NWASNEWS

Volume27 Issue 1

SEPTEMBER 2021

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

WELCOME TO OUR NEW SEASON

It is a bit of a risk to opt for a hall meeting tonight, but we have to do it sometime. And local cases of Covid 19 are escalating and may get worse while the schools start.

But we can go back to zoom meetings quite quickly. Indeed I am experimenting with a WIFI booster and will hopefully be able to allow some at home isolating members to see what is going on. Our speaker Prof Mike Edmunds is a very 'lively' speaker and his topic connects the ancients of the stones through the wonderful Antikythera Mechanism which is a geared astronomical calculator maybe over 2000 years old. I first met professor Edmonds while we were helping an RAS winter solstice event at Stonehenge. I remember it was bitterly cold with snow!

I also feel the need to have a quick AGM at the back end of the evening (congregating around the coffee and biscuits is a bit of a no no so social distancing is needed.

One position we need to fill is the tea/ coffee/milk supplier and projector holder. Dave Buckle is stepping back from duties and we would all thank him for his efforts.

Another 'position' is that of Lye Hall key provider. Philip is getting very poorly now, and other local is finding Tuesday difficult to attend. A Seend resident volunteer would be very welcome.

I did try to take a back seat three years ago but times and circumstances meant I have been at the helm, trying to take decisions and keeping up newsletter writing and out reach work.

If anybody would like to have a go at any of these tasks please step foreword.

I know three of our committee will not be here tonight and have apologies.

Here are the Zoom details

Andy Burns is inviting you to a scheduled Wiltshire Astronomical Society Zoom meeting.

Topic: The Clockwork Universe

Time: Sep 7, 2021 07:45 PM London

Join Zoom Meeting

https://us02web.zoom.us/j/84046617944?pwd=MkxpVEtETHNKL2o5Zm9sRU5BMmtPUT09

Meeting ID: 840 4661 7944

Passcode: 311036

Clear skies

Andy

What a poor summer for observing! Managed to get into my dome observatory once, and that was last night.

There were a few clear nights to capture the Milky Way and meteors when there was no or little Moonlight.

But last night a quickly set up (but then spoiled it by knocking the scope off alignment, and even then camera battery failed, then Starlink satellites streaked through the images.

Here is the wonderful cluster ngc 7789 Caroline's Rose in Cassiopeia.

Andy

Other pictures on images pages 24-26

If you want to add pictures please send to me two days before meeting

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.
During COVID19 ZOOM meetingd

HALL VENUE the Pavilion, Rusty Lane, Seend

Meet 7.30 for 8.00pm start

SEASON 2020/21
2021

7th September Prof Mike Edmunds, The Clockwork Universe.
5th October Colin Stuart, Time in Einstein's Universe.
2nd November Andrew Lound, The Moon at Christmas, The Epic Voyage of Apollo 8.
7th December Katrin Raynor-Evans, Exploring Astronomy Through Philately.

Mike Edmunds is Emeritus Professor of Astrophysics at Cardiff University and former Head of the School of Physics and Astronomy. He was educated at Cambridge, but has lived and worked in Wales for over 45 years.

His research career involved the determination and interpretation of the abundances of the chemical elements in the Universe, and of the origin of interstellar dust. Later work has been in the history of astronomy, in particular the ancient Greek Antikythera Mechanism and the early history of the Royal Astronomical Society, of which he is a past Vice-President. He was a member of two UK Research Councils (PPARC and STFC), and currently chairs the Institute of Physics' Curriculum Committee. He can occasionally be seen in his one-man play about Newton – "Sir Isaac Remembers…".

He is author of more than a hundred academic papers. His 2004 invited George Darwin Lecture "The Elementary Universe" to the Royal Astronomical Society has been published in the August 2005 issue of Astronomy & Geophysics.

From Standing Stones to a Clockwork Universe
Starting with megalithic sites connected to the Sun and Moon as well as Babylonian and Greek studies of the stars and planets, this lecture will focus on the concept of a 'mechanical' Universe. Ideas of this 'mechanical' Universe can be seen in the Antikythera Mechanism, a remarkable geared astronomical calculator probably made around 2,100 years ago. It was discovered on a shipwreck in the Mediterranean over 100 years ago and its functions were finally unravelled in the 21st century.
Early literature shows that models used to explain the Universe were around from 2200 BC – 500 AD, long before the conventional "scientific revolution" of Copernicus, Galileo and Newton. They continued to be used beyond 1605 AD when astronomer, mathematician and astrologer Kepler stated "my aim is to show that the heavenly machine… is a kind of clockwork".
This lecture traces the history of mechanical models of the Universe through some 5,000 years. It shows how they were successfully used to understand and explain celestial phenomena and suggests why, with developments in 20th century physics, they may no longer be able to satisfy us.

Membership Meeting nights £1.00 for members £3 for visitors

Wiltshire AS Contacts
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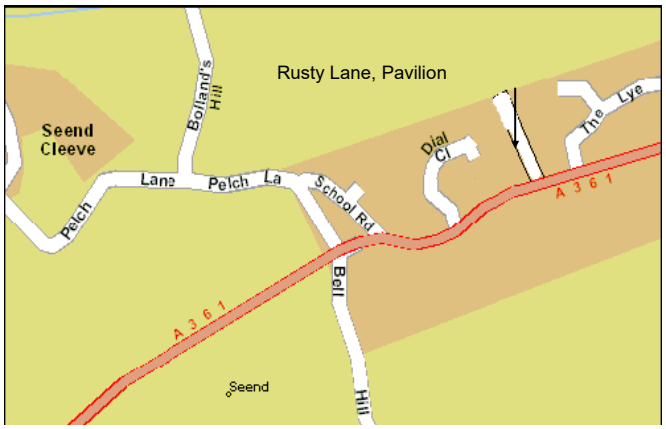
Bob Johnston (Treasurer) Debbie Croker (vice Treasurer)
Philip Proven (Hall coordinator) Dave Buckle (Teas)
Peter Chappell (Speaker secretary)
Nick Howes (Technical Guru)
Observing Sessions coordinators: Chris Brooks, Jon Gale,
Web coordinator: Sam Franklin
Contact via the web site details.



Observing Sessions see back page

Swindon Stargazers

Swindon's own astronomy group

Physical meetings starting again

Following the relaxation of the Covid rules we are re-starting physical meetings in September. .

Next meeting: Dr. Elizabeth Pearson

Our next meeting will be held in the Liddington Hall in person when we will be welcoming Dr. Elizabeth Pearson.

Ezzy Pearson is the News Editor of BBC Sky at Night Magazine and author of Robots in Space: the secret lives of our planetary explorers.

Short summary of the talk: For the last 50 years, humanity has been sending out rovers to explore the many varied worlds of our Solar System. We take a tour through their journey from the clunky machines roving the Moon in the 1970s, to the light weight helicopter scout exploring Mars today.

Ad-hoc viewing sessions postponed

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

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

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

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

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

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

For insurance reasons you need to be a club member to take part. If you think you might be interested email the organiser Robin Wilkey (see below). With this you will then be emailed regarding the event, whether it is going ahead or whether it will be cancelled because of cloud etc.

We are a small keen group and I would ask you to note that you DO NOT have to own a telescope to take part, just turn up and have a great evening looking through other people's scopes. We are out there to share an interest and the hobby. There's nothing better than practical astronomy in the great cold British winter! And hot drinks are often available, you can also bring your own.

Enjoy astronomy at it's best!

Meetings at Liddington Village Hall, Church Road, Liddington, SN4 0HB – 7.30pm onwards

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

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

Friday 17 September 19.30 onwards - Meeting or Zoom

Programme: Dr Elizabeth Pearson: Planetary Rovers

Friday 15 October 19.30 onwards - Meeting or Zoom

Programme: Charles Barclay: Oldest GOTO telescope in the World (Provisional)

Friday 19 November 19.30 onwards - Meeting or Zoom

Programme: TBA

Friday 10 December 19.30

Programme: Christmas Social

Website: http://www.swindonstargazers.com

Chairman: Robin Wilkey

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BECKINGTON ASTRONOMICAL SOCIETY

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

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

Our Committee for 2016/2017 is

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

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

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

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

Post Code for Sat Nav is BA11 6TB.

Our start time is 7.30pm

STAR QUEST ASTRONOMY CLUB

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

Meet at Sutton Veey near Warminster.

BATH ASTRONOMERS

Bath Astronomers are holding webinar sessions linking in with Stargazers web sight.

Feb24
Talk by Nora Eisner, Planet Hunters TESS: discovering exoplanets using citizen science
24 Feb - Zoom
Wednesday 24th February – Monthly meeting. This month's talk will be given by Nora Eisner, Department of Physics, University of Oxford. She is a PhD student at the University of Oxford where her research focuses on citizen-powered exoplanet discoveries using NASA's TESS (Transiting Exoplanet Survey Satellite) data. She is working under the supervision of Professor Chris Lintott and Professor Suzanne Aigrain. The talk is entitled "Planet Hunters TESS: discovering exoplanets using citizen science". Nora's research focuses on citizen-powered exoplanet discoveries using TESS data via Planet Hunters TESS. As the leader of this exciting project she collates the returns from the citizen science campaigns, analyse them, and follows-up on the most promising detections using ground based facilities. The analysis of the extremely large time-series data sets has a strong emphasis on applying various statistical processes, as well as using machine learning in order detect exciting new planet systems that were missed by the main pipelines and other teams of professional astronomers. Abstract: Since the first unambiguous discovery of an exoplanet in 1995, over 4,000 more have been confirmed, and studies of their characteristics have unveiled an extremely wide range of planetary properties in terms of their mass, size, system architecture and orbital periods. While dedicated planet detection algorithms are able to identify the vast majority of planets in data obtained with spaced satellites, they miss certain types of planets that are key to the further development of our understanding of how these systems form and evolve. In this talk, I will discuss how we can harness the power of citizen science, and in particular Planet Hunters TESS, to find these more elusive planets with the help of tens of thousands of volunteers. I will present some of our exciting findings, including both planets and exotic stellar systems, and show that human classification still plays a vital role in a world that is becoming increasingly automated. Bath Astronomers monthly meeting for all members and new comers to meet up, enjoy perhaps a new topic and a cup of tea and a biscuit. Held on the last Wednesday of every month online or at the Herschel Museum of Astronomy, 19 New King Street.

Jun30
Talk by Chris Starr, Cassini and Saturn
30 Jun - Herschel Museum of Astronomy
Wednesday 30th June – Monthly meet

For NWAS Newsletter

Why not take part in Wiltshire Council's survey and make the case for reduced street-lighting during night-time hours.

Here's how to have your say on Wiltshire Council's Climate StrategyWILTSHIRE Council is giving residents, businesses and local groups the opportunity to have their say on its Climate Strategy.www.salisburyjournal.co.uk

Dave Buckle

LETTER FROM LA PALMA – SEP '21
Two new telescopes to be built here

We are still waiting for the final location of the Thirty Meter Telescope (TMT) to be determined. The Biden Administration have stated it will take until at least the Summer of 2022 for them to come to a decision! As many of you are aware, this has been a long-running saga – the Primary site is Mauna Kea in Hawai'i, but this has been effectively blocked by protests from native Hawaiians opposed to its construction on a mountain they hold sacred. Mauna Kea was originally chosen because it is considered the best location in the Northern Hemisphere for InfraRed (IR) observations, which will be the primary task of TMT. El Roque de los Muchachos observatory (ORM) was chosen as a back-up site when measurements carried out by the Project showed there was little difference in the seeing conditions at the two sites. There are two schools of thought: the mainly American-led group (surprise, surprise) that are insisting Mauna Kea is better and the group of mainly the partners in the project, Japan, Canada, China and India who are exasperated by the delays in Hawai'i and just want to get it built – at ORM.

Figure 1 Artist's impression of the Thirty Meter Telescope at its proposed location on La Palma (IAC)

ORM has also been chosen as the location for the Northern Hemisphere part of the Cherenkov Telescope Array (CTA). Cherenkov radiation is generated when high-energy particles from Gamma Ray bursts (GRB) hit the upper atmosphere The project is well-advanced, and it will help to address some of the most perplexing questions in astrophysics, seeking to understand the origin and role of relativistic cosmic particles. Actual construction is expected to begin shortly.

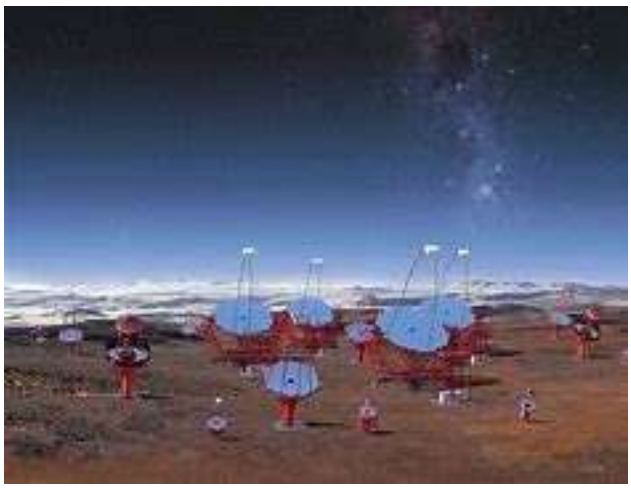


Figure 2 Artist's impression of the Northern Cherenkov Telescope Array at ORM (CTA Project)

Which brings us to the two new projects that have announced during the Summer that they will be built at ORM. The first of these is the European Solar Telescope (EST). It will be the largest European infrastructure dedicated to observing the Sun. EST will be located alongside the existing Swedish Solar Telescope (SST) and Dutch Solar Telescope (DOT) making ORM the location with the highest concentration of solar telescopes in the World.

Construction of EST on La Palma is scheduled to begin in 2023/24 and it expected to see first light in 2028/29. It will feature a 4.2m primary mirror and an adaptive optics system. The main objectives of EST are: to allow for a better understanding of solar magnetic activity; to investigate the structure, dynamics and energy of the lower solar atmosphere and to study phenomena such as sunspots and solar flares with unprecedented precision. EST will be able to distinguish structures on the solar surface as small as 30km.

Figure 3 Artist's impression of the European Solar Telescope (sectioned) at ORM (EST Project)

The second of the major new projects coming to ORM is the New Robotic Telescope (NRT), a project being run by the Liverpool John Moores University (LJMU), Spain's University of Oviedo and the Institute of Astrophysics of the Canary Islands (IAC).

The next generation of transient surveys by the Vera C. Rubin Observatory, previously referred to as the Large Synoptic Survey Telescope (LSST), currently under construction in Chile, will detect transients with typical magnitudes which are beyond the capabilities of 2m-class telescopes for spectroscopic follow up. The single visit depth of the LSST will be approximately 24.5 in the r-band, so many transients will be beyond the capabilities of even a 4m-class telescope. However, the pressure on 8m-class telescopes is high and will still be high in the foreseeable future. So 4m-class facilities will need to do the bulk of this follow-up work and this will be limited by the number of these facilities available. Recently the Public ESO Spectroscopic Survey of transient Objects has shown that dedicating large amounts of 4m-class telescope time can be extremely scientifically productive.

A robotic telescope with a 4m aperture will be a powerful tool for the study of supernovae, also the more exotic classes of transient, such as the afterglows of GRBs. The current Liverpool 2m Robotic Telescope (LT) – also at ORM – has a typical response time to a 'Swift Trigger', including slew time, mirror setting time and instrument overhead etc. is between one and two minutes. If this response time can be reduced, the rapid decay of the afterglow means it can be observed when it is considerably brighter. Response time commonly trumps aperture, in this particular instance.

The £24 million 4m NRT will be 10 times faster and construction is now able to commence thanks to a £4 million grant from the UK Science and Technology Facilities Council (STFC).

> *"Speed is key and gives us a view of mysteries of the universe which have never been observed before.*
>
> *So much happens in the night sky that we simply miss because we are on it too late. The NRT will give us an almost immediate eye onto movements and phenomena, giving us an unprecedented insight into the physics of the changing sky".*
>
> *Dr. Chris Copperwheat, LT Astronomer at LJMU.*

The telescope will feature a 'clamshell' enclosure, designed to protect the telescope from extreme weather and to allow fast rotation onto targets. The NRT will be operated remotely, and scientists make requests and receive data through the web. The telescope itself will pick objects to view itself and at the heart of the robotic system is a sophisticated algorithm.

> *"Despite our ever-increasing knowledge of the universe, there are still some phenomena that remain elusive.*
>
> *This fast efficient eye on the sky will be a real asset to astronomers, who will be able to utilise its capability to see events we've never managed to capture before.*
>
> *The UK's World-class skills in engineering, design and software development will help bring this exciting new facility to life".*
>
> *Professor Grahame Blair, STFC Executive Director for Programmes.*

The NRT will be built alongside its sibling LT facility, also run by LJMU, on the Canary Island of La Palma. It will build upon the highly successful legacy of the LT and will have a 4m Primary mirror made up of 18 hexagonal segments providing a sensitivity four times greater to the LT. The NRT will also respond to transient triggers from space-based or survey telescopes within 30 seconds, capturing the very first seconds of evolution after an explosion and will be a key part of a multi-facility approach to transient events designed to capture the most science possible.

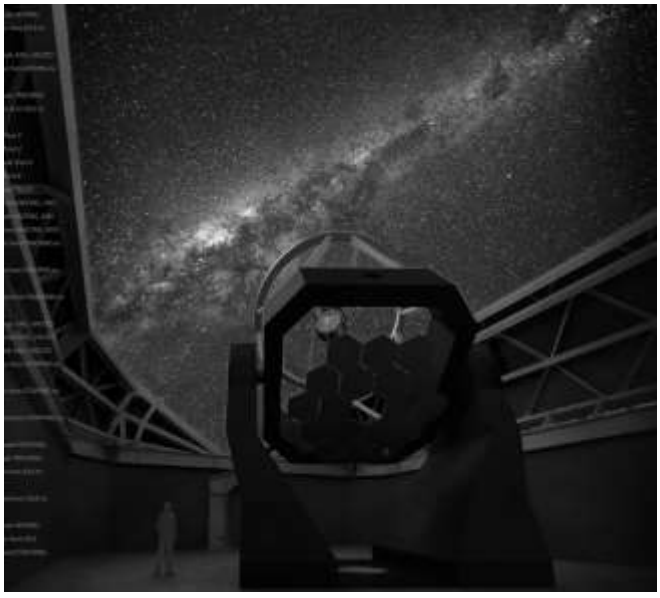


Figure 4 Artist's impression of the New Robotic Telescope (LJMU)

Figure 5 The proposed location of the NRT at ORM (IAC)

Mike Alexander

SPACE NEWS JUNE 2021

The Galactic Beauty of Star Formation

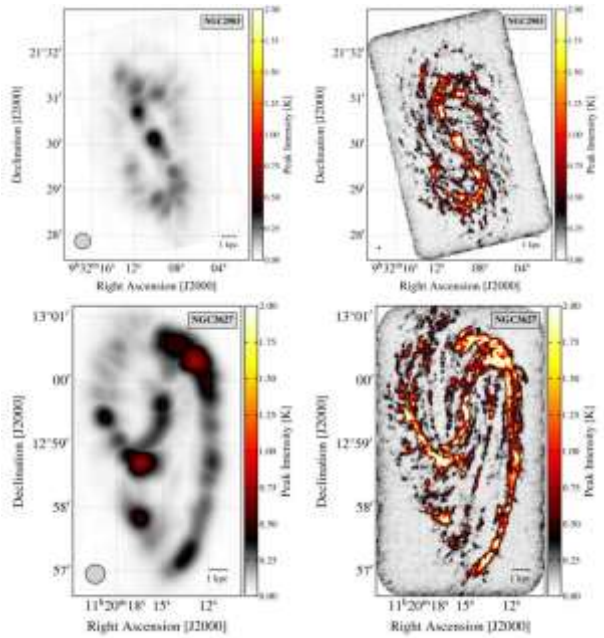
I'd never seen galaxy images like this before. Nobody had! These images highlight star forming regions in nearby(ish) galaxies. There are still a number of unanswered questions surrounding how star formation actually occurs. To answer those questions, we are observing galaxies that are actively forming stars within giant clouds of gas. Until recently, we didn't have the resolution needed to clearly image the individual gas clouds themselves. But images released by a project called PHANGS (Physics at High Angular resolution in Nearby GalaxieS) in a collaboration between the European Southern Observatory Very Large Telescope and the Atacama Large millimeter/submillmeter Array (ALMA) have provided never before seen detail of star forming clouds in other galaxies.

This image combines observations of the nearby galaxies NGC 1300, NGC 1087, NGC 3627 (top, from left to right), NGC 4254 and NGC 4303 (bottom, from left to right) taken with the Multi-Unit Spectroscopic Explorer (MUSE) on ESO's Very Large Telescope (VLT). Each individual image is a combination of observations conducted at different wavelengths of light to map stellar populations and warm gas.. Image and Image Description PHANGS/ESO. Original Image

A Cloud of Stardust

Stars form from Giant Molecular Clouds (GMCs) which are mainly comprised of molecular Hydrogen (H_2). Gas within these clouds collapses under gravity eventually becoming dense spheres. With the increase in density and pressure, heat within these spheres makes nuclear fusion possible fusing hydrogen into helium – a star is born! But what triggers the initial collapse of the gas? Does the star formation rate vary between different clouds in the same galaxy? How varied are the clouds themselves? These are all chapters of star formation we're not entirely certain about. Enter PHANGS.

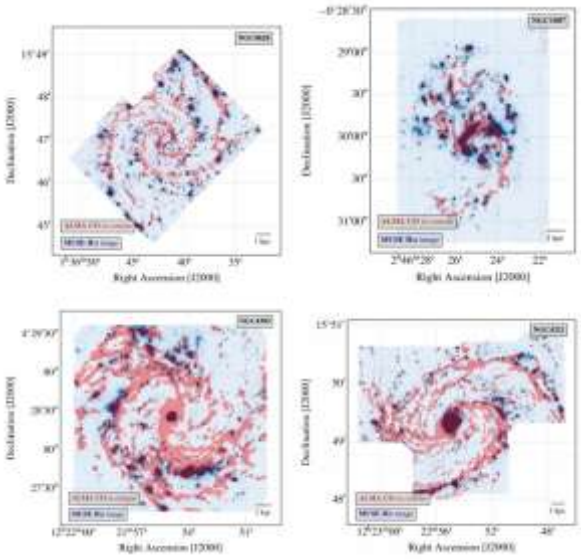
PHANGS researchers chose target galaxies using a number of preconditions. The galaxies had to be close enough so they could be imaged at the required resolution to see individual GMCs. All the targets are therefore within 17 million parsecs of the Milky Way (about 55 million light years). The galaxies are also not too inclined as to provide a clear line of sight into the disks of the target galaxies. And, perhaps most importantly, the target galaxies are actively forming stars. As "Main Sequence Galaxies" these galaxies are forming stars in their disks without the external gravitational interaction of a nearby galaxy or as a result of galaxy mergers both of which can trigger intense periods of star formation call star bursts. Rather these galaxies are forming stars through processes internal to the galaxy. 90 such galaxies met the criteria and were selected for the survey.



These contrasting images show the increased resolution in Carbon Monoxide detection. The left shows previous surveys of cold gas clouds in galaxy NGC 3627 vs the increased "cloud scale" resolution achieved by PHANGS-ALMA showing a much clearer image of GMC locations in the galaxy. c PHANGS-ALMA

Cold and Dark

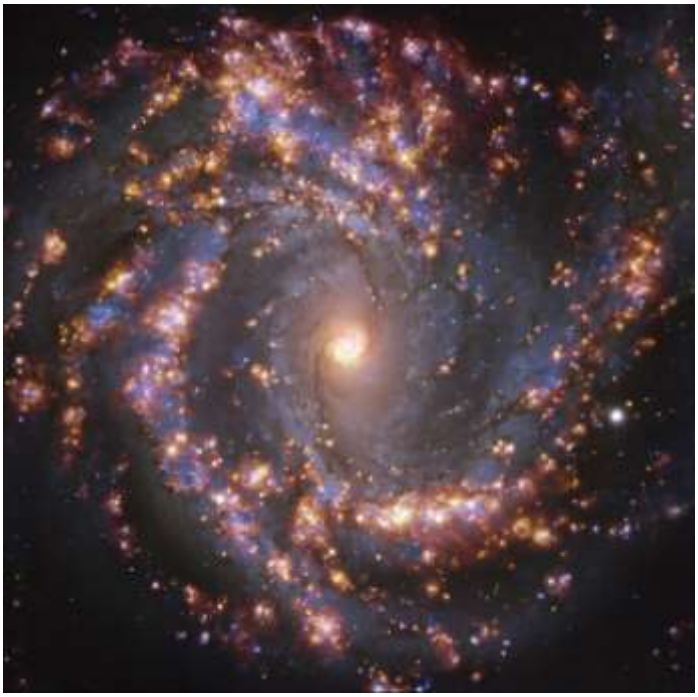
Discovering star forming regions in the targets galaxies is achieved through a combination of finding cold gas as well as hot gases heated by newly formed stars. Cold GMCs birthing new stars are called stellar nurseries. They can range from tens to hundreds of lightyears in diameter with the mass equivalent to thousands of suns. However, the hydrogen these clouds are made from is difficult to see. When hydrogen is exposed to energy, it glows and is easily detectable while cold hydrogen hides in the darkness of space. But GMCs also contain carbon monoxide (CO) which in a cold state is easier to detect than hydrogen. The ratio of CO to hydrogen in GMCs is understood to be a constant and so the amount of detected CO molecule can tell us how much hydrogen is present in a given cloud. It's this CO signal that ALMA hunts for.



This image shows the distribution of cold (CO) vs hot (H-alpha) gas distributed through several galaxies (the colours

are counterintuitive in this diagram). The cold CO gas signatures are mapped by ALMA while the glowing hot H-alpha is mapped by the VLT. The combined map shows where newly forming stars are being born within the cold GMCs. c PHANGS-ALMA

Once hydrogen is excited by the energies of newly forming and young stars, it releases a light known as Hydrogen Alpha. H-alpha is the brightest feature in the spectrum of glowing hydrogen and is how we observe much of the Universe. Combining the hot and cold maps of these GMCs in other galaxies reveals the environment in which stars are forming. An instrument called MUSE on the Very Large Telescope maps the glowing H-Alpha where ALMA detects the cold CO emissions. The finest details resolved by ALMA in the target galaxies are approximately 100 parsecs in diameter (about 326 light years). The researches note this is "cloud-scale" resolution as the target GMCs are also about 100 parsecs in diameter. At this resolution, the clouds can be distinguished as individual structures separate from the structures of the rest of their home galaxies.

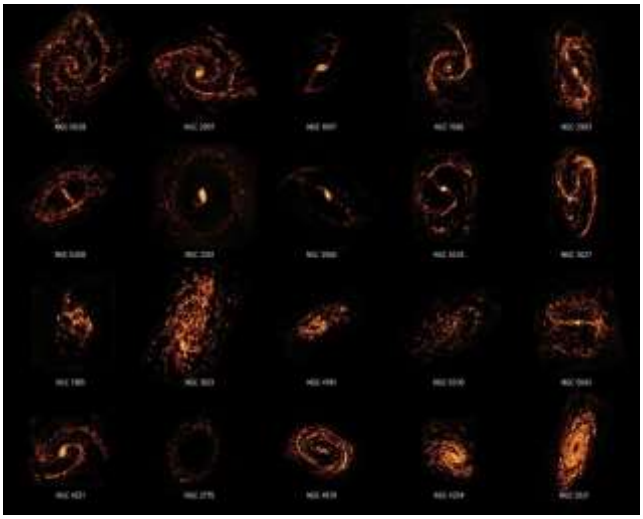


ESO's Very Large Telescope (VLT), shows the nearby galaxy NGC 4303, a spiral galaxy, with a bar of stars and gas at its centre, located approximately 55 million light-years from Earth in the constellation Virgo. The golden glows mainly correspond to clouds of hot hydrogen, marking the presence of newly born stars, while the bluish regions in the background reveal the distribution of slightly older stars.
c. PHANGS/ESO – Original Image

A Map of the Next Generation

While VLT images in optical light, ALMA sees distant galaxies in infrared and radio wavelengths. These wavelengths are helpful for peering at structures that wouldn't be visible in optical wavelengths like cold gas. But there is a disadvantage. Optical wavelengths can typically provide finer resolution for imaging creating a tradeoff between visibility and resolution. The impressive accomplishment of this initiative is that these new ALMA images achieved resolution in infrared and radio that near optical resolutions. The images are further enhanced by adding the optical resolutions of VLT as well as data from the Hubble Space Telescope in other images.

NGC 4254 ALMA (orange/red) data of cold GMC clouds imposed onto Hubble Space Telescope data,
Credit: ALMA (ESO/NAOJ/NRAO)/PHANGS, S. Dagnello (NRAO) original image



Mosaic of ALMA stellar nursery detection combined with Hubble Space Telescope data. The images show the diversity of GMC star forming clouds from across the nearby universe. c. ALMA (ESO/NAOJ?NRAO)/PHANGS, S. Dangnello (NRAO)

The amount of detail is mind blowing. These aren't singular photos taken of each galaxy but rather mosaics. For comparison, the Trottier Observatory where I work could image Andromeda, a much closer galaxy at 2.4 million light years, in a six photo mosaic. Each galaxy imaged in the PHANGS-ALMA project, despite being tens of millions light years away, are mosaics comprised of up to two HUNDRED individuals images. The process of imaging all 90 galaxies at that level of detail spanned a total of 6 years resulting in an new atlas of stellar nurseries – the next generation of stars being born in the Universe.

How do Stars Form? – Video by Fraser Cain

100,000 stellar nurseries were imaged between the 90 target galaxies. Findings show that location in a galaxy can change the nature of star formation. Clouds in central regions of the galaxy are more massive, denser, and turbulent than those that lie in the far reaches of the galaxy's disk. The rate at which the clouds form stars, and the resulting final dissipa-

tion of the cloud by those new stars blowing the gas away, all seem to vary depending on where the cloud resides in its home galaxy.

Atacama Large Millimeter/submillimeter Array (ALMA) with a dramatic meteor overhead.
c. ESO/C. Malin

A Shared View

The facilities needed to capture these images are powerful, and quite picturesque themselves. Rather than one large telescope, ALMA is an array of 66 dishes spread across the Chajnantor Plateau of the Atacama Desert, Chile. Signals collected by the array are combined effectively creating one giant dish. The individual dishes can also be rearranged depending on the needs of a given project. The Very Large Telescope, also located in the Atacama, is comprised of four telescopes, two with 8.2m mirrors and two smaller 1.8m mirrors. Like ALMA, the telescopes work in concert effectively creating one larger telescope.

Telescope “Yepun”, one of 4 of the VLT telescopes seen here firing an adaptive optics laser into the sky which compensates for distortion of the atmosphere creating a sharper image. c. ESO/Y. Beletsky

Although these are the most detailed images of their kind, the resolution achieved by PHANGS-ALMA is still just barely at the threshold needed to image individual GMCs in the targets galaxies. However, now that the these star forming regions have been mapped, future telescopes such as the soon-to-be-launched James Webb Space Telescope and the Extremely Large Telescope (the next after will be *Ultra* Large I’m guessing) will be able to revisit these GMCs with enough resolution to peer *inside* the clouds themselves providing even more insights into star formation.

Cosmic Origins

We were once part of a giant molecular cloud you and I. Everything comprising your body, the computer you’re reading this on, and the planet we inhabit all began from an enormous cloud of stardust. The future of telescopic space exploration is so enticing. James Webb will not only have the capability to study star formation in nearby galaxies, but image some of the first stars ever born in the Universe. The ELT’s primary mirror will be 39 meters in diameter! Its enclosing dome the size of a football field. We’re on the precipice of views of the Universe unlike we’ve ever seen before and ultimately new understandings of our own origins in the cosmos.

Feature Image: Image of Galaxy NGC 3627 located in the constellation LEO. The golden gas glow corresponds to clouds of ionized hydrogen, while the bluish regions reveal the distribution of slightly older stars. Credit: ESO/PHANGS

It’s Time to Send a Lander to Mercury

So much in the astronomy community revolves around the decadal survey. Teams of dozens of scientists put hundreds of hours developing proposals that eventually try to impact the recommendations of the survey panel that influence billions of dollars in research funding over the following decade. And right now is the prime time to get those proposals in. One of the most ambitious is sponsored by a team led by researchers at John Hopkins University Applied Physics Laboratory (APL). Their suggestion – it’s time to land on Mercury.

This isn’t the first time the idea has been aired, but new technologies make this incarnation feasible for the next decade. The current proposal was first floated by APL scientists to NASA, which funded a mission concept study that produced an in-depth 82-page review of a mission outline that is available from NASA.

Detailed discussion of the mission concept by Dr. Ernst
Credit – Lunar and Planetary Institute YouTube Channel

There are five main mission objectives:

1. Land safely and collect data on Mercury’s surface

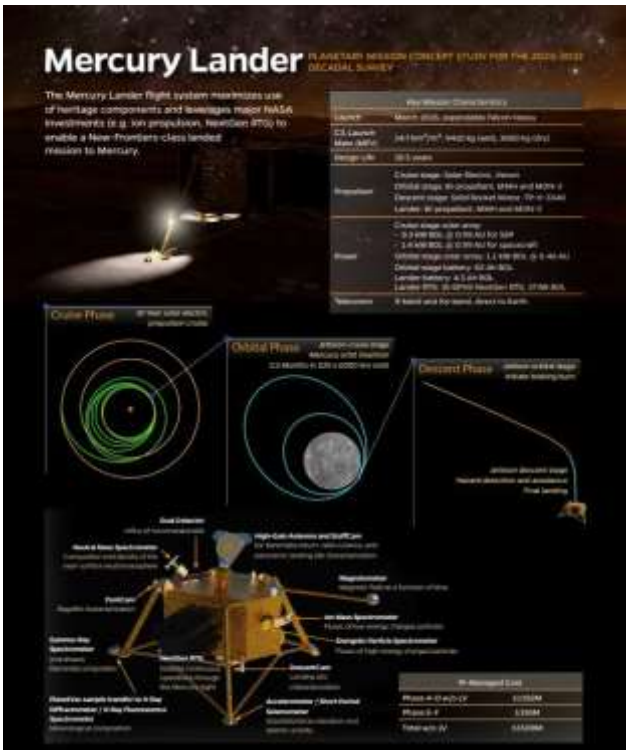
2. Discover more about Mercury’s mineralogy and chemistry

3. Study the planet’s magnetic field and interior structure

4. Understand what processes are affecting Mercury’s regolith and exosphere

5. Look at the surface up close to provide ground truth to help calibrate object size in orbital measurements

Any lander will face a daunting challenge in landing. Currently, the best images we have of the innermost planet were captured by NASA’s MESSENGER spacecraft, which orbited Mercury from 2011–2015. But these images cover only minimal parts of the surface, and their resolution is not ideal for selecting a specific landing site. Each pixel in the highest-resolution images MESSENGER returned covered at best 2–3 m of the planet’s surface at best.

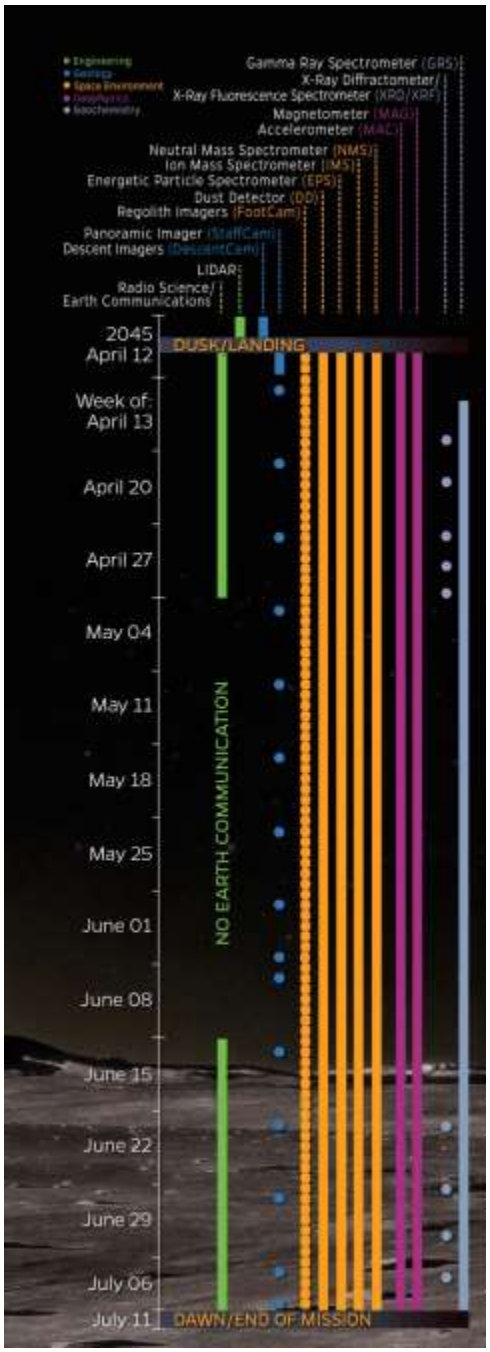


Graphic on the lander included in the report that shows potential scientific payloads, engineering requirements and orbital mechanics.
Credit – Ernst et al.

That resolution is not good enough when a 3-meter boulder could completely topple the lander on its descent. BepiColombo, an ESA/JAXA mission currently on its way to Mercury, should be able to capture some higher resolution images that could aid in landing. However, the process will still most likely be reliant on an autonomous landing protocol.

Assuming the lander does touch down, it will have to get to work quickly. The mission would only be designed to last during Mercury's night, which is 88 Earth days long. Trying to design a lander to withstand the sun's full force during Mercury's daytime would require too much of the instruments the lander hopes to carry. In its current iteration, the mission would plan to touch down during the planet's dusk and then operate continuously for about three months before dawn brings the mission to a close.

The techniques needed to achieve the mission's science goals are similar to those already used on other planets. Many of the technologies, such as magnetometers and spectrometers, can be repurposed from designs used on other missions. This would lower the mission's overall cost, which wouldn't have to do the development work for its scientific instrumentation from scratch.



Timeline of mission objectives with the 88 Earth-day time limit.
Credit – Ernst et al.

A lot of science can get done in those months, though. During dusk, the lander will take some panoramic shots of its surroundings to provide some context to the smallest rocky planet for the first time. It will also be equipped with lights that will allow it to illuminate its nearby surroundings even in the pitch black of Mercury's night.

That light and all the instruments on board will be powered by a radioisotope thermal generator, a common power supply for space-faring landers and rovers. Its adoption showcases another important aspect of the lander's mission design – it will leverage technologies that have already been developed.

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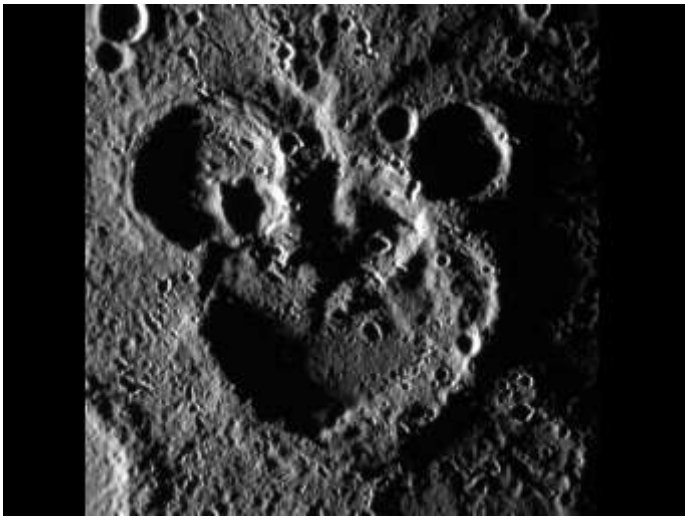
which wouldn't have to do the development work for its scientific instrumentation from scratch.

That scientific instrumentation would still be quite impressive. The suggested suite of instruments includes several spectrometers, cameras, and magnetic sensors, all of which should be able to operate through Mercury's night. But the mission designers stress that the exact payload is still flexible, with the expectation that any future mission planning will adapt other technologies for use as necessary.



Move over, Pluto… Disney already has dibs on Mercury as seen in this MESSENGER photo.
Image credit: NASA/JHAPL/Carnegie institution of Washington

Dr. Carolyn Ernst, the PI of the mission concept, is excited about what those proven instruments will discover. "Mercury is the only rocky planet we haven't landed on – we've never seen the surface up close. We need landed measurements to better understand Mercury and to put our own Earth into context," she says.

But comparing Mercury to Earth isn't the only reason to go. Dr. Nancy Chabot, the deputy PI of the mission concept, points out that the data collected about Mercury so far are both limited and difficult to interpret. To put it in her words, "It's exciting to fill in this black box," where the "black box" refers to a figure in the report that shows an image from the surface of each of the rocky worlds in the inner solar system, but Mercury is shown just as a black box as there is no such view – yet.

Cosmonauts Find Cracks in the Aging Zarya ISS Module

It appears that the International Space Station is showing its age. Or, at least, the older modules that have been in space since 1998 certainly are. According to statements made by a senior Russian space official, cosmonauts aboard the ISS have discovered new cracks in the Functional Cargo Block (FCB) module – aka. Zarya ("Dawn"). These cracks were found in seven of the module's twenty windows and could eventually threaten the entire station.

The Zarya module was the first component launched for the International Space Station. While funding was provided through a NASA subcontract with Boeing and the module is part of the US section, the module itself was built by the Khrunichev State Research and Production Space Center (KhSC) in Russia (a subsidiary of Energia Rocket and Space Corporation) and Roscosmos was responsible for launching it in 1998.

Zarya was also responsible for providing electrical power, storage, propulsion, and guidance to the ISS during the initial stage of assembly. Alas, after twenty-three years in space (and twenty-one in continuous operation), the module is beginning to suffer from its share of structural problems. And in space, the worst structural problem imaginable is to find cracks forming in the fuselage.

The Russian Zarya cargo module in Earth's orbit before being integrated into the ISS. Credit: NASA

News of the issue came from Vladimir Soloviev, general designer of Energia RSC – which designed and built all of the modules in the Russian segment. As Soloviev told the Russian news agency RIA Novosti:

"Superficial fissures have been found in some places on the Zarya module. This is bad and suggests that the fissures will begin to spread over time… In this regard, we have introduced a new procedure for measuring the deflection of glass. They, of course, can be covered with sealed covers, but what is the point of flying at the station without windows?"

Soloviev did not say whether or not the cracks posed any decompression danger, but he did say previously that much of the ISS' equipment is aging and in danger of experiencing an "avalanche" of failures beyond 2025. As of December 2018, the ISS' operation authorization was extended to 2030, and its funding was secured until the end of 2025. However, the recent string of technical problems is leading some to conclude that the ISS may not last that long.

In September of 2019, the crew of Expedition 63 recorded a drop in internal pressure and spent the next year trying to locate the source. The leak was eventually traced to the intermediate chamber of the Russian Zvezda module, which was repaired by March 2020. While this leak did not threaten the station or crew, another leak was identified later that was staunched – but not repaired entirely.

Image of the ISS in Earth orbit. Credit: NASA

Back in January, Soloviev reported that the leak is causing a pressure drop of 0.4 millimeters of mercury per day. In terms of barometric pressure, 760 mm is the equivalent of the atmospheric pressure here on Earth at sea level – or 101,325 pascals (Pa). That works out to a pressure loss of 0.005 pascals (0.0005%) a day, which requires that the station be pressurized with reserves, which are available on both the ISS and are transported from Earth.

Last month, the ISS also suffered a software glitch that caused the thrusters on the Nauka module to inadvertently reignite a few hours after it had docked. This was responsible for temporarily pushing the ISS out of position, which forced a delay of the Orbital Flight Test-2 (OFT-2) mission. Last month, Roscosmos also reported another drop in air pressure in the Zvezda service module.

Roscosmos has committed to remaining a partner in the ISS program until 2024 and has indicated that they may be open to extending their participation beyond that. However, Russia has also expressed interest in building its own orbital space station to replace the ISS, beginning in 2025. Last year, Russia declared they would not be signing the Artemis Accords, which would commit them to participate in NASA's Artemis Program.

According to statements issued at the time, Russia's refusal was based on the that the Accords were "too US-centric" and political in nature while also straying from the spirit of cooperation embodied by the ISS program. Russia has since announced a new partnership with China to create an International Lunar Research Station (ILRS), which was followed by the release of a roadmap and timeline for development – the "International Lunar Research Station (ILRS) Guide for Partnership."

It is a sad thing to acknowledge, but the ISS' days are numbered. That certainly seems to be the consensus among NASA, Roscosmos, and the thirteen other member nations that have participated in the ISS since its inception. But in the twenty-one years that it has been in continuous operation, the station has allowed for all kinds of scientific research, experiments, and breakthroughs.

As the only dedicated microgravity research environment, the ISS has allowed for experiments in fields ranging from astronomy and astrobiology to materials science, space weather, and medicine. In addition to space agencies, commercial entities, research institutes, and universities have managed to benefit from its continuous operation. Above all, the station has consistently served as a means for fostering cooperation between nations and space programs.

Knowing that the ISS is not long for this world (so to speak) and is likely to be replaced by multiple space stations owned and operated by competing power blocs is certainly disheartening. But hopefully, before the ISS has reached the end of its service and is deorbited, those who helped make it a reality will find a way to keep the spirit of cooperation it embodied alive.

Thanks to Ingenuity's Pictures, Perseverance Knows Where to Drive to Next

The Perseverance rover now has a new tool to help scientists and engineers figure out where the rover goes next. The new tool is the little rotorcraft that was tucked away in the rover's belly, the Ingenuity helicopter. Ingenuity has now started doing aerial surveys to scout ahead for Perseverance.

During its most recent flight, Ingenuity captured 10 color images ahead of the region where Perseverance is traversing, to help the team figure out whether the rover should remain in its current location and do more scientific investigations or drive to investigate potentially interesting rocks in the nearby "South Seítah" area.

"From a science perspective, these images of South Seítah are the most valuable Ingenuity has taken to date," said Ken Farley, project scientist for NASA's Perseverance rover. "And part of their value may be in what they are not showing. Sedimentary layers in rocks are not readily apparent in the image, and there may be areas that could be difficult to negotiate with the rover. There is work to do by our science and rover driving teams to understand better how to respond to the new data."

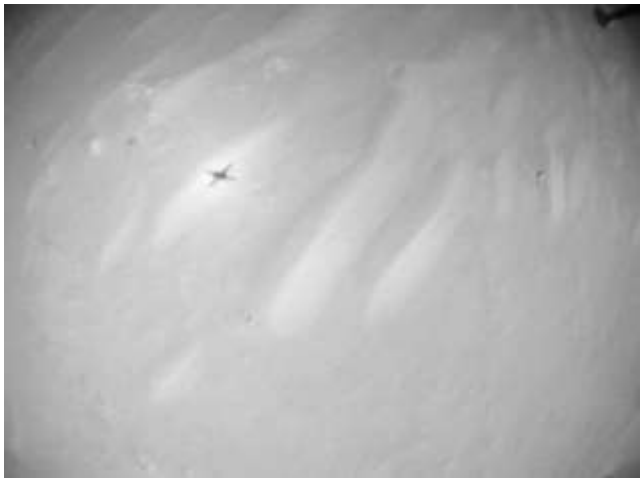


Image from Ingenuity's 12th flight on Mars. Credit: NASA/ JPL.

Ingenuity took the images from an altitude of 33 feet (10 meters). The team said the flight – the helicopter's 12th so far — was one of the most complicated the helicopter team has executed. It was also the longest-duration flight to date (169.5 seconds) with multiple waypoints as it flew from relatively non-descript terrain outside South Seítah into much more varied terrain inside, and then back out again.

Perseverance itself has taken over 125,000 images in the six months since it landed on Mars. The images are incredible, and not only are they stunning pictures from another world, they also allow scientists to make observations of the rocks and Martian regolith. And the images are also important from an engineering perspective, in that they help the "rover drivers" determine the best path forward, based on what they see in the images.

Additionally, the Perseverance team has the power of the Mars Reconnaissance Orbiter at its disposal. MRO carries the most powerful camera ever sent to the Red Planet, and its images can reveal details as small as 1 meter (3 feet) across and create precise 3D maps of the surface. Combined with a complementary camera that provides a wider context of the surface, MRO examines the surface at great detail to identify geologic processes that might be interesting for the rover to examine more closely.

This annotated image depicts the ground track (indicated in white) of NASA's Perseverance rover since it arrived on Mars on Feb. 18, 2021. Perseverance made its first sample-acquisition attempt in the "Crater Floor Fractured Rough" area (labeled "CF-Fr"), right of center in the lower third of image. The "Citadelle" is located in the lower third of graphic, just left of center. The graphic was generated using terrain imaged by the HiRISE camera aboard NASA's Mars Recon-

naissance Orbiter. Credit: NASA/JPL-Caltech/University of Arizona

Prior to Ingenuity's latest flight, the majority of what the Perseverance science team knew of the southern portion of the Seítah feature came from MRO. The team said that based on that data, they believed the site could possibly be a treasure trove of complex geology, providing information that could play a valuable role as the rover team searches for signs of ancient microbial life and attempts to characterize the geology of the area and to understand the area's history.

But Ingenuity has now provided additional data that shows signs of layered, sedimentary rock that could have been deposited in water, intriguing rocky outcrops accessible to the rover, and safe routes the rover could take into and back out of the area.

"What this image may be saying is, we don't need to drive further west to obtain the best geologic variety of this first science campaign," said Farley. "If we decide to make the trip to South Seítah, we've got some valuable intel on what we'll encounter. And if the decision is to stick around 'Artuby Ridge,' the rover's current location, we'll have saved valuable time. It's a win-win."

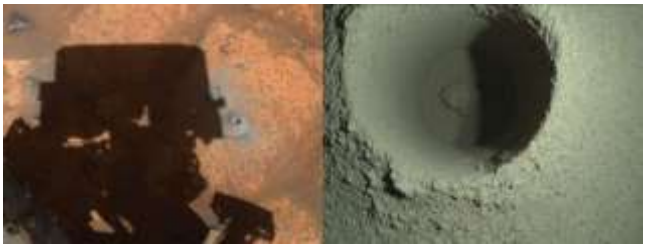
We'll provide more updates on Ingenuity's next flights, and where Perseverance goes next.

After Its Last Rock Sample Crumbled Into Powder, Perseverance is Going to try Again

In the last two decades, we have all grown accustomed to rovers exploring Mars. At least one rover has been active on the planet every day since January 4, 2004, when NASA's Spirit rover landed in Gusev crater. Opportunity (2004) and Curiosity (2012) followed, each making unique journeys of discovery of their own. Perseverance (2021) is the latest and greatest of these robotic explorers, boasting a state-of-the-art in-situ resource utilization experiment to extract oxygen from the atmosphere, an accompanying helicopter to scout the path ahead, and a suite of unparalleled geology instruments. But what really sets Perseverance's mission apart is that, for the first time, it is collecting samples of Martian rock to bring back to Earth.

As advanced as Perseverance's science instruments are, nothing beats the ability to study samples up close in a laboratory here on Earth. So Perseverance is making a rock collection. It is taking samples as its journeys across Jezero Crater, and leaving caches of the samples for a future mission to pick up and return to Earth (sometime in the mid-2020s).

At least, that's the plan. But space exploration is never simple. As routine as rover activity on Mars has become in recent years, the red planet never ceases to surprise mission planners. Earlier this month, Perseverance made its first attempt at collecting a sample in one of its 43 titanium sampling tubes. After drilling the sample core, the team was shocked to discover that the sample tube remained empty, and was nowhere to be found on the ground around the rover, nor in the drill hole.



The empty core hole after an attempted sampling on August 6, 2021. Credits: NASA/JPL-Caltech/MSSS

It turns out the rock into which Perseverance had drill was far softer than previously imagined, and the rock merely crumbled into powder beneath the drill. Thomas Zurbuchen, associate administrator of NASA's Science Mission Directorate told reporters "While this is not the 'hole-in-one' we hoped for, there is always risk with breaking new ground…I'm confident we have the right team working this, and we will persevere toward a solution to ensure future success."

This week, that team is ready for a second attempt. Perseverance has positioned itself next to a new rock outcrop, nicknamed "Rochette." Rochette is about 455 meters from the first sample site, at the top of a ridge named Citadelle. This outcrop has survived millennia of wind erosion, suggesting that it should withstand Perseverance's drill more easily.

The rock at the centre of this image, nicknamed Rochette, is Perseverance's next sampling target. Credit: NASA/JPL-Caltech.

"There are potentially older rocks in the 'South Séítah' region ahead of us, so having this younger sample can help us reconstruct the whole timeline of Jezero," said Vivian Sun, a mission's scientist at NASA's Jet Propulsion Laboratory.

The team is also making some changes to their sampling procedure this time around. Before attempting to take a sample of Rochette, Perseverance will use its robotic arm to 'abrade' the surface of the rock, and examine how it reacts. Then, during the sampling process, the rover's Mastcam-Z camera will look inside the canister to make sure it is full before sealing it shut.

As for the 'empty' canister from the first sample attempt – Perseverance is going to hold onto it too for return to Earth – its has no rocks in it, but it does have a sample of the Martian atmosphere, which might be equally interesting to study.

This isn't the first time Martian rock and soil has caused trouble for NASA's robotic missions. Curiosity had to operate for a long time with a broken drill. The Phoenix lander found Martian soil "sticky" and challenging to work with back in 2008, and more recently, the InSight lander's "mole," which was supposed to drill two meters below ground to study the planet's interior, was unable to dig more than a few dozen centimeters because the soil didn't provide the expected friction.

A closeup of Rochette. Credit: NASA/JPL-Caltech.

These challenges are a frequent reminder that Mars truly is an entirely different planet, and the geology does not always act as we Earthlings expect. But with a little luck and some careful planning, Perseverance has a good chance at succeeding in taking a sample this week. In doing so, it will make the dream of a Mars sample return mission one step closer to reality.

Learn More: https://www.jpl.nasa.gov/news/nasas-perseverance-plans-next-sample-attempt

Interstellar Objects Might Outnumber Solar System Objects in the Oort Cloud

Our solar system is filled with everything from planets to rocky asteroids to small icy bodies beyond Pluto, but surrounding all of it is a diffuse halo of objects known as the Oort cloud. We haven't directly observed the Oort cloud, but we're pretty sure it's there by observing the distribution of comet in our solar system. They can appear from any direction in the sky rather than just along the common plane of known solar system bodies.

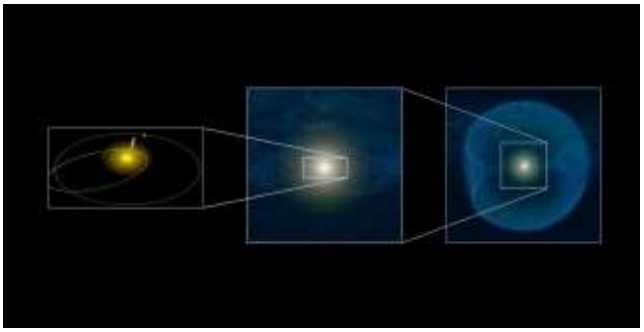
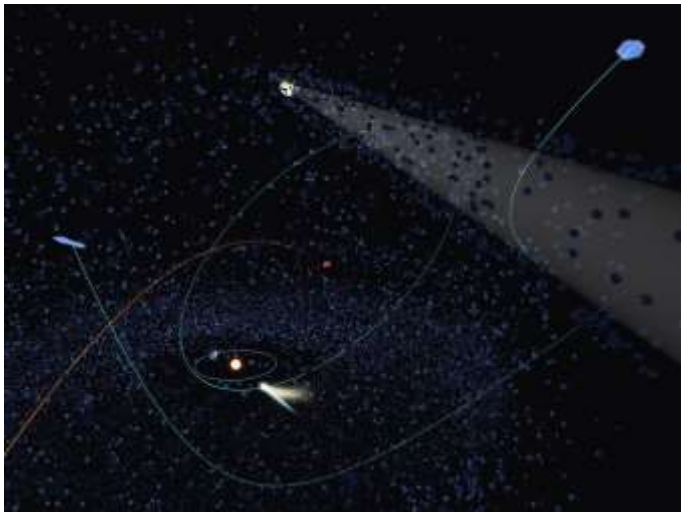


Illustration of the Oort cloud for our solar system. Credit: ESA/AOES Medialab

Our best understanding is that the Oort cloud surrounds our solar system in a thick sphere about 1 – 2 light-years in radius. Based on computer simulations, it likely formed from debris in the early solar system that was thrown out there as the planets jockeyed into their current positions. But a new study argues that much of the Oort cloud might be interstellar in origin.

We've long known that extra-solar objects likely visit our solar system. Asteroids and comets can be thrown out of our solar system by close encounters with planets such as Jupiter, and so the same must be true of other planetary systems. It is only a matter of time before something drifts our way. But it wasn't until 2017 that an object was confirmed to be of extra-solar origin. Oumuamua was the first alien object to reach our cosmic shores, but it wasn't the last. In 2019 Borisov was also confirmed to be extra-solar.

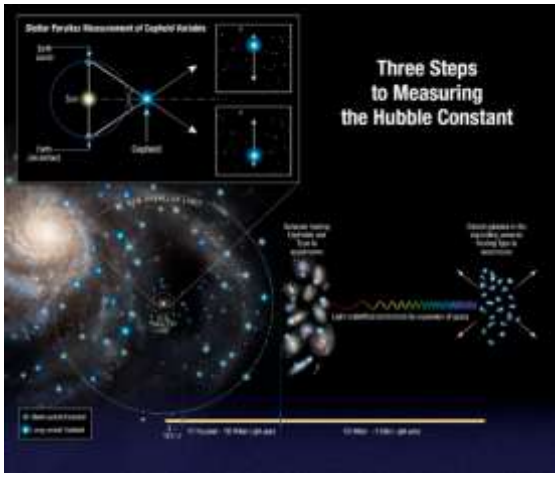


Typical paths of long-term orbit comets. Credit: NAOJ

After two interstellar objects were confirmed so quickly, astronomers began to wonder just how common these interstellar objects are. Some initial studies looking at the long-term orbits of outer solar system bodies suggests that they are quite common. If that's the case, many of the bodies on the edge of our solar system may have originated in other star systems.

This latest study makes a statistical argument based on observations of Borisov. The authors argue that the detection of Borisov supports the idea that more than half of the Oort cloud is made of extra-solar bodies. It's an idea that could be tested by looking for occultations of Oort cloud bodies with distant stars. The upcoming Vera Rubin observatory would be perfect for this kind of thing.

While the idea is interesting, you shouldn't put too much confidence in their estimate. Even the authors admit that the uncertainties of their calculations are very large. But studies such as this and others continue to support the idea that star systems are not as isolated as we once thought, and thus there are plenty of alien objects among us.



BY PAUL M. SUTTER

Astronomy Jargon 101: Standard Candles

In this series we are exploring the weird and wonderful world of astronomy jargon! If only there was a way to measure the distance to today's topic: standard candles!

Measuring distances to stuff in space is really, really hard. One technique is to use parallax, the observed wiggle in stellar positions over the course of a year. That technique is fantastic as long as the star isn't too far away. At a certain distance, your telescope simply won't be able to accurately measure the wiggle, and you'll be out of luck.

The key is to find something called a *standard candle*. If you could look out at a distant object and know for sure exactly how bright it is (in other words, you could know its luminosity), then you could compare that measurement to how bright it *appears* to be. Using a little bit of trigonometry, you could then calculate a distance.

As an example, if you knew for sure that the brand of flashlight that I had was the exact same as the flashlight that you had, then if I was far away you could measure the brightness of my flashlight versus the brightness of your flashlight and figure out my distance.

Now all we need are some flashlights.

Thankfully, nature has given us a few. The first known were the Cepheids, a kind of star that varies in brightness. Astronomer Henrietta Swan Leavitt discovered that the longer a Cepheid takes to cycle, the brighter it is. By calibrating a few Cepheids using parallax, you can then go out and find any Cepheid you want and figure out how far away it is.

In 1998, two teams of astronomers discovered dark energy – the unexplained accelerated expansion of the universe – by looking at another standard candle: Type-1a supernovae. These kinds of supernovae all go off in roughly the same way, and so it's possible to compute their true brightness.

Today, astronomers employ a variety of standard candles, from Mira variables to red giant branch stars. But no matter the method, the underlying technique is the same: know the brightness, know the distance.

The Milky Way Broke one of its Arms

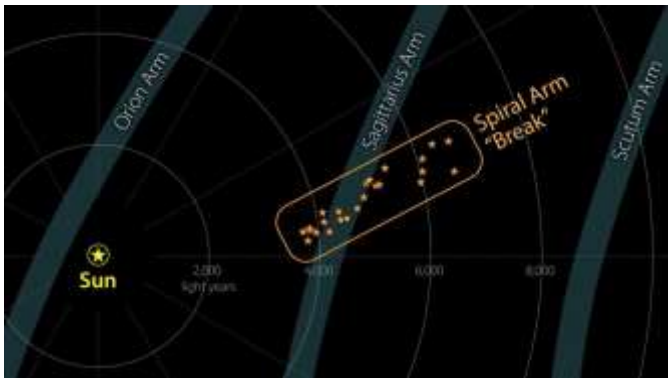
The Milky Way galaxy is our home, and yet in some ways, it is the least understood galaxy. One of the biggest challenges astronomers have is in understanding its large-scale structure. Because we're in the midst of it all, mapping our galaxy is a bit like trying to map the size and shape of a wooded park while standing in the middle of it.

One of the ways astronomers can map our galaxy is to measure the position and distance of thousands upon thousands of stars. This is one of the main goals of the Gaia mission, which studies the location and motion of more than a billion stars. Gaia has already revealed details in the structure of the Milky Way, such as a wave pattern among some stars.

The Eagle, Omega, Triffid, and Lagoon Nebulae, imaged by NASA's infrared Spitzer Space Telescope. Credit: NASA/JPL-Caltech

Another method is to look at specific objects in our galaxy, such as star-forming nebulae. Star-forming nebulae tend to be located within the spiral arms of a galaxy, where there is the most gas and dust. The Spitzer infrared space telescope has measured the distances to young stars within many nebulae, which helped us confirm that the Milky Way has four main spiral arms.

A new study combines data from Gaia and Spitzer, comparing the location of some nebulae with the overall spiral distribution of stars.[^1] The study focused on a main spiral arm within the galaxy known as the Sagittarius Arm. It is the spiral arm just inward from the Sun's arm of Orion. The team hoped to measure an aspect of the spiral arm known as the pitch angle. It tells you how tightly wound a spiral arm is. The larger the pitch angle, the more open the spiral arms are. In the case of the Sagittarius Arm, the pitch angle is about 12 degrees. But pitch the angle of some nebulae are very different.



Astronomers found a break in our galaxy's Sagittarius Arm. Credit: NASA/JPL-Caltech

The team looked at four prominent nebulae in our night sky: the Eagle Nebula (which contains the Pillars of Creation), the Omega Nebula, the Trifid Nebula, and the Lagoon Nebula. These four nebulae are in the same general region and were used in the 1950s to confirm the existence of the Sagittarius Arm. This new study pinned down the location of these nebulae and other stars and found the region has a pitch angle of 60 degrees.

This doesn't mean our original measure of the Sagittarius Arm is wrong, but it does point to a type of structure known as galactic spurs. Some spiral galaxies have very smooth spiral arms, where gas, dust, and star-forming regions are all along the same curve. Other spiral galaxies have more broken spiral arms, with small feathery offshoots called spurs. We don't know for sure which type of galaxy the Milky Way is, but this new study points to it being the latter.

Reference: Kuhn, M. A., et al. "A high pitch angle structure in the Sagittarius Arm." *Astronomy & Astrophysics* 651 (2021): L10.

Astronomy Jargon 101: Hertzsprung–Russell (HR) diagram

In this series we are exploring the weird and wonderful world of astronomy jargon! You'll soon have a better way to categorize today's topic: the Hertzsprung–Russell diagram!

In the early 1900's astronomy was in a bit of a mess (NB it's still in a mess, but a completely different one). Astronomers had figured out the trick of spectroscopy, and were beginning some seriously large-scale surveys of our galactic neighbourhood.

Those astronomers surveyed all sorts of amazing stars. Giant red ones. Giant blue ones. Small red ones. Medium white ones. The stars they saw had different colors, different temperatures, different specta, and different sizes.

And none of it made any sense.

Why were some stars red and big, while others were blue and big? And what about the small red ones? There needed to be some sort of classification system; some way to organize this giant flood of information. Astronomers had proposed various ideas, like the suggestion that stars start out big and hot and shrink as they age, but that didn't fit all the data.

Around 1910, the astronomers Ejnar Hertzsprung and Henry Norris Russell, working independently, both came up with the

same solution. They found that if they arranged stars according to their temperature and their luminosity, a remarkable pattern popped out.

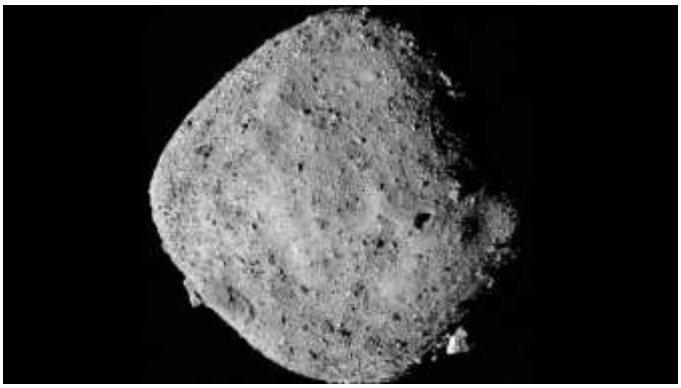
This Hertzsprung-Russell diagram (more commonly called the “HR” diagram) showed that stars didn’t have just any combination of luminosity and temperature. Instead, stars tended to cluster along a narrow band, which came to be called the Main Sequence. Bluer stars tended to be brighter stars. Redder stars tended to be dimmer. And white stars tended to be in the middle.

In addition to the Main Sequence, there was a small clump of dim, white/blue stars (the white dwarfs), and bright, red stars (the red giants). And that…was it.

The Hertzsprung-Russell diagram may not seem like a big deal, but it was a total revolution in our understanding of stellar life cycles. It made sense of all the data. It crafted order out of the chaos. It showed that stars in our universe weren’t just random – there was a central organizing principle to the observable properties of stars.

If you wanted to develop a theory of stellar evolution, then you had to confront the Hertzsprung-Russell diagram. Your model of how stars worked had to explain it. Without the Hertzsprung-Russell diagram, we wouldn’t have known about this relationship between luminosity and temperature, and we would have had to work a lot harder to pin down the physics of stars.

OSIRIS-Rex got to Know Bennu Really Well. Apparently, There’s now a 1-in-1,750 Chance That it’ll hit Earth by 2300



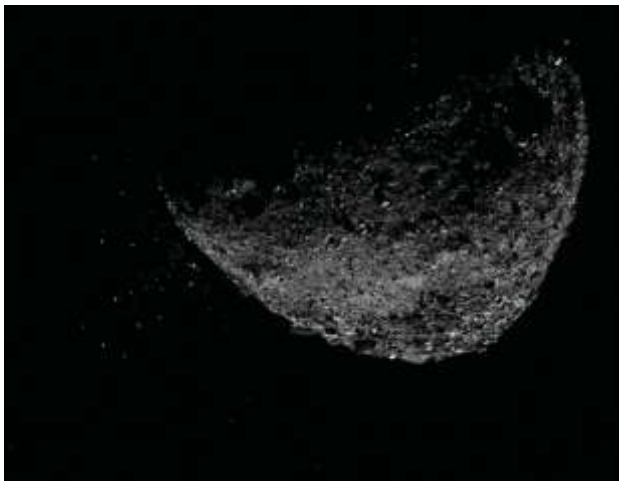
Asteroid Bennu is one of the two most hazardous known asteroids in our Solar System. Luckily, the OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer) spacecraft orbited Bennu for more than two years and gathered data that has allowed scientists to better understand the asteroid’s future orbit, trajectory and Earth-impact probability, and even rule out some future impact possibilities.

In the most precise calculations of an asteroid’s trajectory ever made, researchers determined Bennu’s total impact probability through the year 2300 is really small — about 1 in 1,750 (or 0.057%). The team’s paper says the asteroid will make a close approach to Earth in 2135, where Bennu will pose no danger at that time. But Earth’s gravity will alter the asteroid’s path, and the team identifies Sept. 24, 2182 as the most significant single date in terms of a potential impact, with an impact probability of 1 in 2,700 (or about 0.037%).

“The impact probability went up just a little bit, but it’s not a significant change,” said Davide Farnocchia, lead author of the paper, and scientist at the Center for Near Earth Object Studies at NASA’s Jet Propulsion Laboratory, speaking at a press briefing this week. Farnocchia added that means there is a 99.94% probability that Bennu is not on an impact trajectory.

“So, there is no particular reason for concern,” he said. “We have time to keep tracking the asteroid and eventually come to a final answer.”

101955 Bennu was discovered in 1999 by the Lincoln Near-Earth Asteroid Research Team. Since its discovery, Bennu has been extensively tracked with 580 ground-based optical astrometric observations. The asteroid made three relatively close passes of Earth in 1999, 2005, and 2011, during which the Arecibo and Goldstone radar stations collected a wealth of data about Bennu’s motion.



OSIRIS-REx discovered particles being ejected from asteroid Bennu shortly after arriving at the asteroid. Image Credit: NASA/Goddard/University of Arizona/Lockheed Martin

But OSIRIS-REx’s two-year reconnaissance and sample collection has provided crucial data about the 500-meter-wide asteroid, including some surprises. Scientists expected Bennu’s surface to be smooth and sandy, but the first images from OSIRIS-REx revealed a rugged boulder-field, littered with large rocks and loose gravel. The team also expected the asteroid to be geologically quiet, but just six days after arriving in orbit, the spacecraft observed the asteroid ejecting bits of rock, due to rocks on the asteroid cracking because of the day-night heat cycle. We also learned that Bennu has pieces of Vesta on it. The spacecraft also scooped up a sample of rock and dust from the asteroid’s surface in October of 2020, which it will deliver to Earth on Sept. 24, 2023, for further scientific investigation.

But OSIRIS-REx’s precise observations of Bennu’s motions and trajectory allowed for the best estimate yet of the asteroid’s future path.

“The OSIRIS-REx mission has provided exquisitely precise data on Bennu’s position and motion through space to a level never captured before on any asteroid,” said Lindley Johnson, planetary defense officer at NASA’s Planetary Defense Coordination Office at NASA.

The researchers took into account all kinds of small influences, including the tiny gravitational pull of more than 300 other asteroids, and the drag caused by interplanetary dust. They even checked to see if OSIRIS-REx pushed the asteroid off course when the spacecraft briefly touched its rocky surface with its Touch-And-Go (TAG) sample collection maneuver. But that event had a negligible effect, as expected.

The researchers especially focused on a phenomenon called the Yarkovsky effect, where an object in space would, over long periods of time, be noticeably nudged in its orbit by the slight push created when it absorbs sunlight and then re-emits that energy as heat. Over short timeframes, this thrust is minuscule, but over long periods, the effect on the aster-

oid's position builds up and can play a significant role in changing an asteroid's path.

"The Yarkovsky effect will act on all asteroids of all sizes, and while it has been measured for a small fraction of the asteroid population from afar, OSIRIS-REx gave us the first opportunity to measure it in detail as Bennu travelled around the Sun," said Steve Chesley, senior research scientist at JPL and study co-investigator, in a press release. "The effect on Bennu is equivalent to the weight of three grapes constantly acting on the asteroid – tiny, yes, but significant when determining Bennu's future impact chances over the decades and centuries to come."

A diagram showing OSIRIS-REx's sampling manoeuvre on October 20th, 2020. Image Credit: NASA/GSFC/UA

They also were able to better determine how the asteroid's orbit will evolve over time and whether it will pass through a "gravitational keyhole" during its 2135 close approach with Earth. These keyholes are areas in space that would set Bennu on a path toward a future impact with Earth if the asteroid were to pass through them at certain times, due to the effect of Earth's gravitational pull.

The team wrote in their paper that "compared to the information available before the OSIRIS-REx mission, the knowledge of the circumstances of the scattering Earth encounter that will occur in 2135 improves by a factor of 20, thus allowing us to rule out many previously possible impact trajectories."

"The orbital data from this mission helped us better appreciate Bennu's impact chances over the next couple of centuries and our overall understanding of potentially hazardous asteroids – an incredible result," said Dante Lauretta, OSIRIS-REx principal investigator and professor at the University of Arizona. "The spacecraft is now returning home, carrying a precious sample from this fascinating ancient object that will help us better understand not only the history of the solar system but also the role of sunlight in altering Bennu's orbit since we will measure

Light Pollution is Making it Harder for Animals to Find Their Way at Night

Ah, the majestic dung beetle. The pinnacle of evolution. In all seriousness, these little critters are incredibly sophisticated navigators who have, for millennia, used the night sky to guide them about their business. But light pollution is making their lives more difficult by limiting their ability to navigate by the stars. Other nocturnal creatures, including some birds and moths, may be facing similar challenges.

Dung beetles are known for their penchant for rolling dung into balls, then pushing their prize away from competing beetles as quickly as possible. To swiftly escape the competition, they need to be able to travel in straight lines away from a dung pile, putting as much distance as they can between them and their rivals. The stars provide these rushing beetles with a compass, acting as directional cues in the sky with which the beetles are able to orient themselves. When they reach a safe distance, the beetles then bury the dung and proceed to consume it in relative safety.

James Foster and Marie Dacke performing orientation experiments at a dark-sky site in rural Limpopo. Image Credit: Chris Collingridge

Researchers at the University of Würzburg in Germany, Lund University in Sweden, and the University of the Witwatersrand in South Africa set out to examine how light pollution affects the beetles' ability to travel by starlight.

Their results, published in the journal *Current Biology*, show that the beetles become disoriented in different lighting conditions. For example, in the presence of bright city lights, the beetles have a tendency to travel directly towards the nearest, brightest light source. Instead of dispersing away from a dung pile, the beetles are all drawn in one direction. This makes conflict and competition more likely as individuals encounter each other more frequently.

Even more surprising, and perhaps more unsettling, is that diffuse light pollution, such as occurs on the outskirts of a city with no distinct light sources nearby, wreaked even more havoc on the beetles' senses. Here, researchers discovered, the scarabs were far less capable of travelling in straight lines, becoming disoriented and lost.

As lead author James Foster explains, "Beetles that viewed direct light pollution behaved unnaturally, but were still oriented. But those that viewed light-polluted skies but no brightly-lit buildings were completely disoriented." The implication is that beetles living on the outskirts of cities are the most adversely affected by light pollution. It also means, for other species, like some birds, that light pollution can limit their natural navigation abilities. Birds that would normally navigate by the stars instead fly directly toward bright artificial light sources.

We often think of light pollution as a human problem – it hinders astronomy and puts distance between us and our environment – but the impact of light pollution stretches across species. Animals and insects, just like humans, have evolved to live with the night sky and make use of its starlight. Taking that away has consequences, and its worth learning more about these effects – even if it means taking time to study the lowly dung beetle.

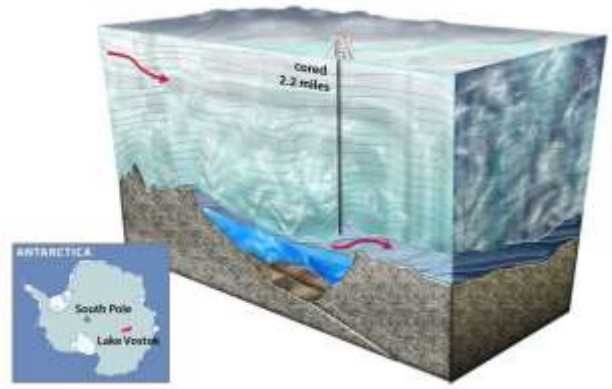
Learn More:

- Robert Emmerich, "Bright Lights, Bad Orientation." University of Würzburg.
- James J. Foster, Claudia Tocco, Jochen Smolka, Lana Khaldy, Emily Baird, Marcus J. Byrne, Dan-Eric Nilsson, Marie Dacke. "Light pollution forces a change in dung beetle orientation behaviour," *Current Biology*, 29 July 2021.

Bad News. Those Underground Lakes on Mars? They're Probably Just Frozen Clay

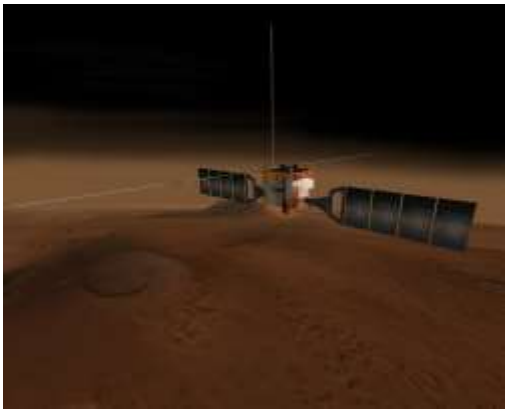
If you were planning an ice-fishing trip to the Martian south pole and its sub-surface lakes observed by radar in 2018, don't pack your parka or ice auger just yet. In a research letter published earlier this month in Geophysical Research Letters by I.B. Smith et al., it seems that the Martian lakes may be nothing more smectite, that is, a kind of clay. Should the findings of the paper, titled *A Solid Interpretation of Bright Radar Reflectors Under the Mars South Polar Ice* (a solid title if you ask me), turn out to be correct, it would be a significant setback for those hoping to find life on the red planet. So why were these supposed lakes so critical for the search for life on Mars? How were they discovered in the first place? Why have our dreams of Martian ice-fishing turned to dust (or, more correctly, clay)?

In 2018, the European Space Agency (ESA) announced that its Mars Express orbiter had discovered evidence of liquid water lakes below the surface of the Martian south pole. Understandably, the discovery bolstered hopes for finding extremophile organisms surviving in the icy water similar to bacteria surviving under 4 kilometers of ice in Antarctica's Lake Vostok.



Lake Vostok, roughly the size of Lake Ontario, is buried under several kilometers of ice in Antarctica yet has been found to support life. Credit: Nicolle Rager-Fuller / NSF

Like Mars, Antarctica had a warm and wet past. As geological and tectonic processes migrated the great continent to the south pole, it underwent extreme glaciation. Microbes adapted to the radical climate change and eventually gave rise to the ecosystem that thrives there today. While the glaciation of Antarctica was driven by the tectonic action of continental drift, the climate change on Mars was global and likely due to the loss of the atmosphere from erosion by the solar wind. It is not unreasonable to imagine microbes adapting to this extreme climate change and clinging stubbornly to life in subsurface lakes at the Martian poles.



Computer-generated image depicting ESA's Mars Express in orbit above the surface of Mars. The MARSIS instrument on Mars Express famously showed evidence of subsurface lakes in the southern polar region of Mars in 2018. Credit: NASA/ JPL/Corby Waste

Mars Express utilized Mars Advanced Radar for Subsurface and Ionosphere Sounding instrument or MARSIS. The radar was pulsed and carefully measured, revealing reflectivity data for the surface and below to a depth of 1.5 kilometers. An exceptionally bright area, roughly 20 kilometers wide, was consistent with what would be expected if a large body of liquid were present.

The authors of the recent paper disputing the validity of the claims of Martian lakes raise some questions that cannot be answered by radar reflectivity alone. They claim that the required amounts of salt and heat needed to sustain the supposed lake are not plausible. Mars is too cold, and while there is salt present on the planet, there is no known mechanism that would concentrate it to the salinity levels necessary for liquid water to persist. They also estimate that the local geothermal flux (would Mars-thermal flux be a more appropriate term?) is one-sixth that is required to maintain liquid as well.

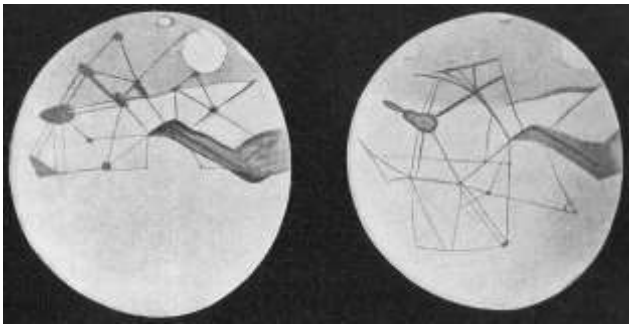
The south pole of Mars as seen by Mars Express. Credit ESA/DLR/FU Berlin

In science, especially when the stakes are as high as identifying possible biomes for extraterrestrial life, it is crucial to seek out the simplest explanation for an observation. The authors posit that rather than a portion of the south pole exhibiting highly anomalous salinity and heating levels, a particularly reflective clay called smectite that is abundant on Mars is the more likely culprit for the radar results seen by MARSIS.

Somewhat ironically, the formation of the smectite is thought to have been formed by various weathering processes that involve groundwater, hydrothermal systems, or surface water bodies. The clay also likely contains water, but critically, frozen solid and distributed throughout the layer of extremely cold smectite. The mineral is common on Mars and has even been detected by the Curiosity rover!

This is not the first time in Martian history (or rather in the history of Earthly observation of Mars) that a tantalizing feature has turned out to be non-existent. Famously, late 19th and early 20th century observers like Giovanni Schiaparelli and Percival Lowell observed so-called canals on the planet's surface. These were imagined to be works of engineering constructed by a civilization of highly advanced Martian life forms. The widespread belief in Martian life from this time

inspired countless works of science fiction, including the HG Wells work *The War of the Worlds.*



Illustrations showing supposed canals on Mars made by Percival Lowell. These features were later found to be optical illusions and are not present on the planet. Credit: Percival Lowell

While it is easy to get swept away in the excitement of imagining alien civilizations or even just subsurface lakes on Mars, it is critical to do good science in our explorations of the solar system. Discovering Mars as it truly is, in reality, is an extraordinary achievement and our findings inform us of the nature of the solar system. Despite crushing our hopes of bodies of liquid water, there's no understating how extraordinary Mars Express is, and the incredible sophistication required to analyze the data displayed by the team in this recent paper is out-of-this-world.

Lead image: Radar imagery provided by Mars Express showing a supposed body of liquid water in the subsurface. This is now thought to be a mineral layer of smectite clay. Credit Context map: NASA/Viking; THEMIS background: NASA/JPL-Caltech/Arizona State University; MARSIS data: ESA/NASA/JPL/ASI/Univ. Rome; R. Orosei .et al. 2018

Follow Ralph Crewe on Twitter @RalphCrewe.

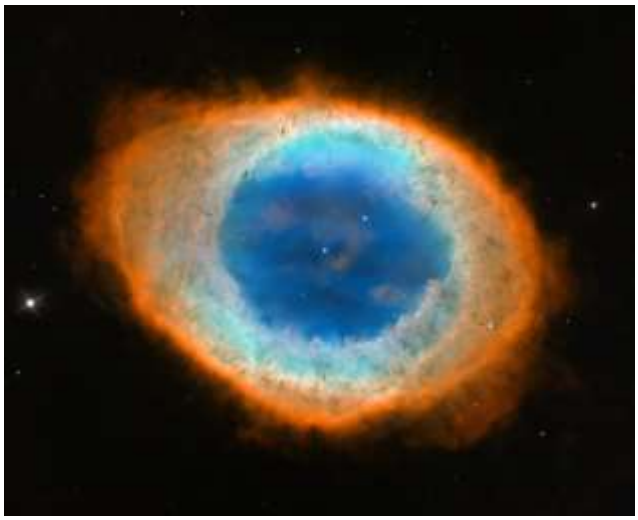
Good News! NASA Announces that they have Fixed Hubble!

***Update:** Hubble took its first picture since it went into safe mode on June 13th! More info here.*

On Sunday, June 13th, the *Hubble Space Telescope* gave the astronomical community a fright when its payload computer suddenly stopped working. This prompted the main computer to put the telescope and its scientific instruments into safe mode. What followed was many tense weeks as the operations team for the HST tried to figure out what the source of the problem was and come up with a strategy for turning *Hubble* back on.

On Friday, July 17th, after more than a month of checking, re-checking, and attempted restarts, the operations team for *Hubble* identified the root of the problem and restored power to the telescope's hardware and all of its instruments. Science operations can now resume, and the pioneering space telescope that gave us over thirty years of dedicated astronomy, cosmology, and astrophysics, still has some life in her!

The problems began when an unspecified issue caused *Hubble's* payload computer, a NASA Standard Spacecraft Computer-1 (NSSC-1) system, to stop working. As part of the telescope's Science Instrument Command and Data Handling (SI C&DH) module, the purpose of this computer is to control and coordinate the scientific instruments aboard the spacecraft.



Hubble image of the Ring Nebula (aka. Messier 57). Credit: NASA/ESA/ Hubble Heritage (STScI/AURA) – ESA /Hubble Collaboration

As a result, the main computer stopped receiving the "keep-alive" signal from the payload computer and automatically placed all of *Hubble*'s scientific instruments into a safe mode. A day later, the *Hubble* operations team restarted the payload computer, but it halted again. That's when the operations team began investigating different SI C&DH components and attempting to switch over to backup modules.

These included the possibility of a degraded memory core, an issue with Standard Interface (STINT) hardware, the Central Processing Module (CPM), the Command Unit/Science Data Formatter (CU/SDF), and a regulator within the Power Control Unit (PCU). At the same time, the team made multiple attempts to restart and reconfigure the computer and the backup computer, but without success.

However, by July 14th, the operations team announced that these tests allowed them to gather vital information that indicated the cause of the problem was in the PCU. This unit ensures a steady voltage supply to the payload computer and its memory. It also contains a power regulator that maintains a constant supply of five volts and a secondary protection circuit that warns the payload computer if the voltage exceeds or falls below this level.

This will trip the secondary protection circuit, which will then instruct the payload computer to cease operations. The team's analysis suggested that either the secondary circuit was tripped, or that degradation over time caused it to get stuck in this inhibit state. On July 15th, the team then began the process of switching over to the SI C&DH units backup, which also contains the backup PCU.

The Eagle Nebula's pillars of creation taken in 1995 (right) and 2015. The new image was obtained with the Wide Field Camera 3, installed by astronauts in 2009. Credit: Left: NASA, ESA/Hubble/HHT/STScI/J. Hester and P. Scowen (ASU)

The team also switched other pieces of hardware over to their alternate interfaces to connect to the backup SI C&DH. Once that was done, the backup payload computer was turned on, loaded with flight software, and brought up to normal operations mode. By July 17th, Hubble's scientific instruments were returned to operational status and NASA announced that the collection of science data will now resume.

This news comes as a welcome relief to NASA and the countless millions that hold the *Hubble Space Telescope* in such high regard. As NASA Administrator Bill Nelson said in a recent NASA press statement:

"Hubble is an icon, giving us incredible insight into the cosmos over the past three decades. I'm proud of the Hubble team, from current members to Hubble alumni who stepped in to lend their support and expertise. Thanks to their dedication and thoughtful work, Hubble will continue to build on its 31-year legacy, broadening our horizons with its view of the universe."

This procedure is similar to what happened in 2008 when *Hubble*'s previous CU/SDF module (another part of the SI C&DH) failed and the operations team switched over to the backup module to keep science operations going. The final servicing mission (STS-125) followed in May of 2009, where the crew of the *Space Shuttle Atlantis* rendezvoused with *Hubble* in orbit and replaced the faulty SI C&DH unit with the one currently in use.

With his feet firmly anchored on the shuttle's robotic arm, astronaut Mike Good maneuvers to retrieve the tool caddy required to repair the Space Telescope Imaging Spectrograph during the final Hubble servicing mission in May 2009. Periodic upgrades have kept the telescope equipped with state-of-the-art instruments, which have given astronomers increasingly better views of the cosmos. Credits: NASA

For anyone whose formative years coincided with the 1990s, the name *Hubble* has been synonymous with astronomy and scientific discovery. In the thirty-one years that it has been in operation, Hubble has conducted over 1.5 million observations of the universe, over 18,000 scientific papers have been published with its data, and it has contributed to some of the most significant discoveries of our Universe.

These include observations that proved the Universe is expanding at an accelerating rate, which gave to the theory of Dark Energy. Its observation campaigns, like the Deep Field and Ultra Deep Field, provided new insight into the evolution of galaxies and hints about the role Dark Matter played. Its observations of exoplanets have also led to the first atmospheric studies of planets beyond the Solar System.

It's good to know that after 31 years and so many scientific breakthroughs under her belt that *Hubble*, the workhorse and pioneer of space telescopes, still has some life left in her. Nancy Grace Roman would be proud of her child!

Further Reading: NASA

Volcanic Activity on Venus Could Explain Phosphine

Ever since the announcement last September that astronomers found evidence of phosphine in the clouds of Venus, the planet has been getting a lot of attention. It's not surprising. Phosphine is a potential biosignature: On Earth, it is produced by microbial life. Might a similar biological process be taking place in the skies of our sister planet? It's a tantalizing prospect, and is definitely worth examining closely, but it's too early to be sure. Microbes aren't the only way to get phosphine. A new paper published on July 12th in the *Proceedings of the National Academy of Science* suggests that volcanism might instead be to blame for the strange chemistry in the Venusian cloud tops.

The Story So Far

Early last fall, a research team led by Professor Jane Greaves (Cardiff University) announced the discovery of phosphine to worldwide fanfare. The team's findings were based on data from two telescopes: the James Clerk Maxwell Telescope (JCMT) and Atacama Large Millimeter Array (ALMA), both of which suggested the presence of phosphine in a quantity as high as 20 parts per billion (PPB) in Venus' atmosphere.

Phosphine (PH_3) is not a very stable gas and tends to decay quickly, meaning that for it to exist on Venus (or on Earth for that matter), there must be an ongoing process replenishing it. On gas giants like Jupiter, the high heat and pressure created by the planet's enormous gravity well can easily produce phosphine, but such conditions do not exist on smaller rocky worlds. Here on Earth, microbes and industrial processes can create it, and so can volcanos.

On Venus, the sheer amount of phosphine detected seemed to suggest that geological processes like volcanos were not sufficient to be the source of the gas. Greaves and her team were careful to rule out, as best they could, any known geological and chemical processes before making the dramatic claim that it could be a sign of alien life. As far as they could tell, biology was the only known process that fit the data.

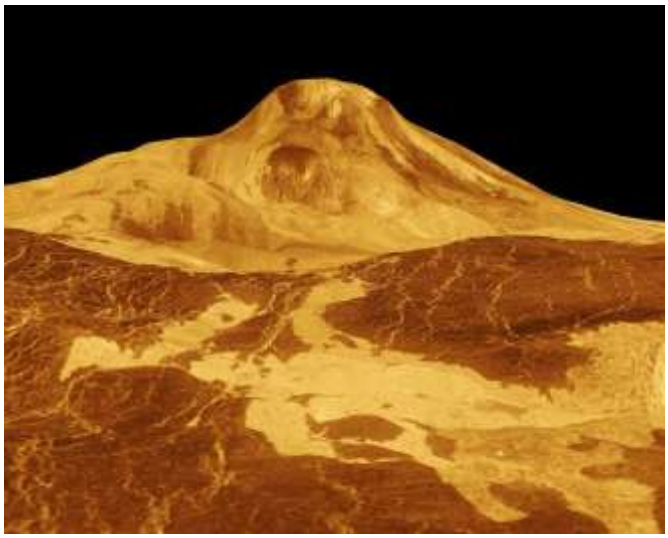
Of course, the claim attracted intense scrutiny, and within a few months several attempts had been made to duplicate the result. As often happens, these additional studies complicated the picture. Some researchers suggested that what Greaves thought was phosphine might actually be sulfur dioxide (SO_2) in a different layer of the atmosphere. The discovery of a software malfunction at ALMA brought the data further into question.

The follow-on studies eventually seemed to settle on the position that yes, phosphine is indeed present on Venus, but in much lower quantities than the initial study suggested: closer to 1-5ppb, not 20ppb. These lower quantities opened the door for an alternative to the biological hypothesis: Venusian volcanos.

Phosphine From Explosive Volcanism

Even with the new, lower phosphine levels (1-5ppb), it would still require an extraordinary volcanic event to recreate what has been observed in Venus' atmosphere. Simple lava flows

would not push phosphine high enough to match the observations. It would take a mighty eruption to push the material to its position about 70km above the planet's surface. Ngoc Truong and Jonathan Lunine, researchers who authored a new paper examining the potential role of volcanism in phosphine production, compared the necessary event to the famously dramatic eruptions of Krakatau in Indonesia.



Maat Mons, a large volcanic structure on Venus. Taken by the Magellan Spacecraft. Image Credit: NASA/JPL.

The process works like this: magma deep within the planet is rich in a substance called phosphide. When blasted into the air by an eruption, the phosphide can mix with sulphuric acid, which is common in Venus's atmosphere. The reaction between these two substances produces – you guessed it – phosphine. As Lunine puts it, "The phosphine is not telling us about the biology of Venus. It's telling us about the geology. Science is pointing to a planet that has active explosive volcanism today or in the very recent past."

Lunine and Truong make a compelling case. But here's the catch with the volcanism hypothesis. We aren't even sure if Venus is volcanically active (it was in the past, but now? We just don't know). Despite being so close to Earth, we know surprisingly little about the surface of Venus. Its clouds hinder observations in visible light wavelengths, and landers sent to the planet's surface don't survive more than a few hours in the harsh environment. Orbiters like Magellan (launch in 1989) mapped the planet using radar, but reliable information about the planet's geology is surprisingly hard to come by.

NASA's Pioneer Venus mission in 1979 found sulfur dioxide in the atmosphere that might point to volcanism, and Magellan observed some geological features that could mean recent volcanic activity, but none of it is conclusive. For the moment, the notion of active volcanos on Venus is just as speculative as the notion of microbial life. Both theories work hard to make sense of the evidence as best they can, but neither can be proven: yet.

What's Next?

If we are able to solve this puzzle and learn the source of the phosphine in Venus' atmosphere, we will have learned a great deal about Venus in the process, regardless of the answer. If microbial life is the source of the phosphine, the implications are obviously game-changing. If the source of the phosphine is eruptive volcanism, we will have learned something new about the geology of a planet that has long been shrouded in mystery.

Venus's cloudy skies, as seen by Mariner 10 in 1974. Image Credit: NASA/JPL-Caltech.

Three new missions are scheduled to visit Venus in the near future: two spacecraft from NASA and one from the European Space Agency (ESA). None of the missions are directly designed to look for phosphine, but all are intended to give a fuller picture of the planetary system. One of the key priorities for these missions is to provide a much higher resolution map of Venus' surface than Magellan was able to make. These three missions could help solve the phosphine mystery, but, as usual in planetary science, they are likely to raise as many questions as they answer.

Where am I placing my bets? It's a tough call. Venus is a hostile place – volcanism seems more plausible there than life – but the Universe is a strange place, and extremophile microbes have been found in inhospitable habitats here on Earth. If something is alive in the clouds of Venus, it would be a surprise, but it wouldn't be beyond the realm of the possible. Only time will tell, and the real answer may end up being something else entirely. Both Greaves and Lunine admit that the source of the phosphine might end up being a third option: there might be some unknown chemistry going on in Venus' atmosphere that we've yet to discover.

Whatever the case, I look forward to finding out.

We Need to Fix Space Junk Before It's Too Late

As of 2020, there were over 19,000 pieces of individually tracked space junk in orbit above the Earth. Of those, a mere 2,200 were operational satellites. As more and more satellites go up, the risk of collisions increases. And what are governments doing to stop it? Basically, nothing.

In addition to the 19,000 known pieces of space junk, there's an estimated 15,000 pieces larger than 10cm across whipping around the Earth. There are an estimated one million pieces larger than a centimeter.

In 2007, the Chinese government conducted an anti-satellite missile test by launching a "kinetic kill vehicle" (essentially a rocket-fired bullet) at a defunct weather satellite. That single incident generated over 3,000 tracked and monitored pieces of space junk, many of which remain in orbit today.

On February 10, 2009 a communications satellite managed by the Iridium company collided with an old Russian military satellite. Both satellites were obliterated, leading to over 2,000 cataloged pieces of space junk.

As satellite-based internet companies continue to launch fleets of "mega-constellations" into orbit, the risk of collisions is only growing with time.

While the drag of our atmosphere can clean up some small pieces of space junk, we're dangerously close to a tipping point. Called Kessler Syndrome, after the NASA scientist who first outlines the possibility, space junk collisions can cascade into more collisions, which generate even more junk, which generate more space junk, spiraling out of control until low-Earth orbit is completely inaccessible for a generation.

What do we do about all this space junk? Right now, not much. The US Space Surveillance Network (part of the Space Force) monitors space junk and issues warnings, but it's up to the individual satellite operators to make decisions about maneuvers.

Proposals abound for cleaning up space junk, but all the solutions are costly and ineffective. The current worldwide strategy is to…launch and cross our fingers.

According to Elon, Starship Could Chomp up Space Junk

At their South Texas Launch Facility, just outside of the village of Boca Chica, SpaceX is gearing up to test the *Super Heavy,* the booster element of their *Starship* launch system. This massive reusable first stage rocket will be responsible for sending the *Starship* orbital vehicle to space, where it will deliver satellites to orbit, payloads and people to the Moon, and (if all goes as planned) the first human settlers to Mars.

According to a recent statement issued by SpaceX founder Musk Musk, the *Starship* could also be used to "chomp up debris" in Earth orbit. As usual, the statement was issued via Twitter, where Musk was once again addressing questions posted by followers and fans. The topic arose after Musk shared the latest updates about Starlink, one of a handful of satellite constellations that are bringing broadband internet services to every corner of the planet.

Specifically, Musk was sharing the latest artwork that will adorn the Starlink satellite covers, the visor-like appendages that make Starlink satellites less visible in orbit. Henceforth, these covers will feature a diagram of a transfer orbit from Earth to Mars, a clear reference to Musk's long-term vision of colonizing the Red Planet. This is not unlike the terms of service for Starlink's public beta test back in Nov. 2020, where participants had to acknowledge Mars as a "free planet."

In any case, a user who goes by the Twitter handle Hide yo memes (@REQNews) asked if SpaceX had any other mitigation measures in mind to reduce the problem of space debris. Specifically, the user referenced the Kessler Syndrome (named for NASA space debris expert Don Kessler) which states that once orbital debris reaches a certain critical mass, it will create a chain reaction of collisions and more debris.

According to their initial FCC filing (issued in Nov. of 2016), SpaceX requested a license to operate a constellation of 4425 non-geostationary satellites (NGS) in orbits of between 1100 and 1300 km (680 and 800 mi). By Nov. of 2018, SpaceX announced that they were adjusting this plan and now wanted to send their first 1600 satellites to an altitude of 550 km (350 mi), where they would deorbit and burn up in the atmosphere sooner.

As of June 30th, when the latest batch was launched, SpaceX has sent 1,740 Starlink satellites to space (1635 are currently active) which orbit Earth at altitudes of 540 to 570 km (335.5 to 354 mi). However, lowering the orbit of satellites is hardly a long-term solution. At present, the ESA indicates that satellites are being deployed at a rate of 70–90 launches a year, with a growing number of launches injecting 30 or more small satellites at a time.

Artist's impression of SpaceX's Starship with its payload fairing open. Credit: SpaceX

Musk's solution, as offered, would be to utilize the *Starship's* fairing, the clamshell-like structure the payload is integrated into. In its standard configuration, the payload fairing measures 9 m (29.5 ft) in diameter, which allows for a greater cargo volume than any other launch vehicle (past or present). As it states in the Starship User Guide:

"Once integrated, the clamshell fairing remains closed through launch up until the payload is ready to deploy… To deploy the payload, the clamshell fairing door is opened, and the payload adapter and payload are tilted at an angle in preparation for separation. The payload is then separated using the mission-unique payload adapter. If there are multiple payloads on a single mission, a rotating mechanism can be provided to allow each satellite to separate with maximum clearance."

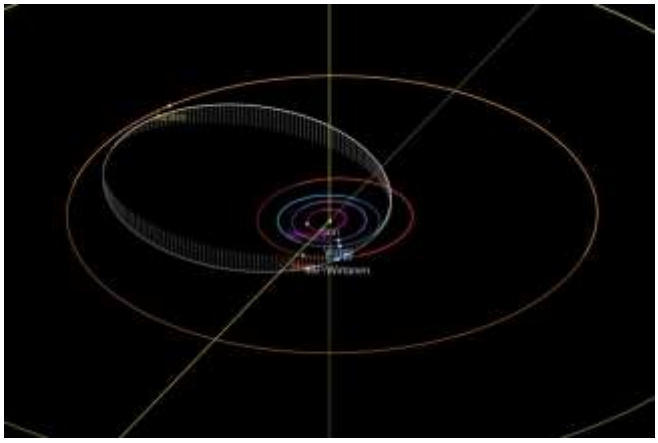
Configured for debris, the *Starship* would likely open its fairing door and rely on inertia to scoop up and trap debris in its payload compartment. This is not unlike how Blue and Humpback whales feed, swimming into schools of krill, crustaceans, or small fish with their mouths open and clamping them shut. With an internal volume of 1,100 m^3 (38,800 ft^3), the fairing could accommodate debris eight times the size of a Crew Dragon (with the trunk).

Naturally, the Twitterverse responded with their usual mix of jibes and feedback (my favourite being that SpaceX should paint these *Starships* to look like Pacman!). In any case, a space junk-clearing *Starship* could be an innovative idea and a potential solution to the space debris crisis. Given Musk's high-profile involvement in the broadband satellite market, a solution that comes from his corner also makes good business sense.

Tales of a 'Drunken Comet'- Astronomers Detect Alcohol Leaking From 46P/Wirtanen into Space

A close pass of Comet Wirtanen in 2018 offered researchers an unprecedented opportunity.

Comets are full of surprises. Not only do they often under- or very occasionally over- perform versus expectations, but they also offer a glimpse of the remnants of the very early solar system. In December 2018, astronomers had an unprecedented opportunity to study one of these relics of the early solar system up close as Comet 46P/Wirtanen sped by Earth just 30 times the Earth-Moon distance (7.1 million miles away) on its closest passage for this century.



The orbit of Comet 46P/Wirtanen. NASA/JPL

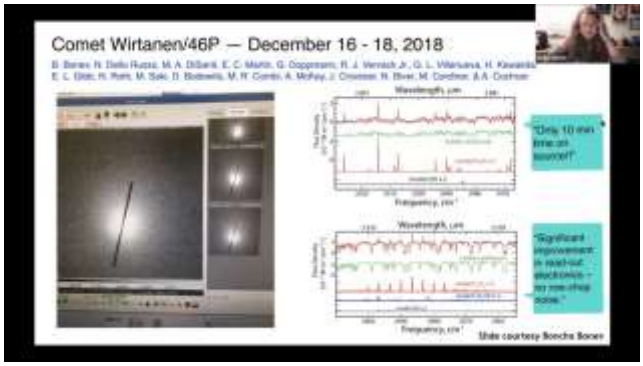
Discovered by astronomer Carl A. Wirtanen in 1948, short period Comet 46P Wirtanen orbits the Sun every 5.4 years, on a path that takes it from a perihelion 1.06 AU from the Sun to an aphelion of 5.13 AU, just outside the perihelion of Jupiter.

The 2018 approach past Earth for the comet was an especially favorable one, and this time, astronomers at the W.M. Keck Observatory on Maunakea, Hawai'i were ready. Keck's Near Infrared Spectrograph (NIRSPEC) just received a major upgrade, featuring more pixels and higher sensitivity, an upgrade that would see first light obtaining spectra of the comet.

Instruments need hugs, too. Dr. Emily Martin with the newly upgraded NIRSPEC instrument. W.M. Keck Observatory.

And the results, recently published in *The Planetary Science Journal* were a spectacular success. Not only did the team classify a list of key compounds seen out-gassing from Comet Wirtanen, but they discovered a high alcohol ratio for the comet, along with an anomalous heating mechanism at play.

"46P/Wirtanen has one of the highest alcohol-to-aldehyde ratios measured in any comet to date," says Neil Dello Russo (JHU/APL) in a recent press release. "This tells us information about how carbon, oxygen, and hydrogen molecules were distributed in the early solar system where Wirtanen formed."



Findings from the recent NIRSPEC upgrade. Keck Observatory Astronomy Talk Video

The Keck study also noticed a continuous heating of cometary material sublimating through the coma, the familiar wreath of gas and dust surrounding the nucleus of a comet. The amount of heating is thought to decrease with distance, and was more than what could be explained by simple incoming solar radiation.

"Interestingly, we found that the temperature measured for water gas in the coma did not decrease significantly with the distance from the nucleus, which implies a heating mechanism," says Erika Gibb (University of Missouri—St Louis) in the recent press release.

One possibility is ionization via sunlight close to the nucleus. "Another possibility is there may be solid chunks of ice flying off of Wirtanen." Says Gibb. This has been documented in the past. Most notably during NASA's EPOXI mission to Comet Hartley 2. "Those ice chunks tumble away from the nucleus and sublimate, releasing energy farther out in the coma."

This copious release release of water is consistent with a young, hyperactive comet such as 46P/Wirtanen. Like many periodic comets, Wirtanen was probably captured in the inner solar system in the last few million years. Ancient comets are thought to be one of the possible sources of Earth's primordial oceans.

Up until now, it has been difficult to capture action in the inner coma where icy grains are releasing water, versus the sublimation of ethane, hydrogen cyanide and acetylene in the outer coma; missions such as ESA's Rosetta to comet 67P/Churyumov-Gerasimenko only gave us a glimpse of this process, and the Earth's own atmosphere makes it difficult to study this process.

The Keck Observatory complex. Credit: W.M. Keck Observatory

The Keck team used the infrared NIRSPEC instrument to target specific water transition wavelengths, allowing analysis of volatile distributions throughout the coma. This capability represents a significant first for a ground-based telescope.

It's also worth studying Comet Wirtanen, as it has been on the short list for exploration proposals in the past: NASA's Comet Hopper mission would have sent a nuclear-powered lander to the comet, and Wirtanen was the original target for the Rosetta mission.

One day, we may see Comet Wirtanen up close. For now, raise a glass to Wirtanen, and NIRSPEC and remember that comets may well be the source of the ice in that next refreshing drink.

E Mails Viewings Logs and Images from Members.

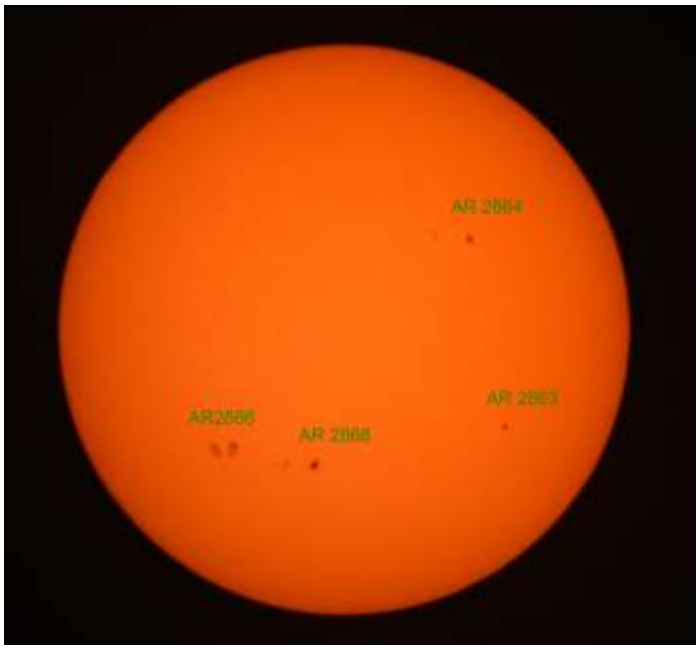
The e-mails for inclusion I have added of the society pages, so thank you to Dave Buckle and Mike Alexande for your contributions.

We also have two fairly active excellent imagers who are both based around Calne, and they add there images to the Wiltshire Society Members Forum after they joined the society.

Matthew Terrell and Steve Allen., also images from Peter Chappell and RJ Dartnell.

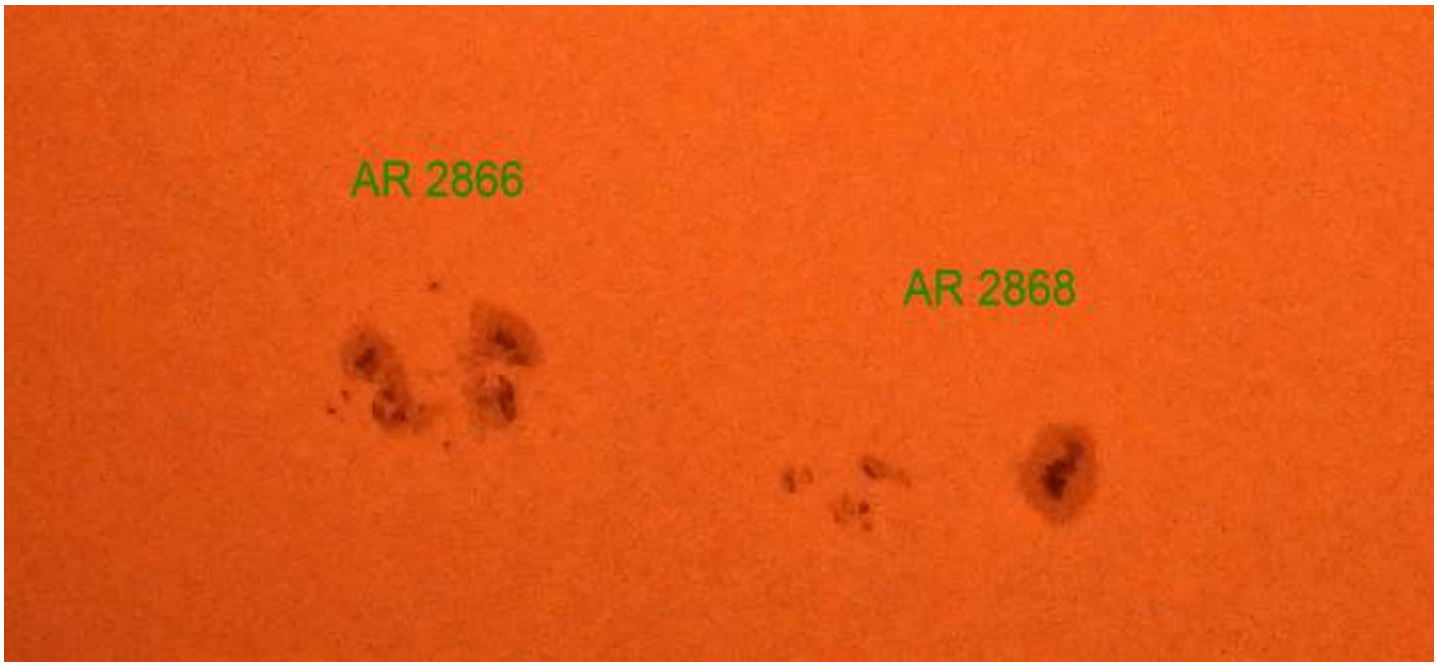
Thank you for helping make the facebook pages more lively.

The Sun has suddenly burst into activity, with 80 Sunspots in 4 Active regions today (7th September).



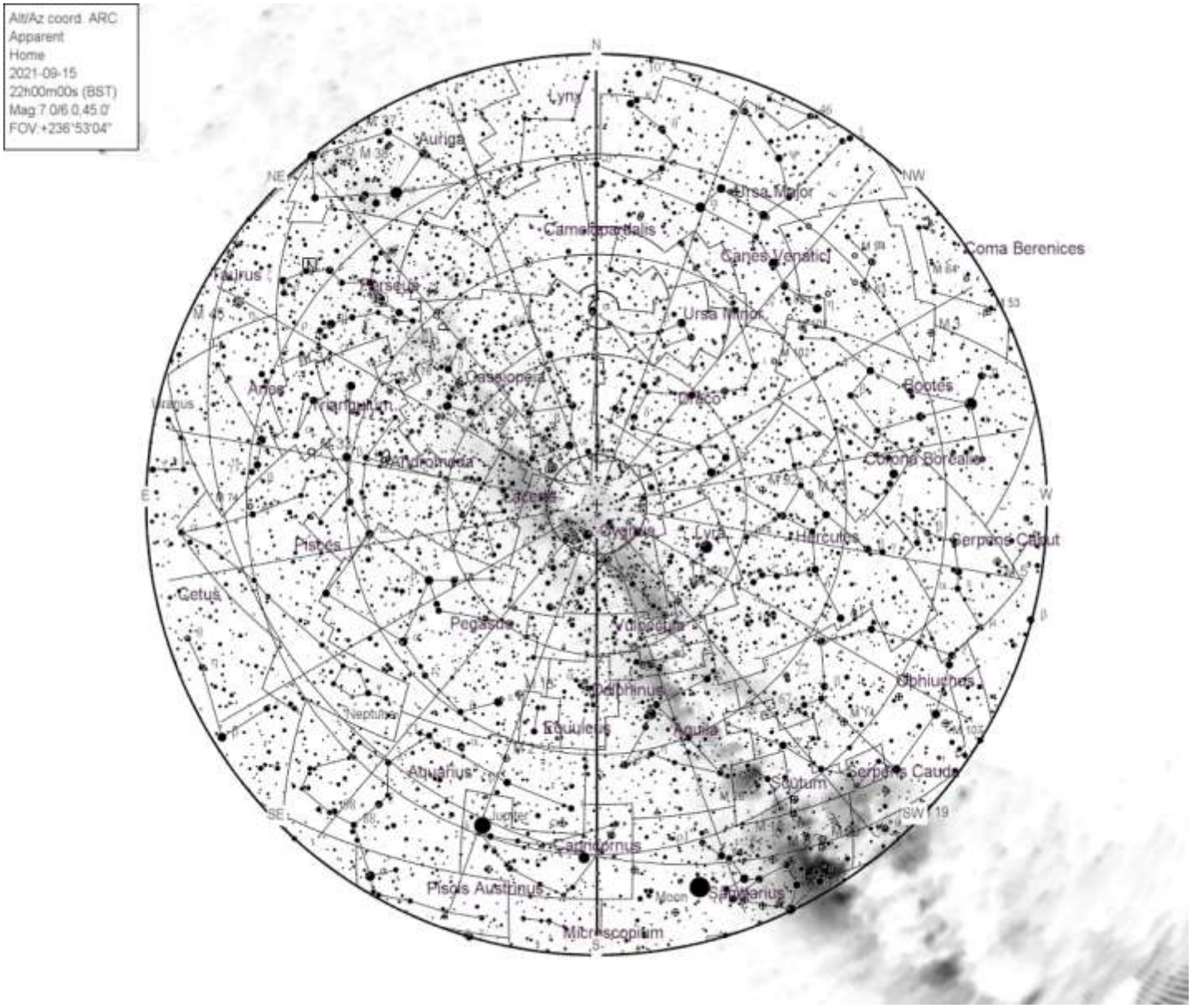
Noctilucent Clouds in June and July.

A lot of lower cloud obstructing the NLCs while other areas seemed to be getting clearer skies.



Some Moon images from the summer: regular readers will know my southern views or very limed so I miss the planets of Jupiter and Saturn.

WHATS UP, SEPTEMBER 2021



September 7 - **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 00:52 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.

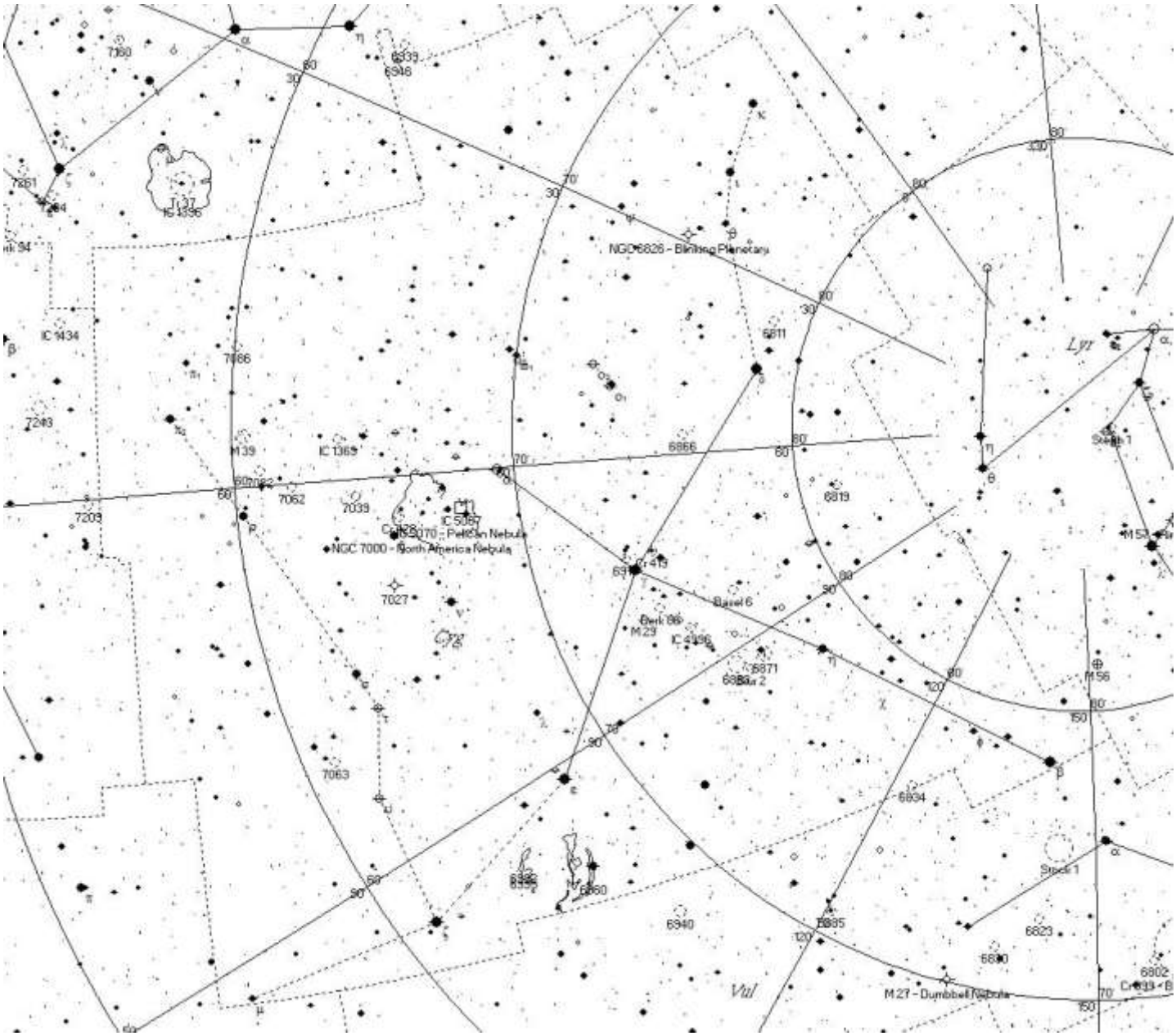
September 14 - **Neptune at Opposition.** The blue giant planet will be at its closest approach to Earth and its face will be fully illuminated by the Sun. It will be brighter than any other time of the year and will be visible all night long. This is the best time to view and photograph Neptune. Due to its extreme distance from Earth, it will only appear as a tiny blue dot in all but the most powerful telescopes.

September 14 - **Mercury at Greatest Eastern Elongation.** The planet Mercury reaches greatest eastern elongation of 26.8 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.

September 20 - **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 23:54 UTC. This full moon was known by early Native American tribes as the Corn Moon because the corn is harvested around this time of year. This moon is also known as the Harvest Moon. The Harvest Moon is the full moon that occurs closest to the September equinox each year.

September 22 - **September Equinox.** The September equinox occurs at 19:11 UTC. The Sun will shine directly on the equator and there will be nearly equal amounts of day and night throughout the world. This is also the first day of fall (autumnal equinox) in the Northern Hemisphere and the first day of spring (vernal equinox) in the Southern Hemisphere.

CONSTELLATIONS OF THE MONTH: Cygnus



Welcome to another edition of Constellation Friday! Today, in honor of the late and great Tammy Plotner, we take a look at the "Swan" – the Cygnus constellation. Enjoy!

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 the constellations identified by Ptolemy was Cygnus, otherwise known as "the Swan". The constellation is easy to find in the sky because it features a well-known asterism known as the Northern Cross. Cygnus was first catalogued the by Greek astronomer Ptolemy in the 2nd century CE and is today one of the 88 recognized by the IAU. It is bordered by the constellations
of Cepheus, Draco, Lyra, Vulpecula, Pegasus and Lacerta.

Name and Meaning:

Because the pattern of stars so easily resembles a bird in flight, Cygnus the "Swan" has a long and rich mythological history. To the ancient Greeks, it was at one time Zeus disguising himself to win over Leda, and eventually father Gemini, Helen of Troy, and Clytemnestra. Or perhaps it is poor Orpheus, musician and muse of the gods, who when he died was transformed into a swan and placed in the stars next to his beloved lyre.

It could be king Cycnus, a relative of Phaethon, son of Apollo, who crashed dear old dad's fiery sky chariot and died. Cygcus was believed to have driven up and down the starry river so many times looking for Phaethon's remains that he was finally transformed into stars. No matter what legend you choose, Cygnus is a fascinating place… and filled with even more fascinating areas to visit!

History of Observation:

Because of its importance in ancient Greek mythology and astrology, the sprawling constellation of Cygnus was one of Ptolemy's original 48 constellations. To Hindu astronomers, the Cygnus constellation is also associated with the "Brahma Muhurta" ("Moment of the Universe"). This period, which lasts from 4:24 AM to 5:12 AM, is considered to be the best time to start the day.

Cygnus is also highly significant to the folklore and mythology of many people in Polynesia, who also viewed it as a separate constellation. These include the people of Tonga, the Tuamatos people, the Maori (New Zealand) and the people of the Society Islands. Today, Cygnus is

one of the official 88 modern constellations recognized by the IAU.

Notable Objects:

Flying across the sky in a grand position against the backdrop of the Milky Way, Cygnus consists of 6 bright stars which form an asterism of a cross comprised of 9 main stars and there are 84 Bayer/Flamsteed designated stars within its confines. It's most prominent star, Deneb (Alpha Cygni), takes it name from the Arabic word *dhaneb*, which is derived from the Arabic phrase *Dhanab ad-Dajajah*, which means "the tail of the hen".

Deneb is a blue-white supergiant belonging to the spectral class A2 Ia, and is located approximately 1,400 light years from Earth. In addition to being the brightest star in Cygnus, it is one of the most luminous stars known. Being almost 60,000 times more luminous than our Sun and about 20 Solar masses, it is also one of the largest white stars known.

Deneb serves as a prototype for a class of variable stars known as the Alpha Cygni variables, whose brightness and spectral type fluctuate slightly as a result of non-radial fluctuations of the star's surface. Deneb has stopped fusing hydrogen in its core and is expected to explode as a supernova within the next few million years. Together with the stars of Altair and Vega, Deneb forms the Summer Triangle, a prominent asterism in the summer sky.

Next up is Gamma Cygni (aka. Sadr), whose name comes from the Arabic word for "the chest". It is also sometimes known by its Latin name, Pectus Gallinae, which means "the hen's chest." This star belongs to the spectral class F8 Iad, making it a blue-white supergiant, and is located approximately 1,800 light years from Earth.

It can easily seen in the night sky at the intersection of the Northern Cross thanks to its apparent magnitude of 2.23, which makes it one of the brightest stars that can be seen in the night sky. It is also believed to be only about 12 million years old and consumes its nuclear fuel more rapidly because of its mass (12 Solar masses).

Gamma Cygni (Sadr) is surrounded by a diffuse emission nebula, IC 1318, also known as the Sadr region or the Gamma Cygni region. Credit: Eric Larsen

Then there's Epsilon Cygni (ak. Glenah), an orange giant of the spectral class K0 III that is 72.7 light years distant. It's traditional name comes from the Arabic word *janah*, which means "the wing" (this name is shared with Gamma Corvi, a star in the Corvus constellation). It is 62 times more luminous than the Sun and measures 11 Solar radii.

Delta Cygni (Rukh), is a triple star system in Cygnus, which is located about 165 light years away. The system consists of two stars lying close together and a third star located a little further from the main pair. The brightest component is a blue-white fast-rotating giant belonging to the spectral class B9 III. The star's closer companion is a yellow-white star belonging to the spectral class F1 V, while the third component is an orange giant.

Last, there's Beta Cygni (aka. Albireo) which is only the fifth brightest star in the constellation Cygnus, despite its designation. This binary star system, which appears as a single star to the naked eye, is approximately 380 light-years distant. The traditional name is the result of multiple translations and misunderstandings of the original Arabic name, *minqar al-dajaja* ("the hen's beak"). It is one of the stars that form the Northern Cross.

The binary system consists of a yellow star which is itself a close binary star that cannot be resolved as two separate objects. Its second star is a fainter blue fast-rotating companion star with an apparent magnitude of 5.82 that is located 35 arc seconds apart from its primary.

Albireo A, the primary star of Beta Cygni (which is itself a binary system). Credit: Henryk Kowalewski

Cygnus is also home to a number of Deep Sky Objects. These include Messier 29 (NGC 6913), an open star cluster that is about 10 million years old and located about 4,000 light years from Earth. It can be spotted with binoculars a short distance away from Gamma Cygni – 1.7 degrees to the south and a little east.

Next up is Messier 39 (NGC 7092), another open star cluster that is located about 800 light-years away and is between 200 and 300 million years old. All the stars observed in this cluster are in their main sequence phase and the brightest ones will soon evolve to the red giant stage. The cluster can be found two and a half degrees west and a degree south of the star Pi-2 Cygni.

There is also the Fireworks Galaxy (NGC 6946), an intermediate spiral galaxy that is approximately 22.5 million light-years distant. The galaxy is located near the border of the constellation Cepheus and lies close to the galactic plane, where causes it to become obscured by the interstellar matter of the Milky Way.

Then there's the famous X-ray source known as Cygnus X-1, which is one of the strongest that can be seen from Earth. Cygnus X-1 is notable for being the first X-ray source to be identified as a black hole candidate, with a mass 8.7 times that of the Sun. It orbits a blue supergiant variable star some 6,100 light-years away, which is one of two stars form a binary system.

Over time, an accretion disk of material brought from the star by a stellar wind has formed around Cygnus X-1, which is the source of its X-ray emissions.

Finding Cygnus:

Cygnus is visible to all observers at latitudes between +90° and -40° and is best seen at culmination during the month of September. For a period of 15 days around the peak date of August 20, watch for the Kappa Cygnid meteor shower. This annual meteor shower has a radiant near the bright star Deneb and an average fall rate of about 12 meteors per hour. It is noted to have many bright fire balls called "bolides" and the best time to watch is when the constellation is directly overhead.

Because Cygus is so rich in things to visit, we shall only touch very briefly on just a few. Let's begin with our unaided eye as we take a look at the brightest star of the constellation, Alpha Cygni – Deneb. Here we have not only an extremely luminous blue super giant star – but a pulsing variable star, too. Its changes are minor – only about 1/10 of a stellar magnitude, but Deneb is its own prototype.

Its stellar oscillations are very complex, consisting of multiple pulsation frequencies as well as a fundamental one. This means changes in brightness occur between 5 and 10 days apart, but that's a good thing. If the changes weren't small, Deneb would blow itself to bits!

If you are looking at Cygnus for an area well away from city lights on a night when there is no Moon, look just northwest of Deneb for the North America Nebula (NGC 7000). This is an excellent emission nebula that covers as much area of the sky as 10 full Moons! At 3 full degrees, you'll be looking for a vague, misty patch of silver-ness that about as broad as your thumb held at arm's length.

While telescopes and binoculars are grand, remember this particular region is so large that you can easily over magnify it and often your unaided eye is all you need to catch this elusive interstellar cloud of ionized hydrogen (H II region). Now, get out your binoculars and let's dance!

Messier 29 is very easy and bright and you can find it about a fingerwidth south and a little east of Gamma Cygni – the "8" shape on our map. This open cluster of stars has just a handful of bright members and will look like a small rendition of the "Big Dipper". M29 is about 7,200 light years away from Earth, so the fact we can see it at all in binoculars is pretty impressive! Now, try Messier 39.

Don't put your binoculars away just yet. You've got to visit Omega 2 before you stop! Its name is Ruchbah and it's a double star about 500 light years from Earth, consisting of a magnitude 5.44 star of spectral class M2 and a 6.6 magnitude star of spectral class A0. The stars are well separated at 256″ apart and can be seen in binoculars and totally glorious in a telescope. Because of the color contrast (red main star and blue companion), Ruchba is a beautiful object for amateur astronomers.

Now try Beta Cygni – Albireo. It is also known as one of the most attractive and colorful double stars in the sky. Beautiful Beta 1 is an orange giant K star and Beta 2 is a main-sequence B star of a soft, blue hue. If you can't separate them in your binoculars, use a telescope! This seasonal favorite is one that's not to be missed! Now, let's try a couple objects for the telescope.

One of the true prizes of the Cygnus region for any telescope is the Holy Veil (NGC 6960, 6962, 6979, 6992, and 6995). You'll find it just south of Epsilon Cygni and the easiest segment to find is 6960, which runs through the star 52 Cygni. This is an ancient supernova remnant covering approximately 3 degrees of the sky and an experience you won't soon forget if you are viewing from a dark sky site.

The source supernova exploded some 5,000 to 8,000 years ago and it is simply amazing to think that anything remains to be seen. It was discovered on 1784 September 5 by William Herschel. He described the western end of the nebula as "Extended; passes thro' 52 Cygni… near 2 degree in length." and described the eastern end as "Branching nebulosity… The following part divides into several streams uniting again towards the south."

Even though it is any where from from 1,400 to 2,600 light-years light years away, you'll find long and wondrous tongues of material to capture your interest and delight your eye and you follow them to their ends!

More challenging is the Crescent Nebula (NGC 6888 or Caldwell 27) located at RA 20h 12m 7s Dec +38 21.3′. This is an emission nebula fueled by a Wolf-Rayet star located about 5000 light years away. It is formed by the fast stellar wind careening off illuminating the slower moving wind ejected by the star when it went into the red giant star stage. What's left is a collision… a shell and two shock waves… one moving outward and one moving inward. A what a grand one it is!

The Fireworks Galaxy (NGC 6946) taken by the Subaru Telescope. Credit: NAOJ/Robert Gendler

For galaxy fans, you have got to point your telescope towards NGC 6946, the "Fireworks Galaxy" (RA 20h 34m 52.3s Dec +60 09 14). Who cares if this barred spiral galaxy 10 million light years away? This is one supernovae active baby! At one time, it was widely believed that NGC 6946 was a member of our Local Group; mainly because it could be easily resolved into stars.

There was a reddening observed in it, believed to be indicative of distance – but now know to be caused by interstellar dust. But it isn't the shrouding dust cloud that makes NGC 6946 so interesting, it's the fact that so many supernova and star-forming events have sparkled in its arms in the last few years that has science puzzled! So many, in fact, that they've been recorded every year or two for the last 60 years…

Now, for the really cool part – understanding barred structure. Thanks to the Hubble Space Telescope and a study of more than 2,000 spiral galaxies – the Cosmic Evolution Survey (COSMOS) – astronomers understand that barred spiral structure just didn't occur very often some 7 billion years ago in the local universe. Bar formation in spiral galaxies evolved over time.

A team led by Kartik Sheth of the Spitzer Science Center at the California Institute of Technology in Pasadena discovered that only 20 percent of the spiral galaxies in the distant past possessed bars, compared with nearly 70 percent of their modern counterparts. This makes NGC 6946 very rare, indeed… Since its barred structure was noted back in Herschel's time and its age of 10 billion years puts it beyond what is considered a "modern" galaxy.

It that all there is? Not hardly. Try NGC 6883, an open cluster located about 3 degrees east/northeast of Eta Cygni. It's a nice, tight cluster that involves a well-resolved double star and a bonus open cluster – Biurakan 2 – as well. Or how about NGC 6826 located about 1.3 degrees east/northeast of Theta. This one is totally cool… the "Blinking Planetary"!

This planetary nebula is fairly bright and so is the central star… but don't stare at it, or it will disappear! Look at it averted and the central star will appear again. Neat trick, huh? Now try NGC 6819 about 8 degrees west of Gamma. Here you'll find a very rich, bright open cluster of about 100 stars that's sure to please. It's also known as Best 42!

There's many more objects in Cygnus than just what's listed here, so grab yourself a good star chart and fly with the "Swan"!

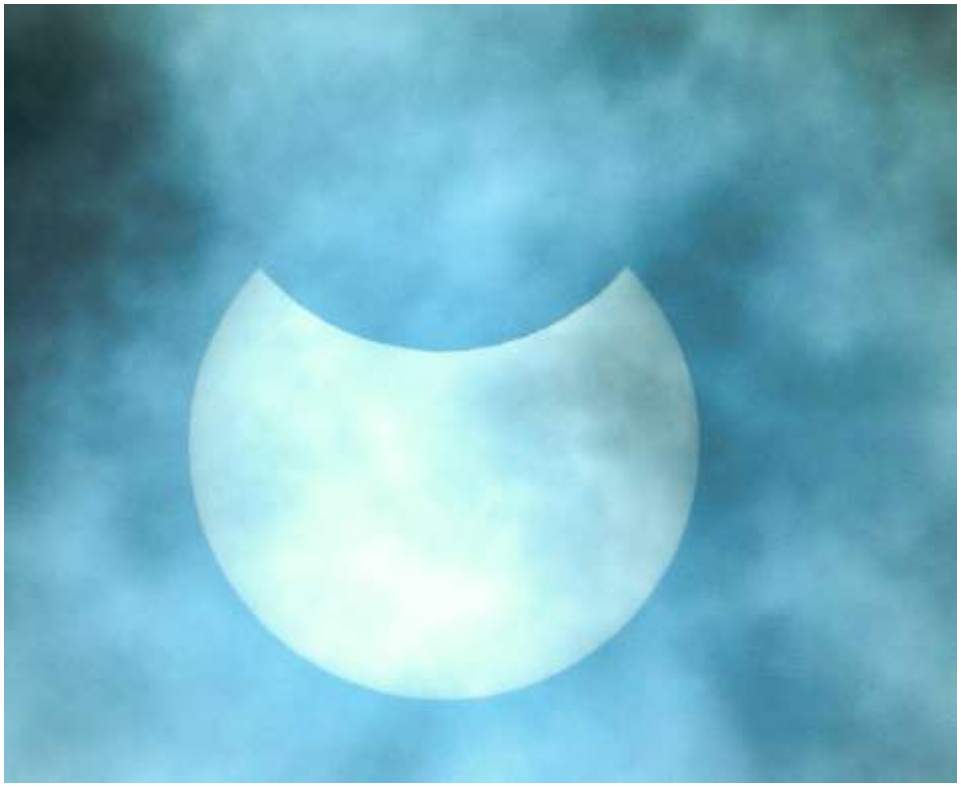
ISS PASSES For SEPTEMBER 2021

from Heavens Above website maintained by Chris Peat.

Date	Brightness	Start	Highest	End						
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
06 Sep	**-0.7**	**02:53:45**	**12°**	**E**	**02:53:45**	**12°**	**E**	**02:53:59**	**10°**	**E**
06 Sep	-3.8	04:26:45	53°	W	04:27:27	85°	N	04:30:52	10°	E
07 Sep	-2.3	03:41:40	35°	E	03:41:40	35°	E	03:43:46	10°	E
07 Sep	-3.8	05:14:40	16°	W	05:17:12	66°	SSW	05:20:34	10°	ESE
08 Sep	-0.5	02:56:40	10°	E	02:56:40	10°	E	02:56:41	10°	E
08 Sep	-3.9	04:29:41	62°	W	04:30:09	80°	S	04:33:33	10°	ESE
09 Sep	-1.9	03:44:49	26°	E	03:44:49	26°	E	03:46:27	10°	E
09 Sep	-3.1	05:17:50	20°	W	05:19:44	38°	SSW	05:22:54	10°	SE
10 Sep	-3.4	04:33:08	47°	S	04:33:08	47°	S	04:36:02	10°	SE
11 Sep	-1.0	03:48:41	12°	ESE	03:48:41	12°	ESE	03:49:02	10°	ESE
11 Sep	-2.3	05:21:43	19°	SW	05:22:06	20°	SW	05:24:37	10°	SSE
12 Sep	-1.4	04:37:32	13°	SSE	04:37:32	13°	SSE	04:38:04	10°	SSE
16 Sep	-1.4	21:23:25	10°	SSW	21:24:09	15°	SSW	21:24:09	15°	SSW
17 Sep	-2.3	20:36:47	10°	SSW	20:39:24	21°	SE	20:39:32	21°	SE
17 Sep	-0.7	22:12:30	10°	WSW	22:12:33	10°	WSW	22:12:33	10°	WSW
18 Sep	-1.8	19:50:28	10°	S	19:52:27	15°	SE	19:54:27	10°	ESE
18 Sep	-2.7	21:25:27	10°	SW	21:27:42	36°	SW	21:27:42	36°	SW
19 Sep	-3.2	20:38:29	10°	SW	20:41:40	40°	SSE	20:42:41	31°	ESE
19 Sep	-1.0	22:14:59	10°	W	22:15:41	15°	W	22:15:41	15°	W
20 Sep	-2.7	19:51:39	10°	SSW	19:54:38	30°	SSE	19:57:33	10°	E
20 Sep	-3.2	21:27:51	10°	WSW	21:30:32	54°	WSW	21:30:32	54°	WSW
21 Sep	-3.8	20:40:43	10°	WSW	20:44:04	69°	SSE	20:45:18	35°	E
21 Sep	-0.9	22:17:31	10°	W	22:18:17	16°	W	22:18:17	16°	W
22 Sep	-3.5	19:53:39	10°	WSW	19:56:57	54°	SSE	19:59:59	12°	E
22 Sep	-3.0	21:30:21	10°	W	21:32:58	51°	W	21:32:58	51°	W
23 Sep	-3.8	20:43:10	10°	W	20:46:33	88°	N	20:47:35	42°	E
23 Sep	-0.7	22:20:01	10°	W	22:20:34	14°	W	22:20:34	14°	W
24 Sep	-3.8	19:55:59	10°	WSW	19:59:22	83°	SSE	20:02:11	14°	E
24 Sep	-2.5	21:32:51	10°	W	21:35:09	41°	W	21:35:09	41°	W
25 Sep	-3.8	20:45:40	10°	W	20:49:03	86°	N	20:49:43	54°	E
25 Sep	-0.4	22:22:32	10°	W	22:22:42	11°	W	22:22:42	11°	W
26 Sep	-3.8	19:58:27	10°	W	20:01:51	85°	N	20:04:17	18°	E
26 Sep	-2.0	21:35:19	10°	W	21:37:15	31°	W	21:37:15	31°	W
27 Sep	-3.9	20:48:07	10°	W	20:51:29	75°	SSW	20:51:49	67°	SE
28 Sep	-3.8	20:00:55	10°	W	20:04:18	87°	S	20:06:23	22°	E
28 Sep	-1.5	21:37:50	10°	W	21:39:21	22°	WSW	21:39:21	22°	WSW
29 Sep	-3.2	20:50:34	10°	W	20:53:49	46°	SSW	20:53:57	45°	SSW
30 Sep	-3.5	20:03:20	10°	W	20:06:40	60°	SSW	20:08:34	23°	SE
30 Sep	-0.9	21:40:43	10°	W	21:41:33	14°	WSW	21:41:33	14°	WSW
01 Oct	-3.6	19:16:07	10°	W	19:19:29	74°	SSW	19:22:51	10°	ESE
01 Oct	-2.1	20:53:11	10°	W	20:55:59	24°	SSW	20:56:13	24°	SSW
02 Oct	-2.4	20:05:49	10°	W	20:08:54	33°	SSW	20:10:56	17°	SSE
03 Oct	-2.8	19:18:31	10°	W	19:21:46	45°	SSW	19:25:00	10°	SE
03 Oct	-1.0	20:56:39	10°	WSW	20:57:57	12°	SW	20:58:44	11°	SSW
04 Oct	-1.3	20:08:40	10°	W	20:10:57	17°	SW	20:13:13	10°	S
05 Oct	-1.6	19:21:06	10°	W	19:23:53	24°	SSW	19:26:39	10°	SSE

END IMAGES, OBSERVING AND OUTREACH

The partial solar eclipse of the 12th was only for the gambling brave.
Silbury car park offered me an hours worth of observing through thinner cloud.
Nikon P1000 and thousand oaks solar filter.
Andy



Observing Sessions and Covid19 - Update

Proposed Observation Sessions for 2021-2022

With the start of the WAS face to face meetings at Seend this month, the Observing Team would also like to announce that we will be starting observation evenings for the 2021-2021 season.

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

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

- **Friday 28 September 2021**
- **Friday 08 October 2021 or Friday 29 October 2021**
- **Friday 05 November 2021 or Friday 26 November 2021**
- **Friday 03 December 2021 or/and Christmas Week Meet tba.**
- **Friday 07 January 2022 or Friday 28 January 2022**
- **Friday 04 February 2022 or Friday 25 February 2022**
- **Friday 04 March 2022 or Friday 25 March 2022 (Messier Marathon)**
- **Friday 08 April 2022 or Friday 29 April 2022**
- **Friday 06 May 2022 or Friday 27 May 2022**
- **Friday 03 June 2022 (limited sky darkness)**

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

OUTREACH

Zoom sessions and Google Classroom sessions have kept outreach going to schools

On July 20th I did a real session on the international lunar day to a group of around 50 pensioners at the Wadswick Green retirement centre.

If any schools or clubs are interested in having talks from WAS please contact Andy Burns.

Dark Skies Wales are starting their live observing sessions, but talks are delayed.