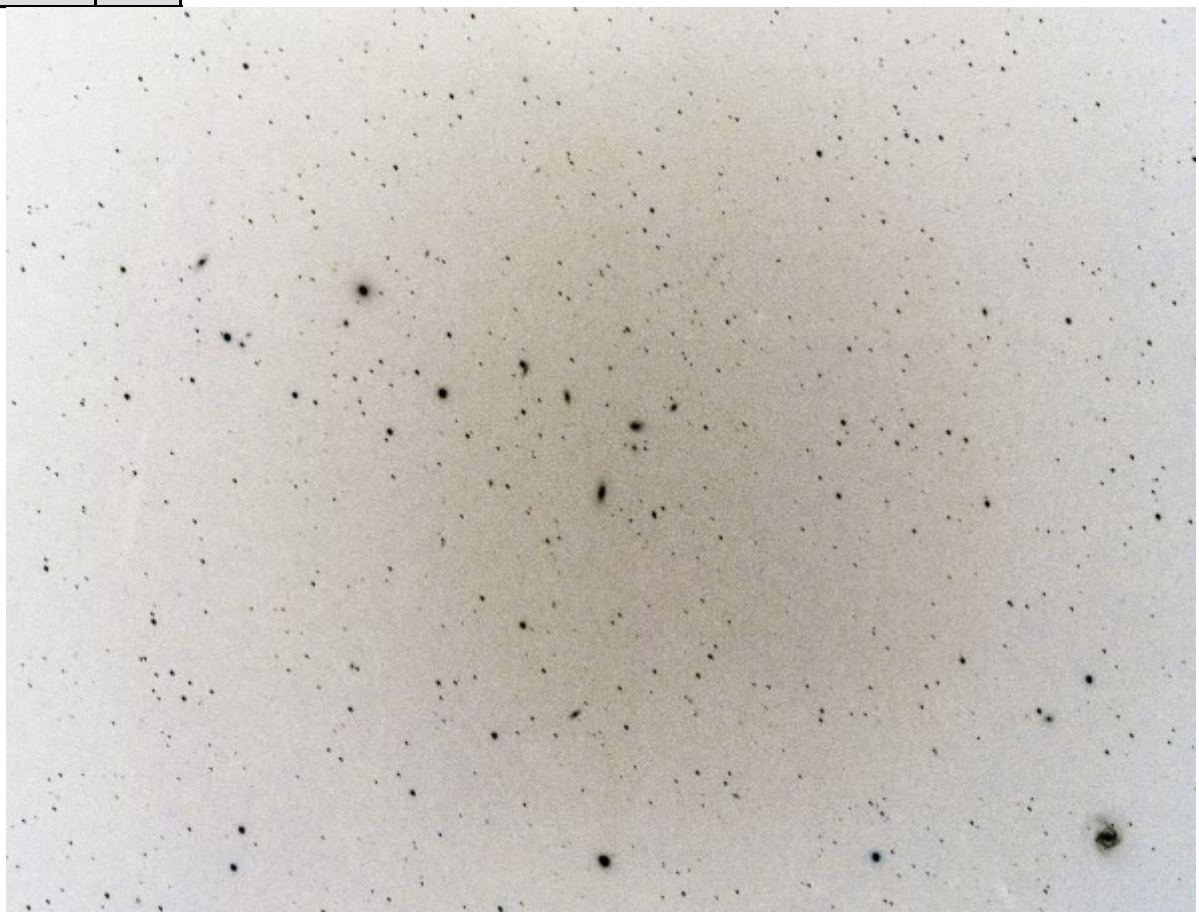
Speaker Pete Williamson FRAS: Herschel to Hawkwind: Astronomy & Music & How each other influence each other
Join Zoom Meeting

https://us02web.zoom.us/j/82352359148?pwd=VTAvMGFPYkdUdDlsQWtPWWs5S3JWZz09

Meeting ID: 823 5235 9148

Passcode: 691538

Clear skies Andy



The 61 (lower right here, and NGC 4261, 4260,4269, 4249, 4252, 4257,4266,4270,4281, 4273,4268,4324 and so many other galaxies in the southerly region of the Virgo cluster of galaxies. The Messier catalogue may be bare of objects here but it it doesn't mean no galaxies are here. Even from Slough William Herschell added tens of galaxies more.
This is a single 120 second exposure on the Nikon D810a through a 5" refracting telescope. ISO 1600.

Andy Burns

Wiltshire Society Page

Wiltshire Astronomical Society

Web site: www.wasnet.org.uk

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

Meetings 2020/2021.

HALL VENUE the Pavilion, Rusty Lane, Seend

Some Speakers have requested Zoom Mweetings and these will be at home sessions.

Meet 7.30 for 8.00pm start

SEASON 2021/22

2022

5th Apr Pete Williamson Herschel to Hawkwind, Astronomy & Music & How each other influence each other

3rd May Andrew Lound The Moon at Christmas: The Epic Voyage of Apollo 8

7th Jun Prof Matt Griffin The hazards of Asteroid Impacts on the Earth – Should we worry?

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

Andy Burns Chair, anglesburns@hotmail.com

Andy Burns Outreach and newsletter editor.

Bob Johnston (Treasurer)

Philip Proven (Hall coordinator)

??? (Teas and Projector)

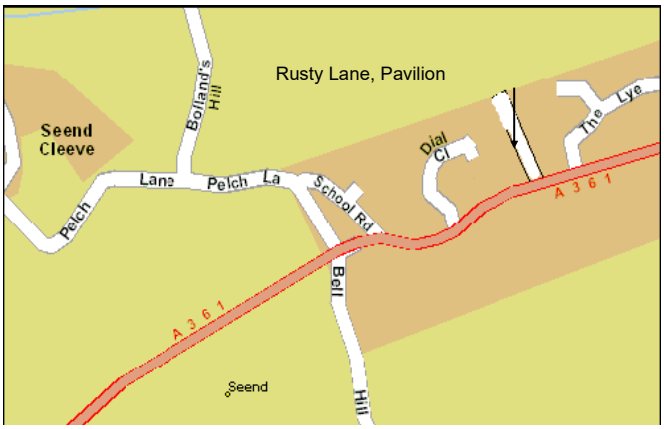
Peter Chappell (Speaker secretary)

Nick Howes (Technical Guru)

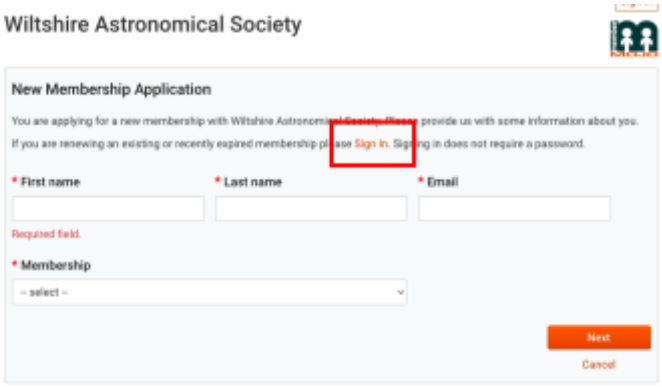
Observing Sessions coordinators: Chris Brooks, Jon Gale,

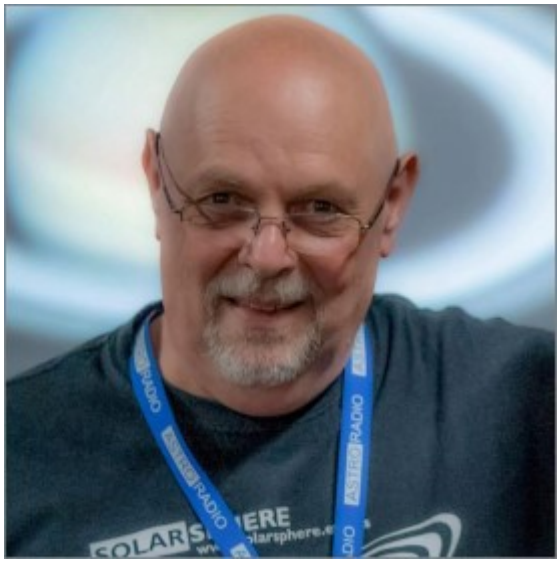
Web coordinator: Sam Franklin

Contact via the web site details.



Observing Sessions see back page





My name is Pete Williamson FRAS welcome to my website, all aspects of my work and how to book me for my services are listed here. I am available for Talks & Workshops for Societies, Schools, Colleges and other organisations such as U3A, WI and many more throughout the UK, Ireland in person plus across the globe via Zoom.

Working as a consultant and imager for many educational remote access telescopes across the globe I am able to deliver workshops directly into the classroom, society practical workshops and photographic club meetings. As a freelance astronomer it allows me to have the flexibility to work along side or with many organisations such as Faulkes Telescope Project, National Schools Observatory, Slooh Educational Projects, Universities, schools and many more astronomical organisations. You can select the remote on-line telescope service of your choice from the footer menu or menu at the top of the page. I will only be too pleased to help you obtain access and assist you to use these telescopes if required.

Access can only be granted if your are eligible and fit the criteria set down by the organisation who control the telescopes observatories. Please do not hesitate to enquire what the criteria requirements are.

Part of my work included presenting astronomy on varying forms of media, The BBC Eye On The Sky my monthly show with BBC Radio Shropshire, Reach Out and Touch Space on Astro Radio, the occasional TV appearance and resident astronomer on at least 7 radio stations across the UK.

My work also takes me to many schools across the UK where I deliver classroom projects for youngsters which includes understanding our Solar System, our place in the galaxy and our place in the universe.

Swindon's own astronomy group

Physical meetings continuing!

Following the relaxation of the Covid rules we are continuing physical meetings.

Next meeting: Jon Gale

Our speaker on the 22 April will be Jon Gale who will be speaking on the 'Herschel 400'.
The Herschel 400 catalogue is a subset of William Herschel's original Catalogue of 2500 Nebulae and Star Clusters.
It was found that by reducing this number it would be an excellent basis for deep sky object selection for amateur astronomers looking for a challenge after completing the Messier Catalogue.

Ad-hoc viewing sessions postponed

All ad-hoc meetings are currently postponed until further notice.

Regular stargazing evenings are being organised near Swindon. To join these events please visit our website for further information.

Membership of Swindon Stargazers is required for insurance purposes (PLI)

Lately we have been stargazing at Blakehill Farm Nature Reserve near Cricklade, a very good spot with no distractions from car headlights.

We often meet regularly at a lay-by just outside the village of Uffcott, near Wroughton. Directions are also shown on the website link below.

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

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 on our website at:

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

Meetings 2022

Friday, 18 Mar 19.30 onwards

Programme: AGM

Friday, 22 April 19.30 onwards

Programme: Jon Gale - The Herschel 400

Friday, 20 May 19.30 onwards

Programme: Hugh Allen - Binary Stars - A history of making waves

Friday, 17 June 19.30 onwards

Programme: Steve Tonkin - Journey Into Space

Website: http://www.swindonstargazers.com

Chairman: Robin Wilkey

Tel No: 07808 775630 Email: robin@wilkey.org.uk Address: 61 Northern Road Swindon, SN2 1PD

Secretary: Hilary Wilkey

Tel No: 01793 574403 Email: hilary@wilkey.org.uk Address: 61 Northern Road Swindon, SN2 1PD

BECKINGTON ASTRONOMICAL SOCIETY

Society Details & Speakers programme can be found on our Website www.beckingtonas.org

General enquiries about the Society can be emailed to chairman@beckingtonas.org.

Our Committee for 2016/2017 is

Chairman: Steve Hill (email chairman@beckingtonas.org)
Treasurer: John Ball
Secretary: Sandy Whitton
Ordinary Member: Mike Witt

People can find out more about us at www.beckingtonas.org

Meetings take place in Beckington Baptist Church Hall in Beckington Village near Frome.

See the location page for details of how to find us on our website……

Post Code for Sat Nav is BA11 6TB.

Our start time is 7.30pm No hall meetings.

STAR QUEST ASTRONOMY CLUB

This young astronomy club meets at the

Sutton Veny Village Hall.

Second Thursday of the Month.

Meet at Sutton Veny near Warminster.

BATH ASTRONOMERS

GRESHAM ON LINE SESSIONS

MAY
The Future of Life on Earth by Professor Roberto Trotta
Monday, May 9, 2022 1:00 PM gres.hm/future-life
Barnard's Inn Hall/ Online Or watch later
Although life is probably widespread in the universe, our pale blue dot, Earth, is the only known place harbouring intelligent life. Even if we manage to stave off extinction by climate change, avoid a nuclear apocalypse and the dangers of runaway AI, biological life on our planet will eventually come to an end in about 5 billion years' time. What are the astrophysical dangers to life on Earth, and the prospects for life's survival into the distant future? JUNE
Life in the Universe by Professor Katherine Blundell
Wednesday, June 1, 2022 6:00 PM gres.hm/life-universe
Museum of London / Online Or watch later
How can life form in the Universe, and what are the necessary ingredients for habitability so that planets can sustain life? Can we expect life elsewhere in the solar system, or on exoplanets? This lecture offers a broader perspective from astrobiology, astrochemistry, and astrophysics on the habitability or otherwise of other planets beyond Planet Earth.
Their website
www.gresham.ac.uk
////////
Best wishes for the new Year
Martin
Martin Baker

FAS News from other societies:

Our Guest Speaker will be Mary McIntyre FRAS

The talk synopsis: Historically, astronomy has been very male-dominated. Throughout history, there have been several trail-blazing women, such as Caroline Herschel, who worked to change that. But in addition, countless less well-known women were doing astronomy before Caroline. This talk is a celebration of women who worked in astronomy during different periods of history and some of the challenges they have faced.
Following the presentation, we will have time for a short Q&A session with Mary.
Guests are welcome to stay with us for our second presentation of the evening... Dr Tony Cook's regular monthly feature "What's happening in the month ahead", which includes member's photos.
Observations may also be shown at the end of the Zoom meeting, when we may join in an informal chit-chat amongst ourselves.
TO JOIN THIS ZOOM MEETING:
Please request payment details BEFORE 10 pm **Thursday 7th April ~~~**
Zoom Meetings are free to fully Paid Up Members of the Newtown Astronomy Society to which zoom log-in details /or recordings (if available) will be automatically sent.
Guests (non-members) wishing to attend the presentation are asked to make a £3 per person contribution for the link details to help cover costs.
Please email our NAS Secretary at **secretary.newtownastrosoc@gmail.com** for information about payment by Bank Transfer or Cheque.
Thank you for taking the time to observe our article.
Clear & Dark Skies!
Les Fry
NAS Secretary

Via Bob Johnstone

Astronomy 101

Nova

In this series we are exploring the weird and wonderful world of astronomy jargon! You'll feel like a brand new person after today's topic: nova!

Ah, the nova. The most classic of the kind of cosmic explosion known as a "cataclysmic variable." In fact, it's so classic that the proper name for a nova is…"classical nova."

Before the twentieth century, every kind of explosion on the night sky was called a "nova." But once we figured out the various processes that were leading to stellar deaths, we came up with a better classification system. That's how we got supernovae, luminous red novae, and the classical novae.

The classical nova starts off as a binary star system. One star will be more massive than the other. Because that more massive star fuses hydrogen at a faster rate, it will go through its life cycle more quickly. Eventually it will die, leaving behind a core of oxygen and carbon called a white dwarf.

Then its less massive companion finally enters old age. Towards the end of that star's life, it will swell and become a red giant.

If the orbits of the red giant and the white dwarf get too close, with orbital periods going down to a few days, then things get interesting. The atmosphere of the red giant, which is made of mostly hydrogen, can start to spill over onto the white dwarf, pulled by the gravitational attraction of that leftover core.

That white dwarf is hot, usually having a temperature of a few hundred thousand Kelvin. As all that hydrogen spills onto its surface, the white dwarf heats it up. If conditions are just right, the hydrogen layer building up on the white dwarf can get *too* hot. This triggers a runaway fusion event which engulfs the entire surface of the white dwarf.

It's a giant nuclear bomb.

Novae like this happen about ten times per year, but they will only be visible to the naked eye every 12 to 18 months. Sometimes the process can happen again and again, as the red giant continues to spill its own atmosphere onto the white dwarf in a fatal cycle.

Open Clusters

In this series we are exploring the weird and wonderful world of astronomy jargon! You'll start drifting away from your friends after reading today's today: open clusters!

An open cluster is a group of stars that formed at roughly the same and are still hanging out together. These groups of stars form from the same giant molec

ular cloud (which is a kind of huge nebula). A typical giant molecular cloud will create a few hundred to a few thousand stars in a relatively short amount of time.

At first, the stars in an open cluster will stick together, because of their mutual gravitational attraction to each other. But over time the open cluster will lose members. Sometimes the cluster will wander too close to a large nebula or another cluster, and the gravity of that object will pull away some stars. Or just over time the stars in the cluster interact with each other, sending one or more stars flying away.

Typically, an open cluster will only survive as a distinct entity for a few hundred million years. That's far shorter than the lifetimes of the individual stars, which can last for billions of years.

Since you need active star formation to make open clusters, they are only found in spiral and irregular galaxies. Within the Milky Way, astronomers know of over 1,100 open star clusters, but they suspect many more exist.

Some open clusters, such as the famous Pleiades cluster that you can see with your naked eye, contain remnants of the nebula that formed the stars. However, over time the radiation pressure from the stars will blow the gas away.

Astronomers just love open clusters. They contain stars of all different sizes, but they'll be roughly the same age and have roughly the same composition. This allows astronomers to compare and contrast the evolution of stars without having to worry about those complicating factors.

Planetary Nebula

In this series we are exploring the weird and wonderful world of astronomy jargon! You'll be confused with an actual planet after today's topic: planetary nebula!

Confusingly, planetary nebulae have absolutely nothing to do with planets. The misnomer comes from the early days of modern astronomy, when telescopes were revealing a strange and wonderful universe. Those astronomers found objects that looked round and fuzzy, so were "nebulous" but also planet-like. By the time astronomers finally figured out what they were, the term had stuck.

Planetary nebulae are what happens at the very end of the life cycle of a Sun-like star. Through their lives stars fuse hydrogen into helium, and that fusion is what keeps them shining. But eventually they run out of usable hydrogen in their cores, and switch to fusing helium instead. When that runs out, they're left with a core of carbon and oxygen.

Sun-like stars don't have enough mass to generate the pressures needed to fuse carbon and oxygen, so that core just sits there.

While all of this is happening, the rest of the star goes through several stages of inflating, becoming what's known as a red giant, and shrinking. With every passing cycle it loses more and more of its atmosphere into its system. Eventually all that's left is the leftover core and a tenuous cloud of hydrogen, helium, and other elements.

When the core is first exposed it has a temperature of a few million Kelvin. The intense radiation pouring out of that core illuminates the gas cloud surrounding it, creating the planetary nebula. Once the core cools off, it can no longer power the show, and the nebula becomes invisible. That's why planetary nebulae have relatively short lifetimes, only a few tens of thousands of years each.

Even though they don't last long, planetary nebulae are common throughout the galaxy, because there are so many Sun-like stars. Indeed, one day our own Sun will create such a nebula.

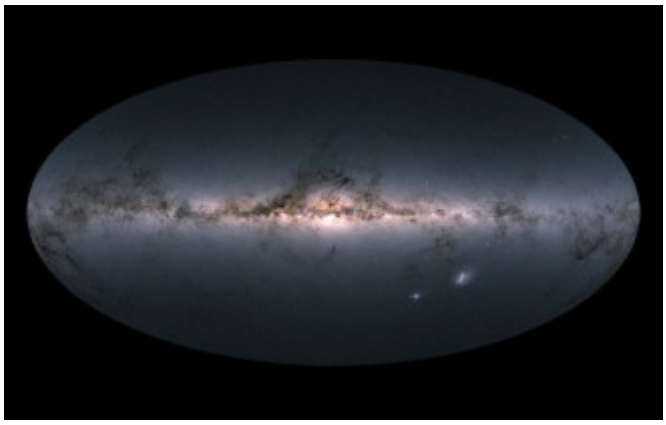
SPACE NEWS TO APRIL 22

The Milky Way has an Inner Ring,Just Outside the Core

In the past century, astronomers have learned a great deal about the cosmos and our place in it. From discovering that the Universe is in a constant state of expansion to the discovery of the Cosmic Microwave Background (CMB) and the Big Bang cosmological model, our perception of the cosmos has expanded immensely. And yet, many of the most profound astronomical discoveries still occur within our cosmic backyard – the Milky Way Galaxy.

Compared to other galaxies, which astronomers can resolve with relative ease, the structure and size of the Milky Way have been the subject of ongoing discovery. The most recent comes from the Max Planck Institute for Extraterrestrial Physics (MPE), where scientists have found a previously undiscovered inner ring of metal-rich stars just outside the Galactic Bar. The existence of this ring has revealed new insights into star formation in this region of the galaxy during its early history.

Determining the structure and size of the Milky Way galaxy has always been marred by the fact that we are situated within the Milky Way's galactic disk, close to one of its spiral arms. From this vantage point, stars are obscured by dense clouds of gas and dust, especially towards the center of the Milky Way. This has made it particularly difficult to determine the structure of the inner Milky Way.



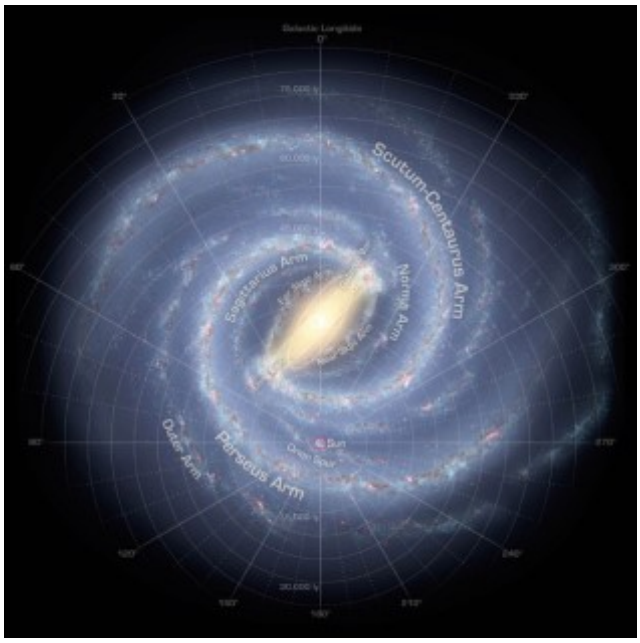
Using information from Gaia's second data release, a team of scientists has made refined estimates of the Milky Way's mass. Credit: ESA/Gaia/DPAC

One enduring mystery about our galaxy is whether or not it had any star-forming inner rings, which have been seen in other disk galaxies. Luckily, scientists at the MPE spent the past decade combining data from various observation campaigns – including the APOGEE survey and the *Gaia Observatory* – with advanced computer simulations. The result was a state-of-the-art model of the inner Milky Way that revealed a slow bar with a peanut-shaped bulge. This bulge is populated by stars that formed four to nine billion years ago, with a peak in age between six and eight billion years.

The APOGEE survey is a large-scale, stellar spectroscopic campaign conducted by the Sloan Digital Sky Survey (SDSS), located at the Apache Point Observatory in New Mexico. This survey was conducted at near-infrared wavelengths, which allows for observations that would not be possible in optical light. In particular, APOGEE's IR observations allow it to see through the dusty regions of the Milky Way, such as the disk and the bulge.

This allowed the MPE team to determine the element abundances, positions, line-of-sight velocities, and approximate ages of all the stars in the newly-observed bulge. Meanwhile, the data obtained by the ESA's *Gaia* mission provided accurate measurements of the positions and proper motions of these stars. The team then combined all of these observations with a model they created of the workings of the inner Milky Way. As Shola M. Wylie, a Ph.D. student at MPE and lead author of the study, explained:

"We integrated more than 30 000 stars from the APOGEE survey with additional data from Gaia in our Milky Way bar-bulge potential to obtain the full orbits of these stars. And with these orbits, we can effectively see behind the galactic bulge as well as other spatial regions not covered by the surveys. Around the central bar, we found an inner ring structure that is more metal-rich than the bar and where the stars have younger ages, around 7 billion years."



Annotated diagram of the Milky Way. The sun is indicated near the bottom in the Orion Spur. Credit: NASA

To separate the stars in the ring and the bar structures, the team observed how much their orbits deviated from a circle (i.e., their eccentricity). From this, they found that the stars in the ring are younger and more metal-rich than the stars in the bar and are more concentrated towards the Galactic plane. This suggests that stars in the stellar ring must have continued to form from inflowing gas after the bar was in place.

Therefore, astronomers can use the age of the inner ring stars to look back at the formation history of the Milky Way. Based on the average age of the stars, the MPE team estimates that the Galatic bar formed at least 7 billion years ago. At present, it's not clear if there is a connection between the newly discovered inner ring and the galaxy's spiral arms and whether gas is currently funneled inwards to a star-forming thin inner ring, as is seen with other spiral galaxies.

With next-generation telescopes becoming operational, more detailed galactic surveys will be possible. When combined with augmented models (which will be possible using more sophisticated software), this data will allow astronomers to learn more about how the ring structure transitions to the surrounding disk in the Milky Way. The study that describes their findings, titled "The Milky Way's middle-aged inner ring," recently appeared in the journal *Astronomy & Astrophysics*.

Further Reading: Max Planck Institute for Extraterrestrial Physics

The ExoMars Rover is Ready, now it Just Needs a new Ride to Mars

When it arrives on Mars, the ESA's *Rosalind Franklin* rover will join a growing fleet of robotic rovers, landers, and orbiters dedicated to searching for life on Mars. As part of the Exomars program, this mission was a collaborative effort between the ESA and the Russian State Space Corporation (Roscosmos). Whereas the ESA would provide the rover, Roscosmos was to provide the launch services and the *Kazachok* lander that would deliver *Rosalind Franklin* to the surface.

After many years of development, testing, and some delays, the *Rosalind Franklin* rover passed its System Qualification and Flight Acceptance Review in March. The Review Board confirmed that the rover was ready to be shipped to the launch site at Baikonur Cosmodrome and would make the launch window opening on September 20th, 2022. Unfortunately, due to the suspension of cooperation with Roscosmos, the ESA's rover finds itself stranded on Earth for the time being.
The decision to suspend cooperation was reached by the ESA's ruling Council, which met in Paris from March 16th to 17th to assess the Russian invasion of Ukraine and the effect this would have on inter-agency cooperation. The Council ruled unanimously, declaring that:

- *it was impossible, at present, to carry out the ongoing cooperation with Roscosmos on the ExoMars rover mission with a launch in 2022, and mandated that the ESA Director General take appropriate steps to suspend the cooperation activities accordingly;*
the ESA Director General was authorized to fast-track an industrial study to better define the available options for a way forward to implement the ExoMars rover mission.

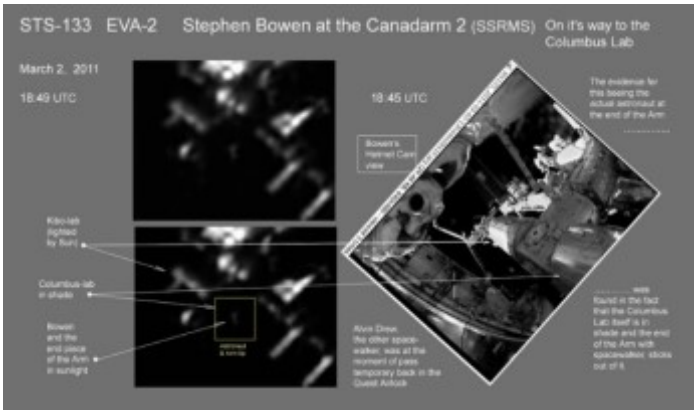
The ExoMars 2016 mission will pave the way for a rover mission to the Red Planet in 2020. Credit: ESA
With the 2022 launch suspended, the Exomars elements – the *Rosalind Franklin* rover, the spacecraft that will transport it to Mars, and the Carrier and Decent modules (CM/DM) – are being sent to a Thales Alenia Space storage site in Italy, where they will await further instruction. Based on the decision by the ESA Member States at the Council meeting, a fast-track industrial study will commence assessing all available options to make the Exomars 2022 mission happen in the near future.
In particular, the teams will be looking for the earliest possible launch opportunity depending on one of two scenarios. For the first, the ESA will attempt to develop all necessary technologies to support a Europea-led mission – i.e., launching from a member state using an ESA launch vehicle provider (such as Arianespace). In the second, the team will assess the possibility of launching with international partners and the availability of compatible launchers and a launch site.
David Parker, Director of Human and Robotic Exploration at ESA, conveyed an optimistic attitude about the future of the ExoMars program. Considering the time and effort the ESA had devoted to this mission, plus the valued contributions it will make to the ongoing exploration of Mars, the ESA is not about to abandon it. As he said in a recent ESA press release:
"I hope that our Member States will decide that this is not the end of ExoMars, but rather a rebirth of the mission, perhaps serving as a trigger to develop more European autonomy. We count on brilliant teams and expertise across Europe and with international partners to reshape and rebuild the mission. The team is dedicated and focused on setting out the next steps to ensure we bring this incredible rover to Mars to complete the job it was designed for."

ExoMars Trace Gas Orbiter analyses the martian atmosphere. Credit: ESA/ATG medialab
Among the cutting-edge instruments that the Rosland Franking rover will bring to the field are its advanced drill and internal laboratory. Whereas other rovers, like *Opportunity*, *Curiosity*, and *Perseverance*, have all drilled into the surface to obtain core samples, the *Rosalind Franklin* will be the first to drill 2 meters (6.56 feet) below the surface. It will also be the first to use novel driving techniques, including wheel-walking, to overcome obstacles.
In the meantime, the ESA still maintains a presence around Mars with the ExoMars Trace Gas Orbiter (TGO), the orbital elements of the ExoMars 2016 mission. The TGO continues to relay most data from surface missions, such as NASA's *Curiosity* and *Perseverance* rovers and the *InSight* lander. The TGO is also expected to play a vital role in the upcoming Mars Sample Return campaign – a joint NASA-ESA mission to return samples obtained by the *Perseverance* rover to Earth.
This disruption is one of many caused by the Russian invasion of Ukraine, which has resulted in widespread condemnation and sanctions by the international community. In response, Russia has terminated its cooperation with other space agencies and recently announced it was withdrawing from the International Space Station (ISS).
However, the ESA and other space agencies continue to cooperate to fulfill their shared vision of space exploration. Considering how beneficial the *Rosalind Franklin* rover will be to the ongoing search for life on Mars, it seems like a safe bet that the ESA (on its own or with the help of international partners) will ensure that it gets to Mars. After all, politics are so trivial compared to answering the fundamental questions about life in our Universe!

Stunning Image of ISS Taken From the Ground Shows two Spacewalking Astronauts

In our age, we've grown accustomed to pictures of astronauts inside the International Space Station, as they float in zero-G and tend their science experiments. We're even getting used to images of spacewalking astronauts. But this is something new.
An image of two astronauts on a spacewalk, taken from the ground.
The photographer is Sebastian Voltmer, an award-winning German photographer published in "Sky and Telescope" and numerous other publications. His astrophotography has been featured in exhibitions at the Smithsonian in Washington, DC, the Carl Zeiss Planetarium in Stuttgart, and numerous other places.
Voltmer took the image on March 23rd. It shows American astronaut Raja Chari and German astronaut Matthias Maurer during a six-hour spacewalk to install a camera and conduct maintenance and upgrades.
"It's probably the first ground-based picture showing two spacewalkers on the ISS at the same time."
Sebastian Voltmer, Astrophotographer Extraordinaire.
"This image of the ISS pass was taken on March 23, 2022,

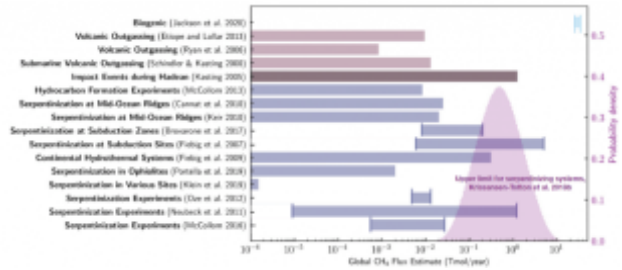
under good seeing conditions through my C11 EdgeHD telescope from the hometown of ESA astronaut Dr. Matthias Maurer," Voltmer said at Spaceweather.com. "I feel like I just made a once in a lifetime image ☺ It's probably the first ground-based picture showing two spacewalkers on the ISS at the same time."
Voltmer explained that when he took the image, he quickly presented it to German media showing Matthias Maurer, and it went viral. Voltmer continued to work on the image to highlight both astronauts. Philip Smith, another well-known photographer, contacted Voltmer to tell him that he had created an image that also highlights Raja Chari, perched on the Canadarm 2 robotic arm. (Full disclosure: I'm Canadian. Yay, Canada!)
Voltmer's image is the first ground-based image of two ISS astronauts spacewalking. But back in 2011, amateur photographer Ralph Vandebergh captured images of American astronaut Steve Bowen during a spacewalk. Vandebergh was also on the Canadarm 2 in that image. (Double-Yay, Canada!)



Astronaut Stephen Bowen (inside the yellow box) was captured in this image during the March 2, 2011, spacewalk for STS-133. Credit: Ralf Vandebergh
Voltmer is a gifted and dedicated astrophotographer whose work is widely published. Check out his Instagram to see some of his gorgeous work, and follow him on Twitter.

It's Not Conclusive, But Methane is Probably the Best Sign of Life on Exoplanets

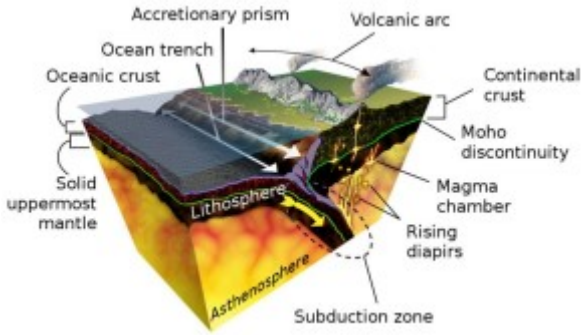
When the James Webb Space Telescope aims at exoplanet atmospheres, it'll use spectroscopy to identify chemical elements. One of the things it's looking for is methane, a chemical compound that can indicate the presence of life.
Methane is a compelling biosignature. Finding a large amount of methane in an exoplanet's atmosphere might be our most reliable indication that life's at work there. There are abiotic sources of methane, but for the most part, methane comes from life.
But to understand methane as a potential biosignature, we need to understand it in a planetary context. A new research letter aims to do that.
Methane is interesting because it doesn't last long in an atmosphere. Photochemical reactions destroy it, so detecting a lot of it means something is constantly replenishing it. There has to be a large and prominent source. "Terrestrial planets, which are the focus of this study, require significant methane surface fluxes to sustain high atmospheric abundances," the study says. "On Earth, life sustains large methane surface fluxes, and so methane has long been regarded as a potential biosignature gas for terrestrial exoplanets."
But not all methane detections will mean life. Scientists need a way to work through any future methane detections in exoplanet atmospheres. The researchers wanted to create a "…dedicated assessment of the planetary conditions needed for methane to be a good biosignature."
"We wanted to provide a framework for interpreting observations, so if we see a rocky planet with methane, we know what other observations are needed for it to be a persuasive biosignature."
Maggie Thompson, lead author, UC Santa Cruz.
The new research letter is titled "The case and context for atmospheric methane as an exoplanet biosignature." It's available online at the Proceedings of the National Academy of Sciences (PNAS.) The lead author is Maggie Thompson, a graduate student in astronomy and astrophysics at UC Santa Cruz.
Part of methane's status as a reliable biosignature is its detectability. Oxygen is a good biosignature, and for some of the same reasons methane is. Like methane, it's also unstable in an atmosphere, so finding a large quantity of it means a significant source is replenishing it.
The James Webb Space Telescope will be operating soon, and one of its jobs is to examine exoplanet atmospheres spectroscopically. It'll be characterizing exoplanet atmospheres, and detecting biosignatures is part of that work. But while Webb will detect methane relatively easily in a terrestrial atmosphere, oxygen is more difficult to detect. "Given the imminent feasibility of observing methane with JWST, it is imperative to determine the planetary conditions where methane is a compelling biosignature," the authors write.
This research letter wants to put scientists in a stronger position to interpret methane's presence in an exoplanet atmosphere. The idea is to identify what other questions researchers need to ask when they detect methane. What other indications will support the conclusion that methane is a biosignature? What will contradict that?
"We wanted to provide a framework for interpreting observations, so if we see a rocky planet with methane, we know what other observations are needed for it to be a persuasive biosignature," lead author Thompson said in a press release.
The team examined abiotic methane sources to understand how they might account for methane in an exoplanet atmosphere. Volcanoes are one abiotic source of methane. Methane also comes from reactions in places like mid-ocean ridges, hydrothermal vents, and tectonic subduction zones. Comet and asteroid impacts can also produce methane. Researchers can look for evidence of these sources on an exoplanet where they detect methane.



This figure from the study compares methane sources on Earth. The top row shows biogenic methane flux; all other rows show abiogenic methane flux from other sources. No abiotic source can produce the same methane flux as life can. Image Credit: Thompson et al. 2022.
In planetary atmospheres, methane exists in relation to other gases. So identifying abiotic methane sources is only part of the picture. How do other gases like carbon monoxide and carbon dioxide fit into a methane-rich atmosphere? How do they affect one another?
"Methane is one piece of the puzzle, but to determine if there is life on a planet you have to consider its geochemistry, how it's interacting with its star and the many processes that can affect a planet's atmosphere on geologic timescales."
Maggie Thompson, lead author, UC Santa Cruz.
From the research letter:
"While methane can be produced by a variety of abiotic mechanisms such as outgassing, serpentinizing reactions, and impacts, we argue that—in contrast to an Earth-like biosphere—known abiotic processes cannot easily generate atmospheres rich in CH4 and CO2 with limited CO…" the authors explain in their paper.
Earth's history provides some clues to methane in exoplanet atmospheres. We know that in the past, Earth had an even more methane-rich atmosphere than it does now. And we know what the source was: life.
"If you detect a lot of methane on a rocky planet, you typically need a massive source to explain that," said co-author Joshua Krissansen-Totton, a Sagan Fellow at UCSC. "We know biological activity creates large amounts of methane on Earth, and probably did on the early Earth as well because making methane is a fairly easy thing to do metabolically."

Methane-producing microorganisms called methanogens were one of Earth's earliest lifeforms, originating between 4.11 and 3.78 billion years ago. They were so effective at producing methane that at several times early Earth likely had a hazy, methane-filled atmosphere similar to Saturn's moon Titan. Maybe we'll find an exoplanet with a methane-rich atmosphere similar to early Earth's one day. If that happens, we'll likely detect it from a great distance, making it challenging to determine if the source is biotic.

But detecting abiotic sources of methane is potentially much more straightforward. Volcanoes, for example, provide other clues that methane is from a non-living source. Volcanoes not only inject methane into the atmosphere but also carbon monoxide. On the other hand, biological activity is likely to consume carbon monoxide. The researchers found that non-biological processes cannot readily produce habitable planet atmospheres rich in methane and carbon dioxide and with little to no carbon monoxide.



This diagram shows the geological process of subduction, where a heavier tectonic plate sinks under a lighter one. Alteration of ultramafic rocks in subduction zones plays a major role in methane production via abiotic processes on Earth and beyond. Image Credit: By KDS4444 – Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=49035989.

"One molecule is not going to give you the answer—you have to take into account the planet's full context," Thompson said. "Methane is one piece of the puzzle, but to determine if there is life on a planet, you have to consider its geochemistry, how it's interacting with its star and the many processes that can affect a planet's atmosphere on geologic timescales."

The authors point out that the detection of methane in an exoplanet's atmosphere is just the beginning. They found that detecting methane is a strong indicator of life for a rocky planet orbiting a Sun-like star if the atmosphere also contains carbon dioxide. If methane is more abundant than carbon dioxide, that's also a more robust indicator of life, as long as the planet isn't too water-rich.

This image is a summary of known abiotic sources of methane on Earth. (©2022 Elena Hartley)

The James Webb Space Telescope is extraordinarily powerful. But no observing tool or method is error-free, even the long-awaited Webb. False positives are an issue in scientific endeavours like the search for biosignatures. The researchers looked at the role false positives play in biosignatures and gave some guidelines for handling methane detections.

"The atmospheres of rocky exoplanets are probably going to surprise us, and we will need to be cautious in our interpretations."

Joshua Krissansen-Totton, co-author, UCSC.

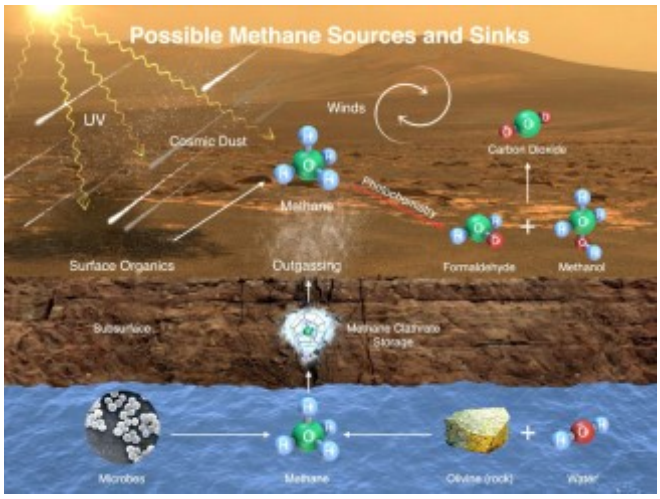
"There are two things that could go wrong—you could misinterpret something as a biosignature and get a false positive, or you could overlook something that's a real biosignature," Krissansen-Totton said. "With this paper, we wanted to develop a framework to help avoid both of those potential errors with methane."

"With the upcoming technological advancements in exoplanet observations enabling the characterization of potentially habitable exoplanets, it is important to consider possible biosignature gases and the sources of false-positive detections," the research letter says. "This is particularly urgent for methane since biogenic methane is likely detectable for some terrestrial exoplanets with JWST."

The researchers acknowledge that various abiotic sources could replenish atmospheric methane in diverse planetary environments. But for a planet to produce a methane flux comparable to Earth's, the same abiotic sources would also generate "observable contextual clues" that would indicate a false positive. "In every case, abiotic processes cannot easily produce atmospheres rich in CH4 and CO2 with negligible CO…" Life would readily consume the CO.

"Clearly, the mere detection of methane in an exoplanet's atmosphere is not sufficient evidence to indicate the presence of life given the variety of abiotic methane-production mechanisms. Instead, the entire planetary and astrophysical context must be taken into account to interpret atmospheric methane."

The hunt for biosignatures in exoplanet atmospheres is a relatively new scientific undertaking. Researchers need to do a lot of groundwork before they can have confidence in detecting things like methane. The recent detection, or non-detection, of methane on Mars, shows how incomplete our understanding of other planets is and how the detection of methane may only be a starting point in painting a complete picture of a planet.



This image illustrates possible ways methane might get into Mars' atmosphere and be removed from it: microbes (left) under the surface that release the gas into the atmosphere, weathering of rock (right), and stored methane ice called a clathrate. Ultraviolet light can work on surface materials to produce methane and break it apart into other molecules (formaldehyde and methanol) to produce carbon dioxide. Credit: NASA/JPL-Caltech/SAM-GSFC/Univ. of Michigan

"This study is focused on the most obvious false positives for methane as a biosignature," Krissansen-Totton said. "The atmospheres of rocky exoplanets are probably going to surprise us, and we will need to be cautious in our interpretations. Future work should try to anticipate and quantify more unusual mechanisms for nonbiological methane production."

"With these results, we provide a tentative framework for assessing methane biosignatures," the authors write. "If life is abundant in the Universe, then with the correct planetary context, atmospheric methane may be the first detectable indication of life beyond Earth."

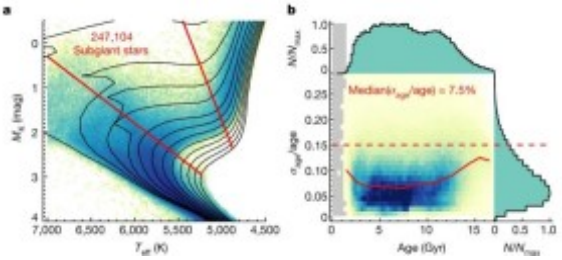
A New Record! Hubble Detects an Individual Star From a Time When the Universe Was Less Than a Billion Years Old

A star that sounds as if it came from "The Lord of the Rings" now marks one of the Hubble Space Telescope's farthest frontiers: The fuzzy point of light, known as Earendel, has been dated to a mere 900 million years after the Big Bang and

appears to represent the farthest-out individual star seen to date.
Based on its redshift value of 6.2, Earendel's light has taken 12.9 billion years to reach Earth, astronomers report in this week's issue of the journal Nature. That distance mark outshines Hubble's previous record-holder for a single star, which registered a redshift of 1.5 and is thought to have existed when the universe was 4 billion years old.
The newly reported record comes with caveats. First of all, we're talking here about a single star rather than star clusters or galaxies. Hubble has seen agglomerations of stars that go back farther in time.
"Normally at these distances, entire galaxies look like small smudges, with the light from millions of stars blending together," lead author Brian Welch, an astronomer at Johns Hopkins University, said today in a news release. "The galaxy hosting this star has been magnified and distorted by gravitational lensing into a long crescent that we named the Sunrise Arc."
A close look at the arc turned up several bright spots, but the characteristics of the light coming from Earendel pointed to a high redshift, which translates into extreme distance. The higher the redshift, the faster the source of the light is receding from us in an ever-more-quickly expanding universe.
The observations were made as part of a Hubble program known as the Reionization Lensing Cluster Survey, or RELICS, led by study co-author Dan Coe at the Space Telescope Science Institute.
RELICS' astronomers made use of gravitational lensing, a weird phenomenon in which a massive object such as a galaxy cluster bends and focuses the light coming from even more distant objects. The lensing effect results in magnified, arc-like images of far-flung stars, clusters and galaxies.
In the case of the Sunrise Arc, the lensing object is WHL 0137-08, a galaxy cluster that's roughly 6 million light-years away in the constellation Cetus.
One fuzzy spot in the Sunrise Arc stuck out. The nickname that Welch and his colleagues gave to that spot, Earendel, comes from the Old English word for "morning star." (It also evokes the name of Eärendil, who was a fictional half-elven mariner mentioned in J.R.R. Tolkien's "Lord of the Rings" and "The Silmarillion.")
Astronomers determined that Earendel was most likely an individual star system rather than, say, a star cluster. "We almost didn't believe it at first, it was so much farther than the previous most-distant, highest-redshift star," Welch said.
The research team estimates that Earendel is at least 50 times the mass of our sun and puts out millions of times more light. But plenty of mysteries remain to be resolved. For example, is it truly a single star, or is it actually a multiple-star system? And does it contain the same stuff that closer-in stars are made of?
If Earendel contains only the primordial elements of hydrogen and helium, it just might be the first known example of the first generation of stars born after the Big Bang.
Solving such mysteries is beyond the capabilities of the 32-year-old Hubble Space Telescope, but the recently launched James Webb Space Telescope could crack the case.
"With Webb, we expect to confirm Earendel is indeed a star, as well as measure its brightness and temperature," Coe said. "We also expect to find the Sunrise Arc galaxy is lacking in heavy elements that form in subsequent generations of stars. This would suggest Earendel is a rare, massive metal-poor star."
The research team has already booked time on the new space telescope, which is expected to begin science observations within the next couple of months.
What they find could take some of the shine off Earendel's fame.
"We may see stars even farther than Earendel, which would be incredibly exciting," Welch said. "We'll go as far back as we can. I would love to see Webb break Earendel's distance record."
Welch and Coe are among 29 authors of the paper published by Nature, "A Highly Magnified Star at Redshift 6.2."
Lead image: The star nicknamed Earendel, indicated by the white arrow, is positioned along a ripple in spacetime that gives the image extreme magnification.
Source: Hubblesite.org. Credit: NASA / ESA / Brian Welch (JHU) / Dan Coe (STScI) / Alyssa Pagan (STScI).
POSTED ON MARCH 29, 2022 BY EVAN GOUGH

Part of the Milky Way Is Much Older Than Previously Believed

The Milky Way is older than astronomers thought, or part of it is. A newly-published study shows that part of the disk is two billion years older than we thought. The region, called the thick disk, started forming only 0.8 billion years after the Big Bang.
A pair of astronomers pieced together the Milky Way's history in more detail than ever. Their results are based on detailed data from the ESA's Gaia mission and China's Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST). The key to this discovery lies in subgiant stars.
The paper is "A time-resolved picture of our Milky Way's early formation history," and it's online in the journal Nature. The authors are Maosheng Xiang and Hans-Walter Rix, both from the Max-Planck Institute for Astronomy (MPIA.)
"Our results provide exquisite details about that part of the Milky Way, such as its birthday, its star-formation rate and metal enrichment history. Putting together these discoveries using Gaia data is revolutionizing our picture of when and how our galaxy was formed."
Maosheng Xiang, study co-author, MPIA.
One of the most difficult things to determine about a star is its age. A star's composition, or metallicity, is key to finding its age. The more accurately astronomers can measure metallicity, the more accurately they can determine its age. The early Universe contained hydrogen and helium almost exclusively. Elements heavier than hydrogen and helium are produced in stars and spread out into the Universe when those stars die and explode. Astronomers call every element heavier than the two primordial elements "metals."
Stars with lower metallicity are older because they formed when mostly just hydrogen and helium were available. So when astronomers identify a population of stars mainly containing hydrogen and helium, they know those stars are older. When they find a population of stars with higher proportions of metals, they know those stars must be younger.
Precision age measurements are the holy grail in some aspects of astronomy, which is true in this case. Xiang and Rix used more than just metallicity to determine stellar ages. They focused on a specific type of star: subgiants. The subgiant phase in a star's life is relatively brief, so astronomers can determine a star's age most accurately when it's a subgiant. Subgiants are transitioning to red giants and no longer produce energy in their cores. Instead, fusion has moved into a shell around the core.



This figure from the study shows some of the detail for the 247,000 subgiant stars in the sample. (a) shows the subgiant selection by magnitude and temperature. (b) shows the distri-

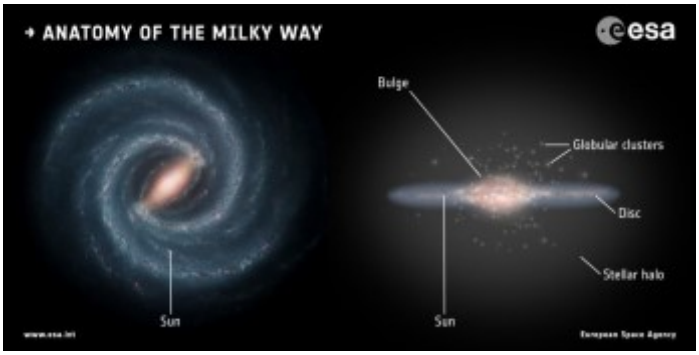
bution in the relative age precision as a function of age. Image Credit: Xhiang and Rix 2022.

In this study, the pair of scientists used LAMOST data to determine the metallicity of about 250,000 stars in different parts of the Milky Way. They also used Gaia data which gives the precise position and brightness data for about 1.5 billion stars.

The ESA's Gaia mission is responsible for increased accuracy in this study and many others. Before Gaia, astronomers routinely worked with stellar age uncertainties between 20% to 40%. That meant that ages could be off by one billion years, which is a lot. But Gaia has changed all this. The current data release from the mission is Gaia EDR 3 or Early Data Release 3, and it's a vast improvement. EDR3 gives precise 3D positions of over 330,000 stars. It also gives high-precision measurements of the stars' motions through space.

The researchers used all this data from Gaia and LAMOST and compared it to known models of stellar parameters to determine the subgiants' ages with greater accuracy. "With Gaia's brightness data, we are able to determine the age of a subgiant star to a few percent," said Maosheng. The subgiants are spread throughout the different parts of the Milky Way, allowing the researchers to piece together the ages of the other components and build a timeline of the Milky Way's history.

The study shows two distinct phases in our galaxy's history. The first phase started 0.8 billion years ago when the thick disk began forming stars. The galactic halo's inner regions started to develop too. Two billion years after that, a merger propelled the star formation in the thick disk to completion. A dwarf galaxy named Gaia-Sausage-Enceladus merged with the Milky Way.



An artist's impression of our Milky Way galaxy, a roughly 13 billion-year-old barred spiral galaxy that is home to a few hundred billion stars. On the right, an edge-on view reveals the flattened shape of the disc. Observations point to a substructure: a thin disc some 700 light-years high embedded in a thick disc, about 3000 light-years high, populated with older stars. The new study shows that the thick disc started forming stars only 0.8 billion years after the Big Bang, about two billion years sooner than thought. Image Credit: NASA/JPL-Caltech; right: ESA; layout: ESA/ATG medialab

The Gaia-Sausage-Enceladus (GSE) dwarf galaxy isn't shaped like a sausage. It gets its name from plotting its stars on a velocity chart, where their orbits are highly-elongated. When GSE merged with the Milky Way, it helped create the thick disk, and the gas that came with it fuelled the star formation in that part of the galaxy. The merger also filled the Milky Way's halo with stars. Astronomers think the globular cluster NGC 2808 might be the Gaia Sausage's remnant core. NGC 2808 is one of the most massive globular clusters in the Milky Way.

The star formation triggered in the thick disk by the GSE lasted for about 4 billion years. About 6 billion years after the Big Bang, the gas was all used up. During that period, the thick disk's metallicity increased by more than a factor of ten.

The study also found a very tight correlation between the metallicity and the ages of the stars in the entire disk. That means that the gas that came with the GSE must have been turbulent, causing it to mix more thoroughly in the disk.

Astronomers only recently discovered the GSE merger in 2018. Discoveries like it have shaped our understanding of the Milky Way's history, and the galaxy's developmental timeline is becoming clearer. This new study is giving us a more detailed account.

The NGC 2808 star cluster might be the remnant of the Gaia-Sausage-Enceladus galaxy that merged with the Milky Way billions of years ago. Credit: NASA, ESA, A. Sarajedini (University of Florida) and G. Piotto (University of Padova)

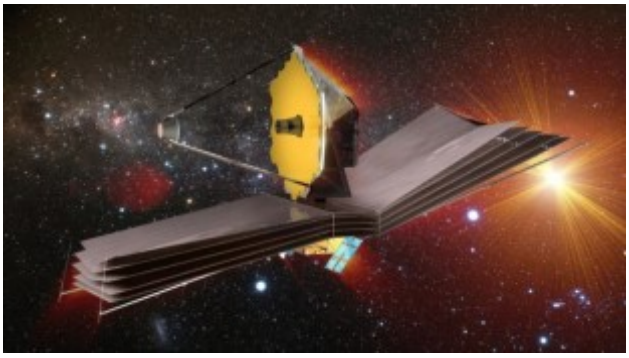
"Since the discovery of the ancient merger with Gaia-Sausage-Enceladus, in 2018, astronomers have suspected that the Milky Way was already there before the halo formed, but we didn't have a clear picture of what that Milky Way looked like. Our results provide exquisite details about that part of the Milky Way, such as its birthday, star-formation rate and metal enrichment history. Putting together these discoveries using Gaia data is revolutionizing our picture of when and how our galaxy was formed," says Maosheng.

In recent years astronomers have discovered more detail about the Milky Way. But it's challenging to map its structure because we're in the middle of it. The ESA's Gaia mission is our best catalogue yet of the stars in the Milky Way. And each data release gets better and better.

"With each new analysis and data release, Gaia allows us to piece together the history of our galaxy in even more unprecedented detail. With the release of Gaia DR3 in June, astronomers will be able to enrich the story with even more details," says Timo Prusti, Gaia Project Scientist for ESA.

The Gaia mission is essential, but observations of other galaxies like the Milky Way also give astronomers insights into the Milky Way's structure and history. But observing galaxies only two billion years after the Big Bang is difficult. That requires powerful infrared telescopes. Fortunately, one long-awaited infrared space telescope is about to begin observations soon.

The James Webb Space Telescope (JWST) has the power to look back in time to the Universe's early years. It'll be able to see the Universe's earliest Milky Way-like galaxies. Astronomers want to know more about the GSE merger and how it led to star formation and shaped our galaxy's thick disk only two billion years after the Big Bang. JWST observations of ancient, high-redshift galaxies similar to the Milky Way could help answer some questions and fill in a more detailed galactic history.



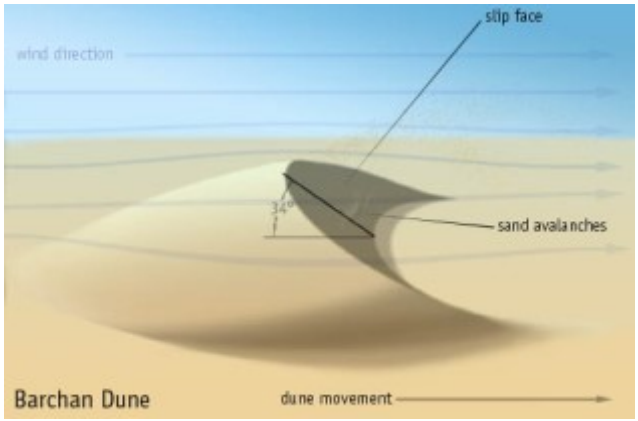
The James Webb Space Telescope was built to answer some of our biggest questions about the early Universe, including how the first galaxies formed. That question directly relates to how the Milky Way began and grew. Image Credit:

ESA
And in June, the ESA will release Gaia's full third data release, called DR3. The DR3 catalogue will contain ages, metallicity, and spectra for over 7 million stars. DR3 and the JWST will be a potent combination.
What will all of that data tell us?
As the Universe evolves, galaxies must either eat or be eaten. Gravity draws galaxies together, but the Universe is also expanding thanks to dark energy, and the dark energy pushes galaxies apart. So galaxies tend to clump together into groups. The Milky Way is part of the Local Group.
The groups stay internally coherent because of the galaxies' combined gravity, but the groups drift away from one another due to expansion. Eventually, the largest galaxies in a group consume the smaller ones. The Milky Way has consumed the GSE and globular clusters. And it's consuming the Large Magellanic Cloud, which is consuming its even smaller neighbour, the Small Magellanic Cloud. Eventually, the Milky Way will consume both, and then in about 4.5 billion years, it'll merge with the even larger Andromeda Galaxy, another member of the Local Group.
It's an odd situation because the Milky Way's future might be easier to discern than its past. That's the conundrum of an expanding Universe: the evidence we seek keeps receding from us, lost to time and distance. But the JWST and the Gaia DR3 have the potential to turn the tables on the expanding Universe. Together they can shed more light on the Milky Way's history and on the details of galaxy mergers in general. Hopefully, we'll end up with a much more thorough historical timeline.

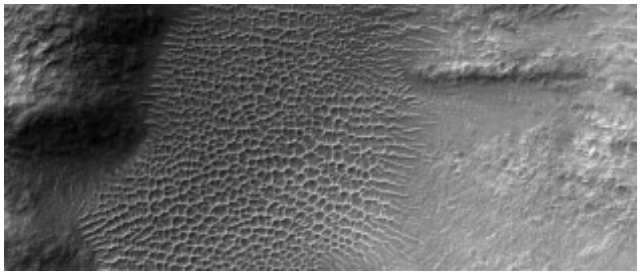
POSTED BY EVAN GOUGH

These are Star Dunes on Mars, Formed When the Wind Comes From Many Different Directions

Missions to Mars are expensive, even orbiters. They're there to do science, not take pretty pictures. But sometimes Mars' beauty is captured inadvertently, usually with some science mixed in.
That's the case with this picture of star dunes captured by the HiRISE camera on NASA's Mars Reconnaissance Orbiter.
In most regions on Mars, winds blow in a prevailing direction. It's the same here on Earth. So most dunes appear as waves, oriented perpendicularly to the wind direction. One common type of dune is Barchan dunes and they have two "horns" that face downwind.



Barchan Dunes are formed in prevailing winds. Image Credit: unknown. CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=571880
But star dunes are different. They form in winds that shift direction. They're comparatively rare—on Earth, only about 8.5% of dunes are star dunes.
NASA's Mars Reconnaissance Orbiter (MRO) has an almost-famous instrument called HiRISE – High-Resolution Imaging Science Experiment. Universe Today is full of HiRISE images. HiRISE wasn't looking for star dunes when it captured this image in 2010. It was examining a crater in Mars' Tyrrhena Terra region, looking at the geologic aspects of possible clays detected with the
MRO's CRISM instrument.
The happy accident shows how much geologic diversity Mars has on display.



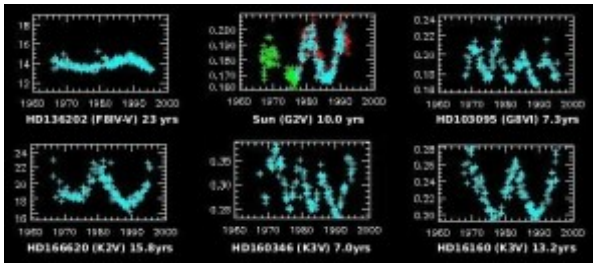
Mars's geologic diversity is stunning. The HiRISE camera does a great job of capturing that diversity, like in this image of star dunes in a crater in the Tyrrhena Terra. Image Credit: NASA/JPL/ UArizona
Star dunes are more common on Mars than they are on Earth because of all the impact craters. The wind swirls around crater rims and comes from many directions before it reaches the sand inside the dune. All that activity shapes the sand into a beautiful pattern.

The Victoria Crater might be Mars' most famous crater, thanks to this gorgeous image. It shows how star dunes tend to form in craters because of the shifting winds. Image Credit: NASA/HiRISE/UofA
The image of star dunes in the crater in the Tyrrhena Terra is just a small part of the entire HiRISE image. You can see the whole image here. Check it out.

The Sun Didn't Have any Sunspots for 70 Years, now we Might Know why

Sunspots are one of the ways we can measure the activity level of the Sun. Generally, the more sunspots we observe, the more active the Sun is. We've been tracking sunspots since the early 1600s, and we've long known that solar activity has an 11-year cycle of high and low activity. It's an incredibly regular cycle. But from 1645 to 1715 that cycle was broken. During this time the Sun entered an extremely quiet period that has come to be known as the Maunder Minimum. In the deepest period of the minimum, only 50 sunspots were observed, when typically there would be tens of thousands. We've never observed such a long period of quiet since, and we have no idea why it occurred.
The problem with trying to understand solar cycles is that you have a sample size of 1. You can track sunspots all you want, but all that tells you is how one particular star behaves. You can never be sure if the Sun's behavior is typical for a

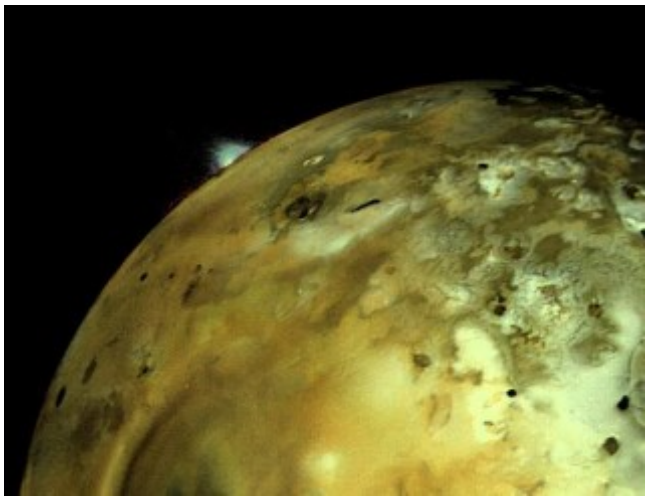
star or unusual. The only way to find out is to look at the cycles of other stars.
Ideally, astronomers would love to count the sunspots, or starspots, of other stars over time, but this isn't easily done. We can't observe the surface details of Sun-like stars, and starspots are typically small compared to the size of a star, so they barely decrease the brightness of a star over time. Random fluctuations in solar brightness easily overwhelm any change in brightness due to starspots. But there is a way to measure stellar activity indirectly.
We know that sunspots correlate to the magnetic activity of the Sun. The more magnetically active the Sun is, the more sunspots we typically see. It turns out that this magnetic activity can be measured using spectral lines. In the ultraviolet range, there are two particular lines known as H and K that are affected by magnetic activity. So if you measure the H-K lines of a star over time, you can measure the rise and fall of a star's activity. It just so happens that Mount Wilson Observatory started measuring the H-K lines of about 400 stars in 1966, and measured them for three decades.



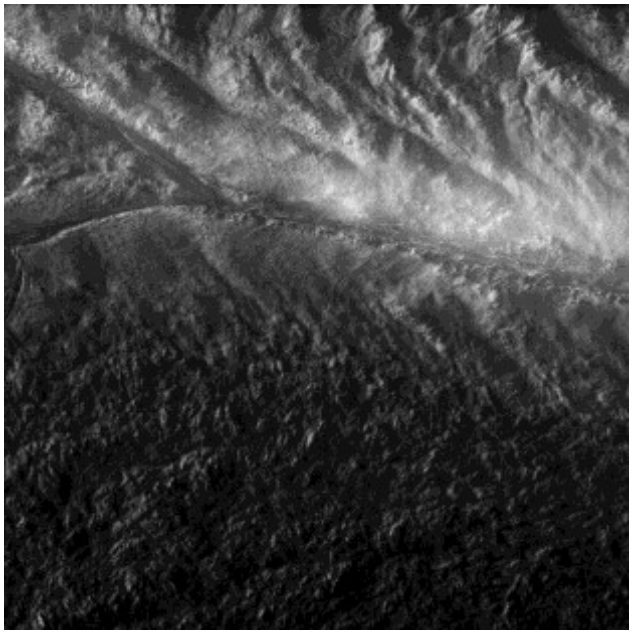
The cycles of several stars. Credit: Mount Wilson Observatory
In a recent study, a team of astronomers combined the Mount Wilson observations with more recent data from observatories such as Keck to measure the activity cycle of 59 stars across 50 to 60 years. They were able to confirm the cycles of 29 of them, by observing at least two full cycles. No small feat given that some of the stars have 20-year cycles. They also found that some stars have no cycles at all. But one star was particularly interesting.
Known as HD 166620, the star typically has a 17-year activity cycle. But since 2003 it's been quiet. This is the first example of another star experiencing a long-term quiet period similar to the Maunder Minimum. HD 166620 is about 80% of the Sun's mass, and about 6 billion years old. A bit smaller and older, close enough in size and age that the dynamics of the two stars should be similar.
It isn't clear why HD 166620 has entered a quiet period, but further observations will be able to measure its magnetic activity in greater detail. In time we may also observe the star as it leaves its quiet period and returns to a 17-year cycle. It could provide the data we need to understand why the Sun was once quiet for decades.
Reference: Baum, Anna C., et al. "Five Decades of Chromospheric Activity in 59 Sun-like Stars and New Maunder Minimum Candidate HD 166620." *The Astronomical Journal* 163.4 (2022): 183.

We Now Understand Why Enceladus has 'Tiger Stripe' Cracks at its Southern Pole

One of the biggest surprises of the 13-year Cassini mission came in Enceladus, a tiny moon with active geysers at its south pole. At only about 504 kilometers (313 miles) in diameter, the bright and ice-covered Enceladus should be too small and too far from the Sun to be active. Instead, this little moon is one of the most geologically dynamic objects in the Solar System.
A new study has modeled how this activity could be taking place, and what mechanism might power the geysers spewing from 'tiger stripe' fissures. While previous studies have indicated some type of unknown internal heat source on Enceladus, the new study infers no heat source would be necessary.
Max Rudolph, from the University of California, Davis and colleagues say that cracks in the ice shell caused by changes in Enceladus' orbit around Saturn would allow water from the subsurface ocean to leak out. And instead of active cryovolcanism, the researchers propose the water spontaneously boils when it hits the vacuum of space.

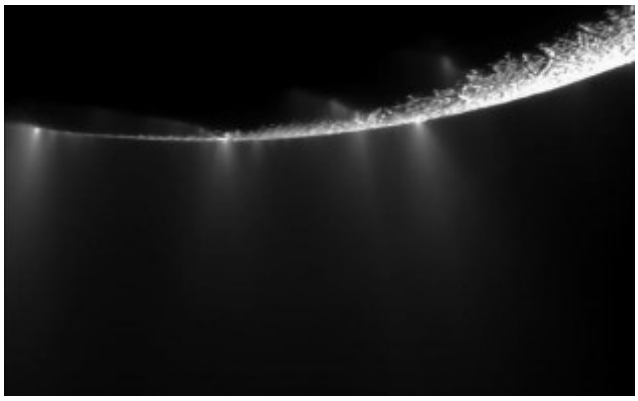


Voyager 1 acquired this image of Io on March 4, 1971. An enormous volcanic explosion can be seen silhouetted against dark space over Io's bright limb. Credit: NASA/ JPL.
Cryo-volcanism is a relatively newly found phenomenon, initially discovered by the Voyager missions' travels to the outer Solar System. Instead of hot, molten lava like volcanoes on Earth, cryo-volcanism spews out water, ice and other materials in environments that can be hundreds of degrees below freezing. For example, temperatures at the surface of Enceladus rarely rise above –200°C (-330 F). Cryo-volcanism has been observed at Jupiter's Io and Europa, as well as at Enceladus and other icy moons. While Io appears to be outgassing sulfur dioxide, other moons are erupting with water, methane and ammonia.



Cassini's view down into a jetting "tiger stripe" in August 2010. Credit: NASA
Rudolph and colleagues said they modeled the orbital and internal evolution of the ice-covered ocean worlds Enceladus and Europa across 100 million years of time. The eccentricity of the moons' orbits leads to varying thicknesses of their ice shells. As the ice thickens and thins, the team said, thermal stresses in the ice shell and pressure in the underlying ocean will change, promoting

the fracturing of the ice shell, creating the tiger stripe fissures.
This takes place as the ice cools and thickens. The pressure exerted on the ocean below would create stress on the ice, since ice has more volume than water. The pressure and stress could cause cracks, and create pathways for fluid to reach the surface, as much as 20-30 kilometers away. The sublimation of the water as it hit the vacuum of space gives the appearance of "jets" when there aren't any.
Rudolph said in a press release that this is consistent with the appearance of the surface of Enceladus, which doesn't show any evidence of cryo-lava flows leaking from the cracks on the surface, which are found on Io. Enceladus appears to be unique in that the tiger stripe cracks are not found anywhere else in our Solar System. They are parallel and evenly spaced, about 130 kilometers long and 35 kilometers apart, and they appear to be continually erupting with water ice.



Dramatic plumes, both large and small, spray water ice out from many locations along the famed "tiger stripes" near the south pole of Saturn's moon Enceladus. Credit: NASA/ JPL/Space Science Institute

But the mechanism identified in this new study of ocean pressure and spontaneous eruption can't explain the cryovolcanism that may be happening on Europa, Rudolph said. Further research and observation on that moon is needed to determine the potential causes of those eruptions, since their models don't show cracks reaching the subsurface ocean on that moon. The upcoming Europa Clipper mission should provide more insights.
This new study, however, does not address previous studies and data which indicate Enceladus' south pole is warmer than expected just a few feet below its icy surface, and what keeps the interior of this tiny moon warm enough to support a liquid subsurface ocean.

ExoMars is Suspended. ESA is Looking for new Solutions to Replace Russian Components
Coordination between countries in space exploration is widespread. However, sometimes that coordination falls apart. In most cases, that failure is due to budgetary constraints. But in more recent times, it is due to geopolitical ones. Specifically, western space agencies have begun to cut ties with Roscosmos, the Russian space agency, on every program excluding the International Space Station, which is still operating normally. One of those project casualties is the timeline of the oft-delayed Exomars rover, Rosalind Franklin.
Originally developed in 2005, the Rosalind Franklin rover, which was named after a British chemist that helped discover DNA, was part of the ExoMars program and conceived as a cooperative arrangement between ESA and NASA. When NASA suffered a budget cut in 2012, the agency pulled out of the project, and Roscosmos, then on much friendlier terms with ESA, stepped in to fill the void both from a budgetary and a technological standpoint.
That wasn't the end of the project's bumpy road, though. Problems with the rover's parachute pushed the initially scheduled launch date from 2018 to 2020 and then again to 2022. In September of this year, Rosalind Franklin was finally supposed to take to the skies onboard a Proton rocket from the Baikonur Cosmodrome in Kazakhstan, which Russia controls.
UT video on landing on Mars – one of the major challenges that has plagued Rosalind Franklin's development.
Unfortunately, Protons are not the only rockets Russia is currently flying. After the country invaded Ukraine late last month, western nations, including those comprising ESA, started ratcheting up the screw of sanctions on the space superpower. At an emergency meeting of ESA's ruling council on March 16-17 in Paris. At this meeting, the agency officially suspended ties with Roscomos and directed Joseph Aschbacher, ESA's Director General, to seek out alternative solutions for both Russian-supplied technology and Russian-supplied lift capabilities.
Those technologies ranged from the landing platform used to drop the rover onto the surface to radioisotope heaters that would be used to keep the rover's instruments at reasonable temperatures during the Martian night. There is already some possibility to replace those components with European-made ones. Some had been tested on another ExoMars project – the Schiaparelli lander, which descended to the Red Planet's surface in 2016 as part of the Trace Gas Orbiter mission.
If they can't find a homegrown source, the first place ESA might look is back at their original partners for the mission. NASA had already reached out to the agency to "identify where [they] could help." according to a statement by Aschbacher. But, if the war in Ukraine came to an end soon, ESA would be open to restarting its cooperation with Roscosmos.

Exomars doing preliminary drill testing on Earth.
Credit – Thales Alenia Space

David Parker, ESA's director of human and robotic exploration, hinted at that possible re-engagement and provided some updated timelines for launch, stating "the possibility of restarting [cooperation with the Russians] at some future date is available and would be compatible with [a] launch in 2024." He also stressed that, without Russian involvement, that launch date would more likely be 2026 or 2028.
Luckily, the rover can sit in storage in a cleanroom at a relatively low cost, at least compared to the $1.1 billion already spent on the project. Parker was quick to stress that the scientific aims of the mission can wait, stating that "…Mars is four and a half billion years old. So we just have to wait a few more years for it to reveal all of its secrets."
Other missions might have to be tabled as well. ESA called out four other missions that need to find alternative launch arrangements, including two Galileo missions (M10 and M11), Euclid, and EarthCare. Some other alternatives might work, but the satellites themselves might have to be modified to fit a different launch platform, or they could potentially wait for the point where connections are reestablished. But, as of the time of writing, that doesn't seem to be any time soon.
Learn More:
ESA – ExoMars suspended
SpaceNews – ESA suspends work with Russia on ExoMars

mission
UT – Europe's ExoMars Rover Will Likely Miss This Year's Launch Window Because of Russia's Invasion of Ukraine
UT – ExoMars Will be Drilling 1.7 Meters to Pull its Samples From Below the Surface of Mars

POSTED ON BY EVAN GOUGH

The Strange Swirls on the Lunar Surface are Somehow Related to Topography

The Moon is the most studied object in space. But our nearest neighbour still holds a few mysteries. One of those mysteries is the lunar swirls. These strange serpentine features are brighter than their surroundings and are much younger. They're not associated with any specific composition of lunar rock, and they appear to overlay other surface features like craters and ejecta.

Scientists have been puzzling over the swirls for decades, and with lunar outposts looming as a real possibility, understanding these swirls takes on new importance. Now a new study finds a link between lunar topography and the swirls.

Dust transport on the Moon is a poorly understood phenomenon. There's no atmosphere, so there's no wind to move dust around. Yet dust must be moving to form the swirls.

We've known about the dust movement on Mars since the earlier days of space exploration. Some of NASA's Lunar Surveyors found evidence of it, as did Apollo 17's Lunar Ejecta And Meteorite (LEAM) experiment.

The Moon is geologically dead or close to it. Whatever's causing the lunar swirls, it's not geology. The Moon has a plasma environment involving the solar wind, the terrestrial magnetotail and other factors. Scientists invoke them as the engine of dust transport, and they've even pointed to comet impacts as a cause. These effects are powerful enough to shift tiny particles around the surface in the absence of wind. But much of the detail around the phenomenon is obscured.

A new study found a link between the swirls and the Moon's topography. While the connection between the swirls and topography may be the beginning of an explanation for the swirls, it also leads to more questions.

The new study is "Topographic Correlations Within Lunar Swirls in Mare Ingenii." The lead author is Deborah Domingue, a Senior Scientist at the Planetary Science Institute. The study is available online at the journal AGU Geophysical Research Letters.

There are three potential explanations for lunar swirls. The first is the cometary impact model. In this model, a comet struck the Moon, and the coma's turbulence exposed the surface by transporting fine dust. The heat from comet impacts magnetized some materially locally, and the magnetized material responded to remnant magnetism in the lunar crust. This chain of events could've created the swirled morphology.

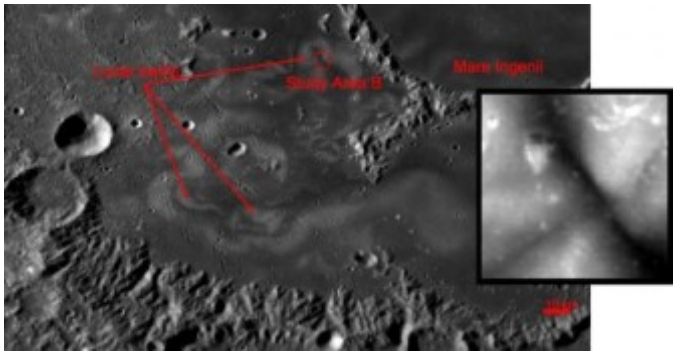
The second model is the solar wind shielding model. This model says that magnetic features on the Moon protected some material from the wind while allowing material with specific albedoes to move around with the solar wind. This formed the swirls over time.

The third is the dust transport model. This model says that interactions between crustal magnetic anomalies and the solar wind attracted or repelled fine lunar dust.

These explanations have to account for magnetism and the swirls' youthful appearance. But none of them hint at topography, which sets this new research apart.

"This is the first time there has been a demonstrated correlation between the swirl albedo patterns and topography," said lead author Deborah Domingue.

"Until now, the swirls were thought to overlay the topography, which has been cited as part of the evidence that they are created through shielding of the surface from the solar wind by the magnetic fields present at swirls. This correlation argues that there is more than just shielding from space weathering that goes into their creation," Domingue said.

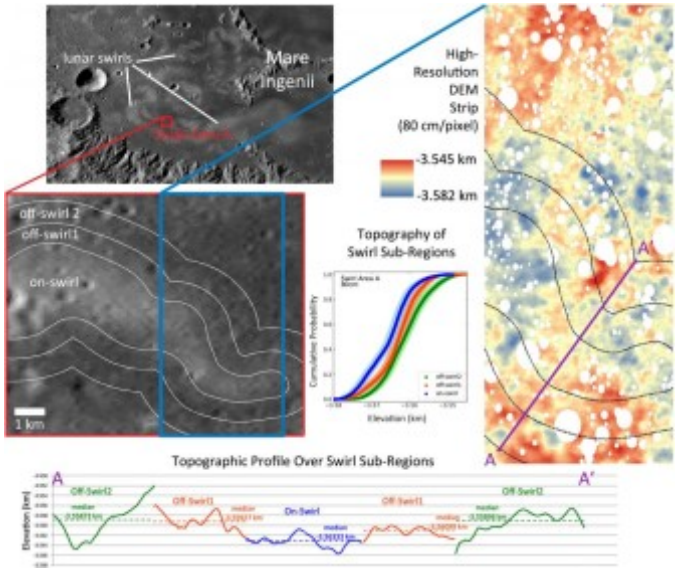


The swirl region within Mare Ingenii is one of the areas examined in the study. It's one of the lunar swirls that displays a correlation between the swirls and topography. Image Credit: LRO

Mare Ingenii is one of the Moon's basaltic plains. Ancient volcanic eruptions created the lunar mares, appearing dark because of their higher iron content. Mare Ingenii has two swirl features, and they both show a correlation between topography and albedo. The bulk elevation in the bright areas of the swirl is lower than in the dark regions. The different heights affect dust transport.

"For swirls, dust transport is the process most affected by elevation changes, and we now re-examine the role of dust mobility across the lunar surface in the context of this new discovery," Domingue said.

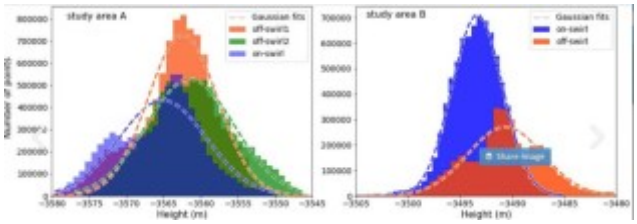
The elevation differences between brighter on-swirl and darker off-swirl areas are not huge. The differences range from about 2.3 meters to 4.4 meters. But they're consistent, and scientists can't ignore them.



This figure presents results for Study Area B, one of two study areas in the research. The high-resolution DEM (Digital Elevation Model) is from the Lunar Reconnaissance Orbiter Camera (LROC) and the Narrow-Angle Cameras (NAC) on NASA's LRO. Image Credit: Domingue et al. 2022.

Magnetic anomalies on the lunar surface play a role too. The Moon has a weak magnetic field, but it doesn't come from an internal dynamo as Earth's does. Instead, it comes from different mineral concentrations in the crust and could be related to giant impacts.

The brighter sections of the swirls are areas shielded by magnetic anomalies, and spectral analysis shows they're younger than the dark areas. The lighter regions also show "… a decreased abundance of implanted solar wind hydrogen, which forms OH (hydroxide.)." Spectral analysis of the darker areas shows that they're older. According to the research, this indicates that shielding of the solar wind helps form the swirls.



This figure from the study presents the off-swirl and on-swirl heights in the lunar swirls in both study areas. Note that the height is along the horizontal axis. The decreasing mean heights from off-to on-swirl are apparent. Image Credit: Domingue et al. 2022

When Apollo astronauts set foot on the Moon, they were surprised by the fine dust. When they entered and exited the lunar module, dust came along for the ride. NASA says the dust "… clogged mechanisms, interfered with instruments, caused radiators to overheat and even tore up their spacesuits."

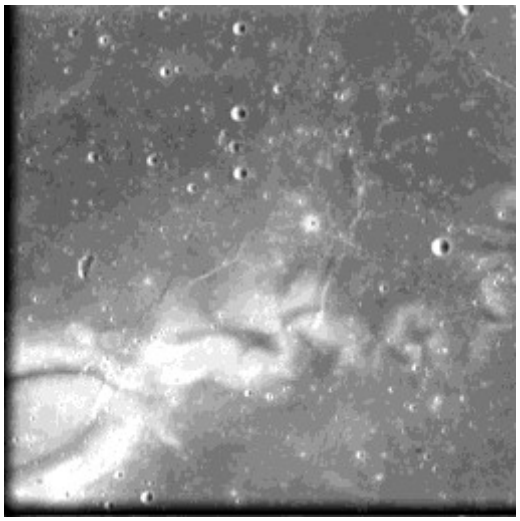
"We learned from Apollo that lunar dust can be less than 20 microns (about 0.00078 inches) in size," said Sharon Miller, the passive dust shedding material program's principal investigator at NASA Glenn. "The dust is very fine, abrasive and sharp, like tiny pieces of glass, making it more of a dangerous threat than just a simple nuisance."

This picture shows Apollo 17 astronaut Harrison Schmitt collecting a soil sample. Notice how dust coats his spacesuit. Credit: NASA

Lunar dust is highly abrasive. All kinds of atmospheric and geological activity grinds away at the dust on Earth, making it smoother. But that's not the case on the Moon.

The lunar swirls are more than just a curiosity. With lunar exploration ramping up in the next years, those swirls indicate one of the puzzles yet to be solved. And if the dust is dangerous to equipment, then it's a hazard that must be understood and mitigated.

"Experiments on dust transport have not yet been conducted at the km scales of our subregions and at the relatively shallow depth differences between on-swirl and off-swirl regions, but there is support for electrostatic dust collection in topographical lows on airless surfaces," the authors write in their conclusion. Some laboratory experiments show particles can be transported into depressions, and simulations show that dust can be deposited into craters as shallow as one meter deep.



Lunar swirls imaged by SMART-1, the ESA's first Moon mission. Image credit: ESA

This all leads to more questions about dust transportation on the Moon, and answers to some of those questions will help missions like Artemis. But at least scientists are making some progress. The team behind this study only examined two swirl regions, and they say other regions should be studied to strengthen the link between lunar dust movement and topography.

"The topographically low, higher albedo, on-swirl regions observed in Mare Ingenii support the process of dust migration across the lunar surface, contributing to swirl formation," the authors conclude. "Future examination of other swirl regions will potentially clarify the correlation of regional topographic differences within swirls, especially in cases where swirls appear on much steeper slopes and drape over impact ejecta."

Wondering how Dependant ISS is on Russia? NASA Gives the Details

The Russian invasion of Ukraine has been dominating the news cycle lately. Amid tragic stories about rocket strikes, stalled offensives, and possible motives and outcomes, there's been an ongoing "war of words" on social media. In particular, Dmitry Rogozin, the Director-General of the Russian State Space Corporation (Roscosmos), has been issuing thinly-veiled threats that Russia might be terminating its cooperation in space.

This included a video posted on Telegram by the state-controlled Russian news agency RIA Novosti that shows the Russian modules detaching from the *International Space Station* (ISS). In response to all the threats and hyperbole, NASA decided to host an FAQ session where they posted commonly-asked questions about the ISS. In what is eerily reminiscent of what happened in 2014, NASA let the world know that the ISS is still going strong and won't be decommissioned anytime soon!

While the FAQ session does not address statements made by Rogozin directly, it tacitly acknowledges and answers them strategically. For example, NASA addressed the nature of the ISS partnership, which nations are involved*, how astronauts will continue to fly to the ISS if one space agency no longer provides launch services, and the plan for decommissioning the station.

**Member states include NASA, Roscosmos, the European Space Agency (ESA), the Canadian Space Agency (CSA), and the Japan Aerospace Exploration Agency (JAXA).*

First and foremost, they stress that one cannot simply disassemble the ISS by detaching its modules. This was a direct challenge to the video posted by RIA Novosti and the way it depicted cosmonauts sealing their modules and leaving like it was no big deal. Says NASA:

"The space station was not designed to be disassembled, and current interdependencies between each segment of the

station prevent the U.S. Orbital Segment and Russian Segment from operating independently. Attempts to detach the U.S. Orbital Segment and the Russian Segment would encounter major logistical and safety challenges given the multitude of external and internal connections, the need to control spacecraft attitude and altitude, and software interdependency."

They then provide a seven-point list detailing how operations are interdependent and who provides what. This includes propulsion and attitude control (Roscosmos), altitude control and orientation (NASA), thrusters and propellant (Roscosmos), solar power (NASA), satellite communications and data transfer between Earth and the station (NASA), life support (both), and mission control (both).

Then there's the issue of getting to and from the ISS, which they admit is not presently doable. "Each astronaut has custom hardware including a launch and entry suit or a seat liner that is not interchangeable between different models of spacecraft," they write, adding that transferring from one spacecraft to another would "require a different launch and entry suit that is custom fitted and created on the ground."

The issue of transportation has been a sore point ever since 2011 when the Space Shuttle's retirement forced NASA and its partners to rely upon Roscosmos to provide launch services. When Russian forces annexed Crimea in 2014, this dependency became a bone of contention. In response to the U.S. declaring sanctions, Dmitry Rogozin (then-deputy Prime Minister to Dmitry Medvedev) chimed in on Twitter to mock the U.S. and NASA.

"After analyzing the sanctions against our space industry, I suggest to the USA to bring their astronauts to the International Space Station using a trampoline," he wrote. Musk responded shortly thereafter, tweeting: "Sounds like this might be a good time to unveil the new Dragon Mk 2 spaceship that @SpaceX has been working on w @NASA. No trampoline needed."

Oh, how history repeats itself! On March 3rd, shortly after President Biden announced new sanctions against Russia, Rogozin took to state television to say that Roscosmos was halting the sale of rocket engines to the U.S. "In a situation like this, we can't supply the United States with our world's best rocket engines," he said. "Let them fly on something else, their broomsticks, I don't know what."

NASA Administrator Bill Nelson responded to The Associated Press, stressing that cooperation between NASA and Roscosmos' was not in jeopardy, regardless of Rogozin's statements. "That's just Dmitry Rogozin. He spouts off every now and then. But at the end of the day, he's worked with us," he said. "The other people that work in the Russian civilian space program, they're professional. They don't miss a beat with us, American astronauts, and American mission control."

Alas, Musk took to Twitter once again to respond. On March 3rd, he shared a video of SpaceX launching its latest batch of *Starlink* satellites, followed by the words "American Broomstick" and four U.S. flags. Was this perhaps a reminder that NASA and SpaceX restored domestic launch capability to U.S. soil in 2020 using the *Falcon 9* and *Crew Dragon* capsule?

Regardless, the issue of steering and control is also raised in the NASA FAQ session. This is especially important, as it addresses the statement made by Rogozin about how – without the Russian modules steering it – the ISS would "fall" on the U.S., Europe, India, or China (basically, anywhere but Russia).

First, they addressed what parts of Earth the station fly over: "The International Space Station orbits with an inclination of 51.6 degrees. This means that, as it orbits, the farthest north and south of the Equator it will ever go is 51.6 degrees latitude." They state. They also offer links to the orbit Tutorial page (so people can see precisely how the ISS orbits Earth) and the Spot The Station page, where sighting opportunities can be found.

In another question, the NASA FAQ addresses which space agency provides propulsion and explains how steerage is dependent on more than just the Russian modules:

"All International Space Station propulsion is provided by the Russian Segment and Russian cargo spacecraft. Propulsion is used for station reboost, attitude control, debris avoidance maneuvers and eventual deorbit operations are handled by the Russian Segment and Progress cargo craft. The U.S. gyroscopes provide day-to-day attitude control or controlling the orientation of the station. Russian thrusters are used for attitude control during dynamic events like spacecraft dockings and provide attitude control recovery when the gyroscopes reach their control limits."

However, they remind us the ISS program has been in continuous operation for 21 years, thanks to ongoing cooperation between its international partners. They further point out that NASA has agreed to extend the life of the ISS through 2028 and that "NASA's space agency partners have all recommended International Space Station extension through 2030 with approvals pending through their own government processes."

This includes Roscosmos, which is committed to remaining with the ISS program until 2024 and even added their "Nauka" module last year. This guidance and navigation module is the first to be added since 2016 and will provide additional attitude control capabilities to the ISS. NASA also explained how the safe deorbiting of the ISS (when it *is* decommissioned, years from now) is a priority all parties are committed to:

"The primary objective during space station deorbit operations is the safe re-entry of the space station's structure into an unpopulated area in the ocean as outlined in the agency's International Space Station transition plan."

The International Space Station's Canadarm2 robotic arm captures Orbital ATK's Cygnus cargo spacecraft on its sixth mission to the station. Credits: NASA

This plan, which was updated on January 31st, 2022, details the administration's goals for the ISS until 2030. The plan calls for operations that allow for a smooth transition to commercial services, the development of the supply and demand end of a "commercial economy" in Low Earth Orbit (LEO), and the technical steps and budgets this will entail.

"The space station will accomplish the deorbit maneuvers by using the propulsive capabilities of the space station and its visiting spacecraft," they add. "NASA and its partners have evaluated varying quantities of Russian Progress spacecraft to support deorbit operations. Additionally, NASA is evaluating whether U.S. commercial spacecraft can be modified to provide capability to deorbit the space station."

This includes the Northrop Grumman Cygnus spacecraft, which NASA claims is "currently in testing to provide limited capability for future reboosts." They acknowledge that this is not a long-term solution or a replacement for attitude control functions and that "[c]hanges to the current propulsion scheme would take considerable new hardware/software development, and significant time and funding to enact."

Not mentioned is the SpaceX Crew Dragon, which Musk and other sources online claim could replace the Russians segment. With relatively minor modifications, they argue, Crew Dragon spacecraft could provide reboost capability and attitude control. If feasible, this could constitute a solid backup option and would be in keeping with how NASA has transi-

tioned to commercial suppliers to meet much of its needs. The takeaway from all of this is that operations aboard the ISS are and always have been interdependent. Russia cannot simply pack up and detach its modules any more than Rogozin could sprout wings and fly there to shoot some propaganda videos. While they don't say so, NASA's FAQ page reminds us that the ISS has endured political turmoil before and survived.

For the past eight years, while Russia and the U.S. have been locked in a state of mutual hostility, NASA and Roscosmos have maintained good relations. Even when politicians were threatening war and sanctions, astronauts and cosmonauts managed to work together amiably aboard the ISS. Perhaps world leaders could take a page from their book?

LEGO Releases the new Rocket Launch Centre set, Recreating the Artemis Moon Missions

One way to inspire kids to get interested in STEM is to introduce them to it at an early age. Lego is one of the best gateways to that interest, and the company has been busy churning out space-themed toys for most of its existence. Now another entry has joined that long, distinguished line of interlocking brick system designs – the Rocket Launch Centre, #60351.

The centre is pretty noticeably modeled on the Space Launch System (SLS) and the Artemis moon exploration program. Lego itself quickly points out that the playset contains "NASA-inspired features" rather than any direct licensee with the agency. They have done so in the past, though, including with a Space Shuttle Discovery set, as well as being part of the drive to name the rovers that eventually became Opportunity and Spirit.

We can only speculate why the set so obviously modeled on one of the agency's main focal projects didn't get the official NASA seal of approval. It might have something to do with the continual delays and budget overruns that the SLS, and the Artemis program by proxy, are suffering through. But a version of James Webb, which suffered from its own set of cost overruns to eventually be successfully launched, is currently undergoing review on the Lego ideas page, so there may be some potential deal in the future for a fully licensed version.

Image from Lego's marketing campaign for the set. Credit – Lego

For now, though, the Rocket Launch Centre is simply part of Lego's more extensive City range of toys. It comes in at 1010 pieces, including six mini-figures, a rocket that looks strikingly like the SLS, a launch tower, an "observation dome," and a launch control centre. It also has several vehicles, including a "planetary rover" based upon what Lego's designers think the Artemis lunar rover would look like.

The service vehicle looks like a little Jeep, while it also appears there is a small meteorite it is supposed to be designed to pick up. There's also a miniature drone, which can fly in front of the observational deck with a hatch that can open. The rocket also fits perfectly into the launch tower while also being multistage, as the planned SLS is supposed to be.

Overall the set has the same quality owners expect from Lego. Space junkies will just have to see if this Rocket Launch Center becomes a limited edition and is eventually replaced by a fully licensed Artemis Mission set.

Learn More:
Lego – Rocket Launch Center

An 1874 Citizen Science Project Studying the Aurora Borealis Helped Inspire Time Zones

For millennia, humans have gazed at the northern lights with wonder, pondering their nature and source. Even today, these once mysterious phenomena still evoke awe, though we understand them a little better now. Still, most of our knowledge about the northern lights has come recently, in the last century or two. Astronomers and meteorologists of the 1800s worked for years to understand the aurora, wondering if they were a feature of Earth's atmospheric weather, of outer space, or, perhaps, something that straddled the boundary in-between. This centuries-old attempt to understand the northern lights was an immense, international-scale project, and, through fortunate happenstance, it even helped inspire one of the underlying foundations of modern society – time zones.

In the 1870s, the man leading the quest to understand the aurora borealis was Cleveland Abbe. Americans might know Abbe as the father of the National Weather Service, who broadcasted some of the first consistent, reliable, weather reports in the country's history from his base in Cincinnati, Ohio. But as a meteorologist and astronomer, he was also involved in geophysics research, and a powerful solar storm in April 1874 presented him with a unique opportunity to study the northern lights.

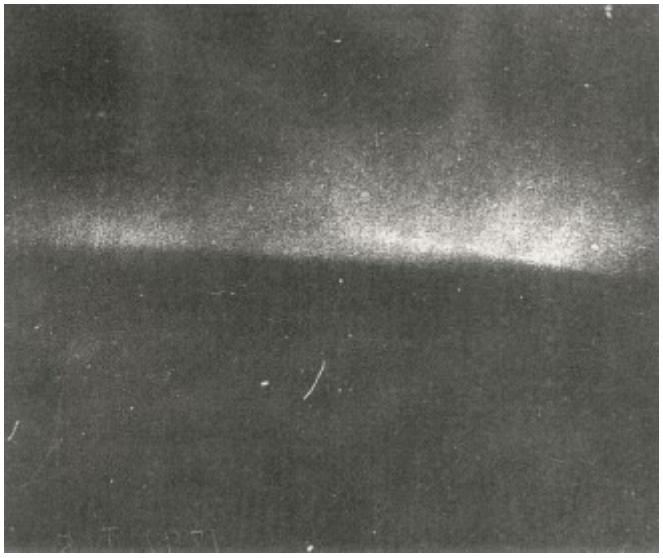
The Aurora Borealis creates stunning displays of dancing light. This particular aurora was captured by Sebastian Kowalski in Norway on March 1, 2017. Credit: Sebastian Kowalski, Wikimedia Commons.

As we know now, auroras are the result of the solar wind interacting with charged particles in the Earth's magnetosphere. When these particles get bombarded in the upper atmosphere, they shed light energy in spectacular fashion, creating marvelous curtains of green and blue (among other colors). Aurora aficionados will know that solar flares – intense bursts of solar radiation – can dramatically increase the aurora's vibrancy and color, but also its breadth. Particularly strong solar storms can, on occasion, push the aurora into more southerly latitudes, making them visible across huge swaths of the United States and mid-latitude regions worldwide.

On April 7, 1874, one of these storms caused a particularly memorable display (though it was a moderate storm compared to the famous Carrington event of 1859, at the time still easily within living memory). Abbe jumped at the opportunity to study the aurora, hoping to learn, if possible, its altitude above the Earth, and compare it to concurrent weather phenomena and magnetic observations.

To carry out this task, Abbe needed multiple data points – in other words, he needed observations from multiple sites across the country. Luckily, due to his position as a weather prediction guru, Abbe already maintained a network of con-

tacts across the USA who helped him gather meteorologic data for his weather reports. That night, Abbe put them to work observing the northern lights instead. This team was made up of about 80 public volunteers and 20 expert observers, making this project an early example of a citizen science collaboration (the indirect ancestor, perhaps, of modern citizen science projects like Zooniverse or Seti@home).



This is the oldest surviving photograph of the northern lights. It was taken on January 6, 1892 by Martin Brendel in Bossekop, Alta, Norway. Credit: World Heritage Rock Art Centre – Alta Museum.

The project didn't all go as planned, however. The problem, Abbe discovered, was that these volunteers, scattered as they were across the country, took their observations using their own local time systems. As a result, comparing the observations to each other in order to draw useful conclusions was frightfully difficult. Abbe wrote in frustration, "The errors of the observers' clocks and watches and even of the standards of time used by them, are generally not stated…so that the uncertainty of this vitally important matter will be found to throw obscurity upon some interesting features."

The problem was so pervasive that Abbe decided to take matters into his own hands, working with the American Metrological Society (AMS) to try and devise a permanent solution. He was particularly impressed by a proposal from AMS member and mathematician Benjamin Peirce, who suggested breaking up the country into a series of hour-wide time zones.

A few years later, Abbe received a letter from a Canadian railroad engineer, Sandford Fleming, who was also trying to find a way to standardize time, in his case to keep cross-continental railroads running in sync. Together, Abbe and Fleming (among others) took their idea to Congress, petitioning them to legally establish time zones in the United States. The railways adopted them first, in November 1883. A year later, an international conference held in Washington D.C. established a global prime meridian for timekeeping at Greenwich. Over the next few decades, countries around the world began adopting time zones, in some form or other, based on this meridian.

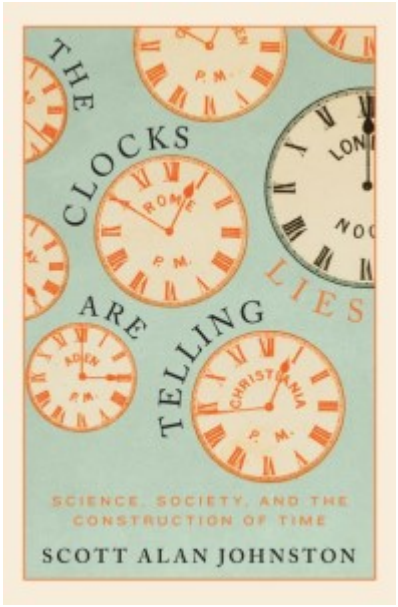
The delegates to the International Meridian Conference, 1884, where Greenwich was chosen as the Prime Meridian. Cleveland Abbe is in the back, second from the left (partially obscured by white-bearded astronomer Lewis Rutherfurd standing in front of him). Wikimedia Commons.

Today, time zones are ubiquitous. Their origin is often attributed to the railroads, and that's partially true, but it's worth remembering that time zones also grew out of the needs of curious people attempting to understand our world and its place in the Universe. Cleveland Abbe and his small group of citizen scientists, who just wanted a better way to keep time while they watched the northern lights dance overhead, literally changed the world we live in. It's a cheerful thought, and speaks to the power of curiosity and collaboration to make a difference.

By the way, if you're wondering, scientists – like Abbe – eventually revealed that the northern lights tend to appear between altitudes of about 100-300 kilometers above the Earth: above the Karman line, but low enough for atmospheric interactions to make the colorful light-shows possible.

Learn More:

The northern lights weren't the only astronomical phenomena to influence human timekeeping. The transit of Venus across the Sun in 1874, and again in 1882, similarly had astronomers across the globe scrambling for a way to synchronize their clocks, lest their observations be useless in comparison to one another (astronomers were attempting to use the transit of Venus to determine the Astronomical Unit – the distance between the Earth and Sun – and that was only possible by comparing transit data from multiple observation points).



These astronomical undertakings eventually brought the

issue of global timekeeping to the attention of the general public. Despite sometimes seeming aloof, science and scientific research had – and still have – a strong influence on culture and society.
You can learn more about this story and others like it in "The Clocks are Telling Lies: Science Society and the Construction of Time," a scholarly history of global timekeeping recently released by McGill-Queen's University Press. Scott Alan Johnston, 2022.
Additional Reading:
Ian Bartky, "The Adoption of Standard Time," *Technology and Culture* (1989).

Featured Image: Sophus Tromholt's photo of his drawing of an auroral display ("auroral break-up") observed at 7:55p.m. on October 6, 1882. The northern lights were notoriously difficult to capture with early cameras. Tromholt wrote in 1885: "Every attempt I made to photograph the Aurora Borealis failed…in spite of using the most sensitive dry plates, and exposing them from four to seven minutes, I did not succeed in obtaining even the very faintest trace of a negative. The reason is, I am convinced, the small strength of light, and its limited chemical action. The illustrations, therefore, of the Aurora Borealis at Koutokeino accompanying this work are… photographic reproductions of my own drawings". Sophus Tromholt, Under the Rays of the Aurora Borealis, English translation by Carl Siewers, published in London, 1885. Credit: Sophus Tromholt, UBB collection.

50-Year-Old Lunar Samples are Opened up for the First Time

NASA's Apollo missions to the Moon brought back about 382 kilograms (842 pounds) of samples, including rocks, rock cores, rock, pebbles, sand, and dust. Scientists have studied those samples intently over the decades and have learned a lot. But they haven't studied all of the samples.
In an impressive act of foresight, NASA left some of the samples unopened and in pristine condition. Why? Because they knew the technology used to study the samples would only improve over the decades.
Apollo 17 was NASA's final Apollo mission and the last of six that made it to the Moon and back. The mission returned to Earth with its samples just over 50 years ago. The three astronauts on that mission were Gene Cernan, Ronald Evans, and Harrison Schmitt. Schmitt was a geologist and the only scientist ever to visit the Moon. The crew collected about 115 kg (254 lb) of lunar samples, the largest payload collected by any Apollo Mission.

Three Apollo 17 sample rocks are being weighed in a lab. Image Credit: NASA
Apollo 17 landed in the Taurus-Littrow Valley on the eastern edge of Mare Serenitatis. The mission had two main geological objectives: to obtain samples of ancient rocks from the lunar highlands and to look for evidence of young volcanic activity on the valley floor.
The astronauts put the samples in Special Environmental Sample Containers. The containers have seals to protect the enclosed sample from atmospheric gases prior to being opened in a vacuum chamber at the Johnson Space Center.
Fifty years have passed since Apollo 17 returned to Earth, and NASA has decided that now is the time to open the last remaining unopened lunar sample from the Apollo Program. The Apollo Next Generation Sample Analysis Program (ANGSA) will unseal the sample. ANGSA is a team of scientists whose goal is to "… maximize the science derived from samples returned by the Apollo Program in preparation for future lunar missions anticipated in the 2020s and beyond."
"Understanding the geologic history and evolution of the Moon samples at the Apollo landing sites will help us prepare for the types of samples that may be encountered during Artemis," said Thomas Zurbuchen, associate administrator of NASA's Science Mission Directorate in Washington. "Artemis aims to bring back cold and sealed samples from near the lunar South Pole. This is an exciting learning opportunity to understand the tools needed for collecting and transporting these samples, for analyzing them, and for storing them on Earth for future generations of scientists."
When the Apollo missions collected their samples in the 1970s, the technology available to study them was formidable. But in the intervening years, technological advances have propelled that technology to new levels. Scientists can now study these samples in ways that would've seemed like science fiction to researchers in the 1960s and 1970s.
"The agency knew science and technology would evolve and allow scientists to study the material in new ways to address new questions in the future," said Lori Glaze, director of the Planetary Science Division at NASA Headquarters. "The ANGSA initiative was designed to examine these specially stored and sealed samples."
Some of the scientists who will study these unopened Apollo samples weren't even born when the samples were collected. Sadly, many of the people involved in the Apollo program have passed away and will never get to see some of the results of their epic missions and their wise decision to leave some samples for the future.
When the Apollo 17 crew collected the samples, they placed them in a two-chamber sample container called a double-drive tube. The unopened sample is called the ANGSA 73001 sample. The crew sealed it under vacuum on the Moon, and it's been stored inside a protective outer vacuum tube in an atmosphere-controlled environment at Johnson ever since. NASA unsealed the other portion in 2019.

They were left to right: Apollo astronauts using sample tube 73001/2 on the Moon. A simple schematic of the sample tube. Unopened sample tube back on Earth. Sample tube in pristine storage at Johnson Space Center. Image Credit: NASA/Lunar and Planetary Institute.
Jessica Barnes from the University of Arizona's Lunar and Planetary Laboratory was one of the scientists given access to the unopened lunar samples in 2019. At the time, Barnes said, "Being able to study these previously unopened samples is like a whole new lunar sample return mission. Not only do we get to be a part of the history of opening these samples, but we also will be using this opportunity to study how curation practices, such as ambient versus cold storage, affect our ability to measure a lunar water signature. "It's exciting because this has never been done before."
"They realized that future technologies would allow us to do things that would have been impossible at the time and that people would come up with new questions, and it's really exciting because we're at that point in time now," Barnes said in 2019.
One of the enduring questions in Solar System science right now concerns the source of Earth's water. But to understand

that, scientists have to look around the rest of the inner Solar System for clues. That's because plate tectonics erased geological evidence from Earth's earliest history. But on the Moon, there is no plate tectonics, and the ancient rocks are intact.

"To understand where water in the solar system came from, and particularly how it ended up on Earth, Mars, and in the asteroid belt, we have to consider the moon," Barnes said in 2019. "Understanding how life on Earth began is intimately tied to the story of how water arrived here. Lunar samples are critical pieces in this puzzle because unlike Earth, where the oldest rocks have largely been erased by plate tectonics, the moon's ancient rock record is still intact."

An Apollo 17 image shows where the samples were collected. Image Credit: NASA

We only discovered water on the Moon about a decade ago and haven't gathered any lunar samples since then. So this unsealed sample could play a role in our quest to understand Earth's water.

Scientists compare water from different parts of the Solar System with isotope ratios. The hydrogen in water molecules is in two isotopes: H1, also called protium, and H2, called deuterium. In a sample of water, there'll be a ratio of these two stable isotopes of hydrogen. A third hydrogen isotope, called tritium, decays rapidly.

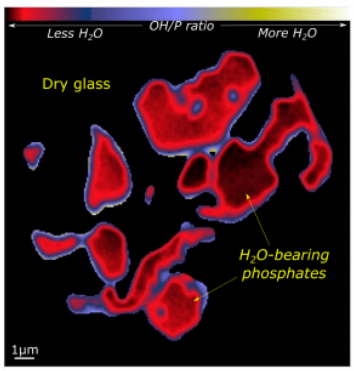
If two Solar System bodies have the same hydrogen isotope ratios in their water, it's called isotope homogenization, and it suggests the water had the same source or history. Scientists have studied hydrogen isotope ratios on Earth and compared them to lunar isotope ratios and meteorite ratios. Understanding all these different waters is part of the effort to understand how our Solar System formed and evolved.

Other elements in lunar rock also have isotope ratios. They're essential evidence in the Giant Impact Hypothesis, which says that the Moon formed from the debris from a collision between early Earth and a Mars-sized protoplanet named Theia. But the world of isotope ratios is complicated. Some isotopic evidence supports the Giant Impact Hypothesis; other isotopic evidence contradicts it.

Will this unopened Apollo sample bring any clarity?

The technology for studying samples has advanced a lot. One of the available devices did not exist when scientists first studied the Apollo samples. It's called a Nano-SIMS, or Nano-Scale Ion Mass Spectrometer.

Nano-SIMS allows scientists to identify isotopes and "create nanoscale maps of elemental or isotopic distribution," among other things. Scientists use Nano-SIMS to measure the content of all kinds of samples, from meteorites to ancient rocks to fine-grained dust from a comet.



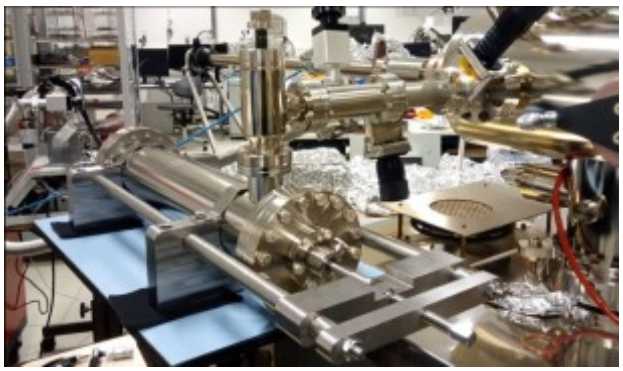
A NanoSIMS isotope ratio image shows water-bearing minerals in a sea of water-poor glass in Apollo sample 10049. These were the last phases to crystallize from the lava as it cooled on the surface of the Moon. The scale bar on the lower left measures about one-fiftieth the width of a human hair. Image Credit: NASA/Lunar Planetary Institute

Nano-SIMS is a powerful technology, and researchers will undoubtedly bring it to bear on this pristine sample. But we're not there yet.

When the Apollo 17 astronauts collected the sample, conditions were very cold at the bottom of the tube. That means that any volatiles like water and carbon dioxide would have been frozen and should still be in the tube. One of the reasons this sample is of such great interest is that it came from the Moon's mid-latitude regions, where NASA is sending the Artemis mission. So understanding these samples will help the Artemis mission prepare for their sampling efforts.

There's probably not a lot of gas in the sealed sample. But if scientists can extract it carefully, the gas will still be full of clues. Modern mass spectrometry tools like Nano-SIMS are extremely sensitive and will be able to determine with great precision the mass of molecules in the gas and identify them accurately. Not only that, but Nano-SIMS needs only a tiny portion of the sample to do its work. That means that the sample can be portioned out to multiple researchers studying different aspects of lunar science.

Extracting the sample from its tube is a whole endeavour in itself. Scientists at Washington University in St. Louis developed special equipment called a manifold to extract and collect the gas in the tube. Another team of scientists at the ESA developed a unique tool to pierce the lunar sample container without letting any gas escape. This unique system was all developed entirely for this sample, and it's undergone rigorous testing.



A piercing tool built by ESA is ready to open a Moon soil container from Apollo 17 that has gone untouched for nearly 50 years. Image Credit: ESA/ANGSA Science Team.

The team responsible for extracting the sample started their work on February 11th, 2021. The entire process will take months, and it started with opening the outer protective tube and collecting any gases. There were no surprises, as the team knew what it should contain in advance, and they found everything as expected. The outer tube contained no lunar gases, meaning that the inner tube's seal was still intact and not leaking.

From left, Dr. Juliane Gross, Astromaterials Research and Exploration Science Division (ARES) deputy Apollo curator, and Dr. Francesca McDonald, from ESA, take precise measurements from the piercing device before using the newly developed tool.
Credits: NASA/James Blair
On Feb. 23, the team began the next step in the complex process. Piercing the inner container and slowly gathering any lunar gases that are hopefully still inside will take weeks. Once the gas is removed, the team from NASA's Astromaterials Research and Exploration Science Division (ARES) will begin carefully removing the soil and rocks.

Front from left, Drs. Ryan Zeigler, Rita Parai, Francesca McDonald, Chip Shearer and back left from left, Drs. Zach Sharp from the University of New Mexico and Francis McCubbin, Astromaterials Research and Exploration Science Division (ARES) astromaterials curator look on in excitement as gas is extracted into the manifold after they pierced the inner tube.
Credits: NASA/James Blair
NASA's Ryan Zeigler is the Apollo sample curator. It's his job to oversee the process of extracting the gas and rock. Zeigler's job is to properly prepare, catalogue, and share the sample with others for research. And the excitement is building.
"A lot of people are getting excited," said Zeigler.

A Meteorite Recently Crashed Into Australia. A Drone Scoured the Area and Found it

Drones have become more and more ubiquitous in recent years. From recently discovering the Endurance to participating in wars, drones have made history in more ways than one. Now they have a new job title to add to their resume – meteorite hunter.
A team from Curtin University in Australia came up with this new use case for a drone and recently reported on their first successful new meteorite find. Using an observational system called the Desert Fireball Network (DFN), the team tracked down and found a recent meteorite in just four days.

Meteorite hunter Seamus Anderson and his drone that helped him find a newly crashed rock.
Credit – Seamus Anderson / Curtin University
The first piece of the puzzle of finding the meteorite was the DFN, a series of observatories that tracks meteorites, or "shooting stars" as they are commonly called, as they enter Earth's atmosphere. Two DFN observatories, one at Mundrabilla station, and one at O'Malley siding, picked up a fireball as it entered Earth's atmosphere for 3.1 seconds on April 1st, 2021. Unfortunately, the two observatories were relatively far away from the eventual landfall of the meteorite (149 km and 471 km, respectively). This distance led to some uncertainty in the exact landfall area, but they were able to limit the potential area to search to a manageable 5.1 km2.
That is still a lot of area to cover, and using a typical meteorite search technique of having groups of volunteers spread out to look for it would likely have been untenable. So the group at Curtin turned to a drone and AI algorithm to help in the process. They had developed and trained a neural network algorithm, a type of AI, to search for fallen meteorites. Using pictures of known meteorites in similar environments, they trained the algorithm on what to look for. Then they released a drone to collect images to feed into the algorithm.
Video discussing a "strewn field" – the type of field that meteorite hunters typically have to hunt for their quarry in.
Credit – Meteorite Men – Science Channel
That process took about three days for a DJI M300 with a mounted camera to cover the entire survey area. Luckily, the Outback of Western Australia is relatively open, making it each to spot unique rocks such as meteorites. And spot it they did. The algorithm, which breaks down images from the drone into 125 x 125 pixel tiles and then analyzes those tiles to look for potential meteorites, found the meteorite they were looking for in an image from the first day.
But that result was just one of several that passed the threshold of being interesting to look at. So after scanning the area for three days with a drone, the research team went out to find the meteorite themselves on foot. To focus their search, they concentrated on areas that the algorithm had returned an item of interest. And there, they found the 70 g meteorite pristinely in the sand. What's more, the space rock's final resting place was only 50 m from the originally suggested flight path calculated by DFN's observational network.

The drone image that held the hidden meteorite – now highlighted by a convenient yellow square. The shadow of the drone itself can be seen on the left of the image.
Credit – Anderson et al.
These results bode well for the future work of a combination of fireball tracking and drone surveillance. But, the Outback actually offers a relatively easy environment to perform such a search. Other areas, such as suburban settings or forests, could pose a challenge to this melding of modern technology. For now, though, the team from Curtin University, and meteorite hunters everywhere, can rejoice in the success of what is sure to be the first of many drone-assisted search missions.

POSTED BY MATT WILLIAMS

What Would a Sustainable Space Environment Look Like?

October 4th, 2022, will be an auspicious day as humanity celebrates the 65th anniversary of the beginning of the Space Age. It all began in 1957 with the launch of the Soviet satellite Sputnik-1, the first artificial satellite ever sent to orbit. Since that time, about 8,900 satellites have been launched from more than 40 countries worldwide. This has led to growing concerns about space debris and the hazard it represents to future constellations, spacecraft, and even habitats in Low Earth Orbit (LEO).

This has led to many proposed solutions for cleaning up "space junk," as well as satellite designs that would allow them to deorbit and burn up. Alas, there are still questions about whether a planet surrounded by mega-constellations is sustainable over the long term. A recent study by James A. Blake, a research fellow with the University of Warwick, examined the evolution of the debris environment in LEO and assessed if future space operations can be conducted sustainably.

For his Ph.D. project, Blake focused on the imaging and tracking of space debris in geosynchronous Earth orbits (GEOs) around 36,000 km (22,370 mi) above the equator. In this region of space, satellites follow the rotation of the Earth and have the same orbital period as the Earth, making it highly sought-after for telecommunications. However, space in this region is very limited, which could lead to serious problems of overcrowding and debris.

In particular, Blake's main body of work was a survey of faint geosynchronous debris carried out using the Isaac Newton Telescope at the Roque de los Muchachos Observatory on the island of La Palma. His work was summarized in a study titled "DebrisWatch I: A survey of faint geosynchronous debris," which appeared in January 2021 in the journal Advances in Space Research. As he indicated in this study, the population of debris in GEO is not well-constrained but represents a growing problem.

A Historic Problem

According to the ESA's Space Debris Office (SDO), as of March 03rd, 2022, about 12,720 satellites have been launched to Earth orbit since Sputnik-1. Of these, an estimated 7,810 remain in orbit, of which about 5,200 are still operational. All told, about 29860 debris objects in LEO are regularly tracked by Earth-based observation networks and are maintained in their catalog.

Previously, it was thought that the population of debris in GEO would be fairly negligible because of the strict spacing regulations that are meant to ensure satellites don't collide. However, the recent apparent destruction of communications satellites – AMC-9, owned by Luxembourg-based telecom SES S.A., and Lockheed Martin's Telkom-1 – has provided clear evidence that a debris field exists in GEO. This presents new implications for future constellations in GEO.

As Blake told Universe Today via email, charting the evolution of space debris is essential to the future of debris mitigation:

"Sputnik 1 was the first of thousands of satellites to be launched into Earth orbit over the past six decades, and that number continues to grow rapidly. Some have re-entered the Earth's atmosphere, while others are orbiting in an abandoned and uncontrolled state, posing a threat to the active satellites we rely on.

"Over time, the orbital debris population has grown due to accidental explosions and collisions, alongside intentional anti-satellite tests. The vast majority of debris produced by these events remains invisible to us, too small to be detected by our current generation of surveillance networks, yet still holding the potential to severely damage spacecraft."

According to Blake, there's a lesson to be learned from humanity's exploitation of the near-Earth environment. In keeping with the interconnected nature of space exploration and life on Earth, this same lesson applies equally to humanity's activities on the ground. In short, humanity needs to act sustainably so that future generations can enjoy and benefit from the freedoms we've enjoyed since the dawn of the Space Age. To do this, says Blake, collision avoidance is a must:

"Effective collision avoidance requires timely and accurate information. As satellite and debris catalogs grow ever larger, surveillance networks are being tasked with monitoring more and more objects to provide sufficient warning to operators, who can then opt to maneuver their craft out of harm's way."

The current strategy for preventing an uncontrollable debris environment in orbit involves a two-pronged approach: tracking and "passivating." The task of tracking satellites and debris is handled by several space agencies and government offices worldwide. For instance, the Joint Space Operation Center at Vanderburg Air Force Base in California (JSpOC) uses the Space Surveillance Networks (SSNs), a combination of optical and radar sensors, to monitor satellites and debris in orbit.

The NASA Orbital Debris Program Office (ODPO), located at the Johnson Space Center, measures the orbital debris environment while developing measures to control debris growth. The Office of Safety and Mission Assurance (OSMA), located at NASA HQ in Washington D.C., is responsible for developing, implementing, and overseeing agency-wide policies and procedures to ensure safety, reliability, and space environment sustainability.

There's also the aforementioned ESA's Space Debris Office (SDO) – located at the European Space Operations Center (ESOC) in Darmstadt, Germany – which is responsible for measuring and modeling the orbital debris environment and developing protection and mitigation strategies. It also coordinates activities and research efforts with the ESA's constituent agencies, which form the European Network of Competences on Space Debris (SD NoC).

At the international level, there's the Inter-Agency Space Debris Coordination Committee (IADC), a forum that includes thirteen national space agencies (including NASA, Roscosmos, the ESA, and the Indian and Chinese space agencies). This body developed guidelines in 2001 that have been revised multiple times (the most recent occurring in 2020) and have since been adopted by the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) – part of the UN Office of Outer Space Affairs (UNOOSA).

On the other end of things, there's the famous "25-year rule," where operators are encouraged to dispose of satellites within 25 years of mission completion via atmospheric re-entry. Low-altitude satellites may already be naturally capable of doing this. In contrast, potentially non-compliant

satellites can be outfitted with thrusters, drag sails, and other instruments to accelerate the deorbiting process. As Blake explained:

"Operators are encouraged to 'passivate' spacecraft at the end of their mission, by depleting or saving any remnant sources of internal energy onboard the satellite or rocket body, thus reducing the chances of explosion. Adherence to the '25-year rule' for deorbiting spacecraft in low Earth orbit is still concerningly low, and a boost to cooperation on an international scale will be paramount to tackling the debris problem."

In the end, Blake indicates that one of the greatest hurdles to achieving sustainability in space is policy. For the past few decades, the IADC guidelines adopted by UNCOUPOUS have formed the basis for standard mitigation practices on the international stage. Unfortunately, these guidelines are voluntary (i.e., not legally binding), and some space-faring nations have chosen not to include them in their national regulatory frameworks.

In addition, adherence to the "25-years rule" remains very low in LEO, and the process of re-entry is not a viable option for objects in the high-altitude GSO region. As a result, operators will typically attempt to raise decommissioned satellites into so-called "graveyard" orbits well beyond GSO – or what is known as a Supersynchronous Orbit (SSO). This has the effect of clearing the operational zone in orbit for use by future satellites, but debris in this orbit may still pose risks down the road.

According to Blake, the evolution of these graveyard orbits and the natural perturbative forces the dead spacecraft are subjected to are not well-understood. Many of these orbits still cross near to or through the operational zone as well, thus still posing a risk to active satellites. What is needed is a policy of Active Debris Removal (ADR) that works in tandem with stricter adherence to regulations for debris mitigation:

"Ultimately, we'll want to conduct regular removal missions to actively dispose of dead spacecraft and debris, though a number of technological hurdles are yet to be cleared. As evidenced by the recent Russian ASAT test back in November 2021, there is also a need for internationally recognized, legally binding regulations, to sanction against reckless behavior."
In addition, NASA, the ESA, the China National Space Agency (CNSA), and other space agencies are currently testing ADR systems. Concepts include Earth-based directed-energy arrays (lasers), spacecraft equipped with plasma beams, harpoons and nets, and magnetic space tugs. In recent years, says Blake, there have also been efforts to formulate a "Space Sustainability Rating" that would incentivize operators to adhere to safe practices and debris mitigation. However, several questions remain unanswered.
For instance, with access to space becoming more widespread, how does a regulatory framework compare University-led CubeSat experiments to commercial constellations of satellites (a la Starlink)? Also, how will lawmakers attribute liability in the event of a collision involving uncontrolled debris? And what mechanisms will be in place to ensure a level playing field between emerging space agencies and those with a decades-long presence in space?
The debate around these questions and attempts to find solutions are actively unfolding around us right now. It has also led to the rise of non-profit organizations like the Space Court Foundation (SCF) the Space Generation Advisory Council (SGAC). There are also the time-honored efforts to formulate and crystallize policy by the Institute of Air & Space Law (IASL) at McGill University and the United Nations Office for Outer Space Affairs (UNOOSA).
As our presence in space continues to grow, we can expect some spirited debate, resolutions, and impressive innovations in the coming years! As always, the driving force behind these developments will be a basic matter of necessity. Humanity's future in space depends upon accessibility and safety, something that cannot happen with huge debris fields in orbit!

E Mails Viewings Logs and Images from Members.

Hi Andy,
I hope you are well.
My wife and I have recently returned from a cruise on Queen Elizabeth 'In Seatch of the Northern Lights'. We went to Alesund, Tromso, Narvik and Bergen.
We managed to see the Northern Lights in the Moskstraumen Straits adjacent to the Lofoten Islands. Unfortunately QE was moving and there was a little ambient

light. I have attached a few images in case they are of interest for the WAS magazine. This was my first time trying to photograph the Aurora, but I have learnt some lessons for

the next time! I recognise that you may already have enough copy.
We had a very interesting guest lecturer who was John Maclean. You probably know of him About | (exeterobservatory.com) but he may be a possible future speaker.

We just want to go again and try to see the Aurora in other settings. It is such a wonderful sight!
Best wishes

Tony Murch

Viewing Log for 4TH of March

After having a game of golf during the afternoon with a lot of sunshine for company I thought I would go out and do some viewing in the evening, just to finish the day off. I arrived at

my usual viewing spot just south of Swindon off of the A4361 near Uffcott and had my Meade LX90 GOTO telescope set up and ready by 20:21, I would be using a Delos 17.3 mm eye piece. When I first arrived there was patches of cloud in the western sky which was not predicted? By the time I had set up the telescope most of the clouds had gone so it should be okay for the evening, let's hope! There was little wind and with a temperature of 4 °C it should be quite pleasant for the session?

Last time I was out (22nd of February) I started doing the Messier (M) marathon list and ended up at M 50. This was the first target for me to look at, this open cluster (O C) in Monoceros was fairly dim to look at, some of the brighter stars made out a triangle but there was not really many stars in the centre. For the next six objects they would all be O C 's starting with M 47 in Puppis, this is a large and very loose cluster with some bright stars. Not far away is M 46, a very large and dense cluster but was dim to look at. I could not find the planetary nebula (P N) within this cluster, no matter how hard I looked at it! M 93 in Puppis also is an O C I do not look at much, a small, dim and dense cluster. Into Hydra and M 48, a large and well spread out cluster. Next constellation to visit was Cancer and starting with M 44, the Beehive cluster best seen with the finderscope as it is too large for the telescope (you end up looking thru the object with the eye piece), the other often over looked cluster in this constellation is M 67, a compact, dense and dim object. That was the last of the O C 's for the evening. Having a short break from the marathon, I did the star count in Orion, not including the four bright stars that makes up the corners I could only count 10 which is not that good? Time to go around to the northern part of the sky and Ursa Major, first object was M 81 (Bode's galaxy), a spiral galaxy (S G) which has a small bright core and is a fuzzy blob (F B) to look at. Not far away is M 82, the Cigar galaxy, again another F B to look at but is long and thin. Onto the first faint fuzzy blob (F F B) for the evening and M 108, could not make out any detail with this object, did not help having two cars go pass me within a couple of minutes, one other car did go past me but that was while I was setting up my equipment which did not really affect my night vision at the time? Onto my once nemesis and M 97, the Owl nebula and final P N for the evening. This seem like a large grey blob, maybe the seeing has improved a bit? Going below the handle of the Plough and M 109, an F F B which could be easy to miss? Not far away is another F B and M 106, this had a small bright core (most galaxies I look at are F B's or worst?). Final object in Ursa Major was M 40, a double star, not much else can be said about this object! By now Leo had climbed a bit more in the eastern sky, so I went to this constellation and M 95, an F F B. Not far away is M 96, an F B to look at, checking the magnitudes of these two S G's they came in a 9.6 and 9.1? First elliptical galaxy for the evening was M 105, an F B to look at. For a change I managed to get two objects in the same field of view, namely M 95 and M 96. Looking at these two F B's I thought M 66 was the brighter of the two, checking the figures later they agreed with me coming in at 9.1 and 9.3 according to the info from the hand controller. Another car went past me which would be the last one for the evening (great). Time to head back to Ursa Major (just come from there!) and M 101, a real challenge, had to use adverted vision to find this F F B. Just below the end of the handle is M 51, the Whirlpool galaxy, I could make out both galaxies, making this object another F B. Into Canes Venatici and M 63, the Sunflower galaxy, just another F B to me! Final object I looked on the marathon was M 94 also in Canes, this S G had a bright core. Next object on the list when I continue will be M 3. Before packing up I had a look at M 42, the great Orion nebula starting to get close to the western horizon, as usual it was brilliant to look at!

As I made out M 97 fairly easy, I thought I would have ago at my current nemesis and NGC 3079 in Ursa Major, think I could just make out this S G using adverted vision? Coming in at a magnitude of 10.6, this is probably the limit of my viewing.

By now it was 21:59, the temperature had only dropped to 3 °C and time to pack up all of the equipment used, this time there was little dew on the telescope, previous time everything was quite wet, even had to change the eye piece which is rare for me!

Clear skies.

Peter Chappell

Viewing Log for 22nd of March

During the day Dawn and I had been down to Devon to go to Trago Mills and visit the newest member of the family, namely Olive, a great niece for me? We got back to Swindon around 18:30 and all of the day we were blessed with clear skies, so I thought I would go out and do a viewing session as we were in a spell of quite weather conditions and lots of dry days. I went to my usual viewing place near Uffcott and had my Meade LX90 GOTO telescope set up and ready by 20:06, I would be using a Delos 17.3 mm eye piece. With a temperature of 9 °C and no wind, conditions should be good for viewing?

First target for the evening was Uranus, by now this planet was starting to hang in the western sky. As usual I found the planet in the finderscope and had to manually adjust the telescope to look at it, there was a hint of blue on the surface probably did not help having the glow of Devizes in the general area? I intended to carry on with my Messier (M) marathon hunt but my next target was M 3 which was still fairly low in the eastern sky, so I had some time to kill before I carried out with it. So, I started with M 79 in Lepus, this globular cluster (G C) was a faint fuzzy blob (F F B) to look at, did not help being only 7 ° above the horizon! Normally this has a bright but small core when higher in the sky? On to M 93, an often over looked open cluster (O C), this object was hiding in a tree but I could make out a small and dense centre? Just below Sirius is M 41, a large and very loose O C, not far away is M 48, again a large but loose O C, while viewing this object a satellite went by! On to M 42 and M 43, still good but now starting to fade in the west, both are diffused nebulas (D N). Still in Orion above the belt stars is M 78, this D N I could only make out to two main stars of this system. Now I notice a bright light about 200 yards from me and a man calling? Turned out he was calling his dog which had a green collar on, soon they went on their way and I was left alone. Onto M 1 in Taurus, as usual a large grey blob to me, another satellite went thru while I was viewing this object. Back to the O C's and M 50, a small cluster with a few stars in it. Managed to get M 65 and M 66 in Leo in the same field of view but I could not find NGC 3624, the third member of this triplet, maybe the next time I am out I should try and find this object first and go from there?

By now Canes Venatici had had cleared the eastern horizon so I could carry on with my marathon. As I said before the next object was M 3, a bright and beautiful G C, the hand controller informed me trying higher power and I should be able to make out some stars? I tried the 10 mm eye piece but it was no better? M 53 is a smaller G C and looked like a fuzzy blob (F B). M 64, the Black-Eye galaxy was another F B, being a spiral galaxy (S G) it did not surprise me. My next area is called 'Realm of the Galaxies' around Virgo, lots of S G's I guess? While putting in the instructions in the hand controller a car went past me only to turn around and come back past me, bit strange! Coming to think I had not seen any cars go pass me yet had noticed an end of division sign at the start of the road but not made any sense of it? In the Realm, the first object was M 60, an Elliptical galaxy (E G), this was an F F B to look at? Next object (M 59) was also and E G but could only find it with adverted vision. Back to an S G and M 58, another F F B. The next two object were easy to miss, namely M 89 and M 90. Across the border and into Coma Berenices and M 88, this is an S G and an F F B! I had a lot of trouble in finding M 91, this S G comes in at mag 10.2 which is probably the limit for me

and this telescope? Next three objects were all E G's, starting with M 87, this is an F B but has a small bright core. M 86 was hard to find, a real F F B! M 84 also had a small bright core, an F B. The next three objects I could easy miss them, starting with M 100, a S G followed by M 85, an E G and finally M 98 which I could only find with adverted vision. While looking at M 98 I noticed a tractor in a nearby field and coming towards me. I thought I would soon pack up if it was working in the field, so I went back to M 93 which by now had cleared the tree, this O C was still small and dense, and so I had not missed anything.

The tractor instead went past me on the road, as we had gone down to Devon early in the morning I thought this was a good time to stop, so at 21:57 I started to pack all of the equipment away. I noticed there was no dew on any of the kit used but would still needed to be air dried overnight. By now the temperature had dropped to 8 °C but there was some wind for company. I think the reason why I had trouble with some of the galaxies I looked at tonight was a hazy sky. The sky was clear but the stars seemed dimmer than other times I had looked at them?

Clear skies.

Peter Chappell

PS Reason for only one car in two hours of viewing to go past me, the road ahead was closed which is great for me when out viewing.

<u>Viewing Log for 25th of March</u> (WAS viewing evening)

This was my second viewing session in the week and the second month on the trot, Chris Brooks managed to get the weather to be on our side for the viewing session J. When I arrived at 19:50, first thing I did was to disable the security light, with this light on it really effects what can be seen during the session? After sorting the light out I started to take some of the telescope gear in to the playing field and was totally taken by surprise! I actually said 'I must have come to the wrong place'? As there was at least five telescopes up and running and about eight people! Anyway, after getting over the nice surprise I had my Meade LX90 GOTO telescope set up and ready by 20:16, I would be using the 14 mm Pentax WX eye piece. With a temperature of 12 °C and no wind, it should be a very pleasant evening for viewing.

My first target was the planet Uranus but this was hiding in the branches of the big tree beside the car park, so I had to find other targets. The idea from Chris was to do the Messier (M) marathon during the night but as I had already knocked about 50 of them off my list over the last two sessions I did at Uffcott, I asked what people would like to look at? I gave a few suggestions like open clusters (O C) or galaxies, could we look at an O C? So, I choose M 48 in Hydra, a large but sparse deep sky object. After a few people looked at this object we went off to M 93, a smaller and dimmer O C in Puppis followed by M 41 which is easy to find as it is about 4 ° below the bright star Sirius. This O C is large with a few bright stars within the group. Requests for M 42, the Great Orion nebula, so we slewed to this diffused nebula and got some positive comments about the structure of this object. Up in to Gemini and M 35, a very large O C. Several people had trouble finding the next object, namely M 1, the only supernova remnant on the list. I told them where it was but still had trouble, knock the eye piece gently while viewing the area and hopefully it will give itself away? Some found it but others did not. I knew everyone who looked at the next object should see it namely M 37 in Auriga, this O C is very large and dense with stars. Time for a change and some galaxies, starting with M 81 and M 82 in Ursa Major, probably some of the brightest galaxies on his list? Down to M 51, the Whirlpool galaxy in Canes Venatici, we could make out both of these interacting galaxies, the other galaxy is NGC 5195. I asked a question, do you want to see probably the most boring object on his list? I slewed to M 40, the only double star on the list, every person I asked what they saw said a double star, and maybe they thought it was a trick question? A look at Mizar and Alcor, a nice double double star combo in the handle of the Plough before going to the fourth brightest star in the night sky and brightest in the northern hemisphere, Arcturus. Time to get two galaxies in the same field of view, namely M 65 and M 66 in Leo (part of the triplet with NGC 3624 which we did not see). Final object for the evening for me was M 104, the Sombrero galaxy in Virgo, a faint fuzzy blob!

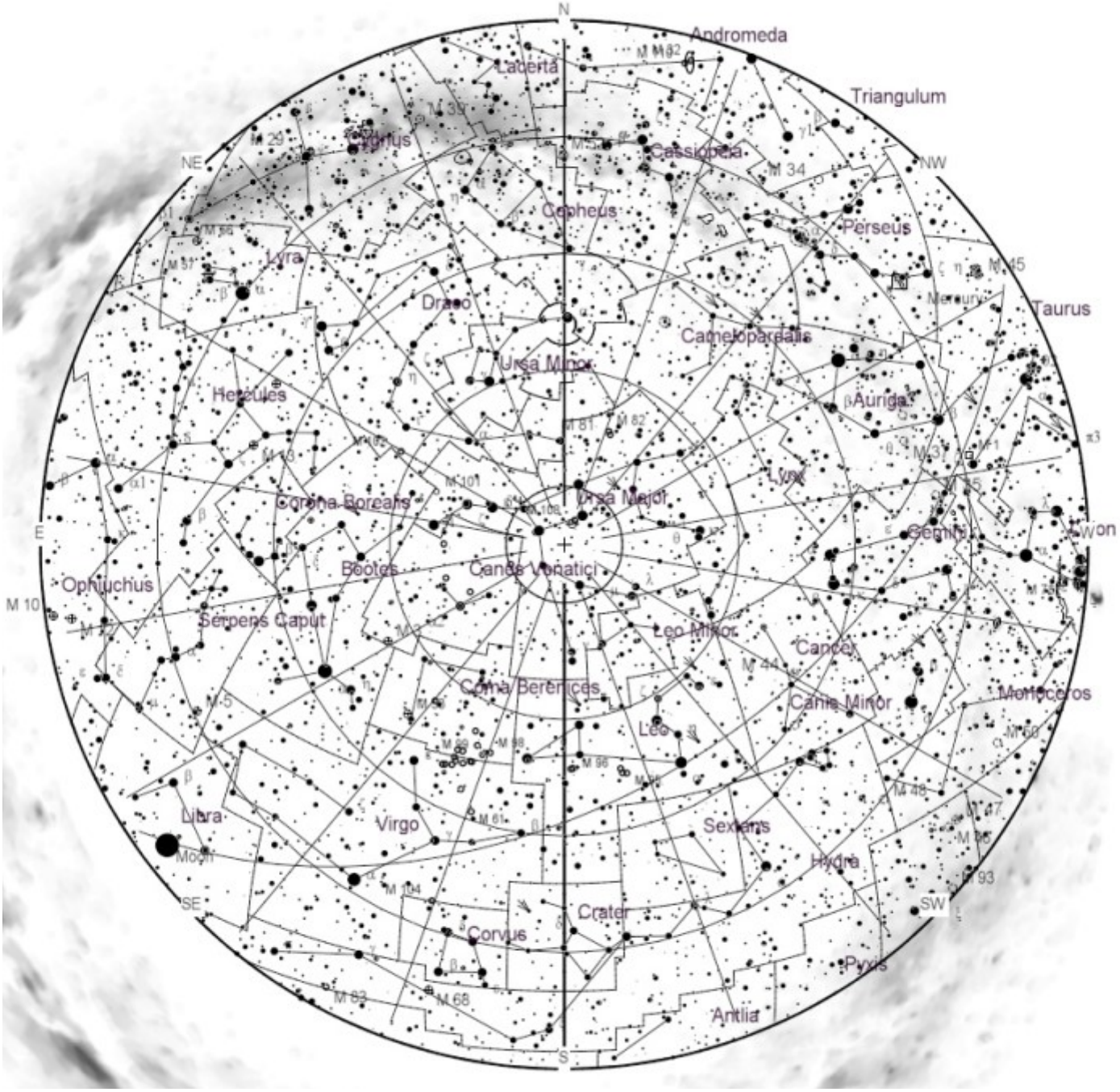
During the evening people came and went, think we had about 14 people during the evening which was brilliant, not had that many in at least 10 years? I decided it was time to pack up at 22:46 as it felt a bit chilly by then, temperature had only dropped to 8 °C. There was still a couple of people left but I think they were doing astrophotography? I knew a chap called Paul was also doing astrophotography which might be featured somewhere in the magazine?

People I spoke to included Tony, Chris, Dave, Paul, Peter and Tracey. Sorry if your name is not included here but could not remember everybody who turned up? Let's hope the next one also has a good turn out?

Clear skies.

Peter Chappell

WHATS UP, APRIL 2022



April 1 - **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 06:27 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.

April 16 - **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 18:57 UTC. This full moon was known by early Native American tribes as the Pink Moon because it marked the appearance of the moss pink, or wild ground phlox, which is one of the first spring flowers. This moon has also been known as the Sprouting Grass Moon, the Growing Moon, and the Egg Moon. Many coastal tribes called it the Fish Moon because this was the time that the shad swam upstream to spawn.

April 22, 23 - **Lyrids Meteor Shower.** The Lyrids is an average shower, usually producing about 20 meteors per hour at its peak. It is produced by dust particles left behind by comet C/1861 G1 Thatcher, which was discovered in 1861. The shower runs annually from April 16-25. It peaks this year on the night of the night of the 22nd and morning of the 23rd. These meteors can sometimes produce bright dust trails that last for several seconds. The waning gibbous moon may block some of the fainter meteors this year, but there is still potential for a good show. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Lyra, but can appear anywhere in the sky.

April 29 - **Mercury at Greatest Eastern Elongation.** The planet Mercury reaches greatest eastern elongation of 20.6 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 evening sky. Look for the planet low in the western sky just after sunset.

April 30 - **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 20:30 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.

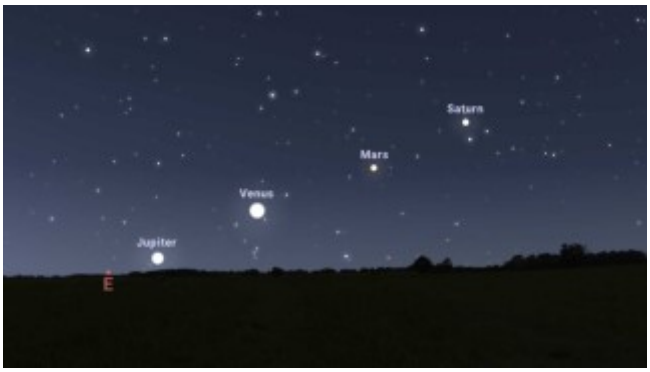
April Morning:See next page for planetary line up.

April's sky brings dance of 4 morning planets: See Jupiter, Venus, Mars and Saturn.

Growing up in the Bronx during the 1960s and '70s, one of my mentors in astronomy was Dr. Kenneth L. Franklin, Chairman and chief scientist at New York's Hayden Planetarium, who wrote about celestial events for the World Almanac and The New York Times.

Periodically Ken would make reference to our "dynamic and ever-changing sky." Such an eloquent description would certainly fit the day-to-day changes among the planets in our early morning sky this month. Morning planets are front and center in April, with four out of the five brightest solar system planets, lined up across the east-southeast sky.

The month starts off with three bright planets clustered low in our east-southeast sky just before sunrise. Venus, Saturn and Mars are within six degrees of separation, but each morning thereafter the configuration noticeably changes. Mars and Saturn approach each other more closely than the apparent diameter of the moon on April 5.



A view of the predawn sky on April 19, 2022 in Stellarium shows the alignment of Jupiter, Venus, Mars and Saturn. (Image credit: Stellarium)

Then, beginning on April 8, Jupiter, still buried deep in the dawn as the month begins, makes its presence felt, albeit far below and to the left of the other three planets. By the morning of April 19, all four planets will be stretched out in a diagonal line spanning just over 30 degrees; from lower left to upper right: Jupiter, Venus, Mars and Saturn.

Towards the end of April the moon scuds along below the planets. (Image credit: Stellarium)

The main event comes during the final week of April with the approach of magnitude -2 Jupiter to magnitude -4 Venus, seven times brighter. Meanwhile, the crescent moon looms, passing below Saturn on April 25, Mars on April 26 and finally Jupiter and Venus on April 27. Make sure you have a wide-open view of the east-southeast horizon that morning with no obstructions and set your alarm clock for 5:15 a.m.

In a single glance, you'll see the three brightest objects in the night sky: a 12% illuminated crescent moon, Jupiter 4 degrees to its upper left and Venus hovering 5 degrees directly above the lunar sliver. Venus and Jupiter are separated by 3.2 degrees that morning, 2 degrees on April 28, and 1.3 degrees on the April 29.

On April 30, Venus and Jupiter stand side-by-side, separated by 0.45 degrees for North America and visible together in a telescope's low-to-medium power view. Jupiter will appear round, three of its four Galilean satellites will be visible and Venus will look slightly more than half-lit.

The Far East sees them near their moments of conjunction and appulse (closest approach) when Venus passes just 0.25 degrees north of Jupiter. This is the closest Venus-Jupiter conjunction since August 2016, when they were deeper in the glow of the sun. A similarly striking pairing of these two planets will occur in the evening sky on March 1, 2023.

The denouement following April 30 is swift. On May 1, the two planets are still strikingly close, separated by 0.6 degrees and this will increase by almost a degree per day, so that by May 8, Jupiter shines 7.1 degrees to Venus' upper right.

In the months to come, these two brightest planets will go in very different ways. Venus will continue to hug the edge of dawn low in the east until August, then will slowly sink into the sunrise. By that time Jupiter will be on the other side of the sky, dominating the evening views.

All of the naked-eye planets, and the moon as well, closely follow an imaginary line in the sky called the ecliptic. The ecliptic is also the apparent path that the sun appears to take through the sky as a result of the Earth's revolution around it.

Technically, the ecliptic represents the extension or projection of the plane of the Earth's orbit out towards the sky. But since the moon and planets move in orbits, whose planes do not differ greatly from that of the Earth's orbit, these bodies, when visible in our sky, always stay relatively close to the ecliptic line.

Twelve of the constellations through which the ecliptic passes form the zodiac; their names which can be readily identified on standard star charts are familiar to millions of horoscope users who would be hard-pressed to find them in the actual sky.

Ancient man probably took note of the fact that the planets — themselves resembling bright stars — had the freedom to wander in the heavens, while the other 'fixed' stars remained rooted in their positions. This ability to move seemed to have an almost magical, God-like quality. And evidence that the planets came to be associated with the gods, lies in their very names, which represent ancient deities.

The skywatchers of thousands of years ago must have deduced that if the movements of the planets had any significance at all, it must be to inform those who could read celestial signs of what the fates held in store. Indeed, even to this day, there are those who firmly believe that the changing positions of the sun, moon and planets can have a decided effect on the destinies of individuals and nations on Earth.

The only problem with this theory is that the planets in the night sky are always shifting in and out of celestial liaisons. Astronomical amnesia allows us to forget the last time we saw them assembling for such a performance.

And we also usually fail to recall that none of the influential magical thinking attributed to the previous event ever materialized.

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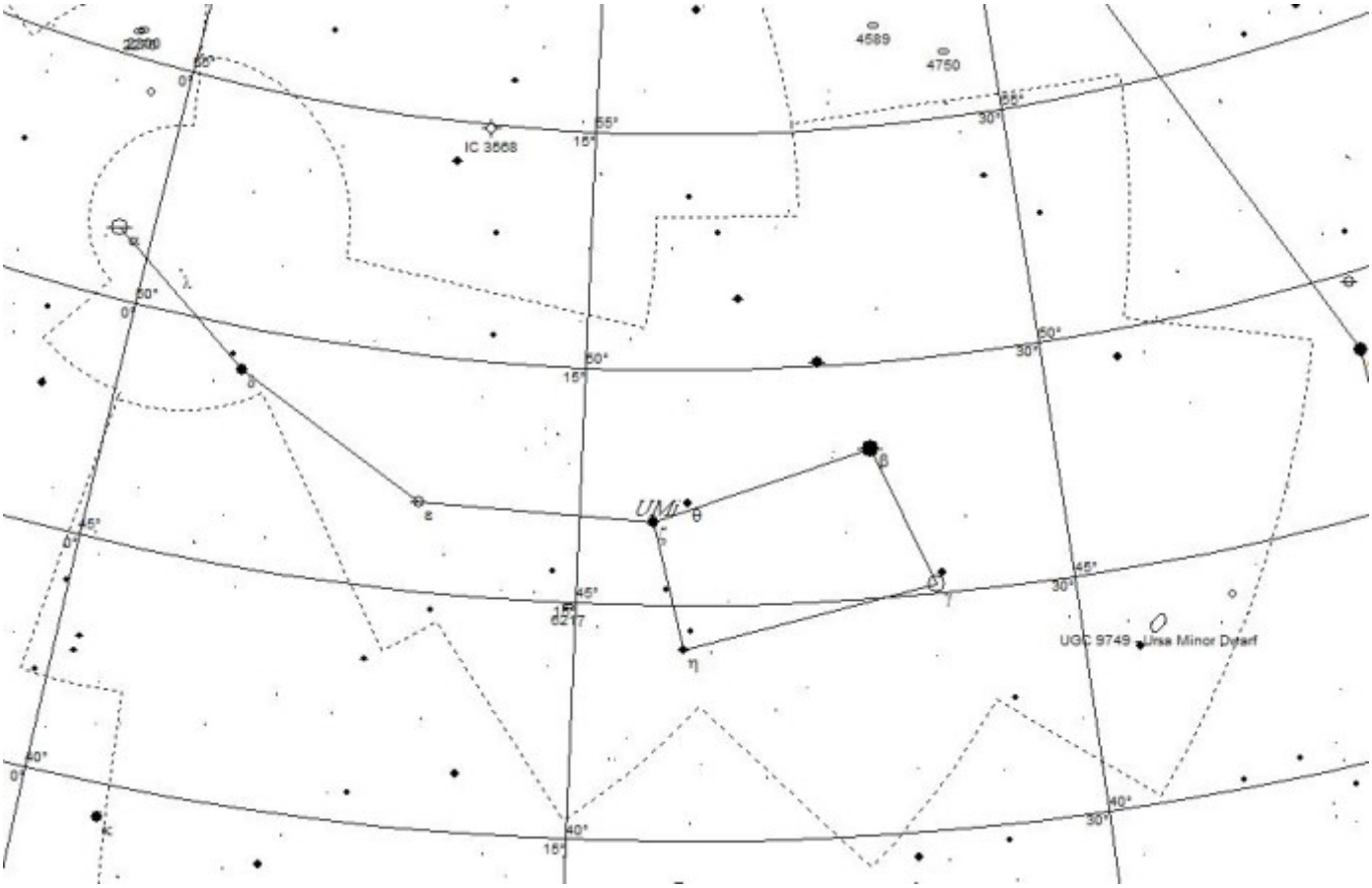
CONSTELLATIONS OF THE MONTH: URSA MINOR



The northern circumpolar constellation of Ursa Minor was one of the 48 original constellations listed by Ptolemy, and remains one of the 88 modern constellations recognized by the IAU. Ursa Minor is currently the location of the north celestial pole, yet in several centuries, due the precession of the equinoxes, it will change. Ursa Minor covers 256 square degrees of sky and ranks 56th in size. It contains 7 main stars in its asterism and has 23 Bayer Flamsteed designated stars within its confines. Ursa Minor is bordered by the constellations of Draco, Camelopardalis and Cepheus. It is visible to all observers located at latitudes between +90° and ?10° and is best seen at culmination during the month of June.

There is one annual meter shower associated with Ursa Minor called the Ursids. Beginning on or about December 17th of each year, we encounter the meteoroid stream and activity can last through the end of December. The meteor shower itself is believed to be associated with Comet Tuttle and was probably discovered by William F. Denning during the 20th century. The peak date of activity occurs on December 22 during about a 12 hour window and you can expect to see about 10 meteors per hour on the average from a dark sky location.

In mythology, Ursa Minor is meant to represent a baby bear with a very long tail. Perhaps this springs from the “tale” of Kallisto and her son, who were placed in the sky as a bear and son. The tail is believed to be elongated from have been swung around the north star! In some forms of mythology, the seven stars of the Little Dipper were considered to be the Hesperides, daughters of Atlas… and it forms the “dragon’s wing” in yet other stories. While the “Little Dipper” asterism is a bit more difficult to recognize because its stars are more faint, once you do understand the pattern, you’ll always remember it. How? The star at the end of the little dipper handle is Polaris, the North Star. Polaris is easily identified by drawing a mental line through the two stars which form the end of the “bowl” of the Big Dipper and extending that line five times the distance.

Now, let’s take a look at Ursa Minor! While there are only a very few deep space objects here (and they require a large telescope) that doesn’t mean the constellation isn’t interesting. One handy thing to note is the stars themselves. The four stars in the “bowl” of the little dipper are unusual because they are of second, third, fourth and fifth stellar magnitude. While that might not seem like a big deal, it’s a great way to judge your sky conditions. What is the dimmest of the stars that you can see? Beta (B) is 2, Gamma (Y) is 3, Zeta (the squiggle) is 4 and the unmarked corner is Eta (n) and it is stellar magnitude 5.

Ready for the brightest star? Then say hello to Alpha (a) – Polaris. Alpha Ursae Minoris is also known as the “North Star” and even as the Lodestar. While it might be 430 light-years from Earth, it is currently the closest star to the north celestial pole and a main sequence supergiant star. But don’t just glance at it and walk away… Get out your telescope! In 1780, Sir William Herschel noticed something a little strange when he was looking at Polaris, and so will you… it has a companion star. That’s right. Polaris is a binary star. Not only that… But when astronomers were examining Polaris B’s spectrum, they noticed something else… You got it! Polaris B also has a spectroscopic companion, making this a tertiary star system. Are you ready for more? Then get this… Polaris A is also a Cepheid variable star! While its changes are very small (about 0.15 of a magnitude every 3.97 days), Polaris has brightened by 15% since we first began studying it and its variability period has lengthened by about 8 seconds each year since. That makes Polaris more than just a another star… It’s a super star!

Now aim your binoculars at Beta Ursae Minoris. Its name is Kochab and it is about 127 light years from our solar system. This orange giant star shines about 130 times more brightly

than our own Sun. Somewhere around 3000 years ago, Kochab was once the pole star – but as Earth's precessional motion changed, so did its position. Even then it still wasn't quite as close as Polaris!

How about Gamma Ursae Minoris? That's the "Y" symbol on our chart. Known as Pherkad, this spectral class A3 star is about 480 light years away and it is pretty special, too. Why? Because it's a Delta Scuti type variable star and its brightness varies by 0.05 magnitudes with a period of 3.43 hours. While you're not going to notice any change by just watching, image the power behind a star that shines 1100 times more luminous than the Sun, and possesses a radius 15 times larger!

Are you ready for Epsilon? Then get out the telescope, because 347 light year distant Epsilon is an eclipsing spectroscopic binary star. (Say that five times fast!) It is classified as a yellow G-type giant star with a mean apparent stellar magnitude of 4.21. In addition to light changes due to eclipses, the system is also classified as an RS Canum Venaticorum type variable star and its brightness varies from magnitude 4.19 to 4.23 with a period of 39.48 days, which is also the orbital period of the binary. The binary it orbited by a third component, Epsilon Ursae Minoris B, which is an 11th magnitude star, 77 arc seconds distant.

Now for Delta – the "8". Delta Ursae Minoris is about 183 light years away and goes by the strange name, Pherkard. While it isn't as grand as its mates, at least it is a white A-type main sequence dwarf star!

Last, but not least, is RR Ursae Minoris. You've got it… The double letter designation denotes a variable star. While changes are very small (4.73 at minimum and magnitude 4.53 at maximum) it's the period that counts here. The changes take period of 748.9 days to happen! This means that RR has been highly studied to make sure it doesn't have a spectroscopic companion – and so far none have been found.

Double stars:

Alpha UMi is a well-known double star with a wide ninth magnitude companion: 2.1, 9.1; PA 218º, separation 18.4".

Variable stars:

Alpha UMi (Pole Star) is a cepheid varying from 1.92 to 2.07 every 3d 23h 16m 28.8s.

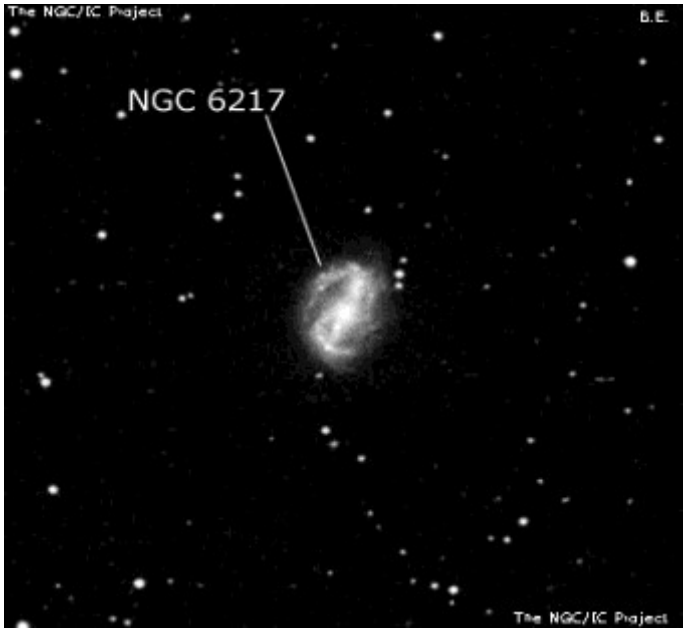
Gamma UMi is a delta Scuti type variable with extremely small range (3.04 - 3.09) every 3h 26m.

Epsilon UMi is an EA type variable: 4.19 - 4.23, period 39.48d

Deep Sky Objects:

NGC 6217

UGC9749 The Ursa Minor Dwarf Galaxy



A consequence of the precession is a changing pole star. Currently Polaris is extremely well-suited to mark the position of the north celestial pole, as Polaris is a moderately bright star with a visual magnitude of 2.1 (variable), and it is located within a half degree of the pole.

On the other hand, Thuban in the constellation Draco, which was the pole star in 3000 BC, is much less conspicuous at magnitude 3.67 (one-fifth as bright as Polaris); today it is invisible in light-polluted urban skies.

The brilliant Vega in the constellation Lyra is often touted as the best north star (it fulfilled that role around 12000 BC and will do so again around the year AD 14000), however it never comes closer than 5° to the pole.

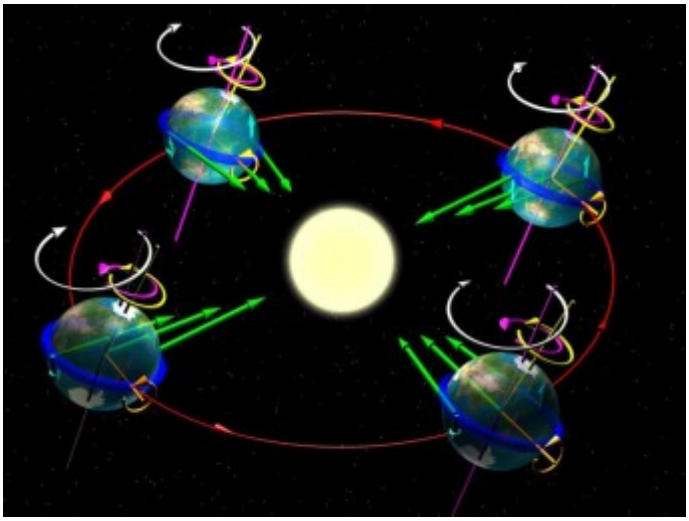
When Polaris becomes the north star again around 27800 AD, due to its proper motion it then will be farther away from the pole than it is now, while in 23600 BC it came closer to the pole.

It is more difficult to find the south celestial pole in the sky at this moment, as that area is a particularly bland portion of the sky, and the nominal south pole star is Sigma Octantis, which with magnitude 5.5 is barely visible to the naked eye even under ideal conditions. That will change from the eightieth to the ninetieth centuries, however, when the south celestial pole travels through the False Cross.

This situation also is seen on a star map. The orientation of the south pole is moving toward the Southern Cross constellation. For the last 2,000 years or so, the Southern Cross has nicely pointed to the south pole. By consequence, the constellation is no longer visible from subtropical northern latitudes, as it was in the time of the ancient Greeks .

Like a wobbling top, the orientation of the Earth's axis is slowly but continuously changing, tracing out a conical shape in a cycle of approximately 25,765 years (the so called Great or Platonic year, and also the determining factor in the length of an astrological age). This movement is caused by the gravitational forces of the Sun and the Moon, and to a lesser extent other bodies, on the equatorial bulge of the spinning Earth. The term "precession" typically refers only to this largest periodic motion; other changes in the alignment of Earth's axis — nutation and polar motion — are very much smaller in magnitude.

The precession of the Earth's axis has a number of observable effects. Firstly, the positions of the north and south celestial poles appear to move in circles against the (assumed fixed) backdrop of stars, completing one circuit in approximately 25,700 years. Thus, while today the star Polaris lies approximately at the north celestial pole, this will change over time, and other stars will become the "north star". As the celestial poles shift, there is a corresponding gradual shift in the apparent orientation of the whole star field, as viewed from a particular position on Earth.



ISS PASSES For Marchand early April 2022

from Heavens Above website maintained by Chris Peat.

Date	Brightness	Start	Highest point	End						
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
26 Apr	-1.0	04:43:23	**10°**	**SSE**	**04:44:03**	**10°**	**SE**	**04:44:42**	**10°**	**SE**
28 Apr	-1.9	04:40:09	10°	SSW	04:42:45	21°	SE	04:45:23	10°	E
29 Apr	-1.5	03:53:05	13°	SSE	03:54:09	15°	SE	03:56:05	10°	ESE
30 Apr	-2.9	04:38:53	13°	SW	04:41:32	39°	SSE	04:44:41	10°	E
01 May	-2.5	03:51:44	23°	S	03:52:47	28°	SSE	03:55:42	10°	E
02 May	-1.9	03:04:31	19°	SE	03:04:31	19°	SE	03:06:33	10°	E
02 May	-3.7	04:37:22	12°	WSW	04:40:21	65°	SSE	04:43:40	10°	E
03 May	-3.4	03:50:06	29°	SW	03:51:29	50°	SSE	03:54:44	10°	E
04 May	-3.0	03:02:47	36°	SE	03:02:47	36°	SE	03:05:44	10°	E
04 May	-3.8	04:35:48	10°	W	04:39:10	89°	SSE	04:42:31	10°	E
05 May	-1.6	02:15:25	18°	ESE	02:15:25	18°	ESE	02:16:37	10°	E
05 May	-3.9	03:48:15	23°	WSW	03:50:11	77°	SSE	03:53:33	10°	E
06 May	-3.8	03:00:50	56°	SSW	03:01:13	62°	SSE	03:04:32	10°	E
06 May	-3.7	04:34:33	10°	W	04:37:55	85°	N	04:41:15	10°	E
07 May	-2.5	02:13:23	32°	ESE	02:13:23	32°	ESE	02:15:29	10°	E
07 May	-3.8	03:46:13	15°	W	03:48:52	86°	N	03:52:14	10°	E
08 May	-1.2	01:25:53	13°	E	01:25:53	13°	E	01:26:22	10°	E
08 May	-3.9	02:58:42	39°	WSW	02:59:48	87°	S	03:03:10	10°	E
08 May	-3.8	04:33:11	10°	W	04:36:33	83°	S	04:39:53	10°	ESE
09 May	-3.7	02:11:09	63°	ESE	02:11:09	63°	ESE	02:14:05	10°	E
09 May	-3.8	03:44:07	10°	W	03:47:28	88°	N	03:50:50	10°	E
10 May	-2.0	01:23:34	23°	E	01:23:34	23°	E	01:25:00	10°	E
10 May	-3.8	02:56:24	23°	W	02:58:21	84°	N	03:01:43	10°	E
10 May	-3.7	04:31:44	10°	W	04:35:02	57°	SSW	04:38:19	10°	ESE
11 May	-3.9	02:08:45	63°	W	02:09:14	87°	N	02:12:35	10°	E
11 May	-3.9	03:42:36	10°	W	03:45:57	73°	SSW	03:49:17	10°	ESE
12 May	-3.0	01:21:04	43°	E	01:21:04	43°	E	01:23:27	10°	E
12 May	-3.9	02:53:52	13°	W	02:56:49	86°	S	03:00:10	10°	ESE
12 May	-3.1	04:30:15	10°	W	04:33:18	33°	SSW	04:36:21	10°	SE
13 May	-1.7	00:33:14	18°	E	00:33:14	18°	E	00:34:16	10°	E
13 May	-3.8	02:06:03	29°	W	02:07:38	86°	N	02:11:00	10°	E
13 May	-3.5	03:41:00	10°	W	03:44:14	46°	SSW	03:47:28	10°	SE
13 May	-2.1	22:03:35	10°	S	22:05:37	15°	SE	22:06:05	15°	SE
13 May	-1.8	23:38:30	10°	WSW	23:44:58	11°	E	23:45:04	10°	E

END IMAGES, OBSERVING AND OUTREACH

Star trails looking north from 10 degrees north of the equator just after sunset. 1 hours worth of tracking from the open restaurant at the hotel in Costa Rica. Canon G7 IIx, internal software makes 6 second exposures and builds the image in camera. I was hoping to do more southerly skies but it meant going out of the hotel and into the dry jungle. This is not advised with the number of poisonous snakes in the leaves! Andy Burns

Observing Sessions and Covid19 - Update

Proposed Observation Sessions for 2021-2022

Any observing meetings will need to to be safe and follow social distancing recommendations.
A reminder email shall be sent out early on in the week to inform you of the planned event but it should also be noted that like the weather, Government guidelines may change at any time and therefore the usual email will be sent out by 16:00 on the day giving notice of whether observing is 'ON' or 'OFF' that evening, so look out for these. If a session is cancelled we may then possibly plan a new different date.

Planned observing evenings will be on a Friday night in the Lacock playing fields behind the Red Lion pub at 19:00 or an Hour after sunset depending on the time of year.
With the New Moon being around the beginning of the month and the full moon generally around the middle, the following dates for observing are proposed:

- **Friday 29 April 2022**
- **Friday 27 May 2022**
- **Friday 03 June 2022 (limited sky darkness)**

The final decision on the planned dates will be advised shortly and published on the website :https://wasnet.org.uk/observing/ **but we shall also try to arrange special evenings for events such as meteor showers/ Lunar eclipses etc.**
Also if members wish to propose a ad-hoc session for other reasons and at other locations, such as astro-photography, solar observing etc, with other like-minded members then they can do so through the Society Members Facebook Page or through the WAS contact page on the website.

OUTREACH

Zoom sessions and Google Classroom sessions have kept outreach going to schools
If any schools or clubs are interested in having talks from WAS please contact Andy Burns.
Dark Skies Wales are starting their live observing sessions, but talks are delayed.