NWASNEWS

Volume28 Issue 8

April 2023

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

SHADOWING THE UNIVERSE...

The wettest March for 40 years. Little wonder I received no input for images or observing logs. OK I caught some images of the Moon in the last couple of nights, but this will also stop images of deep sky objects, The ones I have included here have come from previous years.

With galaxy spotting season upon us for evening viewing (Leo, Virgo and Come Berenices are well positioned) we look out of our own galaxy 90 degrees to the plain of the spiral arms so have a comparatively clear view through the galaxy halo to the galaxy fields.

The Swindon page is also truncated as Robin has retired as chair person over there, and the replacement chair hasn't submitted a new file in time.

I am almost in the stage where my arthritis is stopping me being as mobile as before and it really is time for me to take a back seat, so please be aware this is my final year as chair aswell. At the agm we need to examine what we want to be doing as a society going forward, we need volunteers across the board apart from Treasurer and Viewing evening coordinator.

I have some ideas of where we go, are hall meetings still valid? Do we go to Zoom sessions? Do we become an observing group?

If we want speaker meeting we could go for zoom sessions only (with maybe a physical meeting for AGM etc and viewing sessions.

Doing this would mean less need for committee members, nearly 0 costs for hall hire and lower charges for speakers. It would reduce treasurers/members sec duties too. We could charge for attending the virtual meetings, but it should reduce society annual costs. Also easier for me (and other older damaged individuals) to attend.

Over you, the society members.

I hope we have some clearer skies in April and we get a chance to go out there and observe again.

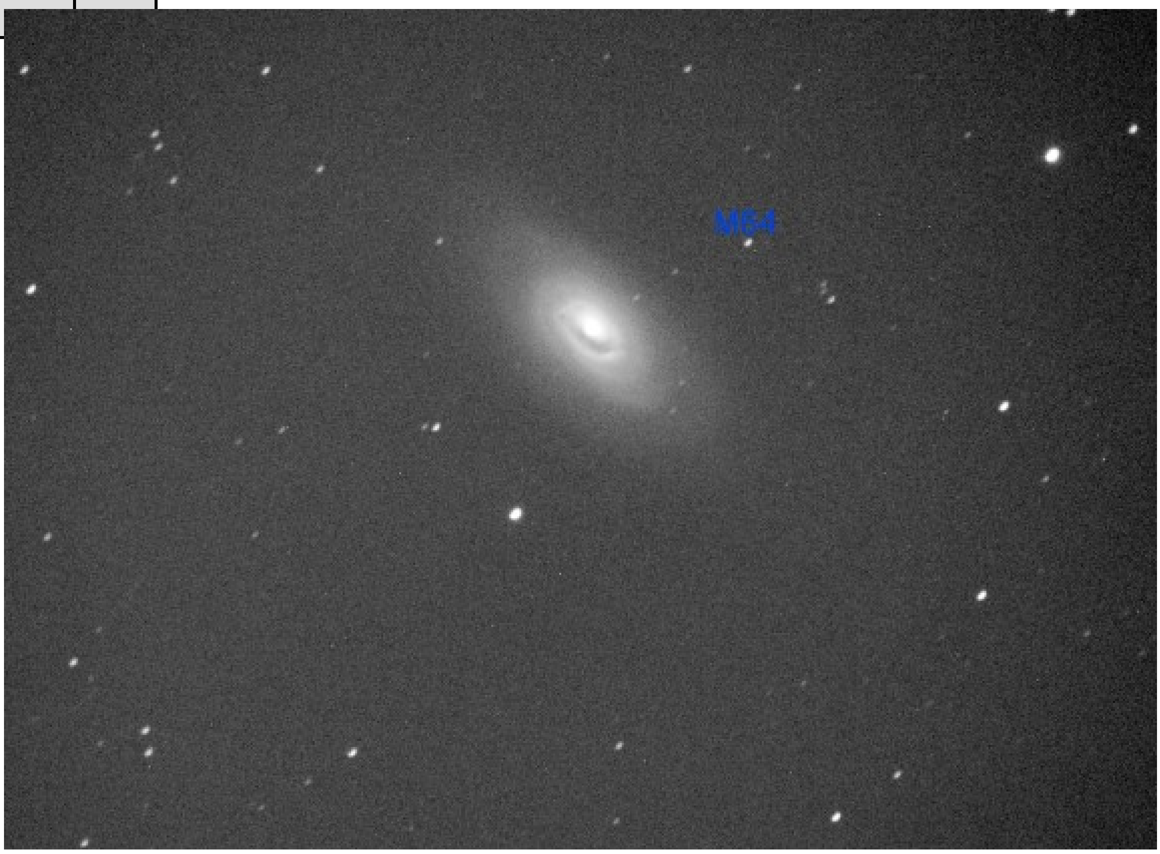
Don't forget next month's meeting (May 2nd) will be on Zoom.

Clear Skies

Andy

Messier 64 in Coma Berenices, the constellation of the month. Taken way back in 2017…another name is the the black eye galaxy with the underlining dark patch being dust lanes of a spiral arm covering the stars on the far side.
Itl ies 18.3 Million light years away and 56,000 light years across.
120 second exposure using Nikon D810a camera on an 9.25" clestron telescope.
The convenient blue name tag was added in photoshop. Wouldn't it be easy if the sky had these on. Perhaps those dratted Starlink satellites could do some sky writing as the pass over, note in the news section the Hubble telescope is now getting satellite trails in its images. Als oin the news a Solar flare on 23rd March hit and damaged some these satellites...

Andy Burns.



Wiltshire Society Page

Wiltshire Astronomical Society

Web site: www.wasnet.org.uk

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

Meetings 2020/2021.

HALL VENUE the Pavilion, Rusty Lane, Seend

Some Speakers have requested Zoom Meetings we will try to hold these at the hall

Meet 7.30 for 8.00pm start

SEASON 2022/23

2023

4 Apr Chris Starr Heavy Metal World
2 May Dr Paul A Daniels The Mega-constellation threat
6 Jun Andrew Lound Venus, Paradise Lost

AWAITING A SPEAKER SECRETARY FOR 23/24 SEASON

Chris Starr

Independant space science consultant, speaker and writer

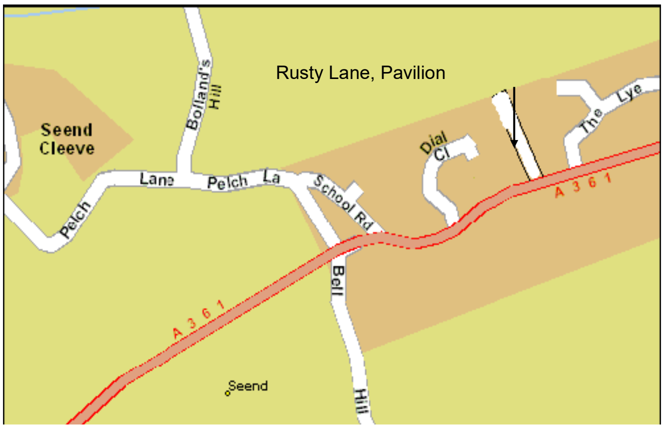
Starscape Education and Public Outreach
Organising public outreach events in astronomy and space science/exploration. Giving talks on astronomy and space exploration. Chairman of the Wells & Mendip Astronomers group in Somerset, UK. Member of the Charterhouse Observatory team in Somerset. Writing and designing educational posters on astronomical themes.
British Interplanetary Society (BIS) South West (Bath) - member of events team.
Staff writer and proof reader for RocketSTEM Media Foundation.
Contributing writer for the BIS' 'Spaceflight' magazine.
Fellow of the Royal Astronomical Society (FRAS), BAA and BIS member.
Associate Member of the International Association of Astronomical Artists (IAAA) - organiser of the 'Visions of Space' IAAA exhibition in Wells, Somerset, November 2015. 'Visions of Space 2' planned for June 2017.
Volunteer helper at Spacefest.

Membership Meeting nights £1.00 for members £3 for visitors

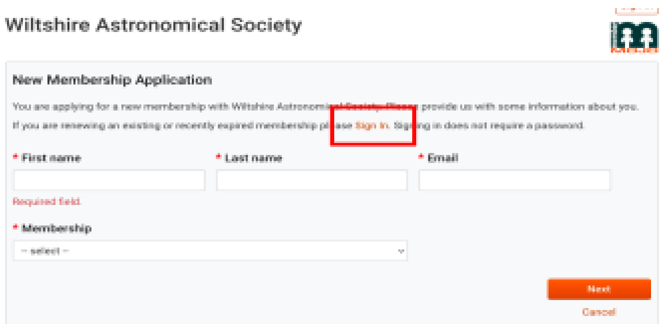
Members can renew or new members sign up online via https://wasnet.org.uk/membership/ and also remind them they can pay in cash too on the door.

Wiltshire AS Contacts

Andy Burns Chair, anglesburns@hotmail.com
Andy Burns Outreach and newsletter editor.
Sam Franklin (Treasurer)
Rebecca Rowan (Hall coordinator)
??? (Teas and Projector)
Peter Chappell (Speaker secretary) Retiring
Nick Howes (Technical Guru)
Observing Sessions coordinators: Chris Brooks, Jon Gale,
Web coordinator: Sam Franklin
Contact via the web site details.



Observing Sessions see back page



Swindon Stargazers

Swindon's own astronomy group

NO NEWSLETTER UPDATE RECEIVED IN TIME

Friday, 21 April 19.30 onwards

Programme: Prof Matt Griffin: Far Infrared Astronomy from Space

Friday, 19 May 19.30 onwards

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

Friday, 16 June 19.30 onwards

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

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

Friday, 15 September 19.30 onwards -

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

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

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

Friday, 8 December 19.30 onwards Programme: Christmas Social

Website:
http://www.swindonstargazers.com

Chairman: Damian O'Hara

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

BECKINGTON ASTRONOMICAL SOCIETY

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

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

Our Committee for 2016/2017 is

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

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

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

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

Post Code for Sat Nav is BA11 6TB.

Our start time is 7.30pm No hall meetings.

STAR QUEST ASTRONOMY CLUB

This young astronomy club meets at the
Sutton Veny Village Hall.
Second Thursday of the Month.
Meet at Sutton Veny near Warminster.

BATH ASTRONOMERS

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 actvities. As a partner to Bath Preservation Trust, they are the resident astronomers at the Herschel Museum of Astronomy, 19 New King Street, Bath, BA1 2BL and partner with Bath Abbey to showcase the skies above the city.

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

Next Meetings:

Wednesday, 3rd May
When we Walked on the Moon – Ian Ridpath takes us back over 50 years in a prelude to the resumption of lunar strolls in 2025

Wednesday, 31st May
Diving through exoplanet atmospheres – Dr Hannah Wakeford drops us into this fascinating new field of discovery. You will dive into the atmospheres of alien planets to discover the truly wild nature of planets in the Universe from chains of rocky worlds around ultra-cool stars to exotic clouds of molten rock in the atmosphere of ultra-hot gas giants.

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 1860 Refractor and more modern telescopes. We try to avoid school nights but will run member's sessions when the clouds look like they'll recede long enough to align a Celestron Goto Scope.

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

Heavy Metal Exoplanet Found Orbiting Nearby Star

With a density close to that of pure iron, GJ 367b may be the remnant metal-rich core of an evaporated giant world

By Jonathan O'Callaghan on December 2, 2021

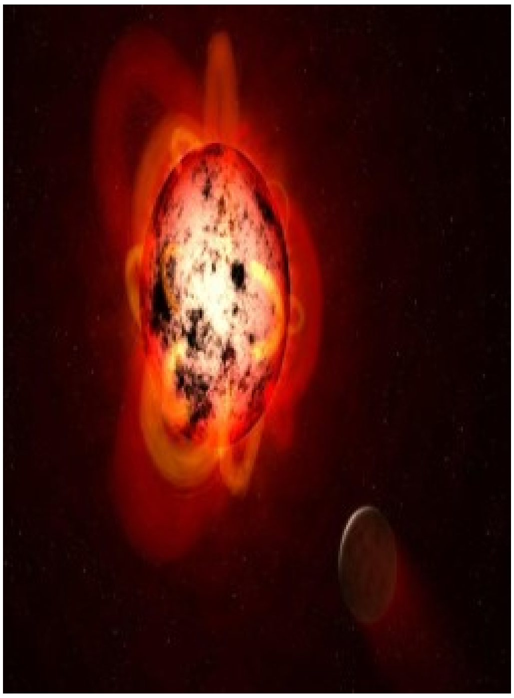


Illustration showing a red dwarf star orbited by a hypothetical exoplanet. Credit: NASA/ESA/STScI/G. Bacon

Five thousand known worlds. That is the next, most ballyhooed milestone in the ongoing hunt for exoplanets, the confirmed total of which presently tallies just a few hundred shy in our catalogues. More remarkable than these sheer numbers, however, is the diversity they reveal. A fraction of the worlds overflowing astronomers' coffers resemble those orbiting our own sun, but most are far more alien: scorched gas giants that circle their star every few days, Neptune-sized puffballs with the density of cotton candy, and hordes of small planets packed like sardines around tiny, cool stars. Compared to such things, our own familiar and supposedly typical solar system turns out to be the oddball.

The latest bizarre exoplanet to challenge our preconceptions and reinforce just how much we still have to discover is GJ 367b, a world so strange it seems more suited for a heavy-metal album cover or the pages of a pulpy sci-fi story rather than reality. Announced December 2 in the journal *Science,* this planet may essentially be a glowing orb of half-molten iron three-quarters the size of Earth.

Discovered by Kristine Lam from the German Aerospace Center (DLR) and colleagues using NASA's Transiting Exoplanet Survey Satellite (TESS), GJ 367b is a peculiar "sub-Earth" world located relatively close by, around a small red dwarf star 31 light-years away from us. TESS's measurements showed the planet to be 9,000 kilometers wide—about a third wider than Mars—and subsequent observations using another facility, the European Southern Observatory's High Accuracy Radial Velocity Planet Searcher (HARPS), revealed it to be just half the mass of Earth. Taken together, these results imply an astonishing density—about eight grams per cubic centimeter, close to that of pure iron. "The planet is most likely to contain about 80 percent iron by radius," Lam says, with the rest of the planet encased by a rocky silicate mantle, a similar structure to Mercury in our solar system.

But unlike Mercury, which revolves 58 million kilometers from our sun in an 88-day orbit, GJ 367b is far closer to its star, completing an orbit in just 7.7 hours at a distance of only a million kilometers. That means the temperature of the planet's starlight-bathed surface could be as high as 1,500 degrees Celsius, enough to melt rock and metal alike. "It's probably not very pleasant to live on," Lam says.

About 100 of these so-called ultrashort-period rocky exoplanets have been previously found, but GJ 367b stands out among them as the smallest and least massive ever seen. Its proximity to its star means it is most likely tidally locked by gravitational effects, meaning it always presents the same hemisphere towards the star, much like the moon does to Earth. The enormous dayside temperatures may mean this half of the planet is covered in a magma ocean. "At those temperatures you expect your silicates to be in the liquid phase," says Alexandre Santerne from the Aix-Marseille University in France, who was not involved in this work but previously discovered another Mercury-like exoplanet. "It would be like a big magma pool." The nightside of the planet, meanwhile, would have vastly lower temperatures, meaning it "should be solid rock," Santerne says. At the terminator between night and day, you would expect "some transition between very cool rocks and the magma," he says. That difference could result in tempestuous winds if the planet has any semblance of an atmosphere, but most experts believe GJ 367b's extreme stellar proximity long ago rendered it airless.

How the planet reached its dismal state is a bit of a mystery that may carry important implications for our own solar system. The same gravitational forces that led to GJ 367b being tidally locked should have long ago disrupted the process of planet formation in the first place; planets are not thought to form extremely close to their stars. Instead, they probably migrate inward from farther out—a process that can sometimes lead to spectacular interplanetary smash-ups when worlds literally collide. Similar giant impacts may have shaped our own Mercury, which perhaps was once somewhat more Earth-like in structure. "The best story, which is not a great story, is that some object smashed into Mercury, and left behind a mostly iron object," says Joshua Winn from Princeton University, a co-author on the GJ 367b discovery paper. But this hypothesis is "a little uncomfortable, because it invokes this collision for which we have no other evidence," he adds. "If we figure out why these iron-rich ultrashort-period planets exist, maybe there would be some connection to the story of Mercury."

One possibility is that, rather than being the result of a cataclysmic collision, ultrashort-period rocky worlds such as GJ 367b could be the remnant iron cores left behind when stellar effects cook off the gassy envelopes of migrating giant planets. Astronomers' ever-expanding exoplanetary census have found both giant "hot Jupiters" as well as GJ 367b–like worlds in very close orbits around stars. Yet notably absent from these extreme environs are Neptune-like worlds midway in size between the two. The reason could be that these worlds, pushed inwards by another planet in the system, are then stripped of their hydrogen and helium atmospheres as they approach their stars, leaving only their rocky interiors behind. "It's quite conceivable [GJ 367b] was a bigger planet that has actually been fried away," says Lam's former professor Don Pollacco from the University of Warwick in the U.K., who was not involved in the study. "You could imagine we're looking at the compressed core of an evaporated planet."

For Mercury, given its comparably greater distance from the sun, such an exotic origin story is unlikely. But further studies of Mercury, along with more observations and discoveries of ultrashort-period planets using next-generation facilities such as the James Webb Space Telescope, could get us closer to an answer of how such worlds come to be. More than anything, such work continues to highlight that, among the thousands of planets now known beyond our solar system, we continue to find strange and wonderful places. "We went looking for solar systems," Pollacco says. What we found instead, and continue to find, were worlds unlike anything we could have imagined.

Dense metal planets like Mercury are probably rare in the universe

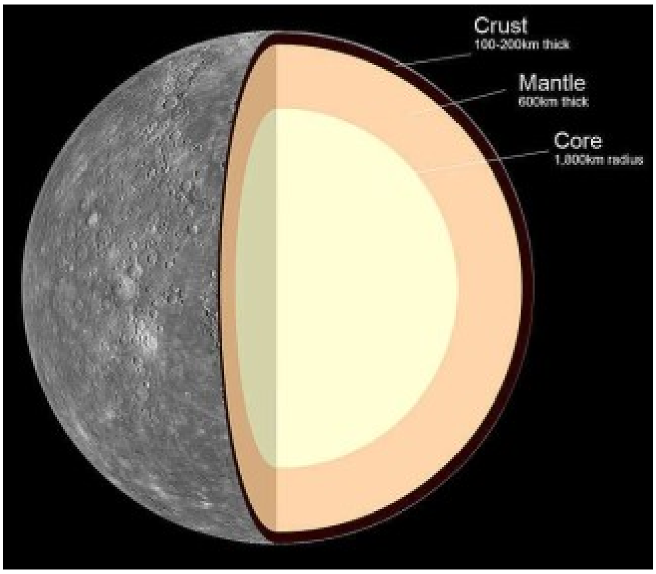
by Matt Williams, Universe Today

The planet Mercury, the closet planet to our Sun, is something of an exercise in extremes. It's days last longer than it's years and at any given time, it's sun-facing side is scorching hot while its dark side is freezing cold. It is also one of the least understood planets in our solar system. While it is a terrestrial (i.e. rocky) planet like Earth, Venus and Mars, it has a significantly higher iron-to-rock ratio than the others.

For decades, the most widely-accepted theory for this was that Mercury experienced a massive impact in the past which caused the planet to shed much of its rocky mantle. However, according to a new study by a team of scientists from the Center for Theoretical Astrophysics and Cosmology (CTAC) at the University of Zurich, Mercury's mysterious nature may actually be the result of multiple collisions with giant objects.

For the sake of their study, titled "Forming Mercury by Giant Impacts," team leader Alice Chau and her colleagues (all of whom are members with the Institute for Computational Science at the CTAC) considered the various reasons for why Mercury has the density and iron-to-rock ratio that it does. In the end, they considered all the possible scenarios to determine which was the most likely one.

To break it down, Mercury has remained something of a mystery to astronomers because of its much more metallic than its neighbors. Much like Earth, Venus and Mars, Mercury is a terrestrial planet, meaning that it is composed of silicate minerals and metals that are differentiated into an iron core and silicate mantle and crust. But unlike the other rocky planets of the solar system, iron makes up a disproportionately large amount of the planet.



Internal structure of Mercury: 1. Crust: 100–300 km thick 2. Mantle: 600 km thick 3. Core: 1,800 km radius. Credit: NASA/JPL

Not only does Mercury's core have a higher iron content that any other major planet in the solar system, but based on its density and size, geologists estimate that Mercury's core occupies about 42 percent of its volume – compared to Earth's 17 percent. The reason for this remains unknown, but many theories have been advanced over the years. As Chau told universe Today via email, these theories can be divided into two categories:

Either Mercury acquired its large iron core from the beginning on, in the solar nebula/disk. Close to the Sun some mechanisms might have been more efficient to separate metals and rocks (because of their different condensation temperature, or conductive properties, or their balance between drag force and gravity), which would drift more metals inward and rocks outward. Mercury would then form at a location more metal-rich than in the rest of the disk. ii) or it formed a core similar in mass ratio than the other terrestrial planets but lost part of its mantle in the late stages of its formation, like in a giant impact or by evaporation (and the vapor mantle would be blown away by solar winds)."

The second possibility, where Mercury lost much of its mantle due to evaporation or a massive impact, remains the most widely-accepted among the scientific community. Building on this, Chau and her colleagues studied standard collision parameters (impact velocity, mass ratio, impact parameter) and considered what an impactor's likely composition would be, as well as how the cooling of Mercury afterwards would play a role.

Artist view of the MESSENGER spacecraft orbiting the innermost planet Mercury. Credit: NASA

The purpose of this was to determine if Mercury's composition was the result of a single, giant impact, or many smaller ones. While both possibilities are rare and would require a unique set of circumstances, Chau and her colleagues determined that either impact scenarios could account for Mercury's curious nature. As she explained, their conclusions came down to five points:

A single giant impact or hit-and-run impact require a highly tuned impact parameter and velocity to reproduce Mercury's mass and iron mass fraction. There is a somewhat larger parameter space of possibilities in the hit-and-run scenario.

The impactor's composition affects the resulting final mass and post-impact iron distribution.

The pre-impact state of the target affects the resulting final mass.

A multiple-collision scenario escapes the fine-tuning of the geometrical parameters but is constrained by the timing and by the volatile-rich composition of Mercury's surface.

Forming Mercury by giant impacts is feasible but difficult.

In short, they found that it is possible that both scenarios could account for Mercury's high iron-to-rock ration, but that the odds of them having happened are not great. This is supported, according to Chau, by the fact that few Mercury-analog exoplanets have been found. In this respect, whatever caused Mercury to become the way it is may be a relatively rare event as far as the evolution of star systems are concerned.

Artist's impression of the impact that caused the formation of the moon. Credit: NASA/GSFC

"Our study isn't the first one to propose giant impacts to explain Mercury's large iron core, but confirms that we need rather specific conditions for giant impacts," said Chau. "It seems that forming Mercury is difficult. In another sense, this is reassuring because we do not observe a lot of exoplanets that are similar to Mercury in composition. Also, even if it is a rare event, only one impact is needed."

In this sense, giant impacts could be seen as fortunate events and a reminder of how chaotic planetary systems are, Chau added. For not only do these types of collisions have a profound impact on a planet's properties (for instance, the Earth-moon system is believed to be the result of a giant impact), but based on exoplanet surveys, such instances also appear to be quite rare.

Perhaps our solar system is unique in several respects, which include the emergence of life and the presence of giant impacts that fundamentally altered several of its planets. Then again, we have really only begun to scratch the surface as far as exoplanet discoveries are concerned, and we may find many Mercury-like planets out there yet.

SPACE NEWS TO APRIL 23

Meet the Four Astronauts Who'll Fly Around the Moon for Artemis II

The four astronauts chosen for NASA's Artemis II mission will check off a string of firsts during their flight around the moon, scheduled for next year. It'll mark the first trip beyond Earth orbit for a woman, for a person of color and for a Canadian. Artemis II will represent yet another first for Canadian astronaut Jeremy Hansen: Based on the current crew schedule, it'll be his first-ever space mission.

Commander Reid Wiseman, pilot Victor Glover and mission specialist Christina Koch round out the first crew for NASA's Artemis moon program, which picks up on the legacy of the Apollo moon program. If all goes according to plan, they'll be the first humans to circle the moon since Apollo 17 in 1972.

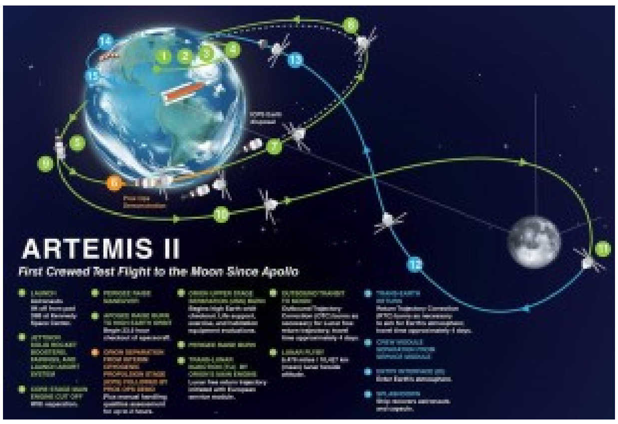
As NASA Administrator Bill Nelson geared up to introduce the crew, he echoed the moonshot vision that President John F. Kennedy laid out in 1962 in his famous "We Choose to Go to the Moon" speech.

"We choose to go to back to the moon, and on to Mars," Nelson said. "And we're going to do it together, because in the 21st century, NASA explores the cosmos with international partners. We will unlock new knowledge and understanding. We've always dreamed about what more is ahead. Why? Because it's in our DNA. It's part of us. It's who we are, as adventurers, as explorers, as frontierspeople."

Dozens of astronauts and scores of VIPs attended today's big reveal at NASA's Johnson Space Center in Texas. Joe Acaba — the chief of the Astronaut Office — joked onstage about the secrecy that surrounded the selection of the four Artemis II crew members. "I'll give you one hint: I am not one of them," he said, drawing a laugh. "Don't be so happy about that."

Metaphorically speaking, the stage was set for Artemis II last fall when NASA's Space Launch System sent an uncrewed Orion deep-space capsule on a weeks-long Artemis I mission around the moon and back. That flight was designed to test NASA's hardware and procedures for Artemis II — and for the even more ambitious Artemis III mission, which currently aims to put astronauts on the lunar surface in late 2025.

The flight plan for the 10-day Artemis II mission, officially planned for November 2024, is analogous to the Apollo 8 round-the-moon mission in 1968. As was the case for Artemis I, the trip would begin with an SLS launch — but this time with people instead of test dummies inside the Orion capsule. After an initial systems checkout in high Earth orbit, the crew would fly past the moon and then make a gravity-assisted turnaround 6,400 miles beyond lunar orbit. The return to Earth would feature a 25,000 mph re-entry and an Apollo-style splashdown.



This NASA infographic lays out the flight plan for Artemis II. Click on the image for a larger version.

"Am I excited? Absolutely," Christina Koch, who would become the first woman to see the moon's far side with her own eyes, told today's audience. "But my real question is, are you excited? I see you and I ask that, because the one thing I'm most excited about is that we are going to carry your excitement, your aspirations, your dreams with us on this mission."

Jeremy Hansen, the only space rookie on the Artemis II crew, gave a shout-out to America's leadership in space and Canada's "can-do attitude." His role on the mission recognizes Canadian contributions to NASA's space effort, including the robotic arms for the space shuttle and the International Space Station as well as a lunar utility vehicle that Canadian companies are building for moon missions.

"For decades now, literally thousands upon thousands of Canadians have risen to that challenge to bring real value to the international partnership with respect to space exploration, to bring real solutions," Hansen said.

Victor Glover, who became the first Black astronaut to join a long-duration crew on the International Space Station in 2020, said the hoopla surrounding the Artemis II mission had a Hollywood feel to it. "I feel like Denzel Washington should be up here talking to you, but you just got us," he said with a laugh.

"Human spaceflight is like a relay race," Glover said. "And that baton has been passed from generation to generation, and from crew member to crew member, from Mercury, Gemini, Apollo, Apollo-Soyuz, Skylab, Mir, the shuttle, International Space Station, commercial crew and now the Artemis missions. We understand our role in that. And when we have the privilege of having that baton, we're going to do our best to run a good race, to make you proud."

Artemis II commander Reid Wiseman closed out the ceremony with a round of thanks to NASA's workforce, its international partners — and particularly to his fellow astronauts, including the International Space Station's current crew.

"If any of you over there are looking for heroes, go Google these folks, because they're our heroes," Wiseman said.

To save you a Google search, here are the basic stats for Artemis II's crew:

Commander Reid Wiseman
Hometown: Baltimore, Md.
Born: 1975
Background: Naval aviator, test pilot, selected to become astronaut in 2009.
Spaceflight experience: Expedition 40/41 on International Space Station, 2014.

Pilot Victor Glover
Hometown: Pomona, Calif.
Born: 1976
Background: Naval aviator, test pilot, selected as NASA astronaut in 2013.
Spaceflight experience: SpaceX Crew-1 and Expedition 64 on International Space Station, 2020-2021.

Mission specialist Christina Hammock Koch
Hometown: Grand Rapids, Mich.
Born: 1979
Background: Engineer at NASA Goddard Space Flight Center, research associate in U.S. Antarctic Program, electrical engineer at Johns Hopkins University Applied Physics Laboratory, researcher at National Oceanic and Atmospheric Administration, selected as NASA astronaut in 2013.
Spaceflight experience: Expedition 59/60/61 on International Space Station, 2019-2020.

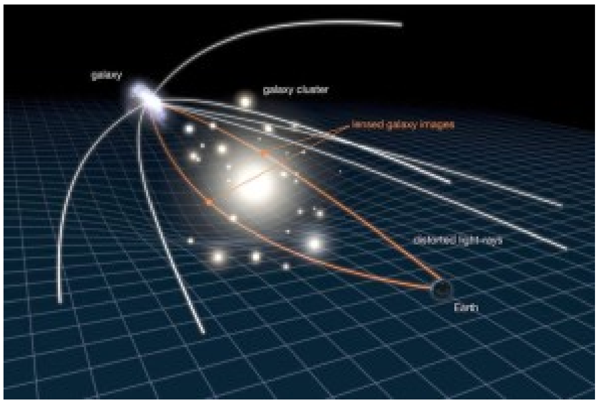
Mission specialist Jeremy Hansen (Canada)
Hometown: London, Ontario
Born: 1976
Background: Fighter pilot, selected as Canadian Space Agency astronaut in 2009.
Training experience: Cave test subject with European Space Agency's CAVES program in 2013, aquanaut with NEEMO 19 underwater test program in 2014.

Astronomers Think They've Found One of the Biggest Black Holes Ever Seen

In 1931, Indian-American physicist Subrahmanyan Chandrasekhar proposed a resolution to Einstein's Theory of General Relativity that postulated the existence of black holes. By 1972, astronomers obtained the first conclusive evidence that these objects existed in our Universe. Observations of quasars and the center of the Milky Way also revealed that most massive galaxies have supermassive black holes (SMBHs) at their cores. Since then, the study of black holes has revealed that these objects vary in size and mass, ranging from micro black holes (MBHs) and intermediate black holes (IMBHs) to SMBHs.

Using astronomical simulations and a technique known as Gravitational Lensing, an international team of astrophysicists detected what could be the largest black hole ever observed. This ultramassive black hole (UMBH) has a mass roughly 30 billion times that of our Sun and is located near the center of the Abell 1201 galaxy cluster, roughly 2.7 billion light-years from Earth. This is the first time a black hole has been found using Gravitational Lensing, and it could enable studies that look farther into space to find black holes and deepen our understanding of their size and scale.

The study was conducted by researchers from the Centre for Extragalactic Astronomy (CEA) at Durham University, the Max Planck Institute for Astrophysics (MPIA), and NASA's Ames Research Center. It was led by Dr. James Nightingale, a post-doctoral research associate at the CEA, with support provided by the UK Space Agency (UKSA), the Royal Society, the Science and Technology Facilities Council (STFC), and the European Research Council (ERC). A paper that describes their findings recently appeared in the *Monthly Notices of the Royal Astronomical Society*.



This illustration shows how gravitational lensing works. The gravity of a large galaxy cluster is so strong it bends, brightens, and distorts the light of distant galaxies behind it. Credit: NASA, ESA, L. Calcada

Gravitational Lensing (GL) refers to a phenomenon predicted by General Relativity, which describes how spacetime curvature is warped by the presence of massive objects. This technique involves astronomers using massive objects in the foreground (like galaxies or galaxy clusters) to amplify light from more distant objects. This enables astronomers to study objects that would otherwise be inaccessible to them, either because of distance or the presence of other objects along the same line of sight. This technique also allows astronomers to study distant objects in greater detail, such as the Abell 1201 cluster.

Dr. Nightingale and his associates began studying this cluster in 2004 when Prof. Alastair Edge, a fellow Durham University astronomer and a co-author of this paper, reviewed images of a galactic survey and noticed a giant lens in its vicinity. For this study, Dr. Nightingale, Prof. Edge, and their colleagues consulted data from the Hubble Space Telescope (HST) in multiple bands – including visible light, X-rays, and other wavelengths. Following up on what Hubble saw years ago, the team compared the data to simulations on the new DiRAC COSmology MAchine 8 (COSMA8) supercomputer facilities at Durham Uni-

versity.
Using open-source software (PyAutoLens) that astronomers rely on to model strong lenses, the team simulated light traveling between Abell 2021 and Earth thousands of times. Each simulation included a black hole with a different mass and how this would influence the way the light traveled over 2.7 billion years to reach Earth. Their results showed that a UMBH located in the foreground galaxy, over 30 billion times as massive as our Sun, would account for what Hubble saw. Astronomers rarely see black holes this massive, and this find (if confirmed) would constitute the largest black hole ever detected.
On top of that, it was the first time astronomers used the GL technique to detect such a massive black hole. What's more, it could help astronomers learn more about UMBHs and dormant black holes in the future. Ordinarily, astronomers are largely restricted to studying active black holes because of how bright they are in multiple wavelengths. This is caused by gas and dust being pulled in toward black holes and forming tightly-bound disks that are accelerated to velocities approaching the speed of light (aka. relativistic speed).
This causes the material in the disk to become highly energetic, emitting radiation in visible light, infrared, X-rays, radio waves, and other wavelengths. The same occurs when the material infalls and is accreted onto the face of the black hole, being torn apart at the subatomic level. This is characteristic of Active Galactic Nuclei (AGN), where a galaxy's center shines brighter than all the stars in the galactic disks. This study has shown how dormant black holes, which are significantly less luminous, can be inferred by the presence of a powerful GL.
The team hopes that this study will lead to deeper explorations of black holes, which will benefit from the new class of 30-meter telescopes that will become operational in the near future. These include the Extremely Large Telescope (ELT), the Giant Magellan Telescope (GMT), and the Thirty Meter Telescope (TMT), which will combine greater sensitivity with adaptive optics and interferometers. Along with improved data analysis and new methods, astronomers will likely be able to study even more distant black holes and gain additional insights into these behemoths.

Further Reading: Durham University, MNRAS

Leaky Soyuz Capsule Returns to Earth

Roscosmos has had quite the run of bad luck lately. In addition to sanctions putting pressure on their space program and the cancellation of agreements (all due to the war in Ukraine), the Russian space agency has experienced several problems in space. On December 14th, 2022, and February 11th, 2023, two space capsules reportedly suffered radiator coolant leaks (Soyuz MS-22 and Progress 82). In addition to delivering fresh supplies to the International Space Station (ISS), one of the spacecraft (M-22) was slated to bring three members of Expedition 68 back to Earth.

Luckily, on February 25th, Russia announced it was sending another Soyuz capsule to replace the M-22 (Soyuz M-23) and retrieve the three crew members, cosmonauts Sergey Prokopyev and Dmitri Petelin, and astronaut Frank Rubio (who will return to Earth now on September 27th). In addition, Tuesday, March 28th, Russia undocked the M-22 from the ISS and successfully brought it home without crew. NASA provided live coverage of the undocking and departure of the uncrewed spacecraft via NASA TV, the agency website, and the NASA app.

The Soyuz MS-22 begins to depart the station following its undocking from the Rassvet module. Credit: NASA TV

After undocking with the ISS at 5:57 AM EDT (2:57 AM PDT), the spacecraft made an automated, parachute-assisted landing in Kazakhstan less than two hours later at 5:46 PM Kazakhstan time (7:46 AM EDT; 4:46 AM PDT). This successful retrieval of this spacecraft and the safe return of the three Expedition 68 crewmembers will put this incident and the delays it imposed to rest. However, the incident raises questions about the state of Roscosmos, given that this is the latest in a recent string of technical failures and malfunctions.
Due to the rescheduled departure date, astronaut Frank Rubio is destined to set a new record for the longest time a U.S. astronaut spent in space. Whereas the record for longest stay goes to the late Russian cosmonaut Valeri Polyakov, who spent 437 continuous days in space aboard the Mir Space Station, Rubio's 371-day stay will be edging out Scott Kelly and Christina Koch, who spent a total of 340 (March 2015 to March 2016) and 328 days (February to December 2019) aboard the ISS (respectively).

Meanwhile, Expedition 69 has started aboard the ISS, with cosmonaut Sergey Prokopyev acting as Station Commander. Other crewmembers include NASA astronauts Stephen Bowen, Woody Hoburg, and Frank Rubio, United Arab Emirates (UAE) astronaut Sultan Alneyadi, and Roscosmos cosmonauts Andrey Fedyaev and Dmitri Petelin. This Expedition will feature research into how cardiac cells behave in microgravity, pharmaceuticals that may protect astronaut health, tests involving the European Robotic Arm, and the Foam and Emulsions physics study.

Further Reading: NASA Blo

Pale Blue Successfully Operates its Water-Based Propulsion System in Orbit

New in-space propulsion techniques seem to be popping out of the woodwork. The level of innovation behind moving things around in space is astounding, and now a company from Japan has just hit a significant milestone. Pale Blue, which I assumed was named as a nod to a beloved Carl Sagan book, recently successfully tested their in-orbit water-based propulsion system, adding yet another safe, affordable propulsion system to satellite designers' repertoires.
Using water to jet around space might seem relatively simplistic. However, despite its simplicity and relatively low cost, water jets for satellite propulsion systems have not yet been widely adopted. This first Pale Blue system, which launched with Sony's EYE satellite as part of its STAR SPHERE program to take pictures of the Earth, was the first time the company successfully tested its system in space.
They did so by operating it for approximately two minutes in early March and adjusting the EYE satellite's orbit in LEO. The thruster pushed EYE closer to an orbit from which the satellite will offer space photography services, which is the business model Sony is pursuing with the STAR SPHERE program.
Pale Blue video describing its inventive propulsion systems. Credit – Pale Blue YouTube Channel
Pale Blue itself was spun out of the University of Tokyo three years ago and is pursuing a few types of water-based

propulsion systems. The one launched on EYE is known as a "resistojet" – essentially, it simply pushes water out of a tube in proportion to the angle to push the satellite where it wants to go. Simple Newtonian physics does the rest, with attitude control and forward motion both controlled by this system.

Some innovative features of the resistojet system include holding the water at a relatively low pressure and allowing it to vaporize at relatively low temperatures. It's obvious that lots of thought had gone into the design, and now all that effort has been validated with a successful mission.

But the company isn't going to stop there. They're working on another type of water-based thruster that is more like an ion thruster than a simple jet mechanism. In this configuration, the water is atomized via a microwave plasma source and ejected out the back of the propulsion system, similar to a typical ion thruster. However, several patented technologies also go into this system, including the plasma generating system and the design of the vaporization chamber.

UT video describing ion engines – like one of the systems Pale Blue is developing.

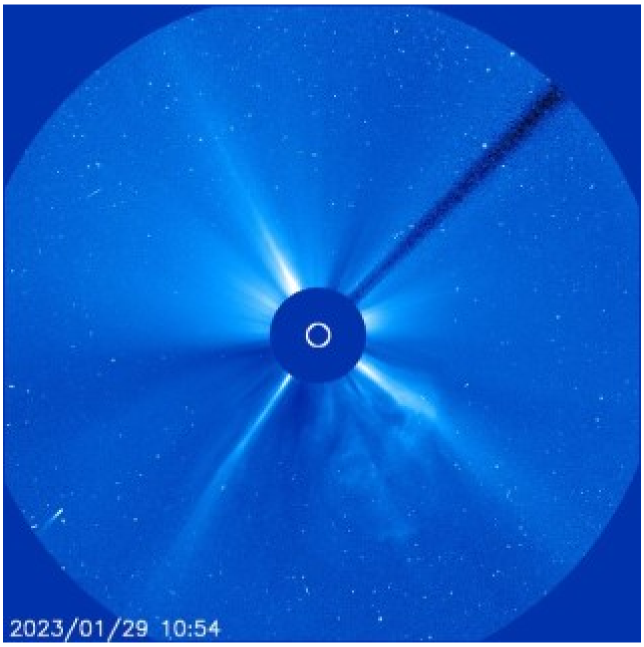
While they haven't gotten a chance to test their ion thruster in space yet, the company is planning something even more ambitious – combining the two thruster configurations into a single hybrid thruster. Such a thruster would benefit both from the relatively strong thrust provided by the jet system and the specific impulse provided by the ion thrust system. While such a system is still a long way off from a test flight like the one just completed, the recent test puts the company on an excellent footing to continue its development. Eventually, the space propulsion industry will settle on a standard configuration, and now Pale Blue has added a new one to that mix. For now, it's sure not to be the final say in this ongoing effort to improve how we move around space.

Now We Know How a Solar Storm Took Out a Fleet of Starlinks

On March 23rd, sky observers marveled at a gorgeous display of northern and southern lights. It was reminder that when our Sun gets active, it can spark a phenomenon called "space weather." Aurorae are among the most benign effects of this phenomenon.

At the other end of the space weather spectrum are solar storms that can knock out satellites. The folks at Starlink found that out the hard way in February 2022. On January 29th that year, the Sun belched out a class M 1.1 flare and related coronal mass ejection. Material from the Sun traveled out on the solar wind and arrived at Earth a few days later. On February 3, Starlink launched a group of 49 satellites to an altitude only 130 miles above Earth's surface. They didn't last long, and now solar physicists know why.

A group of researchers from NASA Goddard Space Flight Center and the Catholic University of America took a closer look at the specifics of that storm. Their analysis identified a mass of plasma that impacted our planet's magnetosphere. The actual event was a halo coronal mass ejection from an active region in the northeast quadrant of the Sun.



A SOHO image of the coronal mass ejection headed out (lower right from the Sun). Several days later it collided with Earth's magnetic field, which helped thicken the atmosphere. That produced atmospheric drag which affected the Starlink satellites. Courtesy NASA/SOHO.

The material traveled out at around 690 kilometers per second as a shock-driving magnetic cloud. Think of it as a long ropy mass of material writhing its way through space. As it traveled, it expanded and at solar-facing satellites—including STEREO-A, which took a direct hit from it—made observations. Eventually, the cloud smacked into Earth's magnetosphere creating a geomagnetic storm.

How Starlink Satellites Experienced the Effects Space Weather

One of the side effects of space weather that can affect satellites is warming in a region called the "thermosphere". That increased the density of the upper atmosphere over a short amount of time and caused it to swell up. A denser atmosphere causes a phenomenon called "atmospheric drag". Essentially, the thicker atmosphere slows down anything moving through. It also heats things up.

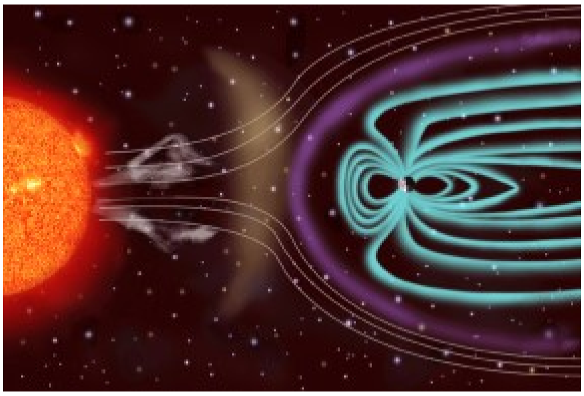
The atmosphere thickened enough that it affected the newly launched Starlink stations. They started to experience atmospheric drag, which caused them to deorbit and burn up on the way down. It was an expensive lesson in space weather and provided people on Earth with a great view of what happens when satellites fall back to Earth. It was also that could have been avoided if they'd delayed their launch to account for the ongoing threat.

Video captured over Puerto Rico of Starlink satellites plunging through Earth's atmosphere on February 7, 2022. Courtesy KevinIZooropa.

How Does Space Weather Work?

The Sun constantly sends a stream of charged particles called the solar wind. This stream varies in density, speed, and temperature. Occasionally, the Sun will also belch out clouds of plasma in what's called a 'coronal mass ejection'. Sometimes it also sends out solar flares. All the material it loses travels away on the solar wind.

During periods when the Sun is more active, those clouds of plasma can come pretty frequently. If they impact Earth, the results can vary from a pretty auroral display all the way to commercial satellite disruptions and power blackouts on the ground. The loss of the Starlink satellites was a particularly massive effect of space weather.



Artist's impression of the solar wind from the sun (left) interacting with Earth's magnetosphere (right). Such activity worked to thicken the atmosphere, which worked to drag down the Starlink satellites. Credit: NASA

Current Space Weather Effects

At the moment, the Sun's activity is increasing as it heads into a period called "solar maximum". We can expect more auroral displays, along with CMEs and flares. With the strong outbursts come threats to our technology. Obviously, communications and other satellites are in danger. So are astronauts on the International Space Station.

But, the threats aren't just in space. Earth-based power grids, communication lines, and other technologies are also at risk. For example, when a geomagnetic storm hits, it sets up huge circulating electrical currents between Earth and space. These are called "geomagnetically induced currents". At the very least, they can short out power lines and grids. When those go down, so do the Internet, computer systems, telephone systems, and other crucial services. The average person would immediately experience a power outage, at the very least. But, airlines, banks, and other systems would be down until power and communications could be restored. There's a great need to strengthen our technology against solar storms.

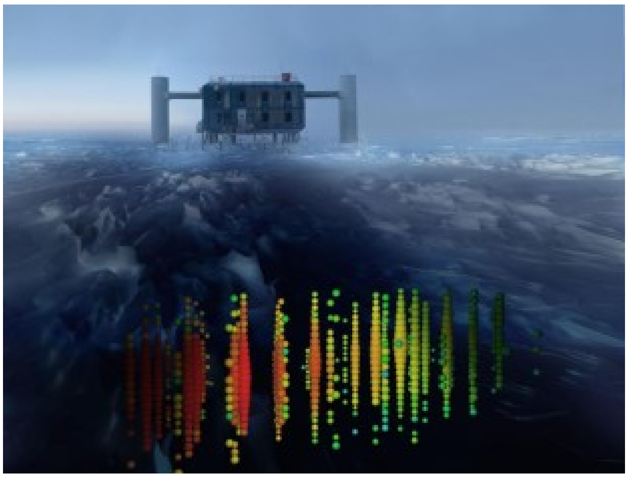
Starlink Lessons Learned?

The loss of the Starlink satellites cost the company millions of dollars. The company elected to launch, even though the space weather community warned about the effects of a geomagnetic storm. For years now, solar physicists have been warning about the effects of space weather. Most satellite companies pay attention to reports from such places as the Space Weather Prediction Center. If they get enough warning ahead of time, they can take steps to protect their equipment. Astronauts on the ISS can take shelter until the storm passes. And, power companies and others can follow forecasts of such storms so they can take whatever action is needed in the event of a strong event.

Solar physicists continue to study these solar outbursts in hopes of coming up with a foolproof prediction system. At the moment, when something erupts from the Sun, we get notifications from a fleet of satellites. Those give us minutes to hours of "heads-up" time to prepare for the worst. NASA and other agencies continue to improve solar studies and prediction methods so that companies launching satellites to low-Earth orbit can take steps to protect their investments.

Plans are Underway to Build a 30 Cubic Kilometer Neutrino Telescope

How do astronomers look for neutrinos? These small, massless particles whiz through the universe at very close to the speed of light. They've been studied since the 1950s and detecting them provides work for a range of very interesting observatories. There's IceCube in Antarctica (below), which uses a cubic kilometer of ice at the South Pole as its collector. Another neutrino detector, called KM3Net, is under development deep beneath the surface of the Mediterranean sea. It joins existing detectors around the world.



This image shows a visual representation of one of the highest-energy neutrino detections superimposed on a view of the IceCube Lab at the South Pole. Credit: IceCube Collaboration

Now, a consortium of Chinese scientists has plans to develop another deepwater neutrino "telescope" that will be more extensive than any current technology online today.

According to lead researcher Chen Mingjun at the Chinese Academy of Sciences, the facility will be the largest neutrino observatory in operation. "It will be a 30-cubic-kilometer detector comprising over 55,000 optical modules suspended along 2,300 strings," said Chen.

Why Study Neutrinos?

Neutrinos come from a number of sources across the universe. Astronomers know that energetic events produce them, such as a supermassive star explosion. Often, a rush of neutrinos alerts astronomers to the fact that a supernova has exploded. They reach Earth before the light from the catastrophic event can get here.

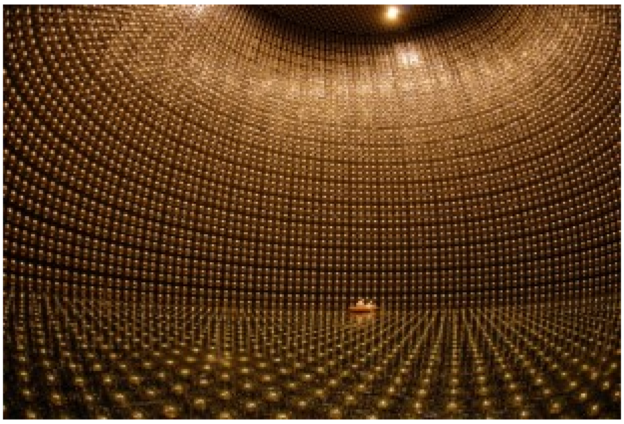
Neutrinos (along with cosmic rays) also come from the Sun, from stellar explosions, from objects called blazars, and there were even neutrinos created in the Big Bang. On Earth, they emanate from the decay of radioactive materials beneath the surface, and from nuclear reactors and particle accelerators.

Black-hole-powered galaxies called blazars are the most common sources detected by NASA's Fermi Gamma-ray Space Telescope. They are sources of neutrinos and cosmic rays. Credits: M. Weiss/CfA

Neutrino astronomy is a way to use these particles (as well as cosmic rays) to search out their sources and understand the physics behind them. Neutrinos offer a chance for astronomers to "see" processes that they can't catch any other way. That includes activity in the Sun's core, the hidden cores of galaxies, gamma-ray bursts, and the events in starburst galaxies.

How to Detect Neutrinos

Spotting and measuring these fast-moving, nearly mass-less particles isn't an easy task. They don't interact very easily with regular matter, which makes them difficult to pin down. Depending on where they originate, neutrinos can travel through many light-years of space before interacting with interstellar gas and dust, or a planet, or star. Once they do, they pass almost completely unimpeded. But, they do interact briefly with matter. That interaction produces other detectable reactions and particles.



Super-Kamiokande, a neutrino detector in Japan, holds 50,000 tons of ultrapure water surrounded by light tubes. Credit: Super-Kamiokande Observatory

Since they're such slippery objects, neutrino detectors have to have a large "collecting area" to detect enough for study. The first neutrino observatories were built underground. That isolated the detectors from local radiation "pollution." Detection requires extremely sensitive equipment and even the best ones on Earth only measure a relative few.

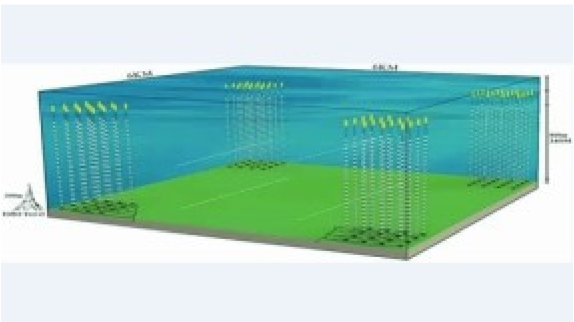
Some neutrino observatories use a fluid called tetrachloroethylene to "capture" clues to neutrinos passing through. You might know this material better as dry cleaning fluid. When a neutrino hits a chlorine 37 atom in the tank, it converts it to an argon-37 atom. That's what the instruments detect.

Another way to measure neutrinos is through what's called a Cherenkov detector. The name refers to Cherenkov radiation, which is emitted whenever charged particles such as electrons or muons move through water, heavy water, or ice. The charged particle generates this radiation as it moves through the detector fluid. That's the method IceCube, KM4Net, Lake Baikal, and others use. The Chinese underwater detector will improve on this method and go hunting for neutrinos on a much larger scale.

Linking Neutrino and Cosmic Ray Sources

The aim of building such an extensive telescope is to detect high-energy neutrinos, but Chen thinks that there may be a link to cosmic rays. He expects that the neutrinos the facility detects will contribute to solving a century-old scientific puzzle of the origin of cosmic rays.

In the early 1900s, scientists discovered that energetic particles constantly bombard Earth. Since then, astronomers have tracked neutrinos as well as gamma rays from space. In 2021, China's Large High-Altitude Air Shower Observatory (LHAASO) in Sichuan province detected 12 sources of gamma rays. These probably came from the same sources as some cosmic rays.



A schematic diagram of the high-energy underwater neutrino telescope under development by Chinese scientists. Courtesy Chinese Academy of Sciences

Chen said one popular hypothesis is that the high-energy neutrinos and gamma rays are potentially produced simultaneously when high-energy cosmic rays originate. "If we can detect the two particles together, we can determine the origin of the cosmic rays," said Chen. The team wants to see if neutrino collisions in their detector produce secondary particles. These should emit light signals for their underwater detectors to see. Some research already hints at this possibility, and Chen believes that neutrino detection could trace the origin of this mystery space radiation.

Next Steps

Most members of the team have spent years in the study of cosmic rays, particularly through project LHAASO. Now they're gearing up to do the same with neutrinos in a whole new facility. There's no doubt hunting extraterrestrial neutrinos from deep water will present new challenges. Underwater equipment and operations are very costly. In addition, the team has to develop a detector that can be completely waterproofed. However, work is underway, and the team just completed the first sea trial to test the detecting system at a depth of 1,800 meters underwater.

China Hints at Its Goals for a Lunar Base

In June 2021, China announced it was partnering with Russia to launch a lunar exploration program that would rival NASA's Artemis Program. This program would include robotic landers, orbiters, and crewed missions that would culminate with the creation of an outpost around the Moon's southern polar region – the International Lunar Research Station (ILRS). While the details are still scant, periodic updates have provided a "big-picture" idea of what this lunar outpost will look like. Case in point, at a recent national space conference, a team of scientists from the Chinese Academy of Sciences (CAS) presented a list of objectives for the ILRS. According to China Science Daily, these objectives will include Moon-based astronomy, Earth observation, and lunar in-situ resource utilization (ISRU). In addition, the CAS scientists indicated that China plans to establish a basic model for a lunar research station based on two planned exploration missions by 2028, which will subsequently expand into an international base.

Zou Yongliao, the head of the lunar and deep space exploration division of the CAS, revealed these goals. According to Zou, while plans for the ILRS are still a work in progress, scientists have already made progress in developing specific objectives for scientific research and operations on the Moon. Similar to what NASA has in store, the main objectives include studying the Moon's composition, formation, and evolution. This research began in earnest with sample-return missions and Moon rocks brought back by the Apollo astronauts, which indicated similarities between Earth and the Moon.

Illustration of NASA astronauts and the elements of the Artemis Base Camp operating around the Moon's southern polar region. Credit: NASA

These same rocks also provided the first evidence of water on the Moon, which future crewed missions intend to explore further. Locating and assessing where critical resources like water ice are located is vital to human exploration on the Moon and could eventually lead to the creation of permanent lunar settlements. Attention was also given to scientific experiments that the ILRS will enable, including growing plants in lunar gravity and ISRU operations involving lunar minerals and solar energy. This research will also have implications for long-duration stays on the Moon and even lunar settlement.

Outposts on the far side of the Moon also present opportunities for astronomy, not the least of which is radio astronomy. Radio telescopes on the Moon will be unencumbered by interference on Earth, while optical telescopes won't have to contend with light pollution or atmospheric distortion. According to Zou, specific objectives will include exploring star formation, stellar activities, Earth observation, and Solar dynamics. These studies will allow scientists to learn more about "space weather" and how to predict major solar eruptions (solar flares).

Zou and his colleagues also noted that the Moon is the "main field" of deep space exploration and that constructing a lunar research station was a "historical necessity." This is consistent with China's near- and long-term priorities for space exploration. Like NASA's "Moon to Mars" architecture, this plan involves creating the infrastructure that will allow for a program of "sustainable exploration and development" while also enabling the crewed exploration of Mars in the 2030s.

While no mention was made concerning Russia's continued participation in the ILRS program (which has become doubtful with the war in Ukraine), it seems clear at this point that China is prepared to go it alone. This should come as no surprise since the original plan involved China doing the majority of the heavy lifting. Without the Russian *Soyuz*-2 and *Angara-5* launchers, China will likely turn to its own *Long March 5* rockets and the super-heavy reusable launch vehicle they currently have in development.

Artist rendering of an Artemis astronaut exploring the Moon's surface during a future mission. Credit: NASA

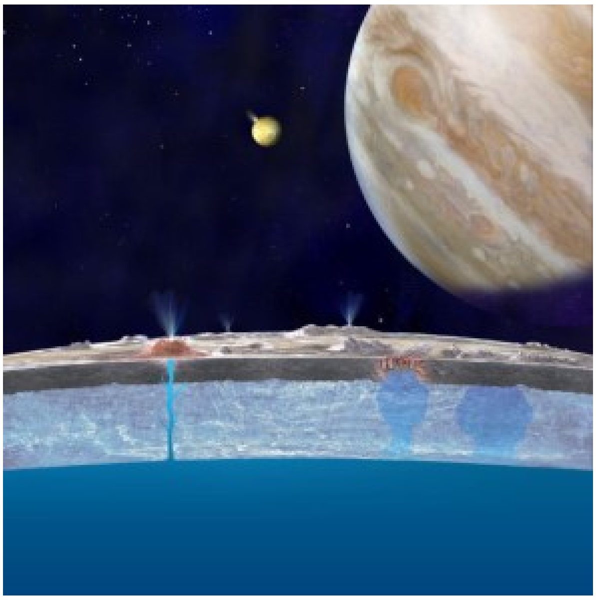
Similarly, in lieu of Russia's proposed *Luna-25, Luna-26,* and *Luna-27* missions (assuming they are further delayed), China is more than capable of relying on its own Chang'e program, which will send two additional missions to the Moon (*Chang'e-6* and *Chang'e-7*) in 2024 and 2026 (respectively). In short, China's space program is making considerable progress and looks to be on track for making crewed lunar missions by the end of the decade (or soon after). This latest announcement and the scientific objectives outlined at the conference reflect that confidence.

Further Reading: Xinhua

Europa's Ice Rotates at a Different Speed From its Interior. Now We May Know Why

Jupiter's moon, Europa, contains a large ocean of salty water beneath its icy shell, some of which makes it to the surface from time to time, and this vast ocean could host life, as well. Europa was most recently observed by NASA's Juno spacecraft, but current examinations of the moon's internal ocean are limited to computer models and simulations produced here on Earth, as no mission is actively exploring this tiny moon orbiting Jupiter. Other than the internal water occasionally breaching the icy shell and making it to the surface, what other effects could the internal ocean have on the icy shell that encloses it?

This is what an international team of researchers hope to answer as they examined the rotational relationship between Europa's icy shell and the small moon's interior ocean. While scientists have long suspected the free-floating properties of the ice shell, meaning it's detached from the interior ocean, this new study is the first to present new modeling that suggests the currents of the ocean could be driving the icy shell's rotation.



Artist illustration of Europa's internal ocean interacting with the icy shell with Jupiter and Io in the background. (Credit: NASA/JPL-Caltech)

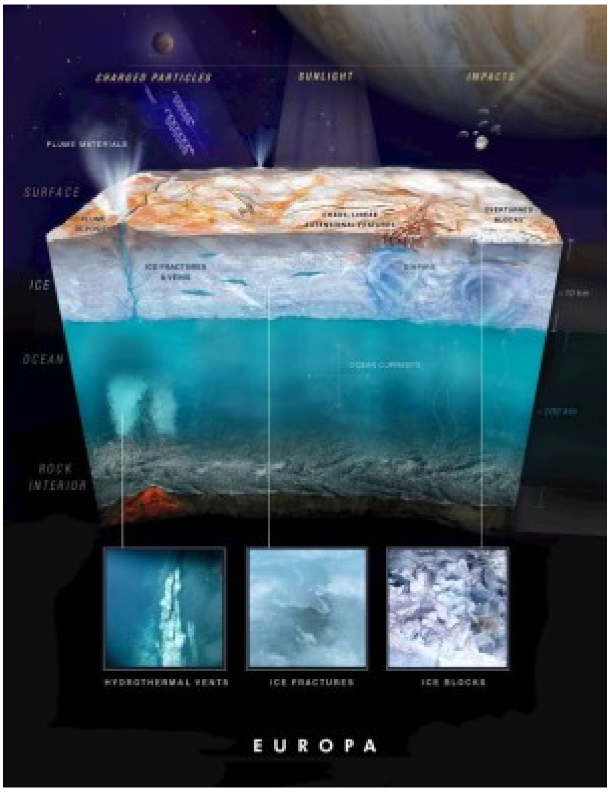
For the study, the researchers examined the drag force exhibited between the icy shell and the ocean beneath it. In fluid mechanics, the drag force is what a solid object experiences as it moves through a surrounding fluid. In this case, the bottom of Europa's icy shell that's moving through the interior ocean. The study also offers hints that Europa's surface features of countless cracks and ridges could also be the result of the icy shell stretching and compressing while it's being dragged along by the interior ocean.

"Before this, it was known through laboratory experiments and modeling that heating and cooling of Europa's ocean may drive currents," said Dr. Hamish Hay, who is a researcher at the University of Oxford University but performed the research while a postdoctoral research associate at NASA JPL-Caltech, and is lead author of the study. "Now our results highlight a coupling between the ocean and the rotation of the icy shell that was never previously considered."

Scientists have been arguing for decades over the rotational speeds between the icy shell and interior ocean, specifically pertaining to if the shell rotates faster. However, scientists have always tried to use Jupiter's massive gravity tugging on Europa and its icy shell as the reason why the icy shell might rotate faster than the ocean, but they haven't considered the ocean itself as being the reason, until now.

"To me, it was completely unexpected that what happens in

the ocean's circulation could be enough to affect the icy shell. That was a huge surprise," said Dr. Robert Pappalardo, who is a Europa Clipper Project Scientist at JPL, and a co-author on the study. "And the idea that the cracks and ridges we see on Europa's surface could be tied to the circulation of the ocean below – geologists don't usually think, 'Maybe it's the ocean doing that.'"
In collaboration with the NASA Advanced Supercomputing Division, the researchers developed circulation models of Europa's interior ocean using the same methods to develop models for studying the oceans of the Earth. Scientists have long hypothesized that Europa's internal ocean is heated from the bottom from a combination of radioactive decay and tidal heating, and created simulations to determine how this could affect the ocean circulation.
The research team discovered that while the ocean circulation appeared to start off with vertical motion—north-south and south-north—from the bottom of the ocean, Europa's rotation caused these currents to eventually veer horizontally—east-west and west-east. When the researchers incorporated the drag force into their models, they discovered that with enough speed the ocean currents could alter the rotation speed of the icy shell above over time, making it move either faster or slower. In the end, the researchers determined that as the internal ocean circulation changes over time, so does the rotation speed of the icy shell.



Artist's in-depth illustration of Europa's internal ocean, plus external forces, interacting with the moon's surface. (Credit: NASA)
"The work could be important in understanding how other ocean worlds' rotation speeds may have changed over time," said Dr. Hay. "And now that we know about the potential coupling of interior oceans with the surfaces of these bodies, we may learn more about their geological histories as well as Europa's."
A vital piece to learning more about Europa and its internal ocean is NASA's upcoming Europa Clipper mission, which is currently scheduled to launch in 2024 and arrive at Jupiter in 2030. While the primary science objective of Europa Clipper will be to determine the potential habitability of Europa, specifically pertaining to its internal ocean, this mission could also offer an enormous opportunity to learn more about how the internal ocean affects the icy shell and the rotational behavior of them both. In preparation for the missions, scientists at NASA JPL are currently using a simulation chamber called "The Ark" to learn more about Europa before Clipper gets there.

What new insights will scientists learn about Europa's internal ocean and its effects on the moon's icy shell in the coming years and decades? Only time will tell, and this is why we science!
As always, keep doing science & keep looking up!

Kazakhstan Seizes Russia's Launch Facility at Baikonur

In February 2022, Russian military forces invaded Ukraine as part of what President Vladimir Putin described as a "limited military operation." This operation quickly turned into a protracted war now in its second year. For Russia, the response from the international community has been anything but favourable, consisting of sanctions, embargoes, and the termination of programs. This has been especially true for Roscosmos, which has had several cooperative agreements cancelled and terminated its participation in the International Space Station (ISS).
On March 7th, 2023, Kazakhstan seized control of the Biaterek launch complex at the Baikonur Cosmodrome – Russia's main launch site since 1955. According to statements by KZ24 News and The Moscow Times, the Kakazh government has impounded Russian assets at the Centre for Utilization of Ground-based Space Infrastructure (TsENKI), a subsidiary of Roscosmos. It is also preventing Russian officials from leaving the country or liquidating Roscosmos assets. This incident is another example of how Russia's space program is suffering collateral damage from the war in Ukraine.
According to The Moscow Times, the decision was made because the Russian state company failed to pay its debts to the Kazakh government, which are now over 13.5 billion tenges (2.258 billion rubles; $29.7 million). This debt is part of the "Baiterek" program, a Kazakh-Russian joint venture related to the development of the Soyuz-5 booster. This program was created in 2005 to speed the transition from launch vehicles that rely on highly-toxic unsymmetric dimethylhydrazine (UDMH) – aka. "heptyl" fuel ($C_2H_8N_2$) – and adopting ecologically safe propellants and launch practices.

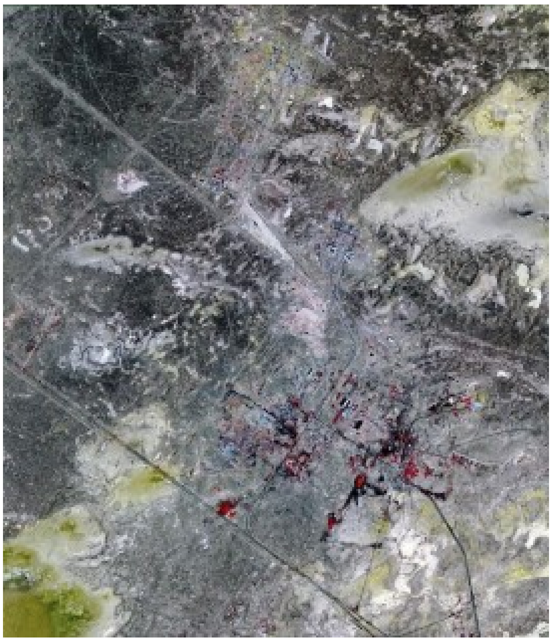


Image acquired by NASA's Terra spacecraft. Credit: NASA/GSFC/METI/ERSDAC/JAROS/ASTER
Other sources attribute this recent decision to "incorrect behavior" and harsh statements on behalf of Yuri Borisov, who became the head of Roscosmos in 2022 as part of an administrative shakeup. Last year, construction of the Soyuz-5 launch pad was pushed back by six months, leading Borisov to criticize the delay in general and Kasakhstan's Minister of Communications (Bagdat Musin) in particular. Musin is directly engaged in Kazakhstan's space industry and responded in kind, calling Borisov's remarks a "diplomatic miscalculation."
The travel ban and the hold on Roscosmos assets extend to the head of the TsENKI unit, who is under arrest pending the

completion of the investigation. The purpose of Baiterek was to estimate the environmental impact of conducting regular launches with the Soyuz-5, which relies on a combination of kerosene and liquid oxygen (LOX). According to the KZ24 News report, this seizure has slowed the construction of a new launch pad at Baikonur and may jeopardize the rocket's development.

"A ban on utilizing resources and conducting financial operations, as well as instability in negotiating positions as a whole are slowing down the priority direction of work at Baikonur, namely the construction of a new launch pad for the Soyuz-5 Booster," says the report. So far, Russia has invested 62 billion rubles ($810 million) in the booster, the construction of the new launch pad, and related efforts. All of that could become a total loss at this point unless Russia can come to an arrangement with Kazakhstan on how to service its debts.

The Baikonur Cosmodrome was built in the 1950s as a test range for the *R-7 Semyorka*, the Soviet Union's first intercontinental ballistic missile (ICBM) and the basis of the Sputnik, Vostok, Voskhod, and Soyuz launch vehicles. The test range was transformed by 1957 to service space launches and became the site where the first artificial satellite was sent into orbit (Sputnik 1) on October 4th, 1957. It was also here that the first man (Yuri Gagarin) went to space on April 12th, 1961 (Vostok 1), and the first woman, Valentina Tereshkova (Vostok 6), on June 16th, 1963.

Russia's Vostochny Cosmodrome ("Eastern Spaceport") near the Russo-Chinese border in Amur Oblast. Credit: Wikimedia/Vladislav Larkin

Since 1994, with the collapse of the Soviet Union, Russia has leased the site from Kazakhstan and continued to use it as its main space complex. In 2012, Russia began constructing a new launch complex to reduce its dependence on Kazakhstan called the Vostochny Cosmodrome in the far eastern Amur region near the Chinese border. However, the planning and construction of this complex have been delayed in recent years due to reports of embezzlement and fraud, leading to the arrest of many officials involved.

While Russia still has launch facilities throughout the country – like Kapustin Yar and the Plestsk and Svobodny Cosmodromes – they are either limited in terms of launch capacity, the types of launches they can support, or are no longer operational. As a result, the seizure of Baikonur's facilities, Roscosmos assets, and the arrest of its officials have effectively grounded Roscosmos for now.

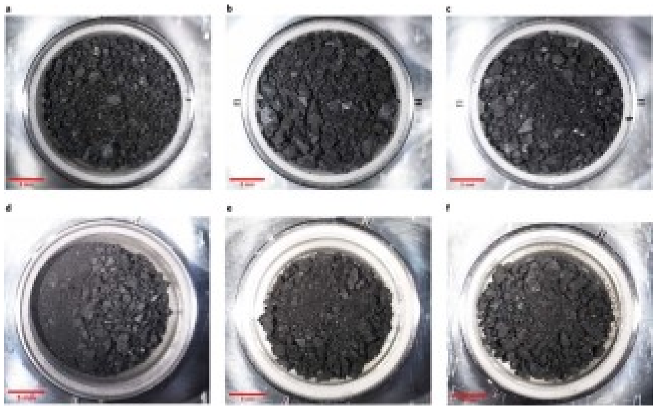
Further Reading: KZ24 News, RFERL, The Moscow Times

Asteroid Ryugu Contains Niacin (aka Vitamin B3)

In December 2020, JAXA's Hayabusa2 spacecraft delivered a pristine sample of otherworldly dust and rock from asteroid Ryugu to Earth. Scientists have since had the opportunity to study the sample, and announced last week that the asteroid contains organic molecules important for life. In particular, they discovered Niacin, otherwise known as vitamin B3, and Uracil, one of the four core components of ribonucleic acid (RNA).

Niacin, which is found in our diets via nuts, seeds, legumes, and meats, helps human bodies build fat and create energy from the nutrients we eat. It also plays a role in repairing DNA.

Uracil, as one of the building blocks of RNA, plays an important function in our bodies too. It carries instructions from DNA, which is contained inside the nucleus of our cells, to the cells' ribosome, where proteins are made.



Optical microscopic images of bulk samples from Hayabusa2 (from Yada et al. 2021, Wikimedia Commons).

Similar molecules have been discovered in extraterrestrial objects before, but the pristine condition of Hayabusa2's sample makes the evidence much more compelling.

"Scientists have previously found nucleobases and vitamins in certain carbon-rich meteorites, but there was always the question of contamination by exposure to the Earth's environment," said Yasuhiro Oba, Associate Professor at Hokkaido University, who led the study.

"Since the Hayabusa2 spacecraft collected two samples directly from asteroid Ryugu and delivered them to Earth in sealed capsules, contamination can be ruled out," he explained.

Hayabusa2's sampling technique involved flying the spacecraft low to the asteroid's surface, then firing a projectile at the asteroid, throwing up dust and rock in a debris cloud that could be caught by the spacecraft's open sampling container. Two samples were taken: one from the surface soil, and another from deeper within the asteroid. To obtain the deep sample, the spacecraft fire a larger projectile at Ryugu to form a crater, and then took a sample from the crater floor.

Asteroid Ryugu as seen by Hayabusa2 in 2018. (JAXA Hayabusa 2, Meli thev, Wikimedia Commons).

Uracil was found in both the surface and subsurface samples, though it was more prevalent in the subsurface. In other words, ultraviolet photons and cosmic rays may have caused the Uracil on the asteroid's surface to begin to decay.
"Organic molecules in the surface materials would have experienced energetic processes more extensively than those in the subsurface materials, which potentially causes preferential degradation of molecules at the surface," the researchers wrote.
Other organic molecules discovered in the samples include amino acids, amines, and carboxylic acids.
The researchers compared the Ryugu samples with previously studied meteorites – especially the Orgueil meteorite, which fell to Earth in southern France in 1864. The similarities are striking, though they are not identical, and suggest that the meteorite came from a similar C-type asteroid.
Studies of carbonaceous chondrite meteorites like the Orgueil sample, and of asteroids like Ryugu, are helping piece together how the building blocks of life ended up on Earth in the first place. Vitamin B3, Uracil, and other organic molecules are present elsewhere in the Solar System, and have been for a long time. This new research suggests we probably have asteroids like Ryugu to thank for these life-giving compounds here at home.

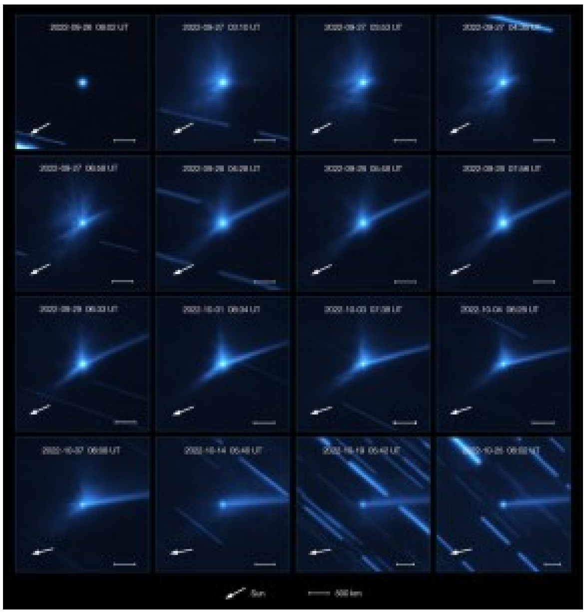
Another Look at the Aftermath of DART's Impact Into Dimorphos

When the DART spacecraft slammed into asteroid Dimorphos on September 26, 2022, telescopes worldwide (and in space) were watching as it happened. But others continued watching for numerous days afterward to observe the cloud of debris. DART's (Double Asteroid Redirection Test) intentional impact was not only a test of planetary defense against an asteroid hitting our planet, but it also allowed astronomers the chance to study Dimorphos, a tiny moon or companion to asteroid Didymos.
New images released by the European Southern Observatory's Very Large Telescope (VLT) show how the surface of the asteroid changed immediately after the impact when pristine materials from the interior of the asteroid were exposed. Other data tracked the debris' evolution over a month, and provided details on how the debris changed over time. Additionally, astronomers searched for evidence of DART's fuel but couldn't find any.

The Cerro Paranal mountain top is home to the world's most advanced ground-based facility for astronomy, hosting the four 8.2-metre Unit Telescopes of the Very Large Telescope, four 1.8-metre Auxiliary Telescopes and the VLT Survey Telescope (VST). Credit: ESO.

"Impacts between asteroids happen naturally, but you never know it in advance," said Cyrielle Opitom, an astronomer at the University of Edinburgh and lead author of one of two studies just published about the impact. "DART is a really great opportunity to study a controlled impact, almost as in a laboratory."

All four of the 8.2-meter telescopes of the VLT in Chile observed the aftermath of the impact, which occurred when Dimorphos was 11 million kilometers away from Earth.
The first study, led by Stefano Bagnulo, an astronomer at the Armagh Observatory and Planetarium in the Northern Ireland, studied how the DART impact altered the surface of the asteroid.
"When we observe the objects in our Solar System, we are looking at the sunlight that is scattered by their surface or by their atmosphere, which becomes partially polarized," said Bagnulo, in an ESO press release. This means that light waves oscillate along a preferred direction rather than randomly. "Tracking how the polarization changes with the orientation of the asteroid relative to us and the Sun reveals the structure and composition of its surface."
Bagnulo and his team used the FOcal Reducer/low dispersion Spectrograph 2 (FORS2) instrument at the VLT to monitor the asteroid, and found that the level of polarization suddenly dropped after the impact. At the same time, the overall brightness of the system increased. One possible explanation is that the impact exposed more pristine material from the interior of the asteroid.
This animation shows how the polarization of sunlight reflected by the Dimorphos asteroid changed after the impact of NASA's DART spacecraft. At the beginning of the video, unpolarized sunlight — represented by wiggly blue lines oscillating in random directions — is reflected off the surface of the asteroid. In so doing it becomes polarized, the reflected waves now oscillating along a preferred direction. The indicator on the lower right shows the degree of polarization of the reflected sunlight.
"Maybe the material excavated by the impact was intrinsically brighter and less polarizing than the material on the surface, because it was never exposed to solar wind and solar radiation," said Bagnulo.
However, another possibility is that the impact destroyed particles on the surface, thus ejecting much smaller ones into the cloud of debris. "We know that under certain circumstances, smaller fragments are more efficient at reflecting light and less efficient at polarizing it," said Zuri Gray, a PhD student also at Armagh.



This series of images, taken with the MUSE instrument on ESO's Very Large Telescope, shows the evolution of the cloud of debris that was ejected when NASA's DART spacecraft collided with the asteroid Dimorphos. The first image was taken on 26 September 2022, just before the impact, and the last one was taken almost one month later on 25 October. Over this period several structures developed: clumps, spirals, and a long tail of dust pushed *away by the Sun's radiation. The white arrow in each panel marks the direction of the Sun. Dimorphos orbits a larger asteroid called Didymos.* ***Credit:****ESO/Opitom et al.*

In the second study Opitom and her team tracked the evolution of the debris cloud from the collision for a month with the Multi Unit Spectroscopic Explorer (MUSE) instrument on the VLT. MUSE allowed the astronomers to study the spectrum of chemicals and gases present in the debris. In particular, they searched for oxygen and water coming from ice exposed by the impact, but they found nothing. "Asteroids are not expected to contain significant amounts of ice, so detecting any trace of water would have been a real surprise," said Opitom in and ESO press release. They also looked for traces of the propellant of the DART spacecraft, but found none. "We knew it was a long shot," she said, "as the amount of gas that would be left in the tanks from the propulsion system would not be huge. Furthermore, some of it would have travelled too far to detect it with MUSE by the time we started observing."

This video shows the evolution of the cloud of debris that was ejected after NASA's DART spacecraft collided with the asteroid Dimorphos. The animation is based on a series of images taken with the MUSE instrument on ESO's Very Large Telescope (VLT) for one month after the impact.

As the debris expanded outward, astronomers noticed that structures started forming, such as clumps, spirals and a long tail pushed away by the Sun's radiation. Parts of the debris started redder and shifted into blue, indicating that the solar wind pushed smaller particles away from the Sun. Other parts of the debris were redder than the initial cloud, meaning that the clumps and structures were made of larger particles that were less affected by the solar wind.

ESO said the two studies show the potential of the VLT when its different instruments work together. In fact, in addition to MUSE and FORS2, the aftermath of the impact was observed with two other VLT instruments, and analysis of these data is ongoing.

"This research took advantage of a unique opportunity when NASA impacted an asteroid," said Opitom, "so it cannot be repeated by any future facility. This makes the data obtained with the VLT around the time of impact extremely precious when it comes to better understanding the nature of asteroids."

Read the teams' papers:

"Optical spectropolarimetry of binary asteroid Didymos-Dimorphos before and after the DART impact" published in *Astrophysical Journal Letters* (doi:10.3847/2041-8213/acb261).

"Morphology and spectral properties of the DART impact ejecta with VLT/MUSE" published in *Astronomy & Astrophysics* (doi:10.1051/0004-6361/202345960).

The Favourite Solar System Moons of Planetary Geologists; An In-Depth Discussion

The moons of our Solar System have garnered quite a lot of attention in the last few years, especially pertaining to astrobiology and the search for life beyond Earth. From the Galilean moons of Jupiter to the geysers of Enceladus to the methane lakes on Titan, these small worlds continue to humble us with both their awe and mystery. But do the very same scientists who study these mysterious and intriguing worlds have their own favorite moons? As it turns out, seven such planetary geologists were kind enough to share their favorite Solar System moons with *Universe Today*!

"My favorite moon is Enceladus, for two reasons," said Dr. Francis Nimmo, who is a professor in the Earth & Planetary Sciences Department at UC Santa Cruz. "First, it is geologically active, which was very surprising given how tiny it is – it is spewing jets of ice and water vapor into space. Second, because it is kind enough to be giving us free samples of its interior, it makes a very attractive target for future spacecraft missions – you can analyze the composition of the ocean (and even look for life) without having to drill through the ice."

Image mosaic of Enceladus taken by NASA's Cassini spacecraft in October 2008 from approximately 25 kilometers (15.6 miles) of the moon's surface. (Credit: NASA/JPL/Space Science Institute)

Saturn's sixth-largest moon, Enceladus, was discovered in 1789 by William Herschel, and whose diameter is approximately the size of the State of Arizona. As noted by Dr. Nimmo, Enceladus possesses geysers that discharge ice and water vapor from a series of fissures known as "tiger stripes". These geysers were first observed by NASA's Cassini spacecraft during its mission in the 2000s, and Cassini even flew through them to test their composition, finding water vapor, a variety of salts, methane, and carbon dioxide.

"My favorite moon of the Solar System is Io, the innermost of the Galilean satellites of Jupiter," said Dr. David Williams, who is a research professor in the School of Earth and Space Exploration at Arizona State University. "Discovered by Galileo Galilei in January of 1610, Io is the most geologically active of all of the moons of our Solar System. A Laplace orbital resonance with Jupiter's other moons Europa and Ganymede results in tidal flexing and heating of Io's interior, producing an enormous amount of energy that powers over 400 volcanoes on Io's surface. Io's volcanic activity, which manifests as both lava flows and lava lakes in caldera-like craters, and in explosive eruption plumes that shoot silicate ash, dust, and sulfur-bearing gases hundreds of kilometers above the surface, results in a world without any large impact craters. This indicates that Io has the geologically youngest surface in the Solar System. Thus, Io serves as an example of potentially active, volcanic lava planets discovered around other stars in our Galaxy."

Image of Io taken by NASA's Galileo spacecraft in July 1999. (Credit NASA/JPL/University of Arizona)

Jupiter's first Galilean moon, Io, was first visited by NASA's Pioneer 10 and 11 in December 1973 and December 1974, respectively, but only one image was taken by Pioneer 11 during the brief flyby. It wasn't until Voyager 1 and 2 flew through the Jupiter system in 1979 that scientists got their first real look at this mysterious moon, revealing a craterless surface and was the first planetary object other than Earth to be observed exhibiting volcanic activity, which is due to the tidal heating between Io and the much more massive Jupiter, along with Europa orbiting just beyond Io.

"The truth is, when it comes to moons, I could never pick one," said Dr. Alyssa Rhoden, who is a principal scientist at the Southwest Research Institute. "They are all intriguing in their own ways, and each one teaches us something different. Although I don't have a favorite, I will take the opportunity to highlight one particular moon that doesn't get much attention: Proteus, a small moon of Neptune. Compared to Neptune's large active moon, Triton, it seems reasonable to neglect battered little Proteus. But here's the thing…Proteus is in the same size range as Mimas and Enceladus (around Saturn), and Miranda (around Uranus), which are much more round and brighter than Proteus," Dr. Rhoden continues. "Enceladus is geologically active with very high heat flows and plumes at its South Pole, showing that even small moons can be quite interesting. And yet, Proteus is heavily cratered, with so many large craters that it doesn't even look spherical anymore."

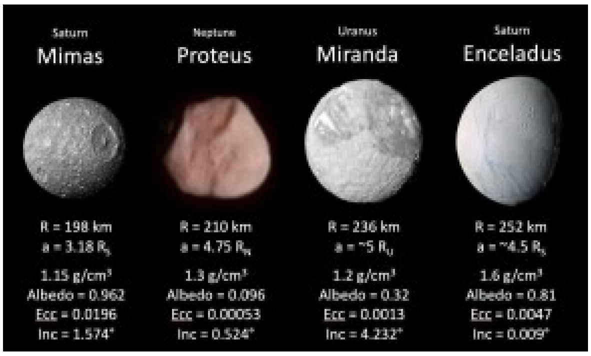


Image gallery of Proteus with other moons. (Credit: Dr. Alyssa Rhoden)

Proteus is Neptune's second-largest moon, and was discovered by Voyager 2 in 1989 when the spacecraft flew through the Neptune system. Despite its non-spherical shape, Proteus shows no signs of current geologic activity, unlike Neptune's much larger moon, Triton, and is one of the darkest objects in the Solar System.

"Of course, my favorite moon is Triton!!" Dr. Candice Hansen-Koharchek, who is a planetary scientist and was a Voyager Imaging Team Assistant Experiment Representative during the Voyager missions, exclaimed. "There is so much that we still don't know…very fundamental questions like whether or not it has an internal ocean, whether or not the bizarre features on the surface are cryovolcanic and whether or not the surface and the subsurface ocean interact. What is the composition of the bright south polar region? How are different ices distributed across the surface? Sooooo many interesting questions…"

Global color mosaic of Triton taken by NASA's Voyager 2 in 1989. (Credit: NASA/NASA-JPL/USGS)

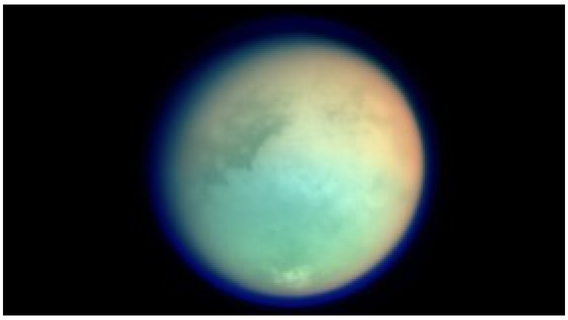
Triton was discovered by William Lassell in 1846. It is the largest of Neptune's 13 moons, and possibly the most intriguing, with its cantaloupe terrain and dark streaks from geysers across its surface, which Voyager scientists determined to be geysers when Voyager 2 flew past in 1989, Triton could possibly contain an interior liquid ocean. Despite the very brief flyby, scientists learned a great deal about this small moon, whose diameter is approximately one-half the width of the United States at 2,700 kilometers (1,680 miles). No spacecraft are currently exploring Triton or are scheduled to travel out there, so Voyager 2 remains the only human-made object to visit this mysterious and intriguing moon way out in the depths of the Solar System.

"Europa, the sixth-largest moon in the solar system, is without a doubt my favorite moon," said Dr. Antonio Paris, who is the Chief Research Scientist with The Center for Planetary Science. "Recent research of Europa has uncovered inferred evidence of an ocean of water below the moon's icy surface. Europa, therefore, may have the necessary ingredients for life: water, energy, and complex molecules known as organics. The current data, however, is still speculation at best. Therefore, planetary scientists like myself hope to find the answers with the Europa Clipper mission!"

True color image of Europa taken by NASA's Juno spacecraft in September 2022. (Credit: NASA/JPL-Caltech/Southwest Research Institute/Malin Space Science Systems/Kevin M. Gill)

Like Io, Jupiter's second Galilean moon, Europa, was discovered by Galileo Galilei in 1610, and also exhibits a crater-less surface due to tidal heating, as well. But instead of extreme volcanism, Europa harbors an interior ocean that is estimated to contain more than twice the volume of all of Earth's oceans combined despite Europa being smaller than Earth's Moon. Europa was first explored up close by Voyager 1 and 2 in 1979, which presented strong evidence of an interior ocean beneath the Europa's ice shell. Dr. Paris mentions NASA's Europa Clipper mission, which is a NASA Flagship mission designed to explore Europa for potential signs of habitability within the small moon's deep ocean.

"My favorite moon in the Solar System is Saturn's giant moon, Titan," said Dr. Jason Barnes, who is a professor in the Department of Physics at the University of Idaho. "Titan is particularly awesome because it is a member of so many different planetary clubs. Titan's subsurface liquid water mantle makes it an Ocean World, like Europa, Ganymede, and Enceladus. But at the same time Titan is one of just four places that we know of in the entire universe that sport both a solid surface and a thick atmosphere, along with Venus, Earth, and Mars. Only Earth and Titan have lakes and seas of surface liquid, and it's just Earth and Titan again that have extensive water in the vicinity of complex organic molecules. All of these make Titan a logical choice for future exploration, and that's why we're sending the Dragonfly relocatable lander to Titan to investigate possibly prebiotic chemistry, to ascertain its habitability, and to search for chemical signatures of potential life there. Dragonfly launches in 2027 June and will arrive at Titan after a 6.5-year space cruise, after which it will fly in Titan's air to more than 20 different landing sites as a nearly one-ton octocopter. We look forward to sharing Dragonfly's adventure with you all once it arrives by 2034!"



False color image of Titan taken by NASA's Cassini spacecraft taken in October 2004. (Credit: NASA/JPL/Space Science Institute)

Saturn's largest moon, Titan, which is also the second largest moon in the Solar System, was discovered by Christiaan Huygens in March 1655, and is the only moon to possess a dense atmosphere comprised of a thick haze that cameras in the visible spectrum cannot penetrate. Titan was first explored by NASA's Pioneer 11 and later by Voyager 1 and 2, but none of the spacecraft possessed the equipment to penetrate the thick atmosphere and see the surface. It wasn't until NASA's Cassini mission with its radar and infrared instruments that scientists were able to see the surface for the first time, revealing countless lakes of liquid methane and ethane, making Titan the only known planetary body other than Earth to have bodies of liquid on its surface. During the mission, Cassini deployed the Huygens probe from the European Space Agency that landed on Titan's surface, becoming the first spacecraft to land on a planetary body in the outer Solar System. As Dr. Barnes stated, NASA's Dragonfly mission will be sent to Titan to explore the moon's potential habitability, and will cover hundreds of kilometers of Titan's surface during two-year mission.

"My favorite moon in the Solar System is Ganymede, simply because it's a planet by any other name," said Dr. Paul Byrne, who is an associate professor in the Department of Earth and Planetary Sciences at Washington University in St. Louis. While Dr. Byrne believes that Ganymede would be called a planet if it wasn't a moon around Jupiter, he's quick to point out that Ganymede wouldn't have stayed a planet if it didn't form around Jupiter in the first place.

Image of Ganymede taken by NASA's Juno spacecraft in 2021. (Credit: NASA/JPL-Caltech/Southwest Research Institute/Malin Space Science Systems/Kevin M. Gill)

"But Ganymede is magnificent," Dr. Byrne continues. "It's got a highly geologically complex outer shell of water ice, showing both ancient and relatively recent regions. Beneath that shell is an ocean of liquid water *up to 900 kilometers deep*. More likely, instead of a single water ocean, there's a layer of high-pressure ice at the base of a somewhat thinner ocean. In fact, it's even possible that there are interleaved layers of ocean and ice, forming an onion-like interior beneath the icy exterior. And then, under all the ice and water is a rocky planetary body about the same size of the Moon. And that rocky body must surely be differentiated, just like the Moon, and Earth, Venus, Mars, and Mercury—because the rocky interior of Ganymede has at its center a liquid iron core, the movement of which generates a modern magnetic field. That field makes Ganymede one of only three rocky bodies in the Solar System to generate a modern magnetic field, the other two being Earth and Mercury. There are lots of other cool things about Ganymede, but it's its size, interior structure, and modern magnetic field that together fascinate me, and make it my favorite Solar System moon."

Much like Io and Europa, Jupiter's third Galilean moon, Ganymede, was also discovered by Galileo Galilei in 1610, and is the largest moon in the Solar System, even bigger than the planet Mercury and the dwarf planet Pluto. Ganymede was first visited by NASA's Pioneer 10 and then Pioneer 11, but received its first up close study from Voyager 1 and 2 in 1979, with Voyager 1 imaging a surface that had a combination of craters and smooth terrain, which contrasts both Io and Europa's respective surfaces. NASA's Galileo spacecraft became the first spacecraft to orbit Jupiter and was able to provide the most in-depth analyses of Ganymede, including the identification of a magnetosphere that Dr. Byrne mentions, along with up close images revealing a very diverse surface. NASA's Hubble Space Telescope, which is in Earth orbit, later provided evidence that Ganymede harbors an interior ocean much like Europa.

What are your favorite moons of the Solar System and which do you think will be the first to confirm the existence of life beyond Earth?

Here's Where Artemis III Might Land. It Looks… Inviting

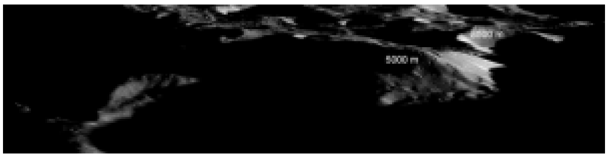
Where on the Moon will the first crewed Artemis mission Land? While NASA is still deliberating on the exact location, they've chosen several candidate landing sites near the lunar south pole. This new image captured by the Lunar Reconnaissance Orbiter reveals what the astronauts might see out the window as they approach their destination.

The region shown here is called Malapert massif, and one of the Artemis III candidate landing sites is the relatively flat spot above a 5,000-meter (16,400 feet) cliff. Another 3,500 -meter (11,480 feet) cliff would be visible from this vantage point. It would be a spectacular place to visit, but the terrain could pose a challenge for landing – especially for the first human mission to land on the Moon in over 50 years.

"Imagine the view from the summit," wrote LROC principal investigator Mark Robinson, on the LRCO website. "One could argue that the sheer grandeur of this region makes it a prime candidate. But then again, a landing here might be too exciting?"

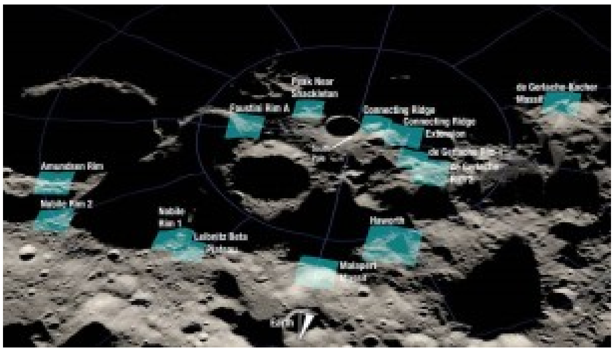
The high-resolution camera on board LRO, the Lunar Reconnaissance Orbiter Camera (LROC) took this photo on March 3, 2023 when the spacecraft was about 170 kilometers (105 miles) beyond Shackleton crater looking towards the nearside. For reference, Shackleton Crater is about 19 km (12 miles) wide.

From this viewpoint, we see the back side of Malapert massif. The Artemis III candidate landing region is partially visible from this viewpoint. Shackleton is the crater near the top left. The relatively flat area above the "5000" in the image below is the heart of the Artemis 3 landing region, which continues down the slope toward the Earth-facing side of the Moon, as seen here:



Full panorama showing the context of the Malapert Massif candidate landing region (NASA/GSFC/Arizona State University).

NASA has identified 13 candidate landing regions near the lunar South Pole. Each region contains multiple potential landing sites for Artemis III, which will be the first of the Artemis missions to bring crew to the lunar surface, including the first woman to set foot on the Moon.



Shown here is a rendering of 13 candidate landing regions for Artemis III. Each region is approximately 9.3 by 9.3 miles (15 by 15 kilometers). A landing site is a location within those regions with an approximate 328-foot (100-meter) radius. Credits: NASA.

See more images from LROC here.

Find out about a new spacecraft that is helping scientists peer into the permanently shadowed regions of Shackleton crater. Mark Robinson is the PI on ShadowCam, too.

Watch the Chelyabinsk Meteor Breakup in this Detailed Simulation

The people of Chelyabinsk in Russia got the surprise of their lives on the morning of February 15, 2013. That's when a small asteroid exploded overhead. The resulting shockwave damaged buildings, injured people, and sent a sonic boom thundering across the region.

The Chelyabinsk impactor was about 20 meters across. It broke up in the atmosphere in an airburst and sent a shower of debris across the landscape. The event awakened people to the dangers of incoming space debris. Since we experience frequent warnings about near-Earth objects, scientists want to understand what a piece of space rock can do.

These days, there are many observation programs across the planet. For example, NASA operates its Sentry System and ESA sponsors the NEODyS project. They and others track incoming space rock. The observation data help predict the impacts of all but the very smallest asteroid chunks that come our way. Despite those programs, it's inevitable that something like the Chelyabinsk asteroid chunk will slip through. So, it's important to understand what happens during such an impact.

Modeling the Chelyabinsk Meteor

Scientists around the world began studying the event almost as soon as it happened. They collected bits of the debris and studied images of the entire event. Researchers with the Planetary Defense program at the Lawrence Livermore National Laboratory recently released a highly detailed 3D animation of a simulated chunk of space rock modeled after the Chelyabinsk impactor. They based the materials of the object in their animation on meteorites recovered from the ground.

Fully 3D simulation of the Chelyabinsk meteor break up in Earth's atmosphere. The meteor is shown as a contour of the damage state (white intact, black fully damaged).

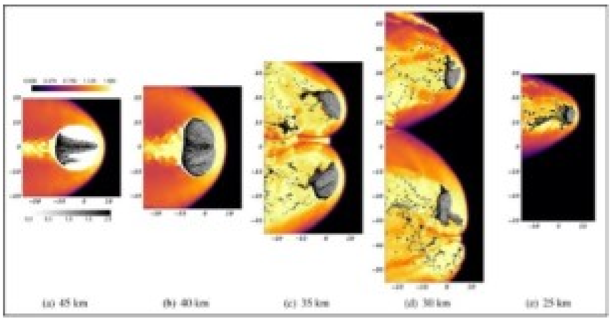
Shock-heated air nodes are displayed as points colored by their temperature. Initially, fracture begins at the rear of the object. The crack then propagates forward eventually splitting the object into three coherent fragments. The fragments are disrupted shortly thereafter.

Because people recorded the event with cell phones and security cameras, the team compared their model to what everybody witnessed. It turned out to be very close to what actually happened.

"This is something that can really only be captured with 3D simulation," said Jason Pearl, lead researcher on the project. "When you combine LLNL's specialized expertise in impact physics and hydrocodes with the Lab's state-of-the-art High Performance Computing capabilities, we were uniquely positioned to model and simulate the meteor in full 3D. Our research underlines the importance of using these types of high-fidelity models to understand asteroid airburst events. A lot of smaller asteroids are rubble piles or loosely bound collections of space gravel, so the possibility of a monolith is really interesting."

So, How Did the Chelyabinsk Object Shatter?

The most often-asked question about the rock that smacked into Earth over Russia was: was it a single chunk of debris? Or was it a flying rubble pile? If it was a monolithic chunk of rock, that would imply specific details about the strength of the rock and how it broke up. If it was a flying rubble pile, it might have broken up earlier and higher in the atmosphere. The LLNL experiment implies strongly that the impact was a single monolithic rock. It broke up under the heat and pressure of atmospheric entry.



Images from a 2D Spheral simulation showing the fragmentation of the Chelyabinsk bolide as it descends through the atmosphere. Image courtesy of LLNL Planetary Defense program.

To model the impactor and its behavior, the research team used a computational method called "smoothed particle hydrodynamics (SPH)." It models an object in a fluidic flow. In this case, it treats the atmosphere as a fluid. The model also simulates what happens as a Chelyabinsk-sized hunk of rock moves through the simulated air.

In their simulation, the team found that the incoming object started to break up from the rear and the cracks moved from back to front. The timescale of crack propagation toward the front of the asteroid controls the time at which the asteroid splits into smaller fragments while entering Earth's atmosphere. A collection of fragments lies near the shock front and that shields the rest of the fragmenting rock. Finally, when the impactor reaches about 30 kilometers above Earth's surface, intact fragments separate. That's when the debris is exposed to the free stream. Eventually, the debris cloud decelerates very quickly and the remaining fragments continue to break up as they fly through the air toward the ground.

The Physics of the Breakup

The disintegration of the Chelyabinsk object provided scientists with a "physics-rich" event to study. According to LLNL physicist Mike Owen, the coupling of the asteroid to the atmosphere depends on how much surface area it has. The greater the surface area, the more exposure it has to heat, stress and pressure. Those all combine to break it up.

"As the asteroid enters the atmosphere, you start to have sort of a catastrophic failure," Owen said. "And it tends to compress in the direction of travel. It was like the asteroid was being squeezed in the direction of travel, breaking into distinct pieces that started to separate and break perpendicular to the direction of travel. All of a sudden, you've got a lot more material being exposed to the hypersonic interaction with the air, a lot more heat being dumped in, a lot more stress on it, which makes it break faster and you get sort of a cascading runaway process."

Using Chelyabinsk To Understand Future Impacts

Models of impactors like this one provide insight into future events when chunks of space rock will hit Earth. One long-term goal would be to use such models to assess what will happen to a target region during an impact. Meteoric impacts are natural disasters that affect our planet just as fires and floods do. As such, there's a need to predict and understand them so that people can be more prepared.

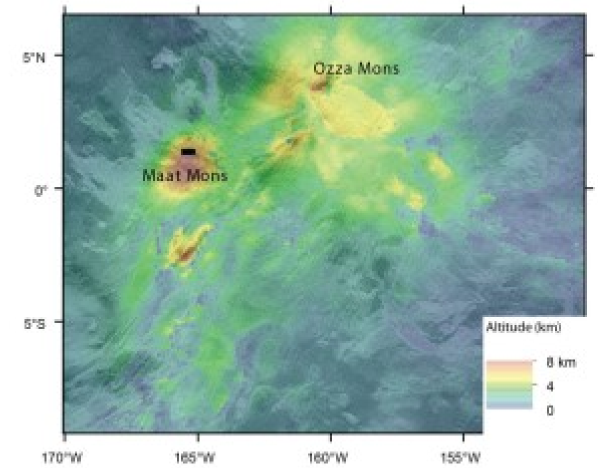
Researcher Cody Raskin points to our increased ability to detect such incoming impactors. "If we can see a small asteroid approaching Earth in time, we could run our model and inform authorities of the potential risk, similar to a hurricane map," said Raskin. "They could then take appropriate protective actions, such as evacuating residents or issuing shelter-in-place orders, ultimately saving lives."

Potentially Active Volcanoes Have Been Found on Venus

Using archival radar images taken in the 1990s by NASA's Magellan spacecraft, scientists have found evidence of recent active volcanism on Venus. The images revealed a volcanic vent that changed shape and increased significantly in size over an eight-month period.

The scientists say their findings confirm long-held suspicions that the planet, which is known to have a very geologically young surface and evidence of past volcanic eruptions, is still active today.

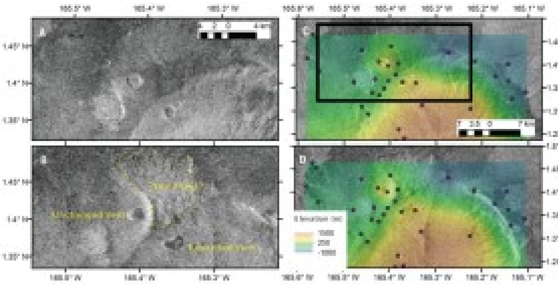
"We made the discovery in the most likely place that there should have been new volcanism," said Robert Herrick, a geophysicist at the University of Alaska Fairbanks, speaking at a briefing on March 15, 2023 from the Lunar and Planetary Science Conference in Texas. "Extrapolating from a data set of one for an entire planet could be dangerous, but most scientists would say it's pretty good evidence that being able to catch an eruption in an eight-month time frame means that others are taking place as well. It confirms there is modern geological activity on Venus."



Topography and radar image of the Study area on Venus. Color indicates elevations, measured relative to the mean planetary radius from gridded Magellan altimetry. X and Y axis are planetary longitude and latitude. The background greyscale image is Cycle 1 east-looking SAR images. The black rectangle indicates the area of change. Credit: Robert Herrick and Scott Hensley/Science.

For the research Herrick teamed up with Scott Hensley, a radar scientist at NASA's Jet Propulsion Laboratory (JPL) to analyze full-resolution radar images captured by Magellan.

They focused on an area containing two of Venus' largest volcanoes, Ozza Mons and Maat Mons. This area has long been thought to be volcanically active, however there has been no direct evidence of recent activity.
Comparing images taken in February and October 1991, they noticed that a volcanic vent measuring 2 square kilometers (0.7 square miles) showed a major change, growing considerably larger to about 4 square km (1.5 square miles.).

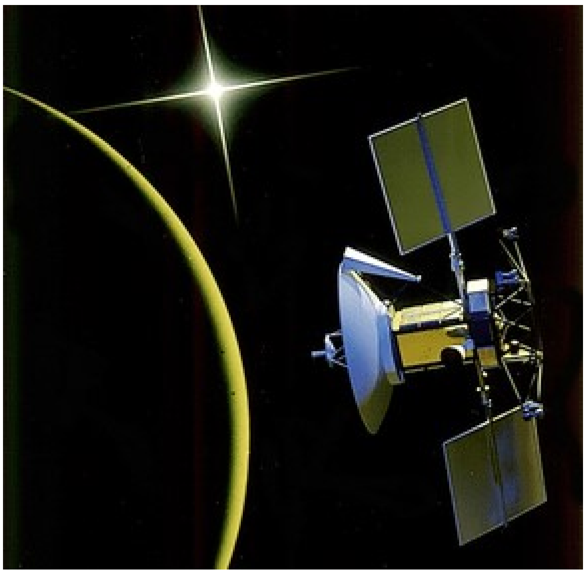


*(**A**) east-looking Cycle 1 and (**B**) west-looking Cycle 2 images of the changed vent and its surroundings. In the Cycle 1 image the vent appears nearly circular and deep with steep walls. In Cycle 2 the vent appears larger, irregular in outline, shallower and nearly filled. The dashed yellow line outlines radar-bright lava flows visible in the Cycle 2 image that were not apparent in Cycle 1. (**C** and **D**) The same images indicating the manually selected match points (purple dots) that were used to generate relative elevations (overlain in color) and to orthorectify the images. The black box in (C) indicates the extent of the unrectified images shown in panels A and B. Credit: Robert Herrick and Scott Hensley/Science.*

Herrick and Hensley then created computer models of the vent in various configurations to test different geological-event scenarios, such as landslides or other collapses. From those models, they concluded that only an eruption could have caused the change.
"Only a couple of the simulations matched the imagery, and the most likely scenario is that volcanic activity occurred on Venus' surface during Magellan's mission," Hensley said.

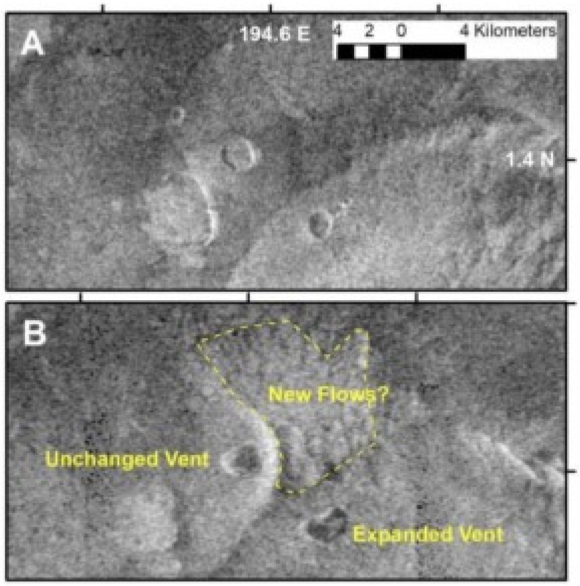
30 Year Old Data

The Magellan mission collected data for 4 years in 1991-1994 but only imaged the surface for 24 months of that period.



Artist illustration of Magellan at Venus. Credit: NASA

"It orbited over every place on Venus' surface three times, so once every eight months," Herrick explained, "but over the course of the mission the spacecraft's orbit was deteriorating, so the area of the planet that got imaged was reduced and changed."
Therefore, the images taken eight months apart ended up being taken at different angles and heights, Herrick said, and he compared them to images being taken from windows on different sides of a plane. That's where the computer modeling helped compare the data.
Why only now has this discovery been made?
Herrick said the purpose at the time of the mission was not to look for changes over time, but to look at as much of the planet as possible.
"You might ask, why didn't they search for something new way back when Magellan was operating? In order do this type of search for new activity, you need to be able to load in a few 100 gigabytes of datasets and be able to pan and zoom around the surface," he said. "That sort of hardware and software capability didn't really come into being until the last decade."
While the software Herrick and Hensley used is tailored for planetary science, it is similar to Google Earth or Google Maps.
Herrick said he started with a list he had created of the fifty top places that might have volcanism. "I bit the bullet and started working with the data and after about 200 hours, I hit paydirt in the area [of Maat Mons]," he said. That's when he brought in Hensley.
"Robbie approached me after he saw the change," Hensley recalled. "The Illumination differences or the shape of the topography could possibly be explained by the direction the spacecraft was looking, or how steeply it was looking. Because of the way radar imagery works, we had to filter out various artifacts, as we had to be sure. But it fits with the story of the volcanism."



*Images from February and October of 1991 showing the changed vent and its surroundings.*Credit: Robert Herrick and Scott Hensley/Science

The image taken in October 1991 shows a kidney-shaped vent with collapsed walls perhaps a few hundred meters deep. Herrick also spotted a brighter patch on the ground farther downhill, which he thinks might be new lava flow that poured out of the volcano.
Maat Mons is located in Atla Regio, a vast highland region near Venus' equator. Herrick compared the size of the lava flow generated by the Maat Mons activity to the 2018 Kilauea eruption on the Big Island of Hawaii.
"On Hawaii, Kilauea erupts every few years" he said, "and on Venus there are volcanos that look somewhat the Big Island overall, so it's reasonable, and it leads you to a conclusion there could likely be eruptions on Venus every few months."

The Future of Venus Exploration

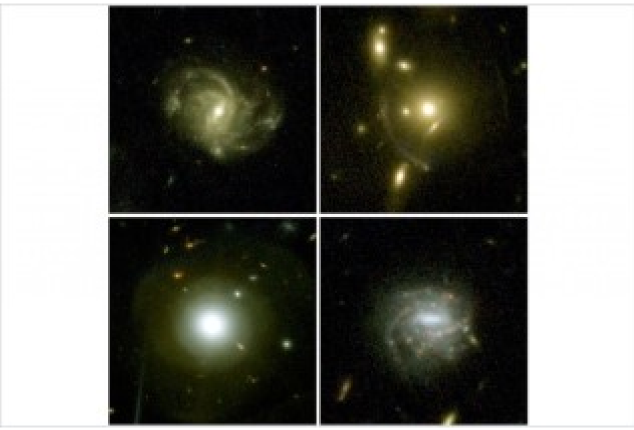
Can we find out more with new data? Maybe, but it will take a while, and this announcement of potential volcanos on Venus comes with a bittersweet revelation, as well. One planned mission, called VERITAS is currently in a delay, and scientists announced at LPSC that NASA has pulled funding

for the mission.
After the potential finding of phosphine in Venus atmosphere, interest in Earth's sister planet has spiked. Plans were announced for a fleet of spacecraft to head to Venus by the 2030s: NASA's VERITAS (Venus Emissivity, Radio Science, InSAR, Topography and Spectroscopy) and DAVINCI (Deep Atmosphere Venus Investigation of Noble gases, Chemistry and Imaging) and Europe's EnVision missions.

DAVINCI will send an atmospheric probe into Venus' clouds, and VERITAS and EnVision are to peer through the planet's thick atmosphere from orbit, able to determine very small changes" on the planet's surface, more than ten times better than the resolution of Magellan.
DAVINCI is slated to launch in 2029. NASA recently announced a delay for VERITAS and it is now scheduled to launch between 2032 to 2034, followed closely by EnVision, which will fly between 2035 to 2039.
However, Sue Smrekar the Principal Investigator of the VERITAS mission has confirmed at the Venus Exploration Analysis Group (VEXAG) town hall at LPSC that NASA pulled all funding for her mission, except for $1.5M for the science team. The ramifications of that announcement have yet to be known in full.

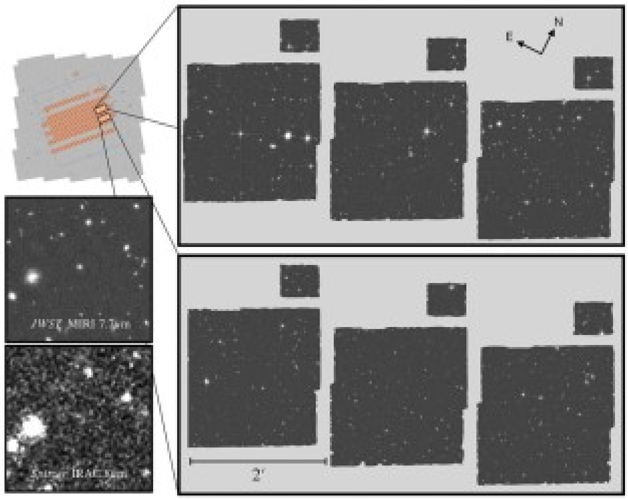
JWST Sees So Many Galaxies, and It's Just Getting Started

Hubble Space Telescope's Deep Field revealed thousands of galaxies in a seemingly empty spot in the sky. Now, the James Webb Space Telescope has taken deep field observations to the next level with its COSMOS-Web survey, revealing 25,000 galaxies in just six pictures, the first from this new survey.
"It's incredibly exciting to get the first data from the telescope for COSMOS-Web," said principal investigator Jeyhan Kartaltepe, from the Rochester Institute of Technology's School of Physics and Astronomy, in press release. "Everything worked beautifully and the data are even better than we expected. We've been working really hard to produce science quality images to use for our analysis and this is just a drop in the bucket of what's to come."
Indeed, the first images to be released from the survey accounts for just 4% of the data that will eventually be collected with COSMOS-Web. The images show many types of galaxies, including spiral galaxies, examples of gravitational lensing, and evidence of galaxy mergers. The only objects in the above image that are individual stars are the ones with JWST's signature diffraction spikes. The rest are galaxies.
COSMOS-Web is the largest program in JWST's first year and the goal of the survey is to map the earliest structures of the universe, as well as create a deep survey of up to 1 million galaxies. With a total of 255 hours of observing time, COSMOS-Web will map 0.6 square degrees of the sky with NIRCam, roughly the size of three full moons, and 0.2 square degrees with MIRI.



Images of four example galaxies selected from the first epoch of COSMOS-Web NIRCam observations, highlighting the range of structures that can be seen. In the upper left is a barred spiral galaxy; in the upper right is an example of a gravitational lens, where the mass of the central galaxy is causing the light from a distant galaxy to be stretched into arcs; on the lower left is nearby galaxy displaying shells of material, suggesting it merged with another galaxy in its past; on the lower right is a barred spiral galaxy with several clumps of active star formation. Image credit: COSMOS-Web/Kartaltepe, Casey, Franco, Larson, et al./RIT/UT Austin/IAP/CANDIDE.

The image above is a mosaic of images taken in early January by JWST's Near-Infrared Camera (NIRCam) and Mid-Infrared Instrument (MIRI). The survey will It will gather additional data in another 77 pointings of the telescope in April and May and then a remaining 69 in December and January 2024.
While the Hubble Deep Field imagers were stunning, these new images from JWST contain details that are inaccessible to Hubble. As JWST's operations project scientists Jane Rigby said last year about some of the first engineering images from the new telescope, "Basically, everywhere ever we look, it's a Deep Field. These engineering images are as sharp and crisp as images that Hubble can take, but at a wavelength of light that Hubble can't see."
The goal of COSMOS-Web is to map the earliest structures of the universe and create a wide and deep survey of up to 1 million galaxies. The survey hopes to map cosmic reionization, study galaxy evolution and determine if dark matter can be linked to visible matter.
Over the course of 255 hours of observing time, COSMOS-Web will map 0.6 square degrees of the sky with NIRCam, roughly the size of three full moons, and 0.2 square degrees with MIRI.
"This first snapshot of COSMOS-Web contains about 25,000 galaxies—an astonishing number larger than even what sits in the Hubble Ultra Deep Field," said principal investigator Caitlin Casey, from the University of Texas at Austin. "It's one of the largest JWST images taken so far. And yet it's just 4 percent of the data we will get for the full survey. When it is finished, this deep field will be astoundingly large and overwhelmingly beautiful."



The first epoch of COSMOS-Web MIRI observations obtained on Jan. 5-6, 2023. The MIRI data are distributed in six non-overlapping tiles and include data from both the MIRI imager and Lyot Coronograph field of view. At left is a comparison between Spitzer IRAC channel 4 (8?m) data and MIRI 7.7?m data in a 40?? × 40?? zoom-in panel. Image credit: COSMOS-Web / Kartaltepe / Casey / Harish / Liu / RIT / UT Austin / CANDIDE.

The team guiding the survey includes nearly 100 astronomers from all over the world.
"JWST has delivered such stunning images of this region that sources are literally popping out in every small patch of the observed sky," said Santosh Harish, a postdoctoral research associate at RIT. "What were thought to be compact objects based on the best images we had so far, the JWST

observations are now able to resolve these objects into multiple components, and in some cases even reveal the complex morphology of these extragalactic sources. With these first observations, we have just barely scratched the surface of what is to come with the completion of this program, next year."

For an overview of COSMOS-Web's survey, see the team's paper on ArXiv. For more information, including downloadable high-resolution images taken for the COSMOS-Web program, see their website.

Finding Life in the Solar System Means Crunching a Lot of Data. The Perfect Job for Machine Learning

There are plenty of places for life to hide. Even on our blue planet, where we know there is abundant life, it is sometimes difficult to predict all the different environments it might crop up in. Exploring worlds other than our own for life would make it exponentially more difficult to detect it because, realistically, we don't really know what we're looking for. But life will probably present itself with some sort of pattern. And there is one new technology that is exceptional at detecting patterns: machine learning. Researchers at the SETI Institute have started working on a machine-learning-based AI system that will do just that.

The training set is one of the essential requirements in any machine learning algorithm. So the researchers looked at the Salar de Pajonales near the Atacama Desert in Chile. This barren wasteland is very similar to the sun-scorched surface of Mars, with very high UV light penetration, very little water, and plenty of salt. But it's still home to life as we know it.

So the researchers, led by Kim Warren-Rhodes, decided to start trying to differentiate locations where life existed in the area versus where it did not. To do so, they collected almost 8000 images of the site and took more than 1100 samples around the area they were imaging. Some of the images were taken by drone, and some were taken by satellite, but they meshed together cohesively enough to provide a total picture of the Salar de Pajonales.

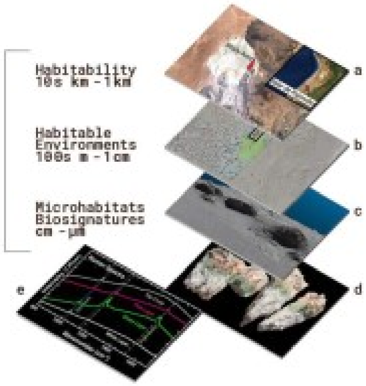
Video meshing together some of the data points used in the study.

Credit – SETI Institute

In those images, the researchers found a statistically distributed pattern that showed life was clumping together in certain areas rather than distributing itself evenly over the entire area. Unsurprisingly, these patches were directly related to the availability of water. But they also formed a pattern that can be fed into an algorithm.

Integrating the images used to feed that pattern recognition was challenging, but the team used integrations like those done with Perseverance's different imaging systems as a baseline. After being trained on what to look for, the design, known as a convolutional neural network, detected biosignatures in areas not used for its training set with 87.5% accuracy. It also had the added advantage of decreasing the overall area needed for the search by 97%

Those are some impressive numbers, but they really only represent the types of dry, arid areas currently comprising the network's data set. They can still be useful for things like directing a rover to a more attractive spot or pointing an orbiting Martian satellite to a promising site. However, there's still a lot of work to be done before this system can confidently and consistently predict the existence of life in these patterns.



Images from different altitudes provide different insights into biosignatures.

Credit – Warren-Rhodes et al.

Some of that work is already the next focal point of the SETI researchers – on their list of places to map are hot springs, permafrost soils, and rocks in Dry Valley. All of these additional locations contain some life on Earth, but it remains to be seen if the same can be said on other planets. But, as we begin to collect more data on potential biosignatures on places like Mars, Venus, and Enceladus, then this new SETI algorithm, or one of its successors, will likely play a key role in determining whether we actually found the holy grail of the search for alien life or not.

Curiosity Sees Spectacular Crepuscular Rays in Martian Clouds

NASA's Curiosity Rover usually looks down at the ground, studying nearby rocks and craters. But sometimes, it looks up and sees something wonderful.

A new image released by Curiosity shows beautiful sun rays, called crepuscular rays, streaming through a bank of clouds on Mars at sunset. While relatively common here on Earth, they have never been seen on Mars. Crepuscular comes from crepusculum, the Latin word for twilight.

Another image from the rover shows a feather-shaped iridescent cloud in the high atmosphere on Mars.

Curiosity, the 'elder' rover on Mars, has been studying the Red Planet for over 10 years. Recently, Curiosity has turned its cameras skyward in a new cloud-imaging campaign, with a focus on studying clouds at twilight. This builds on its 2021 observations of clouds, including noctilucent, or night-shining, clouds.

The image of crepuscular rays was captured by Curiosity at sunset on Feb. 2, 2023, the 3,730th Martian day, or sol, of the mission.

Crepuscular rays — also called sun rays and sunbeams — are created when sunlight shines through gaps in clouds and continues through an atmosphere that contains dust and/or haze. This dust or haze scatters some of the bright light that can be seen against the darker clouds.

NASA says that while most Martian clouds hover no more than 37 miles (60 kilometers) above the ground and are composed of water ice, the clouds in the latest images appear to be at a higher altitude, where it's especially cold. That suggests these clouds are made of carbon dioxide ice, or dry ice.

This feather-shaped iridescent cloud was captured just after sunset on Jan. 27, 2023, the 3,724th Martian day, or sol, of Curiosity's mission. Studying the colors in iridescent clouds tells scientists something about particle size within the clouds and how they grow over time. Credit: NASA/JPL-Caltech/ MSSS

In addition to the image of sun rays, Curiosity captured these shimmery, colorful clouds shaped like a feather on January 27, 2023. When illuminated by sunlight, certain types of clouds can create a rainbowlike display called iridescence.

"Where we see iridescence, it means a cloud's particle sizes are identical to their neighbors in each part of the cloud," said Mark Lemmon, an atmospheric scientist with the Space Science Institute in Boulder, Colorado, in a JPL press release. "By looking at color transitions, we're seeing particle size changing across the cloud. That tells us about the way the cloud is evolving and how its particles are changing size over time."

Curiosity captured both the sun rays and iridescent clouds as panoramas, each of which was stitched together from 28 images sent to Earth. The images have been processed to emphasize the highlights.

Look for more of these 'moody' but serene images from Curiosity as it continues it upward-looking imaging campaign.

Hubble's Orbit Has Dropped So Far that Starlink Satellites are Photobombing its Images

Astronomy is poised for another leap. In the next several years, major ground-based telescopes will come online, including the Extremely Large Telescope (ELT,) the Thirty Meter Telescope (TMT,) the Giant Magellan Telescope (GMT,) and the Vera Rubin Observatory. The combined power of these telescopes will help drive discovery in the next couple of decades.

But something threatens to undermine astronomical observing in the coming years: Starlink and other internet satellite constellations.

Now a group of astronomers have shown that even the Hubble can't escape the satellite problem.

Since the launch of Starlink and other communication satellite constellations, there's been a growing recognition of their negative effect on astronomy. The international astronomy community has pointed out how the growing number of internet satellites in Earth orbit is complicating astronomical observations by ground-based telescopes. Now their concern is spreading to the Hubble.

"With the growing number of artificial satellites currently planned, the fraction of Hubble Space Telescope images crossed by satellites will increase in the next decade and will need further close study and monitoring."

From "The impact of satellite trails on Hubble Space Telescope observations."

A new research letter in Nature Astronomy shows the effect that satellites are having on astronomical observations by Hubble in Low-Earth Orbit. The study is "The impact of satellite trails on Hubble Space Telescope observations." The lead author is Sandor Kruk, a research scientist at the Max

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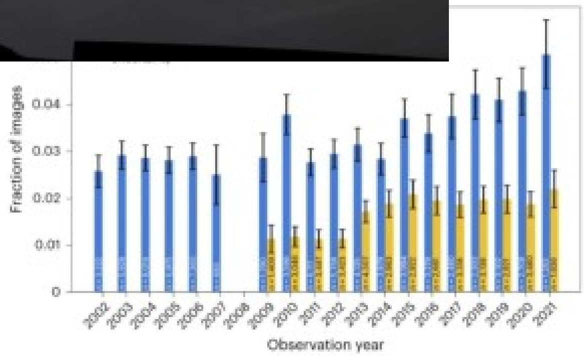
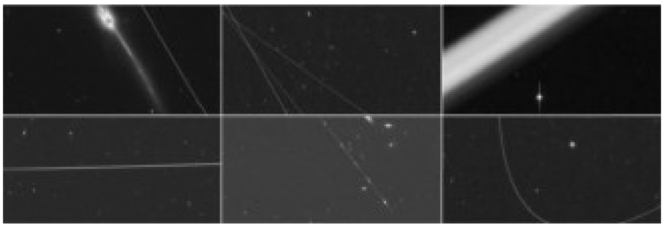


The number of satellite trails in Hubble images is on an upward trend. Image Credit: Kruk *et al.* 2023.

Astronomers were concerned about this as far back as 1986, several years before Hubble launched and before internet satellite constellations were dreamed of. In a paper titled "Artificial Earth Satellites Crossing The Fields Of View Of, And Colliding With, Orbiting Space Telescopes," the authors wrote that artificial Earth satellites "… will cross the field of view of the Hubble Space Telescope (HST) with significant frequencies and brightnesses." In 1986 alone, another 136 satellites were placed in orbit.

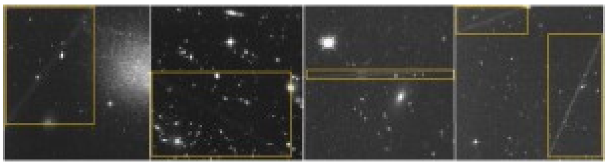
The Hubble's orbit is slowly decaying due to drag. It was placed in orbit in 1990 at 547 kilometres or 340 miles above Earth. Since then, it's decayed down to about 538 kilometres or 333 miles. As it decays, the telescope is sensitive to a larger number of satellites above it. Its sensitivity depends on things like solar illumination angle, position and telescope pointing.

The effect on Hubble images is obvious.



This figure shows six instances of satellite streaks in Hubble images. The column on the left shows typical trails. The middle column shows multiple trails. And the right column shows a broad, out-of-focus trail and a curved trail. These images are 11-minute-long exposures, typical of Hubble observations. Image Credit: Kruk *et al.* 2023.

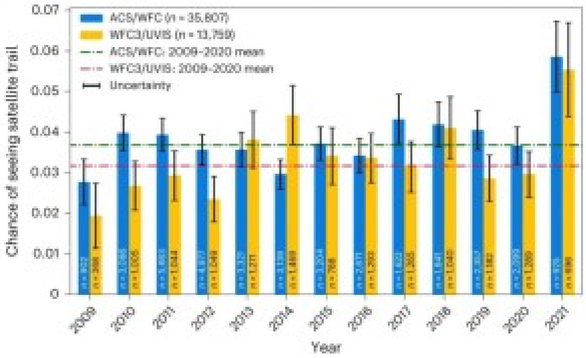
Hubble doesn't take quick snapshots. Its Fine Guidance Sensors (FGS) allow it to take pinpoint time exposures, a necessity for observing faint and distant objects in space. One of Hubble's most famous images, the Hubble Extreme Deep Field, took 22 days of observing time. That's extreme, but the telescope routinely takes stacked composite images that require 35-minute exposures. That increases the effect that satellites have on the Hubble's observations.



This figure shows some of the satellite trails in Hubble 35-minute exposures. In these images, an attempt has been made to remove the trails with limited success. Image Credit: Kruk *et al.* 2023.

The researchers found 144 Hubble images containing multiple satellite trails. 133 of them contained two trails, ten contained three, and one contained four trails.

With all of the data in hand, the team calculated the chance of seeing a satellite trail in any single Hubble image since 2009. For the following graph, an exposure time of 11.2 minutes is used. The two image groups are for the Advanced Camera for Surveys (ACS)/Wide Field Camera (WFC) and the Wide Field Camera 3 Ultraviolet channel. The odds of a satellite trail appearing in an image rose by 59% and 71%, respectively.



This graph from the research shows yearly chances of seeing a satellite trail in Hubble images. 2021 saw a significant leap. Image Credit: Kruk *et al.* 2023.

As it stands now, the risk of satellite streaks is low. But it won't stay low. More satellites are launched every year, and with companies like Starlink and OneWeb poised to launch even more, the problem will quickly become more acute.

"The fraction of HST images crossed by satellites is currently small with a negligible impact on science," the researchers write. "However, the number of satellites and space debris will only increase in the future."

There's been a pronounced increase in satellites since 2009, and that trend will continue. "There has been a 40% increase in the number of artificial satellites in the period 2005–2021, matching the observed increase in the fraction of satellites in HST images (roughly 50% increase,)" the authors say.

Starlink attracts most of the attention in this issue because Musk attracts so much media attention. But the problem is much larger than Starlink. Other companies like the British satellite provider OneWeb and the Chinese company Galaxy Space are part of it. These companies tout the benefits of their satellites, and they have their supporters.

Marian Selorm Sapah is a Lecturer and Research Scientist at the University of Ghana. In a March 2023 piece in The Conversation, Sapah pointed out how uneven internet access is around the world. In Central Africa, only 24% of people have internet access, and that access is heavily favoured toward urban areas. Starlink and others can help alleviate this global inequality, according to Sapah. "Services like Starlink could fuel even greater growth in several areas," Sapah writes. "These include education, participation in democracy and governance, disaster risk reduction and mitigation, health, and agriculture."

Those benefits are hard to deny, and there've been efforts to mitigate the effect that Starlink has on astronomy.

The DarkSat is Starlink's attempt to make their satellites less obtrusive by painting them black. While reports say that DarkSat is less bright, the solar panels can't be painted, which puts a strict limitation on dimming efforts. The dark paint caused the satellites to heat up, so it was abandoned. Another method being tried is the so-called VisorSat. It's a sunshade-like device that lowers the satellite's brightness and has been somewhat effective.

Image correction software can help mitigate the problem. The software can mask the streaks and trails, but streaks that are more than a few pixels wide may always be a problem. You can only mask so much of an image before it loses its scientific value. Observing time on the Hubble is in high demand, and that's another dimension of the problem.

"Taking shorter exposures can alleviate some of the problems, but one will have to account for the telescope time lost with unusable images," the authors explain.

The other problem is not seen in visible light but in radio brightness. All of these satellites produce a growing background noise in radio astronomy. Black paint and visors won't help.

This issue won't go away. And the astronomy community is raising the alarm.

Starlink satellites prepare for deployment. Credit: SpaceX.

In a November 2022 article in Scientific American, journalist Rebecca Boyle talked to astronomers who are very concerned with satellite constellations and their effect on astronomy. "The more meetings I attend about this, where we explain the impact it is going to have, the more I get frightened about how astronomy is going to go forward," said Rachel Street, an astronomer at Las Cumbres Observatory in California.

In The Conversation, Astronomer Samantha Lawler of the University of Regina has written extensively about the problem. Starlink makes up almost half of the approximately 4,000 operational satellites, according to Lawler. In one article, Lawler points out that soon, 1 in 15 points of light in the night sky will be a satellite. "This will be devastating to research astronomy and will completely change the night sky worldwide," she wrote.

Lawler and her colleagues created a visualization of the night sky, including the orbits of 65,000 proposed satellites from Starlink, OneWeb, Kuiper, and Starnet/GW.

Simulation of an all-sky view of future planned mega-constellations of satellites, which includes 65,000 satellites on their planned orbits, as seen from latitude 50 degrees north (southern Canada, mid-Europe) on the summer solstice. There are hundreds of satellites that are bright enough to be seen by the naked eye that are visible all night long, and thousands of sunlit satellites all night that could significantly affect astronomy research. The night sky would look very different than it does now from a dark location.

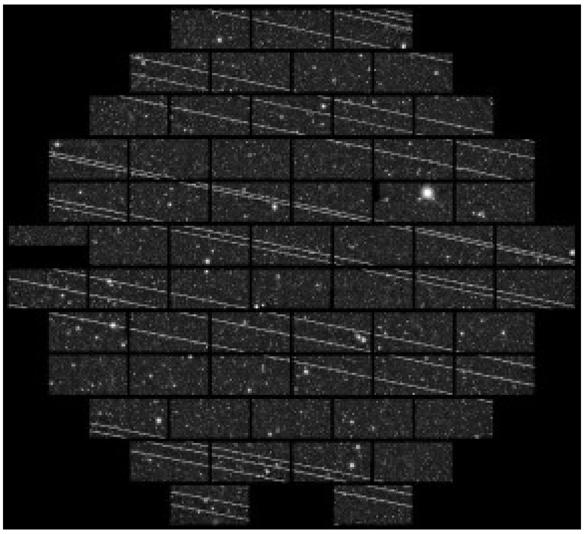
That visualization shows 65,000 satellites, but there could soon be far more than that. Proposals from various satellite companies show that by the 2030s, there could be 100,000 satellites in LEO. The research article contains a detailed table of the numbers while cautioning that "These numbers are highly uncertain, as each project is reviewed periodically by the different government agencies, and based on private company operations which are subject to change."

Entity	Origin	Number	Cumulative Total	Ref.
Starlink Gen 1	USA	4,408	4,408	1
Starlink Gen 2	USA	29,988	34,396	1
OneWeb	UK	6,372	40,768	2
Amazon Kuiper	USA	7,774	48,542	2
Astra	Luxembourg	13,620	62,162	2
Boeing	USA	5,789	67,951	2
Hughes	USA	1,440	69,391	2
SpinLaunch	USA	1,190	70,581	2
Telesat	Canada	1,373	71,954	2
CASC/CASIC "Guo Wang"	China	12,992	84,946	3
Galaxy Space	China	1,000	85,946	4,5

There could be as many as 100,000 LEO satellites by the 2030s, though nobody's certain. Image Credit: Kruk *et al.* 2023.

It's not just research astronomers that will pay the price. The rest of us will see it, too. In another article, Lawler writes: "No longer will you escape your city for a camping trip and see the stars unobstructed: you will have to look through a grid of crawling, bright satellites no matter how remote your location."

While the authors of this new research letter focus on the Hubble, it won't be the only one affected. Anything with a wide field of view will pay the price for increased global internet access as corporations battle with each other for a position in this growing, lucrative field. The soon-to-be-operational Vera Rubin Observatory (VRO) may suffer the most.



This sequence of Starlink streaks was obtained on the night of 12-13 November using the Cerro Tololo Inter-American Observatory (in Chile) all-sky camera. The Vera Rubin Observatory could face similar intrusions on observations from satellite constellations. Image Credit: NOIRLab.

The VRO will see its first light in 2024. By then, there'll be tens of thousands of satellites, including Starlink and others, in the sky. That's a problem for the VRO, which will conduct an extraordinarily wide-field survey of the night sky called the Legacy Survey of Space and Time. It'll image the entire available night sky every few nights with its 8.4-meter primary mirror. One of its jobs is to spot transients like asteroids. It's uncertain what effect the rapidly growing number of satellites will have on its operation.

Though highly unlikely, the worst-case scenario is that satellites blind us to the approach of a dangerous asteroid. Worst-case scenario aside, the satellite population will extract a toll from the VRO. In 2022, the VRO released a statement titled "Vera C. Rubin Observatory – Impact of Satellite Constellations." The statement said, in part, "The estimated 400,000 recent and planned Low Earth Orbit satellites (LEOsats) threaten the discovery potential of the Rubin Observatory Legacy Survey of Space and Time (LSST)."

The night sky is part of humanity's inheritance, but there's a lawlessness to Low Earth Orbit, and companies are rushing in before governments or regulatory agencies exert stricter control. If we degrade our night sky just for wider internet availability, we may never get it back. And while satellite internet is filling a void, it's not the only way to fill it. Earth-bound infrastructure could fill the void, just not as easily or cheaply.

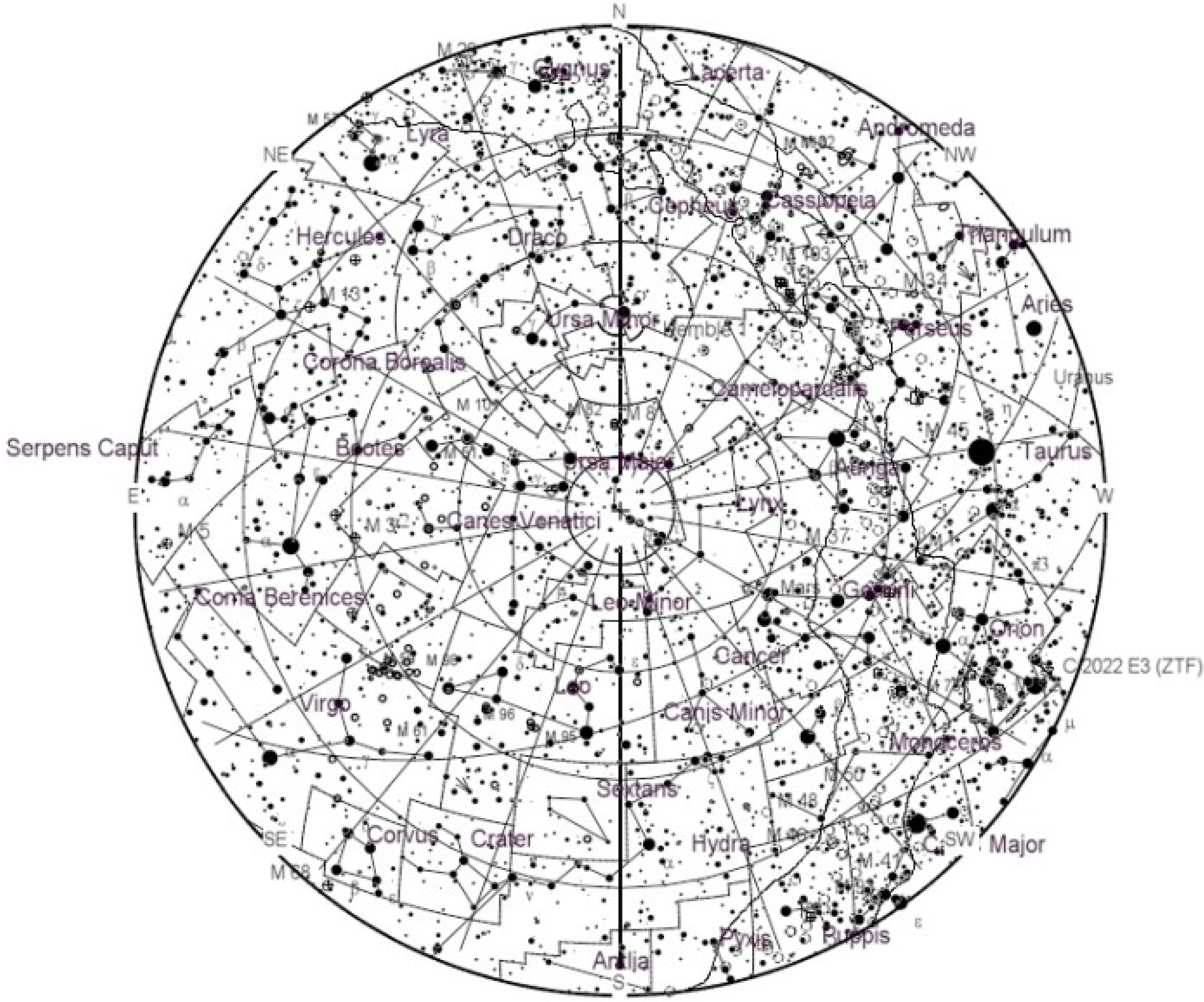
The band of light (the Milky Way) that is visible in the night sky shows the stellar disk of our galaxy. Credit: Bob King

There's an equation at the center of this issue. On one side is greater internet access, and on the other is the natural night sky. But can any of us honestly say that the bulk of internet traffic is so important that astronomy, science, and human wonder should take a backseat? The more we drown out nature, the worse off we'll be. And among all the useful things that happen on the internet, there's also a wasteland of memes, pornography, Karen Tik-Toks, gambling, victimization, and endless scams.

That stuff is part of any real conversation about satellite constellations and their effect on the sky.

"On your next clear night, go outside and look up," Lawler writes in The Conversation. "Enjoy the stars that you can see now because, without big changes in the plans of corporations that want to launch mega-constellations, your view of the stars is about to change dramatically."

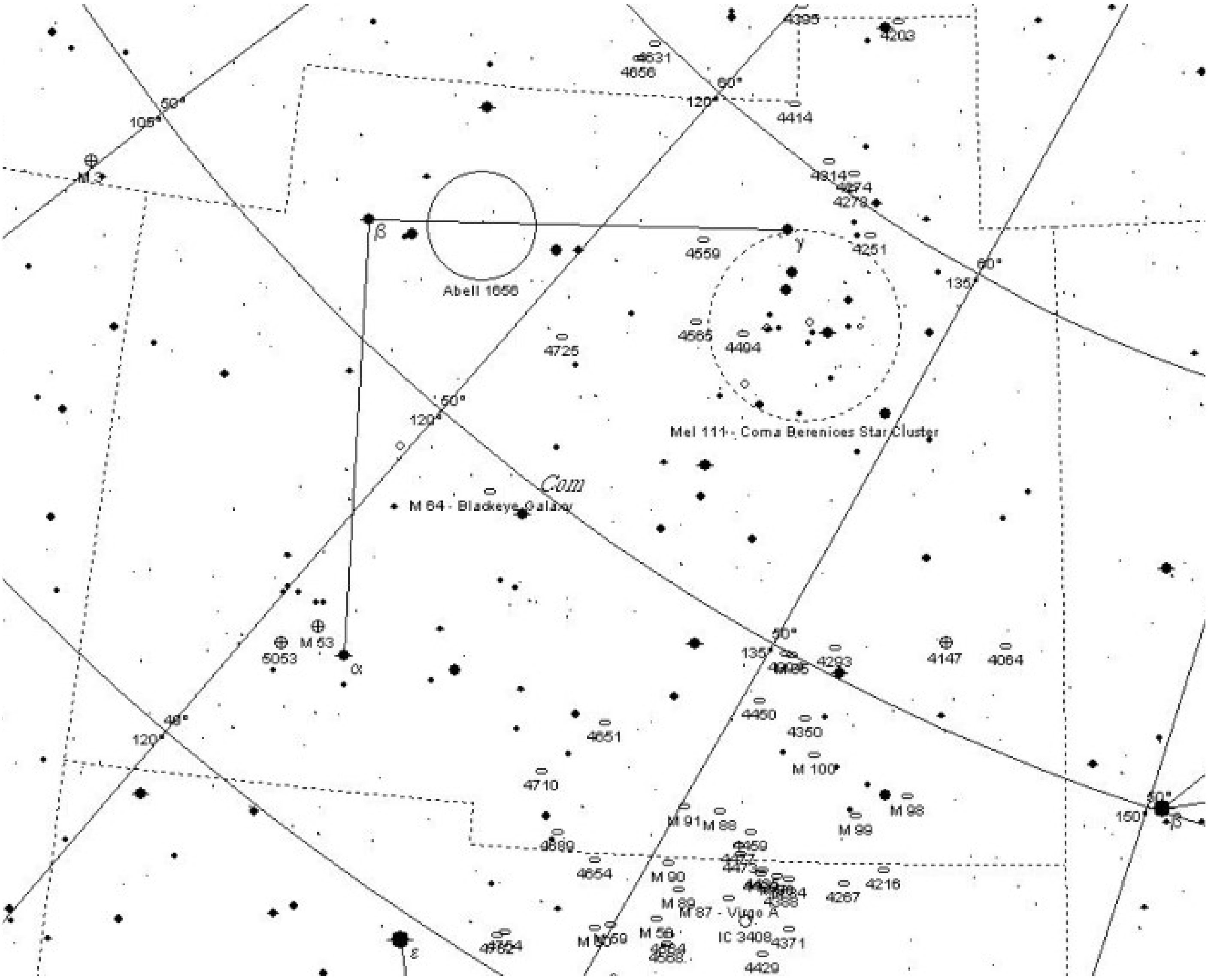
That statement might be a bit hyperbolic but certainly speaks to the tangible fear in the astronomy community. Hopefully, satellite operators will continue to work on their designs, astronomers can figure out how to work around them, and satellites and telescopes can learn to get along.



April 6 - **Full Moon.** The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This phase occurs at 04:37 UTC. This full moon was known by early Native American tribes as the Pink Moon because it marked the appearance of the moss pink, or wild ground phlox, which is one of the first spring flowers. This moon has also been known as the Sprouting Grass Moon, the Growing Moon, and the Egg Moon. Many coastal tribes called it the Fish Moon because this was the time that the shad swam upstream to spawn.
April 11 - **Mercury at Greatest Eastern Elongation.** The planet Mercury reaches greatest eastern elongation of 19.5 degrees from the Sun. This is the best time to view Mercury since it will be at its highest point above the horizon in the evening sky. Look for the planet low in the western sky just after sunset.
April 20 - **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 04:15 UTC. This is the best time of the month to observe faint objects such as galaxies and star clusters because there is no moonlight to interfere.
April 20 - **Hybrid Solar Eclipse.** A hybrid solar eclipse occurs when the Moon is almost too close to the Earth to completely block the Sun. This type of eclipse will appear as a total eclipse to some parts of the world and will appear annular to others. The eclipse path will begin in the southern Indian Ocean and move across parts of western Australia and southern Indonesia. A partial eclipse will be visible throughout most of Indonesia and Australia. (**NASA Map and Eclipse Information**) (**NASA Interactive Google Map**)

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

CONSTELLATIONS OF THE MONTH: COMA BERENICES



The Coma Berenices Constellation

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

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

Name and Meaning:

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

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

History of Observation:

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

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

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

Fragment of Mercator's 1551 celestial globe, showing Coma Berenices. Credit: Harvard Map Collection

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

Notable Objects:

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

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

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

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

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

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

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

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

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

Finding Coma Berenices:

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

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

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

Another interesting aspect about singular stars in Coma Berenices is that there are over 200 variable stars in the constellation. While most of them are very obscure and don't go through radical changes, there is one called FK Comae

Berenices which is a prototype of its class. It is believed that the variability of FK Com stars is caused by large, cool spots on the rotating surfaces of the stars – mega sun-spots! If you'd like to keep track of a variable star that has notable changes, try FS Comae Berenices (RA 13 3 56 Dec +22 53 2). It is a semi-regular variable that varies between 5.3m and 6.1 magnitude over a period of 58 days.

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

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

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

The Needle Galaxy (NGC 4565). Credit: ESO

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

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

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

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

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

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

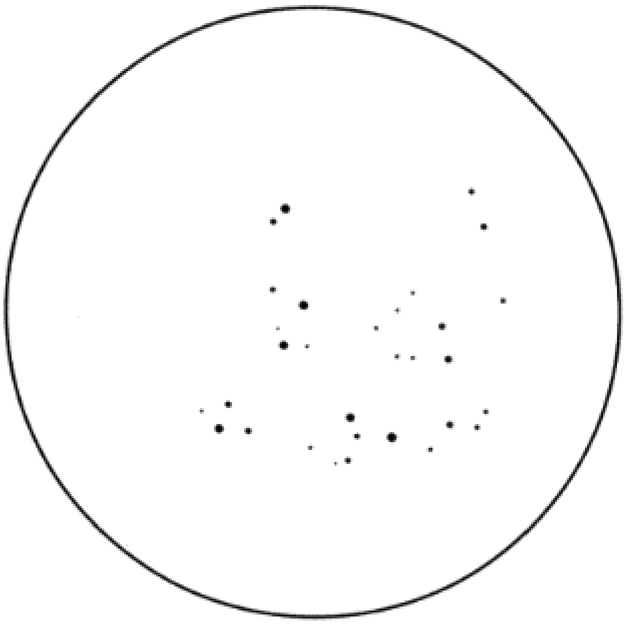
We have written many interesting articles about the constellation here at Universe Today. Here is What Are The Constellations?, What Is The Zodiac?, and Zodiac Signs And Their Dates.

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

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

Source:

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



Mel 111, The hair of Berenices

Bluewalker 3 communication sail will be making itself seen.

Date	Bright-ness	Start			Highest point			End		
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
03 Apr	2.0	20:48:15	10°	W	20:52:10	79°	NNW	20:55:56	11°	ENE
03 Apr	2.2	22:27:03	10°	WNW	22:30:40	67°	NNW	22:30:40	67°	NNW
04 Apr	2.1	20:28:28	10°	W	20:32:24	78°	NNW	20:36:18	10°	ENE
04 Apr	2.0	22:07:16	10°	WNW	22:11:10	71°	N	22:11:41	61°	ENE
04 Apr	4.8	23:45:56	10°	WNW	23:46:25	13°	WNW	23:46:25	13°	WNW
05 Apr	2.0	21:47:28	10°	WNW	21:51:23	72°	N	21:52:38	40°	E
05 Apr	4.3	23:26:08	10°	WNW	23:27:22	19°	W	23:27:22	19°	W
06 Apr	2.0	21:27:40	10°	WNW	21:31:35	72°	N	21:33:34	27°	E
06 Apr	3.7	23:06:20	10°	WNW	23:08:18	26°	W	23:08:18	26°	W
07 Apr	2.1	21:07:51	10°	WNW	21:11:46	73°	N	21:14:29	19°	E
07 Apr	3.1	22:46:31	10°	WNW	22:49:12	36°	WSW	22:49:12	36°	WSW
08 Apr	2.1	20:48:00	10°	WNW	20:51:56	74°	N	20:55:23	13°	E
08 Apr	2.6	22:26:41	10°	WNW	22:30:06	45°	SW	22:30:06	45°	SW
09 Apr	2.1	20:28:09	10°	WNW	20:32:05	74°	N	20:35:58	10°	E
09 Apr	2.4	22:06:50	10°	WNW	22:10:34	45°	SSW	22:11:00	43°	S
10 Apr	2.6	21:46:58	10°	WNW	21:50:41	44°	SSW	21:51:55	32°	SSE
11 Apr	2.7	21:27:05	10°	WNW	21:30:48	43°	SSW	21:32:50	22°	SSE
12 Apr	2.8	21:07:12	10°	WNW	21:10:53	41°	SSW	21:13:47	15°	SE

ISS PASSES For APRIL 2023

from Heavens Above website maintained by Chris Peat.

Date	Brightn	Start	Highest point	End						
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
24 Apr	-1.1	05:05:00	10°	SSE	05:06:13	12°	SE	05:07:27	10°	ESE
26 Apr	-2.0	05:02:07	10°	SSW	05:04:49	23°	SE	05:07:33	10°	E
27 Apr	-1.5	04:14:25	12°	S	04:16:06	16°	SE	04:18:15	10°	E
28 Apr	-1.1	03:27:16	11°	SE	03:27:23	11°	SE	03:28:07	10°	ESE
28 Apr	-3.0	05:00:14	10°	SW	05:03:25	42°	SSE	05:06:37	10°	E
29 Apr	-2.5	04:12:53	19°	SSW	04:14:31	30°	SSE	04:17:30	10°	E
30 Apr	-2.1	03:25:33	21°	SSE	03:25:37	21°	SE	03:28:14	10°	E
30 Apr	-3.7	04:58:36	10°	WSW	05:01:56	69°	SSE	05:05:17	10°	E
01 May	-1.1	02:38:09	12°	ESE	02:38:09	12°	ESE	02:38:39	10°	ESE
01 May	-3.5	04:10:59	22°	SW	04:12:53	53°	SSE	04:16:10	10°	E
02 May	-3.1	03:23:31	37°	SSE	03:23:49	38°	SSE	03:26:58	10°	E
02 May	-3.8	04:57:00	10°	W	05:00:22	90°	NNW	05:03:43	10°	E
03 May	-1.9	02:35:57	22°	ESE	02:35:57	22°	ESE	02:37:39	10°	E
03 May	-3.8	04:08:47	18°	WSW	04:11:10	80°	SSE	04:14:31	10°	E
04 May	-3.8	03:21:10	45°	SW	03:21:57	65°	SSE	03:25:17	10°	E
04 May	-3.7	04:55:17	10°	W	04:58:38	85°	N	05:02:00	10°	E
05 May	-2.9	02:33:29	39°	ESE	02:33:29	39°	ESE	02:35:59	10°	E
05 May	-3.8	04:06:18	12°	W	04:09:20	86°	N	04:12:42	10°	E
06 May	-1.4	01:45:45	16°	E	01:45:45	16°	E	01:46:36	10°	E
06 May	-3.9	03:18:34	32°	W	03:20:00	88°	S	03:23:22	10°	E
07 May	-3.9	02:30:46	74°	SE	02:30:46	74°	SE	02:33:58	10°	E
07 May	-3.8	04:03:59	10°	W	04:07:21	88°	NNE	04:10:42	10°	E
08 May	-2.1	01:42:55	26°	E	01:42:55	26°	E	01:44:33	10°	E
08 May	-3.8	03:15:43	20°	W	03:17:55	85°	N	03:21:15	10°	E
09 May	-1.0	00:55:00	10°	E	00:55:00	10°	E	00:55:04	10°	E
09 May	-3.9	02:27:49	56°	W	02:28:26	87°	N	02:31:47	10°	E
09 May	-3.9	04:01:48	10°	W	04:05:07	72°	SSW	04:08:27	10°	ESE
10 May	-3.0	01:39:52	44°	E	01:39:52	44°	E	01:42:16	10°	E
10 May	-3.9	03:12:40	13°	W	03:15:38	85°	S	03:18:58	10°	ESE
11 May	-1.5	00:51:52	17°	E	00:51:52	17°	E	00:52:43	10°	E
11 May	-3.9	02:24:40	32°	W	02:26:04	87°	N	02:29:25	10°	E
11 May	-3.5	03:59:26	10°	W	04:02:38	45°	SSW	04:05:50	10°	SE
12 May	-3.8	01:36:39	77°	ENE	01:36:39	77°	ENE	01:39:49	10°	E
12 May	-3.8	03:09:48	10°	W	03:13:06	60°	SSW	03:16:24	10°	ESE
12 May	-1.7	21:34:07	10°	SE	21:34:19	10°	SE	21:34:31	10°	SE
12 May	-3.2	23:07:08	10°	SW	23:09:42	36°	S	23:09:42	36°	S

END IMAGES, AND OBSERVING

Lunar images using Nikon P1000 bridge camera using 24-3000mm built in zoom.
I drop the exposure from automatic setting by 1.3 to 1.7 EV faster shutter.
It means I can shoot the whole Moon hand held for grab shots when clouds are broken, but advise tripod mounting for zoomed details.
Andy Burns

Observing Sessions

Proposed Observation Sessions for 2022-2023

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

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

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

OUTREACH:

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