Volume28 Issue10

June 2023

NWASNEWS

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

A Summer for Members to Decide.

Welcome again the hugely entertaining speaker Andrew Lound, speaking about our unlikely twin planet, Venus, and how it has gone from paradise to a kind of hell…

It is a very important summer for the members of Wiltshire Astronomical Society to decide how it goes forward. We need several roles to be filled by volunteers going forward, many of these roles can be done by the same person but a full list of roles and the duties or on the web site.

Our speaker secretary has resigned with plenty of notice but no one hs yet stood in.

The hall coordinator has been ansent with family issues and other duties for tea/coffee supplies and projector etc has also stood down for the past 12 months.

Now I am sorry to say again I have to retire due to health problems, and these may mean if the last ditch medication attempts don't work I shall have to have invasive operations that will mean I can't drive for 3 months plus recovery period for EACH HAND. Thank heavens I'm not an octopus. But seriously I had stood back five years ago but stood back to see us through COVID period.

Individually the tasks I do are not onerous, but when all are added together they are too much for one person.

On the good news side the increase in the Hall hire fee is much less than we initially feared and with the accounts nearly complete for the year we can certainly keep Seend as our meeting base, and Lacock for our observing sessions.

It is now up to the members to attend those meetings. One meeting we only had 8 persons there and 4 were committee.

We have had some ideas to change what we do at meetings. Some more practical sessions on equipment and computer use. Still maintaining some speakers and possibly going to 3-4 meetings on Zoom to keep these costs down.

Here is a list of vacant roles…

Chair Person

Outreach coordinator

Newsletter/Publicity

Hall Coordinator

Live Meeting Supplies and Equipment

Zoom Session Coordinator

Speaker Secretary.

A list of other roles and expectations are on the web site.

But the society is healthy and should go forward in some form or other. It is up to you, the members how this goes forward.

Clear skies

Andy Burns

The summer months, especially June and July are months when the Noctilucent Clouds (NLCs) may be seen in the northern skies above the horizon.
Sunlight from more than 18 degrees below the horizon lights up clouds in the upper atmosphere making the clouds glow very brightly.
These were never seen before 1883 and the explosion of Krakatoa.
It is agreed that these upper atmosphere clouds have been added to by space flights going through the atmosphere and possibly particle left behind by meteors hitting the atmosphere. If the latter, then tey should have been seen before 1883…
Photo Andy Burns, 2022.

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 we will try to hold these at the hall

Meet 7.30 for 8.00pm start

SEASON 2022/23
2023

June 6th Andrew Lound: Venus, Paradise Lost.
September 5th
October 3rd:
November 7th:
December 5th
2024
January 2nd
February 6th
March 5th
April 2nd
May 7th
June 4th

AWAITING A SPEAKER SECRETARY FOR 23/24 SEASON

Andrew Lound

Presenter, writer, lecturer and broadcaster. Former curator of the Avery Historical Museum. Regular commentator on science and history matters on BBC Radio and Talk Radio. Writer and presenter of TV series 'Streets of Birmingham'. Published 4 books (3 history and one biography). Tours the country with his trademark Odyssey Dramatic Presentations® in history and science subjects, having been involved in over 5000 events. Has toured in USA, Europe and North Africa. Presentations contain music, audio FX, SFX and presented in costume.

Venus is a world that has been viewed in numerous ways, firstly as an ocean paradise, a planet of love, perhaps even two worlds one in the morning and one in the evening. Now we know it is one world—a hot corrosive world. Andrew provides an entertaining history of the planet, illustrated by awesome images spanning over 100 years of observation by telescopes and space probes. The images are accompanied by a special arrangement of music that envelopes the audience. Who said science isn't romantic?!

Membership Meeting nights £1.00 for members £3 for visitors

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

Wiltshire AS Contacts

Chairperson:

Outreach coordinator:

Newsletter/Publicity

Treasurer and Membership: Sam Franklin

Hall coordinator:

Live Meeting Supplies

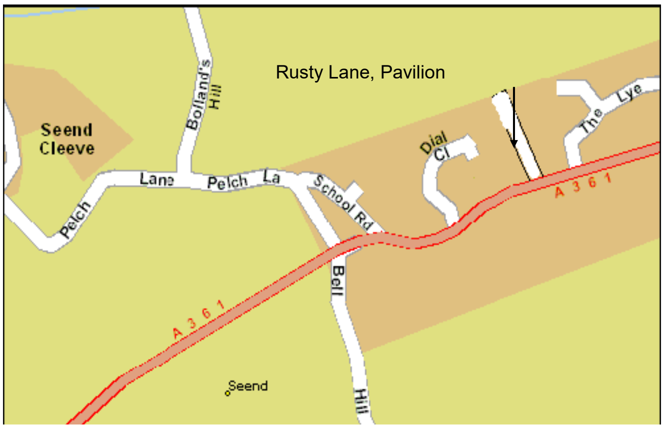
Speaker secretary

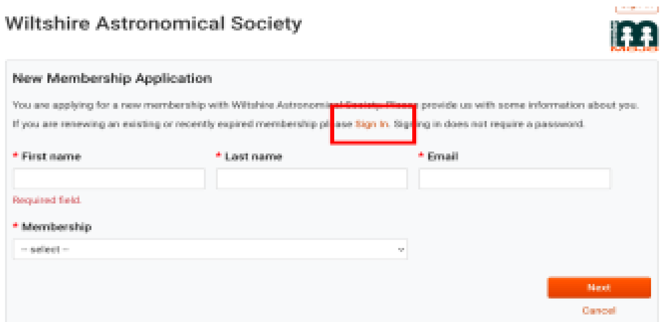
Zoom session coordinator

Observing Sessions coordinators: Chris Brooks, Jon Gale,

Web coordinator: Sam Franklin

Contact via the web site details.




Wiltshire Astronomical Society

New Membership Application

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

* First name | * Last name | * Email

Required field.

* Membership

-- select --

Next

Cancel

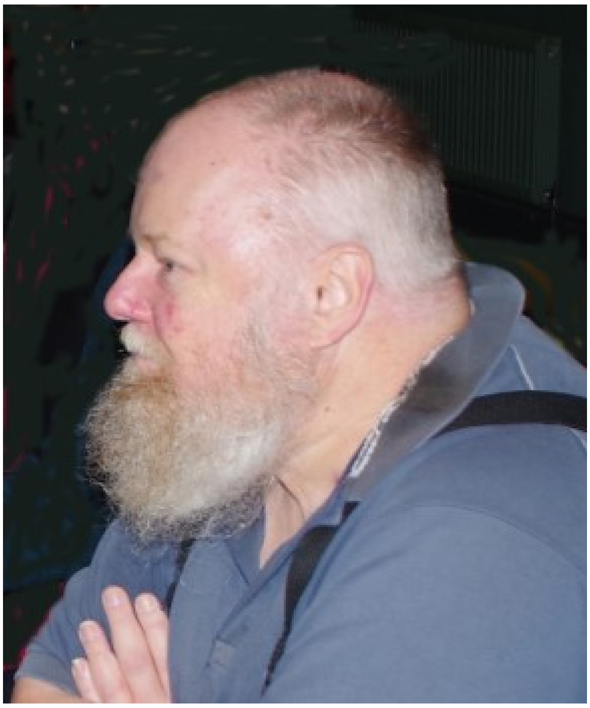
Observing Sessions see back page

Swindon's own astronomy group

Physical meetings

The club meets in person once a month

Friday, 16 June – Talk by Owen Brazzell



Our speaker this month is Owen Brazzell. Owen has played a prominent part in the development of our club since its foundation in 2009.

His interest in astronomy was sparked by an attempt to see a comet from his native Toronto. From early years, he kept up his interest in astronomy which culminated in a degree in astronomy from St Andrews University.

Despite this, he spent his working career on the exploration side of the oil and gas industry.

Owen was assistant director to the BAA Deep Sky Section for 25 years and is currently President of the Webb Deep Sky Society.

His talk is on 'Globular Clusters`

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 here:

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

Meetings at Liddington Village Hall

Church Road, Liddington, SN4 0HB

7.30pm onwards

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

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

Meeting Dates For 2023

Friday, 16 June 19.30 onwards

Programme: Owen Brazell – Globular Clusters

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

Friday, 15 September 19.30 onwards -

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

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

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

Friday, 8 December 19.30 onwards Programme: Christmas Social

Website:
http://www.swindonstargazers.com

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

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, 28th June
A History of Women in Astronomy Part 2 – Following on from Mary McIntyre's part one, this talk looks at the trailblazing women working in astronomy after Caroline Herschel, through the Victorian era and into the modern day. It covers some of the challenges women faced during this time period, particularly around education.

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

Public stargazing is scheduled twice a month on Saturday evenings as well as during school holidays to promote astronomy in Bath and Somerset area. Locations vary to bring telescopes to local communities.

Member's observing is conducted from the Monkton Combe Community Observatory using the 1860s 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 Annie, Jade, Jonathan, Meyrick, Mike, Prim and Simon will be happy to help you.

Fordingbridge Astronomers

June Meeting Zoom details

In Memory of Bob Mizon.

Our June meeting will be on Wednesday 21st June, starting at 7.30pm and will be held in memory of our dear friend Bob Mizon who sadly passed away in April 2023. It will include a number of short astronomical talks, presentations and memories, given by members, on topics that would have been of interest to Bob.
After this, there will be a short 10-15 minute break to charge glasses and to catch up with everyone. After the break we will have our Chairman's **Pick of the Month**, followed by the Fordingbridge Astronomers' **What to look out for in the sky this month**.
We will be holding the meeting in our usual venue at The Elm Tree, Hightown, near Ringwood. The postcode for the Elm Tree is BH24 3DY. We'll be meeting in The Barn at the rear of the pub and, if you've not been before, just ask the bar staff where the meeting is. There is plenty of parking for those who want to come along. Meetings are free to members and £2 each for guests. The Zoom link is included below for those of you who are unable to join us in The Elm Tree.
Fordingbridge Astronomers June Meeting Zoom details
Time: Jun 21, 2023 19:00 London
https://us06web.zoom.us/j/82760734672?pwd=TnRjY2ZUbXRnc1ZXZnpmcHlkNGQ2QT09
Meeting ID: 827 6073 4672
Passcode: 024179
Please note: If you are joining us as a Guest on Zoom, there is a £2 voluntary donation which can be made by BACS (Lloyds Bank - Sort Code: 30-93-94, Account: 34541260) or by PayPal. Our account name for both services is Fordingbridge Astronomers. Please use the reference 'June Meeting'. Please take a moment to add your Astronomical Society to your screen name so we know where you are from. Thank you.
Clear Skies and Best Regards
Martin Davies
Membership Secretary

SPACE NEWS TO JUNE 23

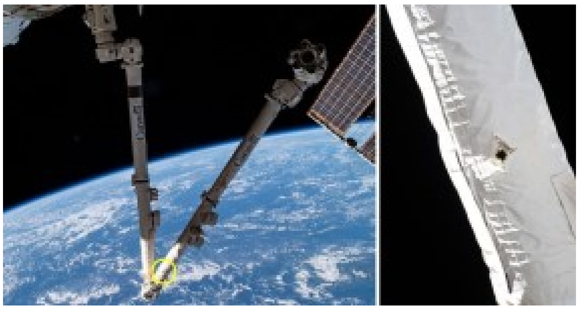
Researchers are Working on a Tractor Beam System for Space

Human technology is crossing another threshold. Tractor beams have been common in science fiction for decades. Now a team of researchers is working on a real-life tractor beam that could help us with our burgeoning space debris problem.

Space debris is made up of human-made objects in space that are now defunct. It ranges from complete satellites or spacecraft, to cast-off pieces like debris shields, all the way down to tiny pieces of those objects produced by collisions. Collision debris is the most numerous, and it has a tendency to multiply.

In 2009, a non-functioning Russian satellite collided with an Iridium satellite over the Siberian Peninsula. The collision produced over 1,800 pieces of debris that are now orbiting the Earth at high velocity. That's just one source of debris, and when scientists add up all the other debris, they conclude that there are over 25,000 pieces of debris orbiting Earth that are large enough to be measured. Estimates show that there are far larger numbers of objects too small to be tracked, including more than 128 million pieces of debris smaller than 1 cm (0.4 in). And these numbers will grow.

That constitutes a palpable hazard for functioning spacecraft. Even small pieces can cause damage because of their high velocities. In low-Earth orbit (LEO,) debris travels at about 25,250 kph (15,700 mph), according to NASA, so when two pieces both travelling that fast collide, the energy released is substantial. And satellites are not hardened targets.

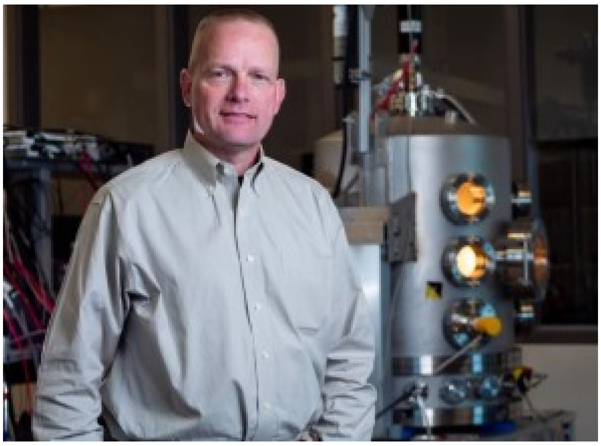


On May 12th, 2021, a routine check showed that a piece of debris hit the Canadarm2 on the International Space Station, poking a hole in its thermal blanket. Credit: NASA/Canadian Space Agency

"The problem with space debris is that once you have a collision, you're creating even more space debris."

Julian Hammerl, doctoral student in aerospace engineering sciences at CU Boulder

Professor Hanspeter Schaub is leading a team of researchers at the University of Colorado, Boulder, who are working on a real-life tractor beam. It uses the electrostatic force to influence an object's motion. While a working model or prototype is a ways away, the researchers are creating a small vacuum chamber mimicking space in their lab. It's called the Electrostatic Charging Laboratory for Interactions between Plasma and Spacecraft (ECLIPS.)



Hanspeter Schaub in his lab with the ECLIPS facility in the background. Image Credit: Patrick Campbell/CU Boulder

The problem with space debris is that it will only get worse. Collisions between objects produce even more objects in a cascading effect. Even if we stopped launching things into orbit, the number of objects will keep growing.

"The problem with space debris is that once you have a collision, you're creating even more space debris," said Julian Hammerl, a doctoral student in aerospace engineering sciences at CU Boulder. "You have an increased likelihood of causing another collision, which will create even more debris. There's a cascade effect."

The only way to reduce collisions is to reduce the number of objects, and in recent years there's been a lot of thinking and research into how to reduce space debris and collisions.

A team from the Australian National University looked at using ground-based lasers to alter the trajectory of objects on a collision course. Both the ESA and China have used drag sails to hasten the de-orbiting of rocket boosters. And a UK company called RemoveDebris tested an interesting harpoon system for handling space debris.

But if Schaub's team can find an answer to space debris, it'll start in their little vacuum chamber. They're developing electron beams that can either be attractive or repulsive and could hopefully be used to change the trajectory of individual pieces of space debris. The small chamber is where they perform tests.

"We're creating an attractive or repulsive electrostatic force," said Schaub, chair of the Ann and H.J. Smead Department of Aerospace Engineering Sciences. "It's similar to the tractor beam you see in Star Trek, although not nearly as powerful."

Their potential solution could bypass one of the huge risks in mitigating the space debris problem: touching it. Contacting a piece of fast-moving, tumbling space debris could change its trajectory unintentionally, making the problem even worse. That could add to the cascading collision problem.

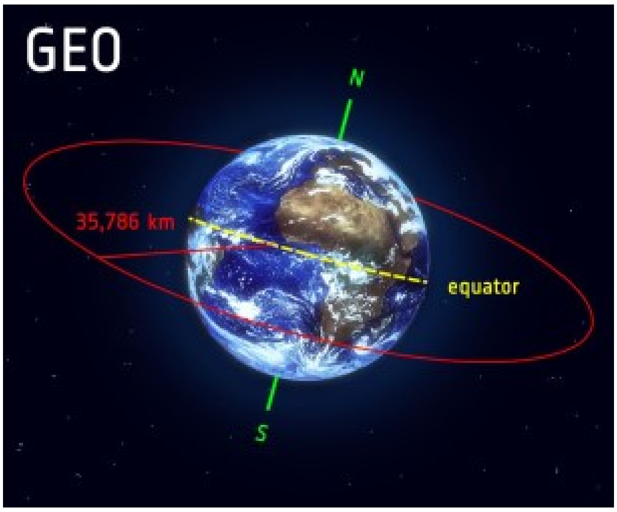
"Touching things in space is very dangerous. Objects are moving very fast and often unpredictably," said Kaylee Champion, a doctoral student working with Schaub. "This could open up a lot of safer avenues for servicing spacecraft."

Eventually, if their work bears fruit, the team envisions a fleet of small spacecraft orbiting Earth. The spacecraft would rendezvous with things like defunct satellites and then use either attractive or repulsive electron beams to alter its trajectory. It's all based on the Coulombe force.

Inside ECLIPS, the researchers recreate the space environment around Earth. That region isn't empty. Instead, it's full of plasma, charged atoms and free electrons. In recent experiments, Schaub and his team recreated a geosynchronous orbit (GEO) environment in their chamber. GEO is much higher than low-Earth orbit (LEO.) LEO is a region extending to about 2,000 km (1,200 mi) above Earth's surface, whereas GEO begins about 34,000 km (22,000 mi) above the Earth's surface.

GEO is where the big boys play. Up there, we find satellites as large as school buses, dedicated to military and telecommunication applications. "GEO is like the Bel Air of space," Schaub said, comparing it to the high-rent neighbourhood in Los Angeles.

But like Earthly Bel-Air, orbital Bel-Air only has so many addresses, and they're filling up quickly. Engineers estimate there are about 180 orbital slots up there that can hold satellites. All 180 or either already filled or have been claimed. The UN's International Telecommunications Union allocates the slots on a first-come, first-served basis.



Satellites in geostationary orbit (GEO) circle Earth above the equator from west to east following Earth's rotation – taking 23 hours, 56 minutes and 4 seconds – by travelling at exactly the same rate as Earth.
This makes satellites in GEO appear to be 'stationary' over a fixed position. In order to perfectly match Earth's rotation, the speed of satellites in this orbit should be about 3 km per second at an altitude of 35 786 km. This is much farther from Earth's surface compared to many satellites. Image Credit: ESA – L. Boldt-Christmas

The problem is that some of those slots are occupied by defunct satellites, and those slots are in high demand. According to Schaub, tractor beams could safely remove defunct satellites and clear the slot for another functioning satellite, and it's based on a fairly simple principle that we all come across when we're kids.

Everybody remembers rubbing a balloon on their hair and then sticking it to the wall. The rubbing creates a static charge by moving electrons from one object to the other. Then the two objects, the balloon and the wall, have different charges. The stationary wall holds the mobile balloon in place. For a while, anyway.

Schaub's team sees it working this way: the spacecraft with the tractor beam would approach a defunct satellite to a distance of about 15 to 25 meters (49 to 89 feet.) Then the spacecraft would fire a stream of electrons at it. The electrons give the spacecraft a negative charge, and the servicing spacecraft would be more positively charged.

Every kid that's played with magnets knows opposites attract. And once the servicing spacecraft and the defunct satellite have opposite charges, they're attracted to one another. This creates what Schaub and his team call a 'virtual tether.'

"With that attractive force, you can essentially tug away the debris without ever touching it," Hammerl said. "It acts like what we call a virtual tether."

Julian Hammerl makes adjustments to a metal cube representing a derelict spacecraft inside the ECLIPS facility. Image Credit: Nico Goda/CU Boulder

The team's experiments in ECLIPS show it could work. So do computer models. Schaub's work shows that their spacetug idea, the Geosynchronous Large Debris Reorbiter (GLiDeR,) could move a spacecraft weighing 1000 kg a distance of 320 km (200 miles) in two or three months. The dead spacecraft would be evicted from orbital Bel-Air and placed into a Graveyard Orbit. That's not fast, but it doesn't need to be fast. It just needs to work to start solving the problem and freeing up orbital slots in GEO.

It could work, but a lot of details need to be worked out.

Defunct satellites aren't moving in a uniform fashion in GEO. Instead, they're tumbling around wildly, and this invites a serious challenge. But Schaub's team thinks they may be on to a solution.

Their experiments show that a pulsed beam fired in a rhythm can calm down the wild tumbling. Once it's calm, it's easier to deal with. Not only could it be directed into a different orbit, but the beam could even be used to calm spacecraft so a repair vehicle could dock with them, or refuel them. Tricky, but not forever impossible.

Earth's orbit is crowded with debris, and it's only getting worse. It needs a remedy. But Schaub and his team are also looking to the future. The cislunar space between the Earth and the Moon is likely to see the same problem arise, and rather than wait, it would be good to have a solution ready before the region gets too active.

But, there's a huge problem: The Sun.

The plasma environment around Earth is much different than it is nearer the Sun. The Sun emits a constant stream of plasma called the Solar Wind. Sometimes vast blobs of plasma burst free of the Sun's embrace, too.

This video from NASA's Solar Dynamics Observatory spacecraft, orbiting more than 20,000 miles above Earth, shows a stream of plasma burst out from the sun on May 27, 2014. Since the stream lacked enough force to break away, most of it fell back into the sun. The video, seen in a combination of two wavelengths of extreme ultraviolet light, covers a little over two hours. This eruption was minor, and such events occur almost every day on the sun and suggest the kind of dynamic activity being driven by powerful magnetic forces near the sun's surface. Credit: NASA/SDO

The closer to the Sun you go, the more unpredictable the plasma environment is. In cis-lunar space, things can get wild and woolly. As a vehicle travels through the plasma, it can create a kind of wake, similar to a boat moving through water. If you've sat on the shoreline while a large vessel passes by, you know what it's like. A large enough vessel can imperil a smaller vessel with its turbulence and wake.

Since the 'wake' is in plasma, it could disrupt the function of an electron beam.

"That's what makes this technology so challenging," Champion said. "You have completely different plasma environments in low-Earth orbit, versus geosynchronous orbit versus around the moon. You have to deal with that."

The team has developed an ion gun that they've used inside ECLIPS to deal with the Sun's disruptive plasma. It creates its own stream of fast-moving ions. It could be used to shape the plasma region where the spacecraft is operating and counteract the Sun's effect.

We'll soon need a solution similar to what the team is working on in their ECLIPS chamber. The Artemis effort to build a presence on the Moon will mean that cislunar space will develop its own space debris problem. Champion hopes that the work her team is doing can help deal with that problem before it gets started and that it can be a part of the effort to get not only to the Moon but to Mars.

"Once we put people back on the moon, that's a stepping stone to travelling to Mars," Champion said.

The team is also examining the idea of using UV lasers as a replacement for electron beams. UV lasers aren't sensitive to the electrostatic environment the same way electron beams are. This would lead to more controllable systems nearer the Sun, the researchers say, and the lasers could be combined with electron beams to achieve even greater flexibility and results.

So can we add tractor beams to the list of things that make the leap from science fiction to reality? Maybe, but not yet. If they can attract the necessary funding, a prototype electrostatic tractor could be launched into space in five to ten years, Schaub says.

"The exciting thing about this technology is that the same servicing craft could move two or three or even dozens of objects during its lifetime. That brings your cost way down," Schaub said. "No one wants to spend a billion dollars to move trash."

New Satellite Successfully Beams Power From Space

Solar power is the fastest-growing form of renewable energy and currently accounts for 3.6% of global electricity production today. This makes it the third largest source of the renewable energy market, followed by hydroelectric power and wind. These three methods are expected to grow exponentially in the coming decades, reaching 40% by 2035 and 45% by 2050. Altogether, renewables are expected to account for 90% of the energy market by mid-century, with solar accounting for roughly half. However, several technical challenges and issues need to be overcome for this transition to occur.

The main limiting factor for solar power is intermittency, meaning it can only collect power when sufficient sunlight is available. To address this, scientists have spent decades researching space-based solar power (SBSP), where satellites in orbit would collect power 24 hours a day, 365 days a year, without interruption. To develop the technology, researchers with the Space Solar Power Project (SSPP) at Caltech recently completed the first successful wireless power transfer using the Microwave Array for Power-transfer Low-orbit Experiment (MAPLE).

MAPLE was developed by a Caltech team led by Ali Hajimiri, the Bren Professor of Electrical Engineering and Medical Engineering and the co-director of the SSPP. MAPLE is one of three key technologies tested by the Space Solar Power Demonstrator (SSPD-1). This platform consists of an array of flexible, lightweight microwave transmitters controlled by custom electronic chips. The demonstrator was built using low-cost silicon technologies designed to harvest solar energy and beam it to desired receiving stations worldwide.

The SSPP began in 2011 when Donald Bren, a lifetime member of the Caltech Board of Trustees, approached Caltech's then-president Jean-Lou Chameau to discuss the creation of an SBSP research project. Bren and his wife (also a Caltech trustee) agreed to donate a total of $100 million to fund the project, while the Northrop Grumman Corporation provided an additional $12.5 million. The SSPD-1 launched on January 3rd atop a SpaceX *Falcon 9* as part of a rideshare program and was deployed by a Vigoride spacecraft (provided by aerospace company Momentus).

For SBSP to be feasible, the satellites need to be lightweight so they can be launched in a cost-effective way and flexible so they can fit inside payload fairings (similar to the *James Webb Space Telescope* (JWST). Harry Atwater, the Otis Booth Leadership Chair of the Division of Engineering and Applied Science, the Howard Hughes Professor of Applied Physics and Materials Science, and the Director of the Liquid Sunlight Alliance, is one of the project's principal investigators. As he explained in a Caltech press release:

"Demonstration of wireless power transfer in space using lightweight structures is an important step toward space solar power and broad access to it globally. Solar panels already are used in space to power the International Space Station, for example, but to launch and deploy large enough arrays to provide power to Earth, SSPP has to design and create solar power energy transfer systems that are ultra-lightweight, cheap, and flexible."

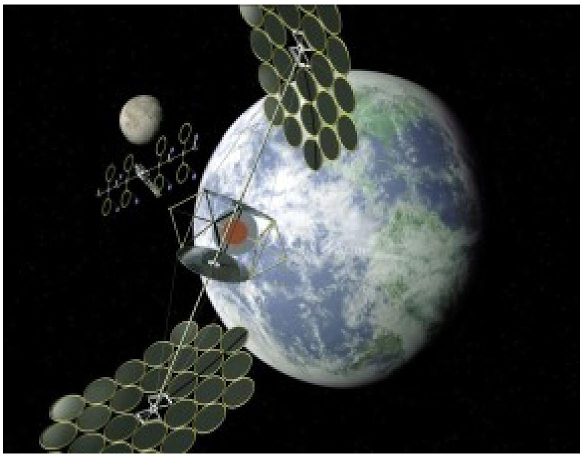
Each SSPP unit weighs around 50 kilograms (~110 lbs), comparable with microsatellites that typically weigh between 10 and 100 kg (22 to 220 lbs). Each unit folds into packages about 1 m3 (~35 ft3) in volume and then unfurls into a flat square measuring about 50 m (164 ft) in diameter, with solar cells on one side and wireless power transmitters on the other. The SPPD-1 components are unsealed, meaning they are exposed to the extreme temperature variations of space. Beyond demonstrating that power transmitters can survive being launched into space, the experiment has provided useful feedback to SSPP engineers.

"Through the experiments we have run so far, we received confirmation that MAPLE can transmit power successfully to receivers in space," said Hajimiri. "We have also been able to program the array to direct its energy toward Earth, which we detected here at Caltech. We had, of course, tested it on Earth, but now we know that it can survive the trip to space and operate there."

The demonstrator has no moving parts and relies on constructive and destructive interference between transmission antennas to shift the focus and direction of the beamed energy. These antennas are clustered in groups of 16, each driven by a custom-made flexible integrated circuit chip. They also rely on precise timing-control elements and the coherent addition of electromagnetic waves to ensure the beamed energy reaches the intended target. Two receiver arrays are positioned about 30 cm (1 ft) from the transmission antennas that convert solar energy into direct current (DC).

This is used to power a pair of LED lights, demonstrating the full sequence of wireless energy transmission. MAPLE successfully demonstrated this by lighting up each LED individually and shifting back and forth between them. MAPLE also includes a small window through which the array can beam energy, which was detected by a receiver at Caltech's Gordon and Betty Moore Laboratory of Engineering. This signal was received at the expected time and frequency and had the predicted frequency shift based on its orbit.

"To the best of our knowledge, no one has ever demonstrated wireless energy transfer in space even with expensive rigid structures," said Hajimiri. "We are doing it with flexible lightweight structures and with our own integrated circuits. This is a first." The team is now assessing the performance of individual system elements by testing the interference patterns of smaller groups and measuring the difference between combinations. This process could take up to six months, giving the team ample time to detect irregularities and develop solutions to inform the next generation of solar satellites.



Artist's concept of a space-based solar array. Credit NASA/SAIC

In addition to MAPLE, the SSPD-1 carries two other main experiments. These are the Deployable on-Orbit ultraLight Composite Experiment (**DOLCE**), a 1.8 x 1.8-meter (6 x 6-foot) structure designed to deploy small modular spacecraft, and **ALBA**, a series of 32 different types of photovoltaic cells to test which are most effective in space. The ALBA tests are ongoing while DOLCE has not yet been deployed, and results from these experiments are expected in the coming months. Meanwhile, the results from the MAPLE experiment are very encouraging and demonstrate key SBSP technologies are feasible. Said Hajimiri:

"In the same way that the internet democratized access to information, we hope that wireless energy transfer democratizes access to energy. No energy transmission infrastructure will be needed on the ground to receive this power. That means we can send energy to remote regions and areas devastated by war or natural disaster."

SBSP has the potential to yield eight times more power than solar panels located on Earth's surface. When the project is fully realized, Caltech hopes to deploy a constellation of modular spacecraft that will collect solar power, transform it into electricity, and convert it to microwaves that can be transmitted wirelessly over anywhere in the world. In addition to assisting the transition towards clean, renewable energy, it also has the potential to expand access for underserved communities. Said Caltech President Thomas F. Rosenbaum:

"The transition to renewable energy, critical for the world's future, is limited today by energy storage and transmission challenges. Beaming solar power from space is an elegant solution that has moved one step closer to realization due to the generosity and foresight of the Brens. Donald Bren has presented a formidable technical challenge that promises a remarkable payoff for humanity: a world powered by uninterruptible renewable energy."

Further Reading: Caltech

The Latest JWST Image Pierces Through a Shrouded Star-Forming Galaxy

Sometimes an image is so engrossing that we can ignore what it's telling us about its subject and just enjoy the splendour. That's certainly true of this image of NGC 5068 released by the ESA. But Universe Today readers are curious, and after enjoying the galactic portrait for a while, they want to know more.

NGC 5068 is pretty close for a galaxy. It's about 17 million light-years away and is face-on from our perspective, making it an optimal object for scientific observations. It's more than 45,000 light-years across and is a field galaxy, meaning it's not associated with a galaxy group or cluster. NGC 5068 is kind of alone out there.

The JWST's view of the galaxy comes from two of its instruments: MIRI and NIRCam. Each of those two instruments captured NGC 5068, and the main image is a combination of the two.

The image shows myriad individual stars, and clouds of gas lit up by the stars embedded in them. While those are stunning, and the JWST's ability to resolve so many stars is extraordinary, something else draws our attention: the galaxy's bar, seen in the upper mid-left.

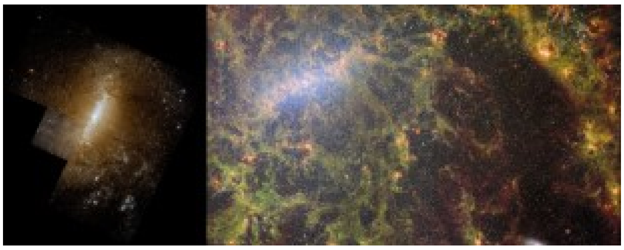
These are the two separate images of NGC 5068 that were combined into the single leading image. On the left is the MIRI image, and on the right is the NIRCam image. Image Credits: ESA/Webb, NASA & CSA, J. Lee and the PHANGS-JWST Team

JWST captured the images as part of the PHANGS (Physics at High Angular resolution in Nearby GalaxieS) program, which studies the multiscale processes of galaxy evolution, star formation, and stellar feedback. PHANGS combines high-resolution observations with the latest theoretical models. The JWST is the latest contributor, but other telescopes like the Hubble and ALMA have already made important contributions to PHANGS.

The idea behind PHANGS is to measure the earliest stages of star formation and feedback. They also want to understand how starlight affected by dust can trace gas and star formation across diverse galactic environments. In short, star formation affects a lot of things, and a better understanding of the entire process will lead to discoveries in other areas of astrophysics and astronomy.

That's ambitious, but the PHANGS team has made a lot of headway, including recently publishing their 100th paper. The JWST is the latest telescope to contribute, and as these JWST images make clear, PHANGS has more progress and papers in its future.

PHANGS already has a large collection of images and data of things like star clusters, active star-formation regions, molecular clouds and complexes, and star-forming emission nebula. But the JWST is taking PHANGS to the next level. Its infrared observing power can peer through the clouds of gas and dust that hide the star-forming process from other telescopes. One of the JWST's explicit science goals is to peer into these shrouded regions more effectively than its predecessors.



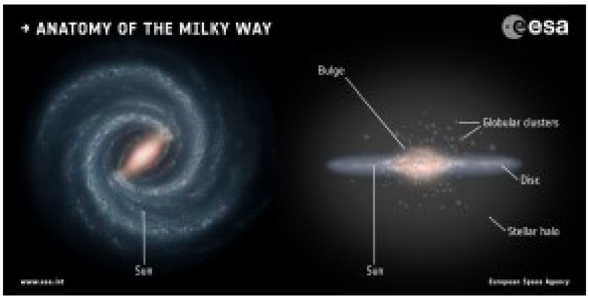
These two images show how powerful the JWST (R) is compared to the Hubble (L). Image Credit: **(L)** NASA/ESA – The Hubble Legacy Archive (HLA): Space Telescope Science Institute (STScI), the Space Telescope European Coordinating Facility (ST-ECF), and the Canadian Astronomy Data Centre (CADC) – zoranknez (Aladin software). **(R)** ESA/Webb, NASA & CSA, J. Lee and the PHANGS-JWST Team

Astronomers are interested in barred spiral galaxies like NGC 5068 for a bunch of reasons, but their bars are an area of particular focus. Bars affect the flow of star-forming gas in the galaxy, and astronomers want to better understand the role they play.

Bars have an important job. They channel gas from the spiral arms into the galactic center and trigger star birth. They also mix material in the inner regions of a galaxy and stimulate radial migration. Astronomers think that the bars are a recurring rather than permanent feature. On a scale of about two billion years, a galaxy oscillates between having a bar and not having one.

There's some evidence that bars influence what's called a metallicity gradient, but it's not conclusive. Metallicity refers to the presence of elements heavier than hydrogen and helium. Everything heavier than hydrogen and helium was created inside stars, while hydrogen and helium have been around since the Big Bang. So metallicity tells astronomers a lot about the nature, age, and composition of a galaxy.

Typically, the stars furthest from the galactic center, in the galactic halo, are older and have the lowest metallicity. Near the galactic center, where the bar channels gas, stars are younger and have higher metallicity. A galaxy's metallicity gradient describes how the metallicity changes from the galactic nucleus to the central bulge, the disk, the spiral arms, and finally, the halo. The globular clusters on the periphery of a galaxy contain the most ancient stars with the lowest metallicity.

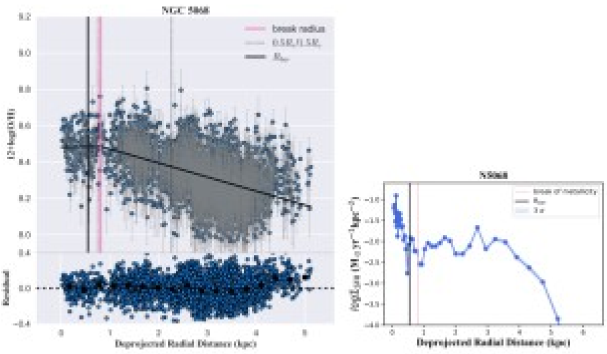


This image shows the anatomy of the Milky Way, also a barred spiral galaxy. Younger stars with higher metallicity exist in the center, while older stars with lower metallicity are in the halo. Image Credit: ESA

The metallicity gradient is an important feature of galaxies like NGC 5068. It's a measure of how rich a galaxy is in elements heavier than hydrogen and helium and how those elements are spread through the galaxy. The early stages of a galaxy's evolution leave an imprint on the gradient. When astronomers can plot the metallicity of stars from the galactic center outwards, it creates a gradient.

In the Milky Way, the gradient shows decreasing metallicity from the core to the halo. That's called a negative gradient. As observing technologies have improved, astronomers have found more detail in the gradients. Barred spirals have a break in the slope, indicating that something shifted as the galaxy evolved. The break in the slope can be shallow, then steep, or steep, then shallow.

NGC 5068 has a 'shallow-steep' metallicity radial profile, meaning that the inner stars have similar metallicity, hence, a shallow slope. But the outer stars have more variation in their metallicity, meaning they have a shallow slope in the gradient.

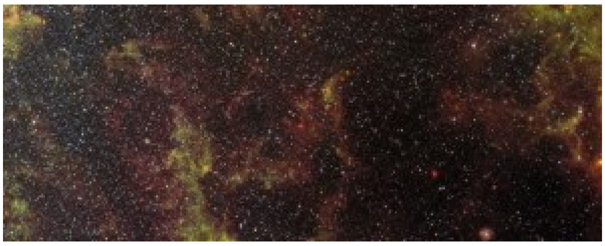


This figure helps illustrate what a metallicity gradient looks like in NGC 5068. It shows the abundance of oxygen, which is considered a metal in astronomy. As the distance from the center of the galaxy increases, the abundance of oxygen decreases. At first, the gradient is shallow, but it drops more steeply with distance. So NGC 5068 has a shallow-steep gradient. Image Credit: Chen et al. 2023.

A 2023 paper showed how NGC 5068's bar induces gas inflows into the central region. The inflows mix interstellar medium inside the bar region, which flattens the metallicity gradient within the break radius (0.82 kpc). "The nearly flat (?0.005 dex/kpc) inner metallicity gradient is strong evidence for efficient radial migration and material mixing driven by the bar," the paper states.

While a galaxy's bar affects the metallicity gradient, there's no single way that happens. Different barred spiral galaxies show different gradients, so there's no single common mechanism. There's a lot going on in a galaxy's center, and while a bar can channel new star-forming gas into the region and drive star formation, there are also outflows that have their own effect.

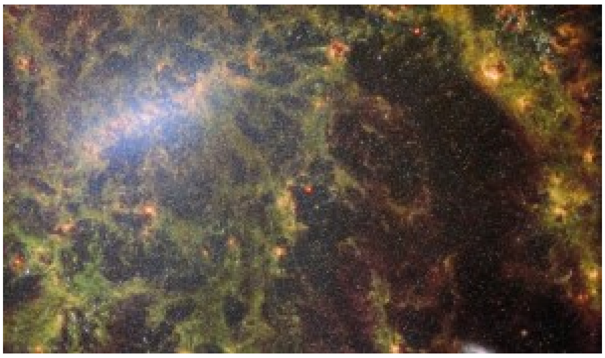
These are the types of details that astronomers are trying to understand better with the JWST. But the image is stunning, regardless of how deeply we want to dig into it.



Zooming in on any part of the image brings it to life. It shows a myriad of individual stars and gas clouds and filaments lit up by stars. Image Credit: ESA/Webb, NASA & CSA, J. Lee and the PHANGS-JWST Team

Astronomy is about understanding the cosmos and how we're a part of it all. But it's also about wonder and open-hearted awe at the beauty and grandeur of nature.

The JWST is feeding us a balanced diet of both.



NGC 5068 in all its glory. ESA/Webb, NASA & CSA, J. Lee and the PHANGS-JWST Team

It Might Take Space Telescopes to Finally Resolve the Crisis in Cosmology

Gravitational wave (GW) observatories have been a great addition to cosmologists' arsenal in the lack decade. With their first effective detection at the Laser Interferometric Gravitational Observatory completed in 2015, they opened up a whole new world of data collection for scientists. However, so far, they haven't solved one of the fundamental problems at the heart of their discipline – the "Hubble tension." Now a new paper discusses the possibility of utilizing a network of new, space-based gravitational wave observatories to get closer than ever to the real value of one of the most important numbers in the Universe.

Edwin Hubble didn't actually discover "Hubble's Law," the equation that contains the constant that bears his name – that work was done earlier and independently by Alexander Friedmann and George Lemaitre. Their work showed that the Universe was expanding and that the rate it was growing seemed determined by the distance between the observer and the galaxy itself.

Now commonly accepted as the expansion of the Universe, this was a groundbreaking theory in the 1920s when it was initially formulated. However, like many good scientific theories, it can be simplified to a single equation: $v = H0D$. In this case, v is the speed of separation (the expansion of the Universe), D is the distance to the galaxy being compared, and H0 is known as the "Hubble Constant."

Anton explains another potential wrinkle in the search for the true Hubble constant – it might not be constant at all.
Credit – Anton Petrov YouTube Channel

The Hubble constant has been a source of argument for years, as its value literally will help determine the fate of the Universe. If it's large, then the Universe will end in heat death, where galaxies are so far apart from one another that they can't ever possibly interact. Alternatively, if it is small, the Universe could end in a "Big Bounce" where gravity overcomes the expansionary force of the Universe. Eventually, everything gets pulled back into a single, solitary point, much like another Big Bang.

Its importance gives scientists plenty of reasons to fret about the Hubble Constant, but it has been notoriously difficult to pin down an exact number, and various experiments have resulted in some variance in the reading. It has never reached a precision threshold that the scientific community is willing to accept – commonly thought to be within 0.9%. In particular, two well-regarded measurement methods, cosmic microwave background radiation measurements and the distance ladder method, don't agree on the value.

According to a new paper from researchers at Northeastern University in China, gravitational waves can resolve this "Hubble Tension" at the heart of cosmology. Recently there has been a flood of new science following the detection of the first gravitational wave. Still, this fundamental new type of instrument could make plenty of other discoveries. But results from even the most sensitive detectors here on Earth would not be able to fully constrain the Hubble constant to a point where its value could finally be ascertained.

UT video on the Universe's expansion.

So why not put the sensing platforms in space? This has several advantages, including not as much interference from ground-based sources of jitter (i.e., earthquakes), but more importantly, they can coordinate together. Several gravitational wave observatories are already planned for launch in the coming decades. Taiji, TianQin, and LISA are all observatories that, when tied together, can detect gravitational waves at the millihertz level. These are typically formed by merging massive black hole binaries, and sometimes those events are joined by emission in the electromagnetic spectrum (i.e., light). Combining the gravitational observatories' detection of gravitational waves with a fortuitous EM signal could help find and constrain the Hubble constant in a way not possible before.

That dream is still a long way off, as none of the space-based gravitational wave observatories are functional yet, and some won't be for at least a decade. However, when they do come online, cosmologists will surely be interested in what data they can collect regarding this most important of numbers, and maybe, humanity will finally get to know the Universe's fate.

Learn More:
Jin et al – The Taiji-TianQin-LISA network: Precisely measuring the Hubble constant using both bright and dark sirens
UT – Is the Hubble constant not…Constant?
UT – Astronomers Have a New Way to Measure the Expansion of the Universe
UT – Hubble's Law

Starliner Faces New Delays for Crewed Flights to ISS

While the SpaceX Crew Dragon is making regular trips to and from the International Space Station, the other vehicle NASA was planning to rely on for crew transportation keeps running into problems and delays. Boeing and NASA just announced another set of delays for the CST-100 Starliner spacecraft, pushing it even further back from its proposed July launch window — which was already years behind schedule.

Problems with its parachute lines and the electrical system were identified, and the program manager isn't sure if Starliner will even fly by the end of 2023.

"We've been working to understand these issues," said Mark Nappi, Boeing's Starliner program manager, "and we've decided to stand down the preparation for the CFT (Crew Flight Test) mission in order to correct these problems."

During reviews over the past several weeks, engineers uncovered two issues that can't be fixed before mid-year. The "soft links" that connect parachute suspension lines to the spacecraft are not strong enough, and the tape that wraps electrical lines use a flammable adhesive.

The kicker is that tests on these items had been run previously and no one caught the problems until now.

"These tests were run many years ago. We reviewed those results. We missed those results, and this could have been caught sooner," Nappi said.

Astronaut Sunni Williams puts on the communications carrier of Boeing's Starliner spacesuit. Credits: Boeing

Veteran astronauts Barry "Butch" Wilmore and Sunita Williams were scheduled to launch on Starliner's flight atop a United Launch Alliance Atlas 5 rocket on July 21. This would have been Starliner's third flight to the International Space Station, but the first with a crew.

Steve Stich, NASA manager of the Commercial Crew Program, said Wilmore and Williams were part of an all-hands meeting to discuss the issues and agreed with the decision to stand down.

"This team will solve these problems and we'll go fly when we're ready," Stich said. "Suni Williams was representing the crew and she voiced they are 100 % behind the decision. They understand that the team has crew safety first and foremost in their minds and they'll fly when the vehicle's ready to go fly."

While SpaceX has now completed 10 crew flights (with three of them private) since its first crewed flight in 2020, Boeing had to repeat its 2019 test flight without a crew because of software problems and other issues. The original plan had been for SpaceX and Boeing to each provide one taxi flight to the ISS each year.

Artist's impression of the Boeing CST-100 Starliner in orbit. Credit: Boeing

"NASA desperately needs a second provider for crew transportation," said Stich.

NASA extended SpaceX's initial six-flight contract to 14, which will provide ISS crew flights through 2026. Both SpaceX and Boeing were awarded Commercial Crew Program (CCP) contracts in 2014 to develop next-generation crew-rated capsules that would transport astronauts and payloads to the ISS and other locations in Low-Earth Orbit. Boeing's contract has not been extended beyond the initial six crew rotation flights booked in 2014, and Nappi said the company is absorbing the costs of the delays.

Despite the delays, Stich said NASA is still counting on Boeing — a long-time player in the space sector — to provide access to the International Space Station through the end of the decade.

"There's an unwavering commitment to Starliner and to having a second crew transportation system," he said.

Jupiter's "Stripes" Change Colour. Now We Might Know Why

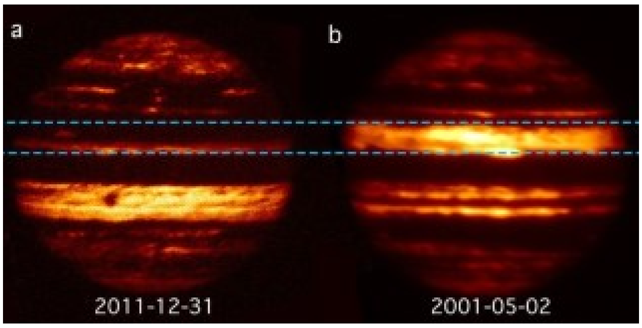
While Jupiter's Great Red Spot is one of the most well-known spectacles in the solar system, Jupiter's clouds and stripes that are responsible for the planet's weather patterns are highly regarded, as well. Though not nearly as visible in an amateur astronomy telescope, Jupiter's multicolored, rotating, and swirling cloud stripes are a sight to behold for any astronomy fan when seen in up-close images. And, what makes these stripes unique is they have been observed to change color from time to time, but the question of what causes this color change to occur has remained elusive.

This is what a recent study published in *Nature Astronomy* hopes to address as an international team of researchers examine how Jupiter's massive magnetic field could be responsible for Jupiter's changing stripe colors. This study was led by Dr. Kumiko Hori of Kobe University and Dr. Chris Jones of the University of Leeds and holds the potential to help scientists better understand how a planet's magnetic field could influence a planet's weather patterns. In this case, Jupiter's massive magnetic field influencing its massive, swirling clouds.

"If you look at Jupiter through a telescope, you see the stripes, which go round the equator along lines of latitude," explains Dr. Jones. "There are dark and light belts that occur, and if you look a little bit more closely, you can see clouds zipping around carried by extraordinarily strong easterly and westerly winds. Near the equator, the wind blows eastward but as you change latitude a bit, either north or south, it goes westward. And then if you move a little bit further away it goes eastward again. This alternating pattern of eastward and westward winds is quite different from weather on Earth."

While previous studies have demonstrated that Jupiter's appearance is somehow altered by infrared fluctuations approximately 50 km (31 mi) below the gas cloud surface, this most recent study demonstrates the infrared fluctuations could be caused by Jupiter's magnetic field, the source of which, like Earth, is far deeper inside the planet.

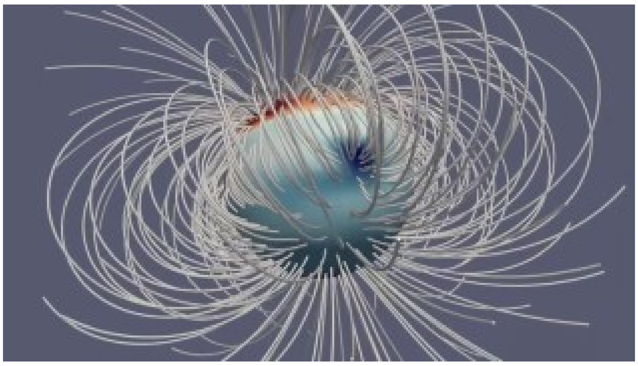
"Every four or five years, things change," said Dr. Jones. "The colors of the belts can change and sometimes you see global upheavals when the whole weather pattern goes slightly crazy for a bit, and it has been a mystery as to why that happens."



Infrared images of Jupiter obtained by a ground-based telescope displaying changes in the color of Jupiter's clouds between 2001 and 2011 (dashed blue lines). (Credit: Arrate Antuñano/NASA/IRTF/NSFCam/SpeX)

For the study, the researchers analyzed data collected over several years from NASA's Juno spacecraft to both observe and measure variations in Jupiter's magnetic field, more commonly known as oscillations. Despite Jupiter's massive radiation belt which can cause immense harm to any spacecraft, Juno has been orbiting the solar system's largest planet since 2016 and is frequently lauded for it still being active despite the constant bombardment from the radiation.

From the data, the team was able to monitor the magnetic field's waves and oscillations. They focused on a specific area of the magnetic field dubbed the Great Blue Spot, which is invisible to the naked eye and located near Jupiter's equator. While this spot has been observed to be traveling eastwards on Jupiter, the data from this study indicates the spot is slowing down, which the team interprets as the start of an oscillation within the magnetic field, meaning the spot could eventually slow enough to where it reverses direction and starts traveling westwards.



Still image taken from a video animation featuring Jupiter's massive magnetic field at one instant in time, specifically its Great Blue Spot located near Jupiter's equator that is invisible to the naked eye, and was a focus for this study. (Credit: NASA/JPL-Caltech/Harvard/Moore et al.)

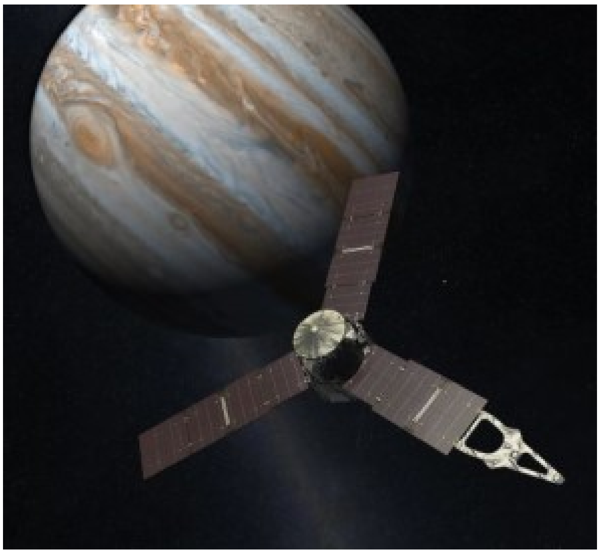
The study's findings indicate that these oscillations could explain the changes in Jupiter's stripes and bands over time, but the study stops short of saying this is the definitive reason for it.

"There remain uncertainties and questions, particularly how exactly the torsional oscillation produces the observed infrared variation, which likely reflects the complex dynamics and cloud/aerosol reactions," said Dr. Hori, who conducted the research while at the University of Leeds and is lead author on the study. "Those need more research. Nonetheless, I hope our paper could also open a window to probe the hidden deep interior of Jupiter, just like seismology does for the

Earth and helioseismology does for the Sun."

NASA's Juno Spacecraft

Launched in 2011 and arriving at Jupiter five years later, NASA's Juno spacecraft has sent back some of the most breathtaking up-close images of Jupiter ever taken, along with images of Jupiter's Galilean Moons on occasion due to the spacecraft's elongated orbit around Jupiter. This most recent study demonstrates Juno's ongoing commitment to conducting new science that teaches researchers something new about Jupiter and its harsh environment.



Artist rendition of Jupiter and NASA's Juno spacecraft. (Credit: NASA/JPL-Caltech)

Now in its seventh year of science operations around Jupiter, Juno is currently scheduled to explore the solar system's largest planet until September 2025, or until Juno's end of life.

What discoveries about Jupiter and its massive magnetic field will Juno teach us in the next few years? Only time will tell, and this is why we science!

Betelgeuse is Almost 50% Brighter Than Normal. What's Going On?

Whenever something happens with Betelgeuse, speculations about it exploding as a supernova proliferate. It would be cool if it did. We're far enough away to suffer no consequences, so it's fun to imagine the sky lighting up like that for months.

Now the red supergiant star has brightened by almost 50%, and that has the speculation ramping up again.

Betelgeuse will explode as a supernova. On that, there is universal agreement. But the question of when is less certain. The star's behaviour is confounding. How can puny humans find out?

Betelgeuse isn't only a red supergiant, it's also a pulsating semiregular variable star. That means there's some periodicity in its brightness changes, though the amplitudes can vary. It has an approximately 400-day cycle where its brightness changes. It also has a shorter 125-day cycle, another 230-day cycle, and a whopping 2200-day cycle, all determined by pulsations. All those cycles can make the star difficult to understand clearly.

A couple of years ago, Betelgeuse dimmed, and people wondered what that meant. It turns out that the star's brightness didn't actually change. Instead, the star had ejected material from its surface that cooled into a dust cloud and blocked the light. The episode is called 'The Great Dimming.'

This graphic shows what likely caused Betelgeuse to become dimmer for a time in 2019. Credit: NASA, ESA, and E. Wheatley (STScI)

Now that it's brightening, it's attracting scientists' attention again. They want to know what evolutionary stage it's in and what all this activity signifies. New research shows that it could explode as a supernova sooner than anyone expected.

The new paper is "The evolutionary stage of Betelgeuse inferred from its pulsation periods." The first author is Hideyuki Saio from the Astronomical Institute, Graduate School of Science, at Tohoku University in Japan. The Monthly Notices of the Royal Astronomy Society has accepted the paper for publication.

The juiciest parts of new research often grab the headlines. No sense railing against that. That's how humanity rolls.

We're not picking on Dr. Eldridge. She's not wrong. It's just that the paper says that's only one possible outcome. It outlines several others.

In their paper, the authors say that Betelgeuse could be the Milky Way's next supernova, regardless of which of their outcomes might prove to be true. "We conclude that Betelgeuse is in the late stage of core carbon burning, and a good candidate for the next Galactic supernova," they write.

As a red supergiant, Betelgeuse has left the main sequence. Throughout its long 8 to 8.5 million-year history, it used up vast quantities of hydrogen by fusing it into helium and releasing the lost mass from that fusion as energy. (Thanks Einstein.) That means it's not fusing hydrogen into helium anymore like the Sun is. When stars like Betelgeuse lose mass, their gravity can no longer contain their outward pressure, and they expand into a more voluminous envelope. So despite losing mass, they grow in size.

This schematic shows the scale of the red supergiant Betelgeuse and its circumstellar medium compared to that of the Solar System. Image Credit: L. Calçada, European Southern Observatory (ESO)

After stars like Betelgeuse leave the main sequence and no longer fuse hydrogen into helium in their cores, things change dramatically. During the helium fusion stage that follows, carbon builds up in their cores. Then they begin a core carbon-burning period that produces other elements. The authors of the new paper say that Betelgeuse is in the late stages of that period.

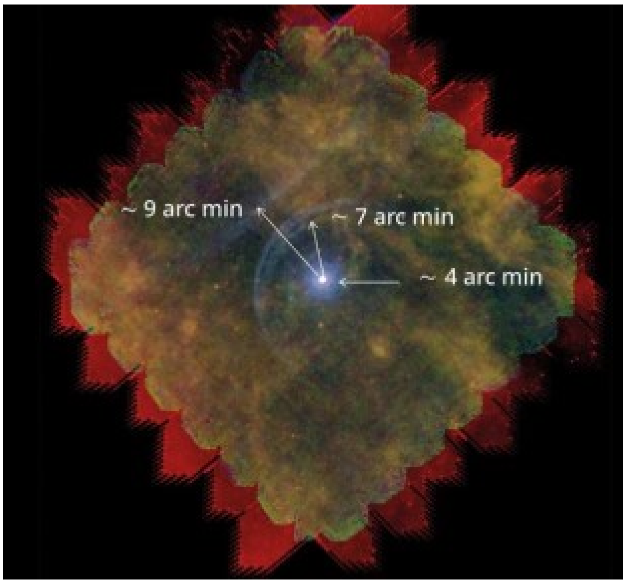
But how late? How much time is left? There's no exact answer for that yet.

"Despite the relatively small distance from Earth, and in some sense because of it, it has been difficult to obtain tight constraints on the distance, luminosity, radius, current and Zero Age Main Sequence (ZAMS) masses, and information about the internal rotational state and associated mixing and hence on the evolutionary state of Betelgeuse and when it might explode," write the authors of a new review of Betelgeuse. ZAMS is particularly critical to understanding the evolutionary stage of particular stars. It's fundamental, though not solely responsible.

But the study presents some solid possibilities.

The work is a combination of observations and models that each suit the observations in different ways. It's a tricky business, which is why headlines or Tweets claiming it could explode in tens of years are a little misleading. Nuance seldom attracts attention.

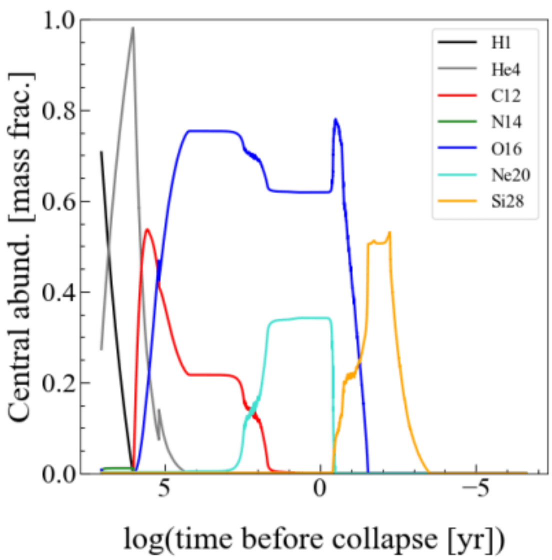
The core carbon-burning period has several stages. The difficulty in determining when Betelgeuse will go supernova comes partly from determining which of those stages it's in. Betelgeuse pulses, ejects material, rotates, and on top of that, is a runaway star speeding through space. Its distance from us is also subject to debate. "Although it lies only ~200 parsecs from Earth, and hence can be spatially resolved with appropriate instrumentation, uncertainties in its distance remain a critical impediment to deeper understanding," the Betelgeuse review explains.



This image is based on data from the Herschel mission and shows the circumstellar medium (CSM) surrounding Betelgeuse as it speeds through space. There's a prominent bow shock at 7 arc min, evidence of its movement. There's also another feature in the CSM at 9 arc minutes that could be evidence of a past merger or material expulsion from Betelgeuse. Betelgeuse is complex and difficult to understand. Image Credit: Decin et al. 2012.

What's attracted everyone's attention is these two sentences from the research: "According to this figure, the core will collapse in a few tens years after the carbon exhaustion. This indicates Betelgeuse to be a very good candidate for the next Galactic supernova, which occurs very near to us."

This is the figure they're talking about.



This figure from the study shows the abundance of different elements in Betelgeuse. Elemental abundances are like a fingerprint or snapshot of what's happening inside the core, what stage of carbon-burning the star's in, and when it will explode. Fusion products from the core are periodically dredged up from the core to the surface by convection, giving researchers a glimpse into the core. But nailing down when it'll explode also depends on knowing the star's initial mass, how quickly it's rotating, and a host of other factors, all of which are difficult to determine to varying degrees. Image Credit: Saio et al. 2023.

But what hasn't attracted as much attention is the following part of the paper.

"In fact, it is not possible to determine the exact evolutionary stage, because surface conditions hardly change in the late stage close to the carbon exhaustion and beyond," the researchers write. Astronomers can only see the surface, but it's what's happening deep inside the star that tells the tale.

The authors of the paper are really saying that according to observations, data, and modelling, Betelgeuse could explode sooner than thought. But—and this is critical—they don't know what stage of core carbon-burning the star's in. Carbon burning could go on for a long time, according to some of the models that fit the data.

But not everyone agrees that Betelgeuse is even in the core carbon-burning stage. The authors of the Betelgeuse review say that the star is still in the helium phase. "Since core helium burning is far longer than subsequent burning phases, Betelgeuse is most likely in core helium burning. The pulsation period likely constrains the radius and distance and the evolutionary state to core helium burning," they write, while acknowledging that there are "arguments to the contrary."

Another way the researchers tried to determine the timing of Betelgeuse's supernova explosion is by matching its periodic pulsations with models of the same. That's what Jonathan McDowell is referring to in the above Tweet.

Table 2. Model examples which excite pulsations consistent with periods of Betelgeuse

Model αOri	$M_i^{(a)}$	α/α_{MLT}	P_0 [d] 2190 ± 270	P_1 [d] 417 ± 24	P_2 [d] 230 ± 29	P_3 [d] 185 ± 4	$M^{(a)}$	$\log L/L_\odot$ 5.18 ± 0.11	$\log T_{eff}$ [K] 3.544 ± 0.009	$\log R/R_\odot$	$X_c(C)^{(b)}$
A	19	0.4	2199	418	240	178	11.23	5.279	3.532	3.100	0.0067
B	19	0.2	2186	434	232	181	11.73	5.276	3.526	3.109	0.0048
C	19	0.2	2181	434	252	184	11.73	5.275	3.526	3.109	0.0500
D	19	0.2	2168	428	249	181	11.73	5.265	3.526	3.103	0.1712

(a) Initial mass M_i and present mass M in the solar unit.
(b) Mass fraction of carbon at the center.

This figure from the research presents four models that match Betelgeuse's (alpha Ori) four cycles or periods. If you're not an astrophysicist, it's confusing. (I'm not one, and I'm confused.) But it does help illustrate the complexity behind predicting Betelgeuse's explosion, and the uncertainty. Image Credit: Saio et al. 2023.

When it finally explodes—and nobody disagrees with its eventual explosion as a supernova—it's not likely to produce a deadly gamma-ray burst as some supernovae do. And while it will eject material and produce powerful X-ray and UV radiation, we're too far away to be affected. Instead, it'll be a light show visible to the entirety of humanity, and that will change the Orion constellation forever. Scientists say it'll probably leave behind a neutron star, maybe a pulsar that will be visible for millions of years. The entire event, from start to finish, will be an unprecedented opportunity to study stellar evolution, supernovae, and stellar remnants. Scientists will be able to work backwards from the explosion to all the research done and all the observations and data and pinpoint where they were correct and where they were wrong. Old Betelgeuse will teach them a lot.

The shock wave from the supernova will arrive in about 100,000 years and will be easily deflected by our Sun's solar magnetosphere. The biggest effect on Earth will be an increase in cosmic rays striking our upper atmosphere.

Most of us will behold this calamitous explosion and sit in rapt awe of nature's power, we hope, while others will degenerate into weird conspiracy theories or quasi-religious, pseudo-scientific, cult-like reverence.

If, that is, humanity is still around when the blessed event occurs.

JWST Scans an Ultra-Hot Jupiter's Atmosphere

When astronomers discovered WASP-18b in 2009, they uncovered one of the most unusual planets ever found. It's ten times as massive as Jupiter is, it's tidally locked to its Sun-like star, and it completes an orbit in less than one Earth day, about 23 hours.

Now astronomers have pointed the JWST and its powerful NIRSS instrument at the ultra-Hot Jupiter and mapped its extraordinary atmosphere.

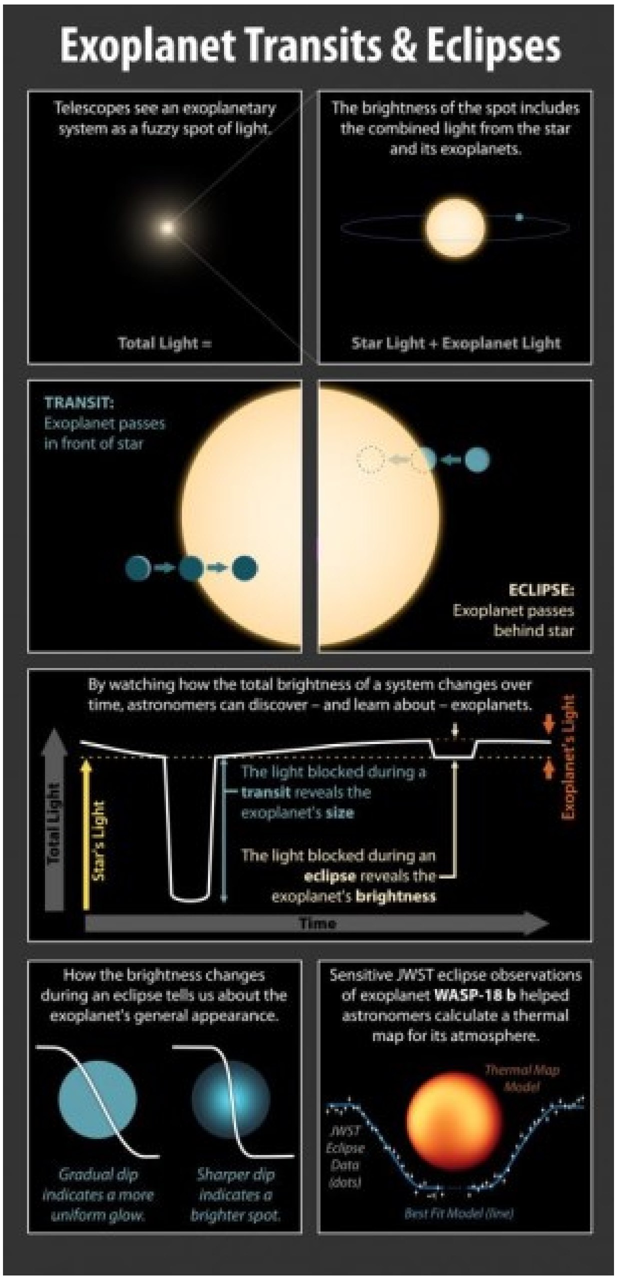
Ever since its discovery, astronomers have been keenly interested in WASP-18b. For one thing, it's massive. At ten times more massive than Jupiter, the planet is nearing brown dwarf territory. It's also extremely hot, with its dayside temperature exceeding 2750 C (4900 F.) Not only that, but it's likely to spiral to its doom and collide with its star sometime in the next one million years.

For these reasons and more, astronomers are practically obsessed with it. They've made extensive efforts to map the exoplanet's atmosphere and uncover its details with the Hubble and the Spitzer. But those space telescopes, as powerful as they are, were unable to collect data detailed enough to reveal the atmosphere's properties conclusively.

Now that the JWST is in full swing, it was inevitable that someone's request to point it at WASP-18b would be granted. Who in the Astronomocracy would say no?

In new research, a team led by a Ph.D. student at the University of Montreal mapped WASP-19b's atmosphere with the JWST. They used the NIRISS instrument, one of Canada's contributions to the JWST. The paper is "A broadband thermal emission spectrum of the ultra-hot Jupiter WASP-18b." It's published in Nature, and the lead author is Louis-Philippe Coulombe.

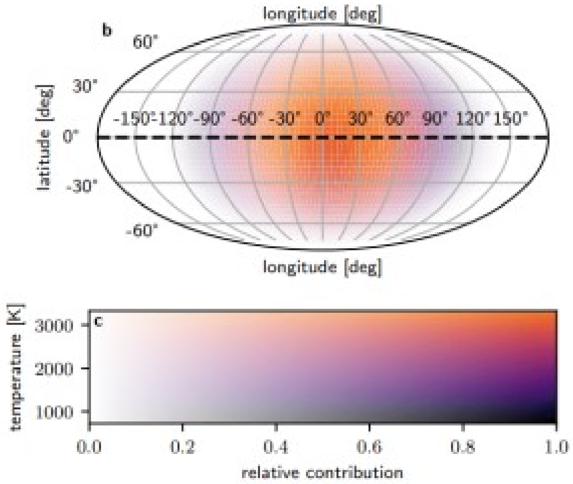
The researchers trained Webb's NIRISS (Near-Infrared Imager and Slitless Spectrograph) on the planet during a secondary eclipse. This is when the planet passes behind its star and emerges on the other side. The instrument measures the light from the star and the planet, then during the eclipse, they deduct the star's light, giving a measurement of the planet's spectrum. The NIRISS' power gave the researchers a detailed map of the planet's atmosphere.



This NASA infographic explains how transits and eclipses can reveal information about an exoplanet. Image Credit: NASA/JPL-Caltech (R. Hurt/IPAC)

With the help of NIRISS, the researchers mapped the temperature gradients on the planet's dayside. They found that the planet is much cooler near the terminator line: about 1,000 degrees cooler than the hottest point of the planet directly facing the star. That shows that winds are unable to spread heat efficiently to the planet's nightside. What's stopping that from happening?

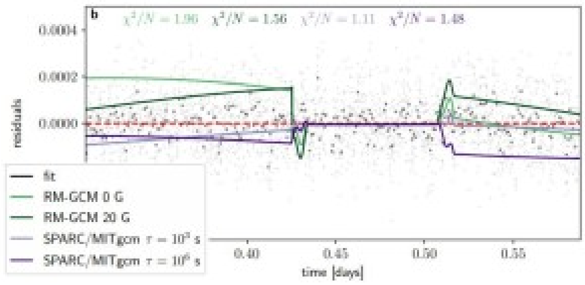
"JWST is giving us the sensitivity to make much more detailed maps of hot giant planets like WASP-18 b than ever before. This is the first time a planet has been mapped with JWST, and it's really exciting to see that some of what our models predicted, such as a sharp drop in temperature away from the point on the planet directly facing the star, is actually seen in the data!" said paper co-author Megan Mansfield, a Sagan Fellow at the University of Arizona.



This figure from the research is a heat map of WASP-18 b's atmosphere. The top panel shows how the point facing the star is much hotter than at other longitudes. At 0°, the temperature is 3121 K, at -90°, it's 1744 K, and at 90° the temperature is 2009 K. (2850 C, 1470 C, and 1735 C.) Image Credit: Coulombe et al. 2023.

The lack of winds moving the atmosphere around and regulating the temperature is surprising, and atmospheric drag has something to do with it.

"The brightness map of WASP-18 b shows a lack of east-west winds that is best matched by models with atmospheric drag," said co-author Ryan Challener, a post-doctoral researcher at the University of Michigan. "One possible explanation is that this planet has a strong magnetic field, which would be an exciting discovery!"



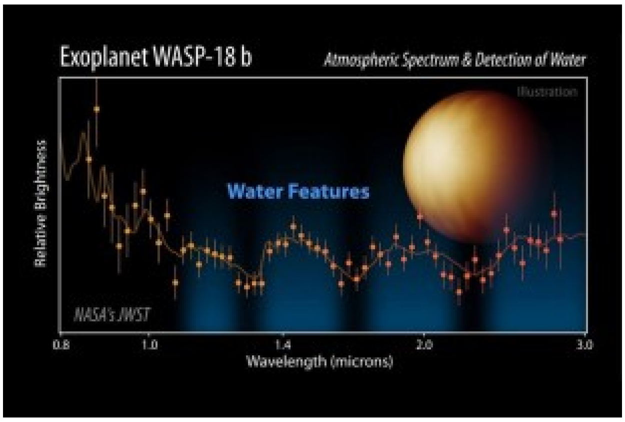
This figure from the research helps show how atmospheric drag can create a lack of heat-spreading east-west winds. The legend shows 'fit' and then four different atmospheric GCMs (General Circulation Models.) Two of the models, RM-GCM 20 G and SPARC/MITgcm ? = 10^3 s, have strong atmospheric drag, and they both match the data better than their counterparts, which feature little atmospheric drag. Image Credit: Coulombe et al. 2023.

In our Solar System, Jupiter has the strongest magnetic field. Scientists think that swirling conducting materials deep inside the planet, near its bizarre liquid, metallic hydrogen core generates the magnetic fields. The fields are so powerful that they protect the three Galilean moons from the solar wind. They also generate permanent aurorae and create powerful radiation belts around the giant planet.

But WASP-18 b is ten times more massive than Jupiter, and it's reasonable to think its magnetic fields are even more dominant. If the planet's magnetic field is responsible for the lack of east-west winds, it could be forcing the winds to move over the North Pole and down the South Pole.

The researchers were also able to measure the atmosphere's temperature at different depths. Temperatures increased with altitude, sometimes by hundreds of degrees. They also found water vapour at different depths.

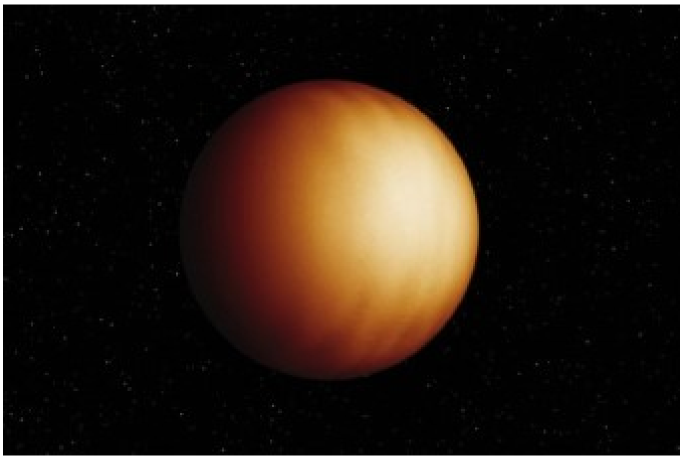
At 2,700 Celsius, the heat should tear most water molecules apart. The fact that the JWST was able to spot the remaining water speaks to its sensitivity.



The team obtained the thermal emission spectrum of WASP-18 b by measuring the amount of light it emits over the Webb Telescope's NIRISS SOSS 0.85 – 2.8 micron wavelength range, capturing 65% of the total energy emitted by the planet. WASP-18 b is so hot on the day side of this tidally locked planet that water molecules would be vaporized. Webb directly observed water vapour on the planet in even relatively small amounts, indicating the sensitivity of the observatory.
CREDIT: NASA/JPL-CALTECH/R. HURT

"Because the water features in this spectrum are so subtle, they were difficult to identify in previous observations. That made it really exciting to finally see water features with these JWST observations," said Anjali Piette, a postdoctoral fellow at the Carnegie Institution for Science and one of the authors of the new research.

But the JWST was able to reveal more about the star than just its temperature gradients and its water content. The researchers found that the atmosphere contains Vanadium Oxide, Titanium Oxide, and Hydride, a negative ion of hydrogen. Together, those chemicals could combine to give the atmosphere its opacity.



An artist's illustration of WASP-18 b. The illustration hints at north-south winds that could be responsible for the atmosphere's heat profile. Image Credit: NASA/JPL-CALTECH/K. MILLER/IPAC

All these findings came from only six hours of observations with NIRISS. Six hours of JWST time is precious to astronomers, and that's all the researchers needed. That's not only because the JWST is so powerful and capable, but also because of WASP-18 b itself.

At only 400 light-years away, it's relatively close in astronomical terms. Its proximity to its star also helped, and the planet is huddled right next to its star. Plus, WASP-18 b is huge. In fact, it's one of the most massive planets accessible to atmospheric investigation.

The planet's atmospheric properties also provide clues to its origins. Comparisons of metallicity and composition between planets and stars can help explain a planet's history. WASP-18 b couldn't have formed in its current location. It must have migrated there somehow. And while this work can't answer that conclusively, it does tell us other things about the giant planet's formation.

"By analyzing WASP-18 b's spectrum, we not only learn about the various molecules that can be found in its atmosphere but also about the way it formed. We find from our observations that WASP-18 b's composition is very similar to that of its star, meaning it most likely formed from the leftover gas that was present just after the star was born," Coulombe said. "Those results are very valuable to get a clear picture of how strange planets like WASP-18 b, which have no counterpart in our Solar System, come to exist."

You Can Detect Tsunamis as They Push the Atmosphere Around

Anyone who's ever lived along a coastline or been at sea knows the effects of tsunamis. And, they appreciate all the early warning they can get if one's on the way. Now, NASA's GNSS Upper Atmospheric Real-time Disaster and Alert Network (GUARDIAN) is using global navigation systems to measure the effect these ocean disturbances have on our atmosphere. The system's measurements could provide a very effective early warning tool for people to get to higher ground in the path of a tsunami.

Earthquakes and undersea volcanic eruptions often trigger tsunamis. Essentially, those tectonic events displace huge amounts of ocean water. During the resulting tsunami, huge areas of the ocean's surface rise and fall. As they do, the ocean movement displaces the overlying column of air. That sets off ripples in the atmosphere. Think of it as if the air is responding by creating its own tsunami. It actually does that in response to fast-moving storms and their squall lines. Meteorologists call those reactions "meteotsunamis." They can push water around into dangerous waves, which then cause flooding and other damage. That's very similar to tsunamis generated by earthquakes.

What NASA's Doing to Predict Tsunamis

Weather forecasters can generally predict bad weather leading to meteotsunamis, but that's not the case for earthquakes and underwater volcanoes and the tsunamis they trigger. So, the NASA project aims to provide advance notice after a temblor or a volcanic eruption.

The GUARDIAN system taps into a constant data stream emitted by clusters of global positioning satellites and other wayfinding stations orbiting Earth. They give real-time information about changes in water heights in the ocean and surface measurements of land masses. Those data-rich radio signals get collected by ground stations and sent to NASA Jet Propulsion Laboratory. There, it gets analyzed by the Global Differential network, which constantly improves the real-time positional accuracy of features on the planet.

So, when a tectonic event happens, the system is alerted to look for changes in the air masses over the oceans. Displaced ripples in the air move out in all directions as low-frequency sound and gravity waves. Those vibrations rush to the top of the atmosphere within just a few minutes. There, they crash into the charged particles of the ionosphere. That distorts signals from the GPS satellites, and those distorted signals tell the system that something's going on down below.

This animation shows how waves of energy from the Tohoku-Oki earthquake and tsunami of March 11, 2011, pierced Earth's ionosphere in the vicinity of Japan, disturbing the density of electrons. These disturbances were monitored by tracking GPS signals between satellites and ground receivers.
Credits: NASA/JPL-Caltech

Normally navigational systems would correct for the distorted signals because they aren't useful to their users, according to Léo Martire, who works on the GUARDIAN project. "Instead of correcting for this as an error, we use it as data to find natural hazards," he said.

Early Warning is the Key

The most active tectonic region on our planet is the area known as the Ring of Fire. It's basically a large ring of volcanically and tectonically active regions in the Pacific Ocean basin. About 78 percent of tsunamis between 1900 and 2015 occurred there.

Most of us remember the tsunami that hit Japan after a magnitude 9.0 earthquake hit just off the coast in 2011. That event devastated 70 kilometers of coastline, destroyed towns and villages, killed hundreds of people, and shut down the Fukushima nuclear power plant.

Damaged village in Japan in the wake of the tsunami onf 2011. Photo: Katherine Mueller, IFRC

One of the most damaging tsunamis occurred on the Big Island of Hawai'i on April 1st, 1946. An earthquake off the Aleutian Islands triggered the tsunami that crushed a small village in Alaska and struck California. It also reached out and touched the Hawaiian coast near Hilo. 50-foot waves crashed into the island, taking out buildings, and bridges, and killing 159 people.

The 1946 tsunami generated huge waves that hit this area near Onomea Bay on the Big Island. Credit: M. Younger.

Volcanic eruptions also trigger these waves. The Tonga eruption of January 15, 2022, sent a tsunami out across the Pacific and disrupted the atmosphere, which affected satellites around the world.

GUARDIAN and the Ring of Fire

With potential damages like these and others, it's no wonder scientists look for ways to predict those events. "When there is a large earthquake near the ocean, we want to quickly know the magnitude and characteristics of the earthquake to understand the likelihood that a tsunami will be generated, and we want to know if a tsunami was indeed generated," said Gerald Bawden, the program scientist for Earth's Surface and Interior at NASA Headquarters in Washington. "Today there are two ways to know if a tsunami was generated before it makes landfall—NOAA's DART buoys and GNSS-ionosphere observations. There is a limited number of buoys and they are very expensive, so systems like GUARDIAN have the potential to complement current warning systems."

At the moment, the GUARDIAN project is using the Pacific Ocean as a testbed for the early warning system. GPS measurements measure the displacements in the atmosphere. The project created a website where experts can look up the state of the ionosphere in real time. There's data from about 90 stations situated around the Ring of Fire, and any signals from events show up nearly instantaneously. Eventually, the system should be useful for events occurring around the world, wherever a tectonic event disrupts sea, land, and atmosphere.

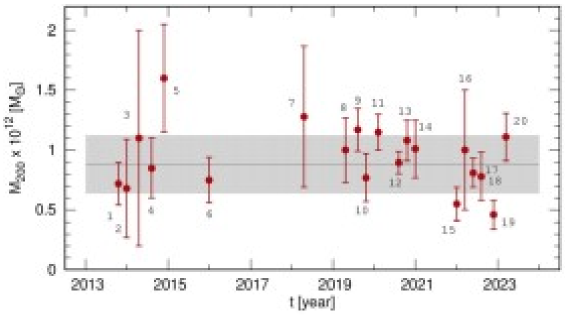
Exactly How Massive is the Milky Way?

How do you weigh a galaxy? It's an astronomical challenge, particularly if it's the galaxy you call home. It turns out there are several ways to get a handle on the mass of the Milky Way, and a recent study summarizes these methods to present the best value.

One method is to look at the motion of stars in the galaxy. Most Milky Way stars follow a roughly circular path around the galactic center. Just as planets orbit the Sun, stars orbit the galaxy. Since gravity is the force holding stars in their orbit, you can use a star's speed and distance from the center to determine the mass within its orbit. Not all stars have circular orbits, but they do on average. So you can plot the speed vs distance from the center for known stars, and get what is known as the rotation curve. Measurements of this curve in the Milky Way and other galaxies were the first evidence that galaxies had much more mass than could be accounted for by visible stars, leading to the idea of dark matter.

One of the problems with the rotation curve method is that we can only measure stars to a certain distance. We now know that most of our galaxy's mass isn't concentrated at the center, but rather extends outward into a galactic halo. We can estimate the mass of the halo from the rotation curve, but we can also look at the motion of globular clusters.

Globular clusters are bright dense clusters of stars. Since stars within a globular cluster are gravitationally bound, these clusters move around the galaxy like a single object. They are found in a sphere surrounding the Milky Way, so measuring their motion helps us measure the mass of the galactic halo.



Various methods for massing the Milky Way. Credit: Bobylev and Bajkova

To measure the outer region of the galactic halo, we can look at the motion of satellite galaxies such as the Magellanic Clouds. There are about 60 small galaxies within about 1.4 million light-years of the Milky Way. Not all of them are in orbit around our galaxy, but many of them are. Since they lay outside our galactic halo, their orbital motions are determined by all of our galaxy's mass. The only downside of this approach is that with only a few dozen orbiting galaxies, the result isn't particularly accurate.

All of these approaches calculate the mass of the Milky Way from orbital motion. There are a few methods that don't rely on the orbital motion. One of these is to look at the tidal plumes of dwarf galaxies. In the history of our galaxy, there are some globular clusters and dwarf galaxies that strayed too close to the central region of the Milky Way and were ripped apart by tidal forces. The remnants of these galaxies form a stream of stars, such as the Sagittarius stream. By calculating the motion of these streams we can estimate galactic mass.

Another approach is to look at stars leaving our galaxy. Occasionally a star will have a near miss with another star and gain enough velocity to escape our galaxy. Since the escape velocity depends on galactic mass, a statistical measure of escaping stars gives a mass for the galaxy.

Finally, we can look at the local group of galaxies. This includes the Andromeda galaxy and its satellite galaxies. Our local group is gravitationally isolated from more distant galaxy clusters, so looking at the equilibrium state of the local group gives us a handle on its overall mass and the mass of the Milky Way.

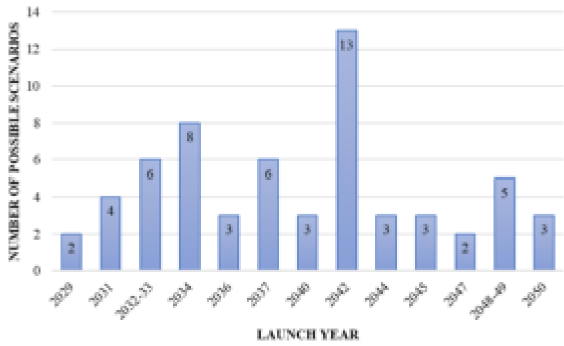
Each of these approaches has its own advantages and levels of accuracy. None of them are the final say on their own. In this latest work, the team took a statistical average of various methods and derived what we might call the best value for the mass of our galaxy. The value they determined was a trillion solar masses, give or take a few hundred billion solar masses.

If You're Going to Visit Venus, Why Not Include an Asteroid Flyby Too?

A recent study submitted to *Acta Astronautica* examines the prospect of designing a Venus mission flight plan that would involve visiting a nearby asteroid after performing a gravity assist maneuver at Venus but prior to final contact with the planet. The study was conducted by Vladislav Zubko, who is a researcher and PhD Candidate at the Space Research Institute of the Russian Academy of Science (RAS) and has experience studying potential flight plans to various planetary bodies throughout the solar system.

"The motivation behind this study was to enhance the efficiency and success rate of Venus missions by including an asteroid flyby in the flight scheme," Zubko tells *Universe Today*. "As widely acknowledged, Venus's particular atmospheric conditions make a mission to the planet a challenging prospect, with designing a spacecraft and achieving a landing being notably difficult tasks. Additionally, Venus' slow rotation, taking 243 Earth days, restricts potential landing sites on its surface."

For the study, Zubko examined the potential for conducting flybys of 117 asteroid candidates with diameters greater than 1 km (0.62 miles) using the Solar System Dynamics catalog from NASA JPL, referring it his plan as an Earth-Venus-Asteroid-Venus flight plan that could potentially occur using launch dates between 2029 and 2050. Using a variety of calculations, Zubko found 53 mission scenarios with 35 asteroid targets between 2029 and 2050 where a spacecraft could encounter an asteroid while en route to Venus.



Graph from the study displaying the number of mission scenarios per year between 2029 and 2050. (Credit: Zubko (2023), Figure 4)

Zubko tells *Universe Today* he believes the "most promising" asteroids for scientific exploration for these mission scenarios are 3554 Amun due to its a M-class (also called M-type) classification, 3753 Cruithne since it exhibits a 1:1 orbital resonance ratio with the Earth, and 5731 Zeus since it's the largest asteroid examined in the study at 5.23 km (3.25 miles) in diameter. M-class asteroids like 3554 Amun are intriguing targets for scientific exploration—and potential resources for Earth—since they are comprised largely of metal phases (i.e., iron-nickel) and are believed to be the source of iron meteorites that have been found on Earth and Mars. For 3753 Cruithne, a 1:1 orbital resonance with Earth means it completes one orbit around the Sun for every one orbit of Earth. Essentially, their orbital periods are exactly the same, otherwise known as a co-orbital object.

Zubko also mentions asteroids 2002 FB3 and 2002 SY50 as potential targets due to their closest approaches to Earth at less than 0.05 astronomical units (AU), or approximately 7.5 million km (4.6 million miles). Along with identifying asteroid candidates for flybys, Zubko also analyzed a potential flyby of the 2P/Eucke comet and potential landing sites on Venus once the spacecraft finally arrives there.

"We believe that conducting an asteroid flyby while en route to Venus is of great importance as it can significantly enhance the scientific value of a mission to Venus, especially in terms of landing on its surface," Zubko tells *Universe Today*. "In addition, an impulse-free flyby of an asteroid can help minimize the mission's costs by combining the exploration of both Venus and the asteroid. The study of asteroids is a high priority for science in general due to their relevance in understanding the history of our Solar System as well as the planetary defense mechanisms (if studying hazardous asteroids)."

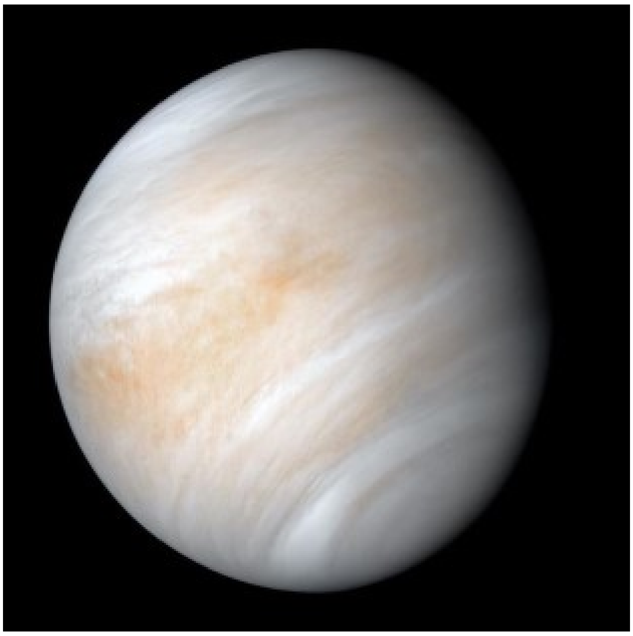


Image of Venus captured by NASA's Mariner 10 spacecraft in February 1974 as it left the planet. While Venus has a rotation of 243 days, the enormous clouds are estimated to circle the planet in just four and a half days. (Credit: NASA/JPL-Caltech)

Aside from being Earth's twin in size, Venus boasts one of the harshest environments in the solar system with searing surface temperatures of 475 degrees Celsius (900 degrees Fahrenheit) and surface pressures 90 times that of the Earth. This is a result of its runaway greenhouse effect, which scientists are eager to learn more about and whether Earth could end up like Venus in the distant future.

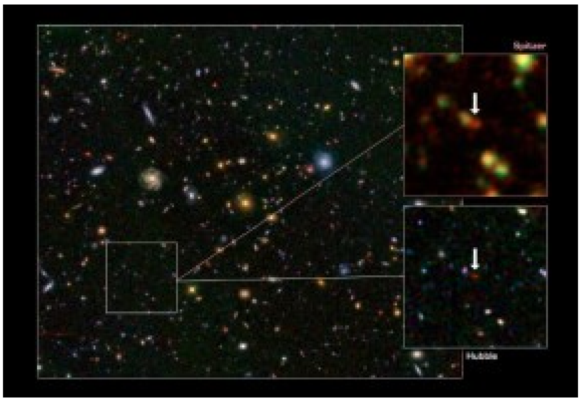
Will we be able to conduct asteroid flybys en route to Venus, and what new discoveries will scientists make about those same asteroids and Venus in the coming years and decades? Only time will tell, and this is why we science!

Here's How You Could Get Impossibly Large Galaxies in the Early Universe

One of the most interesting (and confounding) discoveries made by the *James Webb Space Telescope* (JWST) is the existence of "impossibly large galaxies." As noted in a previous article, these galaxies existed during the "Cosmic Dawn," the period that coincided with the end of the "Cosmic Dark Age" (roughly 1 billion years after the Big Bang). This period is believed to hold the answers to many cosmological mysteries, not the least of which is what the earliest galaxies in the Universe looked like. But after Webb obtained images of these primordial galaxies, astronomers noticed something perplexing.

The galaxies were much larger than what the most widely accepted cosmological model predicts! Since then, astronomers and astrophysicists have been racking their brains to explain how these galaxies could have formed. Recently, a team of astrophysicists from The Hebrew University of Jerusalem Jerusalem published a theoretical model that addresses the mystery of these massive galaxies. According to their findings, the prevalence of special conditions in these galaxies (at the time) allowed highly-efficient rates of star formation without interference from other stars.

The research team was led by Professor Avishai Dekel from The Racah Institute of Physics at the Hebrew University of Jerusalem and the UC Santa Cruz Institute for Particle Physics (SCIPP). He was joined by colleagues from the Racah Institute and Tel Aviv University, Dr. Kartick Sarkar, Professor Yuval Birnboim, Dr. Nir Mandelker, and Dr. Zhaozhou Li. Their results were presented in a paper titled "Efficient formation of massive galaxies at cosmic dawn by feedback-free starbursts," recently published by the *Monthly Notices of the Royal Astronomical Society*.



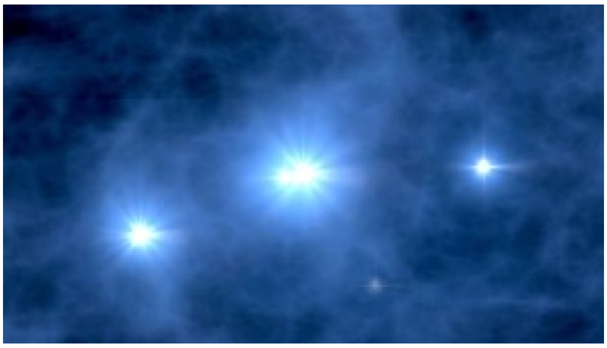
This image shows one of the most distant galaxies known, called GN-108036, dating back to 750 million years after the Big Bang that created our universe. Credit: NASA/ESA/JPL-Caltech/STScI/University of Tokyo

According to the Lambda-Cold Dark Matter (LCDM) model, which best explains what we have observed of the cosmos, the first stars and galaxies formed during the "Cosmic Dark Age." The name refers to how the only sources of photons during this period were from the Cosmic Microwave Background (CMB) and those released by the clouds of neutral hydrogen that shrouded the Universe. Once galaxies began to form, the radiation from their hot and massive stars (1000 times more massive than our Sun) began reionizing the neutral hydrogen.

This period is known as the Epoch of Reionization (ca. 1 billion years after the Big Bang), where the Universe gradually became transparent and visible to modern instruments. Thanks to Webb's extreme sensitivity to infrared light, astronomers have pushed the boundary of what is visible, spotting an abundance of massive galaxies that existed just half a billion years after the Big Bang. According to the LCDM model, there simply wasn't enough time since the Big Bang for so many galaxies to have formed and become so massive. As Professor Dekel shared in a press release from The Hebrew University of Jerusalem:

"Already in the first half-billion years, researchers identified galaxies that each contain about ten billion stars like our sun. This discovery surprised researchers who tried to identify plausible explanations for the puzzle, ranging from the possibility that the observational estimate of the number of stars in galaxies is exaggerated, to suggesting the need for critical changes in the standard cosmological model of the Big Bang."

According to the model put forth by Dekel and his colleagues, the prevalence of special conditions in these galaxies would have allowed for high rates of star formation. These include the high density and low abundance of heavy elements and feedback-free starbursts (FFBs). To break it down, prevailing theories of galaxy formation indicate that the hydrogen permeating the early Universe collapsed into giant spherical clouds of Dark Matter, where it collected together to give birth to the first population of stars (Population III).



Artist's illustration of Population III stars, the earliest stars in the Universe.
Credit: Wikimedia Commons

These theories further state that the stars were almost entirely composed of hydrogen, which was slowly fused in their interiors to create heavier elements (metals). These elements were distributed throughout early galaxies when Population III stars reached the end of their lifespans and blew off their outer layers in supernovae. As a result, more recent stellar populations (Population II and I) have had higher metal content (aka. "metallicity"). To date, astronomers have observed that galaxies' star-formation efficiency (SFE) is low, with only about 10% of the gas falling into clouds becoming stars.

This low efficiency results from the remaining gas being heated or blown out of galaxies by stellar winds or shock waves generated by supernovae. In contrast, Dekel and his team theorized that low-metallicity massive stars were subject to a process they call "feedback-free starburst" (FFB). In essence, star-forming clouds in the early Universe had a density that allowed gas clouds to collapse rapidly into stars 1 million years before they would have developed winds and supernovae. This created a "window of opportunity" where the absence of feedback allowed the rest of the gas to form stars.

This high-efficiency star formation explains the abundance of massive galaxies observed by *Webb* so soon after the Big Bang. As Dekel concluded, the implications their theory has will be the subject of follow-up investigations:

"The publication of this research marks an important step forward in our understanding of the formation of primordial massive galaxies in the Universe and will no doubt spark further research and discovery. The predictions of this model will be tested using the accumulating new observations from the Webb Space Telescope, where it seems that some of these predictions are already confirmed."

Artist's impression of GNz7q, a primordial ancestor to modern supermassive black holes (SMBHs). Credit: NASA/ ESA/STScI.

Of particular interest to astronomers are the primordial supermassive black holes (SMBHs) one thousand times as massive as our Sun that existed about 1 billion years after the Big Bang. Astronomers were surprised to observe SMBHs this massive at the center of early galaxies since (once again) it was assumed that they didn't have enough time to form. Future observations will attempt to find the seeds of these black holes using Webb and observatories like the Laser Interferometer Space Antenna (LISA). Dekel and his colleagues hope they find these seeds among clusters of FFBs that went supernova.

UFO Panelists Say NASA Needs Better Data — and Help From AI

A panel of independent experts took a first-ever look at what NASA could bring to the study of UFO sightings — now known as unidentified anomalous phenomena, or UAPs — and said the space agency will have to up its game.

The 16-member panel's chair, David Spergel, said he and his colleagues were "struck by the limited nature of the data."

"Many events had insufficient data," said Spergel, an astrophysicist who is the president of the Simons Foundation. "In order to get a better understanding, we will need to have high-quality data — data where we understand its provenance, data from multiple sensors."

During today's public hearing, panelists said NASA could contribute to the UAP debate by setting standards for sighting data, creating a crowdsourcing platform for sightings, and reducing the stigma that has discouraged people from reporting and studying anomalous sightings. Some of that stigma was experienced by the panelists themselves.

"It's disheartening to note that several of them have been subjected to online abuse due to their decision to participate on this panel," said Daniel Evans, NASA's assistant deputy associate administrator for research, who served as the space agency's liaison to the panel. "A NASA security team is actively addressing this issue."

Watch the independent panel's hearing on NASA's role in investigating unidentified anomalous phenomena.

The panel was set up last year to make an independent assessment of NASA's resources relating to unidentified anomalous phenomena — previously known as unidentified flying objects, or unidentified aerial phenomena — and to draw up a roadmap for future action.

Spergel emphasized that the panel hasn't yet reached its official conclusions. "Everything we say now represents really preliminary observations," he told reporters during a post-hearing teleconference. The panel is expected to issue its report by the end of July.

NASA's interest in UAPs isn't motivated primarily by the search for extraterrestrial life. Instead, the space agency's effort parallels the Department of Defense's campaign to encourage UAP reporting. The Chinese spy balloon that flew over the United States in February provides a prime example the security and safety concerns raised by UAPs. "The presence of UAP undoubtedly raises concerns about the safety of our skies, and it's our responsibility — again, working together — to investigate whether those anomalies, those phenomena pose any risk to airspace safety," Evans said.

How more data can help

Sean Kirkpatrick, who heads the Pentagon's All-domain Anomaly Resolution Office, or AARO, said his office has encountered some of the same challenges that NASA is now facing. "The stigma exists inside the leadership in all our buildings," he said.

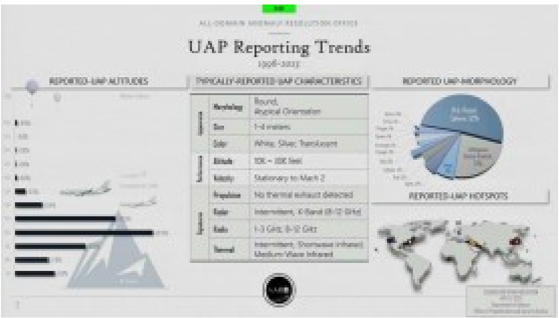
Kirkpatrick said his office has been receiving more and more UAP reports, thanks in part to more open attitudes toward reporting. AARO now has more than 800 cases, with "50 to 100-ish reports" coming in every month, Kirkpatrick said. Most of those cases have eventually been explained, either as natural phenomena or as sightings of artificial objects such as drones or balloons. Kirkpatrick said "2 to 5-ish percent" are still considered anomalous.

Joshua Semeter, director of Boston University's Center for Space Physics, said it's important to have as much data as possible about the circumstances of a sighting, ranging from altitudes and angles to the environmental conditions and the capabilities of the sensors involved.

Semeter pointed to a well-known sighting in 2015, reported by Navy fighter pilots and nicknamed the GOFAST incident, as an example. The data recorded by the fighter jet's instruments helped investigators determine that a parallax effect made the object appear to be traveling faster than it actually was.

"It's not our task to conjecture what this object is," Semeter said. "But it's an example that illustrates the type of data needed to determine critical parameters that will help us identify such objects going forward."

A similar parallax effect may well explain a 2022 UAP report that was based on imagery from a drone flying over an unspecified location in the Middle East.



This graphic summarizes findings from the Pentagon's All-domain Anomaly Resolution Office. (Credit: AARO / DoD)

How NASA can help

Thanks mainly to national security concerns, investigating UAPs has become a multi-agency initiative. Evans said that a NASA manager, Mark McInerney, would be working with the Pentagon's AARO as a liaison officer. The Federal Aviation Administration, which is currently receiving three to five UAP reports per month from air traffic controllers across the U.S., is also in on the initiative.

Several panelists suggested that NASA could create a crowdsourcing platform to give citizen scientists an outlet for reporting UAPs, and that artificial intelligence and machine learning could help researchers sift through archived data.

Kirkpatrick seconded the idea of enlisting AI. "We have a whole bunch of calibrated, large-scale scientific data from all these different instrumentations around the world," he said. "Taking a look at how can you apply some AI / ML tools to search through that data for anomalous signatures that may correlate to things that we've got reporting on — that would be an interesting study."

NASA doesn't have a permanent program office that focuses on UAPs — but Mike Gold, a former NASA executive who is now chief growth officer at Redwire Space, said it might be worth creating one. "I've been a part of far too many panels and studies that end up sitting on the shelf," Gold said. "I don't want this to be one of those exercises."

Space anomalies have been the stuff of science fiction for decades, as well as science fact: In recent years, extraterrestrial phenomena such as interstellar asteroids and fast radio bursts have captured the imagination of professional researchers and amateur UFO fans alike.

Panel member David Grinspoon, an astrobiologist at the Planetary Science Institute, said the study of UAPs could take a page from the playbook that he and his colleagues use in the search for anomalous technosignatures in other star systems. "If NASA applies the same rigorous methodology toward UAPs that it applies to the study of possible life elsewhere, then we stand to learn something new and interesting, whatever the ultimate explanation is for those phenomena," he said.

A New Launch Complex Opens Up in the Ocean

The commercial space sector (aka. NewSpace) is one of the fastest-growing industries of the 21st century. In the past twenty years, what was once considered an ambitious venture or far-off prospect has become a rapidly-accelerating reality. Today, companies are conducting launches using their own rockets and spacecraft, often from their own facilities, to send everything from satellites and cargo to astronauts (commercial and professional) into space. The growing number of launch providers has also led to a dramatic increase in demand for launch-related services.

This includes retrieval operations designed to provide launch flexibility and safe retrieval. This is the purpose behind The Spaceport Company, a Virginia-based aerospace company dedicated to creating a global network of mobile, sea-based launch and landing site systems. On Monday, May 22nd, the company successfully tested its prototype platform by conducting the first-ever commercial rocket launches from U.S. water. This test demonstrated the potential for mobile sea platforms to ease congestion at on-shore launch facilities and expedite the delivery of payloads to orbit.

The Spaceport Company is an emerging leader in developing mobile sea spaceports that enable cost-effective launch services to meet the needs of the modern space sector. This includes the NewSpace industry, which relies on a high-cadence launch schedule and rapid turnaround in proximity to manufacturing sites, and the needs of the Defense sector, which requires responsive spaceports that are rapid, survivable, and distributed. The company's infrastructure also combines proprietary hardware and software with a unique process of government pre-approvals.

During the demonstration, multiple launch vehicles took off from the platform in the Gulf of Mexico, allowing the company to test its infrastructure and all the regulatory procedure that go into orbital-class launches. According to a statement released by the company, this included: "regulatory approvals from the FAA and U.S. Coast Guard, scheduling, control of public access, range surveillance, hazard clearance, airspace integration, anomaly response, and remote launch vehicle ignition at sea."

The successful demonstration also had the bonus of being on schedule and within budget. As The Spaceport Company founder and CEO Tom Marotta said in the statement:

"This demonstration provided numerous lessons which will be incorporated into our next project: building a sea-based spaceport capable of orbital operations. We are working towards offering the U.S.'s first truly commercial spaceport, which can best support the rapidly growing commercial launch industry and alleviate the burdens on government ranges. I'd like to thank all our partners who made this demonstration possible, particularly the Coast Guard, the Federal Aviation Administration, and the National Security Innovation Capital program at the Defense Innovation Unit."

For about sixty years since the dawn of the Space Age, all orbital launches were conducted exclusively from land, and all spent stages were ditched in the ocean. This is why we have the "Rocket Graveyard" off the coast of Florida and the "Spacecraft Cemetary" in the South Pacific, east of New Zealand. Since the late 1990s and especially in the past decade, this has changed with the introduction of marine platforms. Thanks to SpaceX, the retrieval of orbital-class boosters at sea have become a regular event since 2015.

On the other hand, orbital launches at sea require sturdier and more robust platforms, which tend to favor facilities fixed to the ocean floor. However, mobile platforms have the advantage of being able to deploy where needed, offering a degree of flexibility that is otherwise not available. Several more mobile platforms are in the works, and this latest test guarantees that even more are likely to follow in the coming years.

The Kepler Mission's Final Three Planets?

NASA's Kepler spacecraft ended its observations in October 2018 after nine and a half years, a solid six years beyond its planned duration. It discovered 2,711 confirmed exoplanets and another 2,056 exoplanet candidates as of August 2022.

Now, astronomers at MIT and the University of Wisconsin uncovered three more exoplanets in the data from Kepler's final days of observations. They needed the help of dedicated amateurs to do it.

Kepler was still operating when NASA launched Kepler's successor, the Transiting Exoplanet Survey Satellite (TESS,) in August 2018. When Kepler's mission ended later that year, it passed the planet-hunting baton over to TESS. TESS is doing great, but Kepler still accounts for over half of the confirmed exoplanets we know of. That's impressive, and the number ticks a little higher with the newest three.

Kepler worked hard right up until its end. As it ran out of fuel for its reaction control system in October 2018, it kept watching stars in its targeted part of the sky for the tell-tale dips in light that signal a passing planet. It spotted three dips around three separate stars in the same section of the sky. Two of those dips are now confirmed exoplanets, and the other is a candidate awaiting confirmation.

A new paper in Monthly Notices of the Royal Astronomical Society presents the findings. It's titled "Kepler's last planet discoveries: two new planets and one single-transit candidate from K2 campaign 19." The lead author is Elyse Incha, from the University of Wisconsin at Madison. Other authors come from NASA, CfA Harvard and Smithsonian, and the University of North Carolina. Amateur astronomers Tom Jacobs and Daryll LaCourse are also part of the team.

"As some of the last discoveries ever made by the Kepler space telescope, these planet candidates hold significance both sociologically and scientifically."

From 'Kepler's last planet discoveries: two new planets and one single-transit candidate from K2 campaign 19.'

When Kepler began to run out of fuel, it worked hard to fulfill its mission. It relied on its reaction control system, which included reaction wheels and hydrazine thrusters. As it ran out of hydrazine, it struggled to keep itself pointed at its targets. For nearly a month, results were dicey.

For about 8.5 days, it was pointed off-center. It eventually got itself oriented properly for about 7.5 days and performed its observations normally during that period. Then things took a turn for the worse. Kepler could only point itself erratically as the thrusters could only burn intermittently, struggling to keep the spacecraft functioning. This erratic period lasted about 11 days.

The data from the final 11 days was incomplete. Only parts of light curves from that period were usable. After 11 days of that, the Kepler team faced the end. There simply wasn't enough thruster fuel to continue.

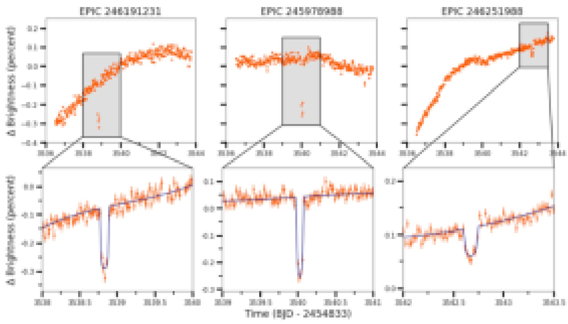
That marked the end of Kepler's 19th observing campaign and the end of its mission. Kepler recorded 27 days of data during campaign 19, but much of it was compromised. Only 7.5 days of the data were suitable for reduction with existing pipelines. (Missions like Kepler gather a massive amount of raw data that has to be processed with data pipelines to become usable.)

The research team behind the new paper says they focused on the 7+ days of precise photometry from the middle of campaign 19 and processed them into light curves.

"This process removed systematic errors from Kepler's instability, leaving behind clean light curves," they explain in their paper.

"We were curious to see whether we could get anything useful out of this short dataset," co-author Andrew Vanderburg from MIT's Kavli Institute said in a press release. "We tried to see what last information we could squeeze out of it."

This created an enormous number of light curves to examine, all of them by human eyes. "The light curves of all 33,000 stars were searched by members of our team by eye," they explain, by using a standard process outlined by other exoplanet researchers. After some detailed processing necessitated by Kepler's erratic pointing, the researchers identified three light curves that indicated planets orbiting stars.



This figure from the paper shows the light curves from the three stars hosting the exoplanets. They all have the prefix EPIC, which stands for Ecliptic Plane Input Catalog, a publicly searchable database of stars and planets associated with Kepler's K2 mission, the second part of its overall mission. Image Credit: Incha et al. 2023.

"We have found what are probably the last planets ever discovered by Kepler, in data taken while the spacecraft was literally running on fumes," says Andrew Vanderburg, assistant professor of physics at MIT's Kavli Institute for Astrophysics and Space Research. "The planets themselves are not particularly unusual, but their atypical discovery and historical importance makes <sic> them interesting."

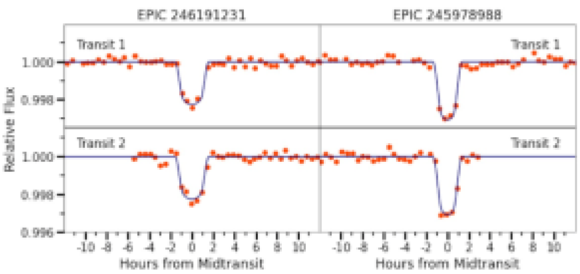
K2-416 b and K2-417 b are the two confirmed exoplanets. K2-416 b is about 2.6 times larger than Earth and orbits its star, an M-dwarf, every 13 days. K2-417 b is a little larger, about 3 times larger than Earth. It orbits its star, a G-type star, every 6.5 days.

The third planet, EPIC 246251988 b, is still a candidate and retains the EPIC prefix. It's the largest of the three, about 4 times larger than Earth. It orbits its star, also an M-dwarf, every 10 days and is much further away from us than the other two.

The discovery involved a lot of human eye work. The Visual Survey Group (VSG) is a team of amateur and professional astronomers that hunt for exoplanets in telescope data. As of 2022, the VSG has visually surveyed over 10 million light curves and authored 69 peer-reviewed papers. The group has proven its value by identifying objects in light curve data that automated search programs either discarded or overlooked. VSG's primary focus is exoplanets, but they've also found cataclysmic variables, eclipsing binaries, and 'black swans,' which are unpredictable events beyond normal expectations.

"They (VSG) can distinguish transits from other wacky things like a glitch in the instrument," Vanderburg says. "That's helpful, especially when your data quality begins to suffer like it did in K2's last bit of data."

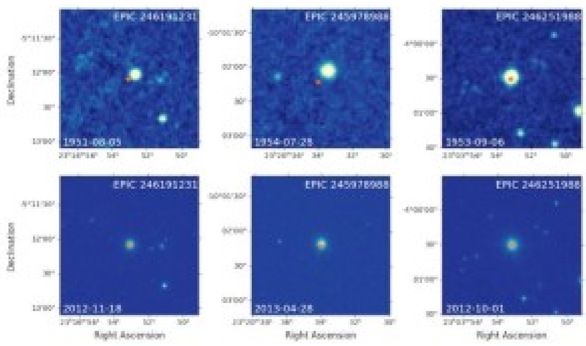
Initially, the team examined the 7.5 days of strong data. In it, they found single transits for three separate stars. Then they examined the final 11 days of lower-quality observations. They needed to find additional transits to confirm them as planets. They found additional transits for two of the planets, K2-416 b and K2-417 b. The team found additional data from NASA's TESS for one of the planets, K2-417 b, which also helped confirm it.



This figure from the research shows both transits detected for each newly confirmed exoplanet. Image Credit: Incha et al. 2023.

"Those two are pretty much, without a doubt, planets," Incha said. "We also followed up with ground-based observations to rule out all kinds of false positive scenarios for them, including background star interference, and close-in stellar binaries."

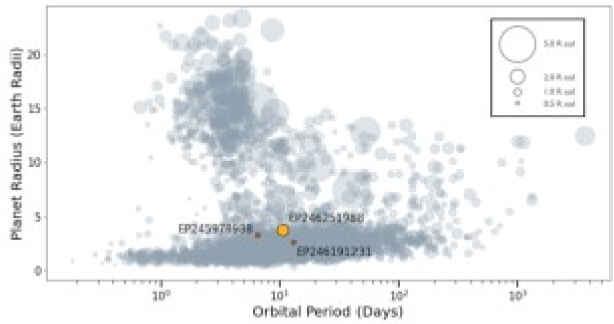
Eclipsing binaries (EBs) can appear as exoplanet transits and must be eliminated as a possibility before a candidate planet is confirmed. As they orbit one another, EBs can block each other's light, creating dips from our perspective. The team examined historical observations of both stars from decades ago to eliminate the possibility that any of their light curves were caused by EBs.



This figure is a comparison of images of each star. The top row is images of the stars from a sky survey done in the 1950s, and the bottom row is images taken with Pan-STARRS. Orange stars mark the locations of all three stars. The first two comparisons eliminate the possibility of EBs, while for the third star, the proper motion is too small to eliminate the possibility. It remains a candidate. Image Credit: Incha et al. 2023.

Despite the team's work, they were not able to conclude that the third transiting event is, in fact, an exoplanet. It could very well be a high-mass brown dwarf. "Our constraints for EPIC 246251988 are weakest because it lacks a precisely measured orbital period, and we struggle to confidently rule out even high-mass brown dwarfs in the long-period tail of the probability distribution," the authors explain in their paper. "Nevertheless, the preponderance of the evidence points to a planetary mass for any companion orbiting EPIC 246251988."

The three planets are not unusual. They're fairly typical of the population of sub-Neptune size objects detected by the transit method. Of the over 5400 confirmed exoplanets, over 1800 of them are Neptune-like. That's about 33%. These planets have radii that indicate the presence of a volatile envelope of some size.



This figure from the research shows how the three new planets compare to the population of known transiting exoplanets. The x-axis shows the orbital period, and the y-axis shows the radius. All three are fairly typical. Image Credit: Incha et al. 2023.

These are likely the final three planets that Kepler found. The team rigorously examined the light curves from 33,000 stars captured during the spacecraft's final days to find them, and because human eyes were involved, it's unlikely there are any more transits in all those curves. But they may not be the last exoplanets found in Kepler's vast collection of data.

"These are the last chronologically observed planets by Kepler, but every bit of the telescope's data is incredibly useful," Incha says. "We want to make sure none of that data goes to waste, because there are still a lot of discoveries to be made."

"As some of the last discoveries ever made by the *Kepler* space telescope, these planet candidates hold significance both sociologically and scientifically," the researchers write in the conclusion to their paper. "We hope our work will help ensure that all *Kepler* data are utilized to its full potential so that no planets are left behind."

There's a New Supernova in a Familiar Galaxy. You Can See it in a Small Telescope

The Pinwheel Galaxy, also known as M101, is a spiral galaxy just 21 million light years away. It's a popular galaxy for photographs because it's oriented to us face-on. This means you can see the bright whorled spirals and dark cloud regions, even in amateur photographs. Since it's relatively close and bright, you can get a good view of it, even with a small telescope. It also happens to have a supernova at the moment.

The last time the Pinwheel Galaxy had a visible supernova was in 2011. That one was a Type Ia supernova, the kind used to measure cosmic distances. This new one appeared in May and is a Type II supernova. These are also known as core-collapse supernovae since they occur when a massive star runs out of elements to fuse and its core collapses under its own weight to become a neutron star.

The supernova is currently at about a magnitude 11, meaning that if you have dark skies and at least a 4-inch telescope, you can see it with your own eyes. If you don't have such luxuries, there are lots of captured images of the supernova popping up on the web, since it's now a popular target for amateur astronomers. The supernova, named SN 2023ixf, is expected to brighten a bit more over the next couple of months before gradually fading.

On the cosmic scale, this supernova is remarkably close. Astronomers observe supernovae all the time, but it is only every decade or so that we get to observe one so near us. SN 2023ixf observations will help astronomers better understand the evolution of core-collapse supernovae, as well as how they enrich the universe with heavy elements.

So if you have the chance, grab your telescope or reach out to your local astronomer, before this brief candle goes out.

NASA's Mars Helicopter Went Silent for Six Agonizing Days

NASA's Ingenuity helicopter on Mars has exceeded everyone's expectations, recently completing its 51st flight when it was supposed to fly just a few times as a demonstration mission. But flights 50 and 51 almost didn't happen.

In a recent blog post, Travis Brown, Chief Engineer for Ingenuity shared how the team lost contact with the tiny rotorcraft for six excruciating days.

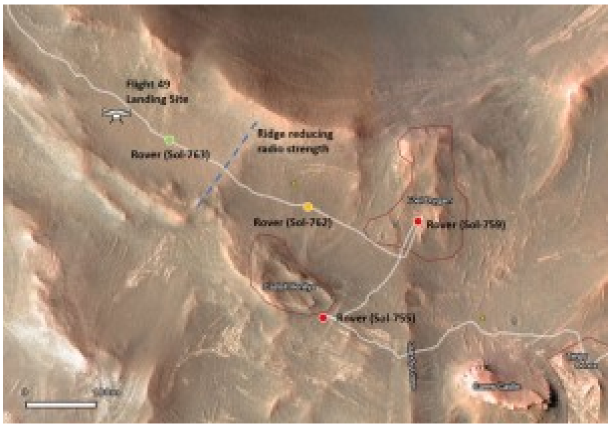
At first, they were not overly concerned when communications ceased from the helicopter on Sol 755. About a year ago, a brief two-day communication glitch occurred because Ingenuity experienced insufficient battery charge as night fell at the start of the Martian winter. This reduced voltage reset the mission clock, causing the helicopter's system to be out of sync with Perseverance rover. While the team quickly figured out the issue, because of Ingenuity's off-the shelf batteries, they expected this issue could happen again.

But now, this time was different.

"In more than 700 sols operating the helicopter on Mars, not once had we ever experienced a total radio blackout," Brown wrote. "Even in the worst communications environments, we had always seen some indication of activity."

But now, there was nothing. The team began to worry that they might not hear from the helicopter again.

Finally, on Sol 761, nearly a week after the first missed check-in, the communications team observed a single, lonely radio ACK (radio acknowledgement). The next day another single ACK confirmed the helicopter was indeed alive, a welcome relief for the team. After some forensics, Brown and his team thinks they have determined what happened.



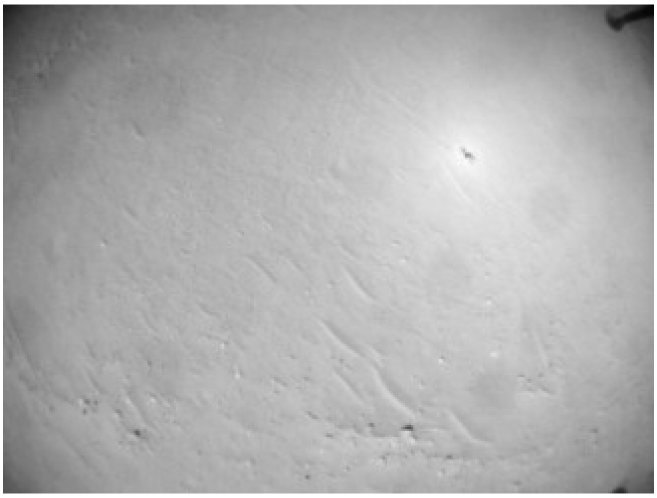
This map shows the locations of NASA's Perseverance Mars rover and its Ingenuity Mars Helicopter in *the sols (Martian days) leading up to the helicopter's 50th flight. The helicopter is shown with a green dot. The rover is shown with a red dot in places where communications with the helicopter were impossible. The rover is shown with a yellow dot at its nearest point to the helicopter before Flight 50 was executed. Credit: NASA/JPL-Caltech*

"Ultimately, this first-of-its-kind communications blackout was a result of two factors," said Brown. "First, the topology between the rover and the helicopter was very challenging for the radio used by Ingenuity. In addition, … a moderate ridge located just to the southeast of the Flight 49 landing site separated the helicopter from the rover's operational area. The impact of this ridge would only abate once the rover had gotten uncomfortably close to the helicopter."

Second, the communications antenna on the rover that 'talks' to the helicopter is located on the right side of the rover, and its position meant the signals between the two robots was partially blocked.

Now that Ingenuity is back, the team realizes future communication glitches are likely to happen. While it has far exceeded its nominal mission and its surprisingly hardy off-the shelf equipment keeps on ticking, the aging equipment and dusty conditions mean the helicopter won't last forever.

"When we first flew, we thought we would be incredibly lucky to eke out five flights," said Teddy Tzanetos, Ingenuity team lead at JPL. "We have exceeded our expected cumulative flight time since our technology demonstration wrapped by 1,250% and expected distance flown by 2,214%."



Mars Helicopter Sol 752 – Navigation Camera: *NASA's Ingenuity Mars Helicopter acquired this image using its navigation camera. This camera is mounted in the helicopter's fuselage and pointed directly downward to track the ground during flight. This image was acquired on April 2, 2023 (Sol 752 of the Perseverance rover mission). Credits: NASA/JPL-Caltech.*

Somehow the helicopter keeps on powering through all the adversity. Even on its 49th flight on Mars, the Guidance Navigation and Control team managed to push the flight envelope with a 16-meter vertical popup at the end of the flight, Brown said. At the peak of its flight, Ingenuity snapped the highest suborbital picture taken of the Martian surface its ever taken.

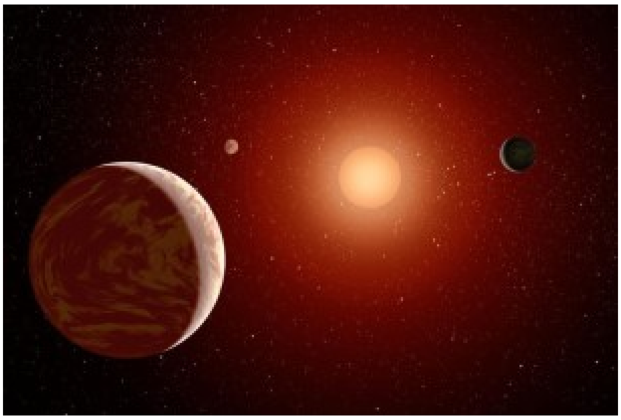
In addition to its primary mission as a technology demonstrator, Ingenuity has proved incredibly useful for the rover, providing tactical and scientific scouting for Perseverance mission. Ingenuity's aerial imaging has proven its worth in helping the rover avoid potential rocky or sandy hazards.

But more 'brown outs' will likely occur and communications will likely come and go. When the end does come, both Ingenuity's and Perseverance's teams will miss the plucky little helicopter.

"Despite the imminent return of Martian summer, it now appears that the dust covering our solar panel will ensure that Ingenuity will likely remain in this transitional power state for some time," Brown said. "This means that, much to the chagrin of her team, we are not yet done playing this high-stakes game of hide and seek with the playful little helicopter."

A Third of Planets Orbiting Red Dwarf Stars Could be in the Habitable Zone

A recent study published in the *Proceedings of the National Academy of Sciences*, a pair of researchers from the University of Florida (UF) examine orbital eccentricities for exoplanets orbiting red dwarf (M dwarf) stars and determined that one-third of them—which encompass hundreds of millions throughout the Milky Way—could exist within their star's habitable zone (HZ), which is that approximate distance from their star where liquid water can exist on the surface. The researchers determined the remaining two-thirds of exoplanets orbiting red dwarfs are too hot for liquid water to exist on their surfaces due to tidal extremes, resulting in a sterilization of the planetary surface.



Artist's illustration of a young red dwarf star with three exoplanets orbiting around it. (Credit: NASA/JPL-Caltech)

"I think this result is really important for the next decade of exoplanet research, because eyes are shifting toward this population of stars," said Sheila Sagear, who is a PhD student at UF and lead author of the study. "These stars are excellent targets to look for small planets in an orbit where it's conceivable that water might be liquid and therefore the planet might be habitable."

For the study, Sagear and her advisor, Dr. Sarah Ballard, analyzed the orbital eccentricities of 163 exoplanets orbiting red dwarf stars across 101 systems using data from NASA's Kepler mission. For context, red dwarf stars are approximately the size of Jupiter, so they're much smaller than our own Sun. This smaller size means red dwarfs give off far less energy and heat than our Sun, meaning the HZ exists much closer to the star, resulting in shorter orbital periods for planets that orbit within the HZ.

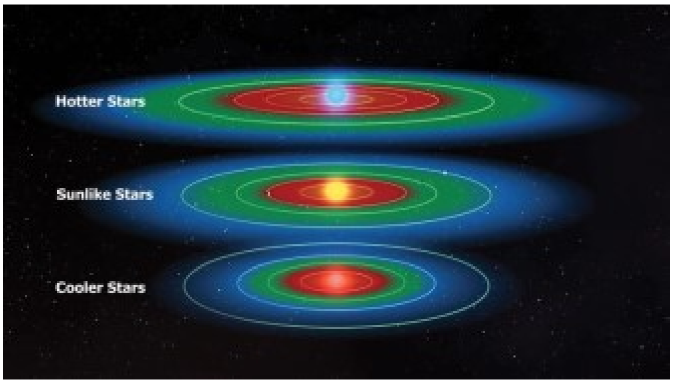


Illustration depicting habitable zones for various types of stars displaying too hot (red), too cold (blue), and just right (green) for liquid water to exist on a planetary surface. Since red dwarfs are cooler than our own Sun, their habitable zone is closer to the star. (Credit: NASA/Kepler Mission/Dana Berry)

A planetary body's orbital eccentricity refers to the shape of its orbit. While Earth's orbit is almost perfectly circular, astronomers have discovered planetary bodies both within and beyond our solar system to exhibit more eccentric, or oval-shaped orbits. Eccentric orbits can result in massive fluctuations within the interiors of planetary bodies, regardless of their size. One such example within our solar system is Jupiter's moon, Io, whose eccentric orbit results in it being the most volcanically active body in our solar system.

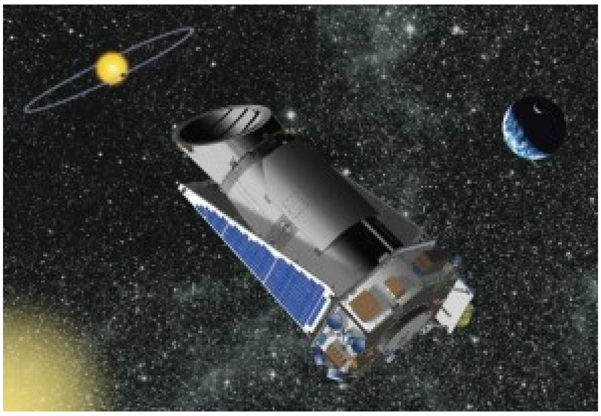
Throughout its orbit, Io is constantly stretched and compressed from the gravitational interactions with Jupiter since its distance changes, becoming closer at times and farther away from Jupiter at other times. Over great amounts of geologic time, the interior of Io heats up from the friction being produced within its interior, which leads to heat, and the volcanic activity we observe to this very day. This process is known as tidal heating, which is what this most recent study explores with exoplanets.

In the end, Sagear and Dr. Ballard discovered that red dwarf stars possessing multiple exoplanets held the highest promise of exhibiting more circular orbits much like the Earth, meaning they could house liquid water on their surfaces. In contrast, the researchers discovered that red dwarfs boasting only one exoplanet were more likely to exhibit an orbit with a higher eccentricity, resulting in it experiencing tidal extremes, much like Jupiter's Io, and less likely to house liquid water on its surface.

While the study found that only one-third of exoplanets in the 163-sample size could possibly house liquid water on their surfaces, this also means that there are potentially hundreds of millions of these worlds throughout just the Milky Way Galaxy.

Kepler

Launched in 2009, NASA's Kepler mission has been instrumental in expanding our understanding of exoplanets and the likelihood of their habitability. During its 9-year mission that ended in 2018 after its fuel was expended, Kepler confirmed the existence of almost 2,800 exoplanets with almost 2,000 still potentially awaiting confirmation, known as exoplanet candidates. While this most recent study encompassed a small slice of those confirmed exoplanets, the data from Kepler will undoubtedly keep scientists busy for the next several years.



Artist rendition of the Kepler telescope searching for exoplanets. (Credit: NASA/Kepler mission/Wendy Stenzel)

What new discoveries will scientists make about M dwarfs, their exoplanets, and their characteristics? Only time will tell, and this is why we science!

HAKUTO-R's Software Got Confused at the Last Minute, Causing it to Crash into the Moon

On April 26, 2023, people around the world watched as the HAKUTO-R lander made its final approach for a landing on the Moon. It had been "on the road" since December 11, 2022, and completed eight Mission 1 milestones. Numbers 9 and 10 would have been landing and establishing a base on the Moon. As we all know, it reached the lunar surface, but not the way the ispace team expected. NASA images confirmed its final resting place.

HAKUTO-R's control team just released an error analysis report, showing that software on the lander performed a faulty altitude estimate as the spacecraft was getting ready to settle onto the surface. According to flight data taken as the lander was navigating to its landing site, the onboard sensors sent back altitude data. It passed over the rim of a crater that was higher than expected. That set up a conflict in the software between the actual measured elevation and the estimated elevation provided before landing. The onboard software decided that this was a sensor error and it “filtered out” further measurements from that sensor.

Essentially, the lander estimated its own altitude to be zero, or on the lunar surface. However, it wasn’t. Instead, it was an altitude of about 5 kilometers. When it got to the scheduled landing time, the lander continued to descend slowly until the propulsion system ran out of fuel. At that point, it was still above the surface and fell the rest of the way down.

Programming Changes Doomed HAKUTO-R

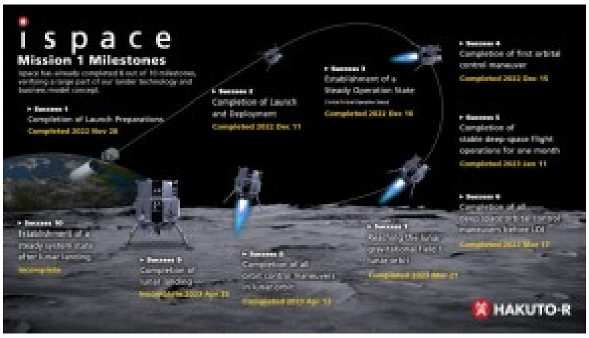
As part of the post-crash analysis of the accident, the ispace team traced the crash to a decision made during a critical design review in February 2021. At that time, they changed the landing site location. That necessitated changes in the verification and validation plans controlled by the software. However, mission simulations didn’t have adequate information about the surface environment in the area of the new landing site. That ultimately led to the mismatch between where the lander thought it was versus where it actually flew. So, while the spacecraft did get to the Moon, and was in control most of the way down, it ultimately crashed due to navigation filtering out data it thought was faulty.

The filter function was designed to reject any altitude measurement that was too far off from the lander’s estimate. The idea behind it was to be able to maintain the smooth operation of the lander in the event of a sensor giving an incorrect altitude measurement.

The crash was a tough blow to the ispace team. But, they’ve taken the analysis and incorporated changes into planning for the next missions. The idea is to provide more highly accurate surface terrain data in the landing sequence planning so that future software conflicts can be avoided.

Otherwise, It Really Was a Successful Mission

So, while milestones 9 and 10 were not achieved, and customer payloads were lost, the ispace team demonstrated a remarkable ability to fly the spacecraft on preplanned trajectories and get it to the Moon, according to Takeshi Hakamada, founder and CEO of ispace. “Mission 1 demonstrated a great deal of technical reliability, as our lander reached the lunar surface just prior to landing. Now, we have been able to identify the issue during the landing and have a very clear picture of how to improve our future missions,” he said. “While it is unfortunate that we were not able to fully meet the expectations of all our stakeholders, including our customers, all of us at ispace are proud of what we accomplished in Mission 1 and are very positive about what we can accomplish.”



Milestones for the HAKUTO-R mission to the Moon. Courtesy ispace.

The milestones for HAKUTO-R were straightforward. They included launch preparations, launch, and orbital deployment. After that, it made the first orbital control maneuver and achieved stable space flight. Then, it performed further orbital control maneuvers and set off for the Moon. Finally, it arrived in the lunar gravitational field and made maneuvers in lunar orbit. Data from all those achievements are already incorporated into the next two ispace missions.

“We have already begun work on Mission 2 and Mission 3,” said Hakamada, noting that the team is prepared to face the challenges and make every effort to improve for future efforts. “We will ensure that the valuable knowledge gained from Mission 1 will lead us to the next stage of evolution. We believe that this is our commitment and our duty to all our stakeholders. ‘Never Quit the Lunar Quest’ In this spirit, we will continue to move forward.”

Future Missions Based on HAKUTO

Ispace began as lunar resource development company in 2010. HAKUTO was originally its entry in the Google Lunar XPRIZE race. The company then worked to develop it for payload delivery to the Moon. Its next missions 2 and 3 should launch in 2024 and 2025. The crashed HAKUTO-R lander carried an interesting set of payloads. The United Arab Emirates supplied the Rashid rover. The Japanese Aerospace Exploration Company (JAXA) supplied a lunar robot called SORA-Q. The agency worked on that in conjunction with the Tomy toy company.

Ispace hopes to provide access to the lunar surface via rovers and other robotic tech demos. Future plans include devices for pharmaceuticals and life sciences projects as well as entertainment and educational programs. In addition, the company sells data services for people and companies who want to enter the lunar exploration market.

JWST Spies a Gigantic Water Plume at Enceladus

The James Webb Space Telescope has observed a huge water vapor plume emanating from Saturn’s moon Enceladus. Astronomers say the plume reaches nearly 10,000 kilometers (6,200 miles) into space, which is about the equivalent distance as going from Ireland to Japan. This is the largest plume ever detected at Enceladus.

Using the sensitive NIRSpec (Near-Infrared Spectrograph) instrument onboard JWST, the researchers were searching for organic compounds in order to characterize the composition and structure of the diffuse plumes. However, their observations revealed only emissions of water. But this giant plume was much larger than expected.

Enceladus itself is just 505 km (314 miles) across, meaning the plume is 40 times as big. We’ve known about the water plumes – which are fueled by a massive subsurface ocean — since shortly after Cassini began studying Enceladus in 2005.

“These first observations with JWST (only a few minutes of integration time) demonstrate the power of this observatory for sensitively characterizing this ocean world, opening a new window into the exploration of Enceladus’ ongoing plume activity while preparing for future missions,” the team wrote in their preprint paper. The research team was led by Geronimo Villanueva from Goddard Space Flight Center and Heidi Hammel from the Association of Universities for Research in Astronomy (AURA). “More generally, JWST can provide detailed quantitative insights into H_2O vapor-dominated geological and cryovolcanic activity elsewhere in the solar system.”

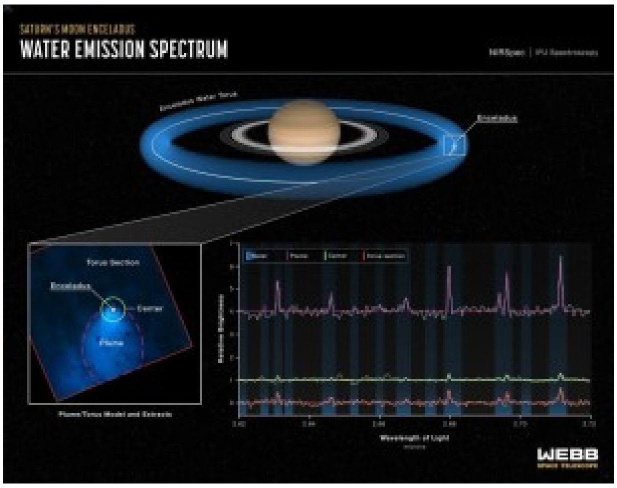
Researchers using the NASA/ESA/CSA James Webb Space telescope recently discovered a plume jetting out from the south pole of Saturn’s moon Enceladus and extending more than 40 times the size of the moon itself. This animation illustrates how the moon’s water plumes feed the moon’s torus. By analysing the Webb data, astronomers have determined roughly 30 percent of the water stays within this torus, and the other 70 percent escapes to supply the rest of the Saturnian system of water. ***Credit:*** *NASA, ESA, CSA, G. Villanueva (NASA’s Goddard Space Flight Center), A. Pagan (STScI), L. Hustak (STScI)*

On Twitter, Villanueva said it was "shocking" to detect a water plume that large.

The observed outgassing rate was at 300 liters a second, which could fill an Olympic-sized swimming pool in just a couple of hours. The researchers added that intriguingly, this outgassing rate is similar to the amount derived from closeup observations with Cassini 15 years ago. This suggests that the amount of eruption from Enceladus has been relatively stable over decadal timescales.

For such a tiny moon, Enceladus is incredibly intriguing. Its distance from the Sun means the moon should be a giant ice ball, but instead it is one of the most hydrothermally active places in our Solar System. Under its icy crust lies a global ocean of salty water and volcano-like jets spew water vapor from just under the moon's surface. Tidal heating from Saturn and other moons likely create an internal environment warm enough to host liquid water.

The team said that the uniqueness of JWST for exploring Enceladus was most evident when probing with unparalleled sensitivity the narrow infrared emissions emanating from the plume.



The Integral Field Unit (IFU) aboard the NIRSpec (Near-Infrared Spectrograph) instrument allowed researchers to detect many spectral features characteristic of water originating from the plume as well as from within a torus around Enceladus. In this spectrum, the white lines are the data from Webb, and the best-fit models for water emission are overlaid in different colors –purple for the plume, green for the area central to the moon itself, and red for the surrounding torus. Credit: NASA, ESA, CSA, STScI, L. Hustak (STScI), G. Villanueva (NASA's Goddard Space Flight Center)

They searched for CO2, CO, CH4, C2H6 and CH3OH molecular emissions across the plume, but none were detected – just water vapor. However, the researchers were also able to observe directly how the moon's water vapor plumes feeds the water supply for the entire system of Saturn and its rings. A donut-shaped torus of water is located within Saturn's E-ring. The team said as Enceladus orbits rapidly around Saturn (with a period of only 1.37 Earth days), the ejected water vapor is spread along and around its orbit, forming the large water ring around Saturn.

By analyzing the data from JWST, the astronomers determined that roughly 30 percent of the water stays within this torus, and the other 70 percent escapes to supply the rest of the Saturnian system with water.

The JWST observations were part of the Solar System Guaranteed-Time-Observations (GTO) program, and were performed on November 9, 2022. The observations focused on Enceladus' trailing hemisphere.

The Cassini mission's observations revealed just how intriguing this moon is. In its first flyby, the spacecraft passed within 1,167 kilometers (725 miles) of the moon and a magnetometer detected a 'bending' of Saturn's magnetic field in the space above Enceladus, almost like it had an atmosphere. In subsequent flybys, Cassini found what appeared to be a surprisingly dense cloud of water vapor and ice grains over the south pole, as well as fissures and fractures on the surface, which were dubbed 'tiger stripes.' These fissures were found to be warmer than the rest of the moon, so clearly something was going on there. Enceladus was no dead little world. It was active.

ESA and NASA say that in the coming years Webb will serve as the primary tool for observing Enceladus, and discoveries from Webb will help inform future Solar System satellite missions that will look to explore the depth of the subsurface ocean, how thick the ice crust is, and more.

China is Planning to Have Humans on the Moon by 2030

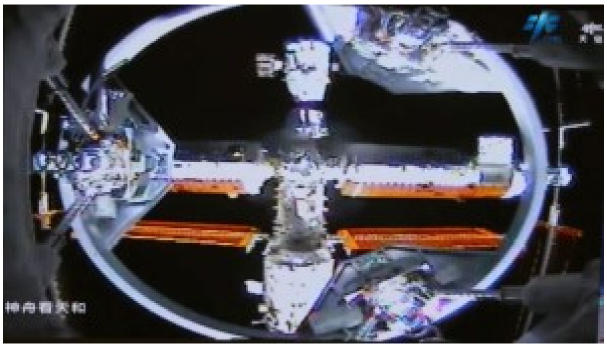
As NASA prepares to return astronauts to the Moon with Artemis III, China is ramping up its efforts for a crewed lunar landing, targeting earlier than 2030. Lin Xiqiang, the deputy director of China's Manned Space Agency announced that the Chinese Lunar Exploration Program (CLEP) is preparing for a "short stay on the lunar surface and human-robotic joint exploration."

Lin Xiqiang made the announcement at a science conference, adding that there will be several robotic missions to the Moon planned before then, with more sample returns and tests of technology to enable a sustained human presence on the Moon.

Artemis III is currently scheduled for launch in December 2025, and would be the second crewed Artemis mission and the first crewed lunar landing since Apollo 17 in December 1972.

"We have a complete near-Earth human space station and human round-trip transportation system," complemented by a process for selecting, training and supporting new astronauts, Lin Xiqiang said, according to CGTN, a state-run foreign-language news channel based in Beijing, China.

This echoes a statement earlier this year by Weiren Wu, the Chief Designer of CLEP who said there would be Chinese footprints on the lunar surface by 2030.



A still from a camera aboard the Shenzhou-16 spaceship showing the China Space Station, May 30, 2023. Credit: Chinese Media Group.

In addition, early today China launched a new three-person crew to its orbiting space station on Tuesday, including China's first civilian astronaut. The Shenzhou 16 spacecraft lifted off from the Jiuquan launch center on a Long March 2-F rocket just after 9:30 a.m. (0130 GMT) Tuesday, and the crew has now docked to the Tiangong space station.

The Shenzhou-16 crew will replace the three-member crew of the Shenzhou-15, who arrived at the space station late in November. The two crews will briefly both be on board the Tiangong station, and the Shenzhou-15 crew will return to Earth after completing their six-month mission. Civilian and payload expert Gui Haichao is a professor at Beijing's top aerospace research institute, and will conduct experiments. He joins mission commander Maj. Gen. Jing Haipeng, who is making his fourth flight to space, and spacecraft engineer Zhu Yangzhu.

The crew will stay aboard the station for around five months, during which they will conduct scientific experiments and regular maintenance.

The station has three modules and was completed at the end of last year after 11 crewed and uncrewed missions since April 2021.

The skills garnered from operating the space station, Lin Xiqiang said, will help in mastering key technologies such as Earth-Moon crewed round-trip missions, short-term stays on the lunar surface, and human-robot joint exploration. This includes multiple tasks of landing, roving, sampling, researching and returning, and forming an independent capability of Chinese lunar exploration.

Juice is Fully Deployed. It's Now in its Final Form, Ready to Meet Jupiter's Moons in 2031

Launched on April 14, 2023, the European Space Agency's (ESA) Jupiter Icy Moons Explorer (Juice; formerly known as JUICE) spacecraft has finally completed the unfurling of its solar panel arrays and plethora of booms, probes, and antennae while en route to the solar system's largest planet.

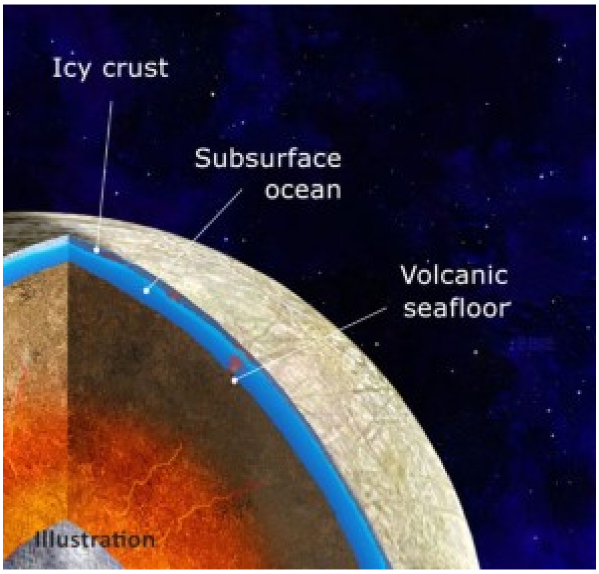
However, Juice's first six weeks in space haven't been so smooth, as its Radar for Ice Moons Exploration (RIME) antenna became stuck and unable to deploy, but the engineers successfully deployed RIME after working the problem for over a month. The RIME unit is deemed as "mission critical" since its purpose is to map underneath the icy crusts of Jupiter's three icy worlds: Europa, Ganymede, and Callisto.

"It's been an exhausting but very exciting six weeks," said Angela Dietz, who is the deputy spacecraft operations manager for the Juice mission. "We have faced and overcome various challenges to get Juice into the right shape for getting the best science out of its trip to Jupiter."

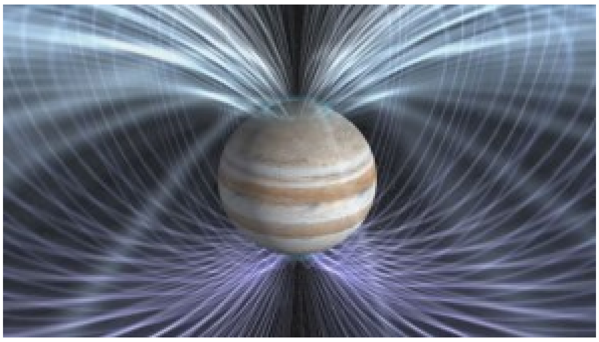
The unfurling of the booms and antennae are crucial as they house either some or all of Juice's 10 instruments, which comprise various scientific packages: the remote sensing package, the in situ package, and the geophysical package. Along with these incredible instruments, Juice will also be conducting an experiment known as the Planetary Radio Interferometer & Doppler Experiment (PRIDE), whose goal will be to use very-long baseline and ground-based interferometry to accurately measure Juice's velocity and location in space.

This incredible cache of instruments will be responsible for exploring Jupiter while conducting 35 flybys of Europa, Ganymede, and Callisto, which are each hypothesized to contain bodies of liquid water beneath their icy crusts. Aside from the moons, Juice will also conduct further examinations of the entire Jupiter system, as scientists hypothesize this could help paint a clearer picture of gas giant exoplanets—and possible exomoons that have yet to be detected—that continue to be discovered throughout the galaxy.

Of the 10 Juice instruments, three stand out as some of the most important to the mission. These include the previously discussed RIME antenna, which will be responsible for mapping the interior environments of these icy worlds; the JANUS optical camera instrument, which will be able to capture images in 13 different colors, ranging from violet light to near infrared, and will be imaging Jupiter's innermost Galilean moon, Io, as well; and the Radio & Plasma Wave Investigation (RPWI) instrument, which will be responsible for producing the first-ever 3D map of Jupiter's electric fields and the interactions between Jupiter's massive magnetosphere and the icy worlds of Europa, Ganymede, and Callisto.



Cutaway illustration depicting the interior of Europa. Mapping this interior will be one of the goals of the Juice mission using its RIME antenna. (Credit: NASA/JPL-Caltech/Michael Carroll)



Artist rendition of Jupiter's enormous magnetic field. Producing the first-ever 3D map of Jupiter's electric fields and the interactions between Jupiter's massive magnetosphere and its icy worlds will be one of the goals of the Juice mission using its RPWI instrument. (Credit: NASA Goddard Space Flight Center)

"Our 3D design strategy makes it possible to measure true physical observables, such as energy and momentum, without resorting to theories or simulations to interpret the data," said Jan Bergman, who is a Senior Scientists at the Swedish Institute of Space Physics and technical manager for RPWI.

As part of ongoing tests for all the instruments during Juice's cruise to Jupiter, the team activated JANUS last week at approximately 8 million kilometers (5 million miles) from Earth and captured numerous images of eta Cyg—which lies in the Cygnus constellation—between 2 and 200 milliseconds (0.002 and 0.2 seconds).

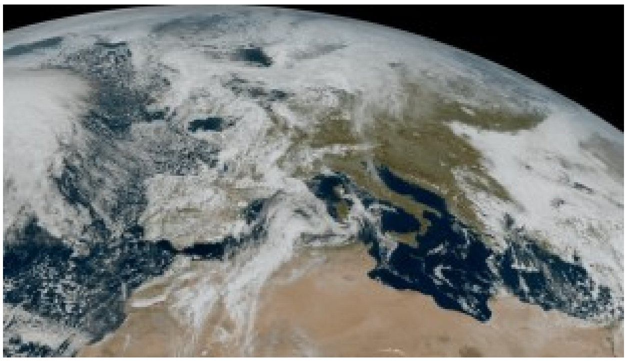
During its trek to Jupiter, Juice will require some help to arrive by 2031. This begins with the first ever Lunar-Earth gravity assist maneuver in August 2024, meaning Juice will slingshot around the Moon followed by a slingshot around the Earth just 1.5 days later. By performing this maneuver, Juice will preserve a substantial amount of fuel during its mission. This will be followed by a Venus gravity assist in August 2025, then two more Earth-only gravity assists in September 2026 and January 2029, respectively, before Juice catapults its way to Jupiter for a scheduled July 2031 arrival. Juice's primary mission is scheduled to only last four years, but with the 35 flybys of Europa, Ganymede, and Callisto, Juice should be able to accomplish a lot of science and teach us more about Jupiter and its many moons during that time.

Amazing Views From ESA's New MeteoSat Weather Satellite

The European Space Agency's latest third generation Meteosat-I 1 weather satellite shows its stuff, with more to come.

You've never seen the Earth and its complex weather systems like this. The European Space Agency (ESA) recently unveiled views from their latest weather satellite in geostationary (GEO) orbit, Meteosat Third Generation Imager-1 (MTG-I 1).

MTG-I 1 promises to revolutionize crucial full-disk weather observations for ESA and the European Union, along with the African continent. The image in the release was captured courtesy of the satellite's new main Flexible Combined Imager on March 18th, 2023. The image shows the full sweep of the Atlantic, Europe and Africa from Scandinavia down to the tip of South Africa.



24 hours over Europe, courtesy of Meteosat-I 1. Credit: ESA/Meteosat

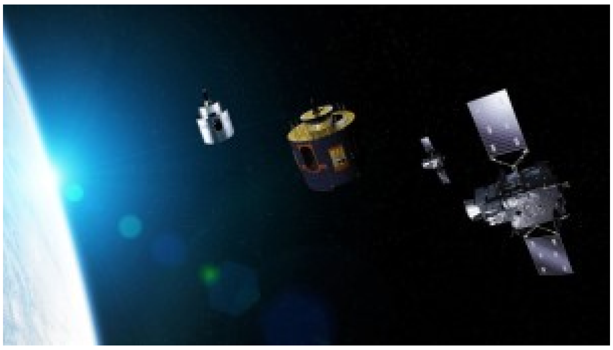
"This remarkable image gives us great confidence in our expectation that the MTG system will herald a new era in the forecasting of severe weather events," says Eumetsat Director General Phil Evans in a recent press release. "It might seem odd to be so excited about a cloudy day in Europe. But the level of detail seen for the clouds in this image is extraordinarily important to weather forecasters."

Imaging at a much higher resolution than previous generations of weather satellites, MTG-I 1 can see cloud structure in greater detail. The satellite will also aid in creating more accurate weather forecasts. This will help with monitoring dust storm events off the Sahara, drought predictions, and fires in the region. This capability is coming none too soon, the 2023 fire season in Spain has gotten off to an early start.

One Heavy Launch

MTG-I 1 was built on a contract between ESA and Thales Alenia Space. MTG-I 1 was launched with Galaxy-35 and -36 atop an Ariane-5 rocket from the Guiana Space Center on December 13th, 2022. The trio represented the second heaviest launch mass to GEO for the Ariane-5 rocket to date (10,972 kg). This is just shy of 11,210 kg for VA255 mission in 2021 with SES-17 and Syracuse-4A. In geostationary orbit, MTG-I 1 is parked over the European/African longitude at an orbital slot of zero degrees, right along the Prime Meridian.

The first generation of Meteosats started on 1977 with Meteosat-1. These were retired in 2017 when Meteosat-7 used its remaining fuel to head to a super-synchronous graveyard orbit. The second generation includes four satellites in GEO, though the constellation is aging and set for retirement by 2033.



Three generations of Meteosats. Credit: ESA

The third generation of Meteosats will feature the first dedicated full-disk lightning imager, developed by Italy's Leonardo corporation. Eventually, the third generation constellation will include six satellites, all to be launched by 2035.

The upcoming MTG-S sounder satellites are especially innovative, as they will include spectrometers working in the ultraviolet, across the visible and into the infrared range. MTG-S will also feature an Infrared Sounder, able to probe the atmosphere in three dimensions. This ability is crucial in understanding volcanic ash, carbon monoxide and ozone content present in the atmosphere layer-by-layer. The first MTG-S satellite will launch in mid-2024.

MTG-I 1 meets its adapter fairing ahead of launch. Credit: ESA

Early Warnings for All

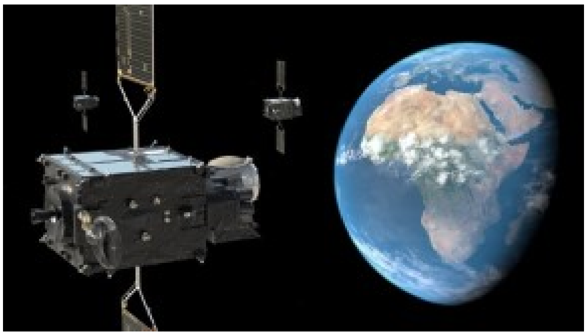
MTG-I 1 is now in a current 12-month commissioning phase. The system features high resolution imagery and a frequent repeat cycle. This will go a long ways towards climate analysis, severe weather forecasting and maritime and agricultural meteorology. This will also aid in the World Meteorological Organization's Early Warnings for All Initiative. This effort covers weather forecasts over the

African continent.

Once fully active, the MTG system with two imaging satellites (plus on-orbit spares) will repeat its imagery cycle once every 10 and 2.5 minutes. Eventually, users will be able to access imagery data from EUMETSat's View page live online.

In addition to crucial weather observations, weather satellites in GEO sometimes provide us with views of unique and unexpected things, such as the shadow of the Earth's Moon crossing the face of the Earth during a total solar eclipse.

Though they're distant and usually below naked eye visibility, you can actually see satellites in geostationary orbit at certain special times of the year. This is known as GEOSat flare season, a time near each equinox when satellites in geostationary/geosynchronous orbit reach full illumination before winking out as they hit Earth's shadow.



An artist's conception of Meteosat in space. Credit: ESA.

GEOSat Legacy

Here's one more amazing fact about GEOSats: they're in ultra-stable orbits lasting millions of years. This means that they may represent some of the oldest remaining artifacts from our civilization. For this reason, some carry plaques similar to the memorials placed on the Pioneer and Voyager spacecraft escaping the solar system. Notable examples were placed on the EchoStar XVI and LAGEOS-1 satellites in GEO orbit.

Its great to see a new generation of Meteosats working to understand the weather and climate of the Earth.

There's a Polar Cyclone on Uranus' North Pole

Uranus takes 84 years to orbit the Sun, and so that last time that planet's north polar region was pointed at Earth, radio telescope technology was in its infancy.

But now, scientists have been using radio telescopes like the Very Large Array (VLA) the past few years as Uranus has slowly revealing more and more of its north pole. VLA microwave observations from 2021 and 2022 show a giant cyclone swirling around this region, with a bright, compact spot centered at Uranus' pole. Data also reveals patterns in temperature, zonal wind speed and trace gas variations consistent with a polar cyclone.

Uranus as seen by NASA's Voyager 2. Credit: NASA/JPL

Scientists have long known that Uranus' south pole has a swirling feature. When Voyager 2 flew past Uranus in 1986, it detected high wind speeds there. However, the way the planet was tilted did not allow Voyager to see the north pole.

But the VLA in New Mexico has now been studying Uranus the past several years, and observations collected in 2015, 2021, and 2022 were able to peer deep into Uranus' atmosphere. The thermal emission data showed that circulating air at the north pole seems to be warmer and drier, which are the hallmarks of a strong cyclone.

"These observations tell us a lot more about the story of Uranus. It's a much more dynamic world than you might think," said Alex Akins of NASA's Jet Propulsion Laboratory in Southern California, who is lead author of a new study published in Geophysical Letters. "It isn't just a plain blue ball of gas. There's a lot happening under the hood."

The researchers said the cyclone on Uranus is similar to the polar cyclones observed by the Cassini mission at Saturn. With the new findings, cyclones (which rotate in the same direction their planet rotates) or anti-cyclones (which rotate in the opposite direction) have now been identified at the poles on every planet in our solar system that has an atmosphere. The researchers said this confirms a broad truth that planets with substantial atmospheres – whether the worlds are made of rock or gas – all show signs of swirling vortexes at the poles.

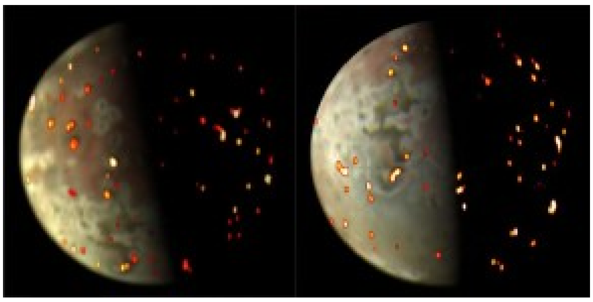
Uranus' north pole is now in springtime. As it continues into summer, astronomers hope to see even more changes in its atmosphere.

Juno Reveals Volcanoes on Io

Jupiter's moon Io is the most volcanic world in the Solar System, with over 400 volcanoes. Some of them eject plumes as high as 500 km (300 mi) above the surface. Its surface is almost entirely shaped by all this volcanic activity, with large regions covered by silicates, sulphur, and sulphur dioxide brought up from the moon's interior. The intense volcanic activity has created over 100 mountains, and some of them are taller than Mt. Everest.

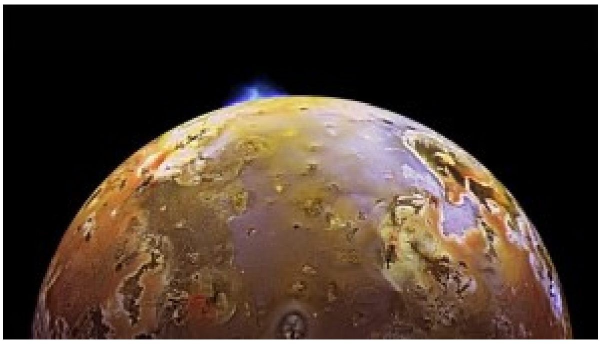
Io is unique in the Solar System, and the Juno orbiter's JunoCam captured some new images of Io's abundant volcanic activity.

Io is in a tough position. It's locked in a kind of gravitational tug-of-war with massive Jupiter and the other Galilean moons, Ganymede, Europe, and Callisto. All that gravitational energy, particularly from Jupiter and Europa, creates friction in the moon's interior that creates 'tidal heating.' That sets it apart from Earth's volcanism, which is caused largely by the heat from the decay of radioactive isotopes in the mantle, including uranium, potassium, and thorium. In fact, Io produces bout 40% more heat than Earth, an amount that simply cannot be produced by radioactive decay.



This composite image shows how volcanoes dot Io's surface. It was created with Juno's JIRAM instrument and its JunoCam instrument. Image Credit: NASA/JPL-Caltech/SwRI/ASI/INAF/JIRAM

While Juno's images of Io are the newest, they're not necessarily the best. Voyager 1 and Galileo both got closer to Io than Juno did, and their images of the surface are even more stunning.



Galileo captured this image of Io's surface with a volcano in 1997. Image Credit: NASA/JPL/DLR

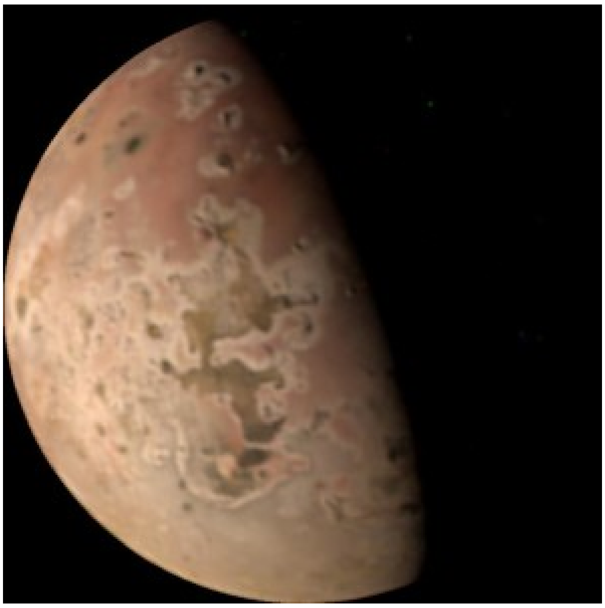
But Juno's much more modern instruments allow it to study Io's volcanic nature in greater detail. This is important because of some questions scientists would like answers to. Although there's widespread scientific agreement that tidal heating creates the heat driving all of the moon's volcanic activity, the heating doesn't create the volcanoes where we expect them to be, according to our best scientific understanding. One of Juno's goals is to image the moon's surface over time to build a more comprehensive picture of the moon's volcanic activity.

Io has about 115 named mountains, and their average height is about 6,300 m (20,700 ft). Boösaule Montes, at 17,500 metres (57,400 ft) is Io's tallest moon. Compare that to Mt. Everest's height of almost 8,850 meters (29,035 ft.) And Io is only 3600 km in diameter, compared to Earth's 12,700 km diameter. Mountains can be so high on smaller bodies because they have weaker gravity.

Io, the Moon, and Earth. Image Credit: By Apollo 17 Picture of the Whole Earth: NASATelescopic Image of the Full Moon: Gregory H. Revera True colour image of Io: NASA / JPL / University of Arizona – The Earth seen from Apollo 17.jpgFullMoon2010.jpgIo_highest_resolution_true_color.jpg, Public Domain, https://commons.wikimedia.org/w/index.php?curid=39083698

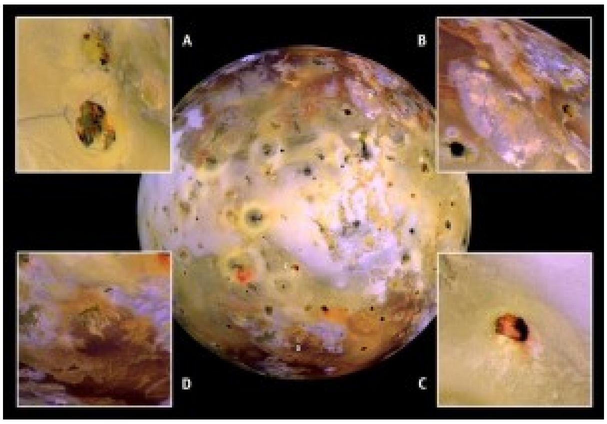
Most of what scientists know about Io's volcanism comes from the Galileo and Cassini missions. And even after decades of research, there are still questions about the moon's abundant volcanic activity and the conditions in the interior that cause it. Juno is not primarily aimed at studying Io, but we're about to get our best look at Io so far.

Yesterday, Tuesday, May 16th, the spacecraft came to within 35,500 km of Io's surface.



Io as seen in JunoCAM's highest-resolution view of the volcanic moon to date. This observation was acquired from a distance of 35,623 kilometres. The spatial resolution is 23.963 kilometres per pixel. Image Credit: NASA / SwRI / MSSS / Jason Perry © CC BY 3.0 Unported

"Io is the most volcanic celestial body that we know of in our solar system," said Scott Bolton, Juno principal investigator from the Southwest Research Institute in San Antonio. "By observing it over time on multiple passes, we can watch how the volcanoes vary – how often they erupt, how bright and hot they are, whether they are linked to a group or solo, and if the shape of the lava flow changes."



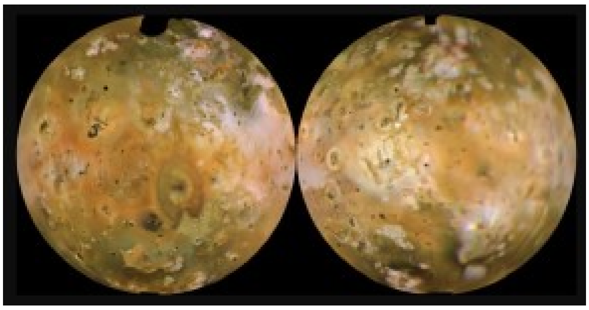
NASA's Galileo spacecraft acquired its highest-resolution images of Jupiter's volcanic moon Io on July 3, 1999. This colour mosaic uses the near-infrared, green and violet filters (slightly more than the visible range) of the spacecraft's camera, processed to enhance more subtle colour variations. Most of Io's surface has pastel colours, punctuated by black, brown, green, orange, and red areas near the active volcanic centers. Image Credit: NASA/JPL/University of Arizona

Future flybys later this year will come even closer, down to only 1500 km. The combined images from all of these flybys will reveal a lot.

"We are entering into another amazing part of Juno's mission as we get closer and closer to Io with successive orbits. This 51st orbit will provide our closest look yet at this tortured moon," said Bolton. "Our upcoming flybys in July and October will bring us even closer, leading up to our twin flyby encounters with Io in December of this year and February of next year when we fly within 1,500 kilometres of its surface. All of these flybys are providing spectacular views of the volcanic activity of this amazing moon. The data should be amazing."

JunoCAM acquired these eight views over a period of an hour and fifteen minutes as the spacecraft approached and receded from Jupiter's volcanic moon. These are the sharpest visible-light images of Io acquired since the New Horizons flew past Jupiter on its way to Pluto in 2007. Image Credit: NASA / SwRI / MSSS / Jason Perry © CC BY 3.0 Unported

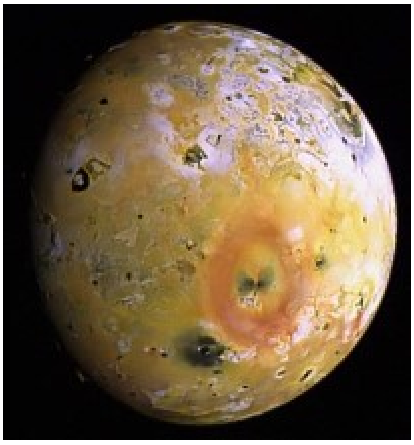
An even greater understanding of Io should come if NASA approves the Io Volcano Observer mission. Its goals are to understand in more detail how the moon is tidally heated, how that heat is transported to the surface, and how Io is evolving.



This global mosaic of Io was pieced together with images from Voyager 1. The left is the eastern hemisphere. Image Credit: NASA/JPL/USGS

Io's heat transport mechanism is much different than Earth's. Earth transports heat from the interior to the surface through plate tectonics, where large slabs of cold oceanic crust are subducted into the warm mantle. But Io loses heat through what are known as heat pipes, and these heat pipes cover only about 1% of the moon's surface.

Those results, if the mission is approved, should shed light on Europa's complex nature. It'll also shed light on other tidally heated moons like Enceladus and Titan. Scientists are also hopeful that it could tell us something about magma oceans, like those experienced by the early Moon and probably Earth.



This Galileo image shows the effect Io's extreme volcanism has on the moon's surface. Sulphur compounds help give it a yellowish colour. Image Credit: NASA/JPL

Even with Juno's imaging efforts, and the results from Cassini, Galileo, and the Voyagers, there's a lot scientists don't know about Io. Galileo's detailed study of the Jupiter system provided the most information on this geologically hyperactive world and also led to more questions, such as:

- Is the tidal heating produced in Io's shallow mantle, or is it widespread?
- Is there a magma ocean in the form of a global layer of melt under Io's crust?

Is Io's magma ocean in any way similar to subsurface oceans on other moons like Europa?

Those answers await the eventual launch of the Io Volcano Voyager, if it's ever approved, or another similar mission. Until then, Juno is the only spacecraft in the vicinity, and scientists are gleaning what information they can from Juno's images and data.

Juno captured these four images of Jupiter's moon Io in the last few months with its JunoCam instrument. From the left to the right, the images were taken at distances of 106,000 km, 86,000 km, 64,000 km, and 51,500 km. Though kind of blurry, it's hard to predict in advance what important piece of information any individual image contains. Image Credit: Image data: NASA/JPL-Caltech/SwRI/MSSS. Image processing, left to right: Björn Jónsson (CC NC SA), Jason Perry (CC NC SA), Mike Ravine (CC BY), Kevin M. Gill (CC BY)

There's So Much Going on in This Star-Forming Nebula

There are some astronomical images that capture rapturous beauty, with their brilliant colors and interplay of shadow and light. A beautiful image can be enough to stir the soul, but in astronomy they often also have a story to tell. An example of this can be seen in a recent image released by NSF's NOIRLab.

It was captured by the Dark Energy Camera at the Cerro Tololo Inter-American Observatory (CTIO), and shows the region surrounding the dark nebula known as Lupus 3. This cold region of gas and dust spans 24 Moon-widths in the southern sky, and is a region where stars are forming. Two of these birthing stars can be seen in radiant blue near the center of the image. Known as HR 5999 and HR 6000, they are only about a million years old. They are so young that their cores haven't collapsed enough to begin fusing elements. Instead, their brilliant light and heat are produced through gravitational collapse, where their material is squeezed and heated by their own weight.

The Dark Energy Camera mounted on CTIO's Blanco 4-meter telescope. Credit: DOE/FNAL/DECam/R. Hahn/CTIO/NOIRLab/NSF/AURA

There are younger stars scattered within the dark nebula. They are smaller and cooler, but will soon evolve into T Tauri protostars before becoming full-fledged stars. You can see hints of their light in the cloudy region to the right of the blue stars.

The Lupus 3 nebula is only about 500 light-years from Earth, so it gives us an amazing view of the early periods of star formation. It is also part of a larger collection of gas and dust known as the Lupus cloud complex. These dark nebula regions are so wide it can be difficult for telescopes to capture in detail, which is why the Dark Energy Camera is so useful. It was primarily designed for the Dark Energy Survey, which observed more than 300 million distant galaxies in order to study dark energy. But with its ability to capture more than four Moon-widths in a single image, it is a perfect tool for studying nebula such as Lupus 3.

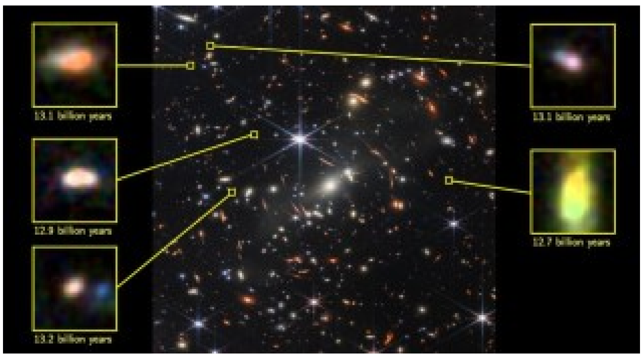
You can find more detailed images and a few animations of the region on NOIRLab's Website, and its worth checking out. Particularly the zoomable image, where you can focus in on subtle details. It's an amazing image, and it will help astronomers understand how clouds become stars and light.

Remember Those Impossibly Massive Galaxies? They May Be Even More Massive

The James Webb Space Telescope (JWST) was designed to probe the mysteries of the Universe, not the least of which is what the first galaxies looked like. These galaxies formed during the Epoch of Reionization (aka. "Cosmic Dawn"), which lasted from about 100 to 500 million years after the Big Bang. By observing these galaxies and comparing them to ones that see closer to our own today, astronomers hope to test the laws of physics on the grandest of scales and what role (if any) Dark Matter and Dark Energy have played.

Unfortunately, early into its campaign, the JWST detected galaxies from this period so massive that they were inconsistent with our understanding of how the Universe formed. The most widely-accepted theory for how this all fits together is known as the Lambda Cold Dark Matter (LCDM) cosmological model, which best describes the structure and evolution of the Universe. According to the latest results from the Cosmic Dawn Center, these galaxies may be even more massive than previously thought, further challenging our understanding of the cosmos.

The research team was led by the Cosmic Dawn Center (DAWN) and included researchers from the Niels Bohr Institute (NBI) at the University of Copenhagen, the European Southern Observatory (ESO), the Kavli Institute for Particle Astrophysics and Cosmology (KIPAC) at Stanford University, and astronomers and astrophysicists from the Université de Genève, the University of Texas at Austin, the University of Colorado, and UC Santa Cruz. The paper that describes their findings appeared in the May 10th issue of *The Astronomical Journal*.



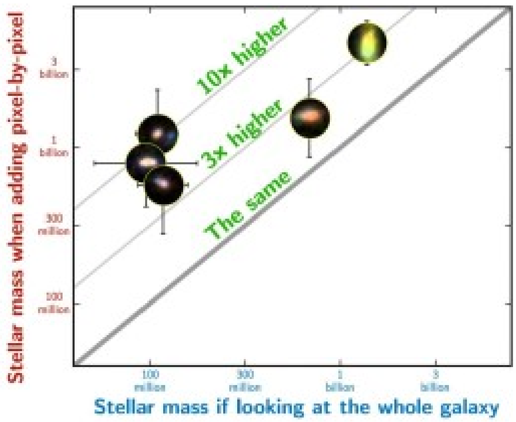
The galaxy cluster SMACS 0723, with the five galaxies selected for closer study. Credit: NASA/ESA/CSA/STScI/Giménez-Arteaga et al. (2023), Peter Laursen (Cosmic Dawn Center).

Among the first images shared by the JWST was the breathtaking view of the SMACS 0723 galaxy cluster known as *Webb*'s First Deep Field (shown above). This image was acquired by Webb's Near-Infrared Spectrograph (NIRSpec) and provided a detailed look at how the galaxies in this cluster appeared 4.6 billion years ago. In addition, the image was filled with gravitational lenses that allowed astronomers to get a closer look at more distant objects, including the most distant galaxy ever seen (GL-z13, now known as GLz-12) and several "Green Pea" galaxies dated to the early Universe.

The only problem is that Webb noticed more galaxies than was anticipated in this period, and some were more massive than what was thought possible. According to the LCDM model, there simply wasn't enough time since the Big Bang for so many galaxies to have formed or become so massive. This led to all kinds of claims, including the notion that the Big Bang model was wrong, a highly-questionable claim made by proponents of the Steady State Hypothesis. While these findings did not throw our entire cosmological understanding into disarray, they nonetheless beggared an explanation.

To clarify *Webb*'s earlier observations, a Ph.D. student at the Cosmic Dawn Center (Clara Giménez Arteaga) and colleagues analyzed the data further. In their paper, they describe how they observed five galaxies in the SMACS 0723 Deep Field with redshifts (z) of 5 to 9, which appear to us as they would have roughly 12.7 to 13.2 billion years ago. Based on their analysis, the team hypothesizes that what we're seeing at work here is an effect that could mean these galaxies are even larger than they appear. As Arteaga explained in an NBI press release:

"We used the standard procedure to calculate stellar masses from the images that James Webb has taken, but on a pixel-by-pixel basis rather than looking at the whole galaxy. In principle, one might expect the results to be the same: Adding the light from all pixels and finding the total stellar mass, versus calculating the mass of each pixel and adding all individual stellar masses. But they're not."



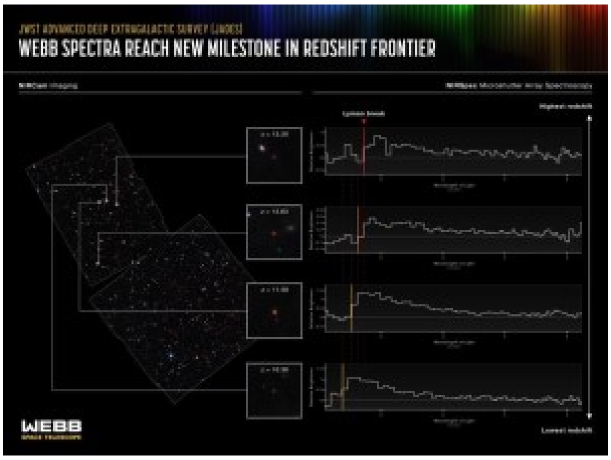
The stellar mass of the five galaxies, showing mass inferred using the two different methods. Credit: Giménez-Arteaga et al. (2023), Peter Laursen (Cosmic Dawn Center).

Ordinarily, astronomers calculate the stellar mass of galaxies by measuring the amount of light emitted, then inferring the population necessary for this amount. However, upon viewing the sample of five galaxies closer, Arteaga and her team found that if the galaxies were considered as an entity made up of multiple stellar groupings (instead of one big mass), the picture would change drastically. Based on this alternative method, they found that the inferred stellar masses of these five galaxies would be up to ten times greater.

The team then compared the mass of the five galaxies using the two methods and found that the values were always much higher by analyzing them pixel-for-pixel (instead of the inferred brightness approach). As for why this is the case, Arteaga and her team believe it has to do with the composition of galaxies, which is far from singular:

“Stellar populations are a mixture of small and faint stars on one hand, and bright, massive stars on the other hand. If we just look at the combined light, the bright stars will tend to completely outshine the faint stars, leaving them unnoticed. Our analysis shows that bright, star-forming clumps may dominate the total light, but the bulk of the mass is found in smaller stars.”

Proper resolution is very important for accurately estimating stellar mass, one of the main properties through which astronomers characterize galaxies. While this is relatively easy for galaxies that are relatively close to the Milky Way, it remains a challenge for far more distant ones. While the effect Arteaga and her colleagues emphasized has been noted before, it has only been with galaxies as they appear in later epochs of cosmic history. Thanks to Webb’s superior resolution, this is the first time it has been applied to the most distant galaxies.



An international team of astronomers has used data from the James Webb Space Telescope to report the discovery of the earliest galaxies confirmed to date. Credit: NASA/ESA/CSA/STScI

Unfortunately, even *Webb* is limited when it comes to observing galaxies that existed around 13 billion years ago when the Universe was barely 1 billion years old. The next step, therefore, will be to look for signatures that correlate to the true mass of these galaxies that do not require high-resolution imaging. As Arteaga summarized:

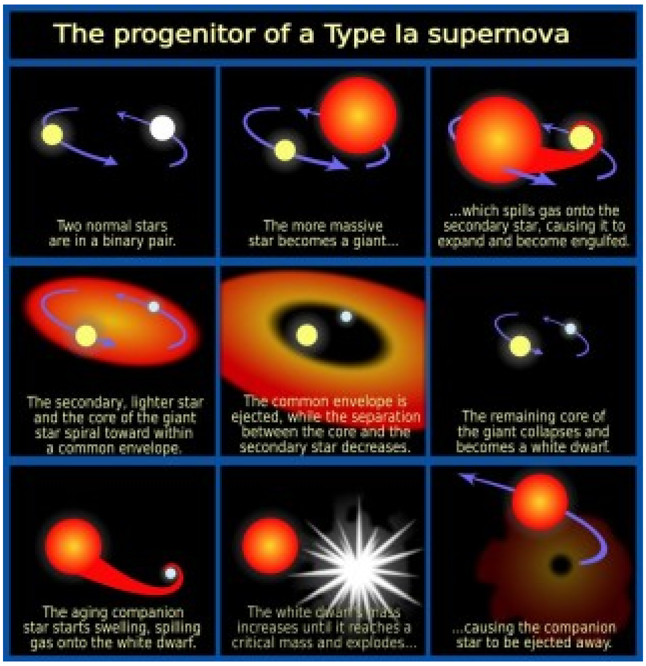
“Other studies at much later epochs have also found this discrepancy. If we can determine how common and severe the effect is at earlier epochs, and quantify it, we will be closer to inferring robust stellar masses of distant galaxies, which is one of the main current challenges of studying galaxies in the early Universe.”

Not All Type 1a Supernovae are Created Equally

Supernovae are brilliant explosions that can, for a time, outshine an entire galaxy. They come in two broad types: Type I and Type II. Type II supernovae are what are known as core-collapse supernovae. They occur when a massive dying star fuses ever heavier elements in its core until it runs out of energy options and its core collapses under its own weight, which triggers the explosion. Type I supernovae occur when…well, it’s complicated. But we’re learning more thanks to a new observation by radio astronomers.

The original distinction between the types was that hydrogen emission lines could be seen in Type II events, but not Type I. From this, it was thought that Type I was likely involved a cataclysmic explosion of white dwarfs since white dwarfs don’t contain much hydrogen. Over time astronomers that a subgroup of Type I supernovae contained emission lines of ionized silicon during their maximum brightness, and these became known as Type Ia.

You’ve likely heard of Type Ia supernovae because they have a very useful property. They all tend to explode with about the same maximum brightness. This means by observing its maximum apparent brightness, you can determine how far away it is. In astronomy, we call them standard candles, and they play a crucial role in cosmology. The discovery of cosmic expansion and dark energy is due to observations of Type Ia supernovae.



How type Ia supernova likely occur. Credit: NASA, ESA and A. Feild (STScI)

They likely occur when a white dwarf has a close stellar companion. As the companion star ages and starts to expand, gas from the star is captured by the white dwarf. This continues until the white dwarf captures too much matter to sustain its own weight, reaching a mass of about 1.4 Suns. At that point the white dwarf collapses, triggering the explosion. Because the critical mass, known as the Chandrasekhar limit, is always the same, these supernovae have similar brightness.

But since Type Ia depend on the accretion of matter onto a white dwarf, they aren’t quite all the same. A few Type Ia are much brighter than usual, with strong iron absorption lines, and there is a variant known as Type Iax, where the white dwarf might not be completely destroyed. So we still aren’t entirely sure how these supernovae are triggered, which is why a recent study is so important.

The study was just published in *Nature*, and it describes the first radio observation of a Type Ia supernova. Supernova types are identified by their spectral lines in optical and infrared. Radio observations of Type II supernovae have helped astronomers understand how very large stars end their lives. But we haven’t had radio observations of white dwarf explosions, since they aren’t bright at radio wavelengths.

Then in 2020, the Zwicky Transient Facility Camera at Palomar Observatory captured a supernova named SN 2020eyj. It was unusual because the spectra observations showed the supernova was surrounded by gas rich in helium. Ionized helium emits radio light, so the team observed the supernova at radio wavelengths, and sure enough, observed the event.

This is important because it gives an astronomer a better understanding of the environment leading up to the supernova explosion. In this case, the companion star likely lost most of its mass before the explosion. Some of its material was captured by the white dwarf, but much of it expanded around the stars, creating a helium-rich environment.

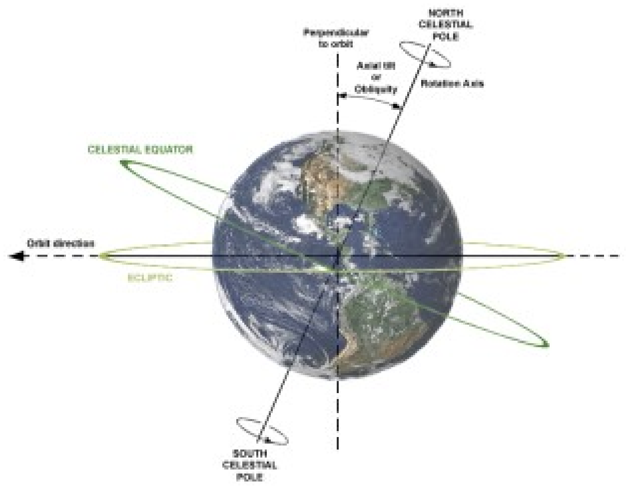
With future radio observations, astronomers could understand why Type Ia supernovae come in several variants. This could also help refine their use as standard candles.

New Climate Model Accurately Predicts Millions of Years of Ice Ages

Earth experiences seasonal changes because of how its axis is tilted (23.43° relative to the Sun's equator), causing one hemisphere to always be tilted towards the Sun (and the other away) for different parts of the year. However, because of gravitational interactions between the Earth, Sun, Moon, and other planets of the Solar System, Earth has experienced changes in its orientation (obliquity) over the course of eons. This has led to significant changes in Earth's climate, particularly the recession and expansion of ice sheets due to significant variations in the distribution of sunlight and seasonal changes.

These warming and cooling periods are known as interglacial and glacial periods ("ice ages"). Another interesting change is how the glacial-interglacial cycle has become slower with time. While scientists have long suspected that astronomical forces are responsible, they have only recently been able to test this theory. In a recent study, a team of Japanese researchers reproduced the cycle of glacial periods during the early Pleistocene Epoch (1.6 to 1.2 million years ago) using an improved computer model that confirmed astronomical forces were responsible.

The team consisted of researchers from the Atmosphere and Ocean Research Institute (AORI) at the University of Tokyo, the Meteorological Research Institute (MRI-JMA), the National Institute of Polar Research (NIPR), the Japan Agency for Marine-Earth Science and Technology, the Center for Computational Astrophysics (CfCA-NAOJ), and the Planetary Exploration Research Cente (PERC-CIT). The team's paper appeared in the May 15th issue of *Communications Earth & Environment* (a journal published by *Nature*).



Earth's axial tilt (or obliquity) and its relation to the rotation axis and plane of orbit. Credit: Wikipedia Commons

For the past 450,000 years, Earth's glacial-interglacial cycle has had a period of about 100,000 years – with glacial periods lasting between 70 to 90 thousand years and interglacials lasting 10,000. However, for 800,000 years during the early Pleistocene (from 1.6 to 1.2 million years before the present date), the cycle had a more rapid period of about 40,000 years. Using state-of-the-art computer simulations, the team considered the impact of astronomical forces on Earth's glacial-interglacial cycle and compared these results to the geological record.

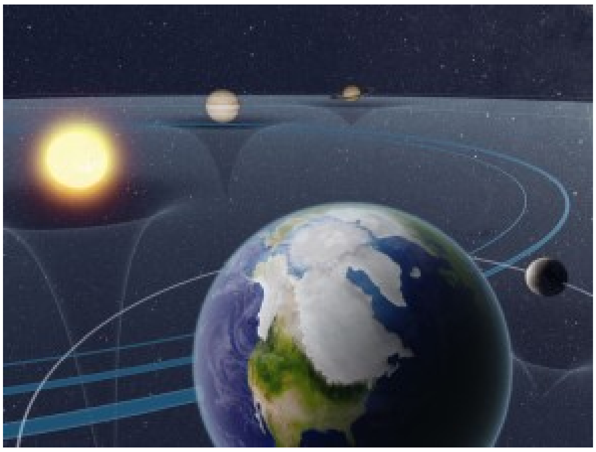
Takashi Ito, a researcher from the CfCA and a co-author on the paper, led the discussion on astronomical forces. As he explained in a CfCA press release, "The numerical simulations performed in this study not only reproduce the Pleistocene glacial-interglacial cycle well, but also successfully explain the complex effects of how astronomical forcing drove the cycle at that time. We can regard this work as a starting point for the study of glacial cycles beyond the present-day Earth."

In addition to replicating the cycle of this earlier period, the team's analysis of the simulations revealed three salient facts about the mechanisms governing climate change. Specifically, they found that the timing of major changes in the cycle was directly associated with certain astronomical phenomena. They included how:

Small differences in the variation of the spin axis' orientation and the orbit of the Earth have a deterministic effect on the glacial cycle.

The onset of an inter-glacial period is also affected by periodic changes in Earth's axial tilt. But it is mainly determined by the position of the summer solstice in Earth's orbit at perihelion.

The duration of an interglacial period is determined by both changes in Earth's spin axis orientation and the position of the summer solstice.



Artist's impression of how astronomical forces affect the Earth's motion, climate, and ice sheets. Credit: NAOJ

This study could have significant implications for Earth science, as it demonstrates that one of the most important forces governing major shifts in our planet's climate has changed over time. This could lead to a better understanding of how Earth's climate evolved, where astronomers can determine the extent of glaciation by applying the three big takeaways from the team's analysis. Given the importance of glacial-interglacial cycles on the evolution of life here on Earth, the results could also have implications for the study of extrasolar planets and the search for life.

In short, by knowing the dynamics of a distant solar system, astrophysicists and astrobiologists could place tighter constraints on an exoplanet's present habitability. In the meantime, the results of this study could be an important step towards a greater understanding of Earth's geological evolution. "As geological evidence from older times comes to light, it is becoming clear that the Earth had a different climatic regime than it does today," added Ito. "We must have a different understanding of the role of astronomical forcing in the distant past."

E MAILS and MEMBERS VIEWING LOGS.

Viewing Log for 21st of May

Looking back thru my records this happens to be my 150th viewing log (from the UK), I do have other viewing logs

which include solar eclipse trips and transits of the sun.

Work wished me to available for the 20th (a Saturday), so I had a free evening on the Sunday and with clear skies and the moon just after new it would be a good time to go out and do some viewing. Looking back in my viewing log, the last time I went out was the 23rd of February, nearly three months ago! I guess the weather or I not being free when the skies were clear stopped me from going out, generally I do not do any viewing between waxing half-moon to waning half-moon, the skies get too washed out to do any good deep sky objects?

I had my trusted Meade LX90 set up and ready by 21:59, being a Sunday evening I would not be expecting many if any cars to go past me, only time will tell there? I would be using my Televue Delos 14 mm eye piece instead of the Pentax one I normally use. With a temperature of 14 °C and no wind, conditions should be good, unfortunately it was still light out to the western horizon! A car did go past me while I was setting up, so it did not affect my night vision as I was still getting it. First object was the thin waxing crescent moon (which was 15.56 % lit or 2.13 days old) as it was getting close to the horizon of my view, hedge gets in the way for low lying objects. I did take a picture of the crescent stage with the telescope and stitched them together later on at home (picture in magazine). Next was Venus which was getting close to a half phase and very bright looking at it with the eye piece, the hand controller said it was – 5.5 magnitude (mag), more like – 4.5? On to Mars which was quiet dim by now, coming in a mag 1.0 and well past it best viewing slot. For a change I thought I would follow the programme called 'Tonight's Best' in the hand controller, would not have a clue what objects it will decide to look at? First object was Venus which I had already done, so on to the 'Double Cluster' or Caldwell 14, I could only make out a few stars in this open cluster (OC) as it was low on the northern horizon and not fully dark yet! Now on to a few stars, starting with Vega in Lyra, this is a class AOV star with a mag of 0.0, making it the fifth brightest star in the night sky. One higher is Arcturus in Bootes, this is a K class of star with a mag of -0.1 and the brightest in the northern hemisphere. Spica in Virgo is a B class star and the 16th brightest with a mag of 0.9 followed by Regulus in Leo, this is a B class of star with a mag of 1.3. While I was getting some info for the stars from the hand controller I noticed quite a few spelling mistakes in the text. On to Albireo in Cygnus probably the best double star in the night sky? These are a white and blue star, while viewing this object a satellite went thru the field of view. Same happened while I was viewing Messier (M) 13, this was also good to look at and could make out a few stars at the edge of this globular cluster (GC). It is not in the same class as Omega Centauri, the best GC in the whole sky but then I was viewing it with a 12 inch SCT instead of the 8 I was using this evening. Castor in Gemini is a tight double star with a spilt of 2.0 arc seconds, this star is a AOV with a mag of 1.9, Castor is actually a six star system but you would need much larger telescope to see them? On to M 44, the Beehive cluster in Leo, this OC is seen best with the finderscope as the main eye piece I am actually looking thru the cluster. M 27 is the first planetary nebula PN) on Messier's list, this was a large grey blob to look at with no detail to be seen, sky not fully dark yet! Tried for Deneb in Cygnus but it was behind a tree, so I would have to give that a miss! Back to Hercules and M 92, the often overlooked GC in this constellation, I could make out some stars and it had a bright core but smaller than M 13. Overhead to Ursa Major and M 82, the Cigar galaxy as it is often known as, this spiral galaxy (SG) was bright to look at and probably the best SG in Messier's list, IMO? On to M 5, just like M 13 but a bit smaller. Back to Virgo and M 104, the Sombrero galaxy, this was a fuzzy blob to look at and not easy to star hop to the object. Another PN, is M 57, the Ring Nebula which is always good to look at. Final object in tonight's list was M 51, the Whirlpool galaxy in Ursa Major could make out both galaxies as they had bright cores. This object was at 81 ° which is nearly directly overhead and not easy to view as I had to do a lot of bending or go down on one knee to view the object.

As a new Supernova had gone off in M 101, I thought I would try and see this object, unfortunately I could not make out the Supernova and it was 86 ° in elevation, even worse than viewing M 51! While viewing during the evening there was no wind around and very quiet. I could hear the motors tracking an object, I had to go over six steps before I could not hear the motors in operation, yes that quiet and no cars went past me either!

Time to pack up at 23:47 with a temperature of 12 °C and very little dew on the equipment used but I would still have to dry all equipment used overnight to make sure it is fully dry before I stored the equipment as I would probably not be viewing again for another two to three months?

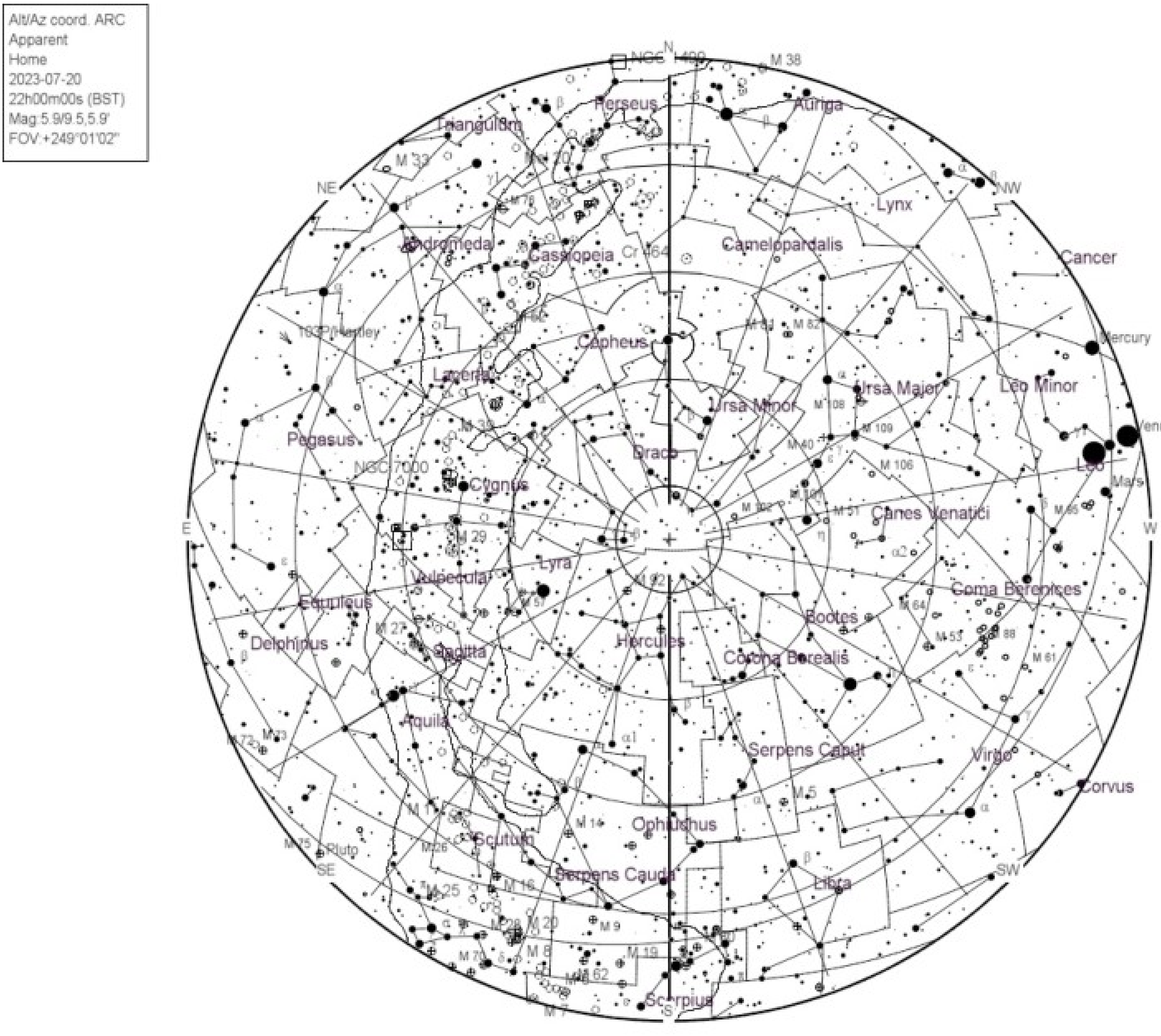
As this is my 150th viewing log, I thought I would go back thru my records and see what else I had viewed. The first viewing log was done on 9th of July 2010 viewing the southern objects with Jon Gale, the 50th was done on the 3rd of October 2015 when I was viewing 'Tonight's Best' which was very similar to what I had seen on the 21st! The 100th was complete on the 19th of January 2020 viewing winter objects with the EQ3-2 pro mount.

Hopefully you have liked my viewing logs over the years and have many more to do?

Clear skies.

Peter Chappell

WHATS UP, SUMMER and JULY 2023



June 4 - **Venus at Greatest Eastern Elongation.** The planet Venus reaches greatest eastern elongation of 45.4 degrees from the Sun. This is the best time to view Venus since it will be at its highest point above the horizon in the evening sky. Look for the bright planet in the western sky after sunset.

June 12, 13 - **Venus in the Beehive.** The planet Venus will pass through the beehive cluster, an open cluster of stars located in the constellation Cancer. Venus can be seen in or very near the cluster on the nights of June 12 and 13. A good pair of binoculars should be enough to see this rare event all though a telescope will provide a much better view.

June 18 - **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 04:39 UTC. This is the best time of the month to observe faint objects such as galaxies and star clusters because there is no moonlight to interfere.

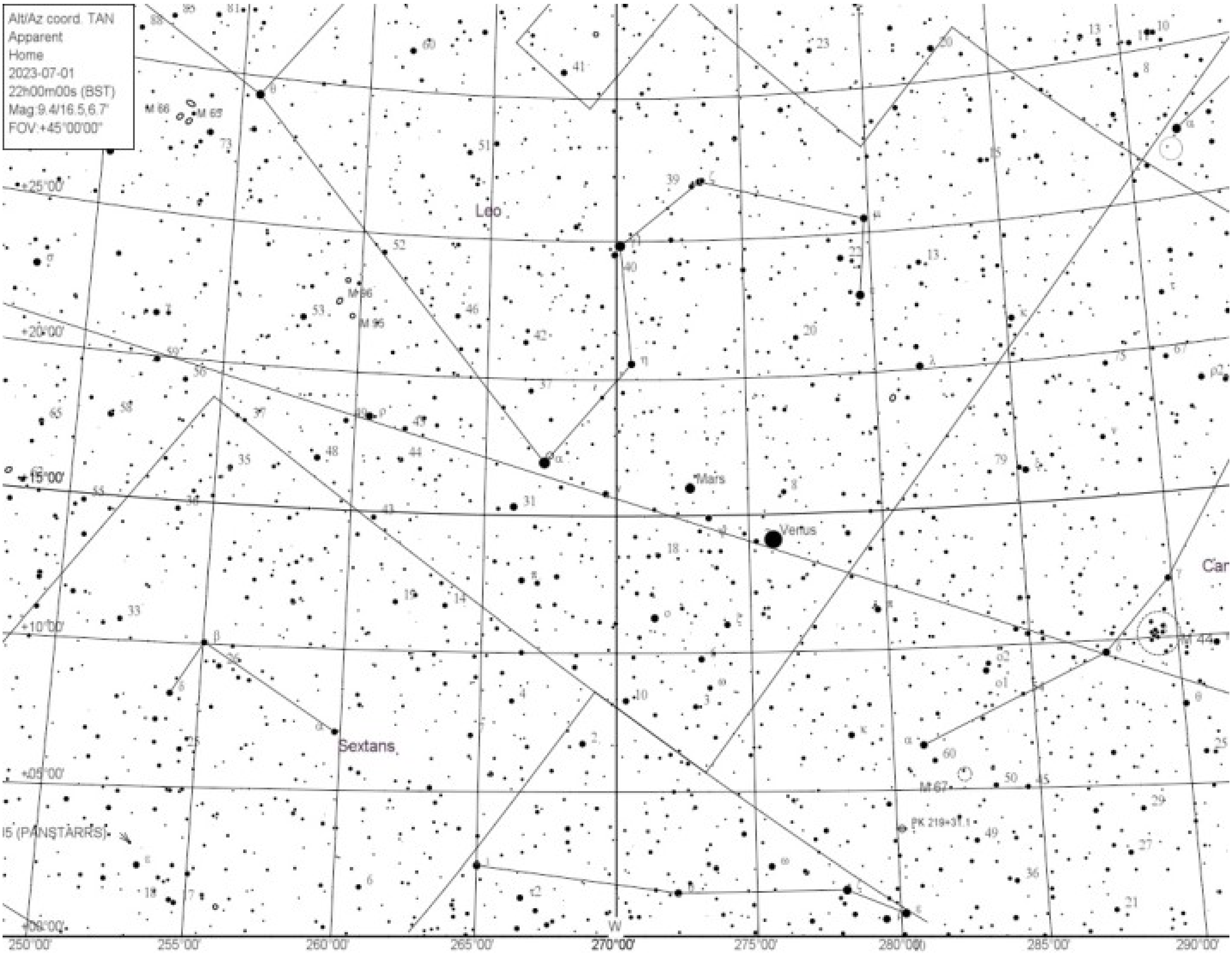
June 21 - **June Solstice.** The June solstice occurs at 14:51 UTC. The North Pole of the earth will be tilted toward the Sun, which will have reached its northernmost position in the sky and will be directly over the Tropic of Cancer at 23.44 degrees north latitude. This is the first day of summer (summer solstice) in the Northern Hemisphere and the first day of winter (winter solstice) in the Southern Hemisphere.

July 1 - **Conjunction of Venus and Mars.** The planets Venus and Mars will pass within 3 1/2 degrees of each other. The event will take place on the morning of July 1 at 2:48 AM (06:48 UTC). Both planets will be visible with the naked eye in the constellation Leo.

July 3 - **Full Moon, Supermoon.** The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This phase occurs at 11:40 UTC. This full moon was known by early Native American tribes as the Buck Moon because the male buck deer would begin to grow their new antlers at this time of year. This moon has also been known as the Thunder Moon and the Hay Moon. This is also the first of four supermoons for 2023. The Moon will be near its closest approach to the Earth and may look slightly larger and brighter than usual.

July 17 - **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 18:33 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.

July 29, 30 - **Delta Aquarids Meteor Shower.** The Delta Aquarids is an average shower that can produce up to 20 meteors per hour at its peak. It is produced by debris left behind by comets Marsden and Kracht. The shower runs annually from July 12 to August 23. It peaks this year on the night of July 29 and morning of July 30. The nearly full moon will block most of the fainter meteors this year. But if you are patient, you may still be able to catch a few good ones. Best viewing will be from a dark location after midnight. Meteors



will radiate from the constellation Aquarius, but can appear anywhere in the sky.

August 1 - **Full Moon, Supermoon.** The Moon will be located opposite the Earth from the Sun and will be fully illuminated as seen from Earth. This phase occurs at 18:33 UTC. This full moon was known by early Native American tribes as the Sturgeon Moon because the large sturgeon fish of the Great Lakes and other major lakes were more easily caught at this time of year. This moon has also been known as the Green Corn Moon and the Grain Moon. This is also the second of four supermoons for 2023. The Moon will be near its closest approach to the Earth and may look slightly larger and brighter than usual.

August 10 - **Mercury at Greatest Eastern Elongation.** The planet Mercury reaches greatest eastern elongation of 27.4 degrees from the Sun. This is the best time to view Mercury since it will be at its highest point above the horizon in the evening sky. Look for the planet low in the western sky just after sunset.

August 12, 13 - **Perseids Meteor Shower.** The Perseids is one of the best meteor showers to observe, producing up to 60 meteors per hour at its peak. It is produced by comet Swift-Tuttle, which was discovered in 1862. The Perseids are famous for producing a large number of bright meteors. The shower runs annually from July 17 to August 24. It peaks this year on the night of August 12 and the morning of August 13. The crescent moon should not be too much of a problem this year. Skies should still be dark enough for a good show. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Perseus, but can appear anywhere in the sky.

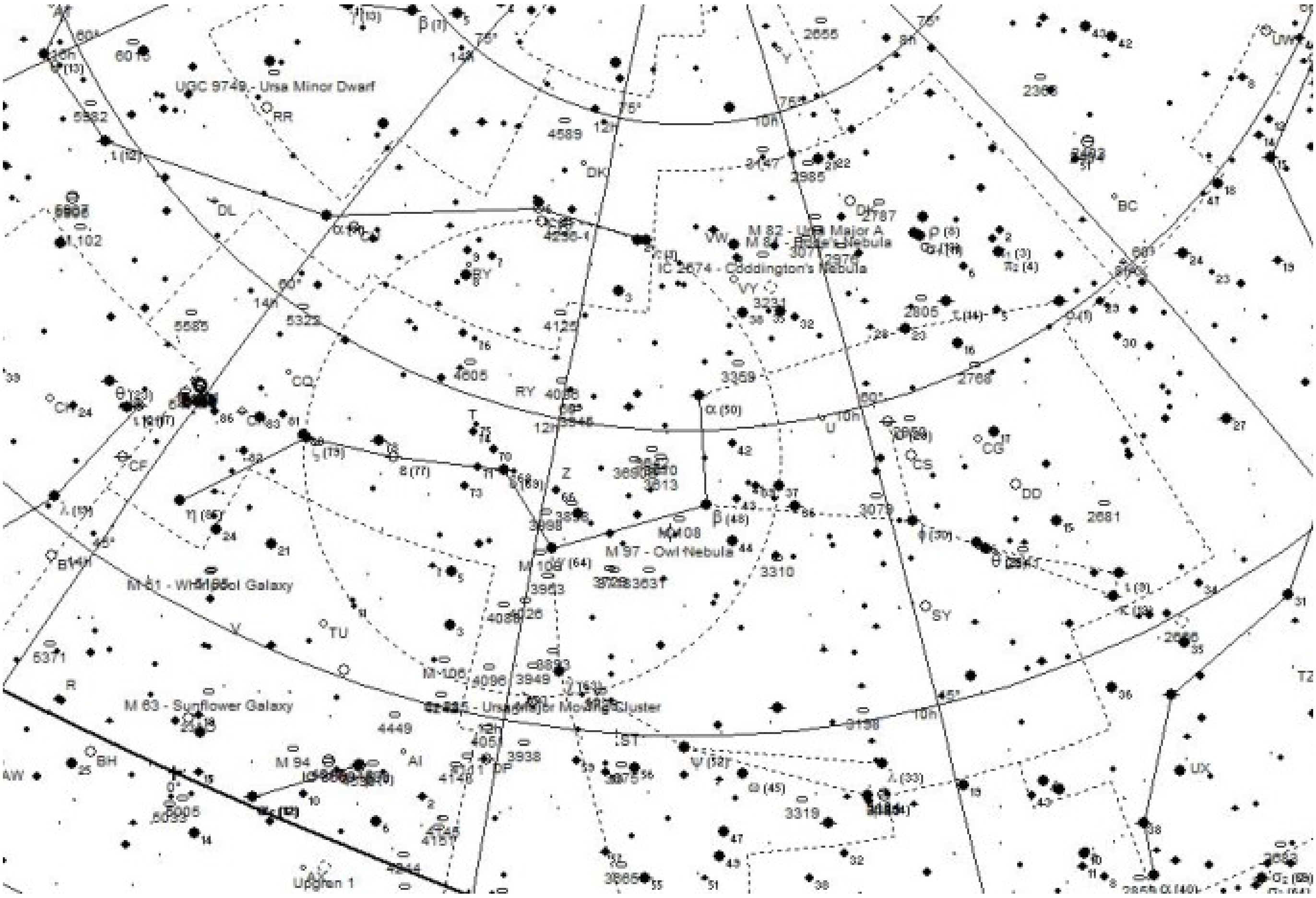
August 16 - **New Moon.** The Moon will located on the same side of the Earth as the Sun and will not be visible in the night sky. This phase occurs at 09:39 UTC. This is the best time of the month to observe faint objects such as galaxies and star clusters because there is no moonlight to interfere.

August 24 - **Moon Occults Antares.** The Moon pass in front of the bright star Antares in the constellation Scorpius. This rare event will happen at 10:29 PM (02:29 UTC) and will be visible in the central US and northern Florida. (**Occultation Map and Details**)

August 27 - **Saturn at Opposition.** The ringed planet will be at its closest approach to Earth and its face will be fully illuminated by the Sun. It will be brighter than any other time of the year and will be visible all night long. This is the best time to view and photograph Saturn and its moons. A medium-sized or larger telescope will allow you to see Saturn's rings and a few of its brightest moons.

August 31 - **Full Moon, Supermoon, Blue Moon.** The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This phase occurs at 01:37 UTC. This is also the third of four supermoons for 2023. The Moon will be near its closest approach to the Earth and may look slightly larger and brighter than usual. Since this is the second full moon in the same month, it is sometimes referred to as a blue moon.

CONSTELLATIONS OF THE MONTH: URSA MAJOR



Ursa Major

The Myth ~ The Great Bear and the Little Bear

To the ancient Greeks, Ursa Major represented Callisto, a follower of Artemis, virgin huntress and goddess of the crescent moon. Zeus, king of the gods, fell in love with Callisto and she gave birth to his child named Arcas. Some say Hera, wife of Zeus and queen of the gods, became intensely jealous and changed Callisto into a bear left to roam the forest. One day Arcas came upon the bear. Callisto stood on her hind legs to welcome her son. Thinking himself attacked, Arcas readied his bow. Zeus, who saw what was about to happen, turned Arcas into a small bear. Grabbing both bears by their tails, Zeus hurled them into the safety of the sky, where they still roam close together as Ursa Major and Ursa Minor. This action might explain why the ancient view of the Great Bear has an unusually long tail.

Variations of the Myth

Some say Hera had the last laugh, she moved the bears into a part of the sky near the celestial pole. There they would never set below the horizon, never resting, remaining the eternal victims of Zeus' wandering eye.

Another legend says Zeus seduced Callisto by taking on the form of Artemis to deceive her. Artemis demanded the strictest chastity from the maidens who followed her hunting through the mountains. In order to save Callisto and Arcas from the wrath of the virgin goddess, Zeus transformed Callisto into the Great Bear and set her in the stars with Arcas, their child, beside her.

Still others say it was the rage of Hera or Artemis which cursed Callisto, who then turned into a bear pursued by her own hounds. Only later was she placed as the Great Bear among the stars.

Some say Arcas grew up to become king of Arcadia and brought agriculture to that wild and rugged country, for which he was immortalized among the stars as Bootes, inventor of the "Wagon," which is the other name for the constellation of the Great Bear.

A more ancient belief behind the story of Callisto is that the Great Bear is really Artemis herself, and that Callisto is another name for Artemis. Artemis is the ancient queen of the stars and the ruler of the Arctic Pole. The she-bear is her symbol. She is the "Sounding One" and the "Lady of the Wild Mountains" giving off a "brilliant blaze" as she hunts. She is the queen of the inviolate meadow far from the haunts of men. She is the queen of the crescent moon, moonlight being her actual presence, and she is believed to cause wild animals and trees to dance.

Later the English linked the constellation to both the Bear and Wagon. They saw it as the wagon of King Arthur, whose Round Table is reflected in the constellations circling the Pole, and whose name comes from the Celtic word for "bear." Legend has it that Arthur is sleeping in a cave with his knights beside him, and will return one day to save his country in its hour of need. The seven most important stars of the Bear-Wagon (the Big Dipper) are also known as the Seven Sleepers of Epheus, who lie dreaming in a mountain cave waiting for the resurrection. These Seven Sleepers, unlike Arthur, are said to have awoken after 200 years and gone down to the local town for provisions, after which they went to sleep once more.

In ancient China the seven stars of the Big Dipper were associated with the celestial palace of the Lord On High, the Star God of Longevity, the heavenly mountain, the paradise of the immortals. The star Sirius, the Heavenly Wolf, guarded this celestial palace. Today Sirius, which shares the space motion Ursa Major, is regarded as an outlying member of it!

The Great Bear throughout the ages has been linked to the gods and goddesses to royality and immortality. Open to this constellation in the springtime and receive its heavenly blessings! The paws of the Great Bear are up high, as if walking in the heavens, and the bowl of its Big Dipper is inverted as if pouring heavenly contents upon an awakening earth. Look up, be blessed and graced!

The Micmac Indians of Nova Scotia and the Iroquois Indians along the St. Lawrence seaway share one story about the Big Bear. In this story, the quadrangle of the dipper represents a bear that is pursued by seven hunters; the three closest hunters are the handle of the dipper. As autumn approaches, the four farthest hunters dip below the horizon and abandon the hunt, leaving the closest three hunters to chase the bear. The hunters are all named after birds. The closest hunter to the bear is named Robin, the second closest is Chickadee, and the third is Moose Bird. Chickadee is carrying the pot in which the bear will be cooked. The second star in the handle is actually two stars [the famous double star system] called Mizar and Alcor which represent Chickadee and the pot. In autumn, as the bear attempts to stand up on two legs, Robin wounds the bear with an arrow. The wounded bear sprays blood on Robin, who shakes himself and in the process colors the leaves of the forest red; some blood stains Robin and he is henceforth called Robin Redbreast. The bear is eaten, and the skeleton remains traveling through the sky on its back during winter. During the following spring a new bear leaves the den and the eternal hunt resumes once more.

An Arab myth associates this asterism with a funeral. The quadrangle represents a coffin and the three handle stars are people following the coffin and mourning. The middle star (really the two stars Mizar and Alcor) represents the daughter and son of al-Naash, the man in the coffin, who has been murdered by al-Jadi, the pole star. Other cultures, too, relate funeral processions to the Big Dipper.

Ursa Major

We commented earlier on the myths and the various significations of Ursa Major, the Big Bear. We now consider a word that is related to bear, namely bier. Other related words are bear (to carry), bairn (a babe, as one borne), burden, fertile, differ, offer, etc. A bier is a platform on which a corpse or coffin is placed before burning or burying. It may be mobile.

Before we begin that, let us examine what the asterism has meant to the peoples of the past.

In North America, the Algonquins and Narragansetts saw them as bears, which most likely came from European traders such as those of Tarshish. Contact between the Algonquins and the Celts was broken in the fifth century A.D. The speculation that the Indians got the bear from the Sanskrit via the Siberians came from Whitney's *Century Dictionary* from about the turn of the eighteenth to nineteenth centuries. It was later embellished by evolutionists to incorporate the land bridge supposed to exist between Siberia and Alaska.

The ancient Syrians called it a wild boar; the Irish King David's chariot (an Irish king), the French the great chariot or the Car of Boötes.

The Greeks are said to have called it *Amaxa*, meaning axle, but that was probably a reference to Ursa Minor. The Swedes and Goths called it Kar's Vagn, meaning Karl's chariot, where Karl was a name for Thor.

The Poles called Ursa Major the heavenly wain. Until the 1800s the later Syrians saw a bier. Egypt, ever the odd man out, saw a bull's thigh or foreshank.6 The Chinese called the seven stars the Government. Ancient

India saw *sugi*, the wain, or Libra's yoke. The English saw a plough, with the dipper's handle stars as the handle of the plough and the cup the plowshare. Others saw the three stars in the handle as a team of oxen pulling the plough.

5 The kingdom of heaven is only mentioned in Matthew; the kingdom of God occurs in Matthew, the other gospels, and beyond.

6 There is in the Dendera star chart a figure that looks like a cattle leg, but given the uncertainties in scale introduced by the oddities of the zodiacal constellation placements, it is not clear to this author whether Ursa Major is the leg or the cherub (ox-like figure) holding the jackal (Ursa Minor) on what appears to be a tray.

The ursas as biers or wagons was prominent among the early Arabs, the later Syrians, and the English. From the latter originated Arthur's Chariot (wain). The "arth" part of Arthur relates to bear, and Uther means wonderful. (Arthur's father, Uther, assumed the surname Pendragon, meaning son of the dragon, after a dragon-like comet appeared in the sky).7 The constellation was usurped by the myth of Arthur. The real Arthur ruled the Britons from ca. A.D. 521-542. On the mainland, the Nordic appellation, Karl's Wain, was later assumed for Charlemagne (ca. A.D. 742-814).

Arcturus and his sons

We now consider the Hebrew appellation for the constellation of the Big Dipper. Allen mentions the names *Kalitsah* and *Parashah* applied to the asterism or an individual star. The former means safety, and the latter

means guiding star. One immediately sees the "ayish" in the Semitic (probably Persian) *Parashah*. *Ayish* appears twice in the Bible, and both times it is translated as Arcturus. Both occurrences are in Job, namely, 9:9 and 38:32.8 Although greatly out of favor these days, Arcturus is the correct (and earliest) translation of *ayish*. Modern versions lean towards the Arabic term for the Big Dipper, namely *Banat Na-ash al Kubra*, the daughters of the Great Bier, meaning the mourners. That is not how the Hebrew scripture reads, however. We have seen before, especially under the constellation Draco, where relying on the Arabic meanings has totally violated the Scripture's integrity, not to mention abandonment of history.

There is really no great mystery associated with the identification of Arcturus (or Ayish, if one must) and his sons. Ayish means assembler, gatherer (as a shepherd gathers his flock), and we noted guiding star before as its full name. The sons of Arcturus are the seven stars known as the Big Dipper (Ursa Major). The star at the tip of the handle (h) is called "Benet Nash" which means son of Ash. The word Arcturus signifies a gatherer (as into a fold); bear-watcher; or consuming (fire). It recalls the Spirit speaking in Revelation 2:7, 11, 17 etc. addressing the spirits of the seven churches (Rev. 1:20). As the Little Dipper was a type of the Jewish remnant, the Big Dipper is a type of the Gentile remnant, the believers of the Gospel.

7 Cooper, Bill, 1995. *After the Flood*, (Chichester: New Wine Press), p. 81.

8 Job 9:9 Which maketh Arcturus, Orion, and Pleiades, and the chambers of the south. Job 38:32 Canst thou bring forth Mazzaroth in his season? or canst thou guide Arcturus with his sons?

The star names in UMa

There appears to be much confusion in the literature about which star is the brightest in the Big Dipper. Some have even speculated that their brightness has changed over the centuries, and that may well be true, but if one will refer to the figure of Ursa Major on the next page, one will note that the usual rule for assigning Greek letters to stars in a constellation was not followed for the Big Dipper. The Greek letter alpha (a) is supposed to be assigned to the brightest star in the constellation, beta (b) to the second brightest, and so on. When it came to the Big Dipper, the rule was abandoned. The stars are labeled in order from the front of the dipper to the end of the handle without any consideration for their relative brightness.

a **Dubhe**: flock; also called Dubb, bear. It is reported on the back of the bear.

b **Merach**, Hebrew for flock, Arab for purchased. Allen says *Al Marahk*, Arabic for loin.

g **Phaeda** with various spellings: visited, guarded, numbered (Psa. 147:4). Allen says from Arabic *Al Falidh*, meaning thigh.

d **Megrez**: not translated by Rolleston. Allen stays with the Arabic, *Al Maghrez*, root of the tail.

e **Alioth**: she-goat. The name is recent, originating with the first edition of the Alfonsine Table. It may mean fat tail of the eastern sheep. Later editions changed it to *Aliare* and *Aliore*, white of the eye.

z **Mirak**, the original name of Mizar. Scalinger changed Mirak to Mizar. In Hebrew Mizar means little one, in Arabic, girdle or waistcloth.

Allen claims the name, Mirak, derives from the Arabic *Anak al Banat* meaning neck of the daughter or goat of the mourners.

Mirak has also been applied to b and e. The nineteenth century defenders of the witness of the stars only recognized Mizar as meaning small, o separate. That name better fits its neighbor, Alcor.

80 **Alcor**: the lamb. Allen reports that the name derives from *Al Khawwar*, the faint one. The Greeks thought it to be the lost Pleiad9 and dubbed it *Alopex*, the fox. It is still a test of good eyesight to be able to resolve the two stars. Physically, Alcor lies three light years beyond Mizar. The figure below plots the relative distances to each of

the seven stars in the Dipper.

h **Benet Naish**: Arabic for daughters of the assembly (Ash). The star is more commonly called **Alkaid**, meaning assembled. Allen expands the name to *Ka'id Banat al Na'ash*, meaning governor of the daughters of the bier, that is, chief mourner.

q **Sarir Banat al Na'ash**: throne of the mourners (Allen).

i **Talitha**: Ulug Beigh, the Arab astronomer's, *Al Phikra al Talitha*.

Allen says Phikra should be Kafzah, in which case it means third spring of the gazelle. The allusion is that each of the three pairs of twin stars along the bottom of the bear represent the footprints of a gazelle's jump.

m, l **Tania Australis** and **Tania Borealis** respectively, representing the second spring of the gazelle.

n, x **Alula Borealis** and **Alula Australis** respectively. They represent the first spring of the gazelle.

o **Muscida**: the muzzle. The name appears to originate in the Middle Ages.

9 See Bouw, G., 1999. "The Bible and the Pleiades," *B. A.,* **9**(87):4.

p1, p2 Also called **Muscida** at times. Locate north of o.

s1, s2 **Al Thuba**: the gazelle. These are to the North-North-East of star 23.

c **El Kophrah**: protected, covered. Hebrew, redeemed, ransomed.

Finally, for some of the other names associated with Ursa Major, Bullinger lists some meanings: Amaxa, or Amaza, as an alternate name for Alcor, the Pleiad, means "coming and going." Callisto is sheepfold, set, or appointed. Finally, Helice of Helike means company of travellers, that is, pilgrims. All in all, the constellation does exhibit overtones of the theme of salvation in our Lord Jesus Christ.

Engineers On Management

A man in a hot air balloon realized he was lost. He reduced altitude and spotted a woman below. He descended a bit more and shouted: "Excuse me, can you help me? I promised a friend I would meet him an hour ago, but I don't know where I am."

The woman below replied: "You're in a hot air balloon hovering approximately 30 feet above the ground. You're about 2 degrees west longitude and about 52 degrees north latitude."

"You must be an engineer," said the balloonist.

"I am," replied the woman, "How did you know?"

"Well," answered the balloonist, "everything you told me is technically correct, but I've no idea what to make of your information, and the fact is I'm still lost. Frankly, you've not been much help at all. If anything, you've delayed my trip."

The woman below responded: "You must be in management."

"I am," replied the balloonist, "but how did you know?"

"Well," said the woman, "you don't know where you are or where you're going. You have risen to where you are due to a large quantity of hot air. You made a promise which you've no idea how to keep, and you expect people beneath you to solve your problems. The fact is you are in exactly the same position you were in before we met, but now, somehow, it's my fault."

Double stars in Ursa Major:

Several have just been mentioned. But there are other binaries in Ursa Major worthy of investigating.

Dubhe (Alpha Ursae Majoris) is a well-known binary, with a close 4.8m companion which orbits every 44.66 years. In 2000 the values are: 1.9, 4.8; PA 214º, separation 0.6".

Phi UMa is even closer these days [PA 243º, separation 0.23"] but the distance is gradually widening. It has a period of 105.5 years. The two stars are similar in magnitude: 5.3, 5.4, resulting in a combined magnitude of 4.6.

Sigma^2 UMa is a much easier binary to resolve; presently the separation is 3.8" at PA 355º. The companion, a rather dim 8.2 visual magnitude, describes a leisurely 1067 year orbit. As with many slowly orbiting binaries, this one has had a variety of calculated periods, although Burnham's "best modern computation [of] 706 years" is now considered out of date.

Xi UMa is an attractive binary [4.3, 4.8] with a fast orbit. This star shouldn't cause too many problems to resolve; its closest point came in 1993 and it too is widening, presently sitting at PA 302º and separation 1.3". The star was designated an RS CVn type variable in 1993.

Zeta UMa, Mizar, is the best of the bunch and probably the easiest to find as well. A multiply system with Alcor, AB form a fixed binary at PA 152º, separation 14.4". Alcor (component C) is a distant 12 minutes east (709").

Mizar was the first binary system to be discovered (in 1650), and is usually the first binary to be found and studied by amateur astronomers. No matter how long you study the stars, coming back to Mizar is always a treat.

Both A and B are also spectroscopic binaries (that is, each one has a companion too faint for observation but which shows up when studied spectroscopically). The presence of such a companion is deduced from changes in the doppler shift in the spectral lines of the primary.

Although at a great distance from Mizar (perhaps three light years away), Alcor (80 UMa) may be gravitationally bound to this star as it shares the same proper motion. However, most authorities believe the stars only form an optical binary.

This is a 3.99 visual magnitude star, 81 light years away. Alcor serves as a good jumping off point to study M101, a spectacular face-on spiral galaxy (see below).

Variable stars in Ursa Major:

Ursa Major has no notable variables, but there are a number which might be of some interest.

Epsilon Ursae Majoris is an alpha-CVn type variable: 1.76-1.78 every five days and two hours.

Alpha-Canum Venaticorum type stars are rotating variables which typically evince very little change in visual magnitude. These stars are generally A-type (that is, they have a spectrum range of B9-A5) but curiously enough they show an unusual abundance of a number of heavy metals and a corresponding lack in the more common elements.

These stars are divided into three groups: those with predominantly silicon spectral lines, those with manganese, and those with chromium-strontium lines. Epsilon Ursae Majoris shows a strong chromium line.

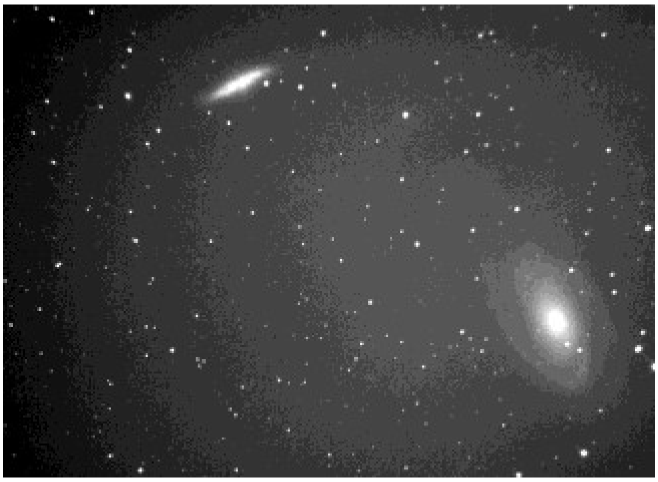
R Ursae Majoris is a Mira-type variable with period of 301.62 days, and a magnitude change from 6.5 to 13.7. Curiously, it is actually a brighter red when at its minimum; at maximum it loses much of its colour. The 2000 maximum was expected in the latter half of March.

Deep Sky Objects in Ursa Major:

Ursa Major has five Messier objects: M40, M81, M82, M97, and M101.

M40 is the Messier object that really isn't one. In 1764 Messier went looking for an object that had been catalogued as a nebulosity in this area. What he found was two ninth-magnitude binary stars, very close together, which he assumed had been mistakenly catalogued as the nebulosity. However instead of leaving the matter there, he proceeded to catalogue the stars as his No. 40.

A hundred years later the stars were catalogued by Winnecke as binaries called "Winnecke 4"; they still go by this name. The binary (9.9, 9.3; PA 83 degrees, and separation 49") is found one and a half degrees north-east of delta UMa. The easiest way to find the binary is to draw a line from delta to 70 UMa, then another half a degree beyond this point.

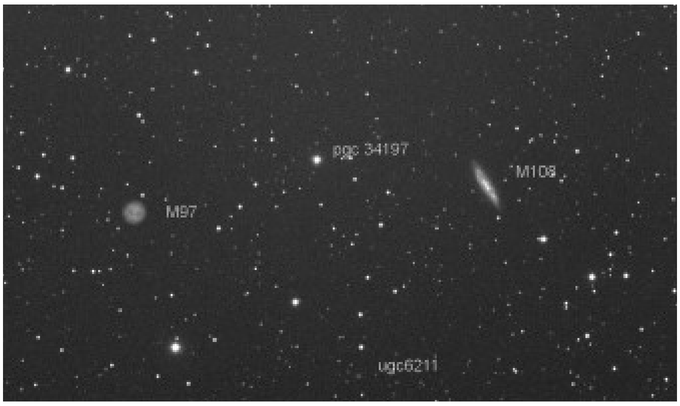


M81 (NGC 3031) is a superb spiral galaxy, and with M82 in the same field, half a degree to the north, forms a splendid pair.

The distance is approximately seven to nine million light years and, as Burnham reports, the galaxy is considered one of the most dense galaxies known, with a total mass of 250 billions suns. A large scope is needed to catch the fine detail in the spiral's arms.

M82 (NGC 3034) floats above M81 like an ethereal UFO; any minute you think it's going to zip away in the night sky.

The galaxy isn't, as one might think, a spiral on edge, but is usually described as spindle shaped. The galaxy is rather mysterious; it's thought that an explosion at its centre one and a half million years ago created the odd shape, which is still expanding at a rate of 950 km/second.



M97 (NGC 3587) often called the "Owl Nebula" for its two dark central areas (revealed only in the largest telescopes) resemble an owl's eyes. The nebula is formed by the still expanding shell of its central star, which is very small and compact, with a surface temperature as much as 85,000 kelvin.

M101 (NGC 5457) is a vast galaxy, one of the largest known, with open spirals. Although seen face on, it's fairly dim; it

takes a large scope and an exceptionally good night to see this nebula at its best.

Located five and a half degrees east of zeta UMa, the usual method given to find M101 is to star hop. From zeta UMa (Mizar) proceed to Alcor, then over and slightly north to 81 UMa, and now down to the southeast to 83, then 84. Now locate 86 UMa, to the southeast. This star forms the bottom point of a wide-v shape with 84 and M101.

ISS Passes Summer 2023

Date	Bright-ness	Start			Highest point			End		
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
29 Jun	-2.1	03:40:06	11°	SSW	03:42:34	22°	SE	03:45:13	10°	E
30 Jun	-1.7	02:52:14	14°	SSE	02:53:13	15°	SE	02:55:14	10°	ESE
01 Jul	-3.1	03:37:07	13°	SW	03:39:51	40°	SSE	03:43:00	10°	E
02 Jul	-2.6	02:49:08	22°	S	02:50:21	28°	SSE	02:53:16	10°	E
03 Jul	-2.1	02:01:03	20°	SE	02:01:03	20°	SE	02:03:23	10°	E
03 Jul	-3.8	03:33:51	10°	WSW	03:37:08	65°	SSE	03:40:27	10°	E
04 Jul	-1.3	01:12:54	11°	ESE	01:12:54	11°	ESE	01:13:08	10°	ESE
04 Jul	-3.5	02:45:41	22°	SW	02:47:31	49°	SSE	02:50:46	10°	E
05 Jul	-3.1	01:57:28	34°	S	01:57:54	36°	SSE	02:01:00	10°	E
05 Jul	-3.8	03:31:02	10°	W	03:34:24	88°	SSE	03:37:44	10°	E
06 Jul	-2.3	01:09:09	23°	ESE	01:09:09	23°	ESE	01:11:08	10°	E
06 Jul	-3.9	02:41:55	14°	WSW	02:44:40	76°	SSE	02:48:00	10°	E
07 Jul	-1.4	00:20:42	12°	ESE	00:20:42	12°	ESE	00:21:03	10°	E
07 Jul	-3.8	01:53:28	29°	SW	01:54:56	60°	SSE	01:58:14	10°	E
07 Jul	-3.7	03:28:13	10°	W	03:31:34	85°	N	03:34:54	10°	E
08 Jul	-3.5	01:04:50	42°	S	01:05:12	44°	SSE	01:08:25	10°	E
08 Jul	-3.8	02:38:25	10°	W	02:41:45	87°	N	02:45:06	10°	E
08 Jul	-3.8	04:15:06	10°	W	04:18:25	72°	SSW	04:21:45	10°	ESE
09 Jul	-2.9	00:15:53	31°	SE	00:15:53	31°	SE	00:18:31	10°	E
09 Jul	-3.9	01:48:35	10°	WSW	01:51:56	85°	SSE	01:55:17	10°	E
09 Jul	-3.9	03:25:16	10°	W	03:28:37	85°	S	03:31:57	10°	ESE
09 Jul	-2.6	23:26:00	22°	SE	23:26:00	22°	SE	23:28:29	10°	E
10 Jul	-3.9	00:58:47	10°	WSW	01:02:06	71°	SSE	01:05:26	10°	E
10 Jul	-3.8	02:35:24	10°	W	02:38:45	87°	N	02:42:06	10°	E
10 Jul	-3.5	04:12:06	10°	W	04:15:19	45°	SSW	04:18:31	10°	SE
11 Jul	-3.8	00:09:00	10°	WSW	00:12:16	55°	SSE	00:15:32	10°	E
11 Jul	-3.8	01:45:31	10°	W	01:48:52	85°	N	01:52:13	10°	E
11 Jul	-3.8	03:22:12	10°	W	03:25:30	61°	SSW	03:28:47	10°	ESE
11 Jul	-3.4	23:19:18	10°	SW	23:22:26	40°	SSE	23:25:36	10°	E
12 Jul	-3.9	00:55:36	10°	W	00:58:57	89°	NNW	01:02:17	10°	E
12 Jul	-3.9	02:32:17	10°	W	02:35:37	77°	SSW	02:38:56	10°	ESE
12 Jul	-2.7	04:09:08	10°	W	04:11:57	26°	SSW	04:14:46	10°	SSE
12 Jul	-2.9	22:29:44	10°	SSW	22:32:38	28°	SSE	22:35:33	10°	E
13 Jul	-3.9	00:05:41	10°	WSW	00:09:01	81°	SSE	00:12:21	10°	E
13 Jul	-3.9	01:42:20	10°	W	01:45:41	89°	S	01:49:01	10°	E
13 Jul	-3.3	03:19:03	10°	W	03:22:09	36°	SSW	03:25:15	10°	SE
13 Jul	-3.9	23:15:46	10°	WSW	23:19:04	65°	SSE	23:22:23	10°	E
14 Jul	-3.8	00:52:22	10°	W	00:55:42	85°	N	00:59:03	10°	E
14 Jul	-3.7	02:29:02	10°	W	02:32:17	50°	SSW	02:35:31	10°	SE
15 Jul	-3.8	00:02:22	10°	W	00:05:42	85°	N	00:09:02	10°	E
15 Jul	-3.9	01:39:01	10°	W	01:42:20	67°	SSW	01:45:25	12°	ESE
15 Jul	-2.3	03:16:02	10°	W	03:17:52	19°	SW	03:17:52	19°	SW
15 Jul	-3.9	23:12:20	10°	W	23:15:40	88°	S	23:19:00	10°	E
16 Jul	-3.9	00:49:00	10°	W	00:52:21	82°	S	00:54:37	19°	ESE
16 Jul	-2.2	02:25:47	10°	W	02:27:18	21°	WSW	02:27:18	21°	WSW
16 Jul	-3.9	22:22:18	10°	WSW	22:25:38	75°	SSE	22:28:57	10°	E

ISS PASSES For Summer 2023 cont.

from Heavens Above website maintained by Chris Peat.

Date	Brightn	Start	Highest	End						
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
16 Jul	-3.9	23:58:57	10°	W	00:02:16	88°	N	00:05:16	12°	E
17 Jul	-3.0	01:35:37	10°	W	01:38:00	34°	WSW	01:38:00	34°	WSW
17 Jul	-3.8	23:08:51	10°	W	23:12:11	85°	N	23:15:32	10°	E
18 Jul	-3.8	00:45:30	10°	W	00:48:47	56°	SSW	00:49:02	54°	S
18 Jul	-3.8	22:18:44	10°	W	22:22:04	87°	N	22:25:24	10°	E
18 Jul	-3.9	23:55:24	10°	W	23:58:43	73°	SSW	00:00:13	30°	ESE
19 Jul	-1.5	01:32:17	10°	W	01:32:58	14°	W	01:32:58	14°	W
19 Jul	-3.9	23:05:15	10°	W	23:08:35	86°	SSW	23:11:28	13°	E
20 Jul	-2.6	00:41:58	10°	W	00:44:13	29°	WSW	00:44:13	29°	WSW
20 Jul	-3.8	22:15:05	10°	W	22:18:24	86°	N	22:21:45	10°	E
20 Jul	-3.5	23:51:44	10°	W	23:54:57	46°	SSW	23:55:31	41°	S
21 Jul	-3.8	23:01:31	10°	W	23:04:49	63°	SSW	23:06:50	21°	ESE
22 Jul	-1.5	00:38:37	10°	W	00:39:35	15°	WSW	00:39:35	15°	WSW
22 Jul	-3.8	22:11:17	10°	W	22:14:37	79°	SSW	22:17:56	10°	ESE
22 Jul	-2.6	23:48:06	10°	W	23:50:56	27°	SSW	23:50:56	27°	SSW
23 Jul	-3.1	22:57:42	10°	W	23:00:50	38°	SSW	23:02:17	24°	SSE
24 Jul	-3.5	22:07:23	10°	W	22:10:38	53°	SSW	22:13:39	12°	SE
24 Jul	-1.6	23:44:48	10°	WSW	23:46:24	14°	SW	23:46:24	14°	SW
25 Jul	-2.1	22:54:01	10°	W	22:56:37	21°	SW	22:57:47	18°	S
26 Jul	-2.6	22:03:27	10°	W	22:06:26	31°	SSW	22:09:11	11°	SSE
27 Jul	-1.3	22:51:05	10°	WSW	22:52:08	11°	SW	22:53:12	10°	SSW
28 Jul	-1.7	21:59:44	10°	W	22:01:59	17°	SW	22:04:14	10°	S
25 Aug	-1.6	04:44:27	11°	S	04:46:30	17°	SE	04:48:46	10°	E
26 Aug	-1.2	03:55:19	11°	SE	03:55:31	11°	SE	03:56:35	10°	ESE
26 Aug	-3.0	05:28:16	10°	SW	05:31:27	43°	SSE	05:34:36	10°	E
27 Aug	-2.5	04:38:51	21°	SSW	04:40:17	30°	SSE	04:43:15	10°	E
28 Aug	-1.9	03:49:35	20°	SE	03:49:35	20°	SE	03:51:45	10°	E
28 Aug	-3.7	05:22:18	12°	WSW	05:25:21	68°	SSE	05:28:38	10°	E
29 Aug	-3.4	04:32:59	33°	SSW	04:34:05	51°	SSE	04:37:19	10°	E
30 Aug	-2.4	03:43:38	31°	ESE	03:43:38	31°	ESE	03:45:55	10°	E
30 Aug	-3.8	05:16:20	13°	W	05:19:13	89°	SSE	05:22:31	10°	E
31 Aug	-0.8	02:54:14	11°	E	02:54:14	11°	E	02:54:24	10°	E
31 Aug	-3.9	04:26:57	44°	WSW	04:27:50	76°	SSE	04:31:09	10°	E
01 Sep	-2.6	03:37:32	37°	E	03:37:32	37°	E	03:39:45	10°	E
01 Sep	-3.8	05:10:15	14°	W	05:13:00	84°	N	05:16:18	10°	E
02 Sep	-0.7	02:48:08	11°	E	02:48:08	11°	E	02:48:17	10°	E
02 Sep	-3.9	04:20:50	52°	W	04:21:33	88°	N	04:24:51	10°	E
03 Sep	-2.3	03:31:26	33°	E	03:31:26	33°	E	03:33:24	10°	E
03 Sep	-3.9	05:04:08	16°	W	05:06:39	87°	S	05:09:58	10°	E
04 Sep	-3.9	04:14:47	68°	WNW	04:15:09	85°	N	04:18:28	10°	E
04 Sep	-3.5	05:48:23	10°	W	05:51:37	49°	SSW	05:54:48	10°	SE
05 Sep	-1.7	03:25:28	24°	E	03:25:28	24°	E	03:26:56	10°	E
05 Sep	-3.8	04:58:12	22°	W	05:00:09	66°	SSW	05:03:26	10°	ESE

END IMAGES, AND OBSERVING

M101 in the area of the sky above Mizar, the middle star of the 'handle' in Ursa Major, is a face on galaxy with spiral arms visible in large telescopes or imaged in small telescopes.
In May a super nova went off in one of the spiral arms, and the star brightened more than a million fold, and shone brighter than 11 magnitude. It is still there for the next few months.
Photograph
Andy Burns

Observing Sessions

Proposed Observation Sessions for 2022-2023

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

a ad-hoc session for other reasons and at other locations, such as astro-photography, solar observing etc, with other like-minded members then they can do so through the Society Members Facebook Page or through the WAS contact page on the website.

OUTREACH:

In August we have been asked to prepare an astronomy weekend for the army corp and families based in Colerne. I am enquiring about getting the Dark Sky Wales Planetarium to come along and we will need solar viewing and evening sky viewing. October 223rd-28th week to tie in with half term.