NWASNEWS

Volume28 Issue 7

March 2023

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

The end of February and start of March brough us the exciting conjunction of Venus and Jupiter in our western skies.

It also brought some Aurora into our skies here in Wiltshire, but it also brought a large amount of cloud at just the wrong time.

But on the 27th February I was able to catch some of the Aurora through the scaffolding poles that prevented me opening windows other than one small fan light.

Venus and Jupiter closest conjunction was on the 1st of March, so no surprise that was clouded out but the 2nd March brought a short break in the cloud so I caught the two planets just past some trees, 400mm, then zoom hand held on Jupiter showed its Galilean moons Callisto, Ganymede, Europa and below Jupiter, Io.

Andy Burns.

SHADOWING THE UNIVERSE...

Welcome to Mary McIntyre, our speaker for the Wiltshire Society this evening. It was touch and go for the weather this evening, but forecasts of snow and ice have given way to more optimistic conditions but I had plans to go to Zoom up my sleeve if things were bad.

At last Mary is used to driving by shadow light with all the wonderful drawings she makes, and a flat full Moon between clouds casts its shadows here rather than the sunlight on its surface.

An interesting article popped up in my monthly trawl through the astronomical news for the newsletter that looks at the images of the black hole image published last year. The dark middle is now thought to be the shadow of a secondary black-hole.at the centre of our galaxy. These shadows get everywhere!

After our last meeting I contacted Nick H about his offer to be speaker secretary for next year, but workload issues with the Ukraine situation means he is not able to give the time he thought he might have, so I am asking for someone to take over from Peter for from the end of this season as speaker secretary.

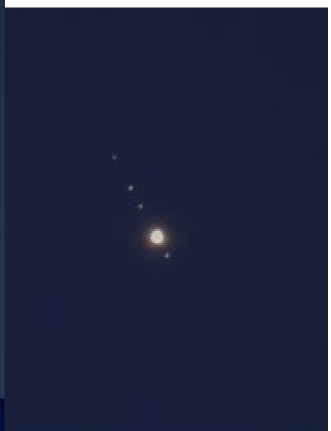
Nick has some ideas for speakers who may attent or be on Zoom but we need to be acting on next year's list sooner rather than later.

I am also looking for someone to takeover the tea/coffee duties. Carrying the supplies box, getting milk and bringing the projector to meetings. I have been doing this briefly while we sorted from Dave Buckle dropping out to move in part to Devon.

I am also still looking for volunteers to be be chair of the society. I nearly retired once, but I had to step back in, then the dreaded COVID happened. But I really feel it is time that the society moved forward with younger blood. I will gladly help with any transition.

Clear Skies

Andy



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 Meetings we will try to hold these at the hall

Meet 7.30 for 8.00pm start

SEASON 2022/23

2023

7 Mar Mary McIntyre Shadows in Space & the stories they tell
4 Apr Chris Starr Heavy Metal World
2 May Dr Paul A Daniels The Mega-constellation threat
6 Jun Andrew Lound Venus, Paradise Lost

Mary McIntyre

I moved to rural Oxfordshire in 2011 where my husband Mark and I have a garden observatory. Most of the pictures on my site were taken in our garden, with a few exceptions which were taken from Astrofarm in France or whilst on holiday.

I am passionate about astronomy outreach and I've been giving talks on Astronomy and Astrophotography since 2015 to a mixture of camera clubs, astronomy societies, local schools and Scouts groups, as well as running astronomy sketching workshops. I love sharing my knowledge and experience, so if you are interested in booking me to speak please check out my talks list page by clicking here and then use the Booking Form to contact me.

You can buy prints of my astronomy photographs and astronomy sketches in my online shop, along with my hand-made jewellery.

The talk Mary will be giving tonight:

"Shadows in Space and the Stories They Tell"– from shadows on Earth to shadows on the surface of the Moon we can learn a lot. But it doesn't stop there; cameras on probes in orbit around other planets and their moons have taught us a lot just by studying the shadows visible there. I gave this talk as the William Fox Memorial Lecture at the BAA Horncastle weekend in 2018 and it was well received. A 30 minute version of this is also available.

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.

Sam Franklin (Treasurer)

Rebecca Rowan (Hall coordinator)

??? (Teas and Projector)

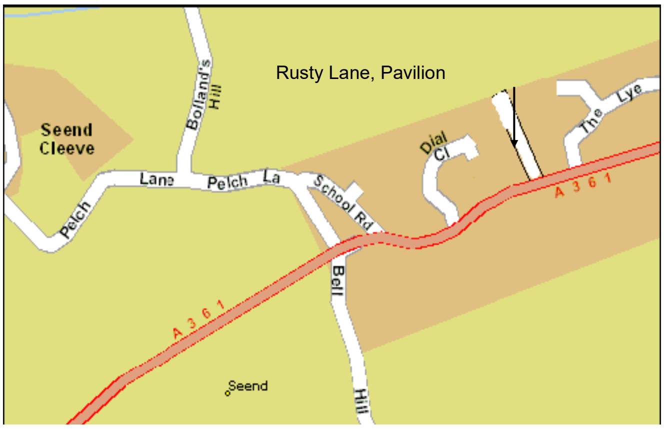
Peter Chappell (Speaker secretary) Retiring

Nick Howes (Technical Guru)

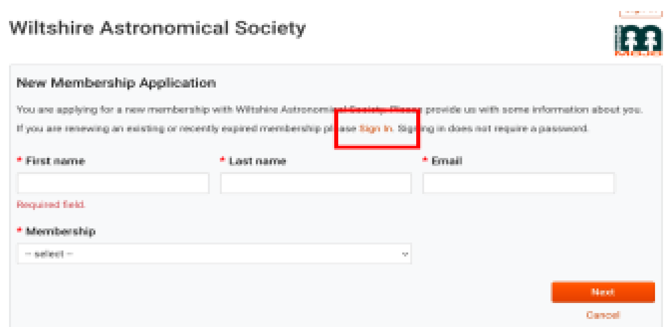
Observing Sessions coordinators: Chris Brooks, Jon Gale,

Web coordinator: Sam Franklin

Contact via the web site details.



Observing Sessions see back page


Wiltshire Astronomical Society

New Membership Application

You are applying for a new membership with Wiltshire Astronomi… provide us with some information about you.
If you are renewing an existing or recently expired membership pl…ase Sign in. Sig…ing in does not require a password.

* First name * Last name * Email

Required field.

* Membership

-- select --

Next

Cancel

Swindon's own astronomy group

Physical meetings continuing!

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

Friday, 17 March - AGM and a talk by Damian Ohara

Our AGM this year will be followed by a talk by

Damian Ohara on 'A Walk Through Astrophotography'

Damian OHara was born in Sheffield and moved to the Swindon area in 1990 after 9 years with the RAF.
He has worked in the Electronics and then the IT industry since then and runs a consultancy that assists large companies with their IT Security.

Although fascinated by astronomy as a boy he only recently had the time and opportunity to take it up more fully. A strong advocate for astrophotography, in 2019 he obtained his first image of M31 and the Orion Nebula and today is an avid user of Electronically Assisted Astronomy.

A Walk through Astrophotography

We will discover how astrophotography captures images and imaginations. A journey through equipment and techniques, challenges and solutions will bring us to a better understanding of this fascinating activity.

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

Meeting Dates For 2023

Friday, 17 March 19.30

Programme: AGM + A Walk Through Astrophotography by Damian Ohara

Friday, 21 April 19.30 onwards

Programme: Prof Matt Griffin: Far Infrared Astronomy from Space

Friday, 19 May 19.30 onwards

Programme: Prof Nick Evans - Dark Energy - a cosmological overview of empty space and links to particle physics

Friday, 16 June 19.30 onwards

Programme: Bob Mizon MBE - Stars over the Nile - Ancient Egyptian Astronomy and star lore

------Summer Break-----

Friday, 15 September 19.30 onwards -

Programme: First Light Optics: Product trends / changes / news and upcoming products

Friday, 20 October 19.30 onwards Programme: Prof Martin Hendry MBE - The Science of Star Wars

Friday, 17 November 19.30 onwards Programme: Dr Lillian Hobbs: Eisa Esinga - The Planetarium in the Bedroom

Friday, 8 December 19.30 onwards Programme: Christmas Social

Website:
http://www.swindonstargazers.com

Chairman: Robin Wilkey

Tel No: 07808 775630
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Address: 61 Northern Road
Swindon, SN2 1PD

Secretary: Hilary Wilkey
Email: hilary@wilkey.org.uk
Address: 61 Northern Road
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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

A friendly bunch of stargazers and enthusiastic astronomers who share experiences and know-how as well as offer an extensive outreach programme of public and young people's observing. As a partner to Bath Preservation Trust, they are the resident astronomers at the Herschel Museum of Astronomy, 19 New King Street, Bath, BA1 2BL and partner with Bath Abbey to showcase the skies above the city.

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

Next Meetings:
Wednesday, 29th March
Asteroids, Comets and the Death of the Dinosaurs – Martin Lunn joins us via Zoom Wizardry to connect kids two favourite things: Space Rocks and Dinosaurs.

Wednesday, 26th April
When we Walked on the Moon – Ian Ridpath takes us back over 50 years in a prelude to the resumption of lunar strolls in 2025

More information and news is available via:
https://bathastronomers.org.uk
https://www.youtube.com/@bathastronomers
On Social Media (Facebook, Twitter, Instagram) as **@BathAstronomers**
https://stem.bathastronomers.org.uk/ for shared outreach materials

Public stargazing is scheduled twice a month on Saturday evenings as well as during school holidays to promote astronomy in Bath and Somerset area. Locations vary to bring telescopes to local communities. The Easter Holidays, 1st to 16th Apr, will include nightly opportunities to discover the night sky.

Member's observing is conducted from the Monkton Combe Community Observatory using the 1860 Refractor and more modern telescopes. We try to avoid school nights but will run member's sessions when the clouds look like they'll recede long enough to align a Celestron Goto Scope.

Get in touch by email hello@bathastronomers.org.uk whether you'd like to find out more, pop in for a visit, share the stars , or have Bath Astronomers visit your school, young persons' group (rainbows, beavers, brownies, cubs, guides, scouts, rangers etc) or your community. The Coordination Team of Annie, Camilla, Jade, Jonathan, Meyrick, Mike, Prim and Simon will be happy to help you.

FORDINGBRIDGE AS

Our March meeting will be on Wednesday 15th March, starting at 7.30pm and we are delighted to welcome our very own **James Fradgely** who will present **"Rodinia and the Boring Billion"**.
This will be followed by Duncan's **Pick of the Month**, Fordingbridge Astronomers' **Object of the Month** and especially **What to look out for in the sky this month**. There will be a short 10-15 minute break after Jame's talk to charge glasses and catch up with everyone.

We will be holding the meeting in our usual venue at The Elm Tree, Hightown, near Ringwood. The postcode to find the place is BH24 3DY. We'll be meeting in The Barn at the rear of the pub and if you've not been before, just ask the bar staff where the meeting is. There is plenty of parking for those who want to come along and there is a £2 charge for non-members attending the meeting.

We will also be holding the meeting on Zoom and the Zoom Invite details are below and will also be on Discord. If the technology lets us, we will start the Zoom meeting a little earlier to sort any gremlins out.

Join Zoom Meeting
https://us06web.zoom.us/j/89390811447?pwd=eDR0aUFVTHMwQ0JrZUJDZTNPbHBZZz09
Meeting ID: 893 9081 1447
Passcode: 850785

SPACE NEWS TO MARCH 23

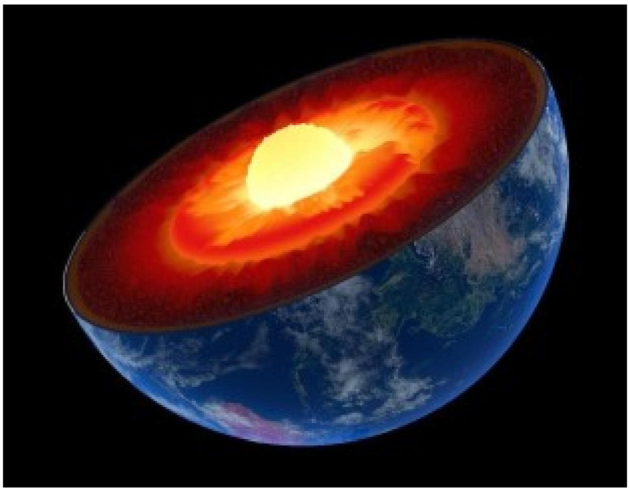
Space News

The Earth has an Even More Inner Core, and it's a Ball of Solid Metal

For generations, scientists have probed the structure and composition of the planet using seismic wave studies. This consists of measuring shock waves caused by Earthquakes as they penetrate and pass through the Earth's core region. By noting differences in speed (a process known as anisotropy), scientists can determine which regions are denser than others. These studies have led to the predominant geological model that incorporates four distinct layers: a crust and a mantle (composed largely of silicate minerals) and an outer core and inner core composed of nickel-iron.

According to seismologists from The Australian National University (ANU), data obtained in a recent study has shed new light on the deepest parts of Earth's inner core. In a paper that appeared in *Nature Communications*, the team reports finding evidence for another distinct layer (a solid metal ball) in the center of Earth's inner core – an "innermost inner core." These findings could shed new light on the evolution of our planet and lead to revised geological models of Earth that include five distinct layers instead of the traditional four.

The research was led by Dr. Thanh-Son Pham and Dr. Hrvoje Tkalcic, a postdoctoral fellow and professor with ANU's Research School of Earth Sciences (RSES), respectively. As they indicate, the team stacked seismic wave data from about 200 earthquakes in the past decade that were magnitude-6 or more. The triggered waveforms were recorded by seismic stations worldwide, which traveled directly through the Earth's center to the opposite side of the globe (the antipode) before traveling back to the source of the earthquake.



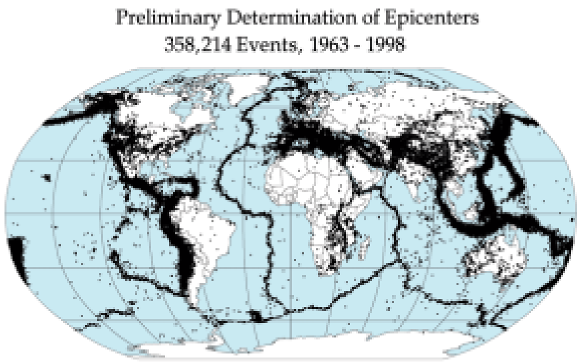
Artist's impression of Earth's interior structure. Credit: Argonne National Labs

Anisotropy measurements of Earth's inner core based on these waves' travel times revealed previously-unrecorded data about Earth's interior structure. This included the possible presence of a layered structure in the innermost part of the inner core. "The existence of an internal metallic ball within the inner core, the innermost inner core, was hypothesized about 20 years ago," said Dr. Pham in an ANU press release. "We now provide another line of evidence to prove the hypothesis."

The direction and travel times of seismic waves indicate differences in the arrangement of iron atoms at high temperatures and pressures or the preferred alignment of growing crystals. After examining the bouncing seismic waves, the team found that they repeatedly probed spots near the Earth's center from different angles. By analyzing the variation in travel times from different earthquakes, they inferred that the crystalized structure in the core's innermost region is likely to have an outer layer.

According to the team, these findings might explain how waves speed up or slow down depending on their angle of entry as they penetrate the innermost inner core. Said Dr. Pham:

"By developing a technique to boost the signals recorded by densely populated seismograph networks, we observed, for the first time, seismic waves that bounce back -and forth up to five times along the Earth's diameter. Previous studies have documented only a single antipodal bounce. The findings are exciting because they provide a new way to probe the Earth's inner core and its centremost region."



Global earthquake epicenters, 1963–1998. Credit: NASA/DTAM

One of the earthquakes they studied originated in Alaska, which triggered seismic waves that 'bounced off' somewhere in the South Atlantic before traveling back to Alaska. According to the ANU team, these findings also suggest that there could have been a major global event in Earth's past that led to a significant change in the crystal structure of Earth's inner core. Therefore, said Prof. Tkalcic, the study of Earth's deep interior could tell us more about the evolutionary history of planet Earth:

"This inner core is like a time capsule of Earth's evolutionary history – it's a fossilized record that serves as a gateway into the events of our planet's past. Events that happened on Earth hundreds of millions to billions of years ago. There are still many unanswered questions about the Earth's innermost inner core, which could hold the secrets to piecing together the mystery of our planet's formation."

The Universe May Have Started with a Dark Big Bang

The Big Bang may have not been alone. The appearance of all the particles and radiation in the universe may have been joined by another Big Bang that flooded our universe with dark matter particles. And we may be able to detect it.

In the standard cosmological picture the early universe was a very exotic place. Perhaps the most momentous thing to happen in our cosmos was the event of inflation, which at very early times after the Big Bang sent our universe into a period of extremely rapid expansion. When inflation ended, the exotic quantum fields that drove that event decayed, transforming themselves into the flood of particles and radiation that remain today.

When our universe was less than 20 minutes old, those particles began to assemble themselves into the first protons and neutrons during what we call Big Bang Nucleosynthesis. Big Bang Nucleosynthesis is a pillar of modern cosmology, as the calculations behind it accurately predict the amount of hydrogen and helium in the cosmos.

However, despite the success of our picture of the early universe, we still do not understand dark matter, which is the mysterious and invisible form of matter that takes up the vast majority of mass in the cosmos. The standard assumption in Big Bang models is that whatever process generated particles and radiation also created the dark matter. And after that the dark matter just hung around ignoring everybody else.

But a team of researchers have proposed a new idea. They argue that our inflation and Big Bang Nucleosynthesis eras were not alone. Dark matter may have evolved along a completely separate trajectory. In this scenario when inflation ended it still flooded the universe with particles and radiation. But not dark matter. Instead there was some quantum field remaining that did not decay away. As the universe expanded and cooled, that extra quantum field did eventually transform itself triggering the formation of dark matter.

The advantage of this approach is that it decouples the evolution of dark matter from normal matter, so that Big Bang Nucleosynthesis can proceed as we currently understand it while the dark matter evolves along a separate track.

This approach also opens up avenues to explore a rich variety of theoretical models of dark matter because now that it has a separate evolutionary track, it's easier to keep track of in the calculations to see how it might compare to observations. For example, the team behind the paper were able to determine that if there was a so-called Dark Big bang, it had to happen when our universe was less than one month old.

The research also found that the appearance of a Dark Big Bang released a very unique signature of strong gravitational waves that would persist into the present-day universe. Ongoing experiments like pulsar timing arrays should be able to detect these gravitational waves, if they exist .

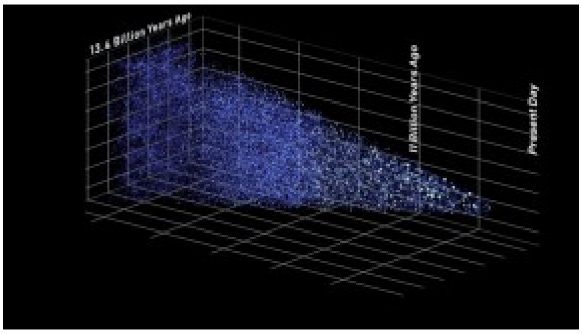
We still do not yet know if a Dark Big Bang happened, but this work gives a clear pathway to testing the idea.

It Would Take Hubble 85 Years to Match What Nancy Grace Roman Will See in 63 Days

Less than a year and a half into its primary mission, the *James Webb Space Telescope* (JWST) has already revolutionized astronomy as we know it. Using its advanced optics, infrared imaging, and spectrometers, the JWST has provided us with the most detailed and breathtaking images of the cosmos to date. But in the coming years, this telescope and its peers will be joined by another next-generation instrument: the *Nancy Grace Roman Space Telescope* (RST). Appropriately named after "the Mother of Hubble," *Roman* will pick up where *Hubble* left off by peering back to the beginning of time.

Like *Hubble*, the RST will have a 2.4-meter (7.9 ft) primary mirror and advanced instruments to capture images in different wavelengths. However, the RST will also have a gigantic 300-megapixel camera – the Wide Field Instrument (WFI) – that will enable a field of view two-hundred times greater than Hubble's. In a recent study, an international team of NASA-led researchers described a simulation they created that previewed what the RST could see. The resulting data set will enable new experiments and opportunities for the RST once it takes to space in 2027.

The team included researchers from the Astrophysics Science Division at NASA's Goddard Space Flight Center, the Flatiron Institute's Center for Computational Astrophysics, the National Astronomical Observatory of Japan (NAOJ), the South African Astronomical Observatory (SAAO), the Space Telescope Science Institute (STScI), the European Southern Observatory (ESO), the Mitchell Institute for Fundamental Physics and Astronomy, the Ecole Polytechnique Fédeérale de Lausanne (EPFL), and multiple universities.



Side view of the simulated Universe, each dot represents a galaxy whose size and brightness corresponding to its mass. Credits: NASA/GSFC/A. Yung

The simulation was based on a well-tested theory of galaxy formation that incorporates the most widely accepted cosmological model – the Lambda Cold Dark Matter (LCDM) model. This allowed the team to simulate five light cones measuring two-square-degree in diameter (about ten times the apparent size of a full Moon) that contained over 5 million galaxies each. These galaxies were distributed across the redshift spectrum (z=1-10), corresponding to distances of 1 million and over 13 billion light-years.

The paper describing their results was published in *The Monthly Notices of the Royal Astronomical Society* in December 2022. Aaron Yung, a postdoctoral fellow at NASA's Goddard Space Flight Center who led the study, said in a recent NASA press release:

"The Hubble and James Webb Space Telescopes are optimized for studying astronomical objects in depth and up close, so they're like looking at the universe through pinholes. To solve cosmic mysteries on the biggest scales, we need a space telescope that can provide a far larger view. That's exactly what Roman is designed to do."

When it commences operations, these and other simulations will provide a framework for astronomers that can be compared to observational data. This will allow scientists to scrutinize their astrophysical and cosmological models, with implications for everything from the formation and evolution of galaxies to Dark Matter, Dark Energy, and much more. This will be possible thanks to *Roman's* ability to combine a field of view two orders of magnitude larger than *Hubble* (and an angular resolution to match) with advanced spectroscopy.

For instance, by observing how Dark Matter causes light from more distant objects to be warped and amplified (gravitation lensing), *Roman* will help us see how Dark Matter Haloes developed over time. Whereas it would take other space telescopes close to a century (or more) to map out these vast cosmic structures, *Roman* could do the same job within 63 days. In addition to its wide field of view, this will be made possible thanks to the observatory's fast slewing speed and rigid structure. Basically, *Roman* can move rapidly from one target to the next since its components (like the solar arrays) are fixed in place.

This means that vibrations caused by repositioning will subside quickly, cutting down on the wait time between image acquisition. "Roman will take around 100,000 pictures every year," said Jeffrey Kruk, a research astrophysicist at NASA Goddard (and a co-author on the paper). "Given *Roman*'s larger field of view, it would take longer than our lifetimes even for powerful telescopes like Hubble or Webb to cover as much sky."

Another exciting aspect of the RST is how it will collaborate with other observatories to study the Universe in more detail. This includes identifying targets for follow-up studies using *Hubble*'s broader wavelength coverage and *Webb*'s more detailed infrared observations. This will provide in-depth studies of cosmic objects ranging from galaxies and galaxy clusters to exoplanets and objects in the Solar System. Said Yung:

"Roman will have the unique ability to match the depth of the Hubble Ultra Deep Field, yet cover several times more sky area than wide surveys such as the CANDELS survey. Such a full view of the early universe will help us understand how representative Hubble and Webb's snapshots are of what it was like then."

"Simulations like these will be crucial in connecting unprecedented large galaxy surveys from Roman to the unseen scaffolding of dark matter that determines the distribution of those galaxies," added Sangeeta Malhotra, an astrophysicist at Goddard and a co-author of the paper. All told, the simulation provides forecasts on the number density of galaxies, star formation rates (SFR), field-to-field variance, and angular two-point correlation functions. It also demonstrates how future wide-field surveys will be able to improve these measurements relative to current surveys.

In addition to the RST, the team's simulations also provide photometry for several other instruments on upcoming observatories. This includes the ESA's *Euclid* mission and the Vera Rubin Observatory, a space-based telescope that will study Dark Energy and a ground-based observatory that will characterize millions of objects in the Solar System (respectively). Both missions are expected to launch or begin collecting light sometime later this year. The coming years will be an exciting time for astronomers and cosmologists. And, with any luck, revelatory!

ESA's Solar Orbiter Spies a Transit of Mercury

Solar Orbiter's unique vantage point recently allowed researchers to make a crucial observation of the solar system's innermost world.

You never know when a chance for some extra space science will present itself. Recently, European Space Agency (ESA) mission controllers had just such a chance, when the planet Mercury passed in front of our host star as seen from the Solar Orbiter's point of view in space.

Also known as SolO, ESA's Solar Orbiter mission launched on a United Launch Alliance Atlas V rocket from Cape Canaveral Space Force Station in Florida on February 10, 2020, on a mission to explore the Sun. Specifically, Solar Orbiter will make up close observations of the deep heliosphere and the nascent (emergent) solar wind, as well as make passes over the solar poles, which are regions that are difficult to observe from the Earth.

Solar Orbiter in the clean room on Earth. Credit: ESA.

To accomplish this, SolO carries a suite of instruments, including its Polarimetric and Helioseismic Imager (PHI) and the Extreme Ultraviolet Imager (EUI), both of which witnessed and documented the January 3, 2023 transit of the innermost planet. All of these instruments sit behind a massive heat shield, needed to survive the intense heat of the blistering perihelion passages that the mission must endure.

None More Black

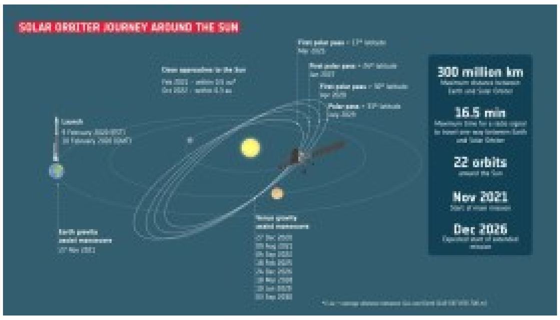
Beyond just a unique view of a rare celestial scene, the silhouette of Mercury allowed researchers a one-time, sharp-edged calibration target that was absolutely black: even ragged-edged sunspots and deep space (which is still dappled with faint stars) doesn't provide such a view in context with the dazzling Sun.

"It's not just looking at Mercury passing in front of the Sun, but passing in front of the different layers of the atmosphere," says Miho Janvier (Institut d'Astrophysique Spatiale-France) in a recent press release.

Indeed, this offered engineers a one time chance to compare the view from their instruments versus a truly black target. "It is a certified black object traveling through your field of view," says Daniel Müller (ESA-SolO Project Scientist) in a recent press release. Any light recorded by an instrument on the disc of Mercury must be the result of light generated by the instrument, and can be accounted for an adjusted.

SolO is part of a flotilla of missions set to scrutinize the our host star like never before, as Solar Cycle 25 gets underway in earnest. We saw evidence of this increase in activity earlier this week, as a powerful solar storm sparked aurora for mid- to high- latitudes. Views from SolO will compliment observations from NASA's Parker Solar Probe, the Solar Dynamics Observatory and the joint ESA/NASA Solar Heliospheric Observatory (SOHO).

SolO made an Earth flyby on November 27, 2021 on its journey to the inner solar system, and completed its first perihelion pass 0.5 AU from the Sun in February 2021. Its next perihelion pass at 0.29 Astronomical Units (AU) (27 million miles or 43.5 million kilometer) from the Sun occurs on April 10, 2023, and a series of passes near Venus which started in 2020 will set the mission up for passes over the Sun's poles, starting in 2025. SolO has a seven year nominal mission.



The looping orbit of SolO. Credit: ESA.

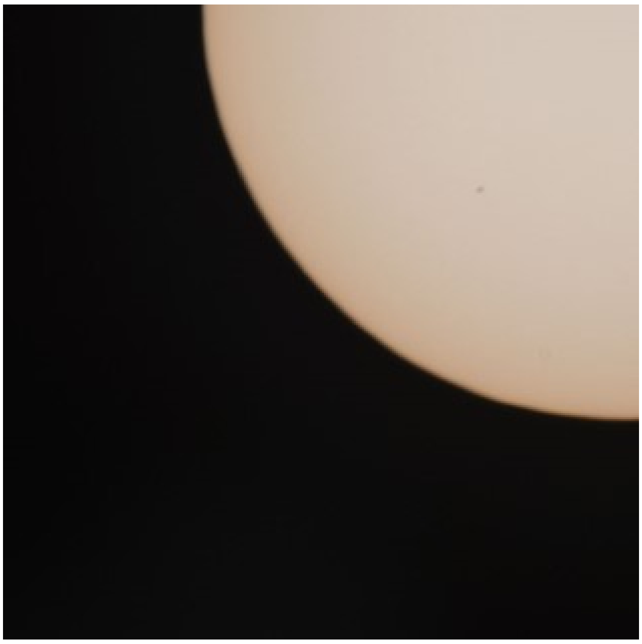
Why Transits

Transits have been vital tools throughout the history of astronomy, right up through modern times.

Astronomers Jeremiah Horrocks and William Crabree was the first astronomers to predict and observe a transit of Venus in front of the Sun on December 4, 1639. Once predictions got more accurate, astronomers realized that observations of transits (mainly of Venus) could be used to measure size and distance in the solar system, sparking some of the first global international scientific expeditions of the 18th and 19th centuries.

Fast forward to the 21st century, and transits still have scientific value, as astronomers use them to discover exoplanets around distant stars. While these faint tell-tale dips in brightness are a dead giveaway for planets orbiting a host star, the method does have drawbacks: most planets do not transit from our line of sight, and the ones that do tend to be ‘hot Jupiters’ close in to their host star, which are much more likely to transit from our point of view.

When’s the next transit of Mercury? As seen from our Earthly vantage point, Mercury transits the Sun 13 times for this century. The last one was on November 11, 2019, and the next one isn’t until November 13th, 2032.



A (hazy) view of the 2019 transit of Mercury. Credit: Dave Dickinson.

It’s amazing to think that one of the oldest astronomical techniques of simply catching one body passing in front of the other is still yielding scientific value, and aiding a modern spacecraft on its mission to unlock the secrets of the Sun.

The Dark Energy Camera Captures the Remains of an Ancient Supernova

The first written record of a supernova comes from Chinese astrologers in the year 185. Those records say a ‘guest star’ lit up the sky for about eight months. We now know that it was a supernova.

All that remains is a ring of debris named RCW 86, and astronomers working with the DECam (Dark Energy Camera) used it to examine the debris ring and the aftermath of the supernova.

Chinese astrologers recorded SN 185 in The Book of the Later Han, or as the Chinese call it, the Hou Han shu. There’s uncertainty around ancient records of astronomical events, and in the Hou Han shu’s case, the uncertainty is amplified by the fact that it was written 200 years after the events that transpired. Ancient Romans may have recorded the supernova explosion too, but that’s less certain.

Ancient records of celestial events can also be uncertain because of confusion between supernovae and comets. In the Hou Han shu, there’s no record of the guest star moving, and the location the Chinese recorded agrees with the position of RCW 86, the debris ring from the SN. Modern astronomers are pretty sure the Hou Han shu recorded SN 185, especially since modern high-tech observations help confirm it.

This image of the supernova remnant RCW 86 is a composite image from Spitzer, WISE, and Chandra. The ring shape has become less clear over 1800 years, but its location matches the location of SN 185 recorded in the Hou Han shu. Image Credit: By NASA/JPL-Caltech/UCLA – WISE, Public Domain, https://commons.wikimedia.org/w/index.php?curid=17141291

SN 185 exploded more than 8,000 light-years away in the rough direction of our nearest stellar neighbour Alpha Centauri. It’s a fascinating object because astronomers can observe the aftermath of a supernova explosion, one of nature’s most climactic events. RCW 86 is just a tattered remnant of SN 185 now, an increasingly misshapen ring of gas and dust. SN 185 was a Type 1a supernova, and unlike other types of supernovae, it left nothing behind other than the expanding, dissipating ring of debris.

But astronomers didn’t know all that at first. They had to figure it all out, and RCW 86 was misleading because of its size.

Its large size led astronomers to believe that SN 185 was a core-collapse supernova. That type of supernova would take about 10,000 years to form the remnant we see today. So astronomers weren’t certain that RCW 86 was associated with SN 185. The timing was way off by over 8,000 years.

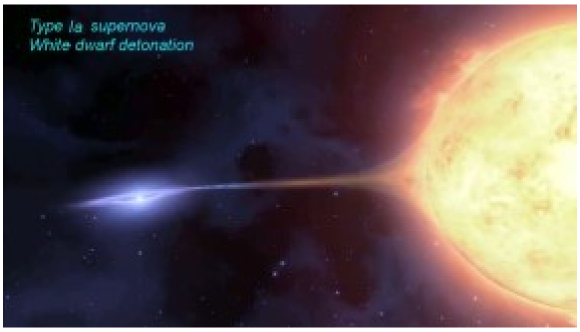
This zoomed-in image shows some of the detail in the wide-field DECam image. Image Credit: CTIO/NOIRLab/DOE/NSF/AURA T.A. Rector (University of Alaska Anchorage/NSF’s NOIRLab), J. Miller (Gemini Observatory/NSF’s NOIRLab), M. Zamani & D. de Martin (NSF’s NOIRLab)

Then in 2006, a study showed that an extremely high expansion velocity was behind RCW 86, meaning it is temporally associated with SN 185. That study was based on x-ray observations. They showed that along some portions of the expanding shell, there was a peculiar mixture of both thermal x-ray radiation and synchrotron x-ray radiation. Simply put, thermal x-rays are generated by heat, and synchrotron x-rays are generated by movement. The presence of synchrotron x-rays suggests a much higher velocity in the shell since charged particles need to travel at relativistic speeds to produce them.

This study corrected RCW 86's age to about 2,000 years old, right in line with SN 185. "Finally," the authors of the 2006 paper wrote, "we show that the derived shock velocity strengthens the case that RCW 86 is the remnant of SN 185."

But that didn't explain why RCW 86 is expanding so fast. Once again, x-ray data led to an explanation. X-ray observations showed a higher-than-expected level of iron in the remnant shell. Type 1a supernovae produce an excessive amount of iron due to their physics. In fact, two-thirds of the iron in our blood and in the Earth itself was produced by type 1a supernovae. Since type 1a supernova can account for the increased iron, and since RCW 86 is expanding so rapidly, astronomers determined that it is indeed SN 185's remnant.

A type 1a supernova consists of a binary pair, including a white dwarf and another star that could be anything from another smaller white dwarf to a giant star. As the two get close, the white dwarf siphons off material from the companion star. The white dwarf's pressure and temperature both rise and the star ejects material at a high velocity. This material forms part of the expanding shell called RCS 86.



In a Type Ia supernova, a white dwarf (left) draws matter from a companion star until its mass hits a limit which leads to collapse and then an explosion. Credit: NASA

But unlike a main sequence star, which can expand and cool to compensate, the white dwarf keeps getting hotter until it eventually explodes. The previously ejected material created an empty shell around the white dwarf that made room for the material from the supernova explosion to expand. The result, 1800 years later, is the tattered, bedraggled ring of debris that we see today.

Of course, the ancients had no idea about any of this. They just witnessed a blazing light in the sky that shone for 8 months and then disappeared. Who knows what impact it had on regular people?

It's fascinating when modern astronomy intersects with what the ancients saw. It's like a one-way conversation between the past and the future. SN 185/RCW 86 is just one example of it.

A 2021 study examined ancient literature for 3,000 years of records of auroras to help understand Earth's magnetosphere over time. A 2018 paper showed that a meteor explosion over the Dead Sea 3,700 years ago could explain the Biblical story of Sodom. There are lots of other examples.

Thanks to modern observing capabilities, we can untangle the complex physics behind things like supernovae and understand them in detail. The Dark Energy Camera's wide-angle image makes it easy for us to relate to them. The aftermath is spread across our screens in intriguing detail.

If you want to go even deeper, download the full-size .tif from NOIRLab's website.

A Mysterious Blob Near the Milky Way's Supermassive Black Hole Might Finally Have an Explanation

At the center of the Milky Way, there is a massive persistent radio source known as Sagittarius A*. Since the 1970s, astronomers have known that this source is a supermassive black hole (SMBH) roughly 4 million times the mass of our Sun. Thanks to advancements in optics, spectrometers, and interferometry, astronomers have been able to peer into Galactic Center. In addition, thanks to the international consortium known as the Event Horizon Telescope (EHT), the world got to see the first image of Sagittarius A* (Sgr A*) in May 2022.

These efforts have allowed astronomers and astrophysicists to characterize the environment at the center of our galaxy and see how the laws of physics work under the most extreme conditions. For instance, scientists have been observing a mysterious elongated object around the Sgr A* (named X7) and wondered what it was. In a new study based on two decades' worth of data, an international team of astronomers with the UCLA Galactic Center Group (GCG) and the Keck Observatory have proposed that it could be a debris cloud created by a stellar collision.

The research effort was led by the Galactic Center Initiative, an international project made up of scientists from the Mani L. Bhaumik Institute for Theoretical Physics, the University of California Los Angeles (UCLA), the W. M. Keck Observatory, the Observatoire de Paris (Sorbonne Universite), the University of California Berkeley, and the Instituto de Astrofísica de Andalucía (CSIS). The paper that describes their findings recently appeared in *The Astrophysical Journal*.

Using the Keck Observatory's 10-meter (32.8 ft) Telescopes on Mauna Kea, the GCG team has been measuring the star closest to Sgr A* (S0-2) for more than twenty years (since 1995). They are one of only two groups in the world to have observed S0-2 make a full orbit of Sgr A* – a process that takes 16 years – for the sake of testing Einstein's Theory of General Relativity. The team has spent that same time monitoring the object known as X7, a dust and gas cloud of about 50 Earth masses that takes 170 years to orbit the SMBH.

As they report in their study, X7 has become elongated and stretched by tidal forces as it has been pulled closer to Sag A*. Within the next few decades, they anticipate that X7 will disintegrate as the dust and gas that make it up are accreted onto the face of the SMBH. As Anna Ciurlo, a UCLA assistant researcher and the paper's lead author, said in a UCLA press release:

"No other object in this region has shown such an extreme evolution. It started off comet-shaped and people thought maybe it got that shape from stellar winds or jets of particles from the black hole. But as we followed it for 20 years, we saw it becoming more elongated. Something must have put this cloud on its particular path with its particular orientation."

The team also notes that X7 has similar properties to other strange dusty objects orbiting Sag A* (aka. G objects). These objects look like dust clouds but behave like stars and were identified using 12 years of spectroscopic measurements made using Keck's OH-Suppressing Infrared Imaging Spectrograph (OSIRIS). The results of this study (also led by Ciurlo) were presented in 2018 at the 232nd American Astronomical Society Meeting. However, X7's shape and velocity have changed more dramatically than Gobjects, reaching speeds of up to 1,126.5 km/s (700 mps).

The twin Keck telescopes shoot their laser guide stars into the heart of the Milky Way on a beautifully clear night on the summit of Mauna Kea. Credit: keckobservatory.org/Ethan Tweedie

These results are the most robust analysis to date of X7's changes in appearance, shape, and behavior and the *first* estimate of X7's slightly elliptical orbit. While the origins of X7 are still the subject of debate, the team's finding suggests that it resulted from a collision between two stars orbiting Sgr A*. Such mergers are very common, especially in the vicinity of black holes. This merger is likely to have ejected gas and dust, which could have formed a shell that is concealing the merged star while the rest became the X7 object.

"The stars circle each other, get closer, merge, and the new star is hidden within a cloud of dust and gas," said Ciurlo. "X7 could be the dust and gas ejected from a merged star that's still out there somewhere." Said Randy Campbell, the science operations lead at the Keck Observatory and a co-author of the paper:

"It's exciting to see significant changes of X7's shape and dynamics in such great detail over a relatively short time scale as the gravitational forces of the supermassive black hole at the center of the Milky Way influences this object. It's a privilege to be able to study the extreme environment at the center of our galaxy. This study can only be done using Keck's superb capabilities, and performed at the very special and revered Maunakea, with honor and respect to the mauna."

Based on its trajectory, the team estimates that X7 will make its closest approach to Sgr A* sometime in 2036 and then spiral inward to be devoured. In the meantime, the research team will continue to monitor X7 using the Keck Observatory and watch as the powerful gravity of Sgr A* pulls it apart.

Further Reading: UCLA, The Astrophysical Journal

Astronomers Prepare for a Total View of Total Solar Eclipses

A team of astronomers have proposed a series of missions utilizing land, sea, and airborne observatories to continuously monitor as many total solar eclipses as possible in the coming decade. These missions will reveal aspects of the solar corona that cannot be studied by any other means.

The space age brought a revolution in understanding the nature of the Sun. With the capability to place an observatory in orbit we could continuously monitor solar activity. The development of the coronagraph, which is a small disk placed in front of a telescope that blocks out the light from the surface of the Sun itself, also allowed observatories to study the corona. The corona of the Sun is the hot, thin atmosphere that extends out to twice the solar radius.

The corona has a temperature of over a million degrees Kelvin, despite the surface of the Sun having a temperature of only around 10,000 Kelvin. Despite decades of intense research, we still do not fully understand how the corona reaches such incredibly high temperature, especially considering its low density and its distance from the Sun. Space-based observatories are able to map extensive regions of the corona, but they have difficulty observing continuous regions out past 50% greater than the Sun's radius. Their limited field of view prevents them from having a complete picture.

The only way to develop a complete picture of the entire solar corona is to use a natural coronagraph, which happens with every total solar eclipse. During a total solar eclipse, the disk of the Moon blocks out that of the Sun, making the corona visible. Ground-based observatories have an advantage here over space-based ones because they can enjoy a much greater field of view.

The downside is that total solar eclipses do not last long and happen all over the globe. To counteract this, a team of astronomers have proposed a call for funding to support a series of total solar eclipse observations. They hope to use mobile ground-based observatories, observatories on ocean-going vessels, and telescopes in aircraft to capture as many coming total solar eclipses as possible.

They hope that their observations will reveal a better, more coherent picture of corona activity, especially its emission spectrum in visible and near-infrared wavelengths. This can reveal critical information as to the components of the solar corona and their energies. This can feed into other observations of the solar corona to put together a complete picture and help untangle its many mysteries.

Blue Origin is Building Solar Cells out of (Simulated) Lunar Regolith

Power infrastructure will be critical for any long-term space colony, and one of the most critical pieces of that power infrastructure, at least in the inner solar system, is solar cells. So in-situ research experts were thrilled when Blue Origin, ostensibly a rocket company, recently announced that they had made functional solar cells entirely out of nothing other than lunar regolith simulant.

The process, which the aptly named Blue Alchemist, has been in the works for some time. According to a press release, Blue Origin has been working on making solar cells and necessary support components, such as wire and cover glass, all from regolith since 2021.

At its heart is a relatively simple process – molten regolith electrolysis. Basically, that means that blue origin uses electricity to split constituent atoms from the oxygen they are bound to in the lunar soil. Normal electrolytic cells separate water into hydrogen and oxygen, but Blue Alchemist takes the process a step further and separates elements such as iron, aluminum, and, most importantly, silicon from the oxygen they are bound to on the lunar surface.

YouTube video discussing the Blue Alchemist project
Credit – Angry Astronaut YouTube Channel

One advantage of this process is that the "waste" product is oxygen – itself an invaluable material for lunar exploration, both as a component of breathable air, but also a potential rocket fuel. Silicon is the basis for not only solar cells but also glass, which needs to cover solar cells on the Moon to allow them to last more than a few days in the harsh radiative lunar environment. And iron and aluminum are useful for structural materials and conductive wire, in aluminum's case. All this comes from the "dirt" that completely covers the surface of the Moon.

Blue Origin went so far as to make their own lunar regolith simulant to prove their process works rather than buying one already commercially available. They seemed to think that the commercially available simulants were too similar to a mish-mash of "lunar-relevant oxides" that didn't truly represent the material found in the samples brought back by the Apollo mission and others.

Whatever their inputs, their process seems impressive, resulting in 99.999% pure silicon of the type used to make effective solar cells. Even more impressively, they did all of this “with zero carbon emissions, no water, and no toxic ingredients or other chemicals.” As the company rightfully points out, that kind of process could be useful even here on Earth if they find enough of a supply of oxides similar to those on the Moon.

UT video on a competing technology – printed perovskite panels.

But for now, this is a considerable step forward in the ISRU space. If used properly, it will form the basis of power infrastructure throughout most, if not all, of the lunar power infrastructure that long-term human exploration programs will need. That in itself is impressive enough, notwithstanding any benefits, it might have back here on our own blue marble.

JWST Sees the Same Supernova Three Times in an Epic Gravitational Lens

The NASA/European Space Agency (ESA)/Canadian Space Agency (CSA) James Webb Space Telescope (JWST) mission continues to dazzle and amaze with every image it beams back to Earth, and a recent observation depicting not one, not two, but *three* images of the *same galaxy* has been no different, as they proudly tweeted on February 28, 2023.

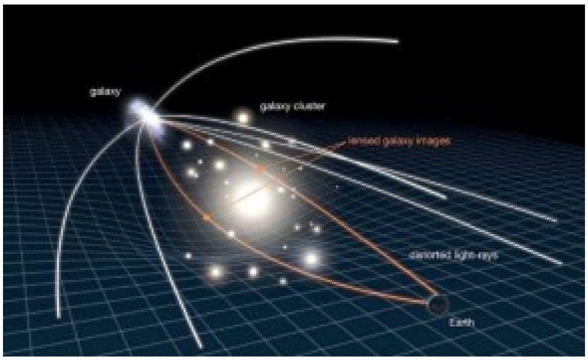
But how can JWST observe three images of the same object at once? This is done thanks to a phenomenon known as gravitational lensing, which happens when light is bent or warped around a massive celestial object that emits an enormous amount of gravity, most commonly a star like our Sun, but can also happen with massive galaxies, as well.

The triple-imaged object in question is a supernova-hosting galaxy whose light is being distorted and bent by the massive galaxy cluster known as RX J2129, which is located approximately 3.2 billion light years from Earth. Astronomers have determined the three separate images are all different ages and characteristics given the varying varying distances that light had to travel in each one.

The oldest image containing the astronomical transient (aka supernova candidate), AT 2002riv, has been determined to be a Type Ia supernova and is identified by the two parallel lines on either side of it. This is followed by an image as the distant galaxy appears ~320 later, and the third image is how it appeared ~1000 days post-AT 2002riv. Both images occurring ~320 and ~1000 days after the first image show the supernova completely gone from view. Type Ia supernova are particularly helpful to astronomers as studying their luminosity can help measure the enormous astronomical distances to them.

“The almost uniform luminosity of a Type Ia supernova could also allow astronomers to understand how strongly the galaxy cluster RX J2129 is magnifying background objects, and therefore how massive the galaxy cluster is,” explains the European Space Agency. “As well as distorting the images of background objects, gravitational lenses can cause distant objects to appear much brighter than they would otherwise. If the gravitational lens magnifies something with a known brightness, such as a Type Ia supernova, then astronomers can use this to measure the ‘prescription’ of the gravitational lens.”

As stated, gravitational lensing is when the gravitational field of a massive celestial object causes background light to appear bent or warped when it comes into view, meaning the celestial object acts a sort of celestial lens so astronomers can view other objects behind it. In this case, a supernova-hosting galaxy whose light has been not only bent but split three times as its light traveled through the “lens” of RX J2129.



Artist’s conception of gravitational lensing of a galaxy. The large object depicted in the center would be RX J2129 and the “lensed gravity images” would be the split images of the supernova-hosting galaxy. (Credit: NASA, ESA & L. Calcada)

Gravitational lensing is one of the most historic predictions of Albert Einstein’s theory of general relativity, and was first discovered in 1979 when two quasars were observed to be in close proximity to each other, but turned out to be the same object whose light had been split in two, similar to what RX J2129 did to the distant galaxy in the recent JWST observation. While gravitational lensing is used to observe large objects like supernovae, a method known as gravitational microlensing is equally used to find exoplanets.

How many more supernovae will JWST observe, and what else will we learn about gravitational lensing in the coming years and decades? Only time will tell, and this is why we science!

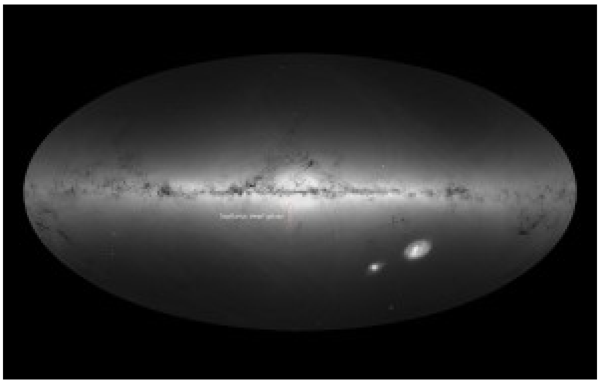
As always, keep doing science & keep looking up!

Hubble Sees an Epic Merger of Three Galaxies

When is 50,000 light-years only a small distance? When three galaxies are that close to one another. At that range, they’re fiercely interacting.

In the case of the three galaxies referred to as SDSSCGB 10189, they’re 50,000 light-years apart and growing closer as they merge into a single massive galaxy.

Galaxy mergers aren’t exotic. The Hubble has caught many galaxies in the act of merging. Our own Milky Way galaxy is in on the game, as it slowly absorbs the Large and Small Magellanic Clouds. Another one of our neighbours, the Sagittarius Dwarf Spheroidal Galaxy (SDSG), is also in the process of merging and has passed through the Milky Way’s disk several times, losing mass each time.



This image based on Gaia data shows the Milky Way’s disk and the location of the Sagittarius Dwarf Galaxy and the Large and Small Magellanic Clouds. All three are slowly merging with the Milky Way. Image Credit: By ESA/Gaia/DPAC, CC BY-SA 3.0 igo, https://commons.wikimedia.org/w/index.php?curid=77752828

While those are all technically mergers, they’re really more like absorptions since the Milky Way is so much more massive than the Magellanic Clouds and the SDSG. Even after the Milky Way has consumed all three, our galaxy will still look pretty much the same.

Things play out differently when three massive galaxies collide, like in the Hubble image. After they merge, they'll be one single, massive galaxy, probably an elliptical. But while they merge, they'll wreak gravitational carnage on each other, streaming tails of gas out into space and triggering widespread star formation.

Astronomers research galaxy mergers because they play a key role in the Universe. The modern Universe contains a vast number of huge galaxies, but scientists think they only grew so large through mergers. (Although recent results from the JWST suggest that there were some massive galaxies in the Universe's first few hundred million years.)

The Hubble has spotted lots of mergers between two massive galaxies. The image montage below is from the Hubble imaging Probe of Extreme Environments and Clusters (HiPEEC), a survey investigating star cluster formation in the extreme environments of six merging galaxies. These images show pairs of galaxies merging.

The Hubble has imaged lots of merging galaxies over the years. Galaxy mergers are spectacular events that trigger abundant star formation. Top left: NGC 3256 Credit: ESA/ Hubble, NASA Top Middle: NGC 1614 Credit: NASA, ESA, the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration and A. Evans (University of Virginia, Charlottesville/NRAO/Stony Brook University) Top Right: NGC 4194, also known as the Medusa merger. Credit: ESA/ Hubble & NASA, A. Adamo Bottom Left: NGC 3690 consists of a pair of galaxies, dubbed IC 694 and NGC 3690, which made a close pass some 700 million years ago. Bottom Middle: NGC 6052 Image Credit: ESA/Hubble & NASA, A. Adamo et al. Bottom Right: NGC 34 Image Credit: ESA/Hubble & NASA, A. Adamo et al.

Triple galaxy mergers are rare, but Hubble has still spotted some. In February 2022, the Hubble team released an image of IC 2431, another distant trio of merging galaxies about 682 million light-years away. The center of the image is obscured by dust, but the three galaxies are still clearly visible as they interact gravitationally with each other.

IC 2431 is another triple galaxy merger almost 700 million light-years away. The tidal distortions are obvious in this image, and the merger is also triggering star formation. Image Credit: ESA/Hubble & NASA, W. Keel, Dark Energy Survey, DOE, FNAL, DECam, CTIO, NOIRLab/NSF/AURA, SDSS Acknowledgement: J. Schmidt

The leading image is from an effort to understand the most massive, brightest galaxies in the Universe. They're called Brightest Cluster Galaxies (BCGs), and they're the brightest galaxies in any given galaxy cluster. Some BCGs are 100 billion times more massive than our Sun, and most of them are ellipticals. BCGs are found at the kinematic and geometric center of their host cluster.

Galaxy mergers will restructure our little corner of the Universe over long periods of time. The Milky Way is in the Local Group of galaxies, along with another large spiral galaxy, Andromeda. In a few billion years, the pair will merge and form a single galaxy (Milkdromeda?) The Local Group also contains about 50 smaller galaxies and thousands of globular clusters. It's arranged in a kind of dumbbell shape, with the Milky Way and its satellites in one lobe and Andromeda and its satellites in the other lobe.

This illustration shows the Local Group. The Milky Way is in the center, and Andromeda (M31) is the red galaxy up and to the left. Eventually, the two will merge, along with all of their satellites, into one gigantic elliptical galaxy. Image Credit: By Antonio Ciccolella – Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=50409931

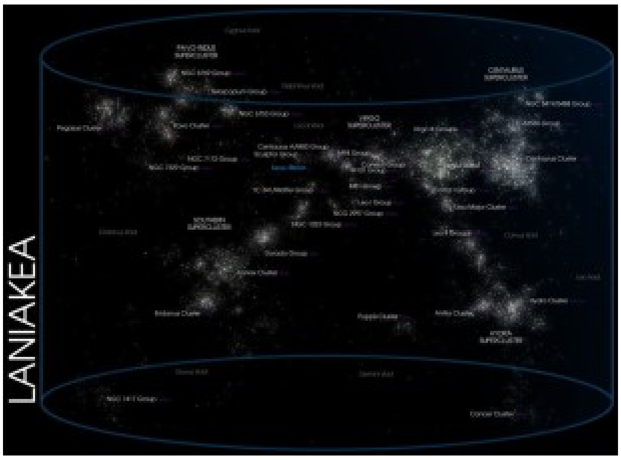
In a few tens of billions of years, all of the objects in the Local Group will be combined into one gigantic elliptical galaxy. When Hubble spots triple-galaxy mergers, they're just snapshots of this epic process of merging and combining matter. When will it end?

It's tempting to think that matter will keep combining into more and more massive agglomerations. But that's not what will happen. Gravity is ultra-powerful, and if it were left to its own devices, it might eventually gather all matter together into one super-gigantic, ultra-turbo-massive elliptical galaxy. But gravity isn't ultra-powerful, and it's not alone.

The Universe is expanding, driven by Dark Energy, gravity's counterbalance. On smaller scales, gravity can work its magic on regions of the Universe that have over-densities of matter. These over-densities date back to the Big Bang. But on larger scales, these over-densities are defeated by Dark Energy. As long as Dark Energy keeps driving the expansion of the Universe, gravity can never achieve ultimate victory. It can never unify all matter.

Our Local Group is massive, but it's still small enough to belong to an even larger structure called the Virgo Supercluster. The Universe is full of these superclusters that exist in a sort of web-like arrangement of filaments and clumps. They're truly vast, and the Virgo Supercluster spans some 110 million light years. At those great distances, gravity is severely weakened. It has no power to reshape superclusters like Virgo.

It doesn't end there. We can zoom out even further and see that the Virgo Supercluster is part of another structure called the Laniakea Supercluster.



The Laniakea Supercluster with our Local Group (blue) in the center. Image Credit: By Andrew Z. Colvin – Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=71065242

The Universe's continuous expansion is like a line in the sand for gravity. It simply can't overcome it. The large-scale structure of the Universe shows why.

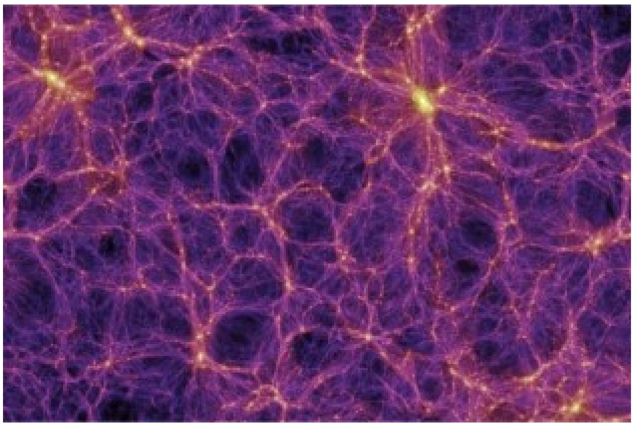


Image of the large-scale structure of the Universe, showing filaments and voids within the cosmic structure. The distances are so vast that gravity can't draw all this matter together. Credit: Millennium Simulation Project

When we zoom back into the Milky Way, it seems small in comparison. Even the triple merger in the leading Hubble image seems small in comparison, and there are hundreds of billions of stars—maybe even more—involved in that merger, and who knows how many more tens or hundreds of thousands more stars are being born as a result. Don't even try to guess the number of planets involved and if one of them might host life.

Take another look at these three merging galaxies and consider the vast scale of the Universe. Image Credit: ESA/Hubble & NASA, M. Sun

It's highly unlikely that humanity will be around when these three galaxies finally combine into a single enormous elliptical galaxy. The same goes for the Milky Way and Andromeda merger. It's highly unlikely that Earth will even be here since the Sun may have consumed it in its red giant phase.

But for those of us alive now and into the near future, we can gaze out into the Universe with our powerful space telescopes and watch it all unfolding.

Humanity has Never Seen the sky in the Longest Wavelengths. That Could Change With a new Space Telescope

Technological revolutions can bring about dramatic changes in various fields, some of which are only tangentially related to the field being disrupted. Occasionally, a few technological revolutions happen simultaneously, enabling concepts that would have been impossible without any of them. Such revolutions are currently happening in the space industry. With rockets more massive than ever coming online, and mega-constellations of satellites roaming our skies, there is plenty of disruption going on. Now a team from MIT hopes to use those technologies to look at an area of astronomy that has never been seen before – low-frequency radio astronomy.

Giant radio telescopes, such as the now-defunct Arecibo, have one major disadvantage – they are located on Earth. Our ionosphere neatly blocks the very low-frequency radio spectrum, from frequencies of 100 kHz to around 15 MHz. So while those massive telescopes are theoretically capable of detecting those signals, none of them make it through the ionosphere for them to detect.

Alternatively, telescopes in space would be perfectly capable of detecting these low frequencies. But they would have to be absolutely massive to do so – on the order of hundreds of meters in diameter, which is currently far beyond the capability of even the most powerful rockets proposed. So far, building a radio telescope for detecting low-frequency signals in space has been a non-starter.

There are other places in the solar system that could support a interferometer – like the far side of the Moon.

But there may be an alternative. Newer radio telescopes, such as MeerKAT, use a technique called interferometry. Instead of requiring one colossal telescope, interferometry telescopes use a series of small ones bound together by the laws of physics and mathematics to detect low-frequency radio waves that would usually be seen only by giant detectors.

What Mary Krupp and her team at MIT have suggested seems like a logical next step – why not build an interferometric telescope in space? Their project, known as the Great Observatory for Long Wavelengths, or, since astronomers are so fond of acronyms, Go-LoW, was recently funded by NASA's Institute for Advanced Concepts, and its premise is relatively simple.

Take an interferometric system similar to MeerKAT and launch it to the L5 Lagrange point. The idea takes ideas from a few current technological advances and combines them. The first would be how to make hundreds of thousands of satellites inexpensively.

Discussion of the MeerKAT telescope, a interferometer that is currently in use here on Earth.
Credit – CreamerMedia YouTube Channel

For that, they rely on the technologies developed by SpaceX for their Starlink mega constellation. Its 40000+ planned satellites have significantly decreased the cost of small satellite components, making it economically feasible to build that many satellites without breaking the bank.

The second technological development is the advent of heavy-launch rockets. With the power of Starship or the SLS, thousands of satellites can be launched to Earth-Sun L5 Lagrange point about 1.5 million kilometers away. While it might not necessarily be cheap to do so, it certainly wouldn't be as expensive as it had been in past generations.

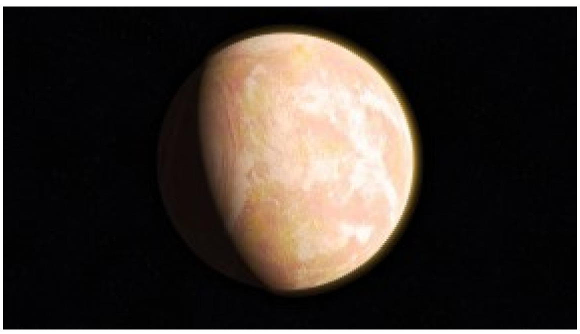
Now seems like an ideal time for such an idea, though NIAC is known for backing projects in the very early stages. The MIT team will work on conceptual aspects of the mission in this Phase I grant, which lasts for nine months. Ultimately, they hope to have a road map to making the project a reality in the next 10-20 years. They might just be able to catch that technological wave at the right time and change our understanding of radio astronomy forever.

Do Red Dwarfs Provide Enough Sunlight for Plants to Grow?

To date, 5,250 extrasolar planets have been confirmed in 3,921 systems, with another 9,208 candidates awaiting confirmation. Of these, 195 planets have been identified as "terrestrial" (or "Earth-like"), meaning that they are similar in size, mass, and composition to Earth. Interestingly, many of these planets have been found orbiting within the circumsolar habitable zones (aka. "Goldilocks zone") of M-type red dwarf stars. Examples include the closest exoplanet to the Solar System (Proxima b) and the seven-planet system of TRAPPIST-1.

These discoveries have further fueled the debate of whether or not these planets could be "potentially-habitable," with arguments emphasizing everything from tidal locking, flare activity, the presence of water, too much water (i.e., "water worlds"), and more. In a new study from the University of Padua, a team of astrobiologists simulated how photosynthetic organisms (cyanobacteria) would fare on a planet orbiting a red dwarf. Their results experimentally demonstrated that oxygen photosynthesis could occur under red suns, which is good news for those looking for life beyond Earth!

The study was led by Nicoletta La Rocca and Mariano Battistuzzi, biologists with the Department of Biology (DiBio) and the Center for Space Studies and Activities (CISAS) at the University of Padua. They were joined by researchers from the National Council of Research of Italy's Institute for Photonics and Nanotechnologies (CNR-IFN) and the Astronomical Observatory of Padua of the National Institute for Astrophysics (INAF-OAPD). The paper that describes their findings was published on February 7th, 2023, in the *Frontiers of Plant Science*.



The "pale orange dot." Artist's impression of what early Earth would have looked like. Credit: NASA/Goddard Space Flight Center/Francis Reddy

The subject of M-type stars, photosynthesis, and the implications for astrobiology has been explored at length in recent decades. Not only are red dwarfs the most common type of star in the Universe, accounting for 75% of stars in the Milky Way alone. Recent surveys have shown they are also very good at forming rocky planets that orbit within the parent star's habitable zone (in many cases, tidally locked with their stars). Given the unstable nature of red dwarfs, their tendency to flare, and other factors, the jury is still out on whether or not they could support life – especially in their early phases. As Dr. Battistuzzi told Universe Today via email:

"M-dwarfs can profoundly change their activity depending on their stage of evolution. 25% of early-life M-dwarfs release X-rays and UV through flares and chromospheric activity. Instead, quiescent stars emit little UV radiation and have no flares. Planets orbiting around M-dwarfs often receive high doses of these kinds of radiation during stellar flares, changing rapidly the radiation environment on the surface and possibly eroding the ozone shield, if present, as well as part of the atmosphere.

"However, it has been pointed out that these planets could remain habitable. Atmospheric erosion could be avoided through a strong magnetic field or with thick atmospheres. Also, in addition to this, possible organisms could develop UV-protecting pigments and DNA repair mechanisms as happens on Earth or develop in subsurface niches, underwater or under the ice, where radiation is less intense."

On Earth, life is theorized to have emerged during the Archean Eon (ca. 4 billion years ago) in the form of simple, single-celled (prokaryote) bacteria. Earth's atmosphere was still largely composed of carbon dioxide, methane, and other volcanic gases at this time. Between 3.4 and 2.9 billion years ago, the first photosynthetic organisms – green-blue microbes called cyanobacteria – began flourishing in Earth's oceans. These organisms metabolized carbon dioxide with water and sunlight to create gaseous oxygen (O_2), eventually leading to more complex, multi-celled organisms (eukaryotes).

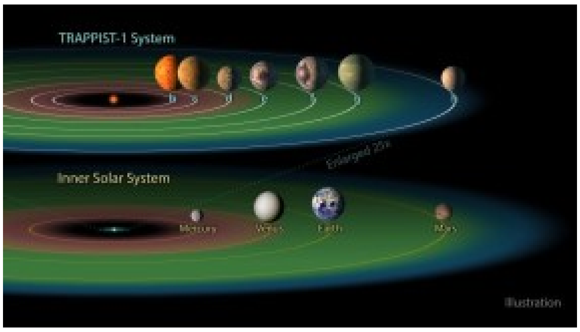
Artist's impression of the Archean Eon. Credit: Tim Bertelink

Hence the concern regarding young red dwarf suns and their rocky planets. These dimmer, cooler stars emit the majority of their radiation in the red and infrared wavelengths (lower energy than the yellow light of the Sun peaks). As a result, scientists have speculated that additional photons would be needed to achieve excitation potentials comparable to those needed for photosynthesis on Earth. For their study, La Rocca and Battistuzzi sought to determine experimentally if this was the case. According to Battistuzzi, this consisted of subjecting cyanobacteria to different wavelengths of light and monitoring the bacteria's growth:

"We exposed a couple of cyanobacteria to a simulated M-dwarf light spectrum and measured their growth, acclimation responses (for example, the changes in the pigment composition and the organization of the photosynthetic apparatus, crucial to absorbing light and converting it into sugars), and oxygen production capabilities under this light spectrum. We compared these data to two different control conditions: a monochromatic far-red light and a solar light spectrum."

The experiment utilized two types of cyanobacteria. This included *Chlorogloeopsis fritschii*, a small group of cyanobacteria capable of synthesizing special pigments (chlorophyll *d* and *f*) that are able to absorb far-red light. Unlike most other photosynthetic organisms (like plants), this gives this strain the ability to grow and produce oxygen using far-red light alone or in addition to visible light. The second strain, *Synechocystis* sp., is a broader group of freshwater cyanobacteria that cannot utilize far-red light alone for photosynthesis and needs visible light.

"The monochromatic far-red light was used as a control to ensure different responses of the far-red utilizing cyanobacterium and the non-far utilizing one: the first should grow in far-red, and the second one should not," added Battistuzzi. "The simulated solar light spectrum was used as a control to check the growth, acclimation responses, and oxygen production in optimal conditions (terrestrial organisms evolved under the Sun's spectrum, so they are adapted to it)."



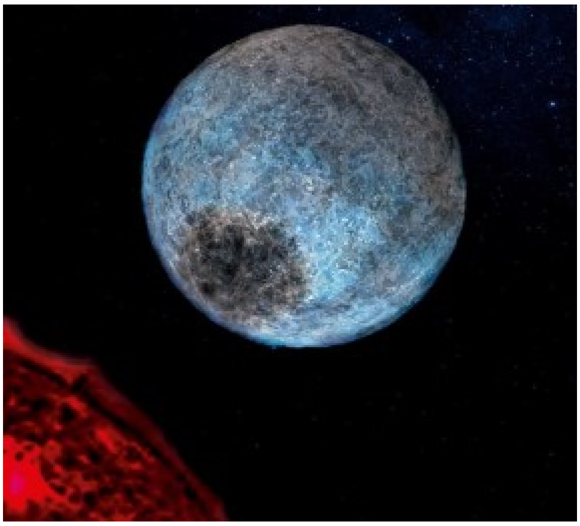
Three of the TRAPPIST-1 planets – TRAPPIST-1e, f, and g – dwell in their star's so-called "habitable zone." Credit: NASA/JPL

As they indicate in their study, the results were surprisingly encouraging. Both cyanobacteria grew at a similar rate under the red dwarf and Solar light conditions. This was impressive, considering that visible light is rather scarce in the M-type stellar spectrum. In the case of C. fritschii, the results could be explained by its capability of synthesizing the necessary pigments to harvest far-red light and its ability to harness visible light. While Synechocystis sp. did not grow under far-red light alone, it could also grow at a similar rate to *C. fritschii* when exposed to both. While the exact cause is not certain, Battistuzzi and La Rossa have some theories:

"This could be explained by recent studies on plants showing that far-red light just helps oxygenic photosynthesis when in combination with visible light, while instead is poorly utilized when provided alone (as demonstrated in this work by Synechocystis sp., which could not grow under this only light source).

"The acclimations of both cyanobacteria moreover led to efficient O_2 evolution under the M-dwarf light spectrum. This shows the potentiality of cyanobacteria to utilize light regimes that could arise on tidally locked planets orbiting the Habitable Zone of M-dwarf stars, and also their potential in producing O_2 biosignatures detectable from remote."

In a previous study conducted in 2021, La Rocca, Battistuzzi, and their teammates conducted a similar experiment where they studied the growth and acclimation of cyanobacteria. This study was led by Riccardo Claudi of the Astronomical Observatory of Padua (INAF-OAPD), a co-author of the current paper. For this experiment, the team relied on solid media to cultivate cyanobacteria as biofilms, which allowed them to obtain results more rapidly but limited the amount and the type of experiments they could conduct.



Artist's impression of a water world, where half of its mass consists of water. Just like our Moon, the planet is bound to its star by tidal forces and always shows the same face to its host star. Credit: Pilar Montañés

This time, the cyanobacteria were cultivated in liquid media, which yielded more samples. This, in turn, allowed far more detailed examinations of the growth, acclimation processes, and oxygen evolution of cyanobacteria exposed to different light conditions. The implications of these latest experiments and what they revealed are potentially groundbreaking. According to Battistuzzi, this includes a new understanding under which photosynthesis can occur, better prospects for red dwarf habitability, and new opportunities for detected biotic oxygen in exoplanet atmospheres:

"Even if the visible light in the M-dwarf spectrum is very low, it can still be utilized by some oxygenic photosynthetic organisms efficiently. This highlights the importance of taking into account the huge diversity of oxygenic photosynthetic organisms, which not only comprise higher plants but also basal plants, and microalgae, down to the simplest cyanobacteria.

"It is also important to consider how the new findings demonstrate the role of far-red light in helping the photosynthetic performance and the growth of all photosynthetic organisms (higher plants included). If life evolved oxygenic photosynthesis on an exoplanet orbiting the habitable zone of an M-dwarf, this process could be far more similar to what happens on Earth than previously anticipated."

"If oxygenic photosynthesis evolved in M-dwarf's exoplanets, with the right conditions, oxygen could, in theory, accumulate in their atmospheres, as happened on Earth billions of years ago during the Great Oxidation Event, becoming a permanent component. This would allow astronomers to detect such biologically produced oxygen, a biosignature, in the atmosphere and infer from that the presence of life from remote."

Artist's conception of a rocky Earth-mass exoplanet like Wolf 1069 b orbiting a red dwarf star. If the planet has retained its *atmosphere, chances are high that it would feature liquid water and habitable conditions over a wide area of its day-side. Credit: NASA/Ames Research Center/Daniel Rutter*

This last implication is especially significant, as astronomers and astrobiologists have explored the possibility that when it comes to red dwarfs, oxygen might not be the smoking gun we tend to think it is. Red dwarfs have an extended pre-main sequence phase (roughly 1 billion years), which means that planets orbiting in what will eventually become their habitable zones would be exposed to elevated radiation. This could trigger a runaway greenhouse effect where water is evaporated and broken down by radiation exposure into hydrogen and oxygen (photolysis).

The hydrogen gas would then be lost to space while the oxygen would be retained as a thick abiotic oxygen atmosphere. Such atmospheres would be inherently hostile to photosynthetic bacteria and other terrestrial organisms that existed when the Earth was young. In short, what is considered a leading biosignature and indicator of life could actually be an indication that a planet is sterile. But as Battistuzzi adds, there is plenty of uncertainty here, and more research is needed before any conclusions can be drawn:

"Of course, these are big ifs. It is not a guarantee that life would evolve even if habitability conditions are met on an exoplanet orbiting an M-dwarf, and it is not a guarantee that life would evolve oxygenic photosynthesis at all, as it could also evolve anoxygenic photosynthesis, a kind of photosynthesis which still uses light but does not produce oxygen as a by-product."

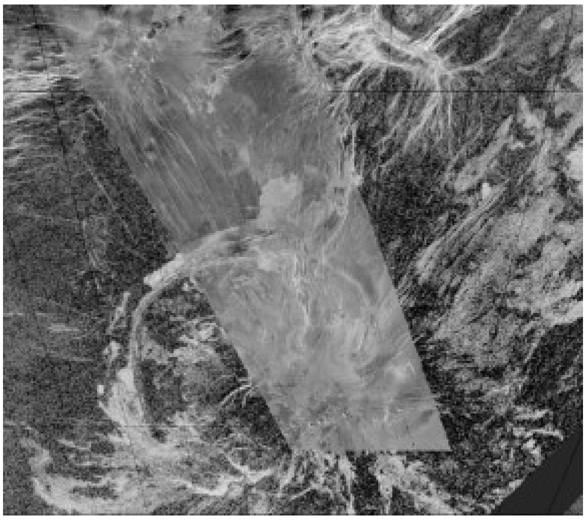
Venus' Outer Shell is Thinner and "Squishier" Than Previously Believed

While Earth and Venus are approximately the same size and both lose heat at about the same rate, the internal mechanisms that drive Earth's geologic processes differ from its neighbor. It is these Venusian geologic processes that a team of researchers led by NASA's Jet Propulsion Laboratory (JPL) and the California Institute of Technology hope to learn more about as they discuss both the cooling mechanisms of Venus and the potential processes behind it.

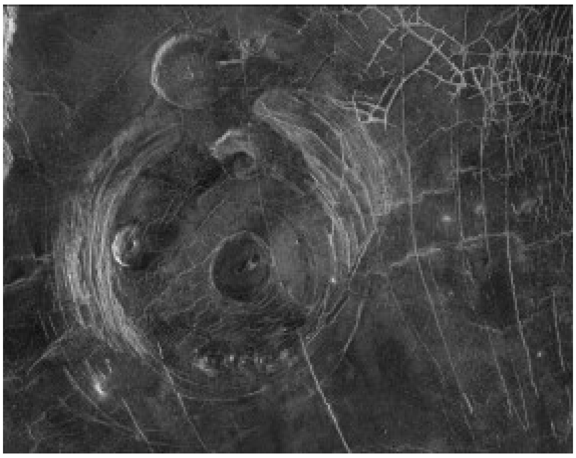
The geologic processes that occur on Earth are primarily due to our planet having tectonic plates that are in constant motion from the heat escaping the core of the planet, which then rises through the mantle to the lithosphere, or the rigid outer rocky layer, that surrounds it. Once this heat is lost to space, the uppermost region of the mantle cools, while the ongoing mantle convection moves and shifts the currently known 15 to 20 tectonic plates that make up the lithosphere. These tectonic processes are a big reason why the Earth's surface is constantly being reshaped. Venus, on the other hand, does not possess tectonic plates, so scientists have been puzzled as to how the planet both loses heat and reshapes its surface.

"For so long we've been locked into this idea that Venus' lithosphere is stagnant and thick, but our view is now evolving," said Dr. Suzanne Smrekar, who is a senior research scientist at NASA JPL, and lead author of the study.

For the study, the researchers examined radar images from NASA's Magellan mission taken in the early 1990s depicting quasi-circular geological features on Venus' surface known as coronae. The reason why the images were taken using radar is because Venus' atmosphere is so thick that normal images taken in the visual spectrum are unable to penetrate Venus' thick, cloudy atmosphere.



Composite radar image of Quetzalpetlatl Corona on Venus taken by NASA's Magellan spacecraft over the course of approximately 70 orbits and sent back to the Arecibo Observatory in Puerto Rico. (Credit: NASA/JPL)



Radar image of circular fracture patterns encircling "Aine" corona taken by NASA's Magellan spacecraft. (Credit: NASA/JPL)

Upon taking measurements of 65 previously unstudied coronae within the Magellan images and calculating the lithosphere's thickness around them, the researchers found these coronae form and exist where Venus' lithosphere is the thinnest. Using computer models, they found the lithosphere around each corona is approximately 11 kilometers (7 miles) thick, which turns out to be much thinner than suggested by previous studies. The researchers also suggest the coronae could be geologically active since these areas exhibit a greater average heat flow than Earth.

"While Venus doesn't have Earth-style tectonics, these regions of thin lithosphere appear to be allowing significant amounts of heat to escape, similar to areas where new tectonic plates form on Earth's seafloor," Dr. Smrekar explains.

It is this greater heat flow that might also help scientists better understand the behavior of the lithosphere on ancient Earth, as well.

"What's interesting is that Venus provides a window into the past to help us better understand how Earth may have looked over 2.5 billion years ago," said Dr. Smrekar, who is also the principal investigator of NASA's upcoming **V**enus **E**missivity, **R**adio science, **I**nSAR, **T**opography, **A**nd **S**pectroscopy (VERITAS) mission, which is currently scheduled to launch no earlier than 2027. “It’s in a state that is predicted to occur before a planet forms tectonic plates.”

Launched from the Space Shuttle Atlantis in May 1989, Magellan arrived at Venus in August 1990, and is considered to be one of the most successful deep space missions ever. Despite this, Magellan’s data consists of low resolution and large margins of error, so VERTIAS will essentially act as Magellan 2.0 by producing three-dimensional global maps of Venus using a state-of-the-art synthetic aperture radar, along with learning more about the surface composition with a near-infrared spectrometer.

Learn more about NASA’s forthcoming VERITAS and DAVINCI missions!

But the exterior of Venus won’t be the only location being studied, as VERITAS will study the planet’s interior by examining its gravitational field. Altogether, VERITAS will paint scientists a greater picture of both ancient and present geologic processes on our twin-sized and mysterious neighbor.

“VERITAS will be an orbiting geologist, able to pinpoint where these active areas are, and better resolve local variations in lithospheric thickness. We’ll even be able to catch the lithosphere in the act of deforming,” explains Dr. Smrekar. “We’ll determine if volcanism really is making the lithosphere ‘squishy’ enough to lose as much heat as Earth, or if Venus has more mysteries in store.”

Another Venus mission of importance will be NASA’s DAVINCI mission, whose objective will be to plunge through the Venusian atmosphere and examine its composition in greater detail than ever before.

What new insights will we learn from Venus and its geologic processes in the coming years and decades? Only time will tell, and this is why we science!

As always, keep doing science & keep looking up!

Not Just Water. Enceladus is Also Blasting Silica Into Space

Deep beneath the icy surface of Saturn’s moon Enceladus, something’s happening that causes particles of icy silica to spew out to space. They eventually end up in Saturn’s E ring. Planetary scientists knew that this was happening, but didn’t have a good explanation for why or how. Now, they do.

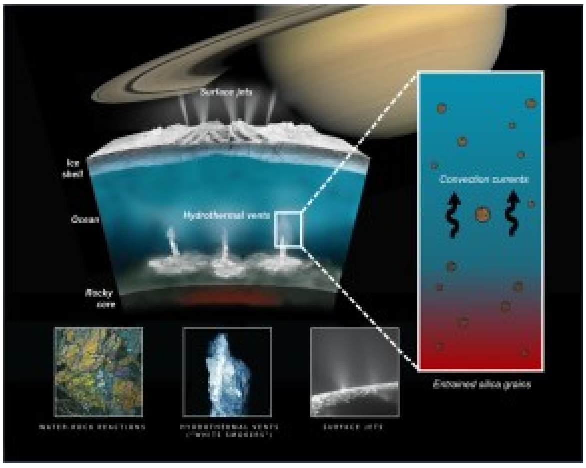
A new study done by a team at the University of California Los Angeles offers some answers. Their work shows that tidal heating in Enceladus’ rocky core creates currents (or flows) that transport the silica. Then, it’s probably released by deep-sea hydrothermal vents over the course of just a few months.

“Our research shows that these flows are strong enough to pick up materials from the seafloor and bring them to the ice shell that separates the ocean from the vacuum of space,” said Ashley Schoenfeld, a doctoral student at UCLA. “The tiger-stripe fractures that cut through the ice shell into this subsurface ocean can act as direct conduits for captured materials to be flung into space. Enceladus is giving us free samples of what’s hidden deep below.”

Why Enceladus Spews its Secrets

Data from the missions that visited the Saturn system keep revealing surprises about the Saturnian moons. We now know that Enceladus is an ocean world, for example. That’s because it has a large volume of liquid water mostly locked away beneath the icy surface. The surface itself is extremely reflective and has cracks that allow fountains of icy particles to escape into space. Those so-called “tiger stripes” provide an exit point for the icy silica.

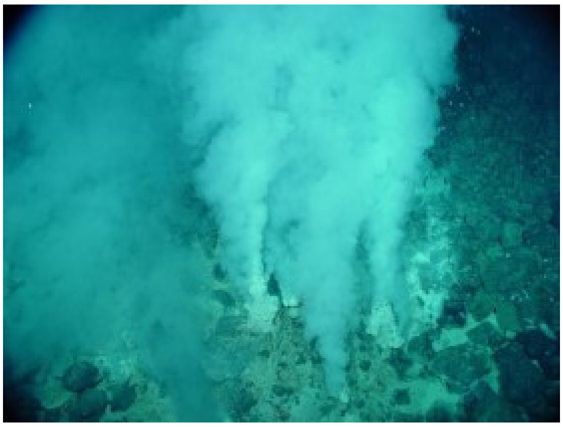
Those particles start out on the sea floor deep beneath the surface. The tidal forces that squeeze Enceladus under the grip of Saturn’s strong gravity deform this little moon. That creates friction in the surface as well as the rocky core underneath the ocean. That sets up currents in the watery ocean.



A rendering of the sediment capture model developed in the UCLA-led study, showing buoyancy effects on silica grains produced at hydrothermal vents along the sea floor and how this eventually leads to their escape through cracks in the outer ice shell of Enceladus. Courtesy: Ashley Schoenfeld/UCLA; NASA/JPL.

Hydrothermal Activity Plays a Role Inside Enceladus

Although the Voyager mission first revealed the strange surface of Enceladus, it wasn’t until Cassini made its long-term studies that planetary scientists found the plumes jetting out from the tiger stripes. The spacecraft measured large amounts of hydrogen gas in those plumes. That’s pretty strong evidence of hydrothermal activity on the ocean floor.



Hydrothermal vents deep in Earth’s oceans. Could similar types of vents power the transport of silica and other materials out from Enceladus? Credit: NOAA

Hydrothermal heating on Earth happens near volcanically active places beneath the sea, particularly in mid-ocean ridges. Those are where tectonic plates are spreading apart. That action allows volcanic material to spew up from beneath and superheat the water. On Enceladus, the friction caused by tidal heating creates hotspots that feed the currents carrying silica particles to space.

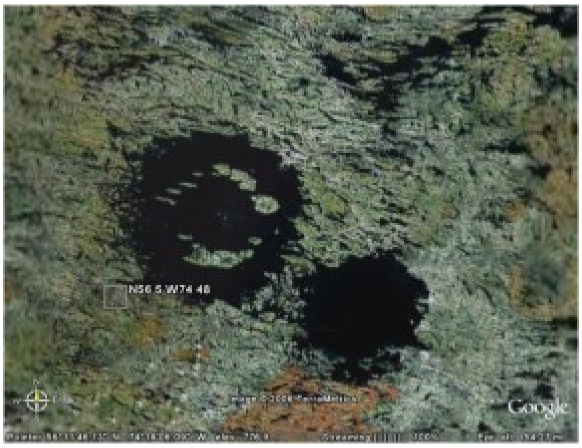
The UCLA team led by Schoenfeld created a model to simulate that process. It also allowed them to estimate a timeframe for it. Their model also explains why the currents are transporting other materials to the surface in addition to the silica. “Our model provides further support to the idea that convective turbulence in the ocean efficiently transports vital nutrients from the seafloor to ice shell," said second author Emily Hawkins, a UCLA alumna who is now an assistant professor of physics at Loyola Marymount University.

Of course, the presence of heat and water raises the question of whether Enceladus is hospitable to life. On Earth, hydrothermal vents support an amazing variety of life forms. It remains for future missions to Enceladus to pin that down. They could study places inside that moon to see if it could support life. Those efforts would require landers to gather more information both on the ice and deep in the subsurface ocean.

Recreating the Extreme Forces of an Asteroid Impact in the Lab

About 50,000 years ago, a nickel-iron meteorite some 50 meters across plowed into the Pleistocene-era grasslands of what is now Northern Arizona. It was traveling fast—about 13 kilometers per second. In just a few seconds, an impact dug out a crater just over a kilometer wide and spread rocks from the site for miles around.

For years, scientists have worked to understand all the forces at work in such an impact event like the one that carved out Meteor Crater. Clearly, impacts have huge effects. The aftermath of the collision affects the landscape and leaves behind a scene of destruction. Yet, as often as Earth has been hit, obvious craters like the one in Arizona are relatively rare. That's because erosion, weathering, and plate tectonics erase them over geologic time. Unless you know exactly where to look, you might not be able to find obvious evidence that something smacked into our planet.



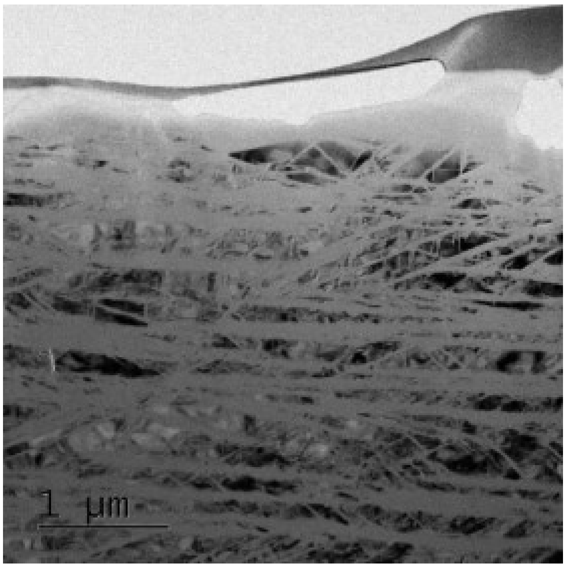
The Clearwater East & West impact craters in Quebec, Canada (image credit: Google Earth). These forms are still visible, even though they are filled with water. Other craters on Earth, such as the Chixculub site in Mexico, are harder to identify.

So, how to understand the forces at work in an impact? According to Professor Falko Langenhorst from the University of Jena, scientists need to study the indirect effects of impacts. These include precision examination of shocked minerals and impact glass—often referred to as lamellar structures. When something hits the ground with tremendous force, it affects materials down to the crystalline level of minerals. These lamellar structures are best studied using electron microscope techniques.

Finding Evidence of Shocked Grains

"For more than 60 years, these lamellar structures have served as an indicator of an asteroid impact, but no one knew until now how this structure was formed in the first place," Liermann said, discussing a set of techniques that allowed them to study these shocked grains. "We have now solved this decades-old mystery."

Langenhorst's team came up with a way to simulate the incredible forces of an asteroid impact in the lab. The idea was to put quartz crystals (similar to the rocks shocked by the Meteor Crater event) under extremely high pressure inside a laboratory instrument. They used something called a "dynamic diamond anvil cell" (dDAC). It allows the science team to control pressures inside and change them very quickly. This simulates the rapidly changing pressures and temperatures at work during an actual impact event.



The impact simulated at the Jena lab creates tiny glass lamellae in quartz crystald. These structures are only tens of nanometers wide, so they had to be studied using an electron microscope. Courtesy: Falko Langenhorst, Christoph Otzen (University of Jena).

With this device, the scientists compressed single, tiny quartz crystals, putting them under tremendous pressure. At the same time, they shone an intense X-ray light through the crystals. This allowed them to witness changes to the crystal structure. "The trick is to let the simulated asteroid impact proceed slowly enough to be able to follow it with the X-ray light, but not too slowly, so that the effects typical of an asteroid impact can still occur," Liermann said.

Looking at an Impact Second-by-Second

Experiments on a scale of seconds proved to be the right duration. This roughly simulates just how quickly an impactor can affect the landscape it's encountering. Essentially, it transforms a quiet grassland into a rapidly expanding upheaval, melting rock and turning the surface into a hole in an extremely short period of time. The experiment in Jena focused on the split-second actions of the impact.

"We observed that at a pressure of about 180,000 atmospheres, the quartz structure suddenly transformed into a more tightly packed transition structure, which we call rosiaite-like," reported team member Christoph Otzen, who is writing his doctoral thesis on these studies. (Technically, rosiaite is an oxidic mineral and the namesake for the crystal structure that is known from various materials. It does not consist of silica, but is a lead antimonate (a compound of lead, antimony, and oxygen).)

"In this crystal structure, the quartz shrinks by a third of its volume. The characteristic lamellae form exactly where the quartz changes into this so-called metastable phase, which no one has been able to identify in quartz before us," said Otzen.

Looking Beyond Impacts

Understanding asteroid impacts on our planet (and others), gives a lot of insight into the interaction between these space rocks and planetary surfaces. After all, impact events shaped our worlds—starting from the first collisions of planetesimals in the early solar system. Earth has been hit many times and is not yet free from the dangers of impacts. So, it's important to understand the intricate forces at work when something from space smacks into our planet.

However, the Jena team's study has implications beyond the study of cratering events, according to Langenhorst. "What we observed could be a model study for the formation of glass in completely different materials such as ice," Langenhorst pointed out. "It might be the generic path that a crystal structure transforms into a metastable phase in an intermediate step during rapid compression, which then transforms into the disordered glass structure. We plan to investigate this further because it could be of great importance for materials research."

"The Universe Breakers": Six Galaxies That are Too Big, Too Early

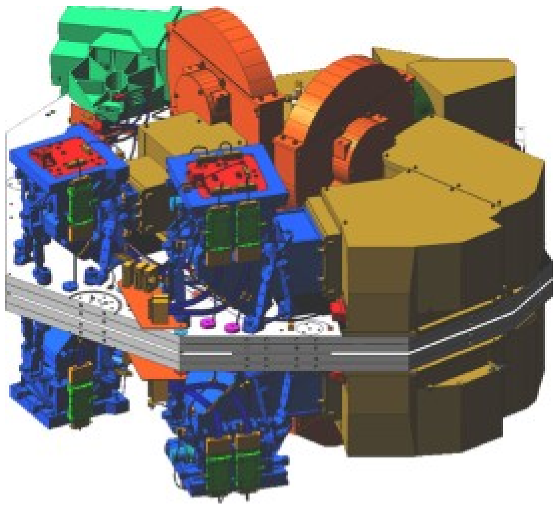
In the first data taken last summer with the Near Infrared Camera (NIRCam) on the new James Webb Space Telescope, astronomers found six galaxies from a time when the Universe was only 3% of its current age, just 500-700 million years after the Big Bang. While its incredible JWST saw these galaxies from so long ago, the data also pose a mystery.

These galaxies should be mere infants, but instead they resemble galaxies of today, containing 100 times more stellar mass than astronomers were expecting to see so soon after the beginning of the Universe. If confirmed, this finding calls into question the current thinking of galaxy formation and challenges most models of cosmology.

"These objects are way more massive than anyone expected," said Joel Leja, assistant professor of astronomy and astrophysics at Penn State, who modeled light from these galaxies. "We expected only to find tiny, young, baby galaxies at this point in time, but we've discovered galaxies as mature as our own in what was previously understood to be the dawn of the universe."

The data was taken by JWST as part of the Cosmic Evolution Early Release Science (CEERS) program and was the first dataset released as part of the telescope's early release program, which is helping to showcase the new telescope's observing capabilities and allow the astronomical community to learn how to get the most out of their observing time with the various instruments.

NIRCam's infrared eyes are capable of detecting light that was emitted by the oldest stars and galaxies, allowing scientists to see back in time roughly 13.5 billion years, near the beginning of the universe as we know it. The targeted area of the sky for these sets of observations was a "blank" field – where no stars or galaxies had ever been seen before — and overlapped with existing Hubble Space Telescope (HST) imaging.



NIRCam Engineering Diagram. Credit: Space Telescope Science Institute.

While large galaxies with stellar masses as high as 100 billion times that of the Sun have been identified previously at approximately one billion years after the Big Bang, it has been difficult to find massive galaxies at even earlier times, the team wrote in their paper, published in Nature.

Within the JWST early release observation data, the team searched for intrinsically high redshifted galaxies in the first 500- 750 million years of cosmic history. Redshift is a measure of the age of an astronomical object, as due to the expansion of the Universe, light from distant objects shifts to wavelengths towards the red end of the spectrum. The redder the image, the more distant the object is.

They found six candidate massive galaxies at high redshifts ($z = 6.5$ and $z = 9.1$), with masses up to ten billion times that of our Sun, including one galaxy with a possible stellar mass 100 billion times that of the Sun. This is much bigger than anticipated.

"We looked into the very early universe for the first time and had no idea what we were going to find," Leja said, in a press release. "It turns out we found something so unexpected it actually creates problems for science. It calls the whole picture of early galaxy formation into question."

Leja explained that the galaxies the team discovered are so massive that they are in conflict with 99% of models for cosmology. Accounting for such a high amount of mass would require either altering the models for cosmology or revising the scientific understanding of galaxy formation in the early universe. Either scenario requires a fundamental shift in our understanding of how the universe came to be, he added.

However, the team needs more observations and data to confirm their findings, and admitted more data might reveal other explanations for what they found.

"This is our first glimpse back this far, so it's important that we keep an open mind about what we are seeing," Leja said. "While the data indicates they are likely galaxies, I think there is a real possibility that a few of these objects turn out to be obscured supermassive black holes. Regardless, the amount of mass we discovered means that the known mass in stars at this period of our universe is up to 100 times greater than we had previously thought. Even if we cut the sample in half, this is still an astounding change."

The plan is to take more data on these galaxies with NIRCam, and which will provide more details on how and distant these galaxies are. and how far away they are.

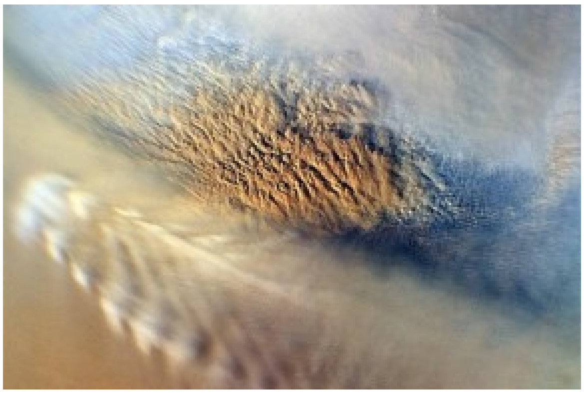
"What's funny is we have all these things we hope to learn from James Webb and this was nowhere near the top of the list," Leja said. "We've found something we never thought to ask the universe — and it happened way faster than I thought, but here we are."

Dust Storms on Mars Generate Static Electricity. What Does This Do to Its Surface?

Dust storms are a serious hazard on Mars. While smaller storms and dust devils happen regularly, larger ones happen every year (during summer in the southern hemisphere) and can cover continent-sized areas for weeks. Once every three Martian years (about five and a half Earth years), the storms can become large enough to encompass the entire planet and last up to two months. These storms play a major role in the dynamic processes that shape the surface of Mars and are sometimes visible from Earth (like the 2018 storm that ended the *Opportunity* rover's mission).

When Martian storms become particularly strong, the friction between dust grains causes them to become electrified, transferring positive and negative charges through static electricity. According to research led by planetary scientist Alian Wang at Washington University in St. Louis, this electrical force could be the major driving force of the Martian chlorine cycle. Based on their analysis, Wang and her colleagues believe this process could account for the abundant perchlorates and other chemicals that robotic missions have detected in Martian soil.

Dr. Wang led an international team of researchers from Texas Tech University, the University of Delaware, the McDonnell Center for the Space Sciences (MCSS), and Oxford University. The paper that describes their findings recently appeared in the *Geophysical Research Letters*. In it, Wang and her colleagues demonstrated how electrical discharge caused by dust storms could be responsible for decomposing chloride salts and creating atmospheric chlorine and other chemical compounds found on the surface (chlorates. perchlorates, and carbonates).



Close-up image of a Martian dust storm acquired by NASA's Mars Reconnaissance Orbiter (MRO) on Nov. 7th, 2007. Credit: NASA/JPL-Caltech

On Mars, chlorine is considered one of five " mobile elements," the others being hydrogen, oxygen, carbon, and sulfur. Like Earth's water cycle (or Titan's methane cycle), this means that chlorine is transferred between the Martian surface and the atmosphere in different forms. It exists in gaseous form in the atmosphere, while chloride deposits are found across the surface. These deposits are similar to salt pans found across Earth, like the Bonneville Salt Flats in Utah, the Etosha Pan in Namibia, and the Salar de Uyuni in Bolivia (the largest in the world).

Similar to Earth, these chloride deposits are likely to be the dried remains of briny patches of water that existed on the surface. It is theorized that they formed from interactions between the surface and atmosphere during the Amazonian period. This geological era extends to this day and is thought to have begun with the end of the Hesperian period (ca. 3 billion years ago) when Mars was still transitioning from a warmer, wetter environment to what we see there today (extremely cold and desiccated).

Since there is no longer exchange between the surface and atmosphere, scientists have wondered how atmospheric chlorine and chloride deposits could be linked. In their new study, Wang (a faculty fellow with the MCSS) and her colleagues demonstrated that electrical discharges caused by dust storms are an efficient way for chlorine exchange between the surface and air. The possibility that dust storms might be a source of reactive chemistry on Mars was first proposed when the *Viking 1* and *2* missions landed there in the 1970s.

However, the chemical effects of dust activities were difficult to study since the ESA's *Schiaparelli* lander (which would study the phenomenon) crashed on the surface in 2016. As a result, scientists have had to stick with climate modeling and experimental studies, including research that Wang and other planetary scientists have done in recent years. These have shown that when electrostatic discharges interact with chlorine salts in a carbon dioxide-rich environment (like the Martian atmosphere), chlorine gas is released, and perchlorates and carbonates can be generated.

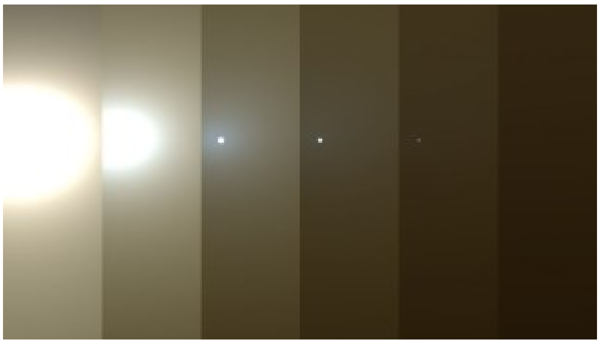
A Martian dust devil in the Amazonis Planitia region on March 14th, 2012, captured by NASA's Mars Reconnaissance Orbiter. Credit: NASA/JPL-Caltech

However, this latest study was the first time planetary scientists attempted to quantify how much of these chemicals are produced during Martian dust storms. This was done through a series of experiments at Washington University's Planetary Environment and Analysis Chamber (PEACh), where the team subjected various common chloride mineral salts to electrical discharges under Mars-like conditions. As Wang indicated in a Washington University (The Source) press release, the results confirmed their theory:

"Frictional electrification is a common process in our Solar System, with Martian dust activities known to be a powerful source of electrical charge buildup. The thin atmosphere on Mars makes it much easier for accumulated electrical fields to break down in the form of electrostatic discharge. In fact, it's a hundred times easier on Mars than on Earth.

"The reaction rates are huge. Importantly, the released chlorine in a short-time mid-strength electrostatic discharge process is at a percent level. No other process that we know of can do this, especially with such quantitatively high yield of chlorine release."

During a seven-hour simulated electrostatic discharge experiment, they found that at least 1 out of 100 chloride molecules decomposed and released a chlorine atom. In addition, the electrical discharge also accounted for the very high global concentrations of perchlorate and carbonate compounds in Martian topsoil – though the formation rates were slightly lower (sub-percent per-thousand levels). The experiment also showed that the observed concentration ranges could be accumulated within half of the Amazonian period.



Simulated views of a darkening Martian sky from NASA's Opportunity rover's point of view, the right side simulating Opportunity's view in the global dust storm as of June 2018. Credit: NASA/JPL-Caltech/TAMU

Lastly, the high yields could account for the high atmospheric concentrations of hydrogen chloride observed during the 2018 and 2019 dust storms. Said Kevin Olsen, a research fellow at The Open University and a co-author of the new study:

"The high-releasing rate of chlorine from common chlorides revealed by this study indicates a promising pathway to convert surface chlorides to the gas phases that we now see in the atmosphere. These findings offer support that Martian dust activities can drive a global chlorine cycle. With the ExoMars Trace Gas Orbiter, we see repeated seasonal activity that coincides with global and regional dust storms."

Another interesting takeaway from this study was how the team theorized what electrostatic discharges might look like on Mars. According to Wang, the discharge would not look like a flash of lightning (as is the case on Earth). Instead, she said, it would be more akin to a glow due to Mars' thin atmosphere. "It could be somewhat like the aurora in polar regions on Earth, where energetic electrons collide with dilute atmospheric species," she said.

To date, no robotic missions on Mars, be they landers, rovers, or orbiters, have witnessed an electrical discharge during a dust storm. The glows would likely be obscured by the heavy dust concentrations and not be visible from orbit. Meanwhile, surface missions that rely on solar power are forced to suspend operations in heavy storms to preserve power (as was the case during the recent storm season for the *Ingenuity* helicopter). But perhaps the nuclear-powered *Curiosity* or *Perseverance* rover could get a candid shot of this phenomenon before their missions are complete.

Otherwise, we might have to wait on crewed missions to see one of these "aurora," which could lead to a Mark Whatney-like situation!

Astronomers Find a Group of Water-rich Asteroids

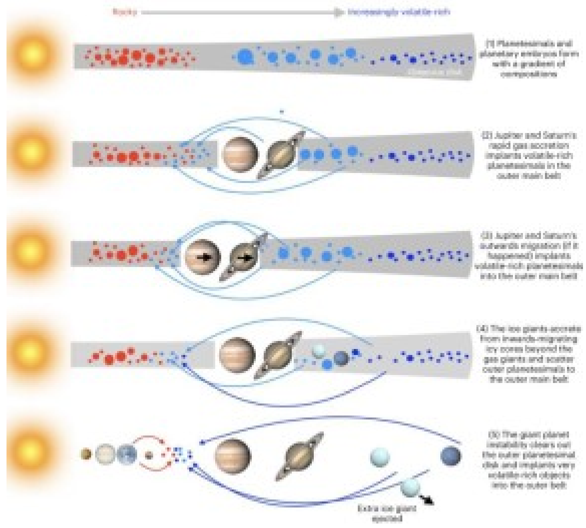
If you've ever been at sea or visited a seacoast, you probably looked out at the vast expanse of ocean and wondered, "How did all this water get here?" The answer goes back to Earth's origins some 4.5 billion years ago. In those early times, water-rich planetesimals and other bodies transported water to our still-growing planet. A recent discovery of a previously unknown population of such asteroids between Mars and Jupiter seems to prove that point.

An international group of geoscientists used the NASA Infrared Telescope in Hawaii to measure the spectra of these so-called "low-albedo" (or "dark") worldlets. The characteristics of the light reflected off their surfaces show what chemical elements and minerals exist there. From those measurements, the research team created a model of the newly found asteroids.

Measuring Dark Asteroids

"The astronomical measurements permit the identification of Ceres-like asteroids with a diameter as small as 100 kilometers, presently located in a confined region between Mars and Jupiter near Ceres' orbit," said Dr. Driss Takir, an astrophysicist at the NASA Johnson Space Center and lead author of the study. The team's infrared spectra support a conclusion that, just like Ceres, there are minerals on the surface of the discovered asteroids that originated from interaction with liquid water. Further, these dark asteroids preserve a record of the primordial solar system planetesimals and the conditions in the solar nebula.

"These are the remains of the building materials from which the planets of our solar system were created four and a half billion years ago," said Dr. Mario Trieloff from the Institute of Earth Sciences in Heidelberg, Germany. He is part of the study team. "In these small bodies and their fragments, the meteorites, we find numerous relics that point directly to the process of planet formation."



How asteroids were implanted into the Asteroid Belt during the growth and evolution of the early solar system. Courtesy *Nature Astronomy* (2023). DOI: 10.1038/s41550-023-01898-x

How Did Asteroid Water End Up on Earth?

The general consensus today among planetary scientists is that much of Earth's water got here by way of smaller bodies. They smashed together to make larger bodies that themselves crashed together to make our home planet. These dark, water-rich "leftovers" from the solar system's formation had water "inclusions". Those could be small fluid deposits inside the rocks or even icy layers.

Or, they have "hydrated" minerals. Essentially, water exists inside them as part of the rock's crystalline structure. Silicates (rocks that are mainly silicon and oxygen and make up much of Earth's crust) are good examples of this. Some could have clay minerals (phyllosilicates). Certainly, many larger asteroids show evidence of these types of hydration. If you bring enough of them together, as happened with

Earth's formation, the water ends up at the growing body, along with the minerals.

These little worlds are also quite porous, which tells scientists they're part of the original inventory of the solar system. "Shortly after the formation of the asteroids, temperatures were not high enough to convert them into a compact rock structure; they maintained the porous and primitive character typical of the outer ice planets located far from the sun," explained Dr. Wladimir Neumann, a member of Prof. Trieloff's team. That porosity also lends credence to their water-rich qualities.

An artist's rendering of the early moon and Earth, which sustained many asteroid impacts. Many of those asteroids contributed their water to the infant Earth. As it cooled, the water outgassed as vapor and rained onto the surface. Credit: Simone Marchi (SwRI)/SSERVI/NASA

What Water-Rich Asteroids in the Belt Tell Us About Early Solar System History

The properties of the Ceres-like objects in the study and their presence in a relatively narrow zone of the outer Asteroid Belt have some interesting implications. They probably first formed in a cold region at the edge of our solar system, as Ceres likely did. Gravitational disruptions in the orbits of large planets like Jupiter and Saturn—or "giant planet instability"—changed the trajectory of these asteroids. Eventually, they ended up in today's Asteroid Belt.

Like the smaller asteroids that resemble it by composition, Ceres has a water ice component. Some of that ice is in the surface layer and some is hidden inside. Deposits of ammonium salts near one of Ceres's craters suggest it was born in the outer solar system. Perturbations caused by Jupiter's migration to its present position also shifted Ceres to its present position. That sent this dwarf planet toward its current home in the Belt. Those same disturbances also moved other planetesimals and asteroids around. Eventually, they became part of other worlds closer to the Sun.

That ancient history is reflected today in Earth's oceans and Mars's current water-ice deposits. So, the next time you're at the seashore, what you see was part of a bombardment of icy asteroids and comets. They delivered water from the outer regions of the solar system to the newly formed worlds of the inner solar system.

Meteorites are Contaminated Quickly When They Reach Earth

On Earth, geologists study rocks to help better understand the history of our planet. In contrast, planetary geologists study meteorites to help better understand the history of our solar system. While these space rocks put on quite the spectacle when they enter our atmosphere at high speeds, they also offer insights into both the formation and evolution of the solar system and the planetary bodies that encompass it. But what happens as a meteorite traverses our thick atmosphere and lands on the Earth? Does it stay in its pristine condition for scientists to study? How quickly should we contain the meteorite before the many geological processes that make up our planet contaminate the specimen? How does this contamination affect how the meteorite is studied?

These are questions that a team of researchers at the University of Glasgow in the United Kingdom (UK) hope to answer in a recent study as they investigate the Winchcombe meteorite, which made landfall in the UK in early 2021 with a total known weight of 602 grams (21.2 oz). What makes the Winchcombe meteorite unique is that some of the fragments were collected and sealed within hours after blazing through our atmosphere, which helped preserve the meteorite for scientific study. However, even this quick containment might not be able to prevent contamination, as the researchers attempted to find out.

"Analysis of meteorites can provide insights into the asteroids they come from and how they have formed," said Laura Jenkins, who is a PhD student in Glasgow's School of Geographical and Earth Sciences, and lead author of the study. "Winchcombe and other meteorites like it contain extraterrestrial water and organics, and the asteroids they come with may be responsible for delivering water to Earth, giving it enough water to form its distinctive oceans. However, when a meteorite is exposed to terrestrial contaminants, especially moisture and oxygen, it undergoes changes, affecting the information it provides."

Fragment of the Winchcombe meteorite stored in the UK's Natural History Museum. (Credit: Geni; licensed under the Creative Commons Attribution-Share Alike 4.0 International license)

For the study, the researchers used Raman spectroscopy, transmission electron microscopy, and scanning electron microscopy to analyze two polished samples of the Winchcombe meteorite for what are known as "terrestrial phases", or the development of minerals and salts when the meteorite fragments interacted with Earth's damp environment upon landing. One sample was collected on March 2, 2021, from a domestic garden lawn, and the other sample was collected on March 6, 2021, from a sheep-grazing field.

The researchers identified halite on the March 2nd, driveway sample and a combination of calcite and calcium sulfates on the March 6th, sheep-grazing sample. The calcite veins crosscut the meteorite's fusion crust, the melted material that results from the heated entry into the Earth's atmosphere, which indicates calcite veins postdate the crust, meaning it happened after the meteorite landed.

The halite was found on the surface of the polished section, and the calcium sulfates were found on the edges of the sample and contained anhydrite, gypsum, and bassanite. The team hypothesizes that the halite was formed from the laboratory's humidity over a period of months, while the calcite and calcium sulfates likely formed from the sheep field's damp environment.

Learn more about the Winchcombe meteorite and how it was discovered!

"The Winchcombe meteorite is often described as a 'pristine' example of a CM chondrite meteorite, and it's already yielded remarkable insights," said Jenkins. "However, what we've shown with this study is that there's really no such thing as pristine meteorite – terrestrial alteration begins the moment it encounters Earth's atmosphere, and we can see it in these samples which we analyzed just a couple of months after the meteorite landed.

"It shows just how reactive meteorites are to our atmosphere, and how careful we need to be about ensuring that we take this kind of terrestrial alteration into account when we analyze meteorites," Jenkins continued. "To minimize terrestrial alteration, meteorites should be stored in inert conditions if possible. Understanding which phases are extra-terrestrial and which are terrestrial in meteorites like Winchcombe will not only help our understanding of their formation but will also aid in relating meteorites that have landed on Earth to samples returned by sample return missions. A more complete picture of the asteroids in our solar system and their role in Earth's development can be built."

The researchers stress the importance of storing quickly recovered samples in an inert atmosphere, or an atmosphere that doesn't contain oxygen or carbon dioxide, which are often responsible for creating the "terrestrial phases" found in meteorites. They used the Hayabusa2 and OSIRIS-REx missions as examples of pristine samples being returned to Earth and that sample return missions are important for scientists to better understand our solar system. The researchers concluded by noting that better understanding meteorite weathering will help improve sample storage protocols, along with comparing such samples to Earth-altered samples.

History of the Winchcombe Meteorite

Learn more about the Winchcombe meteorite one year after it landed, and what's it teaching us!

Just before 10:00 pm on the evening of February 28, 2021, a small meteorite broke apart over the English county of Gloucestershire traveling at approximately 14 kilometers per second (8.7 miles per hour), briefly appearing as a green fireball witnessed by over 1000 people. The following morning, the Wilcock family residing in the small English town of Winchcombe found a pile of powder and dark stones littered in their driveway and a small dent in the driveway's tarmac. While they heard the sonic boom the night before, they chose not to investigate it.

After collecting the fragments from their driveway, the family contacted the UK Meteor Observation Network (UKMON) and spent the following two days collecting powder and stones from their driveway and front lawn. In the following weeks, hundreds of fragments were recovered spanning an area from the neighbor's driveway to several towns over and the surrounding countryside. When all fragments were collected, the total known weight came in at 602 grams (21.2 oz), and this meteorite was henceforth named the Winchcombe meteorite after the town it landed in.

What new discoveries will we make about meteorites and how Earth alters their composition in the coming years and decades? Only time will tell, and this is why we science!

All of Jupiter's Large Moons Have Auroras

Jupiter is well known for its spectacular aurorae, thanks in no small part to the *Juno* orbiter and recent images taken by the *James Webb Space Telescope* (JWST). Like Earth, these dazzling displays result from charged solar particles interacting with Jupiter's magnetic field and atmosphere. Over the years, astronomers have also detected faint aurorae in the atmospheres of Jupiter's largest moons (aka. the "Galilean Moons"). These are also the result of interaction, in this case, between Jupiter's magnetic field and particles emanating from the moons' atmospheres.

Detecting these faint aurorae has always been a challenge because of sunlight reflected from the moons' surfaces completely washes out their light signatures. In a series of recent papers, a team led by the University of Boston and Caltech (with support from NASA) observed the Galilean Moons as they passed into Jupiter's shadow. These observations revealed that Io, Europa, Ganymede, and Callisto all experience oxygen-aurorae in their atmospheres. Moreover, these aurorae are deep red and almost 15 times brighter than the familiar green patterns we see on Earth.

The research team included astronomers from the Center for Space Physics (CSP) at Boston University, the Division of Geological and Planetary Sciences (GPS) at Caltech, the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado, Earth and Planetary Science at the UC Berkeley, Large Binocular Telescope Observatory (LBT), the Southwest Research Institute (SwRI), the Planetary Science Institute (PSI), the Leibniz-Institute for Astrophysics Potsdam (AIP), and NASA's Goddard Space Flight Center. The two studies, titled "The Optical Aurorae of Europa, Ganymede, and Callisto" and "Io's Optical Aurorae in Jupiter's Shadow," appeared on February 16th in the *Planetary Science Journal*.

Galilean Family Portrait. Credit: NASA/JPL

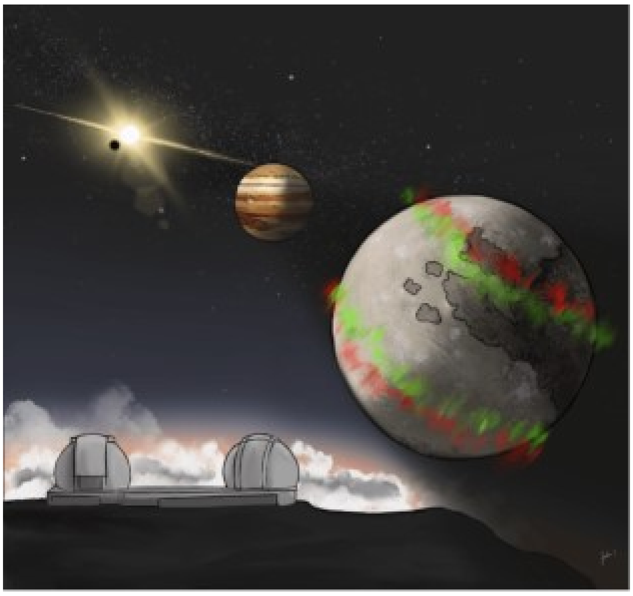
The team's observations combined data from the Keck Observatory's High-Resolution Echelle Spectrometer (HIRES) with high-resolution spectra from the Large Binocular Telescope (LBT) and the Apache Point Observatory (APO). These observations were timed to see Io, Europa, Ganymede, and Callisto when they entered Jupiter's shadow to avoid interference from sunlight reflected off their surfaces. This data revealed valuable information concerning the composition of the moons' atmospheres, which included oxygen gas (as expected).

Katherine de Kleer, a Caltech professor and the lead author of one of two papers, explained in a Keck Observatory press release:

"These observations are tricky because in Jupiter's shadow the moons are nearly invisible. The light emitted by their faint aurorae is the only confirmation that we've even pointed the telescope at the right place. The brightness of the different colors of aurora tell us what these moons' atmospheres are likely made up of. We find that molecular oxygen, just like what we breathe here on Earth, is likely the main constituent of the icy moon atmospheres."

All four Galilean Moons showed the same oxygen aurorae, similar to what we see with the Aurora Borealis and Australis (the Northern and Southern Lights) here on Earth. In the case of Europa, Ganymede, and Callisto, the oxygen content of their atmospheres is due to photolysis, a process where water ice sublimates and is broken down by solar radiation into its hydrogen gas and oxygen. In Io's case, the oxygen is caused by sulfur dioxide (spewed from the many volcanoes that dot its surface) interacting with solar radiation to form sulfur monoxide and elemental oxygen.

But because of their much thinner atmospheres, this oxygen glows in the deep red and (for Europa and Ganymede) in infrared wavelengths – the latter being undetectable to the human eye. Because of Io's volcanic activity, salts like sodium chloride and potassium chloride are also present in the atmosphere, where they are also broken down by solar radiation. This leads to aurorae on Io emitting a yellow-orange glow (caused by sodium) and glowing in the infrared (caused by potassium).



Artist's depiction of oxygen aurora on Jupiter's moon Ganymede, the largest moon in the solar system, as observed by the twin Keck Observatory telescopes. Credit: Julie Inglis

This was the first time astronomers observed this infrared glow in these moons' atmospheres. What's more, the new measurements also revealed minimal evidence of water vapor, which was previously thought to be a component in the atmospheres of Europa, Ganymede, and Callisto. All three moons are theorized to have interior oceans beneath their icy surfaces, and there's even some tentative evidence that water vapor in Europa's atmosphere may result from plume activity. These plumes are thought to be connected to the moon's interior ocean or liquid reservoirs within its icy shell.

The observations also showed how Jupiter's tilted magnetic field causes aurorae to vary in brightness as the gas giant rotates. The tilt of this field, roughly 10° from Jupiter's axis of rotation compared to Earth's 11° tilt, means that the moons will experience greater interaction at certain times of their orbit. Lastly, they also noted how the atmospheres responded rapidly to temperature changes caused by the transition between exposure to sunlight and passing within Jupiter's shadow. Said Carl Schmidt, a professor of astronomy at Boston University and the lead author of the second paper:

"Io's sodium becomes very faint within 15 minutes of entering Jupiter's shadow, but it takes several hours to recover after it emerges into sunlight. These new characteristics are really insightful for understanding Io's atmospheric chemistry. It's neat that eclipses by Jupiter offer a natural experiment to learn how sunlight affects its atmosphere."

These latest observations have added excitement to what is already a very exciting field of research. In the coming years, space agencies will send more robotic explorers to Europa and Ganymede – NASA's Europa Clipper and the ESA's JUpiter ICy moon Explorer (JUICE). These missions will conduct multiple flybys of these moons, gather data on the compositions of their atmospheres and surfaces, and attempt to spot indications of possible life in their interiors ("biosignatures"). Seeing these bright red aurorae up close will be nothing short of jaw-dropping!

Are Black Holes the Source of Dark Energy?

By the 1920s, astronomers learned that the Universe was expanding as Einstein's Theory of General Relativity predicted. This led to a debate among astrophysicists between those who believed the Universe began with a Big Bang and those who believed the Universe existed in a Steady State. By the 1960s, the first measurements of the Cosmic Microwave Background (CMB) indicated that the former was the most likely scenario. And by the 1990s, the Hubble Deep Fields provided the deepest images of the Universe ever taken, revealing galaxies as they appeared just a few hundred million years after the Big Bang.

Over time, these discoveries led to an astounding realization: the rate at which the Universe is expanding (aka. the Hubble Constant) has not been constant over time! This led to the theory of Dark Energy, an invisible force that counteracts gravity and causes this expansion to accelerate. In a series of papers, an international team of researchers led by the University of Hawaii reported that black holes in ancient and dormant galaxies were growing more than expected. This constitutes (they claim) the first evidence that black holes could be the source of Dark Energy.

The research was made up of astronomers and astrophysicists from the University of Hawai'i, the Kavli Institute for Cosmological Physics, the Enrico Fermi Institute, the European Southern Observatory (ESO), the Netherlands Institute for Space Research (SRON), the National Radio Astronomy Observatory (NRAO), the Instituto de Astrofísica e Ciências do Espaço (IA), the Mitchell Institute for Fundamental Physics and Astronomy, and multiple universities. Their findings appeared in two papers published in *The Astronomical Journal* and *The Astronomical Journal Letters*.

Cosmological Crisis

According to the most widely accepted model of the Universe, Dark Energy accounts for 68% of the mass-energy content in the Universe. This theory resurrected an idea Einstein had proposed but later rejected – that there was a "Cosmological Constant" (represented by the scientific symbol delta) that "held back" gravity and prevented the Universe from collapsing in on itself. The force and Dark Matter (which accounts for 26.8% of the mass-energy content) are integral to the most widely held cosmological model today, known as the Lambda-Cold Dark Matter (LCDM) model.

The main argument behind Dark Energy is that there is a special type of energy within spacetime (called vacuum energy) pushing the Universe apart. There are a few problems with this theory, though, not the least of which has to do with the fact that no direct evidence exists for this mysterious energy. Moreover, while this vacuum energy is consistent with quantum mechanics, all attempts to calculate it using quantum field theory have come up dry. On top of that, there is the question of how this energy coincides with supermassive black holes (SMBHs) in our Universe.

By the 1970s, astronomers had determined that the persistent radio source at the center of our galaxy (Sagittarius A*) was a black hole with a mass of 40 million Suns. Further observations demonstrated that most massive galaxies had SMBHs in their core region, which was the reason for Active Galactic Nuclei (AGNs), or quasars. The extremely powerful gravity of SMBHs causes surrounding matter to infall around them, forming accretion disks and powerful relativistic jets where matter is sped up to close to the speed of light (and releases tremendous amounts of radiation in the process).

The presence of these mammoths at the center of most massive galaxies would require an extremely strong force to counteract them. This is particularly true when it comes to the singularities theorized to exist at their cores, where the very laws of physics break down and become indistinguishable. This gave rise to an exotic theory known as "cosmological coupling," which states that SMBHs might have tremendous vacuum energy and that they are the reason the Universe is expanding.

Extraordinary Claims…

In their papers, the team led by Duncan Farrah (an astronomer with the University of Hawai'i at Manoa and a former Ph.D. with Imperial College report the first observational evidence that black holes gain mass in a way consistent with them containing vacuum energy. Whereas astrophysicists have been looking for a theoretical resolution to the problem of Dark Energy and Black Holes, the team's findings allegedly constitute the first *observational* evidence that black holes are the source of Dark Energy.

If true, the finding removes the need for singularities to form at the center of black holes, resolving a long-standing debate. It also means that nothing more is needed (no new forces or modified theories of gravity) for our cosmological models to make sense. Dr. Chris Pearson, a researcher from RAL Space, a research council overseen by the UK's Science and Technology Facilities Council (STFC), and Dr. Dave Clements of the Department of Physics at Imperial College were co-authors on the studies.

"If the theory holds, then this will revolutionize the field of cosmology, because at last we've got a solution for the origin of dark energy that's been perplexing cosmologists and theoretical physicists for more than 20 years," said Pearson in a RAL Space press release. "This is a really surprising result. We started off looking at how black holes grow over time, and may have found the answer to one of the biggest problems in cosmology," added Clements.

…Require Extraordinary Evidence

The team reached this conclusion by examining the evolutionary history of SMBHs at the center of giant elliptical galaxies. This refers to a type of "early galaxy" that formed early in the Universe and has since ceased forming stars (aka. "dormant galaxies"). Decades of observations have shown that black holes can increase their mass in two ways: by accreting matter or by merging with black holes. As they indicated in their first paper, the team examined giant elliptical galaxies at redshifts of less than z<2 (as they appeared nine billion years ago).

Artist's impression of merging black holes in the early Universe. Credit: LIGO/Caltech/MIT/R. Hurt (IPAC)

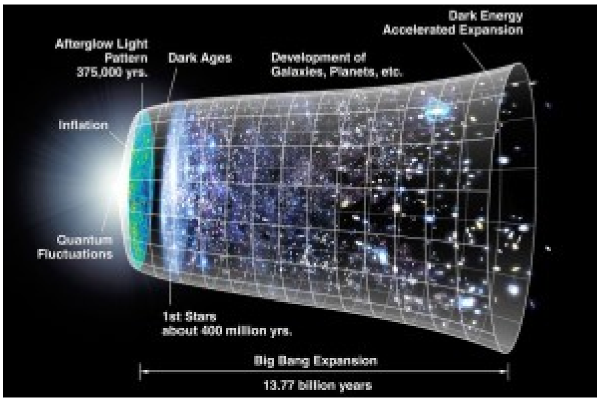
These dormant galaxies have little material left for their SMBHs to accrete, meaning that further growth cannot be explained by the two mechanisms mentioned above. The team then compared observations of these elliptical galaxies – which still appear young – to local galaxies dated to ca. 6.6 billion years ago, which have since become dormant. These observations revealed that the SMBHs were 7 to 20 times larger than they were nine billion years ago, much greater than what is predicted by accretion or mergers.

In their second paper, they further state how measurements of related populations of galaxies at different points in their evolution (ca. 7.2 billion years ago) showed a similar correlation between the mass of SMBHs and the size of the Universe. This constitutes the first evidence of "cosmological coupling" by showing that the expansion of the Universe and the growth of SMBHs are related. If this is born out by further observations, it could effectively redefine our understanding of the Universe and the nature of black holes. As Farrah concluded:

"We're really saying two things at once: that there's evidence the typical black hole solutions don't work for you on a long, long timescale, and we have the first proposed astrophysical source for dark energy. What that means, though, is not that other people haven't proposed sources for dark energy, but this is the first observational paper where we're not adding anything new to the Universe as a source for dark energy: black holes in Einstein's theory of gravity are the dark energy."

Correlation, not Coupling?

Naturally, these claims have been met with some skepticism by the astronomical/astrophysical community. In particular, the authors' claim that their observations constitute proof of coupling has been challenged for conflating correlation with causation. Astrophysicist, author, science communicator, and Forbes senior contributor Ethan Siegel addressed this in a recent installment of *Ask Ethan* – a special series in his column Starts with a Bang!, where he addresses audiences' questions. Upon examining their research, Siegel notes how the authors' conclusions rest upon a major assumption.



Expansion of the Universe from the Big Bang to today. Credit: NASA/WMAP Science Team

This assumption is that there is "a universal relationship between the mass of the central black hole and the mass of the stars within a galaxy, which can evolve over cosmic time but should be universal at any particular time." From this, they compared the SMBHs they chose for their sample data to determine whether there is a "coupling parameter" (represented as *k*) that has the same value across cosmic time. In the end, the team determined with a confidence of 99.8% that k has a non-zero value. While ostensibly compelling, this conclusion comes down to an assumed relationship. As Ethan concluded:

"The authors are assuming the existence of a coupling that isn't there and ascribing the perceived evolution of the black hole-to-stellar mass ratios to a coupling, when what's happening is these galaxies and their black holes are evolving. Since we're only measuring each galaxy at a 'snapshot' in time, we have no way of knowing how any individual object is evolving, and this particular method is precisely how the article authors are fooling themselves, and by extension, anyone who believes them."

At the risk of repeating the overused adage, “extraordinary claims require extraordinary evidence.” The ability to verify results repeatedly is one of the most important qualifiers for evidence to be considered sound. In other words, results must be demonstratable again and again and (preferably) using varying methods. The authors acknowledge this and hope that repeated observations will bear them out. But for the time being, the claim they’ve made remains extraordinary and (given the implications) demands further investigation.

Galaxies Aren’t Just Stars. They’re Intricate Networks of Gas and Dust

Astronomers have studied the star formation process for decades. As we get more and more capable telescopes, the intricate details of one of nature’s most fascinating processes become clearer. The earliest stages of star formation happen inside a dense veil of gas and dust that stymies our observations.

But the James Webb Space Telescope sees right through the veil in its images of nearby galaxies.

The PHANGS (Physics at High Angular resolution in Nearby Galaxies) collaboration is a large survey of nearby spiral galaxies. Its goal is to ” … understand the interplay of the small-scale physics of gas and star formation with galactic structure and galaxy evolution,” according to the PHANGS website.

Telescopes like the Hubble Space Telescope and ALMA have contributed to PHANGS and resolved individual gas clouds and star-forming complexes in galaxies that are the cradles of star birth and the engines of galactic evolution. Now that the JWST is operational, it’s also taking part in PHANGS.

In these PHANGS images, the James Webb Space Telescope is displaying its impressive power once again. The Webb’s high resolution and infrared capabilities reveal new details in the distant spiral galaxies, including intricate networks of gaseous and dusty features. Its observations have led to no fewer than 21 new papers. This is after the telescope has imaged only 5 of its 19 total targets:

- NGC 1433
- M 74
- NGC 7496
- IC 5332
- NGC 1365

The images show galaxies whose spiral arms are nearly frothing with overlapping filaments of gas and dust and bubbles carved out by newly formed stars.

The leading image shows NGC 1433, a barred spiral galaxy with a double-ring structure about 46 million light-years away. Its central region experiences intense star-forming activity. Its spiral arms are also rife with young stars, and the JWST brings it all out in glorious detail. NGC 1433 has an interesting double-ring feature in its core, where tight spiral arms wrap around each other and the bar.

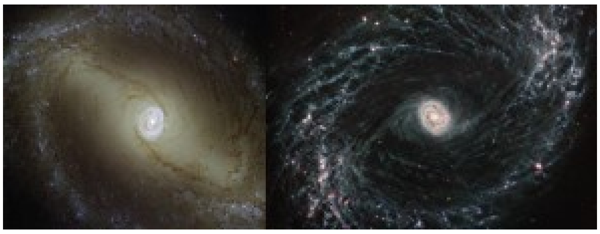
The JWST’s infrared observing prowess brings something new to the table. When very young stars are born, the action is hidden behind a veil of gas and dust. Only once the star has been shining for a while does it blow the veil away with its stellar wind, and astronomers can see the young star. But the JWST doesn’t have to wait. It can see through the gas and dust and give astronomers views of stars much younger than other telescopes can.

The Hubble can’t easily see past the dust like JWST can because the Hubble can’t see mid-infrared photons. When tiny dust grains in galaxies like NGC 1433 absorb UV and optical photons from young stars, the dust grains are heated enough that they produce mid-infrared photos in a process called stochastic heating. The James Webb excels at seeing the mid-IR, and the galaxy’s entire structure is clearer in JWST images because of it.

Near-Infrared (NIR)	0.75 – 1.4 micrometres
Short-Wavelength Infrared (SWIR)	1.4 – 3 micrometres
Mid-Wavelength Infrared (MIR)	**3 – 8 micrometres**
Long-Wavelength Infrared (LWIR)	8 – 15 micrometres
Far-Infrared	15 – 1,000 micrometres

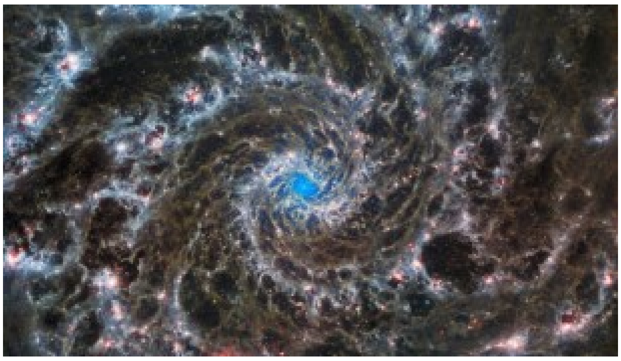
The JWST excels at seeing in the mid-wavelength infrared, allowing it to peer into the clouds surrounding very young stars.

The Webb image is a dramatic improvement over previous images, and while the visual detail is what grabs most regular eyeballs, the WEBB also gives astronomers a dramatic improvement in scientific detail.



The spiral galaxy NGC 1433, as imaged by Hubble (left) and the JWST (right.) Image Credits: (L) NASA/ESA/Hubble. (R) NASA/ESA/CSA/JWST

The next galaxy on the list is M 74, a spiral galaxy about 32 million light-years away that’s also known as the Phantom Galaxy. It’s an example of the grand design spiral galaxy type because of its two clearly-defined spiral arms. While the arms of other spiral galaxies can appear muddy and ill-defined, M 74’s arms pop out in sharp relief.



This image from the NASA/ESA/CSA James Webb Space Telescope shows the heart of M 74, otherwise known as the Phantom Galaxy. The JWST captured this image, but well-known astronomy image processor Judy Schmidt improved it. Image Credit: NASA/ESA/CSA/JWST/J. Schmidt.

The JWST is not only better at seeing MIR (mid-infrared) photons than other telescopes like the Hubble, but it also has higher angular resolution, meaning small details are more clearly visible. The space telescope’s improved resolution shows how intricate M 74’s structure is, with gossamer-like filaments of gas and dust winding outwards from the center to the galaxy’s grand spiral arms.

The arms of the spiral galaxy M74 are studded with rosy pink regions of fresh star formation in this image from the NASA/ ESA Hubble Space Telescope. The Hubble is an awesome telescope that has expanded the boundaries of human knowledge and inspired countless curious minds. The JWST is simply more better, but the real power comes when multiple telescopes with different strengths combine their observations, like in the PHANGS program. Image Credit: NASA/ ESA/Hubble

M 74 is face-on from our vantage point, making it a valuable target for astronomers. One of M 74's defining features is its center, or what astronomers call the nuclear region. M 74's nuclear region lacks the gas common in other spiral galaxies, giving astronomers a clear view of the galaxy's nuclear star cluster.

The next galaxy is NGC 7496, a barred spiral galaxy about 24 million light-years away. The galaxy's most notable feature is its active galactic nucleus (AGN.) The supermassive black hole at the center is actively accreting material and heating it up in a swirling disk around the black hole. This makes the AGN visible as the heated material emits photons.

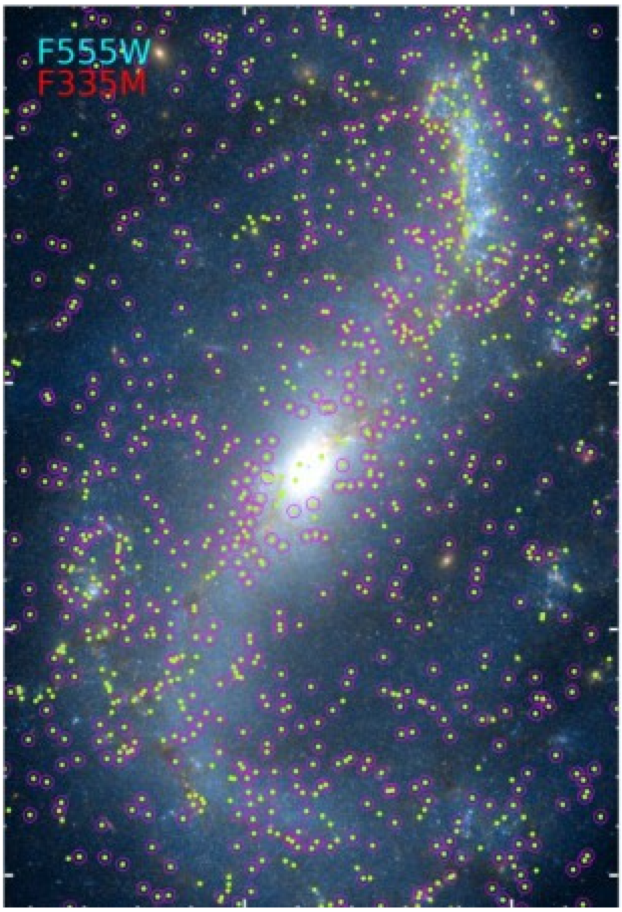
This is NGC 7496, another spiral galaxy in the PHANGS project. The active galactic nucleus shines brightly in this image as the super-massive black hole accretes material. Image Credit: NASA, ESA, CSA, and J. Lee (NOIRLab), A. Pagan (STScI)

The JWST is so powerful that it can detect PAHs (polycyclic aromatic hydrocarbons) which play a critical role in star formation and in planet formation. They're organic compounds that form in the clouds of gas and dust that give rise to stars. By sensing them, the JWST allows astronomers to trace the boundaries and details of gas clouds that eventually collapse and form stars.

Some researchers consider the launch of the JWST as the first step in a PAH revolution. Emissions from PAHs encode a lot of information about their surrounding physical and chemical conditions, including star formation. Other telescopes can see PAH regions, but not in the same detail. "JWST's incredible spatial resolution and sensitivity will disentangle these regions and allow us unprecedented views on PAH characteristics on small spatial scales," according to Western University.

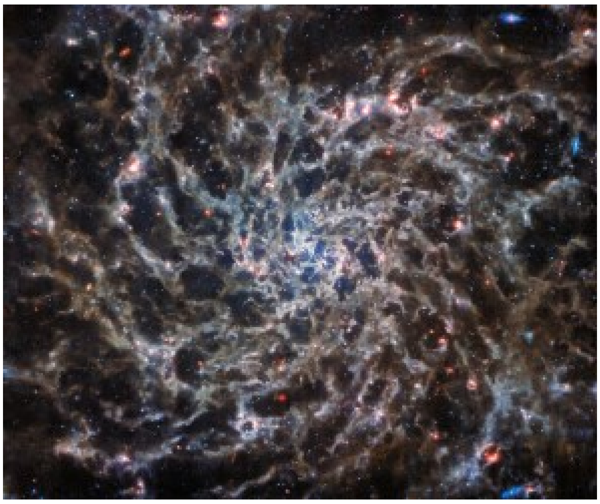
The JWST also detected 59 new embedded star clusters in NGC 7496. These detections, like other detections in PHANG, are because of the JWST's ability to see in the MIR better than other telescopes. Embedded clusters contain stars so young that they haven't blown away the obscuring clouds of gas and dust yet. Their progenitor molecular clouds still surround the stars, and the active star formation taking place inside the clouds is hidden from telescopes like the Hubble. But the JWST easily clears that hurdle.

One of the new papers based on JWST and PHANGS is "PHANGS–JWST First Results: Dust-embedded Star Clusters in NGC 7496 Selected via 3.3 ?m PAH Emission." As the title makes clear, the JWST's ability to see PAH emissions is a game changer. "The earliest stages of star formation occur enshrouded in dust and are not observable in the optical. Here we leverage the extraordinary new high-resolution infrared imaging from JWST to begin the study of dust-embedded star clusters in nearby galaxies throughout the Local Volume," the authors of that paper write.



This image from the paper is a combination of Hubble (Blue F555W) and JWST (Red F335M) data from NGC 7496. The green dots are sources detected by the JWST, and the ones without a magenta circle are the strongest PAH emitters and mostly found in the main dust lanes within the spiral arms. This image is a good example of the scientific detail revealed in JWST images that lies underneath the beautiful visual detail we can more easily relate to. Image Credit: Rodríguez *et al.* 2023.

The next galaxy is IC 5332, an intermediate spiral galaxy about 30 million light-years away. Like M 74, IC 5332 is also face-on from our viewpoint. It has a small central bulge and open arms. It doesn't have as much star formation activity as some of the other PHANGS galaxies.



This image from the NASA/ESA/CSA James Webb Space Telescope shows IC 5332, a spiral galaxy, in unprecedented detail thanks to observations from the JWST's Mid-InfraRed Instrument (MIRI).

The JWST image shows how IC 5332's symmetrical spiral arms are actually complex webs of gas emitting infrared light at different temperatures. The Webb's MIRI (Mid-Infrared Instrument) is responsible for this spectacular image, just as it is for the others.

This video shows the difference between Hubble's view of IC 5332 and the JWST's view. The Hubble image is hazy and less detailed, though still beautiful and useful.

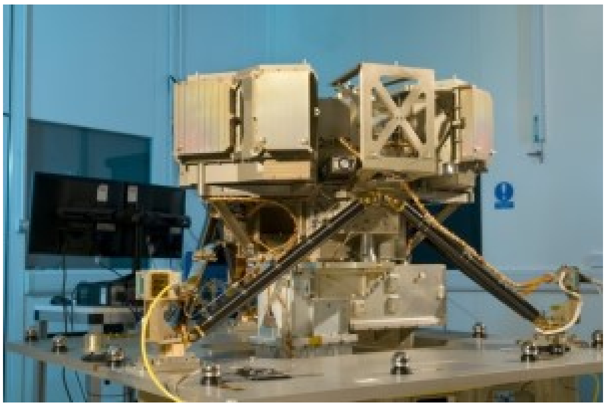
NGC 1365 is another barred spiral galaxy about 56 million light-years away. It has two bars, with the smaller of the two comprising the galactic core. The inner bar probably rotates faster than the outer bar, creating the diagonal shape. Its pair of prominent arms are more extended than other spiral galaxies.

Recent observations show that the Milky Way is also a barred spiral, so when astronomers study NGC 1365, it also sheds light on the Milky Way. Astronomers think that the bars in these galaxies act almost like a funnel, feeding gas into the galactic center, triggering star formation and the growth of the central black hole.

This JWST images shows the double-barred spiral galaxy NGC 1365. The JWST's MIRI instrument reveals the clumps of gas and dust in the interstellar medium lit up by the galaxy's young stars. NGC 1365 is twice as broad as the Milky Way. Image Credit: NASA/ESA/CSA

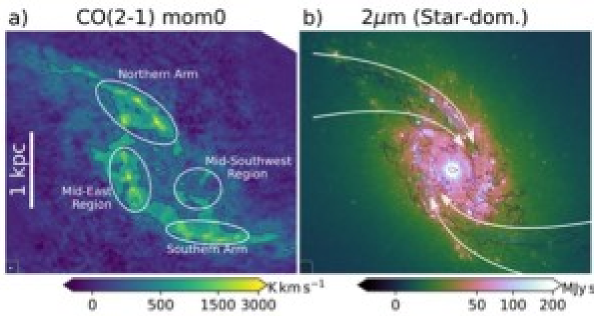
NGC 1365 is called a starburst galaxy because it's experiencing an extraordinary amount of star formation. This takes place in the starburst ring, a region in the galaxy's center. The starburst phase is just one phase of a galaxy's evolution and uses up so much gas that it's over relatively quickly. NGC 1365's complex doube-bar structure helps funnel gas into the starburst ring, triggering a maelstrom of starbirth.

NGC 1365 hosts " … one of the strongest nuclear starbursts and richest populations of YMCs (Young Massive Clusters) within 20 Mpc.," according to a new paper examining stellar feedback in the galaxy. These clusters are responsible for a lot of star formation and are hidden inside thick clouds of molecular hydrogen that hide them from other telescopes. But again, the JWST has the capability to see them more clearly due to its MIRI.



This is the JWST's MIRI (Mid-InfraRed Instrument) during testing in a clean room in 2010. MIRI has to be kept cold to do its work, and a helium gas mechanical cooler takes care of that. Image Credit: By NASA – https://jwst.stsci.edu/files/live/sites/jwst/files/home/science%20planning/science%20corner/flyer/_documents/miri-pocket-guide.pdf, Public Domain, https://commons.wikimedia.org/w/index.php?curid=53870317

The JWST spotted new clusters both in the central region and in the galaxy's arms. It also shed light on the stellar feedback in the starburst ring, where gas flows in and forms new stars, which then feedback and affect the gas flow. This feedback between stars and the interstellar medium (ISM) is a critical topic in galaxy evolution.



These images are from one of the new PHANGS papers based largely on JWST observations. It shows the names given to the inner regions of NGC 1365 (left) and the flow of gas into those regions (right.) The images are part of understanding stellar feedback in the galaxy's starburst ring, where gas is funnelled into the center to form stars, and the stars, in turn, affect the gas. Image Credit: Liu *et al.* 2023.

"We find that the gas flowing into the starburst ring from northeast to southwest appears strongly affected by stellar feedback, showing decreased excitation and increased signatures of dissociation in the downstream regions," the authors of the paper write. Dissociation is when UV light splits molecules into its constituent atoms. “Our results are consistent with a scenario where gas flows into the two arm regions along the bar, becomes condensed/shocked, forms YMCs, and then these YMCs heat and dissociate the gas.”

Even that brief excerpt from new research gives a clue to how complex galaxies and star formation are. When the JWST was in its design phase, scientists identified which questions needed better answers and what instruments and capabilities could generate those answers. Starbirth in galaxies and how galaxies grow and evolve are some of those questions.

One year into its mission, we’re seeing how effective the JWST is at finding deeper answers to our questions. Along the way, we get these beautiful images.

A Galaxy has Been Found that’s Almost Entirely Dark Matter

Astronomers have discovered a galaxy with very little or no stellar mass. Galaxies like these are called ‘dark galaxies.’ It contains clouds of gas but very few stars, possibly none. This is the only isolated dark dwarf galaxy in the local universe.

All galaxies are made of mostly dark matter. The visible matter, like stars, gas and dust, makes up only a small percentage of a galaxy’s mass. But galaxies like this one, named FAST J0139+4328, are even more extreme, and its low luminosity suggests there are no stars, only clouds of gas. The astronomers who discovered it say the galaxy is “without any optical counterpart.”

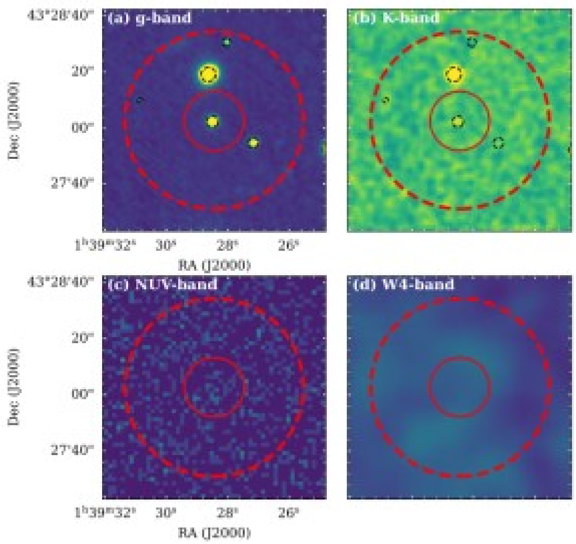
Astronomers found the new dark galaxy with the Five-hundred-meter Aperture Spherical radio Telescope (FAST) and the Panoramic Survey Telescope and Rapid Response System (Pan-STAARS.) It’s a newly discovered galaxy and appears in most ways to be a typical disk galaxy. But it has an extremely low magnitude and low stellar mass. “These findings provide observational evidence that FAST J0139+4328 is an isolated dark dwarf galaxy with a redshift of z = 0.0083. This is the first time that an isolated dark galaxy has been detected in the nearby universe,” the researchers write in their article.

The research article is “Discovery of an isolated dark dwarf galaxy in the nearby universe.” The lead author is Jin-Long Xu from the Chinese Academy of Sciences and the National Astronomical Observatory. His co-authors are also from Chinese scientific institutions.

A redshift of z = 0.0083 means the galaxy is between about 1 million and 1.25 million light-years away. It’s an isolated HI cloud, meaning it’s a cloud of neutral hydrogen rather than ionized hydrogen or molecular hydrogen. The researchers say it’s in the form of a disk galaxy due to its shape and its rotational structure.

Modern cosmological theory explains the relationship between dark matter and galaxies. Theory says that dark matter haloes contain galaxies as if the dark matter provides the structure for the galaxy to form. The halo envelops the entire galactic disk and extends beyond the edge of the visible galaxy. Astronomers can’t see dark matter, but they infer its existence because of its effects on objects around it. The haloes play a critical role in galaxy formation and evolution according to our current models.

Dark galaxies like this one are oddballs. Astronomers think that their gas failed to form stars. That’s why astronomers think they’re critical in understanding how galaxies form and evolve. “Furthermore, the discovery of dark galaxies is crucial to understanding galaxy formation since gas-rich dark galaxies may reflect the earliest stage of galaxy formation,” the authors explain.



These images from the research show four different views of the dark dwarf galaxy. The black ellipses are stars, but the researchers used Gaia data to determine that they’re part of the Milky Way, not the dwarf galaxy. The images, across four different wavelengths, show that the galaxy has no optical counterpart, no stars. Image Credit: Xu *et al.* 2023

This dark dwarf galaxy and others like it could also help solve a problem in cosmology. The Cold Dark Matter (CDM) model predicts that there should be more dwarf galaxies than astronomers have been able to observe. It’s called the missing satellite problem or the dwarf galaxy problem.

The Milky Way has 11 dwarf galaxies, and the Local Group has about 38, according to observations. But the dark matter simulations show there should be about 500 dwarf galaxies as satellites of the Milky Way alone. Dark dwarf galaxies like this one could plug that gap and strengthen our understanding of dark matter and the cosmos itself.

While dark dwarf galaxies like this one are definite oddballs, they’re not the only ones. Astronomers have also found galaxies that contain little or no dark matter, though that finding is still controversial.

In 2018 a team of researchers published a paper titled “A galaxy lacking dark matter” in Nature. NGC 1052 is a group of galaxies, and the authors of the 2018 paper identified an ultra-diffuse galaxy named NGC 1052 DF2. “NGC1052–DF2 demonstrates that dark matter is not always coupled with baryonic matter on galactic scales,” the authors of that paper wrote. A subsequent paper published in 2019 announced the detection of another ultra-diffuse galaxy with no dark matter in the same region named NGC 1052 DF4.

In their article’s conclusion, the authors explain the significance of finding a dark dwarf galaxy.

“This is the first time that a gas-rich isolated dark galaxy has been detected in the nearby universe,” they write. “In addition, a galaxy is assumed to form from gas, which cools and turns into stars at the center of a halo. FAST J0139+4328 has a rotating disk of gas and is dominated by dark matter but is starless, implying that this dark galaxy may be in the earliest stage of the galaxy formation.”

These dark dwarf galaxies may just not have enough dark matter to hold onto their gas. It may be that the amount of gas is too small to trigger Toomre instability in the galaxy’s rotating disk. Without stars, these dark dwarf galaxies are extremely faint and difficult to detect. They can only be detected by looking for neutral hydrogen (HI) rather than by electromagnetic radiation. To find more of them, we need more HI surveys..

E Mails Viewings Logs and Images from Members.

Viewing Log for 13th of February

As I had taken some holiday from work (work afternoons and evenings) and the sky was clear, it would not be the right thing to miss a viewing session! I asked if anyone from Swindon Stargazers WhatsApp group would be interested in attending and Hilary said she would join me around 19:30.

I arrived at my usual viewing location near Uffcott just south of Swindon off of the A4361 and had my Meade LX90 using a Pentax WX 14 mm eye piece set up and ready by 19:17, the temperature was 6 °C but with some wind it could get cold later on?

Venus has now finally come back into the evening sky and it was just above the horizon at 4 ° attitude, all I could make out was a multi coloured (mainly orange, yellow and red) point of light, too much atmosphere to look thru was the trouble? By now Hilary joined me and I help her set her equipment up, a 102 mm refractor on a Skywatcher AZ 4 mount. A lot higher up was Jupiter but this is slowly getting closer to the western horizon, I could make out Ganymede to the west of Jupiter with Europa, Io and Callisto out to the east, no Great Red Spot on view this evening. Light Time was 46.75 minutes away or 5.617 AU away. While I was looking at Jupiter, Hilary managed to find comet E3 by star hopping from Aldebaran, took her about 10 minutes to locate the now fading comet. The first of many cars went past us while viewing the comet. I used my Skywatcher 15x70 mm binoculars to locate the comet and then found it manually with my telescope, could not see it with my finderscope like last time. The comet had a bright core and dust trails further out, not much more could be said about the object? While I was trying to find Uranus we had four cars go past us, the first went down and then up the road with the other two stopping beside us before carrying on again, wonder if they have never seen anyone out with a telescope before? It took me three attempts to find this planet, all I could make out was the pale surface of the planet, and at least Hilary was happy seeing this planet, her favourite. While trying to find Uranus using the finderscope, the stars seem rather dim? Turns out the finderscope had already dewed up, a lot of moisture in the air tonight! After cleaning the finderscope glass with a tissue, I went off to Mars, there was a hint of red with this planet but no surface details could be seen. Hilary had set a goal of finding Messier (M) 1, the Crab nebula in Taurus, I told her it was close to Zeta Tau and let her try and find it. I got, 'I have found the Crab', so I had a look to either confirm or not, turns out Hilary had found M 35 in Gemini! Off she tried again and said 'I found it', turns out Hilary had found M 37 in Auriga! To help her out I went to M 1 with the GOTO kit, I had trouble finding it as it was rather dim to look at. Turns out the fog which had been to the west of us now rolled in a bit, this is when Hilary decided to pack up and go home, the time was 20:40. I thought I would see how the conditions went on for a bit. Sky was fogged up for seven minutes and then cleared a bit. Time to go to the winter favourite and M 42, the Great Onion nebula, it was hard to spot the nebula, turns out the eye piece had fogged up which is rare for me? After drying the eye piece, the Trapezium stars were good as was the two main dust lanes. Another car went past me while I tried to find M 105 in Leo, not sure if I found it? Back to M 42, it was okay now but no better, another car went past me. Tried M 41 just below Sirius, it was dim to look at and it came and went as the fog rolled by, even the belt stars in Orion came and went, usually these are very easy to find! Tried M 37 in Auriga which was nearly overhead and this open cluster was dim to look at. By now I was getting fed up with the car lights going past me, so I decided to pack up and go home as well at a time of 21:10.

The wind we had earlier had now gone and been replaced with fog and a lot of dew! Temperature had dropped to 4 °C.

Would like to thank Hilary for keeping me company for this viewing session, the time goes by much quicker when you have someone to talk to as well as doing astronomy.

Clear skies.

Peter Chappell

Viewing Log for 23rd of February

For most of the day, the sky was very cloudy but late afternoon the skies started to break up, so I decided I would try a sunset session at Hackpen Hill. Turns out I managed to get a 'Green Flash' on the top of the Sun when first contact with the horizon happened. This is the first time I have manged to see or even capture this flash? Even with the Sun above the horizon I could make out Venus in the sky and above that, a waxing crescent Moon. My weather App suggested there would be a clear patch for about five hours that evening, so once I had gone home and had some tea, I got my kit into the car and headed off to Uffcott and my usual layby for viewing. I was using my Meade LX90 with 14 mm Pentax WX eye piece with a temperature of 2 °C and no wind, conditions should be good? While I was setting up three cars went past me but did not affect my eye sight as I had not been long out of my car.

By now Neptune is too close to the Sun to be viewed, so my first object was Venus, now higher in the western sky at 6 ° attitude, like last time all I could make out was multi colours in orange, red and white, too much atmosphere to view thru? Once the telescope had finished slewing to Venus it was nearly in the centre of the cross hairs of the finderscope! Jupiter was now starting to get close to Venus (the two of them have a less than Moon's diameter conjunction at the end of the month), I could make out Io and Callisto (a long way from Jupiter, probably its furthest in line of sight?) to the west and Europa and Ganymede to the east, the Great Red Spot was just coming into view but I missed it again! Jupiter was also in the eye piece, wonder if Uranus would be the same? Err, no, as usual finding the seventh planet from the Sun would be a challenge for me, took about six goes at looking at points of light in the finderscope to find it! This time the planet was a colourless dot to look at. On to Mars still in Taurus, a pale red dot with no surface details, the planet has dimmed a lot since I last looked at it 10 days ago? Had a go looking for comet E3 but had no luck finding it, probably too dim for me to see now? Time to carry on with my Messier (M) marathon, last time I came out I forgot to bring the list with me but not this time. First object was M 95 in Leo, a spiral galaxy (SG), this object was a faint fuzzy blob (FFB) to look at, had to use adverted vision to find it, very easy to miss? The same could be said for M 96 (an SG) and M 105, an Elliptical galaxy (EG). Off to the tail of Leo and the 'Triplet' galaxies of M 65, an SG which had some brightness in the core. M 66 another SG was a FFB to look at, did not help having a small patch of cloud in the general area would come back to this object later on once the cloud has gone by, the other object in the Triplet is NGC 3628 which I did not look at. Off to Canes Venatici and M 94 the Cat's Eye galaxy, this SG was a FFB to look at, same statement could be said for M 63 the Sunflower galaxy another SG. Nearby is M 51, the Whirlpool galaxy another SG, this was a faint blob (FB) to look at. Probably does not help having the glow of Swindon under these objects? That was all I could do with the marathon until next month at best when Virgo should be on show, it was now clearing the eastern horizon but the objects here are all dim, typical galaxies! As I had brought along my Sky Atlas, I thought I would have a look at some objects below Sirius in Puppis. First object I tried to get was NGC 2298 at – 36 ° Dec, this is a globular cluster (GC), turns out it was just at the top of the hedge and I could not see it. Tried the double star Furud in Canis Major, at – 30 ° Dec approx., the secondary star is probably more than 10 diameters of the main star away, magnitude 3.6 for this binary pair. First car for quite a while now went past me. As the cloud had now moved on I went back to M

66, it was not much better than before? Thought I would now do the Orion star count not including the four corner stars. Could make out 12 stars which is not that good but my eyes are not that good either, I think the seeing conditions for the evening were very good as well? Thought I would have ago at doing some of the lower Messier objects which will soon disappear for another season starting with M 41 just below Sirius. This open cluster (OC) was large and loose with some bright stars, conditions were good? Another car went past me as I looked at M 79 in Lepus, this GC is an oddball as there are no other GC's nearby? I was looking at this object through the bare branches of a tree, it was small with a bright core. Back to Orion starting with M 43 for a change, this diffused nebula was good to look at. Right next door is M 42, the Trapezium stars were bright and the dust lanes excellent to look at. Just above and to the east of the belt stars is M 78, a reflection nebula with two stars and some dust to look at. Final object in deep sky was M 1, the Crab nebula in Taurus, this was a large grey blob to look at. By now the Moon was getting close to the horizon (would set in 39 minutes time), some thin cloud had come to that area of sky. I could see Mare Crisium (Sea of Crises) had cleared the terminator, as well craters Endymion, Cleomedes, Biot and Reichenbach to name a few putting on a good display.

As I had brought out my binoculars to try and find the comet, I thought I would use them to explore some parts of the sky as well, manage to find M 41 which can be hard for me? M 44, the Beehive cluster and M 45, the Pleiades cluster looked very good, also found M 48 on a line between Sirius and Procyon. Trouble was using binoculars the eye cups would soon fog up, cold equipment and my warm body do not go together very well. After looking thru them for about 20 seconds I had to put them down to cool down before I could use them again. While I was viewing I could clearly hear some cows mooing about half a mile away, the conditions were very still?

With the Moon just gone from my view point and a hint of some cloud on the horizon I called it a day at 21:39, the temperature had dropped to zero with some ice on the dew shield of the telescope but no dew on the finderscope at all (pictures attached).

Clear skies.

Peter Chappell

Messier Marathon quiz

As March is normally Messier marathon month, I thought I would do a quiz (just for fun), see how you get on with the questions. All answers come from 'The Ultimate Messier Object Log'. Below are 15 questions, some are easy with some difficult to get, hope you enjoy the quiz? Peter Chappell

1) Which constellation has the second most objects on his list?

A) Virgo

B) Ophiuchus

C) Coma Berenices

2) Which is the 2nd largest object (in area of sky)?

A) M42

B) M45

C) M44

3)How many Supernova remnants are there on the list?

A) 0

B) 1

C) 2

4) Which is the only object in Draco?

A) M100

B) M101

C) M102

5) Which is the most southerly object

A) M6

B) M7

C) M93

6) Going in the other direction, which is the most northerly (by declination)

A) M101

B) M81

C) M82

7) Lat target object on Messier night?(?)

A) M90

B) M72

C) M73

8) Only IC object in Messier catalogue (others ngc)

A) M23

B) M24

C) M25

9) Which two make up part of the Leo Triplet

A) M95 & M96

B) M65 & M66

C) M105 & M106

10) How many objects were in Messier catalogue at the time of his death.

A) 101

B) 103

C) 110

Messier quiz continued…

11) Which is the most numerous object type in the catalogue?

A) Globular Clusters

B) Open Clusters

C) Galaxies (but not spirals)

12) How many objects are in Aquarius or Puppis?

A) 2

B) 3

C) 4

13) How many catalogued objects are NOT deep sky?

A) 1

B) 2

C) 3

14) How many Planetary Nebulae are in the catalogue?

A) 4

B) 3

C) 2

15) Which is the largest Globular cluster in arc minutes?

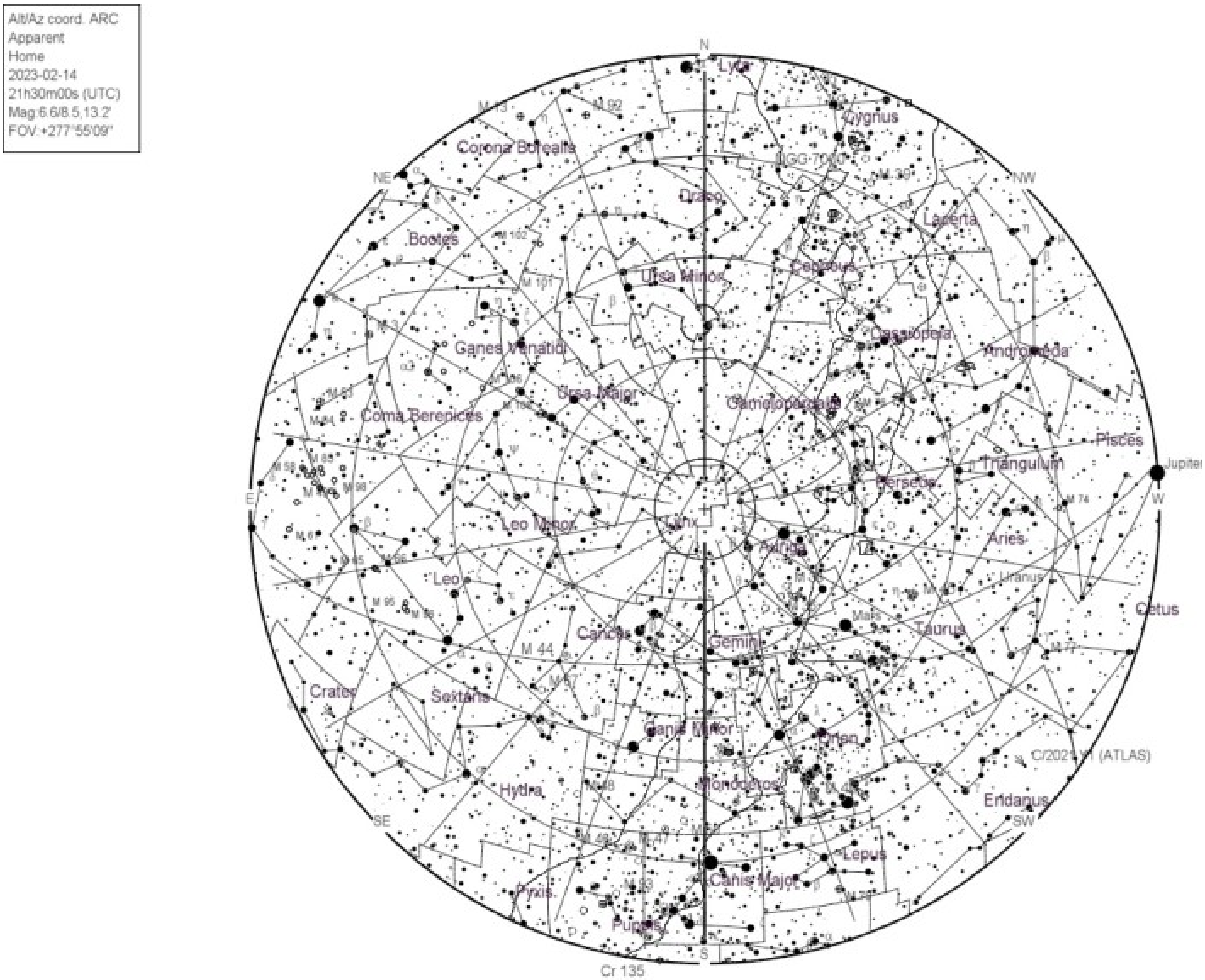
A) M4

B) M13

C) M22

Answers

1. Answer A: Virgo has 11, Sagittarius has 15.
2. Answer B: M45, size 110, Andromeda is 178.
3. Answer B: M1 in Taurus.
4. Answer C: M102.
5. Answer C: M7 at -34.49 Dec.
6. Answer C: M82 at +69.41 Dec.
7. Answer A: M30, cannot be seen from UK if doing marathon in March.
8. Answer C: M25, IC4725 in Sagittarius.
9. Answer B: M65 & M66 together with NGC 3628.
10. Answer B: Others were added in 20th century, he made notes about them.
11. Answer C: 35 with 26 for Open and 24 for Globular clusters.
12. Answer B: Aquarius (M2, M72 & M73) & Puppis (M46, M47 & M93)
13. Answer B: M40 (Double Star) & M73 (Asterism).
14. Answer A: M27, M57, M76 & M97.
15. Answer A: M4, 26 arc minutes in size (M13 is 17 & M22 is 24).

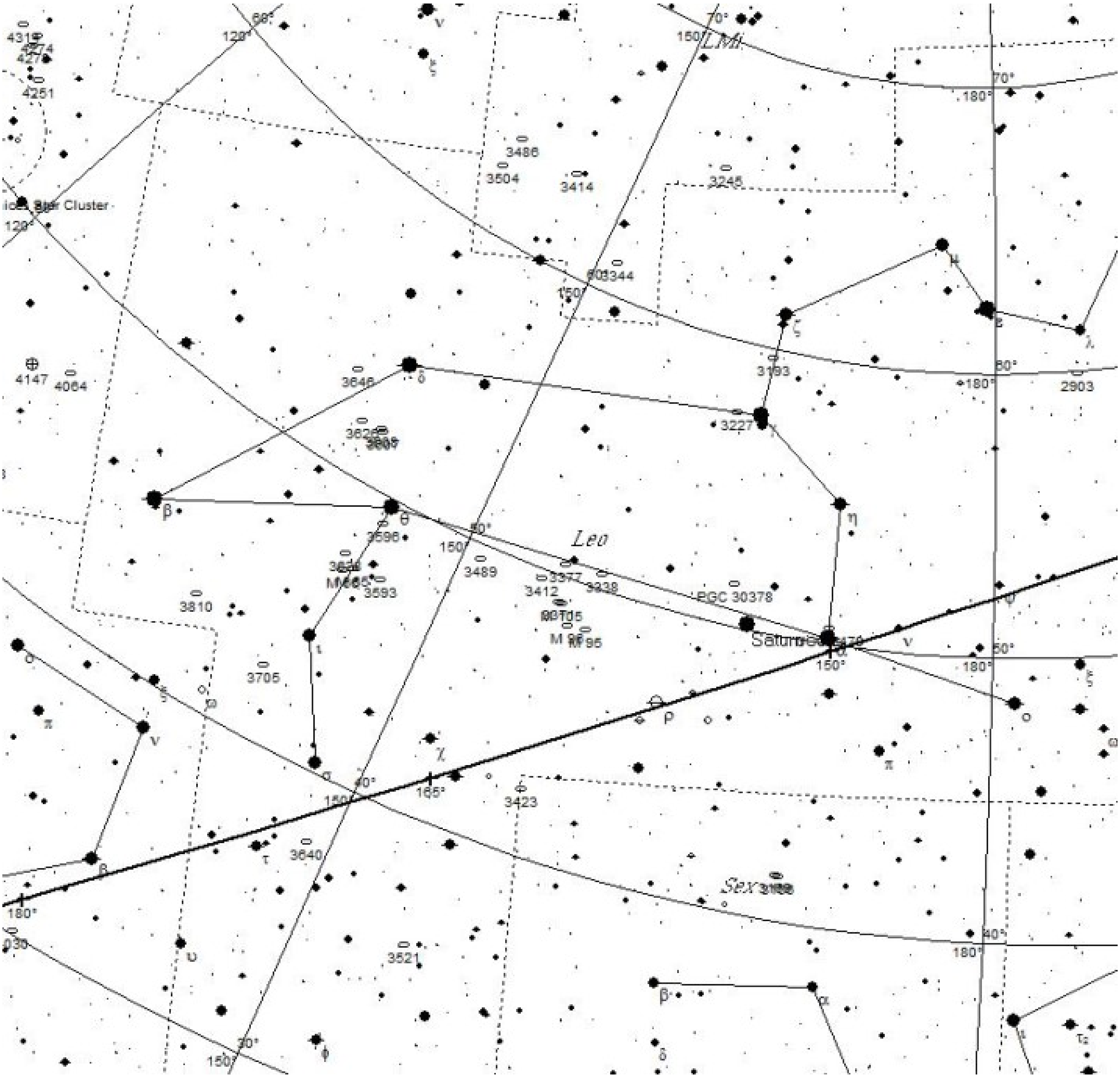


March 7 - **Full Moon.** The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This phase occurs at 12:42 UTC. This full moon was known by early Native American tribes as the Worm Moon because this was the time of year when the ground would begin to soften and the earthworms would reappear. This moon has also been known as the Crow Moon, the Crust Moon, the Sap Moon, and the Lenten Moon.

March 20 - **March Equinox.** The March equinox occurs at 21:17 UTC. The Sun will shine directly on the equator and there will be nearly equal amounts of day and night throughout the world. This is also the first day of spring (vernal equinox) in the Northern Hemisphere and the first day of fall (autumnal equinox) in the Southern Hemisphere.

March 21 - **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 17:25 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.

CONSTELLATIONS OF THE MONTH: LEO



Leo

Positioned directly on the ecliptic plane, Leo is a constellation of the zodiac preceded by Cancer to the west and followed by Virgo to the east. It is an ancient constellation, originally charted by Ptolemy and recognized by the International Astronomical Union as one of the 88 modern constellations. Leo spans 947 square degrees of sky and is the twelfth largest of all. It contains 3 bright stars and around 15 stars in its asterism, with 92 Bayer/Flamsteed designated stars within its confines. It is bordered by the constellations of Ursa Major, Leo Minor, Lynx, Cancer, Hydra, Sextans, Crater, Virgo and Coma Berenices. Leo is visible to all observers located at latitudes between +90° and ?65° and is best seen at culmination during the month of April.

There are five annual meteor showers associated with constellation Leo. The first is the Delta Leonid meteor stream which begins becoming active between February 5 through March 19 every year. The activity peaks in late February with no exact date, and the maximum amount of activity averages around 5 meteor per hour. The next date is April 17 and the Sigma Leonid meteor shower. Look for this rare occurrence to happen near the Leo/Virgo border. It is a very weak shower and activity rates no higher than 1 to 2 meteors per hour. The next is the most dependable shower of all – the November Leonids. The peak date is November 17th, but activity occurs around 2 days on either side of the date. The radiant is near Regulus and this is the most spectacular of modern showers. The year 1966 saw 500,000 per hour a rate of up 140 per second! Just a few years ago, in 2005 the rates were equally impressive. Why? Comet Temple-Tuttle is the answer. Whenever it nears perihelion, it adds fresh material to the stream and gives us a spectacular show. On the average, you can expect around 20 per hour between 33 year shows, but they are the fastest known at 71 kps. The last is the Leo Minorids which peak on or about December 14. This meteor shower was discovered by amateurs in 1971 and hasn't really been confirmed yet, but do look for around 10 faint meteors per hour.

In Greek mythology, Leo was identified as the Nemean Lion, which may have been the source of the "tail" of the lion that killed Hercules during one of his twelve labours. While many constellations are difficult to visualize, Leo's backwards question-mark is relatively easily to picture as a majestic lion set in stars. One of the reasons for its placement in the zodiac is possibly due to the fact that lions left their place in the desert for the banks of the Nile when the Sun was positioned in these stars. It is also possible that the Nile's rise at this time and the lion's migration is also the reason for the Sphinx to appear as it does – a leonine figure. The Persians called it Ser or Shir; the Turks, Artan; the Syrians, Aryo; the Jewish, Arye; the Indians, "Sher"; and the Babylonians, Aru — all meaning a lion. Early Hindu astronomers recognized it by regal names, as did other cultures. All befitting of the "King of Beasts"!

Let's begin our tour by taking a look at the brightest star – Alpha Leonis – the "a" symbol on our map. Its name is Regulus and it is one hot customer when it comes to spin rate. Revolving completely on its axis in a little less than 16 hours, oblate Regulus would fly apart if it were moving any faster. Ranking as the twenty-first brightest star in the night sky, Alpha Leonis is a helium type star about 5 times larger and 160 times brighter than our own Sun. Speeding away from us at 3.7 kilometres per second, Regulus isn't alone, either. The "Little King" is a multiple star system composed of a hot, bright, bluish-white star with a pair of small, faint companions easily seen in small telescopes. The companion is itself a double at around magnitude 13 and is a dwarf of an uncertain type. There is also a 13th magnitude fourth star in this grouping, but it is believed that it is not associated with Regulus since the "Little King" is moving toward it and will be about 14″ away in 785 years. Not bad for a star that's been reigning the skies for around for a few million years!

Let's fade east now, and take a look at Beta Leonis – the "B" symbol on our map. Its name is Denebola which means the "Lion's tail" in Arabic. Located about 36 light years from Earth, this white class A dwarf star is more luminous than the Sun, emitting 12 times the solar energy and a Delta-Scuti type variable star. While that in itself isn't particularly rare, what makes Denebola unusual is that it belongs to the Vega-class stars – ones that have a shroud of infra-red emitting dust around them. This could mean a possibility of planet forming capabilities! In binoculars, look for an optical double star companion to Beta. It's not gravitationally, or physically related, but it's a pleasing pairing.

Now, return to Regulus and hop up for Eta Leonis, the "n" symbol on our map. Eta is very special because of its huge distance – about 2100 light years from our solar system – and that's only a guess. It is a supergiant star, and one that is losing its stellar mass at a huge rate. Compared to Sol, Eta loses 100,000 times more mass each year! Because of its position near the ecliptic plane, Eta is also frequently occulted by the Moon. Thanks to alert observers, that's how we learned that Eta is also a very close binary star, too – with a companion only about 40% dimmer than the primary. Some time over the next 17 million years, the pair of red supergiant stars will probably merge to become a pair of massive white dwarf stars… or they may just blow up. Only time will tell…

Hop north for Gamma Leonis – the "Y" symbol on our map. Its name is Algeiba and it is a very fine double visual star for binoculars and true binary star small telescopes. Just take a look at this magnificent orange red and yellow pair under magnification and you'll return again and again. The brighter primary star is a giant K type and orbiting out about four times the distance of Pluto is its giant G type companion. Further north you'll find another excellent visual double star for binoculars – Zeta Leonis. It's name is Aldhafera and this stellar spectral class F star is about 260 light years away.

Are you ready to try your hand at locating a pair of galaxies with binoculars? Then let's try the "Leo Trio" – M65, M66 and NGC 3623. Return towards Beta and

look for the triangular area that marks the asterism of Leo's "hips". If the night is suitable for binocular galaxy hunting, you will clearly see fifth magnitude Iota Leonis south of Theta. Aim your binoculars between them. Depending on the field of view size of your binoculars, a trio of galaxies will be visible in about one third to one fourth of the area you see. Don't expect them to walk right out, but don't sell your binoculars short, either. The M65 and M66 pair have higher surface brightness and sufficient size to be noticed as two opposing faint smudges. NGC 3623 is spot on the same magnitude, but is edge on in presentation instead of face-on. This makes it a lot harder to spot, but chances are very good your averted vision will pick it up while studying the M65/66 pair. The "Leo Trio" makes for a fine challenge!

Now let's begin working with larger binoculars and small telescopes as we head for M96 galaxy group (RA 10h 46m 45.7s Dec +11 49′ 12″). Messier 96 is the brightest spiral galaxy within the M96 Group which includes Messier 95 and Messier 105 as well

as at least nine other galaxies. Located about 38 million light years away, this group of galaxies with the Hubble Space Telescope and 8 Delta Cephei variable stars were found to help determine each individual galaxy's distance. While you can't expect to see each member in small optics, larger telescopes can hope to find elliptical galaxies NGC 3489 (11:00.3 +13:54), NGC 3412 (10:50.9 +13:25), NGC 3384 (10:48.3 +12:38) and NGC 3377 (10:47.7 +13:59), as well as barred spiral galaxy NGC 3299 (10:36.4 +12:42),

For an awesome spiral galaxy in a small telescope,

don't overlook NGC 2903 (RA 9:32.2 Dec +21:30). At a bright magnitude 9, you can often see this particular galaxy in binoculars from a dark sky site as well. Discovered by William Herschel in 1784, this beauty is often considered a missing Messier because it just so bright and conspicuous. As a matter of fact, the comet of 1760 passed it on a night Messier was watching and he didn't even see it! For larger telescopes, look for NGC 2905 – a bright knot which is actually a star forming region in the galaxy itself with its own Herschel designation.

Before we leave, you must stop by NGC 3521 (RA 11:05.8 Dec -00:02). This 35 million light year distant spiral galaxy is often overlooked for no apparent reason – but it shouldn't be. At a very respectable magnitude 9, you can often find this elongated gem with the bright nucleus in larger binoculars from a dark sky site and you can easily study spiral galaxy structure with a larger telescope. Look for an inclined view with patchiness in the structure that indicates great star forming regions at work. Its stellar counter rotation is being studied because it has a bar structure that we are seeing "end on"!

This doesn't even begin to scratch the surface of what you can find on Leo's hide. Be sure to get yourself a good star chart or sky atlas and go lion taming!

Sources: SEDS, Wikipedia

Images Andy Burns

Bluewalker 3 communication sail will be making itself seen.

Date	Bright-ness	Start			Highest point			End		
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
07 Mar	4.8	03:24:26	13°	ESE	03:24:26	13°	ESE	03:25:11	10°	E
07 Mar	2.2	04:59:11	31°	SW	05:00:48	60°	SSE	05:04:35	10°	ENE
08 Mar	2.1	04:40:33	47°	SSW	04:41:23	62°	SSE	04:45:12	10°	ENE
09 Mar	2.0	04:21:52	63°	SSE	04:21:58	64°	SSE	04:25:47	10°	ENE
09 Mar	2.1	05:56:46	10°	W	06:00:36	67°	N	06:04:26	10°	E
10 Mar	2.4	04:03:06	55°	ESE	04:03:06	55°	ESE	04:06:20	10°	ENE
10 Mar	2.1	05:37:51	13°	W	05:41:10	67°	N	05:45:00	10°	E
11 Mar	3.2	03:44:18	39°	E	03:44:18	39°	E	03:46:53	10°	ENE
11 Mar	2.1	05:19:03	19°	W	05:21:43	66°	N	05:25:33	10°	E
12 Mar	3.8	03:25:27	28°	E	03:25:27	28°	E	03:27:24	10°	ENE
12 Mar	2.1	05:00:12	26°	W	05:02:14	66°	N	05:06:04	10°	E
13 Mar	4.4	03:06:35	20°	ENE	03:06:35	20°	ENE	03:07:54	10°	ENE
13 Mar	2.1	04:41:20	36°	WNW	04:42:45	66°	N	04:46:35	10°	E
14 Mar	2.1	04:22:26	50°	WNW	04:23:14	66°	N	04:27:04	10°	E
15 Mar	2.0	04:03:32	65°	NNW	04:03:42	66°	N	04:07:32	10°	E
15 Mar	1.9	05:38:34	10°	WNW	05:42:26	84°	SSW	05:46:17	10°	ESE
16 Mar	2.4	03:44:38	58°	NE	03:44:38	58°	NE	03:47:59	10°	E
16 Mar	1.9	05:19:23	12°	WNW	05:22:52	82°	SSW	05:26:43	10°	ESE
17 Mar	3.2	03:25:45	41°	ENE	03:25:45	41°	ENE	03:28:24	10°	E
17 Mar	1.8	05:00:30	18°	WNW	05:03:17	81°	SSW	05:07:08	10°	ESE
18 Mar	3.9	03:06:53	28°	ENE	03:06:53	28°	ENE	03:08:49	10°	E
18 Mar	1.8	04:41:38	26°	WNW	04:43:42	79°	SSW	04:47:32	10°	ESE
19 Mar	4.5	02:48:05	18°	E	02:48:05	18°	E	02:49:13	10°	E
19 Mar	1.8	04:22:50	41°	W	04:24:04	78°	SSW	04:27:54	10°	ESE
20 Mar	1.8	04:04:05	68°	WSW	04:04:26	76°	SSW	04:08:16	10°	ESE
21 Mar	2.2	03:45:26	57°	SE	03:45:26	57°	SE	03:48:37	10°	ESE
21 Mar	3.3	05:20:12	11°	W	05:22:55	21°	SW	05:25:51	10°	S
22 Mar	3.4	03:26:56	29°	SE	03:26:56	29°	SE	03:28:56	10°	ESE
22 Mar	3.3	05:01:42	16°	WSW	05:03:13	20°	SW	05:06:07	10°	S
23 Mar	4.4	03:08:37	14°	ESE	03:08:37	14°	ESE	03:09:13	10°	ESE
23 Mar	3.3	04:43:24	20°	SW	04:43:30	20°	SW	04:46:20	10°	S
27 Mar	3.2	21:27:26	10°	SSW	21:29:45	26°	S	21:29:45	26°	S
28 Mar	2.7	21:07:35	10°	SSW	21:11:06	33°	SE	21:11:47	30°	ESE
29 Mar	2.7	20:47:43	10°	SSW	20:51:16	34°	SE	20:53:30	18°	E
29 Mar	3.0	22:25:43	10°	WSW	22:28:17	39°	W	22:28:17	39°	W
30 Mar	2.7	20:27:50	10°	SSW	20:31:24	34°	SE	20:34:58	10°	E
30 Mar	1.9	22:05:52	10°	WSW	22:09:44	83°	NNW	22:09:44	83°	NNW
31 Mar	2.7	20:07:57	10°	SSW	20:11:32	35°	SE	20:15:07	10°	E
31 Mar	1.9	21:46:00	10°	WSW	21:49:55	82°	NNW	21:51:01	45°	ENE
01 Apr	1.9	21:26:06	10°	WSW	21:30:02	81°	NNW	21:32:08	26°	ENE

ISS PASSES For FEBRUARY 2023

from Heavens Above website maintained by Chris Peat.

Date	Brightn	Start	Highest point	End						
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
07 Mar	-3.2	04:47:53	43°	S	04:47:53	43°	S	04:50:52	10°	SE
08 Mar	-1.4	04:02:25	18°	SE	04:02:25	18°	SE	04:03:26	10°	ESE
08 Mar	-1.9	05:35:24	15°	WSW	05:36:27	17°	SW	05:38:40	10°	S
09 Mar	-2.0	04:50:19	20°	S	04:50:19	20°	S	04:52:01	10°	SSE
16 Mar	-1.7	19:24:48	10°	S	19:26:16	13°	SE	19:26:16	13°	SE
17 Mar	-2.5	20:14:41	10°	SW	20:16:47	29°	SSW	20:16:47	29°	SSW
18 Mar	-2.7	19:30:06	10°	SSW	19:33:02	29°	SSE	19:34:13	23°	ESE
18 Mar	-1.2	21:06:25	10°	WSW	21:07:22	18°	WSW	21:07:22	18°	WSW
19 Mar	-3.7	20:21:50	10°	WSW	20:24:54	65°	SSW	20:24:54	65°	SSW
20 Mar	-3.6	19:37:31	10°	WSW	19:40:49	56°	SSE	19:42:34	24°	E
20 Mar	-1.4	21:14:26	10°	W	21:15:45	22°	W	21:15:45	22°	W
21 Mar	-3.2	18:53:31	10°	SW	18:56:45	44°	SSE	18:59:58	10°	E
21 Mar	-3.8	20:30:19	10°	W	20:33:34	83°	WNW	20:33:34	83°	WNW
22 Mar	-3.8	19:46:26	10°	W	19:49:49	87°	S	19:51:34	26°	E
22 Mar	-1.3	21:23:32	10°	W	21:24:47	21°	W	21:24:47	21°	W
23 Mar	-3.8	19:02:51	10°	WSW	19:06:12	77°	SSE	19:09:34	10°	E
23 Mar	-3.6	20:39:56	10°	W	20:42:59	71°	W	20:42:59	71°	W
24 Mar	-3.8	19:56:35	10°	W	19:59:57	85°	N	20:01:23	32°	E
24 Mar	-1.1	21:33:42	10°	W	21:34:37	17°	W	21:34:37	17°	W
25 Mar	-3.7	19:13:27	10°	W	19:16:50	85°	N	19:20:01	11°	E
25 Mar	-3.0	20:50:36	10°	W	20:53:16	48°	WSW	20:53:16	48°	WSW
26 Mar	-3.8	21:07:46	10°	W	21:11:07	74°	SSW	21:12:09	41°	ESE
26 Mar	-0.7	22:45:09	10°	W	22:45:25	12°	W	22:45:25	12°	W
27 Mar	-3.8	20:25:09	10°	W	20:28:32	84°	SSW	20:31:17	15°	ESE
27 Mar	-2.0	22:02:26	10°	W	22:04:34	26°	WSW	22:04:34	26°	WSW
28 Mar	-2.9	21:20:03	10°	W	21:23:14	40°	SSW	21:23:58	34°	S
29 Mar	-3.2	20:37:55	10°	W	20:41:13	50°	SSW	20:43:38	16°	SE
29 Mar	-1.0	22:16:04	10°	WSW	22:16:58	13°	WSW	22:16:58	13°	WSW
30 Mar	-1.7	21:33:48	10°	W	21:36:10	18°	SW	21:36:56	17°	SSW
31 Mar	-1.9	20:51:59	10°	W	20:54:44	23°	SW	20:57:12	11°	SSE
03 Apr	-1.0	20:27:01	10°	WSW	20:28:27	12°	SW	20:29:52	10°	SSW

END IMAGES, AND OBSERVING

The Moon, Jupiter and Venus setting over the Sun stone in the Avebury southern circle.

Andy Burns

Observing Sessions

Proposed Observation Sessions for 2022-2023

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:

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.

Opportunity	**Day**	**Date**	**Month**	**Set-up**	**Observe**
First	Friday	17th	March	19:00	19:30
Second	Friday	24th	March	19:30	20:00
First	Friday	14th	April	20:00	20:30
Second	Friday	21st	April	20:30	21:00
First	Friday	12th	May	20:30	21:00
Second	Friday	19th	May	20:30	21:00

OUTREACH:

In August we have been asked to prepare an astronomy weekend for the army corp and families based in Colerne. I am enquiring about getting the Dark Sky Wales Planetarium to come along and we will need solar viewing and evening sky viewing. They are looking for the 12th/13th August.