NWASNEWS

Volume30 Issue 4

December 2023

Newsletter for the Wiltshire, Swindon, Bath Astronomical Societies

The November full Moon (+12 hours)
Nikon P1000 bridge camera, I set the exposure to automatic +1.7 EV, prevents blowing out detail and gives a fast exposure of around 1/2000th second and f8.
Photo Andy Burns,

WINTER SKIES, WINTER WEATHER

This evening we have the redoubtable Martin Griffiths returning to give us a talk, this time on Zoom.
He has chosen the Winter Skies, which gives us a good extension to our back to basics year.
Details for the Zoom link below.
Wiltshire Astronomical Society December Meeting
Andy Burns is inviting you to a scheduled Zoom meeting.
Winter Skies, Martin Griffiths
Time: Dec 5, 2023 07:45 PM London
Join Zoom Meeting
https://us02web.zoom.us/j/85816052255?pwd=VnJIRlZ0V2hMQnZvbmdoN2VnUk8yZz09
Meeting ID: 858 1605 2255
Passcode: 353585
Speaker Martin Griffiths
Topic The Winter Skies
Meeting ID: 858 1605 2255
Passcode: 353585

Our January meeting will also be on Zoom. Paul Money speaker.

Wiltshire Society Page

Wiltshire Astronomical Society

Web site: www.wasnet.org.uk

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

Meetings 2023

HALL VENUE the Pavilion, Rusty Lane, Seend

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

Meet 7.45 for 8.00pm start

SEASON 2023/24

2023 October 3rd: Hall Meeting Andy Burns The Dark Nebulae, History and Imaging
November 7th: Practical Session &A
December 5th Zoom meeting Martin Griffiths
2024
January 2nd Zoom Meeting Paul Money
February 6th
March 5th
April 2nd
May 7th
June 4th

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

December Meeting ZOOM meeting

Martin Griffiths: The Winter Skies

In a continuation of back to basics I thought it would be good to Martin, a practical observer to give us a low down on the winter night skies.

Membership Meeting nights £1.00 for members £3 for visitors

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

Wiltshire AS Contacts

Chairperson:

Outreach coordinator:

Newsletter/Publicity

Treasurer and Membership: Sam Franklin

Hall coordinator:

Live Meeting Supplies

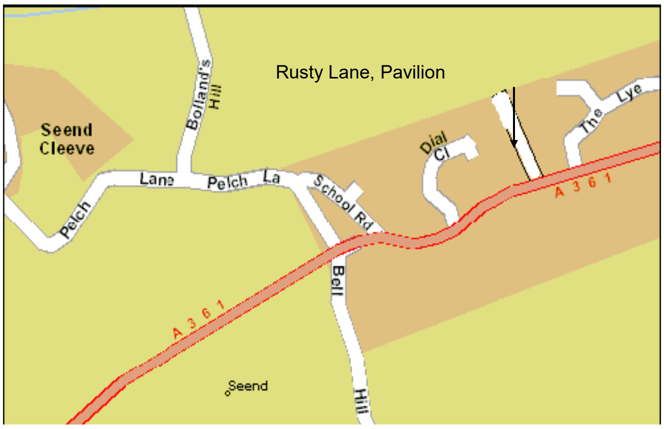
Speaker secretary

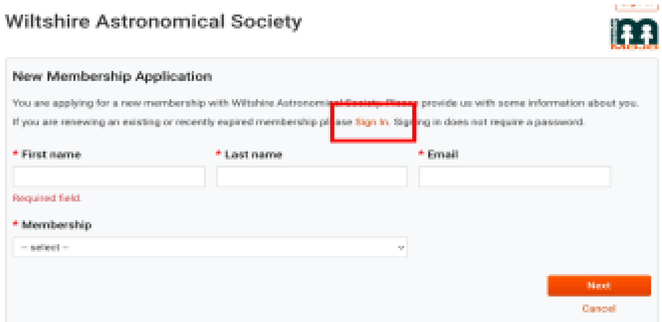
Zoom session coordinator

Observing Sessions coordinators: Chris Brooks, Jon Gale,

Web coordinator: Sam Franklin

Contact via the web site details.





Observing Sessions see back page

Swindon's own astronomy group

Physical meetings

The club meets in person once per month.

Online Meetings

Once per month to discuss equipment and techniques.

Friday, 8th December

Christmas Meal !

Our annual Christmas Meal will take place on Friday 8th December at the Sun Inn in Swindon.

We'll also announce the winners of our Image of the Year 2023 and Image of All Time competitions at the meal.

Ad-hoc viewing sessions

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

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

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

Meetings at Liddington Village Hall

Church Road, Liddington, SN4 0HB

7.30pm onwards

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

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

Next Meeting Dates

Friday 19 January 2024 @ 19:30

Bernard Henin: Imaging our Solar System

Friday 16 February 2024 @ 19:30

John Gale: The Lunar 100

Friday, 15 March 2024 @ 19:30

Club AGM

Friday, 19 April 2024 @ 19:30

Michael Perriman: Gaia and Advances in our Understanding of the Galaxy

Friday, 17 May 2024 @ 19:30

Kate Earl: Magnetars – The Beauty behind the Beast

Friday, 21 June 2024 @ 19:30

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

Website:
http://www.swindonstargazers.com

Chairman: Damian OHara
Email: damian@cog2.com

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

BECKINGTON ASTRONOMICAL SOCIETY

Sadly the Beckington Astronomical Society is closing its regular society.

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 community of stargazers and enthusiastic astronomers who share experiences and know-how. They offer an extensive outreach programme of public and young people's observing and activities. As a partner with Bath Preservation Trust, they are the resident astronomers at the Herschel Museum of Astronomy, Bath. They also partner with Bath Abbey to showcase the skies above the city both day and night. Bath Astronomers operate a 5m mobile planetarium which they take to schools and community events to present the night sky even when the clouds mask the starry sky.

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, 13th December
A talk by Richard Hook. His talk is entitled "The Quest for Monster Telescopes". This meeting will be held at the Herschel Museum of Astronomy, 19 New King Street, Bath.

More information and news is available via:
https://bathastronomers.org.uk
https://www.youtube.com/@bathastronomers
On Social Media (Facebook, Twitter, Instagram, Threads, Mastodon, Bluesky) 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.

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

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 Martin, Meyrick, Prim and Simon will be happy to help you.

SPACE NEWS

Red Sprites are Best Seen from Space
Planet Earth is full of some truly awe-inspiring spectacles, but few are as intriguing as a sprite, which are officially known as a Transient Luminous Event (TLE) and consist of large-scale electric discharges that shoot upwards while occurring above the cloud tops in the Earth's mesosphere at approximate altitudes of 50-90 km (31-56 mi). In October 2023, European Space Agency (ESA) astronaut, Dr. Andreas Mogensen, who is currently onboard the International Space Station (ISS) as Commander of the Expedition 70 mission, took an incredible image of a red sprite with the Davis camera as part of the Thor-Davis experiment and his Huginn mission.
Sprites have been observed from the ground and aircraft. However, the preferred observation method is from outer space due to the sprites occurring above the cloud tops and the low altitude of the ISS offering pristine views of these unique lightning features. While they are observed above cloud tops, they are hypothesized to originate from normal lightning near the Earth's surface and act as a "balancing mechanism" used by the Earth's atmosphere to distribute vertical electrical charges.

Since red sprites are essentially lightning strikes and visible for only a fraction of a second, specialized event-based cameras such as the Davis camera are required to precisely capture them. The Davis camera contrasts with a normal camera in that it does not take direct photographs, but instead creates images by sensing light and contract variances. Through this, the Davis camera capabilities are analogous to a normal camera taking 100,000 images per second.
Images of a red sprite taken by the Davis camera from the International Space Station in October 2023 by Expedition 70 Commander, Dr. Andreas Mogensen. (Credit: ESA/DTU/ A. Mogensen)
"These images taken by Andreas are fantastic," said Dr. Olivier Chanrion, who is a senior researcher at Danish Technical University (DTU) Space and lead scientist for this experiment. "The Davis camera works well and gives us the high temporal resolution necessary to capture the quick processes in the lightning."
The Thor-Davis experiment builds off the Thor experiment also conducted by Dr. Mogensen during his first mission to the ISS in 2015. During that experiment, Dr. Mogensen shot a 160-second video displaying 245 blue jets, which are another type of lightning event that shoots up towards space, with results from those findings being published in a 2016 study in *Geophysical Research Letters*.

The earliest recorded report of sprites—though they weren't called that right away—occurred in November 1885 from the *R.M.S. Moselle* as it was leaving port in Jamacia with the sprites then being described as a "meteorological phenomenon" while "sometimes tinged with prismatic hues, while intermittently would shoot vertically upwards continuous darts of light displaying prismatic colours in which the contemporary tints, crimson and green, orange and blue, predominated."
It took more than 100 years for the first photographic evidence of sprites to happen, when a team of scientists from the University of Minnesota accidentally imaged electrical discharges using a low-light-level television camera in 1989, with their findings later being published in *Science* the following year. It wasn't until a 1995 study published in *Geophysical Research Letters* that these electrical charges were officially dubbed "sprites". In the last several decades, sprites have been observed from all continents except for Antarctica, along with being observed from the ground, aircraft, and even outer space.

Image of red sprites taken in 2022 from the European Southern Observatory's (ESO) La Silla Observatory in Chile. (Credit: Zdenek Bardon/ESO)
What new discoveries about sprites will researchers make in the coming years and decades? Only time will tell, and this is why we science!

How Can Astronauts Maintain Their Bodies With Minimal Equipment?

Decades of research aboard the International Space Station (ISS) and other spacecraft in Low Earth Orbit (LEO) have shown that long-duration stays in microgravity will take a toll on human physiology. Among the most notable effects are muscle atrophy and bone density loss and effects on eyesight, blood flow, and cardiovascular health. However, as research like NASA's Twin Study showed, the effects extend to organ function, psychological effects, and gene expression. Mitigating these effects is vital for future missions to the Moon, Mars, and other deep-space destinations.
To reduce the impact of microgravity, astronauts aboard the ISS rely on a strict regiment of resistance training, proper diet, and cardiovascular exercise to engage their muscles, bones, and other connective tissues that comprise their musculoskeletal systems. Unfortunately, the machines aboard the ISS are too large and heavy to bring aboard spacecraft for long-duration spaceflights, where space and mass requirements are limited. To address this, NASA is investigating whether exercise regimens that rely on minimal or no equipment could provide adequate physical activity.
For every month in space, astronauts' weight-bearing bones become roughly 1% less dense if they don't take precautions to counter this loss, while muscles atrophy due to severely reduced loads. On Earth, these symptoms are associated with the aging process, sedentary lifestyles, and degenerative diseases. This has serious implications for astronaut health since missions to deep space require that astronauts be exposed to microgravity for several months. Upon arrival, they will be expected to conduct surface operations that require them to be hale and hearty. Otherwise, they could suffer serious injuries.

A Long Tradition

For decades, astronauts have used stationary bikes and treadmills to get their exercise. The Soviet Salyut program, which operated between 1971 and 1986, carried out multiple studies on astronaut health. To test possible "countermeasures," these stations included a treadmill, a gravity simulation suit for long wear, a bicycle with an ergometer, drugs, and an anti-gravity suit to be worn immediately post-flight. Exercise regiments were divided into two one-hour shifts in the morning and afternoon between work cycles.

The Soviet/Russian space station Mir had two treadmills (with bungee cords to anchor the cosmonauts) and a stationary bicycle. Each cosmonaut was required to cycle the equivalent of 10 kilometers (6.2 mi) and run the equivalent of

5 kilometers (3.1 mi) per day. NASA followed a similar regimen, as astronauts aboard Skylab were required to perform 90 minutes of exercise a day using equipment that included a stationary bicycle and treadmill-like device, and astronauts found that they could jog around the water tank.

After the ISS became operational in 2001, one of the first exercise systems delivered was the Treadmill with Vibration Isolation Stabilization System (TVIS), which uses a harness to keep users tethered to the machine while adding extra resistance. There's also the Cycle Ergometer with Vibration Isolation and Stabilization System (CERVIS), an exercise bike contributed by Danish Aerospace. Astronauts also have the Advanced Resistive Exercise Device (ARED) that uses vacuum cylinders and pistons to create resistance, letting astronauts simulate weightlifting in microgravity.

Muscular Atrophy

While medical science understands the broad causes of atrophy, researchers continue to investigate the fundamental mechanisms and contributing factors to look for solutions to microgravity-induced atrophy. Much of this research is focused on determining the right combination of diet, exercise, and medication to keep astronauts healthy in space and during missions on the Moon or Mars and to assist with the transition when they return to Earth. For example, the Zero T2 experiment involves astronauts not using the treadmill and focusing instead on aerobic and resistance exercises.

ESA astronaut Alexander Gerst gets a workout on the Advanced Resistive Exercise Device (ARED).
Credit: NASA

Once the experiment is complete, research teams will compare the participants' muscle performance and recovery to those of their crewmates who used the treadmill. Another experiment, VR for Exercise, aims to create an immersive virtual reality environment astronauts can enjoy while using the station's exercise bike. There's also research that involves "tissue chips," which are small devices that imitate complex functions of specific tissues and organs.
One such experiment, Human Muscle-on-Chip, used a 3D model of muscle fibers created from muscle cells taken from younger and older adults. The experiment consisted of administering electrical pulses to the tissues to make them contract while looking for changes in function attributed to microgravity. The researchers found that for muscle cells exposed to microgravity, there was decreased expression of genes related to muscle growth and metabolism related to age.

Skeletal Health

In addition to testing different exercise regimes, researchers are also studying how the entire musculoskeletal system experiences exercise in microgravity. This is the purpose of the ARED Kinematics human physiology experiment supported by the Italian Space Agency (ASI) and the ESA. This system aims to quantify the joint torque, muscle forces, and bone stresses that occur during exercise in microgravity, as well as the adaptations in performance that may occur over time.

Addressing bone density loss, there's the Vertebral Strength experiment, where detailed scans were taken of astronauts before and after they went to space. These scans examined the bones and muscles supporting the vertebral column, providing researchers with information about how spaceflight affects overall musculoskeletal strength. This and other research into bone density loss and musculoskeletal health overlap with research into osteoporosis here on Earth and could lead to mutually beneficial applications. Similarly, drugs that fall into the class of myostatin inhibitors have a proven track record on Earth in the treatment of osteoporosis. These drugs suppress myostatin, a human growth factor that prevents excessive muscle growth, which helps reduce bone density loss and prevent fractures in patients. The Rodent Research 19 (RR-19) experiment recently tested this drug on a group of mice during spaceflight, which indicated that the drug could be an effective treatment for astronauts and people with degenerative diseases here on Earth.

Psychological Health

Of course, no research into the effects of microgravity on human health would be complete without considering the psychological effects that long periods spent in space can have. This is the purpose of the Complement of Integrated Protocols for Human Exploration Research (CIPHER), an integrated experiment that arrived on the ISS earlier this year. For this experiment, astronauts will participate in 14 studies sponsored by NASA and international partners that will measure the physiological and psychological changes in crew members on missions lasting for a few weeks, 3.5 to 8 months, or up to one year in space.
These research studies will monitor the health of astronauts before, during, and after their missions. By conducting the same research over missions of different durations, scientists can extrapolate the results for multi-year missions – such as a three-year round trip to Mars. As CIPHER project scientist Cherie Oubre explained:
"CIPHER is the first study to integrate multiple physiological and psychological measures, giving us a chance to assess the whole human response to time spent in space. As more astronauts head to space through Artemis and other programs, we hope to learn more about how the various systems of the body, such as the heart, muscles, bones, and eyes, adapt to long-term spaceflight."

Understanding the effects of prolonged exposure to microgravity and developing countermeasures is particularly important as NASA plans future missions that will take astronauts far beyond LEO. For long-duration missions on the Moon, Mars, and beyond, astronauts will spend extended periods in microgravity or low gravity. Once they arrive, they may need to perform strenuous activity and be in optimal health. Possible solutions currently under study include exercise, diet, and drugs and simulating gravity using rotating modules.

In all likelihood, astronauts bound for Mars or other deep-space destinations in the future will be relying on an "all of the above" approach.
Further Reading: NASA

Will Wide Binaries Be the End of MOND?

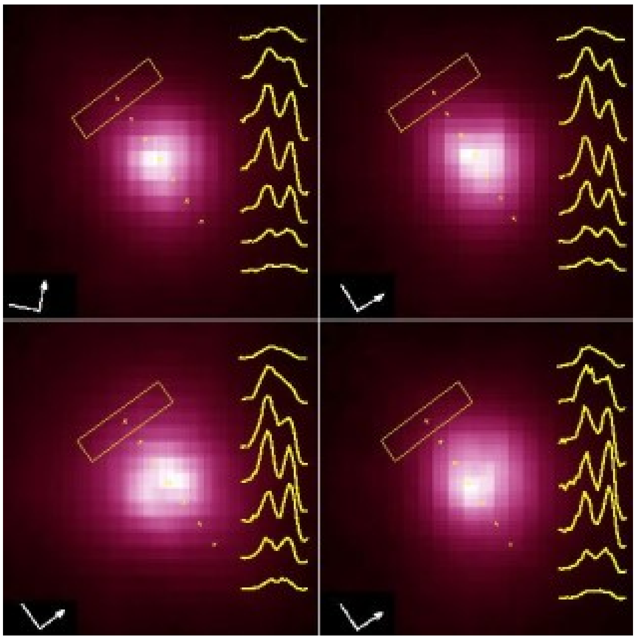
It's a fact that many of us have churned out during public engagement events; that at least 50% of all stars are part of binary star systems. Some of them are simply stunning to look at, others present headaches with complex orbits in multiple star systems. Now it seems wide binary stars are starting to shake the foundations of physics as they question the very theory of gravity.
General relativity has been part of the foundation of modern physics since it was published by Albert Einstein in 1915. One of the challenges though is that, along with normal mat-

ter (known by its official name baryonic matter) general relativity is unable to explain the current theories of the evolution of the universe without dark matter. Alas dark matter has not been observed in any lab experiment or indeed directly in the sky.
The idea for dark matter was developed in the early 1930's to explain the movement of the galaxies in the Coma Cluster. It was Fritz Zwicky who coined the phrase dark matter in 1933 to explain the unseen matter that was driving the movement. Current theories suggest there is something like five times more dark matter in the Universe than there is normal matter but It's a type of matter that we know little about other than it doesn't interact with normal baryonic matter.

The Coma Galaxy Cluster. It appears to participate in the dark flow.
The standard model – that describes how the building blocks of matter interact – assumes that the current laws of gravity are all correct however a 'tweak' is required to explain certain observations and that tweak is called dark matter. In other words, we can see the effect of dark matter but we just haven't actually directly detected it yet. In a paper published by J. W. Moffat, there is a bold suggestion that maybe it's the gravitational model that is incorrect.
Enter MOND – 'Modified Newtonian Dynamics' – which proposes an adjustment to Newton's second law (nicely encapsulated in the formula that force equals mass multiplied by acceleration) to explain the movement of galaxies without dark matter. The theory, proposed by M. Milgrom in 1983 suggests that the gravitational force exerted upon a star in the outer reaches of a galaxy was proportional to the square of its centripetal acceleration (instead of the centripetal acceleration itself). Remember the existing models do not explain this without inserting dark matter which we have yet to discover.
The paper by Moffat suggests that they should be able to detect the changes proposed by MOND but in applying the formulas correctly the galaxy constrains must be significantly affected. Wide binary data from Gaia (the Global Astrometric Interferometer) seems to conclude that any modified gravity theory must reliy upon scale and length rather than acceleration. If this continues to be the case for future observations then it may well mark the demise of the MOND model for good.

Does Betelgeuse Even Rotate? Maybe Not

Betelgeuse is the well known red giant star in the corner of Orion the hunter. The name translated in some languages means 'armpit of the giant' which I think of all the star names, is simply the best! Betelgeuse has been fascinating observers of late not only because it unexpectedly faded a few years ago but more recently a study shows it's super fast rotational speed which is, when compared to other supergiants, is like nothing seen before.
One of the brightest stars in the northern hemisphere sky, in fact the tenth brightest, Betelgeuse has a stunning red colour. It is a semi regular variable star which means there is some regularity to its varied light output but there are occasions, perhaps lasting between 20 and 2000 days where the variation is interrupted. If Betelgeuse were placed in the Sun's position then its visible surface would more than likely extend beyond the orbit of Mars and swallow up everything in between.



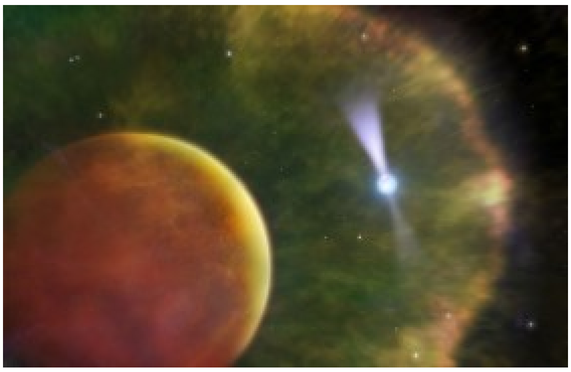
1998/9 UV HST images of Betelgeuse showing asymmetrical pulsations with corresponding spectral line profiles (Credit : STScI, NASA, ESA)
Like all stars, Betelgeuse rotates but a recent study using the Atacama Large Milimeter Array (ALMA) has showed that Betelgeuse is rotating faster than expected. Cool stars like Betelgeuse expand as they evolve and to conserve momentum the rotation must slow. It is possible that mass loss due to stellar winds decreases rotation speeds further. The current theory predicts that red giants rotate at around 1km per second while red supergiants a little less than 0.1km per second.

Two of the Atacama Large Millimeter/submillimeter Array (ALMA) 12-metre antennas (Credit : Iztok Bon?ina/ESO)
Current theory aside it seems there have been a number of observations of at least a few hundred giant stars rotating faster. Betelgeuse in particular has shown faster than expected rotation. Somewhat usefully, it's proximity to Earth has meant its surface can be resolved and accurate measurements taken. Measurements showed that half of the visible hemisphere was blue shifted and the the other half red shifted. We can use this information to accurately calculate a rotational velocity.
When it comes to Betelgeuse, the radial velocity with ALMA was measured to be around 5.47 km per second. This value was compared against previous observations using Hubble Space Telescope and thankfully this agreed. One leading theory takes binary star evolution as a possible cause and in particular a merger with a low mass companion star. This is not an unusual process with an expected one-third of red

supergiants experience stellar merger before their core collapses marking the end of their life. When it comes to red giants the team considered the impact of merging with planetary systems on the rotational velocity.
There are complications however in attaining sufficient data but the team modelled 3D radiation hydrodynamic simulations of red supergiants with properties similar to Betelgeuse. Throwing a proverbial spanner in the works, the team suggest that it is possible that the observations could be wrong and false signals have been picked up from churning convective plasma at the surface rather than the rotation of the star itself!
In an attempt to ascertain if it is possible to accurately measure the rotational speed of red giants and supergiants they had to develop new processing techniques to establish predictions that they could compare with observations of Betelgeuse. The team finally conclude that to be able to establish without doubt that Betelgeuse and other red supergiants are rotating rapidly, higher resolution observations are required than current technology can reliably provide.
Source : Is Betelgeuse really rotating? Synthetic ALMA observations of large-scale convection in 3D simulations of Red Supergiants

Spider Pulsars are Tearing Apart Stars in the Omega Cluster

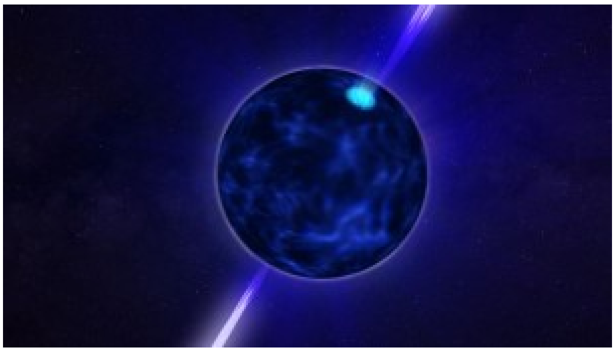
Pulsars are extreme objects. They're what's left over when a massive star collapses on itself and explodes as a supernova. This creates a neutron star. Neutron stars spin, and some of them emit radiation. When they emit radiation from their poles that we can see, we call them pulsars.
In the last decade or so, astrophysicists have discovered many more millisecond pulsars, ones that rotate very rapidly. Not only is the number of known pulsars increasing, but researchers have also identified pulsar sub-types that have companions. These are called spider pulsars, and their companions face great peril. New research sheds light on how spider pulsars in Omega Centauri are tearing their companions to pieces with their powerful outflows.
The first spider pulsar ever discovered is PSR B1957+20, more widely known as the Black Widow Pulsar. It has a companion that's either a brown dwarf or a super Jupiter. High-energy outflows from the Black Widow are destroying its companion. All pulsars that destroy their companions are known as spider pulsars, but there are two further subtypes of spider pulsars: redback pulsars and black widow pulsars.



Artist's impression of the pulsar PSR B1957+20 (seen in the background) through the cloud of gas enveloping its brown dwarf star companion. Credit: Dr. Mark A. Garlick; Dunlap Institute for Astronomy & Astrophysics, University of Toronto

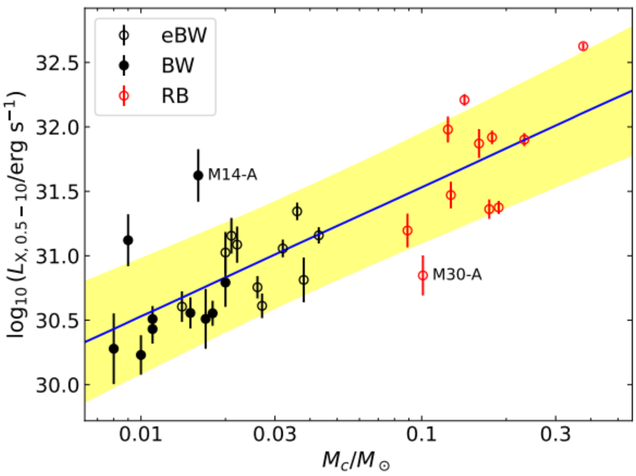
Researchers working with the Chandra Space Telescope have examined Omega Centauri to learn more about how spider pulsars destroy their binary companions. Their work will be published in the Monthly Notices of the Royal Astronomical Society. The title is "A Chandra X-ray study of millisecond pulsars in the globular cluster Omega Centauri: a correlation between spider pulsar companion mass and X-ray luminosity." The authors are Jiaqi Zhao and Craig O. Heinke, both from the Physics Department at the University of Alberta, Edmonton, Canada.

Omega Centauri is the largest globular cluster (GC) that we know of in the Milky Way. It's almost 16,000 light-years away and contains about 10 million stars. Some of those stars are spider pulsars, a class of millisecond pulsars with companions.



Visualization of a fast-rotating pulsar. Credit: NASA's Goddard Space Flight Center Conceptual Image Lab
Spider pulsars are terribly destructive neighbours. Their energetic winds methodically strip away their companions' outer layers. To understand more about this phenomenon, the pair of researchers examined Chandra data from Omega Centauri, home to 18 recently discovered spider pulsars.
"Millisecond pulsars (MSPs) are faint X-ray sources commonly observed in Galactic globular clusters (GCs)," the researchers write. "In this work, we investigate 18 MSPs newly found in the GC Omega Centauri and search for their X-ray counterparts using Chandra observations."
Out of the 18 millisecond pulsars, 11 of them emit x-rays that Chandra can see. Five of them are spider pulsars near Omega Centauri's center. They combined these with Chandra's observations of 26 spider pulsars in 12 other globular clusters. Using this data, the pair of researchers examined empirical correlations between X-ray luminosities and the minimum masses of their companions.

This image shows Omega Centauri's central region in both optical light and X-rays, with some of the millisecond pulsars labelled. Image Credit: X-ray: NASA/CXC/SAO; Optical: NASA/ESA/STScI/AURA; Image Processing: NASA/CXC/SAO/N. Wolk
There are two classes of spider pulsars, and they're based on their companions' masses. Redback spider pulsars have companions between one-tenth and one-half of a solar mass, while black widow class pulsars have companions with less than 5% of the Sun's mass.
The researchers found that redback spider pulsars are brighter in X-rays than black widow pulsars. This is in line with previous research.
But this is the first time that research has shown a correlation between X-ray luminosity and companion mass. We can see in the data how redback spiders with more luminous X-rays have more massive companions. That might seem counter-intuitive on the surface. What's behind it?



This figure from the research shows the X-ray luminosity of the spider pulsars on the y-axis and the minimum masses of their companion stars on the x-axis (logarithmic). There's a clear correlation between redblack spider pulsars, shown in red circles, and black widow pulsars, shown in black, and their companions' masses. (M14-A and M30-A are outliers.) Image Credit: Zhao and Heinke, 2023.

Spider pulsars create X-rays when particles in their stellar winds strike the winds coming from their companions and produce shock waves. The more massive its companion is, the stronger the companion's winds. That means the colliding winds produce more luminous X-rays.

"Therefore, our findings indicate that as the companion mass increases, the X-ray luminosity of the spider pulsar tends to increase as well," the authors write in their paper. "It likely suggests that a more massive companion can produce stronger winds and thus generate stronger intra-binary shocks with relativistic pulsar winds, leading to higher X-ray luminosities as observed."

These findings agree with theories of how spider pulsars work. Since spiders and their companions are never very far apart—between one and 14 times the distance between the Earth and the Moon— energetic particles from the pulsar are very destructive to their companions. This creates stronger shocks that produce brighter X-rays.

"It is clear that there is a correlation between X-ray luminosities and companion masses of spider pulsars," the authors write. "This is consistent with the evidence that RBs generally produce more energetic shocks than BWs, and RBs are commonly an order of magnitude brighter than BWs."

Spider pulsars follow a narrative trajectory worthy of Shakespeare. They live their lives of fusion as main sequence stars before exploding as supernovae, extremely energetic explosions that light up the sky for months with light equal to trillions of Suns. Then they exist as a kind of stellar zombie, an extraordinarily dense neutron star.

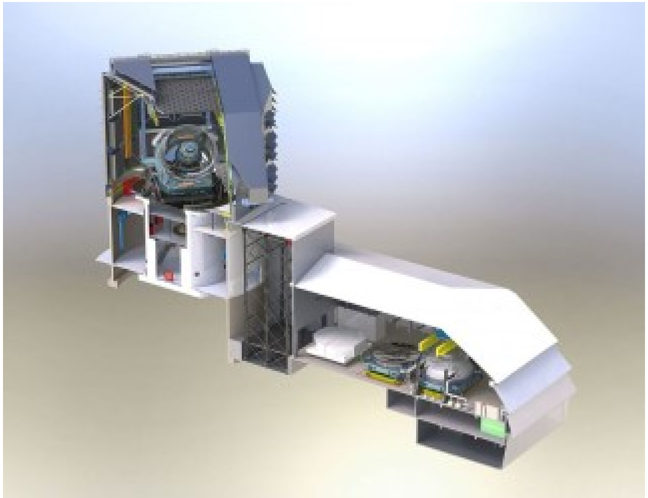
They spin rapidly while emitting powerful outflows of energetic particles. If they're fortunate enough to have a companion, then their final act is to destroy that companion like the spider pulsars in this research.

Over time, pulsars cool down, and their rotation slows. After a few tens of millions of years, they cross what's called the "Death Line" and stop pulsing. Then they're just regular neutron stars, aging forever.

Vera Rubin Will Generate a Mind-Boggling Amount of Data

When the Vera C. Rubin Observatory comes online in 2025, it will be one of the most powerful tools available to astronomers, capturing huge portions of the sky every night with its 8.4-meter mirror and 3.2-gigapixel camera. Each image will be analyzed within 60 seconds, alerting astronomers to transient events like supernovae. An incredible five petabytes (5,000 terabytes) of new raw images will be recorded each year and made available for astronomers to study.

Not surprisingly, astronomers can't wait to get their hands on the high-resolution data. A new paper outlines how the huge amounts of data will be processed, organized, and disseminated. The entire process will require several facilities on three continents over the course of the projected ten-year-long survey.



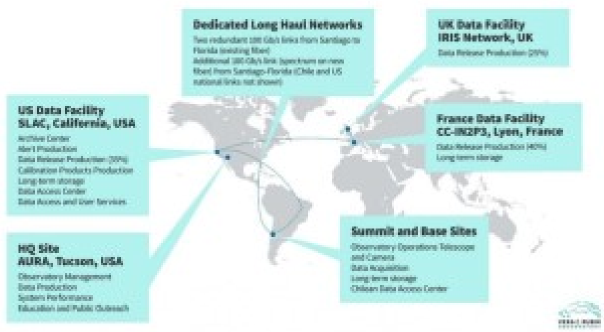
Detailed cut-away render of the telescope model showing the inner workings. Credit: LSST Project/J. Andrew

The Rubin Observatory is a ground-based telescope located high in the Chilean Andes. The observatory's 8.4-meter Simonyi Survey Telescope will use the highest resolution digital camera in the world, which also includes the world's largest fish-eye lens. The camera is roughly the size of a small car and weighs almost 2,800 kg (6,200 lbs). This survey telescope is fast-moving and will be able to scan the entire visible sky in the southern hemisphere every four nights.

"Automated detection and classification of celestial objects will be performed by sophisticated algorithms on high-resolution images to progressively produce an astronomical catalog eventually composed of 20 billion galaxies and 17 billion stars and their associated physical properties," write Fabio Hernandez, George Beckett, Peter Clark and several other astronomers in their preprint paper.

The main project for Rubin Observatory is the Legacy Survey of Space and Time (LSST) and researchers anticipate this project will gather data on more than 5 million asteroid belt objects, 300,000 Jupiter Trojans, 100,000 near-Earth objects, and more than 40,000 Kuiper belt objects. Since Rubin will be able to map the visible night sky every few days, many of these objects will be observed hundreds of times.

Because of the telescope's repeated observations, the enormous amount of data will help calculate the positions and orbits of all these objects.



Images flow from the Summit Site, where the telescope is located in Chile, to the Base Site and then to the three Rubin Data Facilities which collectively provide the computational capacity for processing the images taken by the Observatory for the duration of the survey. Credit: Vera Rubin Observatory.

Images and data will immediately flow from the telescope to the Base Facility and Chilean Data Access Center in La Serena, Chile and then go to the three Rubin data facilities on dedicated high-speed networks connecting the sites: the French Data Facility CC-IN2P3 in Lyon, France, the UK Data Facility, IRIS network, in the United Kingdom and the US Data Facility and Data Access Center at SLAC National Accelerator Laboratory in California, USA. There is also a Headquarters Site at the Association of Universities for Research in Astronomy (AURA) in Tucson, Arizona, USA.

Once images are taken, they will be processed according to three different timescales: prompt, daily, and annually. The Hernandez et al paper outlines how raw images collected each observing night will be quickly processed (within 60 seconds), and objects that have changed brightness or position will generate and emit alerts for "transient detection."

Hernandez told Universe Today that for this process, known as Prompt Processing, there will be no proprietary period associated with alerts, and they will be available to the public immediately, since the goal is to quickly transmit nearly everything about any given event, to enable quick classification and decision making. Scientists estimate Prompt Processing could generate millions of alerts per night.

Daily products, released within 24 hours of observation, will include the images from that night. The annual campaigns will reprocess the entire image dataset collected since the beginning of the survey.

Hernandez said that reprocessing the entire image dataset every year has several purposes.

"First, is to use an ever increasing set of images of each patch of the sky to extract information about the celestial objects present in them," he said via email. "The more images we have, the more information we can extract. Second, with time we will refine our algorithms for extracting that information from images since we will progressively learn about the instrument itself and about the celestial objects."

The yearly data release will be made available to science collaborations for use in studies in four main science pillars: probing dark matter and dark energy, taking inventory of Solar System objects, exploring the transient optical sky and mapping the Milky Way.

For each data release, there will be raw and calibration images in addition to science-ready images which have been processed with updated scientific algorithms. There will also be catalogs with the properties of all the astrophysical objects detected.

The annual data processing will be run at the three data facilities, with the final dataset assembled at SLAC and made available to astronomers and physicists via the Rubin Science Platform.

"The volume of released data products generated by the annual processing of the accumulated set of raw images is on average 2.3 times the size of the input dataset for that year and is estimated to reach more than one hundred petabytes by the end of the survey," the astronomers wrote. They also said that over the ten year-long survey the volume of data released for science analysis is estimated to increase by one order of magnitude.

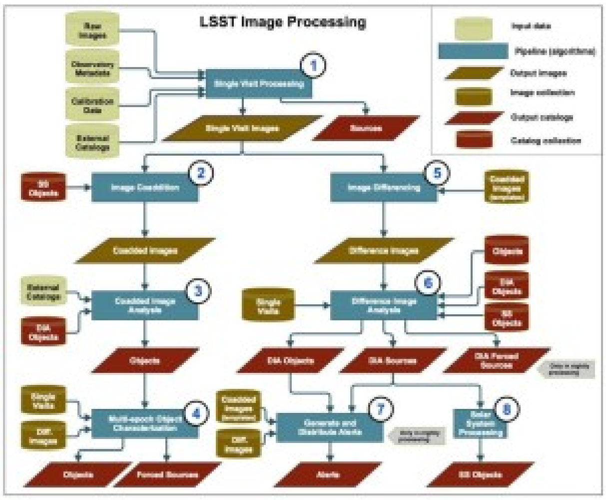


Illustration of the conceptual design of the LSST Science Pipelines for image processing. Credit: Hernandez et al.

The Rubin Observatory will utilize several kinds of data products and services for archiving and dissemination of the data to the various science collaborations. The paper says the Rubin LSST "Science Pipelines" are composed of about 80 different kinds of tasks, which are all implemented on top of a common algorithmic code base and specialized software. There is a feature called the Data Butler, which is the software system that abstracts the data access details (including data location, data format and access protocols).

Hernandez said the Rubin Observatory data will become fully public after two years.

For more details and information, see the Vera Rubin Observatory website.

Paper: Overview of the distributed image processing infrastructure to produce the Legacy Survey of Space and Time

A Gamma-ray Burst Disturbed the Earth's Ionosphere

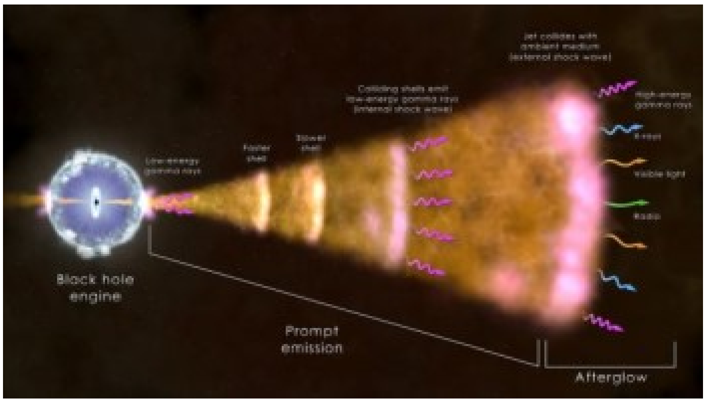
You'd think that something happening billions of light-years away wouldn't affect Earth, right? Well, in 2002, a burst of gamma rays lasting 800 seconds actually impacted our planet. They came from a powerful and very distant supernova explosion. Its gamma-ray bombardment disturbed our planet's ionosphere and activated lightning detectors in India.

This particular gamma-ray burst (GRB) occurred in a galaxy almost 2 billion light-years away (and took two billion years to reach us). Not only did ground-based detectors record the bombardment, but satellites sensitive to high-energy outbursts "saw" it, too. That included the European Space Agency's International Gamma-Ray Astrophysics Laboratory (INTEGRAL) mission. It typically records gamma-ray bursts on a daily basis, but this one—named GRB 221009A—outshone all the rest.

GRBs this strong happen (on average) about once every 10,000 years, so this was one that caught everyone's attention. "It was probably the brightest gamma-ray burst we have ever detected," says Mirko Piersanti, University of L'Aquila, Italy, and lead author of a paper analyzing the event.

How The Gamma-ray Burst Affected the Ionosphere

Most of the time, radiation from the Sun bombards our planet. That's often strong enough to affect the ionosphere. That's an atmospheric layer that bristles with electrically charged gases called plasma. It stretches from around 50 km to 950 km in altitude above the surface. There's a "topside ionosphere" (which lies above 350 km) and a "bottomside ionosphere") which lies below that. Scientists are pretty familiar with how the Sun treats this region of the atmosphere, particularly during periods of heavy solar activity.



GRB 221009A: looking back through time at a gamma-ray-burst. Courtesy ESA

This GRB blast triggered instruments generally reserved for studying the immense explosions in the Sun's atmosphere known as solar flares. "Notably, this disturbance impacted the very lowest layers of Earth's ionosphere, situated just tens of kilometers above our planet's surface, leaving an imprint comparable to that of a major solar flare," says Laura Hayes, research fellow and solar physicist at ESA. That imprint basically was an increase in ionization in the bottom-side ionosphere. It left an imprint in low-frequency radio signals that move between Earth's surface and the lowest levels of the ionosphere. "Essentially, we can say that the ionosphere 'moved' down to lower altitudes, and we detected this in how the radio waves bounce along the ionosphere," explained Laura.

Gamma Ray Bursts in the Data

Past GRBs bothered the bottom-side ionosphere but didn't always disturb the topside. Scientists just assumed that by the time it reached Earth, the blast from a GRB didn't have the "oomph" to change that part of the ionosphere. GRB 221009A proved that idea wrong. Thanks to data from the orbiting China Seismo-Electromagnetic Satellite (CSES), scientists saw a strong disturbance in the upper ionosphere. It created a strong electric field variation and was the first time scientists saw this connected to a GRB. The result is the first-ever top-side ionospheric measurement of electric field variations triggered by a gamma-ray outburst at cosmic distances.

INTEGRAL and other spacecraft continually record GRBs from around the Universe. Have they all affected our ionosphere in some way? Is there a way to find out? Now that scientists know what ionospheric effects to look for, they can search the data to find answers. Data from INTEGRAL, and CSES will be particularly useful. They should be able to correlate it with other GRBs seen since 2018. That's when CSES was launched.

Evidence of ionospheric disturbances from GRBs goes back as far as 1988. That's when the effects of a 1983 gamma-ray burst were first reported. Scientists now have an array of ground-based and space-based detectors—such as Swift, Fermi, MAXI, AGILE, INTEGRAL, and CSES—gave strong detections of the emissions from GRB221009A.

Implications for Future GRB Effects on Earth

This kind of disturbance from a very distant event poses a question: what would happen if such an explosion happened "closer to home"? A supernova in our own galaxy, for example, releasing a huge burst of gamma rays, could very well "reach out and touch" Earth in a drastic way. "There has been a great debate about the possible consequences of a gamma-ray burst in our own galaxy," says Mirko Piersanti.

For one thing, a close-by and strong GRB would have drastic effects on our ionosphere, much stronger than a typical solar flare. It could also do some significant damage to the ozone layer (which provides a protective shield against radiation from the Sun). That would allow a lot more ultraviolet (UV) to reach the surface than we're accustomed to experiencing. It's possible (although not proven) that some of Earth's past extinction events could be related to an increase in UV radiation on the surface.

Gamma-ray Bursters and Extinctions

Earth's ozone layer is a first-line defense mechanism against radiation, which is why people stopped using gases such as chlorofluorocarbons. They were destroying the ozone layer, allowing in more UV radiation. This affected the atmosphere as well as people, plants, and animals. At least one research paper looked at ozone depletion by GRBs by studying what happens over the polar regions. Increased UV radiation produces changes in the middle atmosphere, including the creation of ground-level ozone, which can damage life in high concentrations. A burst that sent radiation into the south polar regions is suggested as one reason that the Ordovician extinction happened around 445 million years ago. An estimated 85 percent of species alive at that time were wiped out.

If a nearby GRB was involved, that might explain the Ordovician event and may offer insight into other mass extinctions. It's not far-fetched to think that some of them may have had cosmic triggers. Those could have affected life on Earth more powerfully than the two-billion-year-old bombardment from GRB 221009A.

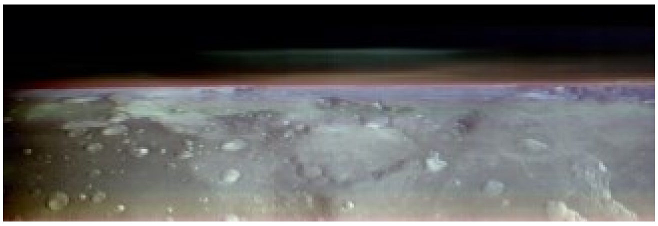
For More Information

Blast from the Past: Gamma-ray Burst Strikes Earth from Distant Exploding Star
Evidence of an Upper Ionospheric Electric Field Perturbation Correlated with a Gamma Ray Burst
How Deadly Would a Gamma-ray Burst Be?

Odyssey Gives Us a Cool New View of Mars

Chances are that you've seen images of Earth from space, thanks to the astronauts aboard the *International Space Station* (ISS), who regularly share stunning photos of our planet. These images provide us regularly with breathtaking views of cities, oceans, storms, eruptions, clouds, the curvature of the planet, and the way the atmosphere glows against the horizon. Thanks to NASA's *Mars Odyssey Orbiter*, which has been in orbit for over 22 years, we now have an equally breathtaking view of Mars from orbit that captured what its curvature and atmosphere look like from space.

The images were taken back in May when the orbiter was at an altitude of 400 km (250 mi) above the surface, the same altitude that the ISS orbits Earth. The spacecraft took ten pictures in total, which were stitched together to create a panoramic image showing the curving Martian landscape below a hazy layer of dust and clouds, as well as Mars' smaller satellite Phobos. The THEMIS camera is ideally suited to capturing what's happening in Mars' atmosphere, as its sensitivity to infrared (heat) enables it to map ice, rock, sand, dust, and temperature changes on the planet's surface. Because THEMIS is fixed to the bottom of the orbiter, adjusting the camera's angle requires that the entire spacecraft be reoriented. In this case, the team needed to rotate the orbiter about 90 degrees while making sure



the solar panels were still pointed at the right angle so they could continue to draw power from the Sun. At the same time, they had to ensure that the orbiter's sensitive instruments would not overheat. This included the THEMIS camera itself since external heat would cause extreme interference with its re

This unusual view of the horizon of Mars was captured by NASA's Odyssey orbiter using its THEMIS camera, in an operation that took engineers three months to plan. It's taken from about 250 miles above the Martian surface – about the same altitude at which the International Space Station orbits Earth. NASA/JPL-Caltech/ASU

This required that the orbiter's antenna be pointed away from Earth, which meant that the mission team could not communicate with Earth until the operation was complete. Preparing for this maneuver took three months and involved engineers at NASA's Jet Propulsion Laboratory and Lockheed Martin Space, which together manage the mission and lead its day-to-day operations. Jonathon Hill, Arizona State University, is the operations lead for Odyssey's camera, the Thermal Emission Imaging System (THEMIS). As he explained in a NASA press release, the image is reminiscent of what astronauts may see someday:

"If there were astronauts in orbit over Mars, this is the perspective they would have. No Mars spacecraft has ever had this kind of view before. We got a different angle and lighting conditions of Phobos than we're used to. That makes it a unique part of our Phobos dataset," he said. "I think of it as viewing a cross-section, a slice through the atmosphere," added Jeffrey Plaut, Odyssey's project scientist at JPL. "There's a lot of detail you can't see from above, which is how THEMIS normally makes these measurements."
The resulting panorama is not only impressive to look at but will provide scientists with new insights into the composition and dynamics of the Martian atmosphere. Seeing where layers of water-ice clouds and dust are (and how they are stacked) in relation to each other is essential to improving models of Mars' atmosphere. The mission team hopes to take similar images in the future that capture seasonal changes in the Martian atmosphere. The spacecraft also captured images of Phobos, which is the seventh time the mission has pointed THEMIS towards Phobos in the 22 years it has been orbiting Mars.
The latest imagery shows temperature variations across the moon's surface and provides insight into the composition and physical properties of the moon. These images will also be helpful to the Odyssey scientists who are also working on the joint NASA-JAXA sample-return mission to Phobos and Deimos – the Mars Moon eXplorer (MMX). It is hoped this mission will finally settle the long-standing debate about whether Phobos is a captured asteroid or a chunk of Mars that was blasted into orbit by a past impact.
Further Reading: NASA

We Should Hit Peak Solar Activity Next Year

You may be familiar with the solar cycle that follows a 22 year process shifting from solar minimum to maximum and back again. It's a cycle that has been observed for centuries yet predicting its peak has been somewhat challenging. The Sun's current cycle is approaching maximum activity which brings with it higher numbers of sunspots on its surface, more flares and more coronal mass ejections. A team from India now believe they have discovered a new element of the Sun's magnetic field allowing them to predict the peak will occur early in 2024.
The Sun is a gigantic sphere of plasma or electrically charged gas. One of the features of plasma is that if a magnetic field passes through it, the plasma moves with it. Conversely if the plasma moves, the magnetic field moves too. This magnetic field is just like Earth and is known as a dipole magnetic field. You can visualise it if you can remember your school science days with a bar magnet and iron filings.
A dipole magnetic field has two opposite but equal charges and at the start of the Sun's cycle the field lines effectively run from the north pole to the south. As the Sun rotates, with the equator rotating faster than the polar regions, then the plasma drags the magnetic field lines with it, winding them tighter and tighter.
The field lines become stretched causing the magnetic field to loop up and through the visible surface of the Sun. This localised event prevents the convection of super heated gas from underneath and appears as a cooler area of the surface which appears dark. As the solar cycle starts, these sunspots appear around the polar regions and slowly migrate toward the equator as it progresses with peak activity occurring when the sunspots fade away as we head toward the start of another cycle.

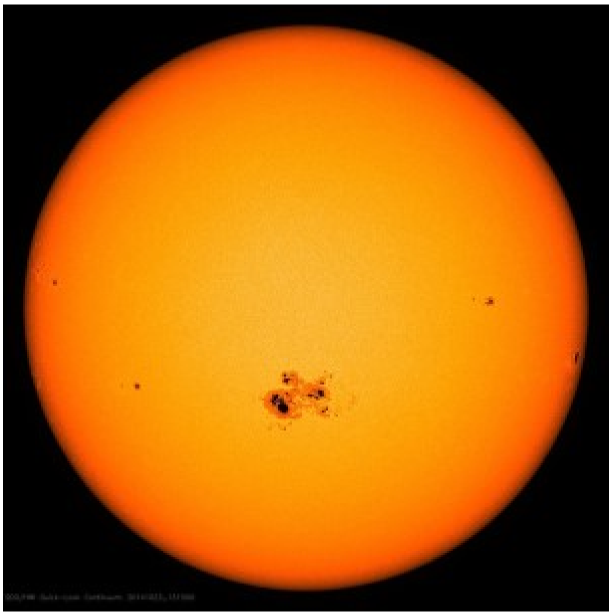


Image of sunspots (Credit : NASA Goddard Space Flight Center // SDO)

On occasions the magnetic field of sunspots are disrupted and we can experience flares or coronal mass ejections hurling vast amounts of charged particles out into space. If they reach us here on Earth they give rise to the beautiful aurora displays but they do also have a rather negative impact to satellites, power grids and telecommunications systems.
Deep inside the Sun, a dynamo mechanism is driving all this. It is created by the energy from the movement of plasma and it is this that is responsible for the flipping of the Sun's magnetic poles where the north pole becomes south and the south pole becomes north which happens every 11 years or so. It's another aspect of the solar cycle.
It's been known since the 1930's that the rate of rise the sunspot cycle relates to its strength with stronger cycles taking less time to reach peak. In the paper published in the Monthly Notices of the Royal Astronomical Society Letters; Priyansh Jaswal, Chitradeep Saha and Dibyendu Nandy from the Indian Institutes of Science Education and Research announced their findings. They discovered that the rate of decrease in the Sun's dipole magnetic field also seems to relate to the rise of the present cycle.
The team have looked back through archives and have shown how the observation of the dipole decrease rate along with observations of sunspots can predict the peak of activity with better accuracy than before. They conclude the current cycle is expected to peak somewhere between early 2024 and September next year. Being able to better predict the peak of activity will help understand the likely intensity of space weather events here on Earth providing us more warning to be able to prepare.

It Doesn't Take Much to Get Tilted Planets

Chinese and Indian astronomers were the first to measure Earth's axial tilt accurately, and they did it about 3,000 years ago. Their measurements were remarkably accurate: in 1120 BC, Chinese astronomers pegged the Earth's axial tilt at 24 degrees. Now we know that all of the planets in the Solar System, with the exception of Mercury, have some tilt.
While astronomers have puzzled over why our Solar System's planets are tilted, it turns out it's rather normal.
Now that astronomers have observed so many other solar systems, they've learned that axial tilt is to be expected, even in so-called "pristine" solar systems. Pristine refers to the precise mathematical relationship between planets.
New research in The Astronomical Journal explains why some axial tilt is to be expected. It's titled "Evidence for Low-level

Dynamical Excitation in Near-resonant Exoplanet Systems." The lead author is Malena Rice, an assistant professor of astronomy at Yale's Faculty of Arts and Sciences. The orbital resonance concept is at the heart of this research.

As planets orbit a star, they can exert regular and periodic gravitational influence on one another. When they do, astronomers say they're in resonance with one another. It also happens in moon systems around planets with many moons. Some resonant systems can be self-stabilizing, while others can become unstabilized over time.

This video does a good job of illustrating orbital resonance using three of Jupiter's moons.

Early in a solar system's history, planets are more likely to be in resonance with one another.

"This type of configuration, where one planet's orbit is precisely ordered with another in an exact integer ratio of orbital periods, is likely common to find in a solar system early in its development," said Rice. "It's a gorgeous configuration — but only a small percentage of systems retain it."

"Given that near-resonant systems have likely experienced minimal dynamical disruptions, the spin-orbit orientations of these systems inform the typical outcomes of quiescent planet formation, as well as the primordial stellar obliquity distribution," the authors write in their research. The spin-orbit orientation is the tilt of companion planets' orbits relative to the host star's spin axis.

What that boils down to is that in a system that's suffered few disruptions, like migrating planets, for example, the spin-orbit and axial tilt of the planets in the system should be largely unchanged from the time of formation. But the problem is astronomers haven't rigorously measured the spin-orbit orientations of near-resonant systems.

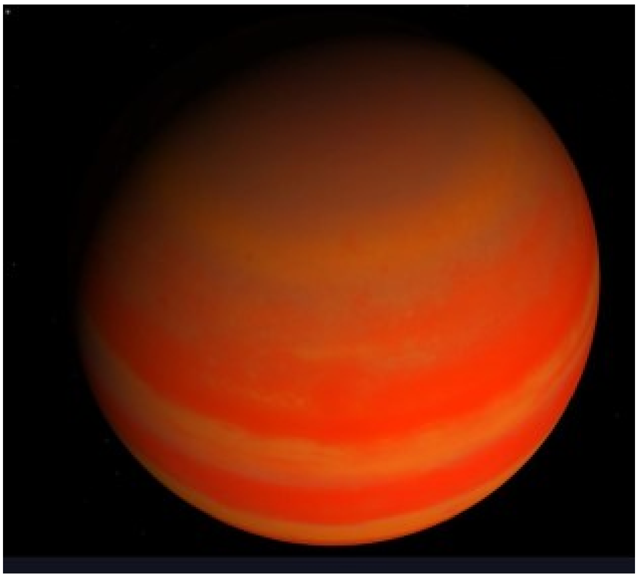
"To date, only a handful of near-resonant systems have had spin-orbit angles measured to characterize the tilts of their constituent planetary orbits," the authors explain in their research.

In this work, the researchers started out by examining a warm Jupiter named TOI-2202 b. It's a near-resonant planet that's only slightly less massive than Jupiter. It orbits a K-type star about 770 light-years away. TOI-2202 b is tight to its star, only 0.09564 AU away, and it completes an orbit in only 11.9 days. For comparison, Mercury is 0.387098 AU away from the Sun.

TOI-2202 b is in a pristine solar system, and it's in a 2:1 mean-motion resonance with another planet further from the star. The researchers compared it to archival data and new observations of the exoplanet from multiple telescopes. They arrived at a spin-orbit angle of about 31 degrees. Then they compared that to the full census of other similar planets in pristine systems found in NASA's Exoplanet Archive.

"To place this measurement into context, we examined the full set of transiting exoplanet systems with (1) a sky-projected spin-orbit measurement and (2) evidence that the transiting planet lies near a low-order mean-motion resonance with a neighbouring companion," the authors explain in their research.

They found that planets in these pristine systems exhibit a typical spin-orbit angle of around 20 degrees. So even "quiet" solar systems have axial tilt. TOI-2202 b was one of the most strongly tilted planets in the sample. "The measured spin-orbit angle of TOI-2202 b, together with the full census of spin-orbit measurements for near-resonant exoplanets, indicates that even quiescently formed systems may experience low-level dynamical excitation that produces some dispersion in their spin-orbit orientations," the authors write.



This is an artist's illustration of TOI-2202 b. Image Credit: NASA

This told the researchers that our Solar System's tilted planets are the norm rather than an oddball outlier.

"It's reassuring," Rice said. "It tells us that we're not a super-weird solar system. This is really like looking at ourselves in a funhouse mirror and seeing how we fit into the bigger picture of the universe."

Our Solar System does contain one oddball, though: Uranus. Uranus's tilt angle is 97.77 degrees, nearly parallel to the Solar System's plane. Astronomers aren't certain, but a collision with an Earth-sized protoplanet in the Solar System's early days is likely the cause.

One of Rice's research areas concerns hot Jupiters and why they exhibit such pronounced axial tilts. "I'm trying to figure out why systems with hot Jupiters have such extremely tilted orbits," Rice said. "When did they get tilted? Can they just be born that way? To find that out, I first need to find out what types of systems are not so dramatically tilted."

That search continues.

A Protoplanetary Disc Has Been Found… in Another Galaxy!

Astronomers have imaged dozens of protoplanetary discs around Milky Way stars, seeing them at all stages of formation. Now, one of these discs has been found for the first time — excitingly — in another galaxy. The discovery was made using the Atacama Large Millimeter/Submillimeter Array (ALMA) in Chile along with the , which detected the telltale signature of a spinning disc around a massive star in the Large Magellanic Cloud, located 160,000 light-years away.

"When I first saw evidence for a rotating structure in the ALMA data I could not believe that we had detected the first extragalactic accretion disc, it was a special moment," said Anna McLeod, an associate professor at Durham University in the UK and lead author of the study published in Nature. "We know discs are vital to forming stars and planets in our galaxy, and here, for the first time, we're seeing direct evidence for this in another galaxy."

McLeod and her fellow researchers were doing a follow-up study on a system named HH 1177, which was located deep inside a gas cloud in the Large Magellanic Cloud LMC). In 2019, the researchers reported that in using the Very Large Telescope, they observed a jet emitted by a fledgling but massive star with a mass 12 times greater than our Sun. This was the first time such a jet has been observed in visible light outside the Milky Way, as they are usually obscured by their dusty surroundings. However, the relatively dust-free environment of the LMC allowed for HH 1177 to be observed at visible wavelengths. At nearly 33 light-years in length, it is one of the longest such jets ever observed.

This dazzling region of newly-forming stars in the Large Magellanic Cloud (LMC) was captured by the Multi Unit Spectroscopic Explorer instrument on ESO's Very Large Telescope. The relatively small amount of dust in the LMC and MUSE's acute vision allowed intricate details of the region to be picked out in visible light. ***Credit:*** *ESO, A McLeod et al.*

"We discovered a jet being launched from this young massive star, and its presence is a signpost for ongoing disc accretion," McLeod said in an ESO press release. But to confirm that such a disc was indeed present, the team needed to measure the movement of the dense gas around the star.

The gas motion indicated that there is a radial flow of material falling onto a central disk-like structure. In their new observations, the team found that the disk exhibits signs of Keplerian rotation – which is a disk of material that obey's Kepler's laws of motion due to the dominance of a massive body at its center. Their observations revealed that "the rotating toroid [was] feeding an accretion disk and thus the growth of the central star," the McLeod and team wrote in their paper. "The system is in almost all aspects comparable to Milky Way high-mass YSOs (young stellar objects) accreting gas from a Keplerian disk.

As matter is pulled towards a growing star, it cannot fall directly onto it; instead, it flattens into a spinning disc around the star. Closer to the center, the disc rotates faster, and this difference in speed is the clear evidence to show astronomers an accretion disc is present.

"The frequency of light changes depending on how fast the gas emitting the light is moving towards or away from us," said Jonathan Henshaw, a research fellow at Liverpool John Moores University in the UK, and co-author of the study, in the ESO press release. "This is precisely the same phenomenon that occurs when the pitch of an ambulance siren changes as it passes you and the frequency of the sound goes from higher to lower."

Massive stars like HH 1177 live fast and die hard. In the Milky Way, stars like this are challenging to observe because they are often clouded from view by the dusty material from which they form — which also obscures the disc that might be shaping around them.

"They form in heavily embedded regions full of gas and dust, such that the accretion phase typically occurs before the star has time to become exposed due to stellar feedback, whether internal or external," the team wrote in their paper. "The primary reason for the lack of observations of extragalactic accretion disks around forming stars has been the limited spatial resolution of both ground- and space-based observatories."

But the Large Magellanic Cloud is fundamentally different from because the stars that form there have a lower dust content than in the Milky Way. Because of that HH 1177 is no longer cloaked in its early dust cloud, providing astronomers an unobstructed view, even though it is so far away.

The researchers said the instruments on ALMA enables the high-sensitivity and high-angular-resolution observations needed to detect and resolve rotating circumstellar gas in the LMC.

"We are in an era of rapid technological advancement when it comes to astronomical facilities," McLeod says. "Being able to study how stars form at such incredible distances and in a different galaxy is very exciting."

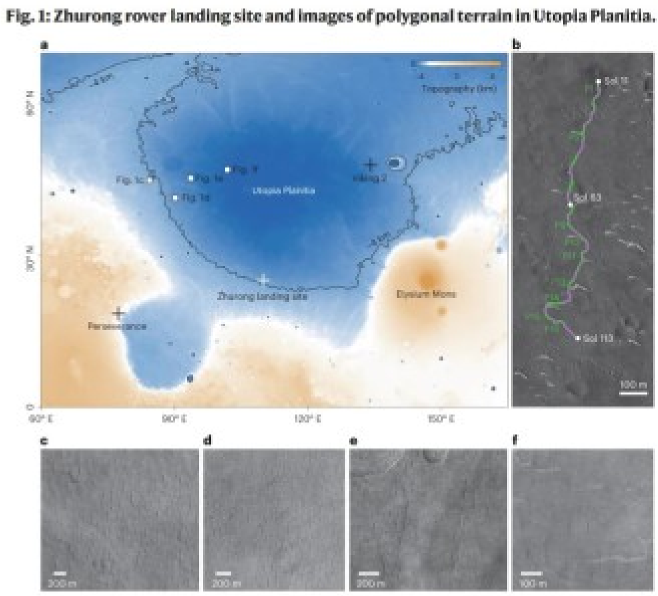
There are Mysterious Polygons Beneath the Surface of Mars

China's Zhurong rover was equipped with a ground-penetrating radar system, allowing it to peer beneath Mars's surface. Researchers have announced new results from the scans of Zhurong's landing site in Utopia Planitia, saying they identified irregular polygonal wedges located at a depth of about 35 meters all along the robot's journey. The objects measure from centimeters to tens of meters across. The scientists believe the buried polygons resulted from freeze-thaw cycles on Mars billions of years ago, but they could also be volcanic, from cooling lava flows.

A wireless camera took this 'group photo' of China's Tianwen-1 lander and rover on Mars' surface. Credit: Chinese Space Agency

The Zhurong rover landed on Mars on May 15, 2021, making China the second country ever to successfully land a rover on Mars. The cute rover, named after a Chinese god of fire, explored its landing site, sent back pictures — including a selfie with its lander, taken by a remote camera – studied the topography of Mars, and conducted measurements with its ground penetrating radar (GPR) instrument. Zhurong had a primary mission lifetime of three Earth months but it operated successfully for just over one Earth year before entering a planned hibernation. However, the rover has not been heard from since May of 2022.

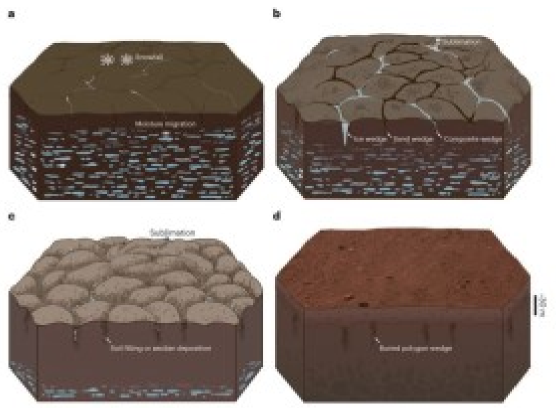
Researchers from the Institute of Geology and Geophysics under the Chinese Academy of Sciences who worked with Zhurong's data said the GPR provides an important complement to orbital radar explorations from missions such as ESA's Mars Express and China's own Tianwen-1 orbiter. They said in-situ GPR surveying can provide critical local details of shallow structures and composition within approximately 100-meter depths along the rover's traverse.



a, Topographic map of Utopia Planitia, showing the landing sites of the Zhurong rover, the Viking 2 lander and the Perseverance rover. The ?4?km elevation contour is shown. Four local regions (c–f) with polygonal terrain are marked with white squares. b, The Zhurong rover traverse from Sol 11 through Sol 113 (HiRISE image: ESP_073225_2055). Green segments denote the wedges of buried polygons recognized from Fig. 2 (P1–P16). Purple segments denote the interiors of the polygons. c–f, Four representative HiRISE images of polygons in Utopia Planitia whose locations are marked in a: PSP_002202_2250 (c), PSP_006962_2215 (d), PSP_002162_2260 (e) and PSP_003177_2275 (f). Note the range of spatial scales for the sizes of the polygons. The average diameters of polygons shown in c–f are calculated in Extended Data Fig. 6. Credit for HiRISE images: NASA/JPL/University of Arizona.

Utopia Planitia is a large plain within Utopia, the largest recognized impact basin on Mars (also in the Solar System) with an estimated diameter of 3,300 km. In total, the rover traveled 1,921 meters during its lifetime.

The researchers, led by Lei Zhang, wrote in their paper published in Nature, that the rover's radar detected sixteen polygonal wedges within about 1.2?kilometers distance, which suggests a wide distribution of similar terrain under Utopia Planitia. These detected features probably formed 3.7 – 2.9 billion years ago during the Late Hesperian–Early Amazonian epochs on Mars, "possibly with the cessation of an ancient wet environment. The palaeo-polygonal terrain, either with or without being eroded, was subsequently buried" by later geological processes.



Schematic model of the polygonal terrain formation process at the Zhurong landing site. a, The origination of thermal contraction cracking on the surface. b, The formation of cracks infilled by water ice or soil material, causing three types of polygonal terrain (ice-wedge, composite-wedge and sand-wedge polygons). c, The stabilization of the surface polygonal terrain in the Late Hesperian–Early Amazonian, possibly with the cessation of an ancient wet environment. d, The palaeo-polygonal terrain, either with or without being eroded, was subsequently buried by deposition of the covering materials in the Amazonian. The Mars surface image was acquired by the Navigation and Terrain Camera (NaTeCam). Credit: Zhang et al.

While polygon-type terrain has been seen across several areas of Mars from many previous missions, this is the first time there has been indications of buried polygon features.

The buried polygonal terrain requires a cold environment, the researchers wrote, that might be related to water/ice freeze–thaw processes in southern Utopia Planitia on early Mars. "The possible presence of water and ice required for the freeze–thaw process in the wedges may have come from cryogenic suction-induced moisture migration from an underground aquifer on Mars, snowfall from the air or vapor diffusion for pore ice deposition," the paper explains.

Earlier research from Zhurong's radar data indicated that multiple floods during that same time frame created several layers beneath the surface of Utopia Planitia.

While the new paper indicates that the most likely possible formation mechanisms would be soil contraction from wet sediments that dried, producing mud-cracks, however, contraction from cooling lava could have also produced thermal contraction cracking.

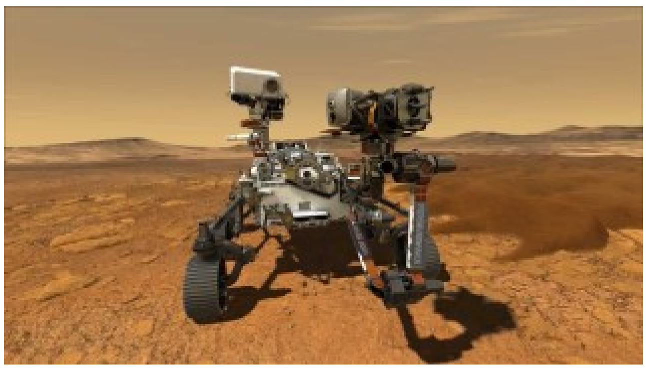
Either way, they note that a huge change in Mars' climate was responsible for the polygon's formation.

"The subsurface structure with the covering materials overlying the buried palaeo-polygonal terrain suggests that there was a notable palaeoclimatic transformation some time thereafter," the researchers wrote. "The contrast above and below about-35-meter depth represented a notable transformation of water activity or thermal conditions in ancient Martian time, implying that there was a climatic upheaval at low-to-mid latitudes."

A Tiny Quadcopter Could Gather Rocks for China's Sample Return Mission

Space exploration is always changing. Before February 2021 there had never been a human made craft flying around in the atmosphere of another world (other than rocket propelled landers arriving or departing). The Mars Perseverance rover changed that, carrying with it what can only be described as a drone named Ingenuity. It revolutionised planetary exploration and now, China are getting in on the act with a proposed quadcopter for a Mars sample return mission.

Our exploration of Mars has generally been limited to orbiters, landers and rovers. The orbiters are fantastic at getting planet wide data or data covering huge swathes of land and the landers are great at getting surface detail, even analysing surface material. The rovers added an extra dimension by being able to explore the landing area but generally, the rovers were slow and unable to traverse significant distances. They were also unable to move over very uneven terrain giving them limited capability.



Mars Perseverance Rover (Credit : NASA)

When Perseverance landed it took with it the Ingenuity drone or more correctly it was classed as a helicopter. Its wingspan was 1.2m from tip to tip of the rotor blades and weighed in at 4 pounds (although on Mars it weighed 1.5 pounds). Whilst its range was only 300m it proved it could be done and since its deployment has completed 66 flights, covering a total of 14.9km.
A paper recently published by the Harbin Institute of Technology and the China Academy of Space Technology proposed a quadcopter for use on Mars that would, unlike Ingenuity, be capable of collecting a sample weighing up to 100g and return it to the lander. The key challenge to achieve this is the rarefied nature of the Martian atmosphere. It is less than 1% of that on Earth and as a result, the lift generated by a rotor blade is significantly lessened. To enable sufficient lift, the blades are oversized by Earth standards.
Alternative solutions to drones were explored from earlier designs like the aeroplane based ‘Astroplane’ with a wingspan of 21m or the ‘MAP MarsFlyer’ with a wingspan of 1.73m. Both styles were discounted due to construction availability of take off and landing areas. The team concluded rotorcraft were the correct configuration and set themselves to design something that could retrieve and transport samples for return missions to Earth.
The paper provides detailed design schematics of both flight (including autonomous flight) systems, rotor configuration, mechanical arm, imaging technology and the avionics system. The described MarsBird V11 is very much just on the drawing board at the moment and is not slated for any mission yet but it is exciting to think the future of Mars exploration is from the Martian air.

JWST Reveals a Newly-Forming Double Protostar

As our newest, most perceptive eye on the ongoing unfolding of the cosmos, the James Webb Space Telescope is revealing many things that were previously unseeable. One of the space telescope’s science goals is to expand our understanding of how stars form. The JWST has the power to see into the cocoons of gas and dust that hide young protostars.
It peered inside one of these cocoons and showed us that what we thought was a single star is actually a binary star. The JWST’s image of the Herbig Haro object 797 (HH 797) is the telescope’s Picture of the Month.
Herbig-Haro objects are luminous patches of nebulosity associated with young protostars. These stars are still gathering mass, a stage that can last about 500,000 years. As the protostar gathers mass, in-falling gas generates shocks on the star’s surface. So, while protostars haven’t begun their life of fusion, they still release energy. In a Herbig-Haro object, the energy that lights it up comes from twin jets of ionized gas coming from the star.

Astronomers know of more than 1000 Herbig-Haro objects in the Milky Way. The Hubble Space Telescope captured this image of the Herbig-Haro object HH 24 in the constellation Orion. HH 24 has the telltale twin jets and illuminated nebulosity of Herbig-Haro objects. Image Credit: HST/NASA

Astronomers have found hundreds of HH objects in the Milky Way, and they’re common in star-forming regions. The jets of partially ionized gas travel at hundreds of kilometres per second, slamming into nearby gas clouds and lighting them up. Most HH objects are within 3.26 light-years (one parsec) of the protostar emitting the jets.
HH objects don’t last long, only a few tens of thousands of years, which is a proverbial blink of an eye in astronomy. Astronomers can see them visibly change as they travel away from their source into the interstellar medium (ISM). The ISM can be clumpy, and the HH can fade in some parts and brighten in others as the jets encounter more diffuse and more dense regions of gas.
HH 797 doesn’t advertise itself in optical light. Instead, molecular hydrogen, carbon monoxide, and other molecules are excited by the energetic jets and emit infrared light. The JWST was built to scrutinize infrared light like this, which brings HH 797’s details into view.
The colours in the image come from different molecules present in the gas clouds. Not only are there molecular hydrogen and carbon monoxide, but iron, methane, and polycyclic aromatic hydrocarbons—a potential building block of life—are also present.

Molecules excited by the turbulent conditions, including molecular hydrogen and carbon monoxide, emit infrared light that Webb can collect to visualize the structure of the outflows. NIRCam is particularly good at observing the hot (thousands of degrees Celsius) molecules that are excited as a result of shocks. Image Credit: JWST/CSA/ESA/NASA

Research using ground-based observations showed that the gas associated with HH 797 is moving at different speeds. Most of the red-shifted gas moving away from us is in the bottom right of the image. But most of the blue-shifted gas moving toward us in the bottom left. Research also found a velocity gradient across the gas so that at any given distance from the star, the gas on the eastern end of the red-shifted jet is more red-shifted than the gas on the western edge. Astronomers chalked it up to rotation in the outflow.

But with its exceptional infrared acuity, the JWST has revealed a second protostar hiding inside the gas and dust. So what astronomers thought was a single outflow is actually two parallel outflows with their own shocks coming from two separate stars. So the velocity asymmetries are because astronomers were actually measuring two different outflows.

The source is in the bottom right small dark region, and the JWST image shows that it's, in fact, two sources. So rather than a single protostar being responsible for what we see, there are two protostars at work.

This shouldn't come as a surprise. As many as half of the Milky Way's stars are in binary pairs or even multiple groups. It only makes sense that some of the HH objects we can see are, in fact, binary HH objects.

For its Next Trick, Gaia Could Help Detect Background Gravitational Waves in the Universe

Ripples in a pond can be captivating on a nice sunny day as can ripples in the very fabric of space, although the latter are a little harder to observe. Using the highly tuned Gaia probe, a team of astronomers propose that it might just be possible to detect gravitational waves through the disturbance they impart on the movement of asteroids in our Solar System!

In the teaser I said that gravitational waves were difficult to observe, largely because they are invisible and incredibly fast, travelling at the speed of light (approximately 300,000 km per second). Despite the challenge in observing them, the first waves were detected in 2015 using the Laser Interferometer Gravitational-Wave Observatory or LIGO for short.

LIGO Observatory from above (Credit : LIGO Observatory)

Let's go back a little first though. It was Einstein who first suggested that an event in the Universe that exhibited movement; perhaps two objects orbiting each other or a star exploding might generate ripples through space, stretching and squeezing anything in its path. These are the gravitational waves and that's what LIGO detected eight years ago, supporting Einstein's theory.

Current observations of gravitational waves are limited to those in the 100 Hz frequency which are produced during the merger of compact binary stars. Another technique uses Pulsar Timing Arrays (PTAs) to explore wave frequencies between 10 to 8 Hz. The PTA method examines a known selection of millisecond pulsars across the Galaxy. Pulsars are the highly magnetised remains of a supermassive star that has gone supernova and emit beams of radiation out of their magnetic poles. As the pulsar rotates and if its poles are aligned with Earth, we see a regular burst or pulse of radiation as the beam sweeps by.

Pulsar PSR B1509?58 – X-rays from Chandra are gold; Infrared from WISE in red, green and blue/max (Credit : ASA/CXC/SAO (X-Ray); NASA/JPL-Caltech (Infrared))

A pulsars pulse is highly precise and they make fabulous timekeepers across the Universe. PTA's observe these pulsars and constantly review the pulse timings. If a gravitational wave passes through, then tiny yet observable differences in the arrival of the pulse will occur showing up as differences in the time signature. Measuring pulsar timings is an accurate way of detecting gravitational waves but it looks like Gaia wants in on the act.

Gaia is capable of making highly accurate astrometric measurements of an object's position. The team suggest that using Gaia, then the position of stars or other more nearby objects may reveal the passage of a gravitational wave.

The paper goes on to state that Gaia might even be able to detect gravitational waves based on the effect they have on asteroids in our Solar System. It depends, on the wavelength of the gravitational waves which can range from the diameter of the Earth up to the distance between the Sun and Pluto, maybe even longer. The researchers concentrated their study on waves of the order 1 million astronomical units and concluded that the could indeed be revealed by the disturbance in the movement of asteroids.

Apollo Samples Contain Hydrogen Hurled from the Sun

According to the U.S. National Academies of Sciences, Engineering, and Medicine, men should drink 3.7litres of water a day and women 2.7litres. Now imagine a crew of three heading to the Moon for a 3 week trip, that's something of the order of 189 litres of water, that's about 189 kilograms! Assuming you have to carry all the water rather than recycle some of it longer trips into space with more people are going to be logistically challenging for water carriage alone. Researchers from the U.S. Naval Research Laboratory (NRL) have discovered lunar rocks with hydrogen in them which, when combined with lunar oxygen provide a possibly supply for future explorers.

A total of 382 kilograms of rock was brought back from the Moon by the Apollo program (I weigh about 80kg so that's almost five of me in weight – and its all muscle I promise!) Some of the samples were immediately studied while others were sealed for future research hoping that future instrumentation would be more sensitive.

A research team from NRL, led by Katherine D. Burgess and team members Brittany A. Cymes and Rhonda M. Stroud, have recently announced their findings whilst studying some of the lunar rock. They wanted to understand the source of water on the Moon and to understand its formation. Future lunar exploration especially permanent lunar bases will rely heavily upon existing lunar resources. The paper articulates "Effective use of the resource depends on developing an understanding of where and how within the regolith the water is formed and retained".

Buzz Aldrin's footprint in the lunar regolith – the soft powdery material found over the surface of the Moon (Credit – NASA)

Transmission electron microscopy was used as part of the study to explore lunar sample 79221. The technique utilises a particle beam of electrons to visualise specimens and generate a highly magnified image. In particular, the team looked at grains of the minerals apatite and merrillite and discovered signs of 'space' weathering due to the solar wind. The solar wind is a stream of charged particles that rush outward from the Sun at speeds of up to 1.6 million km per hour!

They found hydrogen signatures in samples in vesicles – small holes left behind after lava cools. The discovery confirms that solar wind is being trapped in detectable quantities proving a potential reservoir that could be accessible to future explorers.

Hydrogen itself is a tremendously useful resource and if that can be mined from the lunar surface material it can aide many aspects of exploration. The real buzz around the discovery is that it may finally resolve the mystery about the origins of lunar water and that it might well be the result of chemical interactions between the solar wind and lunar rocks. If we can understand the origins of the lunar water – and we may finally be close to that now – then we can be sure we use it effectively to reach out further into the Solar System.

Where are All the Double Planets?

A recent study published in the *Monthly Notices of the Royal Astronomical Society* examines formation mechanisms for how binary planets—two large planetary bodies orbiting each other—can be produced from a type of tidal heating known as tidal dissipation, or the energy that is shared between two planetary bodies as the orbit close to each other, which the Earth and our Moon experiences. This study comes as the hunt for exomoons and other satellites orbiting exoplanets continues to expand and holds the potential to help astronomers better understand the formation and evolution of exoplanets and their systems. So, why is studying binary planets specifically important?

"Binary planets are not present in our Solar System, at least nominally, given the similarities with the Pluto-Charon system which, however, is a dwarf planetary analog," Dr. Cecilia Lazzoni, who is a Postdoctoral Research Fellow at the University of Exeter and lead author of the study, tells *Universe Today*. "Proving new formation mechanisms that enable the formation of such pairs would justify the existence of a complete new type of worlds. For example, if a Jupiter-like planet could host an Earth-like satellite, that satellite could be in principle habitable though far from its star, using the energy coming from the giant planet."

The Pluto-Charon duo is currently hypothesized to have likely formed from Like the Earth's Moon, which was from a collision of another planetary body into Earth. Additionally, Charon is also more tidally locked with Pluto that our Moon is with the Earth, as Charon orbits over the same spot above Pluto, whereas our Moon's freely orbits around the Earth. However, what makes the Pluto-Charton system unique is Charon's size compared to Pluto, as its diameter and mass are half and one-eighth of Pluto, respectively, making it the largest moon compared to its parent body in the entire solar system, and the center of gravity between the two bodies is more centered than the Earth-Moon system. It is for these reasons that the Pluto-Charon system is often referred to as a dwarf planet binary system.

Image comparing the sizes of Earth and its Moon (top right) and Pluto and its largest moon, Charon (bottom right). (Credit: NASA, JHUAPL, SWRI, Gregory H. Revera)

For the study, the researchers conducted seven simulations using amended computer code emanating from a 1998 study that analyzed terrestrial planet formations, with the amendment accounting for energy distribution between two planetary bodies through their tidal interactions, or as they tug on each other like the Earth and Moon. The researchers used a variety of set-ups for the simulation, specifically pertaining to the number of initial planets within the system and range from two to five initial planets. For each set-up, the team conducted 10 sets of simulations across 100 systems spanning 1.5 million years. In the end, the team found the inclusion of tidal dissipation is a logical method in producing binary planets.

Short video from study lead author, Dr. Cecilia Lazzoni visualizing how binary planets are formed through tides. Dr. Lazzoni tells *Universe Today*, "We found out that forming binary planets in systems with 2 or more giant planets is quite easy when considering dynamical interactions and tidal dissipation. Basically, one system out of ten can host a binary planet." Dr. Lazzoni also tells *Universe Today* that motivation for this study came from the discovery of the potential binary planet DH Tau Bb in 2020 that was published in *Astronomy & Astrophysics*, for which she was the lead author. The study also notes additional binary planets used as motivation for this study include Kepler 1625 b-i and Kepler 1708 b-i.

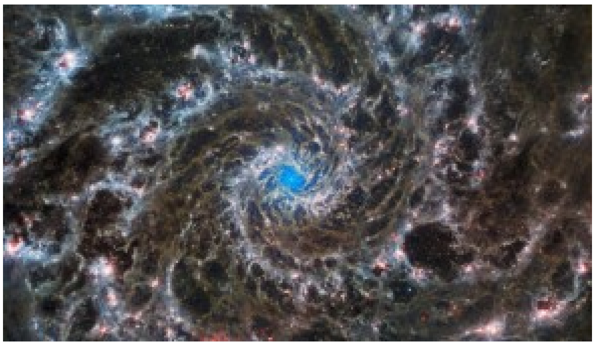
As noted, this study comes as the hunt for exomoons and satellites orbiting exoplanets continues to expand with several moons within our solar system potentially harboring life, specifically Europa, Enceladus, and Titan. Therefore, further understanding binary planets could help scientists better understand the conditions necessary for sustaining life beyond our solar system.

What new discoveries will researchers make about binary planets in the coming years and decades? Only time will tell, and this is why we science!

The First Colour Pictures From Euclid

Many a space enthusiast first became interested in the topic when they saw some astounding picture taken by one of the world's great telescopes and began to get a sense of scale of the universe. This author personally remembers the first time he saw Hubble's Ultra Deep Field – arguably the image that has changed his life more than any other. Given the massive size of the universe, there are always more incredible pictures to be taken, and now humanity has a new tool for that task. Euclid, the European Space Agency's dark matter/energy hunter, has released its first set of images – and they are absolutely mesmerizing.
One of the most breathtaking is something equivalent to the famous Ultra Deep Field shot. Except in this case, Euclid decided to concentrate on the Perseus Cluster, a group of over 1,000 galaxies located about 240 million light years away from us. It's one of the most massive known structures in the universe and will undoubtedly shed some insights into the nature of dark matter and how it affects galaxy formation.
But even more impressively, the shot of the cluster also contains around 100,000 additional galaxies in the background, some as far as 10 billion light years away from us. So look again at those little dots in the background – each of those is a galaxy, and while it might not be quite as big as the Milky Way, it is still likely comprised of hundreds of millions of stars. If that doesn't provide some sense of scale of the universe, it's unclear what would be able to.
Video showing off some of the new images from Euclid. Credit – European Space Agency YouTube Channel
Closer to home, there are some images of more familiar-looking objects. One, known as IC 342, is a spiral galaxy that looks suspiciously like the Milky Way if we were able to see it from the top. It's also known as the "Hidden Galaxy," but Euclid's infrared imaging system makes it pop in the newly released picture.
Globular clusters are also of particular interest in hunting for dark matter, and Euclid's first crop of images contained one of NGC 6397, the second closest globular cluster to Earth. At only 7800 light years distant, it's only a short hop in astronomical terms, but Euclid has allowed us to see it as never before by capturing an image of the entire cluster in a single observation – no other telescope developed so far can do that.
But possibly one of the author's personal favorites of this set of images is a new rendition of one of the most famous structures in all of space. Euclid's capture of the Horsehead Nebula is stunning and ethereal in its sharpness and quality. Part of Euclid's mission will be to collect information about Jupiter-sized planets being created in this star-forming region. But taking a fantastic picture is a nice bonus, if for no other reason than the aesthetics.
Fraser interviews a Euclid project scientist who goes into details about the plans for the mission.
There are several other fascinating images in the first round, including a type of galaxy called an "irregular dwarf," which looks more like a diffuse shell of light rather than the spiral or other structures we typically associate with galaxies. ESA also released a video showing a series of captured images, and they probably have more sitting on the telescopes' data banks as we speak.
However, we might have to wait a little while before they are released. Euclid is currently at the Earth-Sun Lagrange 2 point, and its operators are starting up systems and testing them out. They currently plan on starting full scientific observations in early 2024 and release the data from those observations once a year. With about six years of data expected as part of the mission, expect plenty more stunning photos to come out of this new telescope over the coming years.

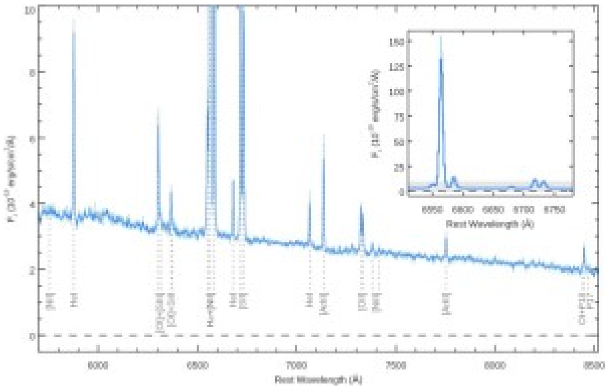
Adolescent Galaxies are Incandescent and Contain Unexpected Elements
If the Universe has adolescent galaxies, they're the ones that formed about 2 to 3 billion years after the Big Bang. New research based on the James Webb Space Telescope shows that these teenage galaxies are unusually hot. Not only that, but they contain some unexpected chemical elements. The most surprising element found in these galaxies is nickel.
The new observations are part of CECILIA, which stands for Chemical Evolution Constrained Using Ionized Lines in Interstellar Aurorae. It uses the JWST's NIRSpec instrument to study the spectra of 33 galaxies at z ~ 1-3. That corresponds roughly to 2 to 3 billion years post-Big Bang. But in an interesting twist, the spectra weren't studied individually; instead, the researchers combined 23 of them into one composite spectrum.
"This washes out the details of individual galaxies but gives us a better sense of an average galaxy. It also allows us to see fainter features," said Allison Strom from Northwestern University. Strom is the lead author of a new paper presenting CECILIA's results. "It's significantly deeper and more detailed than any spectrum we could collect with ground-based telescopes of galaxies from this time period in the universe's history."
The new paper is titled "CECILIA: The Faint Emission Line Spectrum of z ~ 2-3 Star-Forming Galaxies." It's published in The Astrophysical Journal Letters.
"Never in my wildest dreams did I imagine we would see nickel."
Dr. Alison Strom, Northwestern University
"We're trying to understand how galaxies grew and changed over the 14 billion years of cosmic history," said Strom. "Using the JWST, our program targets teenage galaxies when they were going through a messy time of growth spurts and change. Teenagers often have experiences that determine their trajectories into adulthood. For galaxies, it's the same."
This work is based on star-forming regions in these adolescent galaxies. Active star formation produces lots of light. That light creates nebular emissions. "The nebular emission lines originating in galaxies' star-forming regions are among the most powerful tools available for investigating the physical conditions in galaxies at all redshifts," the authors write.
The nebular emissions have spectral lines that are like galactic DNA. Examining this "chemical fingerprint" in adolescent galaxies gives researchers insight into how the galaxies formed and what their future evolution will look like. Galaxy formation and evolution is a hot topic in space science, and "Galaxies Over Time" is one of the JWST's main science objectives.



The study of galaxies is one of the JWST's primary activities. This image from the NASA/ESA/CSA James Webb Space Telescope shows the heart of M74, otherwise known as the Phantom Galaxy. Webb's sharp vision has revealed delicate filaments of gas and dust in the grandiose spiral arms which wind outwards from the centre of this image. While this image is not part of CECILIA, it does show how powerful the JWST is and what it's capable of when it studies galaxies. Image Credit: NASA / ESA / CSA / Judy Schmidt (CC BY 2.0)

By combining the spectra of multiple adolescent galaxies, the researchers produced an ultra-deep composite spectrum. The spectrum contained the chemical signatures of eight distinct elements: Hydrogen, helium, nitrogen, oxygen, silicon, sulphur, argon and nickel. In astronomy, all elements heavier than hydrogen and helium are called metals. Finding metals in galaxies is not unusual. But the presence of nickel comes as a surprise.

"Never in my wildest dreams did I imagine we would see nickel," Strom said. "Even in nearby galaxies, people don't observe this. There has to be enough of an element present in a galaxy and the right conditions to observe it. No one ever talks about observing nickel. Elements have to be glowing in gas in order for us to see them. So, in order for us to see nickel, there may be something unique about the stars within the galaxies."



This figure from the study is the composite spectrum for the CECILIA sample of 23 galaxies. Hydrogen and helium are expected, but the other metals are objects of interest. Most interesting and surprising is the presence of nickel, something not seen before. The inset panel shows the lines for H-alpha and SII, the only lines routinely observed in ground-based observations and shallower JWST spectra of individual high-z galaxies. Image Credit: Strom et al. 2023.

The CECILIA galaxies are also surprisingly hot. What exactly the temperature and the presence of nickel tell us about these galaxies is yet to be determined. But temperature and chemistry are linked, and both findings drive home an important point, one that the JWST has repeatedly made since it began observations.

"This is just additional evidence of how different galaxies likely were when they were younger," Strom said. "Ultimately, the fact that we see a higher characteristic temperature is just another manifestation of their different chemical DNA because the temperature and chemistry of gas in galaxies are intrinsically linked."

As hoped, the JWST is driving us toward a new understanding of how galaxies form and evolve and what types of chemistry they contain. This is just one of the space telescope's results that force us to rethink some of our theories. It's already found the oldest and most distant spectroscopically-confirmed galaxy known. It's also found early galaxies that are more fully formed than we thought they should be. It also found grand spiral galaxies that formed 11 billion years ago, far sooner than we thought.

But behind all these surprises are the complexity and the newness of JWST's data. As this study shows, the data can reveal even more than scientists thought when analyzed in novel ways.

"Deep observations, such as those obtained as part of CECILIA and outlined here, will be critical for developing and testing the new tools necessary to accurately interpret this wealth of data," the researchers write in their article.

"JWST is still a very new observatory," said Ryan Trainor, paper co-author and associate professor of physics at Franklin & Marshall College. "Astronomers around the world are still trying to figure out the best ways to analyze the data we receive from the telescope."

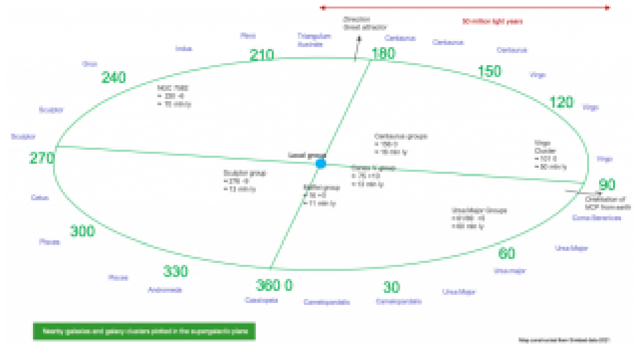
If CECILIA is any indication of what new JWST data analysis techniques can reveal, then the telescope's study of galaxies is only going to get more interesting.

There Aren't Many Galaxies Like The Milky Way Nearby. Now We Know Why

The Milky Way is a barred spiral galaxy, maybe even a grand design spiral galaxy. We can't be sure from our vantage point. But one thing is certain: there aren't many disk galaxies like it in our part of the Universe called the supergalactic plane.

We can locate things on Earth using compass points and latitudes and longitudes. But in space, that doesn't work. Astronomers use the supergalactic coordinate system to describe where galaxies are.

Part of that coordinate system is the Supergalactic Plane (SGP), which contains the Local Group of galaxies that the Milky Way is in. The SGP is nearly perpendicular to the Milky Way's plane.

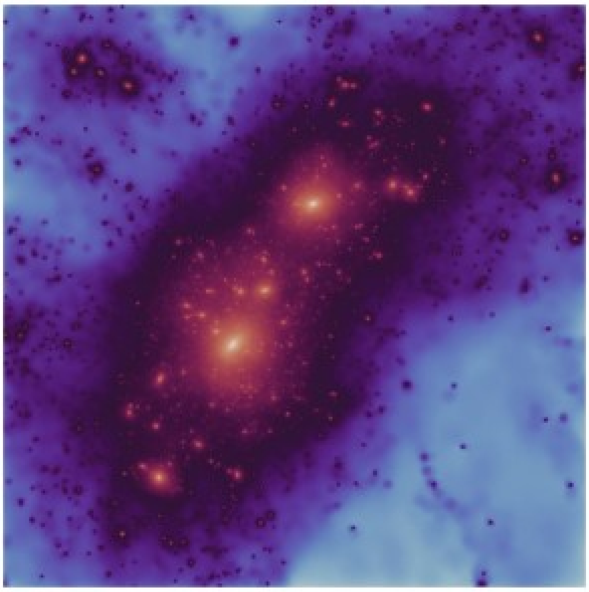


The supergalactic plane is part of a reference system for the Local Universe. It's a flat, enormous circle one billion light-years across, though this image only shows part of it. It's centred on the Local Group, which is where the Milky Way resides. Image Credit: By RobbertMoolhuijsen – Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=99507637

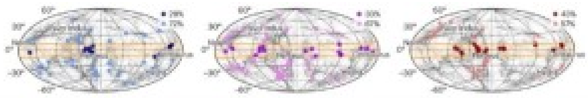
The exact nature of the SGP—its dimensions, its shape, and its relation to other cosmological structures—isn't certain. "The structure of the SGP is not well described by a homogeneous ellipsoid," a team of researchers wrote in their 2000 paper in MNRAS, adding that "the structure changes shape with radius, varying between a flattened pancake and a dumbbell."

But scientists do know that the SGP is filled with galaxies. Bright elliptical galaxies dominate the SGP, while spirals

like the Milky Way are rare. The paucity of spiral galaxies caught the attention of a group of researchers from Europe. They used supercomputer simulations to try to gauge the population and distribution of galaxies in the SGP.
The results are published in Nature Astronomy in their paper "Distinct distributions of elliptical and disk galaxies across the Local Supercluster as a ?CDM prediction." The lead author is Till Sawala, from the Department of Physics at the University of Helsinki in Finland. Sawala was formerly associated with the Institute for Computational Cosmology at Durham University in the UK.
"Galaxies of different types are not equally distributed in the Local Universe," the researchers write in their paper. "The supergalactic plane is prominent among the brightest ellipticals but inconspicuous among the brightest disk galaxies." That striking difference sets the stage for their research, which is aimed at testing our understanding of how galaxies form and evolve, and if their formation and evolution conform to the Lambda CDM model.
The researchers used SIBELIUS, which stands for Simulations Beyond the Local Universe, to probe the nature of the SGP. In their words, they intend to "confront the predictions of the standard Lambda Cold Dark Matter (?CDM) model and standard galaxy formation theory with these observations."
SIBELIUS is aimed at connecting the Local Group to its cosmic environment.



This is one of SIBELIUS's simulations that's not a part of this paper. It shows how the simulation can produce galaxies that are analogues of the Milky Way and M31. Image Credit: Till Sawala/SIBELIUS
One of SIBELIUS' strengths is that it can show how small perturbations can change larger-scale outcomes. Previous SIBELIUS simulations showed that the presence of the Large Magellanic Cloud affects how the Milky Way and Andromeda (M31) orbit each other as a binary galaxy pair. But that's just some explanatory backdrop for the new research.
SIBELIUS can simulate the Universe from its birth over 13 billion years ago up until now. In these current simulations, Sawala and his colleagues found that the distribution of ellipticals and spirals is because of the different conditions inside and outside of the SGP. Inside, galaxies are more tightly packed together, and outside of the SGP, the galactic density is lower.
Inside the SGP, galaxies interact and merge with each other more frequently. These interactions change beautiful spirals like the Milky Way into ellipticals, which are basically ellipses or spheres with no discernible arms.
But outside of the SGP, galaxies interact less frequently. So the Milky Way and others like it are able to retain their form.
"We find that SIBELIUS DARK reproduces the spatial distributions of disks and ellipticals and, in particular, the observed excess of massive ellipticals near the supergalactic equator," the researchers write.



This figure from the research illustrates some of the team's findings. It shows the distribution of the most massive disks (left), intermediates (centre) and ellipticals (right.) Dark and light symbols show individual galaxies that lie inside and outside this region, respectively, and percentages in the top right of each panel express their relative numbers. SIBELIUS shows that 72% of the most massive disk galaxies, like the Milky Way, are outside the SGP, while 57% of the most massive ellipticals are inside the SGP. Image Credit: Sawala et al. 2023
The SIBELIUS results are in line with observations, which helps confirm its usefulness. "This mass difference agrees with observational studies of galaxies in the Local Universe, which also find that the most massive galaxies are overwhelmingly elliptical," Sawala and his colleagues write in their paper.
To grow large, disk galaxies like the Milky Way need a supply of gas and minimal interactions with other galaxies. That environment is found outside of the SGP. "We conclude that the environment prevailing in the supergalactic plane inhibits the conditions necessary for massive disk formation: a quiet merger history and the continuous supply of cold gas," the authors explain.
So what do these results tell us about the Lambda Cold Dark Matter (CDM) model? That model is cosmology's current standard model. It says that 27% of the Universe is dark matter, while 68% is dark energy, and only 5% is baryonic matter, or regular matter that constitutes stars, planets, and even us. Cold refers to the fact that dark matter moves much more slowly than the speed of light. Dark refers to the fact that it barely interacts with regular matter or electromagnetic energy.
According to Sawala and his co-authors, these results help confirm the Lambda CDM model. That's because SIBELIUS is based on our understanding of the Universe, including CDM. So if it reproduces what we see, it helps confirm CDM.
"The strikingly different distributions of bright ellipticals and disks in relation to the supergalactic plane do not require physics beyond the standard model," they write. Instead, the distributions relative to the SGP "arise naturally in the Lambda CDM framework." The distribution is a part of the standard model of how galaxies form and evolve.
For us, it doesn't make much difference whether we live in a spiral/disk galaxy or in an elliptical. But examining how our type of galaxy fits into nature is worth exploring. These results strengthen the already powerful arguments in favour of the Lambda CDM model.
Now, if we could only figure out what the heck dark matter actually is.

A Chinese Booster (and Additional Secret Payload) Caused a Double Crater on the Moon
Last year, astronomers warned that a large piece of debris was on a collision course with the Moon. Initially, they speculated that it was a SpaceX booster but later zeroed in on a Chinese Long March 3C rocket booster that launched the Chang'e 5 mission. When it did impact on March 4, 2022, astronomers noted a strange double crater.
A new paper suggests that it couldn't have been a single object breaking up since there's no atmosphere on the Moon. Instead, the booster must have been carrying an additional, undisclosed payload.

The object was originally discovered on March 14, 2015 with the Catalina Sky Survey. At first, it was thought to be a near-Earth asteroid and was provisionally named WE0913A. However, further study of the object's orbit revealed it was in a geocentric orbit rather than heliocentric, suggesting it could be space junk.

Additional observations showed that the object had a lunar flyby on February 13, 2015. Working backwards, astronomers thought that since NASA had launched the Deep Space Climate Observatory (DSCOVR) spacecraft on a Falcon 9 rocket on February 11, 2015, WE0913A was initially thought to be the Falcon 9 rocket body. Astronomers continued to monitor this object and in late 2021 it became apparent that the object would impact the Moon by March 2022.

Still further observations and study of the object when it made several Earth flybys, however, revealed it likely was NOT the Falcon 9 booster and that instead, its orbit and timeline coincided with the launch of the Chinese Chang'e 5-T1 mission to the Moon on October 23, 2014.

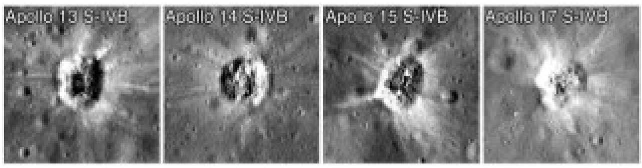
"This led us to believe that the object that would impact the Moon on 2022 March 4 was likely the Long March 3C [rocket body] from the Chang'e 5-T1 mission," wrote Tanner Campbell, Adam Battle, Bill Gray and several other astronomers who had been analyzing data on this object. "Adding to the confusion, after this realization, the Chinese Ministry of Foreign Affairs issued a press release on 2022 February 21 saying that the object impacting the Moon was not the Long March 3C upper stage from the Change 5 mission."

But in the new paper by Campbell et al, they said that their trajectory and spectroscopic analysis of the object from ground-based telescope observations during several Earth flybys shows conclusively that WE0913A is the Long March 3C rocket body from the Chang'e 5-T1 mission.

This animated GIF confirms the location of the newly formed rocket body double crater. The before image is LRO's view from Feb. 28, 2022 (M1400727806L). The after image is from May 21, 2022 (M1407760984R). The width of the frame is 367 meters, about 401 yards. Credit: NASA/ Goddard/Arizona State University

But there's another mystery in this crazy space debris story. Using Campbell and team's predicted impact location, NASA's Lunar Reconnaissance Orbiter was able to image the crater site approximately 7.5 km from the prediction. Surprisingly, the crater was actually two craters, an eastern crater (18-meter diameter, about 19.5 yards) superimposed on a western crater (16-meter diameter, about 17.5 yards). The double crater was unexpected and lunar impact experts said the twin craters indicated that the rocket body must have had another payload as part of the booster.

"Typically, a spent rocket has mass concentrated at the motor end; the rest of the rocket stage mainly consists of an empty fuel tank," wrote Mark Robinson, principal investigator with the Lunar Reconnaissance Orbiter Camera, back in June of 2022 when the LRO images were released. "Since the origin of the rocket body remains uncertain, the double nature of the crater may indicate its identity."



These four images show craters formed by impacts of the Apollo SIV-B stages: crater diameters range from 35 to 40 meters (38.2 to 43.7 yards) in the longest dimension. Credits: NASA/Goddard/Arizona State University.

Robinson also pointed out that no other rocket body impacts on the Moon created double craters, and offered images of craters from four Saturn rocket boosters from Apollos 13, 14, 15, 17.

"The results from the Bayesian analysis imply that there may have been additional mass on the front of the rocket body," Campbell and team wrote. "Comparing the pre- and post-impact images of the location shows two distinct craters side by side that were made by the Chang'e 5-T1 R/B. The double crater supports the hypothesis that there was additional mass at the front end of the rocket body, opposite the engines, in excess of the published mass of the secondary permanently affixed payload."

The researchers noted that Chinese foreign ministry officials denied that the space junk is from their rocket, insisting that the Chang'e 5 rocket already burned up on its return trip to Earth in 2014. However, on March 1, 2022, the U.S. Department of Defense's Space Command, which tracks low-Earth orbit space junk, released a statement saying that China's 2014 rocket never deorbited. Additionally, Chinese officials have never commented on the nature of the double crater.

While the origins of the rocket don't really matter — it was going to impact the Moon no matter who launched it — many have said that the confusion surrounding the object's identity highlights the need for space agencies and private launch companies to develop better procedures for tracking their rockets. This would keep such objects from being mistaken for Earth-threatening asteroids. It is also hoped that confusion like this — and subsequent denials of responsibility — would prompt space agencies and launch providers to readily disclose the number of payloads on board.

SpaceX Tested Its Starship Again. Successful Launch But Both Vehicles Were Destroyed

After months of waiting, SpaceX made its second attempt at an orbital flight this past Saturday (November 18th). During their previous attempt, which occurred back in April, a fully-stacked *Starship* (SN24) and *Super Heavy* (BN7) prototypes managed to make it off the landing pad and reach an altitude of about 40 km (25 miles) above sea level. Unfortunately, the SN24 failed to separate from the BN7 booster a few minutes into the flight, causing the vehicle to fall into an uncontrolled tumble and forcing the ground teams to detonate the onboard charges.

Things went better this time as the SN25 and BN9 prototypes took off at about 7:00 AM local time (8:00 AM EDT; 05:00 AM PDT) from the Starbase launch complex. The SN25 successfully separated from its booster two minutes and fifty seconds later – at an altitude of 70 km (43 mi) – and reached an altitude of about 148 kilometers (92 miles), just shy of SpaceX's goal of 150 km (~93 mi). However, the booster stage was lost about 30 seconds after separation, exploding over the Gulf of Mexico. The SN25 also exploded about eight minutes into the flight, reportedly because its flight termination system was activated.

Elon Musk chimed in on X after the launch, reposting the company's live video of the flight test (as well as a shorter slow-motion closeup video taken from the launch tower). Musk also posted pictures of the launch pad the day after the launch to confirm that there was no damage this time around. "Just inspected the Starship launch pad and it is in great condition!" he shared on his X page. "No refurbishment needed to the water-cooled steel plate for next launch. Congrats to @Spacex team & contractors for engineering & building such a robust system so rapidly!"

Post-launch images of the landing pad at Boca Chica. Credit: SpaceX

This is a big improvement over the first launch attempt, which caused significant damage to the landing pad and sent debris in all directions, causing collateral damage to the facility. This was avoided thanks to the water-cooled steel plate, a deluge system installed after the last test. This was one of dozens of corrective measures recommended by the Federal Aviation Administration (FAA), which engineers at Boca Chica have spent months integrating. This included the addition of a forward heat shield interstage to the Starship and expanding the Area of Potential Effects for cultural resources.

Another improvement over the previous test flight was that all 33 of the booster's Raptor 2 engines ignited this time, whereas 31 ignited the last time. "The real topping on the cake today, that successful liftoff," said SpaceX commentator John Insprucker. The successful separation of the Starship from the Super Heavy was another major success, as was the altitude achieved, just two kilometers shy of the goal of 150 km (93 mi). "We got so much data, and that will all help us to improve for our next flight," added commentator Kate Tice.

After the launch, the FAA released a statement about the test, saying that a "mishap" led to the loss of both the spacecraft and booster. "The anomaly resulted in a loss of the vehicle. No injuries or public property damage have been reported," they said. They also reported that an investigation was underway to determine what went wrong, which is standard procedure whenever a spacecraft is lost. Like the last test flight, SpaceX will not be cleared for more launch tests until the review is complete and corrective measures are taken.

The *Starship* and *Super Heavy* is the biggest and most powerful launch system in the world, standing 121 meters (400 feet) tall, weighing 5 million kg (11 million lb), and capable of generating 75.9 meganewtons (MNs) or 17.1 million pounds thrust (lb_f). This exceeds the three-stage *Saturn V* rocket that was the workhorse of the Apollo Program and (until recently) the most powerful rocket ever developed. It also exceeds NASA's *Space Launch System* (SLS) that will send the Artemis astronauts to the Moon in the coming years.

The launch vehicle will also play a vital role in the Artemis Program in the form of the Starship Human Landing System (HLS). In April 2021, NASA awarded SpaceX a $3 billion contract to develop the human landing system that will land astronauts on the Moon by 2025 as part of the *Artemis III* mission. This will consist of four astronauts in an Orion spacecraft launching atop an SLS and rendezvousing in lunar orbit with the Starship HLS – which will launch separately. Two astronauts will transfer to the Starship HLS and use it to descend to the surface, then return to orbit about a week later.

Musk has also been clear that the ultimate aim of the *Starship* and *Super Heavy* is to conduct regular missions to Mars that will culminate in the creation of the first self-sustaining city there. Other objectives include sending crews and payloads to the Moon to assist NASA's plans for a "sustained program of lunar exploration and development" and launching batches of Starlink 2.0 satellites to provide high-broadband internet access to the entire world. With this latest test, SpaceX has taken a significant step in that direction.

On the downside, the booster and spacecraft were lost before the ground teams could attempt the all-important retrieval phase. This is vital for the "entirely reusable" Starship and Super Heavy launch system and Musk's long-term vision for conducting regular flights to orbit, the Moon, and Mars. On the plus side, this test flight lasted twice as long as the first attempt, and the launch system managed to make it past the Karman Line: 100 km (62 mi) above sea level, the official boundary of "space." This essentially demonstrated that the *Starship* and *Super Heavy* are capable of orbiting flight.

Granted, the rockets need to stop exploding first, but such has always been the way with SpaceX's rapid prototyping and testing approach. Every launch, even the ones that go "kaboom" – no, especially the ones that go "kaboom" – is another step towards success.

Saturn's Rings will Disappear in 2025. Don't Worry, They'll Return Soon Enough

The rings of Saturn are some of the most well-known and captivating spectacles in the night sky, which are so large they can easily be observed with amateur telescopes or even a pair of high-powered binoculars. However, from time to time, Saturn's rings "disappear" from view, a phenomenon known ring-plane crossing, with the rings being observed as a flat line running straight through the massive gas giant. Ring-plane crossing occurs approximately every 15 years and is slated to happen next in March 2025, with the rings slowly getting "larger" in the months afterwards before "disappearing" again in November 2025. But what causes ring-plane crossing?

Saturn's ring-plane crossing is due to the viewing angles from Earth changing as both planets are tilted during their respective orbits around our Sun and orbit at different speeds and times, as the Earth orbits the Sun in one year, Saturn takes approximately 29.4 years to complete one orbit. As a result, our view of Saturn changes over time, and the "size" of the rings appear to get larger and smaller, and periodically disappear entirely from view for a short time. As noted, ring-plane crossing happens approximately every 15 years, with the most recent occurrence being observed directly from Earth happening in 2009. However, both the 2009 and 2025 events are not observable from Earth since Saturn will be too close to the Sun. NASA's Hubble Space Telescope captured some fantastic images of Saturn's rings edge-on in 1995, which provided astronomers the opportunity to observe some of Saturn's larger moons and try to discover new moons, as well. The reason why ring-plane crossing allows astronomers to find new moons is due to the decreased glare of the bright rings that normally obscure smaller objects orbiting Saturn from being seen. In fact, between 1655 and 1980, ring-plane crossing is responsible for astronomers discovering 13 new moons of Saturn, with additional moons of Saturn being discovered by NASA's Voyager 1 spacecraft in 1980. Two of Saturn's most well-known moons, Enceladus and Mimas (aka the Death Star), were discovered by William Herschel during the ring-plane crossing of 1789-1790, and Hyperion was discovered during the ring-plane crossing of 1848-1849.

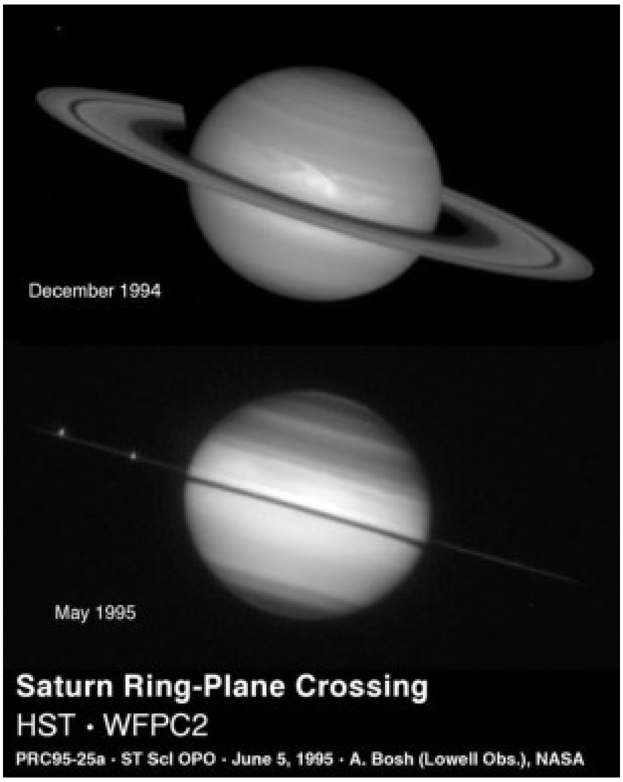


Image of ring-plane crossing at Saturn taken by NASA's Hubble Space Telescope in May 1995, with a similar ring-plane crossing event scheduled to occur in March 2025. (Credit: Reta Beebe (New Mexico State University), D. Gilmore, L. Bergeron (STScI), NASA/ESA, Amanda S. Bosh (Lowell Observatory), Andrew S. Rivkin (Univ. of Arizona/LPL), the HST High Speed Photometer Instrument Team (R.C. Bless, PI), and NASA/ESA)

Ring-crossing was accidentally discovered by Galileo Galilei in 1612, who is also responsible for first discovering Saturn's rings only two years earlier. When he observed the rings had apparently disappeared, he wrote in his notes, "I do not know what to say in a case so surprising, so unlooked for and so novel".

As noted, ring-plane crossing occurs due to the combination of the tilts of Earth and Saturn and their respective orbits, which also influences the north-south direction of the rings during the crossing. For example, the ring-plane crossing event occurring in March 2025 will see Saturn's rings proceed from south to north, but this contrasts with the ring-plane crossing event that will occur several decades from now in August 2068. For this event, the rings will proceed from north to south.

While ring-plane crossing causes Saturn's rings to give the illusion they are "disappearing", this illusion won't be around forever. This is because the icy grains that comprise Saturn's rings are slowly being lost to the planet with a 2019 study using ground-based observations to estimate the rings will be gone for good in approximately 292 million years. Most recently, a 2023 study used data from NASA's Cassini mission to provide a larger range of the remaining lifespan of Saturn's rings at between 15 to 400 million years.

What new discoveries will astronomers make using Saturn's ring-plane crossing in the coming years and decades? Only time will tell, and this is why we science!

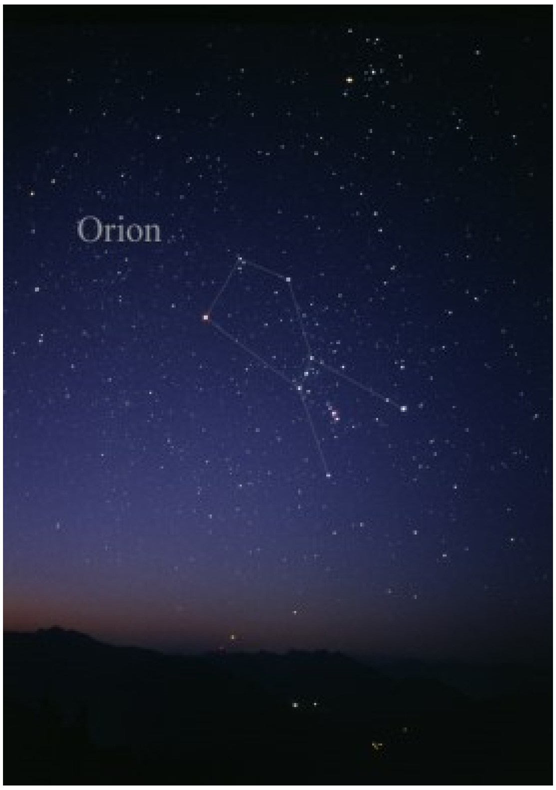
An Asteroid Will Occult Betelgeuse on December 12th

I cannot for the life of me remember when it was or what it was but a fair few years ago I remember positioning a telescope to observe an asteroid as it silently and perhaps slightly eerily drifted between us and the Moon. I say eerily as this asteroid had the ability to cause widespread damage had it hit but of course we knew it posed no threat. I remember at the time thinking it was mind blowing that even today, we still use mathematics with roots (pardon the pun) centuries old to calculate the position of objects in our Solar System. We get to see evidence of this again on 12th December when something rare happens!

I have rather hinted to what I am referring, on 12th December, asteroid 319 Leona will pass directly in front of Betelgeuse, the red giant in the constellation of Orion whose name amusingly translates to armpit of the giant – now there's a fact to amuse and astound your friends. To be able to calculate that a rock approximately 60 km across is going to pass directly in front of a star that is just over 650 light years away is really quite staggering.

Perhaps more excitingly if you live along a corridor from central Asia and southern Europe to Florida and Mexico then at around 01:17 UTC you have a chance – clouds permitting – to see it for yourself and you don't need any telescope or equipment, just your eyes.

Betelgeuse is the second brightest star in the constellation Orion and is a familiar favourite with its piercing red colour. It hit the news back in 2020 when it unexpectedly dimmed in the sky due to the star itself ejecting a cloud of dust. Next month it will fade for a few seconds due to the passage of Leona right in front of it. An event like this is quite rare where the light from a bright star is blocked (or occulted) by an asteroid happening every few decades at most. It will be fascinating to watch but is also scientifically useful giving us a chance to learn more about Betelgeuse and how it's large convection cells behave, and to learn more about the orbit and shape of the asteroid too.



The Constellation of Orion showing Betelgeuse at upper

left (Credit : Till Credner)
Anyone out there wishing to observe the event needs to be warned though, the predictions are just that, there are a few uncertainties. The size and shape of the asteroid itself is still subject to debate. Typically we tend to assume asteroids are spherical unless we know otherwise but a previous occultation of Leona in September 2023 determined that it was more of ellipsoidal in shape measuring 80km by 55km. At its distance from Earth that means it will cover an area of sky 46 x 41 milliarcseconds which is a little more than the approximate 40 milliarcseconds for Betelgeuse. Taking this into account suggests Betelgeuse will be completely blocked from view and therefore blink out for a few seconds.
Betelgeuse's somewhat diffuse outer atmosphere may mean its apparent size is more like 50 milliarcseconds so it just fades instead. Until the event happens we will not know exactly how it will appear in the sky or exactly when. It's a great opportunity to learn more about these two fascinating objects so head outside on 12th December around 01:00 UTC, wait and watch and hopefully you can witness one of natures rather more rare events.

The Lunar Swirl Mystery Deepens

For years, people noticed strange features on the Moon dubbed "Lunar Swirls." They're bright regions that appear to be concentrations of lighter-colored material on the surface. It turns out that interactions between the solar wind and magnetic regions on the Moon may play a role at two sites.
Scientists long thought that these swirls weren't related to the surrounding topography, but it turns out there's some kind of interaction going on between the swirl deposition and the surface. Planetary Science Institute senior scientist John Weirich led a team to study topographic data for lunar swirls at high resolution. They found a correlation between the swirl areas and lower topography in a region called the Reiner Gamma swirl.

About Swirl Regions

The Moon has a number of similar regions with high-contrast bright markings that appear to loop across the surface. Generally, they look like wide bright swirls separated by darker off-swirl lanes. The fact that they exist spurs questions about how they form and there isn't a clear answer, yet. Once that mystery is solved, scientists will have a better understanding of how the lunar surface is affected by the solar wind, bombardment by micrometeorites, how the lunar soil "migrates", and what other effects the local environment has on the surface.

Lunar swirls are found in several regions on the Moon. Courtesy NASA.

"Lunar swirls have piqued scientists' interest since they were discovered, partly because the scientific community doesn't completely understand how they formed. There are many hypotheses about their formation process. Each hypothesis has observations that support it, but there are also other observations that contradict them," Weirich said. "Since we don't have a full understanding of how these swirls formed, we don't completely understand the story they can tell us about the Moon. Forming them could involve a combination of well-understood processes interacting together or a currently unknown process. Unusual objects or phenomena are sometimes the key to obtaining deeper knowledge, and for this reason, lunar swirls are very intriguing. And the fact that they look really cool."

Studying Swirls in Higher Detail

To do their work, Weirich's team looked at earlier research showing that bright areas are 2-3 meters lower than dark areas, particularly in the Mare Ingenii lunar swirl. "However, it is not as simple as the bright areas are uniformly lower than the dark areas. If that was the case this relationship between topography and swirl would be easy to demonstrate by comparing an elevation map to a picture of the swirl. Instead, this relationship is only seen when we compare the average height of the bright areas and the average height of the dark areas."

Weirich studied Lunar Reconnaissance Orbiter mission images and applied a special software suite to determine the surface topography. The team also used machine-learning tools on specific images. It classified the swirls into various units: bright areas (on-swirl)and dark areas (or "off-swirl"). The studies allowed them to identify transition regions between the two units, and they labeled those "diffuse-swirl".

The correlation between topography and swirl formation still doesn't explain exactly why they form. But, it does give planetary scientists some new clues as they study other swirl features on the Moon. At present, there are several theories about formation, but none of them explain all of the details. One idea is that they formed as a result of cometary impacts. That explains the brightness of these features. Another theory is that the swirls form when weak magnetic fields protect lighter-colored lunar surface soil (regolith) from the solar wind. Finally, weak electric fields created by brief interactions between the magnetic anomalies and solar wind plasma could play a role. Those fields could affect electrically charged fine dust on the surface. How topography plays into any of these theories is still an unknown.

How They Did It

The specialized software the team used does stereophotoclinometry to analyze the topography of a surface. It combines stereo imaging and photoclinometry to get the surface height of a region. The swirl units of interest were defined by machine learning procedures. The team then compared that information to the SPC-derived topography. That allowed them to statistically determine if height correlations existed and what differences they showed.

The SPC methodology has been used on various surfaces, including using data from the OSIRIS-REx mission, among other missions. Planetary scientists use SPC methodologies to describe the shapes of planets, asteroids, comets, and other small bodies. Still, there's not yet a definite explanation for these swirls. However, the combo of high-resolution imaging, machine learning, and advanced software techniques gives planetary scientists more insight into their still-mysterious origins.

JWST Shows Ice-Covered Pebbles Delivering Water to New Planets

The JWST has delivered a breakthrough in planetary science. Its observations show that a long-proposed theory of planet formation is true. Up until now, thick veils of dust in young solar systems have obscured the evidence.
But the JWST saw through it all, and now we know the truth: Ice-covered pebbles from outer solar systems deliver water to still-forming planets closer to their stars.
The debate over Earth's water has raged for decades. Somehow, Earth ended up with oceans of water, but it's not clear where it came from.
Earth formed about 4.5 billion years ago in the inner Solar System. It formed inside the rotating disk of gas and dust called the protoplanetary disk. These disks form around young stars throughout the galaxy. The most persistent

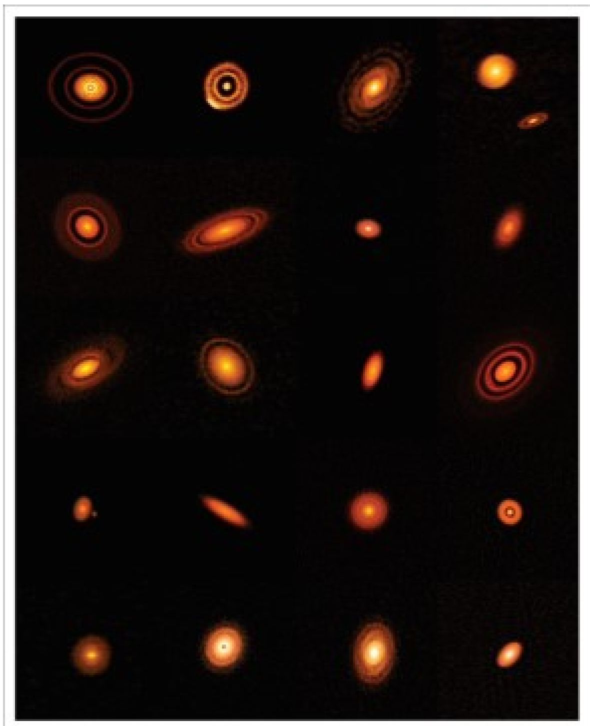
idea is that the water came from elsewhere in the protoplanetary disk and not from Earth's vicinity in the inner Solar System. The most well-known hypothesis is that Earth received its water from comets and asteroids after it formed and cooled.

The protoplanetary disks around young stars are still a bit of a mystery. We can see them around other stars in the galaxy, and we can even see the gaps traced in the disk by young, still-forming planets. But seeing inside these disks is tough. One of the reasons the JWST was built was to probe these disks better than any other telescope.

"This finding opens up exciting prospects for studying rocky planet formation with Webb!"

Andrea Banzatti, Texas State University

Protoplanetary disks are a very active area of research because there's so much we don't know about how solar systems and planets form. But the origin of Earth's water is also a hot topic, and the two are linked. The idea that our planet's water came from objects further out in the Solar System has staying power. The inner Solar System was too hot for water to stick around, the hypothesis goes. But further away, beyond the frost line, frozen water was taken up by comets and asteroids.



These are ALMA's high-resolution images of nearby protoplanetary disks, which come from the Disk Substructures at High Angular Resolution Project (DSHARP). The gaps and rings are where planets are forming. Credit: ALMA (ESO/NAOJ/NRAO), S. Andrews et al.; NRAO/AUI/NSF, S. Dagnello

The early Solar System was a chaotic place, and asteroids, comets, and even icy planetesimals from the outer Solar System continually rained down on the Earth. Over time, water accumulated and formed the oceans, according to this explanation. Now we have an Earth rich in water.

But there's always been some stubborn problems with this hypothesis. Some isotope ratios indicate that Earth had a sizeable portion of its water very early in its lifetime. Studies of lunar isotope ratios also show that Earth received much of its water prior to the Giant Impact that created the Moon only a few million years after the Solar System formed.

But now, the powerful JWST has entered the chat. Its evidence supports another long-held theory of planet formation. That theory states that Earth's water arrived as Earth formed. Ice-covered pebbles drifted inward from the outer Solar System, and as they reached the warmer inner Solar System, the water sublimated into vapour. The vapour and the pebbles were both accreted into young planets. This is known as the icy pebble drift theory.

These findings are in a new paper in The Astrophysical Journal Letters titled "JWST Reveals Excess Cool Water near the Snow Line in Compact Disks, Consistent with Pebble Drift." The lead author is Andrea Banzatti, an assistant professor of physics at Texas State University, San Marcos, Texas.

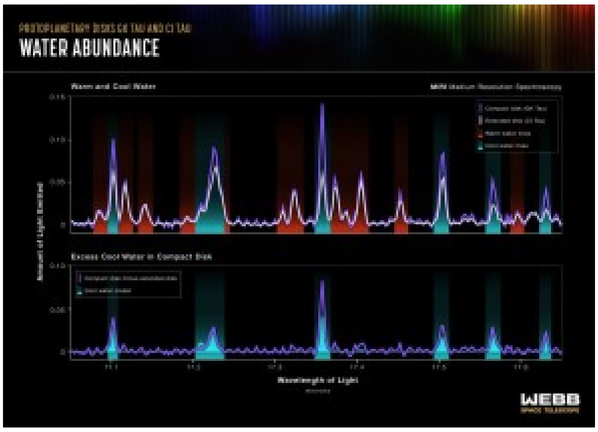
"Webb finally revealed the connection between water vapour in the inner disk and the drift of icy pebbles from the outer disk," said Banzatti. "This finding opens up exciting prospects for studying rocky planet formation with Webb!"

Banzatti and his colleagues used the JWST's MIRI (Mid-Infrared Instrument) to study four young, Sun-like stars only two or three million years old and surrounded by protoplanetary disks. Two of them were compact disks about 10 to 20 AU in size, and two of them were extended disks around 100 to 150 AU. The extended disks also have large radial gaps in them. The pebble drift theory states that compact disks deliver icy pebbles more efficiently into the inner solar system, well within the equivalent of Neptune's orbit in our Solar System. Conversely, the theory also states that extended disks are less efficient at it.

The JWST's powerful Medium-Resolution Spectrometer (MRS) works in conjunction with MIRI. The MRS can differentiate cool water from warm water, a critical part of untangling the complicated picture in protoplanetary disks. MRS data shows that there's more cool water in the compact disks than there is in the extended disks.

"We present new JWST-MIRI spectra of four disks, two compact and two large with multiple radial gaps, selected to test the scenario that water vapour inside the snow line is regulated by pebble drift," the article states.

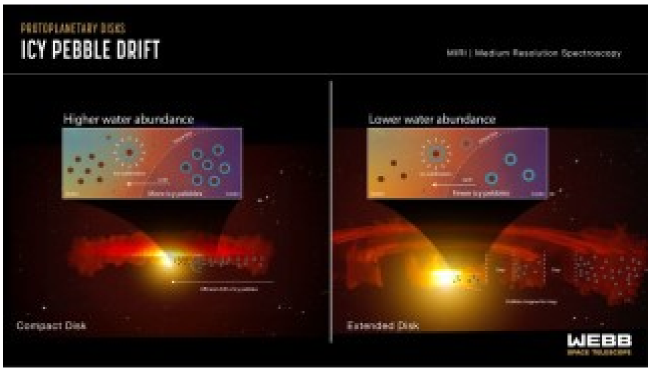
"Observation of this process opens up multiple exciting prospects to study planet formation chemistry in inner disks with JWST."



This graphic compares the spectral data for warm and cool water in the GK Tau disk, which is a compact disk without rings, and the extended CI Tau disk, which has at least three rings on different orbits. MRS can separate the spectra into individual lines that probe water at different temperatures. These spectra, seen in the top graph, clearly reveal excess cool water in the compact GK Tau disk, compared with the large CI Tau disk. The bottom graph shows the excess cool water data in the compact GK Tau disk minus the cool water data in the extended CI Tau disk. The actual data, in purple, are overlaid on a model spectrum of cool water. Note how closely they align. Image Credit: NASA, ESA, CSA, Leah Hustak (STScI)

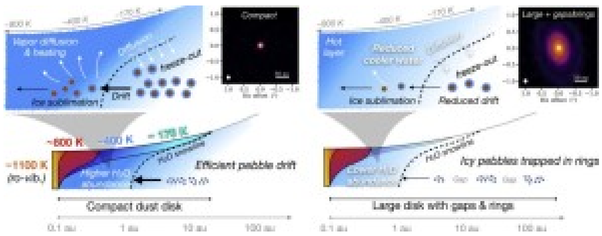
The pebble drift theory says that pebbles behave differently in different-sized disks. Some disks are much larger than others, and the hydrodynamical forces are much stronger in these larger disks. They effectively lock pebbles in place in their outer rings, inhibiting inward drift.

But compact rings don't have the same strong hydrodynamical forces. Icy pebbles are freer to drift inward, becoming part of the rocky planets that typically form in the inner regions of Solar Systems. Up until now, researchers have had trouble gathering observations to test this theory. Researchers using ALMA imaged numerous protoplanetary disks around young stars with telltale gaps showing where planets are forming. Based on these images and other data, scientists developed models showing that the presence or lack of gaps in protoplanetary disks regulated pebble drift into the inner solar systems.
However, previous observations lacked the high resolution needed to see inside these disks and test these ideas. Thanks to the James Webb Space Telescope and MIRI, scientists have finally observed the predicted pebble drift behaviour in both large and compact disks.



This graphic is an interpretation of data from Webb's MIRI and its MRS, which is sensitive to water vapour in disks. It shows the difference between pebble drift and water content in a compact disk versus an extended disk with rings and gaps. Image Credit: NASA, ESA, CSA, Joseph Olmsted (STScI)

Here's how pebble drift works. In compact disks like the one on the left in the above image, ice-covered pebbles drift inward toward the warmer region closer to the star unimpeded. When they cross the snow line, or astrophysical frost line, their ice sublimates to vapour. That delivers a large amount of water to the still-forming, rocky planets nearer the star. The right side of the above image shows an extended disk with rings and gaps likely created by large planets that are still forming. These rings have higher pressure than the gaps. As the ice-covered pebbles drift inward, more of them are stopped by the rings in the protoplanetary disk and trapped there. So fewer icy pebbles make it across the snow line to deliver water to the inner regions.
It took a while for Banzatti and his colleagues to understand the Webb data. It wasn't initially clear what the observations were telling them. "For two months, we were stuck on these preliminary results that were telling us that the compact disks had colder water, and the large disks had hotter water overall," remembered Banzatti. "This made no sense because we had selected a sample of stars with very similar temperatures."
The answer became clear when the researchers combined the data from compact and large rings. It showed that the compact disks have extra cool water just inside their snowlines, at about ten times closer than the orbit of Neptune.



This figure from the research article shows how pebble drift is more efficient in compact disks. Compact disks that lack the large rings where massive planets form. These rings have higher pressure and impede icy pebbles from delivering their water to the inner solar system. Image Credit: Banzatti et al. 2023.
"Now we finally see unambiguously that it is the colder water that has an excess," said Banzatti. "This is unprecedented and entirely due to Webb's higher resolving power!"
Now that scientists have observed this in other solar systems it's very likely and almost certain that this is how Earth got its water. It also shows how the regions of a solar system interact with each other and that the inner regions of a solar system aren't isolated from the outer regions.
"In the past, we had this very static picture of planet formation, almost like there were these isolated zones that planets formed out of," explained team member Colette Salyk of Vassar College in Poughkeepsie, New York. "Now we actually have evidence that these zones can interact with each other. It's also something that is proposed to have happened in our solar system."

Some of the Moon's Craters are From Interstellar Impacts. Can We Tell Which?
By discovering two interstellar objects (ISOs), we know that asteroids and comets from other star systems pass through the Solar System from time to time. By inference, some of these must have crashed into the Moon, creating impact craters. If we could study the impact sites, we might be able to learn about the star systems that they came from.
A new paper suggests there could be a way to determine which lunar craters came from interstellar object impacts. The authors say that young, small craters with high-melt volume near the Moon's equator are likely the best candidates for ISO-generated craters on the lunar surface.
The two landmark discoveries of ISOs have changed our thinking on what's possible for the origins of objects in our Solar System. Detecting the cigar-shaped body named 'Oumuamua (2017) and the speedy rogue Comet 2I/Borisov (2019) suggest that these objects — which have somehow been ejected from other solar systems — can wander through the Milky Way, unattached to any star system, for hundreds of millions of years. Astronomers say their detections – made possible by improved telescopes and observing techniques — implies a large population of such objects exist and that ISOs enter our Solar System on a fairly regular basis. Estimates have ranged from one, to seven, to twenty-one and even seventy objects every year.

Even if just a few pass through every year, over time there has likely been ISO-generated craters on the Moon. This new paper by Daniel Chang, Cheng-Han Hsieh, and Gregory Laughlin, published in AAS Research Notes, explores how different crater properties such as age, size, melt, and position can be used to search for ISO-generated craters on the lunar surface.
"We find that selecting young, small craters with a high volume of melt located away from the lunar poles increases the likelihood of association with a high-speed ISO by 100-fold as compared to selecting randomly, assuming high-speed ISO impacts generate melt," the authors wrote.

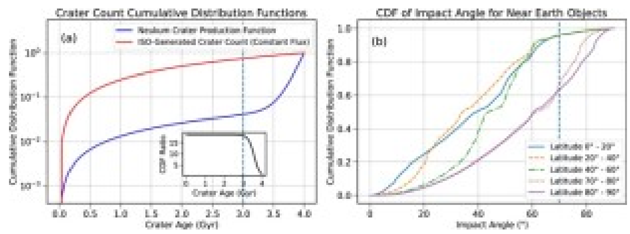


Figure 1. *(a) shows the difference between the cumula-*

tive distribution functions of craters generated from solar system objects and ISOs. Most craters generated from solar system objects were formed in the first billion years, so that the ratio of the CDFs for craters with ages less than 3?Gyr is ?20. (b) shows the cumulative probabilities of impact angles at various latitudes on the Moon for Near Earth Objects, calculated from the probability found in (Robertson et al. 2021). For latitudes 0° through 70°, there is a <10% probability that the crater is generated from vertical impact, while the probability is much higher at around 40% for latitudes 70°–90°. Credit: Daniel Chang, Cheng-Han Hsieh, and Gregory Laughlin.

Most craters on the surface of planetary bodies in our Solar System were formed during the first heavy bombardment period about 4 billion years ago. Therefore, since about 95% of lunar craters were formed during the first billion years of the Moon's existence, and assuming a constant ISO flux, the scientists write that selecting young craters (<3?Gyr) "increases the probability of ISO association by a factor of 20 as compared to selecting randomly."

Among that selection, the next criteria would be to search for craters formed from high-velocity impactors. This would be craters with diameter less than 300?m with visible high-impact melt pond. Impact melt is exactly what its name implies: surface rocks that were instantly melted due to a high-velocity impact from an asteroid or comet. Large volumes of impact melt can pool to form what's known as crater-fill deposits, which over time hardens to form an entirely new rock.

Craters with impact melt ponds accounts for 15% of the crater population. Then, the authors say, discard all the craters that appear to be created by vertical impact and choose craters that nearer to the equator.

"In total, selecting craters that fit these constraints [crater age, size, melt, and latitude] results in a 100 times higher probability of association with a high-speed ISO as compared to selecting randomly," the authors write.

But, they note, no one should expect that a large number of lunar craters are the result of ISO impacts, since "craters from other sources, however, still massively outnumber ISO-generated craters."

Meteorite Found in Gutter by Canadian Man Estimated to Be From Astroid Belt Between Mars and Jupiter

If there's noise in your gutter, it could be a hailstorm. Or it could be something from farther up in the atmosphere.

Knewz.com has learned about the surprise one Canadian man found in a gutter of his home earlier this year. Scientists confirmed Friday, December 1, that he caught an item from outer space.

An Alberta man found a surprise from outer space in his gutter. By: Zachary Kelmig/Unsplash© Knewz (UK)

"People call me the meteorite guy at the coffee shop," Doug Olson of Edmonton said.

It took more than a year for Olson to know exactly what he had. His story goes back to October 2022, when he heard a thud on his roof while putting away his laundry.

Olson went outside, but didn't find anything unusual.

"How come I couldn't find it back when I was looking the first time?" Olson wondered.

Perhaps it was because the meteorite was hiding in his rain gutter. Olson found a rock there last May, during spring cleaning.

The rock weighed about 1.2 ounces, the size of a pebble. But it was still unusual, so Olson gave it to scientists at the University of Alberta for study.

Their conclusion: Olson caught a mix of iron, nickel and chondrule. Scientist Chris Herd told CBC News the last ingredient is common in meteorites.

Chris Herd of the University of Alberta displays part of a meteorite found in Edmonton. By: Edmonton,CTVNews.ca© Knewz (UK)

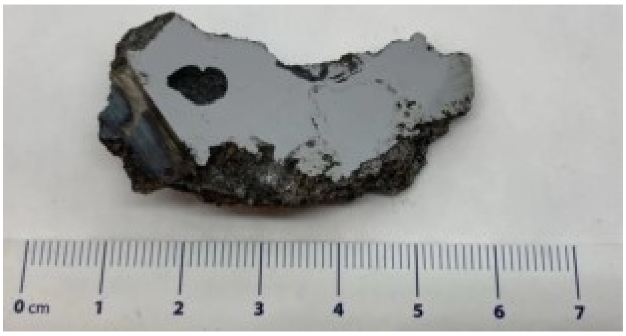
"There's a bunch of stuff that's making its way around the solar system all the time," Herd explained. "We think we know where the biggest stuff is that might threaten us. The small stuff is a complete surprise."

Olson knew the rock was unusual when he showed it to his wife.

"She reaches for a magnet and sticks it on there, and it stuck on there," Olson told CFRN-TV.

His "small stuff" now is in two pieces. Olson was allowed to keep part of it, while the university will put the rest on display in its meteorite collection.

The university named the rock "Menisa," after the neighborhood where Olson lives. It probably was on a long journey.



This meteorite landed in Somalia in 2020 and was studied at the University of Alberta in November 2022. By: MEGA© Knewz (UK)

"It was probably a piece of an asteroid in the asteroid belt between Mars and Jupiter and a piece got knocked off," Herd speculated.

It actually could be the second catch from outer space for Olson. He contacted the university several years ago when he found another possible meteorite in Fort McMurray, far north of Edmonton.

If you dream of catching a falling meteor, Herd says it helps to be in an area without a lot of precipitation.

"We have lots of open spaces and we're also more northern," Herd said, increasing the possibility of finding a meteorite in a field.

But Alberta doesn't have meteorites that often. Scientists have recorded only 18 there, and Olson's find was the first confirmed one since 1977.

This rock found in a New Jersey home in May was confirmed as a meteorite. By: Facebook.com/HopewellTownshipNJPolice© Knewz (UK)

Herd said he gets hundreds of reports each year, but almost all of them are something else.

Olson should be thankful his meteorite landed in a gutter. Knewz.com reported in May on one that crashed through the roof of a home in New Jersey.

Olson also may be thankful it was a meteorite, instead of his first hunch.

"I thought, did somebody just shoot my roof?" Olson said.

E MAILS and MEMBERS VIEWING LOGS.

Viewing Log for 10th of November (WAS Lacock viewing session)

Chris Brookes arranged another viewing session for WAS, turns out two on the trot is pretty good for the club. I arrived a bit later than the planned start time of 19:00 as I had other plans beforehand. When I arrived there was Chris, Andy, Dave and Peter there with some members of the general public, I think? Turns out there was six telescopes and two imaging rigs on the go, I had my Meade LX90 set up and ready by 19:52, with a temperature of 5 ° C and no wind, conditions should be good. This time I would be using my Televue Delos 14 mm eye piece instead of the usual Pentax one I normally use.

Guide stars tonight was Vega and Capella. First object for the evening was Saturn, now starting to get low in the south western sky, I could make out the rings and the moon Titan out to the west of Saturn, the planet I could not get in good focus, mage a bit hazy in that part of the sky? Tried for Neptune and this time I actually managed to locate the planet, think this is the first time in this season I have actually found it! As usual I could not made out anything of this planet, several people by now had come over to the telescope and had a look at these planets. Next stop was Jupiter, shining at – 2.9 mag, this was an excellent object to look at, the two main weather belts could be seen and the moons were spilt two on each side with Calisto and Europa out to the east and Ganymede and Io out to the west. Final planet for the evening was Uranus, could make some colour out on this planet. I asked the people around me what they would like to look at, gave them some choices but they had not seen any open clusters yet. So I went off to Auriga to look at the three Messier (M) objects in this constellation starting with M 38, a large cluster with a lot of dim stars within the group. Close by is M 37, a compact and dim cluster finishing off with M 36, this cluster had some bright stars in it. I asked the people around me if they had a good idea of what things could look like or not? So, I went to NGG 457, the ET or Owl cluster, some comments I got included birds eyes, once I explained about the stars going out from these bright stars like a wing, things fell into place. There was a lot of questions asked which did not require looking at anything with the telescope, phases of the moon was one of them, so with the three of us as the Sun, Earth and moon I explained how the phases worked.

By 21:34, I was the only one with a telescope still up but dew was now a major problem, so I decided to pack up as well. In fact I think everyone had gone or where in the process of going before I had switched off the power to the telescope?

Clear skies.

Peter Chappell

PS November has not been a good month for viewing, when the skies have been clear (not many last month), either the half (plus) moon is around or I have been doing other things.

Hi Andy,

Several years ago, whilst attending Astrofest in London, I purchased a book called "Life and Death of the Stars" by Professor Ganesan Srinivasan (Sringer Publications, ISBN: 987-3-642-45383-0). This was the 2nd book in a series of 3 publications aimed at undergraduate students and other interested readers. It is based on a series of lecture notes presented by Professor Sriivasan at St Joseph's College in Bangalore, India. The first book is entitled "What are the Stars" (ISBN: 978-3-642-45301-4). The 2nd book, in its epilogue, mentions the forthcoming 3rd book entitled "Neutron Stars and Black Holes". It is while searching for this 3rd book in the series (I'm not sure it actually made it into print) that I discovered the below mentioned series of lectures on YouTube. There appear to be 49 of them on various Astronomy and Astrophisics topics, each being approx. 90-100 min. in duration.

Having read his book and watched the first half dozen or so lectures, I can highly recommend them for viewing. The presentation style of both the book(s) and lectures is very accessible and although some of the subject matter is at a slightly higher level than I studied (i.e. A-level Maths, Physics , and subsequently a lifelong interest in astronomy), it is presented in a way which deliberately allows the underlying concepts and ideas to be followed and understood. The ideas in the lectures are presented in an historical context, and explain how we came to our present level of understanding of the cosmos.

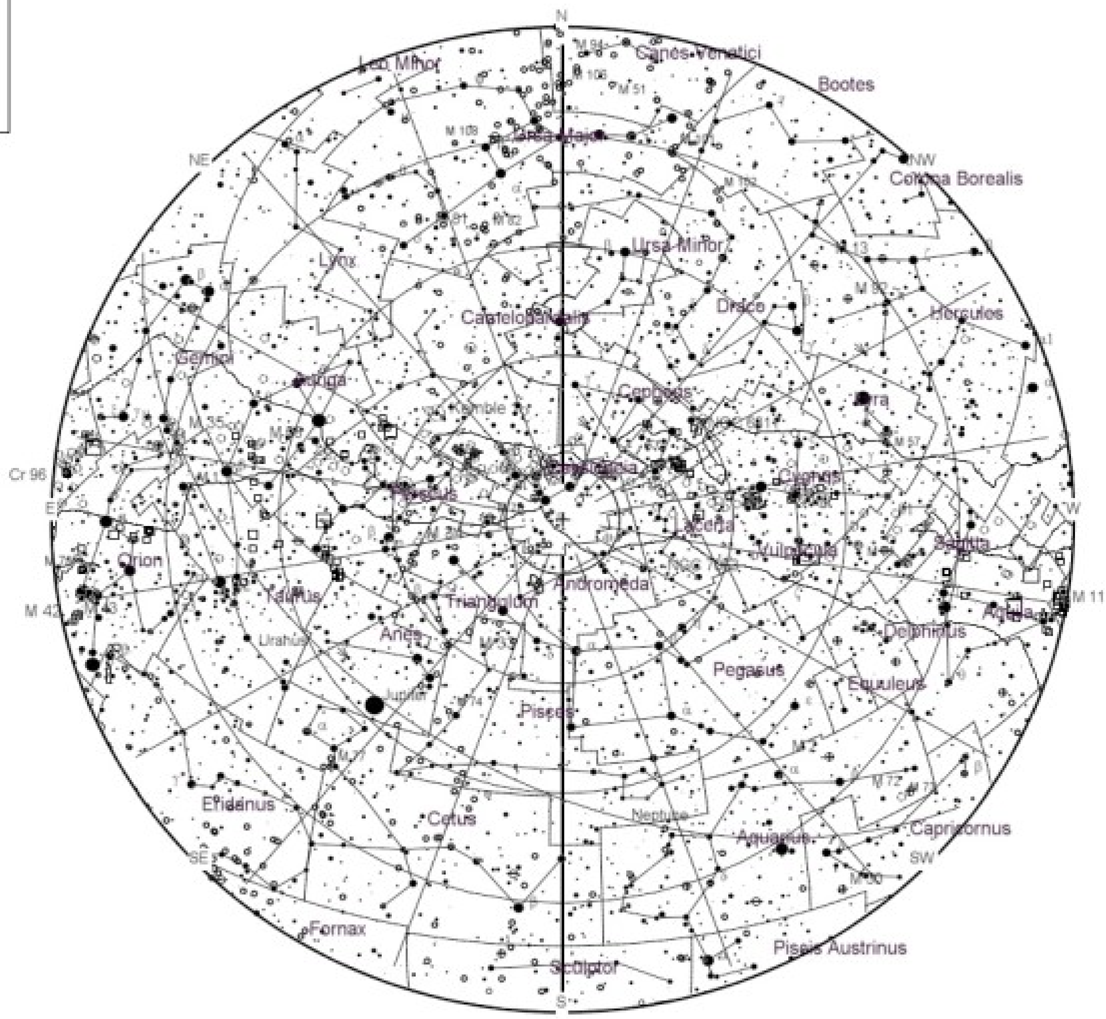
I thought that other members might like to view them and also that one or two might be suitable for hall meetings (if this is possible and there are no copyright restrictions).

Regards,
Dave Buckle.

https://www.youtube.com/playlist?list=PLo2-KX0epqHdIOxlKhaDxCxgR0J3Vk3aC

WHATS UP, DECEMBER 23

Alt/Az coord. ARC
Apparent
Home
2023-11-15
21h00m00s (UTC)
Mag:6.4/11.5,1.2'
FOV:+249°01'02"



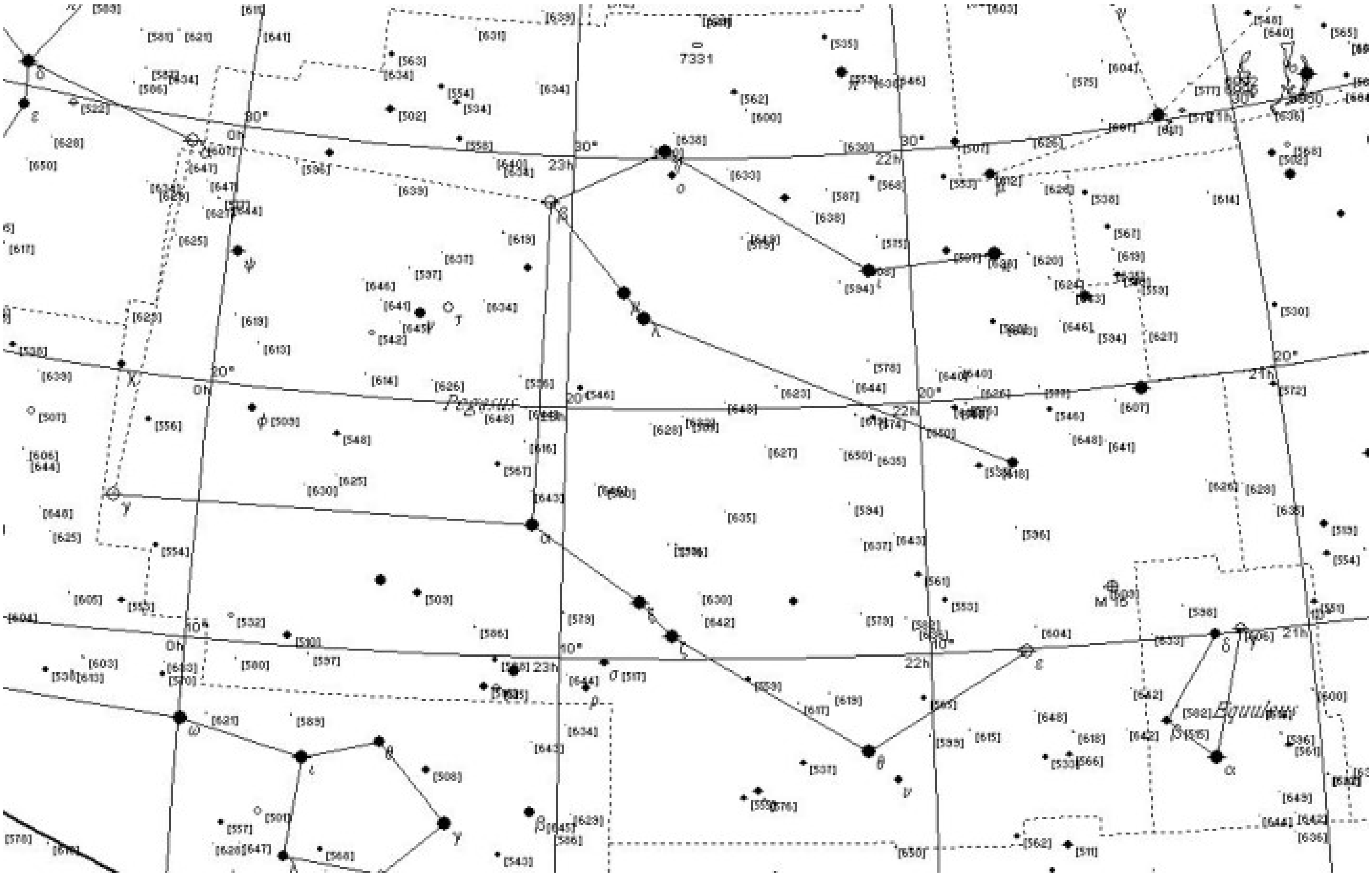
December 4 - **Mercury at Greatest Eastern Elongation.** The planet Mercury reaches greatest eastern elongation of 21.3 degrees from the Sun. This is the best time to view Mercury since it will be at its highest point above the horizon in the evening sky. Look for the planet low in the western sky just after sunset.

December 12 - **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 23:33 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.

December 13, 14 - **Geminids Meteor Shower.** The Geminids is the king of the meteor showers. It is considered by many to be the best shower in the heavens, producing up to 120 multicolored meteors per hour at its peak. It is produced by debris left behind by an asteroid known as 3200 Phaethon, which was discovered in 1982. The shower runs annually from December 7-17. It peaks this year on the night of the 13th and morning of the 14th. This should be an great year for the Geminids. The nearly new moon means dark skies for what should be an excellent show. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Gemini, but can appear anywhere in the sky.

December 21, 22 - **Ursids Meteor Shower.** The Ursids is a minor meteor shower producing about 5-10 meteors per hour. It is produced by dust grains left behind by comet Tuttle, which was first discovered in 1790. The shower runs annually from December 17-25. It peaks this year on the the night of the 21st

CONSTELLATION OF THE MONTH: PEGASUS



Pegasus

Positioned north of the ecliptic plane, the constellation of Pegasus was one of the original 48 constellations listed by Ptolemy, and endures as one of the 88 modern constellations.adopted by the IAU. It covers 1121 square degrees of sky and ranks 11th in size. Pegasus contains between 9 and 17 main stars in its asterism (depending on how you depict it) and has 88 Bayer Flamsteed designated stars within its confines. Pegasus is bordered by the constellations of Andromeda, Lacerta, Cygnus, Vulpecula, Delphinus, Equuleus, Aquarius and Pisces. It is visible to observers located at latitudes between +90° and ?60° and is best seen at culmination during the month of October.

There is one annual meteor shower associated with the constellation of Pegasus which peaks on or about November 12 of each year – the Pegasids. The radiant – or point of origin – for the meteor shower is near the asterism of the "Great Square". Activity begins around October 10 and lasts to late November. The average fall rate at maximum during the peak is 10 per hour. This particular meteor used to be spectacular, but Jupiter has perturbed the meteor stream over the years and lessened the activity.

In mythology, Pegasus represents the Winged Horse, and child of Medusa who was slain by the hero Perseus. According to Greek mythology, Pegasus was delivered to Mount Helicon by Bellerophon, where the magnificent horse kicked the source of poetic inspiration – the Spring of Hippocrene – into flowing. When Bellerophon defeated Chimaera, he became so proud he ordered Pegasus to fly him to Mount Olympus. This action angered Zeus, who ordered an insect to sting Pegasus, resulting in Bellerophon's fatal fall to Earth. Zeus then went on to recognize Pegasus in the stars as the "Thundering Horse of Jove" – carrier of his lightning bolts.

Let's begin our binocular tour of Pegasus with its brightest star – Alpha – the "a" symbol on our map. Alpha Pegasi's proper name is Markab and it marks the southwestern corner of the asterism of the Great Square. Located 140 light years from Earth, Markab is a hot class B (B9) dwarf star which shines about 205 times brighter than our own Sun and is about three times larger. This fast rotator completes a full turn on its axis in just about 36 hours! Right now, Markab sits on the edge of the main sequence, about to die and become a much cooler orange giant star. It's about as "normal" as a star can be!

Now, turn your binoculars towards Beta – the "B" symbol. Named Scheat, you'll find this particular star located in the northwestern corner of the Great Square and about 200 light years from our solar system. Scheat is unusual among bright stars in having a relatively cool surface temperature of 3700 degrees Kelvin, compared to stars such as our Sun. Scheat is a red giant star some 95 times larger than Sol and has a total stellar luminosity of 1500 times solar. It is also an irregular variable star, its brightness changing from magnitude 2.31 to 2.74.

You'll need a telescope to reveal the mysteries surrounding Eta Pegasi – the "n" symbol on our map. Named Matar and located about 215 light years away, this spectral class G2II-III star has a close binary star companion of class F0V. There are also

2 class G stars further away that may or may not be physically related to the main pair. According to Jim Kaler, "Matar is double star and may well be quadruple, consisting of a very unequal pair of pairs, an unbalanced double-double. The brighter of the bright pair is on its way to becoming a much larger giant, and will eventually expand to a radius of a quarter the distance that now separates the two stars, streams of matter running from the brighter to the dimmer creating quite a sight from the smaller pair. Eventually the bright star of the brighter pair will fade to become a white dwarf, this double perhaps looking something like Sirius does today."

Next up? Epsilon Pegasi – the backwards "3" symbol on our map. Located 670 light years away, Enif is a cool star for more than one reason! To begin with, Enif is orange class K (K2) supergiant star whose stellar temperature only averages about 4460 degrees Kelvin. Even in binoculars you'll notice the reddish hue. It's big, too… About 150 times the size of our Sun and if located in our solar system would fill out the space about halfway to the orbit of Venus. This supergiant star's fate awaits it as a supernova, but there is always a possibility it could become a heavy, rare neon-oxygen white dwarf whose size would be no larger than the Earth. What makes Enif so cool is that it is very unpredictable. According to records, in 1972 Enif had a flare event which caused it to brighten 5 times more than its normal stellar magnitude!

Keep your binoculars handy, because following the trajectory from Theta to Epsilon just another third of the way will bring you to awesome globular cluster – Messier 15 (RA 21:29:58.3 Dec +12:10:01). Located almost equidistantly from both the galactic center and from us, this superior globular cluster was first discovered by Jean-Dominique Maraldi on September 7, 1746 and later listed by Charles Messier on his famous Messier Catalog list of "objects which are not comets". It ranks third in variable star population and M15 is perhaps the oldest and most dense of all globulars located in the Milky Way Galaxy. Its compact central core may be the result of mutual gravitational interaction, or it could contain a dense, supermassive object – a black hole. One thing we do know that M15 contains is a planetary nebula known as Pease 1 – only four known planetary nebulae in Milky Way globular clusters! Another curiosity is M15 also contains 9 pulsars, the remnants of ancient supernova explosions leftover from its youthful beginnings. While you can easily see M15 with binoculars, even a small telescope can begin resolution on this great deep sky object!

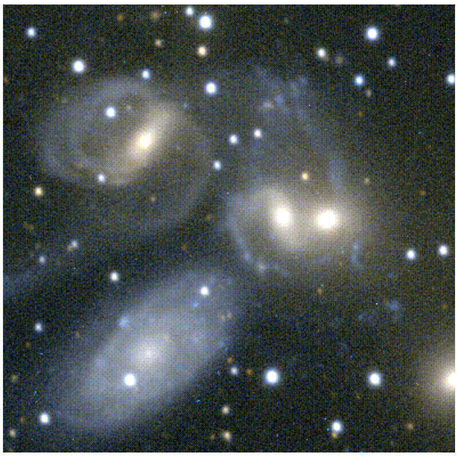
For telescopes, have a look at spiral galaxy NGC 7217 (RA 22:07.9 Dec +31:22). This magnitude 10 jewel displays a bright nucleus and hazy frontier over its generous 3.7 arc minute size. Taken photographically this particular galaxy exhibits very tight spiral galaxy structure and is sometimes considered an "unbarred" spiral galaxy with a dark ring of obscuring material around the nucleus.

Try your hand at spiral galaxy NGC 7814 (RA 0:03.3 Dec +16:09), too. At magnitude 10 and a huge 6.3 arc minutes in diameter, this particular galaxy is easily seen in small telescopes and larger binoculars. Often referred to as Caldwell 43, it's located about 40 million light years from Earth and gives a great edge-on presentation! It is sometimes referred to as the a miniature version of Messier 104, or "the Little Sombrero".

Now, it's time for NGC 7331 (RA 22:37.1 Dec +34:25). Easily spotted in big binoculars and small telescopes under dark skies, it was first discovered by Sir William Herschel. This beautiful, 10th magnitude, tilted spiral galaxy is very much how our own Milky Way would appear if we could travel 50 million light-years away and look back. Very similar in structure to both our own Milky Way and the Great Andromeda Galaxy, this particular galaxy gains more and more interest as scope size increases – yet it can be spotted with larger binoculars. At around 8″ in aperture, a bright core appears and the beginnings of wispy arms. In the 10″ to 12″ range, spiral patterns begin to emerge and with good seeing conditions, you can see "patchiness" in structure as nebulous areas are revealed, and the western half is deeply outlined with a dark dustlane. But hang on… Because the best is yet to come!

Return to NGC 7331 with a big telescope. What we are about to look at is truly a challenge and requires dark skies, optimal position and excellent conditions. Now breathe the scope about one half a degree south-southwest and behold one of the most famous galaxy clusters in the night. In 1877, French astronomer Edouard Stephan was using the first telescope designed with a coated mirror when he discovered something a bit more with NGC 7331. He found a group of nearby galaxies! This faint gathering of five is now known as "Stephan's Quintet" and its members are no further apart than the diameter of our own Milky Way galaxy.

Visually in a large scope, these members are all rather faint, but their proximity is what makes them such a curiosity. The Quintet is made up of five galaxies numbered NGC 7317, 7318, 7318A, 7318B, 7319 and the largest is 7320. Even with a 12.5″ telescope, this author has never seen them as much more than tiny, barely-there objects that look like ghosts of rice grains on a dinner plate. So why bother? Because I've seen them with large aperture… What our backyard equipment can never reveal is what else exists within this area – more than 100 star clusters and several dwarf galaxies. Some 100 million years ago, the galaxies collided and left long streamers of their materials which created star forming regions of their own, and this tidal pull keeps them connected. The stars within the galaxies themselves are nearly a billion years old, but between them lie much younger ones. Although we cannot see them, you can make out the soft sheen of the galactic nuclei of our interacting group. Enjoy their faint mystery!



There are many more faint galaxies and deep sky objects in Pegasus to be enjoyed, so grab a good star map and fly with the "Winged Horse"!

Sources:
Chandra Observatory
SEDS
Wikipedia

My view of the quintet from Chippenham...

ISS PASSES For December 2023

from Heavens Above website maintained by Chris Peat.

Date	Brightn	Start	Highest	End						
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
16 Dec	-0.5	06:42:00	10°	SSE	06:43:36	13°	SE	06:45:12	10°	ESE
18 Dec	-1.4	06:38:30	10°	SSW	06:41:18	25°	SSE	06:44:06	10°	E
19 Dec	-1.0	05:49:48	10°	S	05:52:05	17°	SE	05:54:22	10°	E
19 Dec	-3.2	07:25:00	10°	WSW	07:28:17	59°	SSE	07:31:36	10°	E
20 Dec	-0.7	05:02:30	11°	SE	05:02:52	11°	SE	05:04:03	10°	ESE
20 Dec	-2.7	06:35:41	10°	SW	06:38:54	44°	SSE	06:42:07	10°	E
21 Dec	-2.2	05:48:27	26°	S	05:49:29	32°	SSE	05:52:30	10°	E
21 Dec	-3.7	07:22:35	10°	WSW	07:25:56	85°	S	07:29:17	10°	E
22 Dec	-1.0	05:01:15	18°	ESE	05:01:15	18°	ESE	05:02:44	10°	E
22 Dec	-3.6	06:34:06	19°	WSW	06:36:22	71°	SSE	06:39:42	10°	E
23 Dec	-3.3	05:46:43	55°	SSE	05:46:45	55°	SSE	05:50:03	10°	E
23 Dec	-3.8	07:20:01	10°	W	07:23:22	85°	N	07:26:45	10°	E
24 Dec	-0.9	04:59:11	19°	E	04:59:11	19°	E	05:00:18	10°	E
24 Dec	-3.8	06:32:00	28°	W	06:33:40	89°	N	06:37:01	10°	E
25 Dec	-3.4	05:44:20	64°	E	05:44:20	64°	E	05:47:15	10°	E
25 Dec	-3.8	07:17:13	10°	W	07:20:34	89°	SSW	07:23:56	10°	E
26 Dec	-0.8	04:56:33	17°	E	04:56:33	17°	E	04:57:25	10°	E
26 Dec	-3.8	06:29:21	33°	W	06:30:44	85°	N	06:34:06	10°	E
27 Dec	-3.2	05:41:29	55°	E	05:41:29	55°	E	05:44:12	10°	E
27 Dec	-3.5	07:14:17	11°	W	07:17:29	67°	SSW	07:20:49	10°	ESE
28 Dec	-0.7	04:53:31	15°	E	04:53:31	15°	E	04:54:14	10°	E
28 Dec	-3.8	06:26:20	36°	W	06:27:33	82°	SSW	06:30:55	10°	ESE
29 Dec	-2.9	05:38:18	51°	E	05:38:18	51°	E	05:40:55	10°	E
29 Dec	-2.9	07:11:06	12°	W	07:14:03	41°	SSW	07:17:13	10°	SE
30 Dec	-0.5	04:50:14	14°	E	04:50:14	14°	E	04:50:50	10°	E
30 Dec	-3.5	06:23:02	37°	WSW	06:24:03	56°	SSW	06:27:21	10°	ESE
31 Dec	-2.6	05:34:55	43°	ESE	05:34:55	43°	ESE	05:37:19	10°	ESE
31 Dec	-2.1	07:07:43	11°	W	07:10:15	23°	SW	07:12:58	10°	SSE
01 Jan	-0.4	04:46:47	13°	ESE	04:46:47	13°	ESE	04:47:09	10°	ESE
01 Jan	-2.8	06:19:34	30°	SW	06:20:13	33°	SSW	06:23:16	10°	SE
02 Jan	-2.0	05:31:25	28°	SSE	05:31:25	28°	SSE	05:33:18	10°	SE
02 Jan	-1.4	07:04:37	10°	WSW	07:06:04	12°	SW	07:07:32	10°	SSW
03 Jan	-1.9	06:16:02	19°	SW	06:16:02	19°	SW	06:18:24	10°	S
04 Jan-	1.2	05:27:52	15°	SSE	05:27:52	15°	SSE	05:28:41	10°	SSE

END IMAGES, AND OBSERVING

The morning when the Moon occulted Venus. November 7th.
From upstairs window (trees spoiled the outside view, So no tripod, I leaned the camera on the upper window frame for the pictures I took. Nikon Z9 camera and 400mm lens with 2x converter.
Lucky to get the clouds to clear as Venus ducked behind the walls of a crater of the Moon.   Andy Burns

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

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

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

Opportunity	Day	Date	Month	set-up	Observe	Moon Phase and Rise/Set Times			Suggested Observing Targets
First	Friday	08th	December	18:30	19:00	Cres	Rising	13:15	Orion makes an appearance above the horizon much earlier and we catch the end of the Geminid Meter shower on the 16th, bring your binoculars and comfy chair!
Second	Friday	15th	December	18:30	19:00	Cres	Setting	17:45	
Third	Friday	29th	December	18:30	19:00	Gibb	Rising	18:45	New Equipment Practical session with nearly full moon
First	Friday	5th	January	18:30	19:00	Cres	Rising	3:00	Saturn has now gone but the remaining outer planets are still on deplay. Worth observing and photographing the Andromeda Galaxaxy as it is high in the sky now.
Second	Friday	12th	January	18:30	19:00	Cres	Setting	16:45	
First	Friday	2nd	February	18:30	19:00	Cres	Rising	1:45	Jupiter is still observable but is starting to head to the horizon at the start of the month and becomes less favourable.
Second	Friday	9th	February	19:00	19:30	New	Rising	17:30	
First	Friday	01st	March	19:00	19:30	Qtr	Rising	1:00	The outer planets are becoming less favourable and Orion is at his heighest at the very beginning of the night. Galaxy season is beginning with as Leo Coma Berenices and Ursa Major rising.
Second	Friday	08th	March	19:30	20:00	Cres	Rising	6:45	
First	Friday	05th	April	20:00	20:30	Cres	Rising	6:00	With Virgo rising the Galaxy observbing season is well underway. We are also graced by the Great Star Clust M13 in Hercules with Venus and Mars only obserable in the morning skies
Second	Friday	12th	April	20:30	21:00	Cres	Setting	1:00	
First	Friday	03rd	May	20:30	21:00	Cres	Rising	4:30	The nights are short and the rise of Vega, Deneb and Altair, mark the rise of the summer triangle and the final few weeks of the Wiltshire Astronomical Societies observing season.
Second	Friday	10th	May	20:30	21:00	Cres	Setting	23:45	

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

Wiltshire Astronomical Society Observing Team