NWASNEWS

Volume27 Issue 10

June 2022

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

We'll Be Back...

Sorry we had to go back to a Zoom meeting for June meeting. It was due to circumstances out of our control. The Lye Pavilion had one month to make improvements or they would lose a grant they rely on.

Alternatives were tried, but getting the right evening and time was not possible in the time from confirmation of this work.

WE WILL BE BA|CK AT THE HALL MEETINGS IN SEPTEMBER. And we have delayed the AGM until then. I have a temporary treasurer seconding Bob Johnstone so he should hopefully be allowed to retire next year. But we thank him for his tireless service, dealing with Lloyds bank has not been fun. Red tape, green tape and even blue tape…

This change to Zoom has also affected our speaker for the month, but Professor Matt Griffin has been very accommodating on this. Asteroid Impact… I have included some basics from the web, but I remember standing at the edge of the Vredefort crater in South Africa which was a very beneficial impact, perhaps raising oxygen levels on Earth, but also melted gold into accessible lumps around it crater edge. Then just 10km North going to the Tswaing crater, an impact crater about 220,000 years old. As large as the meteor crater in Arizona but less well known. It is believed to be a stoney chrondite rather than a metal meteorite impact, which is quite rare for an Earth crater. Shoemaker visited thecrater to learn more for teaching Apollo lunarnaughts about expectations on the Moon. One of my bizarre links here… it is with sadness the Earth lost his wife and co comet hunter in May.

It is a bit of a bumper edition with lots of various space news but you have time to read it before we test you in September…

Topic: Wiltshire AS June' Zoom Meeting

Time: Jun 7, 2022 07:45 PM London

Speaker Professor Matt Griffin

Topic: The hazards of Asteroid Impacts on the Earth – Should we worry?

Join Zoom Meeting

https://us02web.zoom.us/j/81811773783?pwd=T25tUHFrMFZHWlpSQmtRM1h1dG1PUT09

Meeting ID: 818 1177 3783

Passcode: 678966

Clear skies Andy

Noctilucent clouds from June 2020, over the Kennet Avenue standing stones and the super surprise of that summer, Comet Neowise to the right of the picture.
The NLCs were so bright driving over that I thought a big event was going on in Swindon!

Andy Burns.

Wiltshire Society Page

Wiltshire Astronomical Society

Web site: www.wasnet.org.uk

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

Meetings 2020/2021.

HALL VENUE the Pavilion, Rusty Lane, Seend

Some Speakers have requested Zoom Mweetings and these will be at home sessions.

Meet 7.30 for 8.00pm start

SEASON 2021/22

2022

7th Jun   Prof Matt Griffin   The hazards of Asteroid Impacts on the Earth – Should we worry?

Professor Matt Griffin

Far infrared and submillimetre astronomy and instrumentation, especially developing technology and instruments for both ground-based and satellite-borne observatories.

Recent and present activities include:

Principal Investigator for the Herschel-SPIRE instrument
Coordinator of the SPACEKIDS European Union FP-7 project
Co-I on FP-7 projects HELP (Herschel-related extragalactic astronomy) and FISICA (FIR interferometry technology development)
Member of the SPICA collaboration and of the ESA SPICA Science Study Team. SPICA was studied by ESA and the Japanese space agency JAXA, for study as a candidate for the ESA M5 mission, but not selected
UK Co-PI for the ARIEL exoplanet characterisation mission, adopted by ESA as its M4 mission, with launch envisaged in 2029

Membership Meeting nights £1.00 for members £3 for visitors

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

Wiltshire AS Contacts

Andy Burns Chair, anglesburns@hotmail.com

Andy Burns Outreach and newsletter editor.

Bob Johnston (Treasurer)

Philip Proven (Hall coordinator)

??? (Teas and Projector)

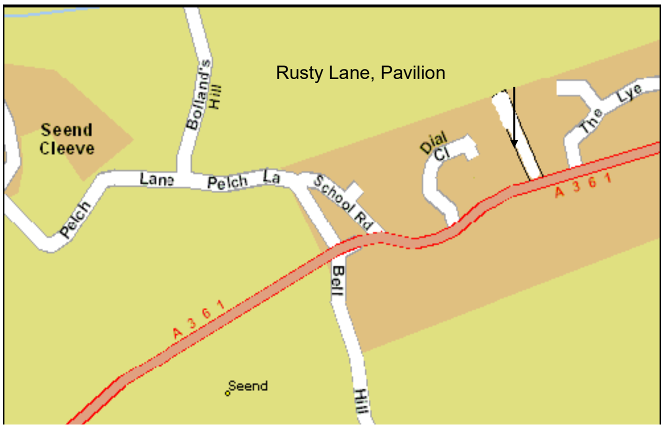
Peter Chappell (Speaker secretary)

Nick Howes (Technical Guru)

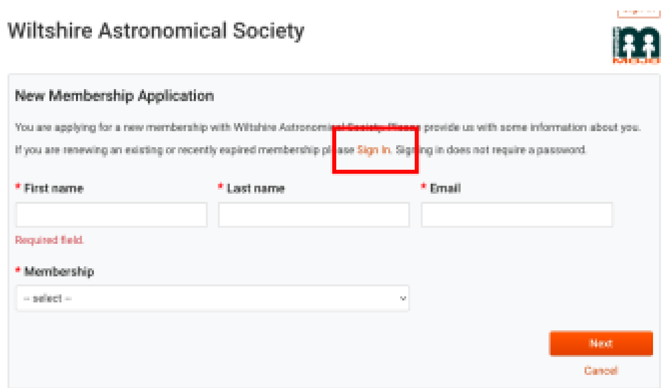
Observing Sessions coordinators: Chris Brooks, Jon Gale,

Web coordinator: Sam Franklin

Contact via the web site details.



Observing Sessions see back page


Wiltshire Astronomical Society

New Membership Application

You are applying for a new membership with Wiltshire Astronomical Society. Please provide us with some information about you.

If you are renewing an existing or recently expired membership please Sign In. Signing in does not require a password.

* First name * Last name * Email

Required field

* Membership

-- select --

Next

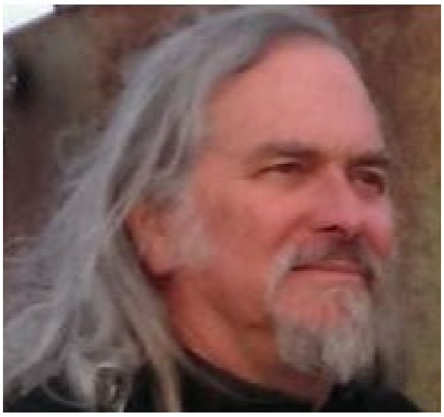
Cancel

Swindon's own astronomy group

Physical meetings continuing!

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

Next meeting: Steve Tonkin



Our speaker on 17 June will Steve Tonkin who whose presentation will be 'Journey Into Space'.

Steve Tonkin is a Fellow of the Royal Astronomical Society and is best known for his expertise in binocular astronomy. He runs a website www.binocularsky.com which contains copious advice about choosing and using binoculars with detailed sky maps showing the best objects to observe. He also writes for 'The Sky At Night' magazine.

Steve is the Dark Skies Advisor to the AONB, and is an astronomy educator, STEM ambassador, and author.

Ad-hoc viewing sessions

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

Membership of Swindon Stargazers is required for insurance purposes (PLI)

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

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

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

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

Meeting Dates for 2022

Friday, 17 June 19.30 onwards

Programme: Steve Tonkin - Journey Into Space

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

Friday, 16 September 19.30 onwards

Programme: Kate Earl - Secret Stowaways

Friday, 21 October 19.30 onwards

Programme: Mark Radice - Deep Sky Observing

Friday, 18 November 19.30 onwards

Programme: Richard Fleet - The Winchcombe Meteorite

Friday, 9 December 19.30 onwards

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 No hall meetings.

STAR QUEST ASTRONOMY CLUB

This young astronomy club meets at the

Sutton Veny Village Hall.

Second Thursday of the Month.

Meet at Sutton Veny near Warminster.

BATH ASTRONOMERS

GRESHAM ON LINE SESSIONS

JUNE
Life in the Universe by Professor Katherine Blundell
Wednesday, June 1, 2022 6:00 PM gres.hm/life-universe
Museum of London / Online Or watch later
How can life form in the Universe, and what are the necessary ingredients for habitability so that planets can sustain life? Can we expect life elsewhere in the solar system, or on exo-planets? This lecture offers a broader perspective from astrobiology, astrochemistry, and astrophysics on the habitability or otherwise of other planets beyond Planet Earth.
Their website
www.gresham.ac.uk
////////
Best wishes for the new Year
Martin
Martin Baker

FAS News and from other societies:

Dear FAS Member

Just a reminder of the free, two-day, international Zoom webinar *The Challenge of Megaconstellations* organised by the FAS and an updated programme for you to send out to your members.

There will be 20 talks of 25 minutes each given by 20 speakers from Australia, Canada, Chile, Germany, the UK and the USA.

The level is aimed at the interested amateur up to early-career post-doctorate researcher so is specifically for those who will be *doing* astronomy over the next couple of decades to be prepared for the challenge of LEO satellite megaconstellations.

For free registration members can go to the FAS website and follow the links (or click on this link) to see the megaconstellation page. At the foot of that page click on the link to the Zoom webinar registration page; you just need to provide your name and a confirmed email address and click on the blue 'Register' button and Zoom will send you the joining link which works for both days.

I urge you to please forward this to your members as soon as possible so that they can register for this, our biggest event yet!

Best wishes

Paul

EARTH STRIKE!
A BACKGROUND NOTE FOR OUR TALK

Crater	Location	Radius (km)	Estimated Impact Date
Vredefort Crater	Free State, South Africa	190	2 billion years ago
Sudbury Basin	Ontario, Canada	130	1.8 billion years ago
Acraman Crater	South Australia, Australia	90	580 million years ago
Woodleigh Crater	Western Australia, Australia	40-120	360 million years ago
Manicouagan Crater	Quebec, Canada	100	215 million years ago
Morokweng Crater	North West, South Africa	70	145 million years ago
Kara Crater	Nenetsia, Russia	65	70.3 million years ago
Chicxulub Crater	Yucatan, Mexico	170-300	65 million years ago
Popigai Crater	Siberia, Russia	100	35.7 million years ago
Chesapeake Bay Crater	Virginia, United States	85	35 million years ago

Notable Asteroid Impacts in Earth's History

Throughout Earth's history, there have been many instances of near-Earth objects (NEOs) impacting our planet, either reaching the surface [illegible] ploding above ground from the intense energy released as the obje[illegible] shape the surface of our planet, like volcanoes. The vast majority o[illegible] ble exceptions.

The Chelyabinsk Event

In 2013, an asteroid about 20 meters in diameter entered Earth's atmosphere above the city of Chelyabinsk, Russia. It exploded while it was [illegible] the air, releasing the same amount of energy as 500 kilotons of TNT. Luckily it exploded about 30 kilometers above ground and did not cause [illegible] impact damage. Still, it created a shockwave that injured 1,500 peo[illegible] caused by curiosity: people saw the bright flash and walked to winc[illegible] arrived later and shattered the windows, injuring people with flying glass.

The Tunguska Event

In 1908 an approximately 30-meter-diameter asteroid or comet entered the atmosphere and exploded above ground in Tunguska, Russia. Th[illegible] plosion knocked down approximately 80 million trees over an area of 2,150 square kilometers (830 square miles). This explosion has been e[illegible] at 1,000 times more powerful than the explosion of the atomic bomb at Hiroshima. Had this taken place over a metropolitan area, that city wo[illegible] have been completely destroyed. Luckily, it happened in a remote area of Siberia, and nobody is thought to have been killed.

The Chicxulub Event

65 million years ago an asteroid roughly 10 to 15 kilometers (6 to 9 miles) in diameter hit the Earth in what is now Mexico. The impact killed 70% [illegible] species on Earth, including the dinosaurs.

An impact of that size would have had devastating effects, and the geological record gives us an indication of what happened. The astero[illegible] water, creating mega-tsunamis reaching from southeastern Mexico all the way to Texas and Florida and up a shallow interior ocean that cove[illegible] what is now the Great Plains. The blast would have thrown chunks of the asteroid and Earth so far that they would have briefly left the atmos[illegible] before falling back to the ground.

Like millions of shooting stars, all this material would have been heated to incandescence upon re-entry, heating Earth's surface and igniting [illegible] fires. It is possible that all of Earth's forests burned. Meanwhile, colossal shockwaves would have triggered global earthquakes and possibly [illegible] eruptions. A cloud of super-heated dust, ash and steam would have spread from the crater as the impactor slammed underground in less tha[illegible] ond. This dust could have covered the entire surface of Earth for up to a decade, creating a harsh environment for living things. Perhaps mor[illegible] cantly, the dust could also have lingered in the atmosphere, blocking out the Sun and interrupting the photosynthesis of plants that the entire [illegible] chain depends on, as well as cooling the temperatures of the Earth for many years.

The Next Event?

Although immense impactors like the one that devastated the entire planet 65 million years ago are rare, NEOs of many different sizes can p[illegible] serious threats. An impact on or over a densely populated city could cause millions of deaths, and an impact on water could cause massive f[illegible] on coastlines. Any major impact would lead to widespread damage, injury and death, and would create humanitarian and refug[illegible] ses around the world.

What is at stake?

The largest near-Earth asteroids (> 1 km diameter) have the potential to cause geologic and climate effects on a global scale, disrupting human civilization, and perhaps even resulting in extinction of the species. Smaller NEOs in the 140m to 1 km size range could cause regional up to continental devastation, potentially killing hundreds of millions. Impactors in the 50 to 140-meter diameter range are a local threat if they hit in a populated region and have the potential to destroy city-sized areas. NEOs in the 20 to 50 m diameter range are generally disintegrated in Earth's atmosphere but can cause localized blast and impact effects.

"The largest near-Earth asteroids – those with a diameter of more than 1 kilometre – have the potential to cause geologic and climate effects on a global scale, disrupting human civilisation, and perhaps even resulting in the extinction of our species."

How much do we know?

Surveys of the NEO population ongoing since the 1990s have discovered more than 26,000 NEOs of all sizes as of June 2021. A new record 2959 NEOs of all sizes were discovered in 2020. The current surveys have discovered more than 96% of the population of NEOs larger than 1 km in diameter – 889 individual asteroids. In the United States, NASA's Planetary Defense Program has a Congressionally directed objective to discover at least 90% of potentially hazardous asteroids 140 meters and larger in size. As of 1 June 2021, 9663 NEOs larger than 140 m have been discovered. This is estimated to be approximately 39% of the total population of NEOs this size or larger. Smaller asteroids are also continually being discovered, with the estimated number of NEOs with diameters between 50 and 140 meters expected to be approximately 300,000, making these the more likely impact threat in the near term. Impactors of these sizes are expected to have an average frequency of one per ~1000 years. The Tunguska event (1908) is believed to have been an impactor in the lower end of this size range. The total number of NEOs larger than 10 m could be as high as 50-100 Million.

What are key factors affecting risk levels?

The assessment of the risk presented by an NEO is related to the probability of impact with Earth, the size and composition of the asteroid, and where on Earth the impact occurs. Beyond discovery of NEOs, the risk assessment for a NEO with the potential to impact Earth requires an observational assessment program to refine knowledge of the orbit and to characterize the size and composition of the asteroid. This could include specialized ground and space based observations, or a spacecraft reconnaissance mission to the asteroid. Accurate orbital knowledge is required to establish the "impact corridor" – the areas on Earth where, given uncertainties in the orbital knowledge, the impact is most likely to occur. The impact location and potential severity of damage will determine the risk level, and the required governmental response, either in terms of disaster preparedness or potential asteroid deflection attempts.

The recent sample return missions to the asteroids Ruygu (Hayabusa2) and Bennu (OSIRES-REx) contribute considerable to our knowledge of these NEOs. The main objectives of these missions were scientific, but the characterisation of natural parameters of these objects is also important for planning of potential future Planetary Defence missions.

"With vigilance and sufficient warning, an asteroid impact is a devastating natural disaster that can be prevented."

In the event of a credible impact threat prediction, warnings will be issued by the IAWN if the object is assessed to be larger than 10 meters in size. If the object is larger than about 50 m and the impact probability is larger than 1% within the next 50 years, the SMPAG would start to assess in-space mitigation options and implementation plans for consideration by the Member States. With vigilance and sufficient warning, an asteroid impact is a devastating natural disaster that can be prevented.

At the end of 2021 the DART impactor will be launched by NASA. DART will impact Dimorphos, the smaller 160 m companion of the 780 m large Didymos, in early fall 2022. It will test the capabilities to deflect an asteroid by a high velocity impact of the spacecraft. A few years later ESA will launch the HERA spacecraft to study the impact effects in detail. If successful these missions will demonstrate that an impact can be avoided by active measures if the object is discovered soon enough.

SMPAG plans to perform exercises to test their function and coordination for realistic impact threats. These exercises should also clarify the working procedure, form of recommendations and flow of information. They should also identify missing technologies and other potential deficiencies in the field of space-based NEO mitigation.

The issue of near-Earth objects (NEOs) has long been on the agenda of the Committee on the Peaceful Uses of Outer Space (COPUOS), the primary United Nations body for coordinating and facilitating international cooperation in space activities, established in 1959 by the UN General Assembly and supported by the Office for Outer Space Affairs (UNOOSA). In the last year several important events have contributed to our understanding of NEOs and to a better preparedness in case of a real impact threat. The International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG) provide mechanisms at the global level to address the global challenge posed by NEOs, including detection, tracking and impact risk assessment and, subsequently, planetary defence measures like civil protection or asteroid deflection.

UNOOSA, through the IAWN and SMPAG, facilitates the dissemination of information related to NEOs to UN Member States. Important linkages are being made with civil protection communities, including through UNOOSA's UN-SPIDER programme and its global network of Regional Support Offices (RSOs).

IAWN and SMPAG - global mechanisms for coordinating action in the area of planetary defence

The IAWN links together the institutions that are already performing many of the proposed functions, including: discovering, monitoring and physically characterizing the potentially hazardous NEO population. One of its purposes is to maintain an internationally recognized clearing house for the receipt, acknowledgment and processing of all NEO observations. IAWN recommends policies regarding criteria and thresholds for notification of an emerging impact threat. IAWN also assists Governments in the analysis of impact consequences and in the planning for mitigation responses, using well-defined communication plans and protocols (see iawn.net). As at June 2021, there are thirty-two official signatories to the IAWN Statement of Intent.

The SMPAG, (pronounced "same page") is composed of Member States with space agencies or inter-governmental entities that coordinate and fund space activities and are capable of contributing to or carrying out a space-based NEO mitigation campaign. In the event of a credible impact warning by the IAWN, the SMPAG would assess and propose through their member Governments space-based mitigation options and implementation plans for consideration by the Member States. SMPAG currently has 19 members and 6 permanent observers, with UNOOSA acting as its secretariat. In 2016, SMPAG established the Ad-Hoc Working Group on Legal Issues to address possible legal questions related to the work of SMPAG. This group published a report entitled ´Planetary Defence Legal Overview and Assessment´ (see smpag.net under ´Documents and presentations´).

International Asteroid Day

As part of the effort to raise awareness about this topic, the UN General Assembly proclaimed in resolution A/71/492 that International Asteroid Day would be observed annually on 30 June to raise public awareness of the asteroid impact hazard. 30 June is the anniversary of the Tunguska impact over Siberia in what is now the Russian Federation, which occurred on 30 June 1908. That event was Earth's largest confirmed asteroid impact in recorded history, devastating over 2,000 square kilometres of forest.

International Planetary Defense Conference (PDC) 2021

As the key biannual global conference that brings together key experts in this area, the 7th International IAA (International Academy of Astronautics) PDC was hosted by UNOOSA from 26 to 30 April 2021 as a virtual conference that attracted wide audience, with more than 700 participants from all over the globe. Highlight presentations included results from the sample return space missions Hayabusa2 (lead by JAXA) and OSIRIS-REx (lead by NASA) and latest status information on the upcoming missions DART and HERA which will demonstrate the capability to deflect an asteroid by the kinetic impactor technique. The 2021 PDC also included a number of dedicated panels on different aspects of Planetary Defence. In a panel with Heads and Representatives of Space Agencies, 11 high ranked officials (from AEB, AEM, Austrian Space Agency FFG, CNSA, ESA, KASI, NASA) gave statements and expressed their support for international collaboration on Planetary Defence issues. As in previous PDCs, a hypothetical asteroid impact scenario was part of the Conference. This time the scenario included a hypothetical impactor of approximately 100 m in size discovered only six months before impact. Due to the imposed short warning time, a space mission for deflection was not possible. The main emphasis of this exercise was an assessment of impact effects and the role, interaction and mitigation measures from civil protection agencies. Several disaster management representatives from both national, regional and intergovernmental levels (Copernicus EMS, ERCC, FEMA, UN-SPIDER, UNOSAT) were engaged in discussing practical solutions to this hypothetical asteroid scenario that was initially predicted to pose a threat to most parts of Earth and eventually impacted the border areas of Austria, Czech Republic and Germany. The next PDC will be held in 2023 and hosted again by UNOOSA in Vienna as an in-person or hybrid meeting.

SPACE NEWS TO JUNE 22

Does a "Mirror World of Particles" Explain the Crisis in Cosmology?

The idea of a mirror universe is a common trope in science fiction. A world similar to ours where we might find our evil doppelganger or a version of us who actually asked out our high school crush. But the concept of a mirror universe has been often studied in theoretical cosmology, and as a new study shows, it might help us solve problems with the cosmological constant.

The Hubble constant, or Hubble parameter, is a measure of the rate at which our universe expands. This expansion was first demonstrated by Edwin Hubble, using data from Henrietta Leavitt, Vesto Slipher, and others. Over the next several decades, measurements of this expansion settled on a rate of about 70 km/sec/Mpc. Give or take quite a bit. Astronomers figured that as our measurements became precise, the various methods would settle on a common value, but that didn't happen. In fact, in the past several years measurements have become so precise they outright disagree. This is sometimes known as the cosmic tension problem.

At this point the observed values of the Hubble constant cluster into two groups. Measurements of fluctuations in the cosmic microwave background point toward a lower value, around 67 km/sec/Mpc, while observations of objects such as distant supernovae yield a higher value around 73 km/sec/Mpc. Something clearly doesn't add up, and theoretical physicists are trying to figure out why. This is where the mirror universe might come in.

A mirror of our world in the stars. Credit: Beate Bachmann, via Pixabay

Wild ideas tend to fall in and out of popularity in theoretical physics. The mirror universe idea is no exception. It was studied quite a bit back in the 1990s as a way to deal with the problem of matter-antimatter symmetry. We can create matter particles in the lab, but when we do, we also create antimatter particles. They always come in pairs. So when particles formed in the early universe, where did all their antimatter siblings go? One idea was that the universe itself formed as a pair. Our matter universe and a similar antimatter universe. Problem solved. The idea fell out of favor for various reasons, but this new study looks at how it might solve the Hubble problem.

The team discovered an invariance in what are known as unitless parameters. The most famous of these is the fine structure constant, which has a value of about 1/137. Basically, you can combine measured parameters in such a way that all the units cancel out, giving you the same number no matter what units you use, which is great if you are a theoretician. The team found that when you tweak cosmological models to match the observed expansion rates, several unitless parameters stay the same, which suggests an underlying cosmic symmetry. If you impose this symmetry more broadly, you can scale the rate of gravitational free-fall and the photon-electron scattering rate so that the different methods of Hubble measurement better agree. And if this invariance is real, it implies the existence of a mirror universe. One that would affect our universe through a faint gravitational pull.

It should be pointed out that this study is mostly a proof of concept. It lays out how this cosmic invariance might solve the Hubble constant problem, but doesn't go so far as to prove it's a solution. A more detailed model will be needed for that. But it's an interesting idea. And it's good to know that if your evil doppelganger is out there, they can only influence your life gravitationally…

The Early Solar System was Total Mayhem

There's no question that young solar systems are chaotic places. Cascading collisions defined our young Solar System as rocks, boulders, and planetesimals repeatedly collided. A new study based on chunks of asteroids that crashed into Earth puts a timeline to some of that chaos.

Astronomers know that asteroids have remained essentially unchanged since their formation in the early Solar System billions of years ago. They're like rocky time capsules that contain scientific clues from that important epoch because differentiated asteroids had mantles that protected their interiors from space weathering.

But not all asteroids remained whole. Over time, repeated collisions stripped the insulating mantles away from their iron cores and then shattered some of those cores into pieces. Some of those pieces fell to Earth. Rocks that fell from space were of great interest to people and were a valuable resource in some cases; King Tut was buried with a dagger made from an iron meteorite, and Inuit people in Greenland made tools out of an iron meteorite for centuries.

Scientists are keenly interested in iron meteorites because of the information they contain. A new study based on iron meteorites—which are fragments from the core of larger asteroids—looked at isotopes of Palladium, Silver, and Platinum. By measuring the amounts of those isotopes, the authors could more tightly constrain the timing of some events in the early Solar System.

The paper "The dissipation of the solar nebula constrained by impacts and core cooling in planetesimals" is published in Nature Astronomy. The lead author is Alison Hunt from ETH Zurich and the National Centre of Competence in Research (NCCR) PlanetS.

"Previous scientific studies showed that asteroids in the solar system have remained relatively unchanged since their formation, billions of years ago," Hunt said. "They, therefore, are an archive in which the conditions of the early solar system are preserved."

The ancient Egyptians and the Inuit didn't know anything about elements, isotopes, and decay chains, but we do. We understand how different elements decay in chains into other elements, and we know how long it takes. One of those decay chains is at the heart of this work: the short-lived 107Pd–107Ag decay system. That chain has a half-life of about 6.5 million years and is used to detect the presence of short-lived nuclides from the early Solar System.

The researchers gathered samples of 18 different iron meteorites that were once parts of the iron cores of asteroids. Then they isolated the Palladium, Silver, and Platinum in them and used a mass spectrometer to measure the concentrations of different isotopes of the three elements. A particular isotope of Silver is critical in this research.

One of the iron meteorites that the researchers analyzed in their study. Image Credit: Aurelia Meister

During the first few million years of the Solar System's history, decaying radioactive isotopes heated the metallic cores in asteroids. As they cooled and more of the isotopes decayed, an isotope of Silver (107 Ag) accumulated in the cores. The researchers measured the ratio of 107 Ag to other isotopes and determined how quickly the asteroid cores cooled and when.

This is not the first time researchers have studied asteroids and isotopes in this way. But earlier studies didn't account for the effects of galactic cosmic rays (GCRs) on the isotope ratios. GCRs can disrupt the neutron capture process during decay and can decrease the amount of 107 Ag and 109 Ag. These new results are corrected for GCR interference by also counting Platinum isotopes.

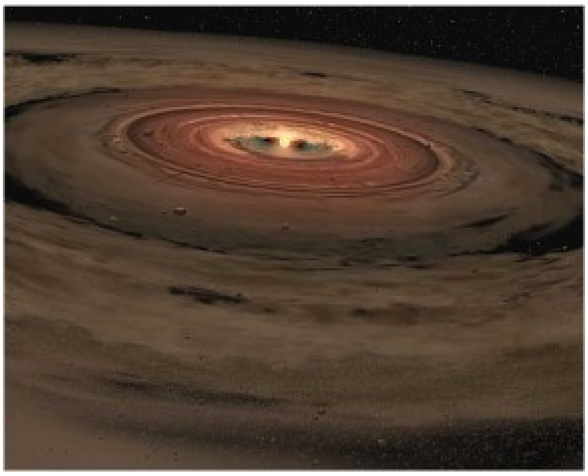
"Our additional measurements of Platinum isotope abundances allowed us to correct the Silver isotope measurements for distortions caused by cosmic irradiation of the samples in space. So we were able to date the timing of the collisions more precisely than ever before," Hunt reported. "And to our surprise, all the asteroidal cores we examined had been exposed almost simultaneously, within a timeframe of 7.8 to 11.7 million years after the formation of the solar system," Hunt said.

An artist's conception of an asteroid collision in the belt between Mars and Jupiter. Credit: NASA/JPL-Caltech

A four million-year time span is short in astronomy. During that brief period, all of the asteroids measured had their cores exposed, meaning collisions with other objects stripped away their mantles. Without the insulating mantles, the cores all cooled simultaneously. Other studies have shown that the cooling was rapid, but they couldn't constrain the timeframe as clearly.

For the asteroids to have the isotope ratios the team found, the Solar System had to be a very chaotic place, with a period of frequent collisions that stripped the mantles from asteroids.

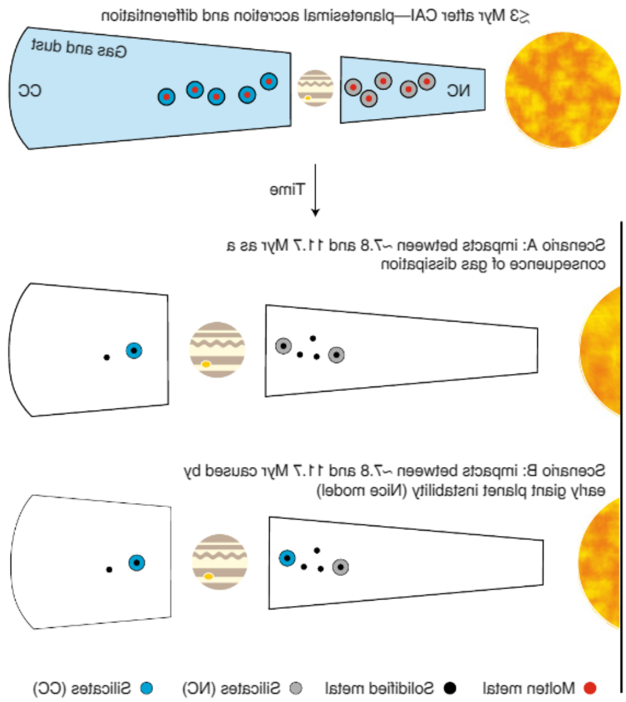
"Everything seems to have been smashing together at that time," Hunt says. "And we wanted to know why," she adds. Why would there be a period of such chaotic collisions? There are a couple of possibilities, according to the paper. The first possibility concerns the Solar System's giant planets. If they migrated or were unstable somehow at that time, they could've reorganized the inner Solar System, disrupted small bodies like asteroids, and triggered a period of increased collisions. This scenario is called the Nice model. The other possibility is gas drag in the solar nebula.



Artist's impression of the Solar Nebula. Image credit: NASA

When the Sun was a protostar, it was surrounded by a cloud of gas and dust called a solar nebula, just like other stars. The disk contained the asteroids, and the planets would eventually form there too. But the disk changed in the Solar System's first few million years.

At first, the gas was dense, which slowed down the motion of things like asteroids and planetesimals with gas drag. But as the Sun got going, it produced more solar wind and radiation. The solar nebula was still there, but the solar wind and radiation pushed on it, dissipating it. As it dissipated, it became less dense, and there was less drag on objects. Without the dampening effect of dense gas, asteroids accelerated and collided with each other more frequently.

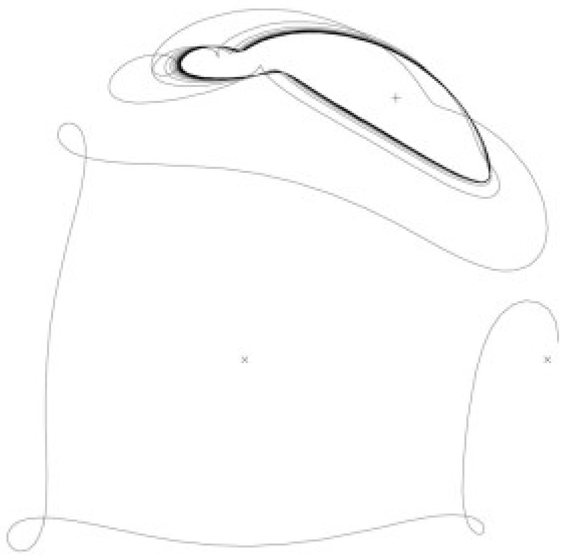


This figure from the study shows the evolution of differentiated iron meteorite bodies in the early Solar System. At the top, the parent bodies accrete and differentiate within the first ~3 Myr after CAI formation. Then there are two compet-

ing scenarios for the period of increased collisions among asteroids. Scenario A is the gas dissipation scenario and the one that the research team thinks fits the data best. Scenario B is the Nice model, where a giant planet creates instability and causes a period of increased collisions. Image Credit: Hunt et al. 2022.
According to Hunt and her colleagues, the reduction of gas drag is responsible.
“The theory that best explained this energetic early phase of the solar system indicated that it was caused primarily by the dissipation of the so-called solar nebula,” study co-author Maria Schönbächler explained. “This solar nebula is the remainder of gas that was left over from the cosmic cloud out of which the Sun was born. For a few million years, it still orbited the young Sun until it was blown away by solar winds and radiation,” Schönbächler said.
“Our work illustrates how improvements in laboratory measurement techniques allow us to infer key processes that took place in the early solar system – like the likely time by which the solar nebula had gone. Planets like the Earth were still in the process of being born at that time. Ultimately, this can help us to better understand how our own planets were born, but also give us insights into others outside our solar system,” Schönbächler concluded.

Objects That Share the Same Orbit are Common in the Solar System. But we’ve Never Seen co-Orbital Exoplanets. Why?

“Where are all the Trojans” is a question valid in both the study of ancient history and the study of exoplanets. Trojan bodies, which share orbital paths with other, larger planets, are prevalent in our solar system – most obviously in the Trojan asteroids that follow Jupiter around on its orbital path. However, they seem absent from any star system found with exoplanets. Now, a team of researchers from the SETI Institute and NASA’s Ames Research Center thinks they have found a reason why.
According to Anthony Dobrovolski of SETI and Jack Lissauer of Ames, an extreme version of tides might be the cause. While most people think of tides as simply a reason the water goes in and out of shorelines everywhere, there’s another effect that is much more difficult to discern. The friction from all that water moving back and forth on the Earth’s surface actually slows down the planet’s rotation. In turn, that slower rotation allows the Moon to slip farther and farther away.
Sure the speed and distances are almost imperceptible – about 1.78 milliseconds over a century and 3.78 cm per year, to be precise. But scale those up to billions of years that it takes a planet to form, and you’re talking about some pretty significant changes. That idea inspired the team to think about how much tidal forces might play a role
.It turns out it could be a pretty significant role. The researchers developed a model that placed an Earth-size planet at either the L4 or L5 Lagrange points of a giant planet or its equilateral point. They noticed that the tides caused by the three-body system caused what looked like innocuous original oscillations in the orbit of the Earth-sized planet to eventually spiral out of control, ultimately knocking the planet itself into either its giant neighbor or the star itself.
Given that the current technology we have only lets us view planets down to about Earth-sized, this model would show how unlikely a planet of that magnitude would form in the orbital pathway of a much larger planet. However, there is still a chance that a smaller planet, or even a set of asteroids such as the Trojans and Greeks, might be able to hold the same orbit as a larger planet without being disrupted by tidal forces.



A graphical depiction of the orbit that a potential Trojan exoplanet takes when under the influence of tidal forces.
Credit – SETI Institute
If there are any such objects, it will only be a matter of time before we find them, with humanity’s ever-increasing ability to detect exoplanets. When we do, the new model will also help to inform astronomers about the internal make-up of any such co-orbital planet. That might come in handy sooner rather than later, as there is already a mission on its way to the Trojan asteroids. Lucy, which launched in October, could help characterize what the co-orbital objects in our own solar system look like – and therefore be able to help characterize what they might look like in other star systems. Either way, finding the Trojans will continue to be a question with very cross-disciplinary roots.

The Stars in Other Galaxies are Generally Heavier Than the Milky Way’s Stars

How many of what kinds of stars live in other galaxies? It seems like a simple question, but it’s notoriously hard to pin down, because astronomers have such a difficult time estimating stellar populations in remote galaxies. Now a team of astronomers has completed a census of over 140,000 galaxies and found that distant galaxies tend to have heavier stars.

Stellar Census

Even though astronomers lack a complete census of all the hundreds of billions of stars in the Milky Way galaxy, they’ve sampled enough of them to get a pretty good handle on the population. We know, roughly, how many small dwarf stars there are, how many medium Sun-like ones there are, and how many giant ones there are.
But repeating this exercise for other galaxies is enormously difficult. Most galaxies are simply too far away to identify and measure individual stars within them. We only see their brighter, heavier stars, and have to guess about the populations of smaller ones. Typically astronomers just assume that the demographics of a distant galaxy roughly match what we see in the Milky Way, because on average galaxies shouldn’t be all that different from each other.
Recently a team of astronomers used the COSMOS catalog to study 140,000 individual galaxies, developing techniques to estimate the population of stars in each one. The research was conducted at the Cosmic Dawn Center (DAWN), an international basic research center for astronomy supported by the Danish National Research Foundation. DAWN is a collaboration between the Niels Bohr Institute at the University of Copenhagen and DTU Space at the Technical University of Denmark.

The future fate of heavier galaxies

"We've only been able to see the tip of the iceberg and known for a long time that expecting other galaxies to look like our own was not a particularly good assumption to make. However, no one has ever been able to prove that other galaxies form different populations of stars. This study has allowed us to do just that, which may open the door for a deeper understanding of galaxy formation and evolution," says Associate Professor Charles Steinhardt, a co-author of the study.

The team found that on average more distant galaxies tended to have bigger stars than the Milky Way. On the other hand, nearby galaxies were relatively similar to our own.

The Messier 60 Elliptical Galaxy. Credits: NASA, ESA and the Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration

"The mass of stars tells us astronomers a lot. If you change mass, you also change the number of supernovae and black holes that arise out of massive stars. As such, our result means that we'll have to revise many of the things we once presumed, because distant galaxies look quite different from our own," says Albert Sneppen, a graduate student at the Niels Bohr Institute and first author of the study.

This work has several important implications. For one, astronomer can no longer assume a uniform population of stars when looking at distant galaxies, which represent the youngest galaxies to appear in the universe. It also forces us to rethink how galaxies evolve through billions of years.

"Now that we are better able to decode the mass of stars, we can see a new pattern; the least massive galaxies continue to form stars, while the more massive galaxies stop birthing new stars. This suggests a remarkably universal trend in the death of galaxies," concludes Albert Sneppen.

Compare Sand Dunes Across the Solar System, From Venus to Pluto

One of the most interesting things we can learn from studying the planets and bodies of our Solar System is how much they have in common. Mars has polar ice caps and features that formed in the presence of water. Venus is similar to Earth in size, mass, and composition and may have once been covered in oceans. And countless icy bodies in the Solar System experience volcanism and have active plate tectonics, except with ice and water instead of hot silicate magma. Another thing they have in common, which may surprise you, is sand dunes!

According to a new study by researchers from Monash University and the University of Pennsylvania, multiple planets in our Solar System have sand dunes on their surfaces – just in different forms! These features further indicate that the mechanisms for dune formation are ubiquitous throughout the Solar System.

These findings could lead to new methods for assessing the surface conditions of planets and moons and could have significant implications for future robotic and crewed missions to study them up-close.

The research was conducted by Andrew Gunn, a lecturer in physical geography at the School of Earth, Atmosphere and Environment at Monash University in Victoria, Australia; and Douglas J. Jerolmack, a professor with the Department of Earth and Environmental Science and Mechanical Engineering and Applied Mechanics at the University of Pennsylvania. The paper that describes their findings, "Conditions for aeolian transport in the Solar System," recently appeared in the journal *Nature.*

Mars' Barchan Dunes, captured by the MRO's HiRISE Camera. Credit: NASA/ HiRISE/MRO/LPL (UofA)

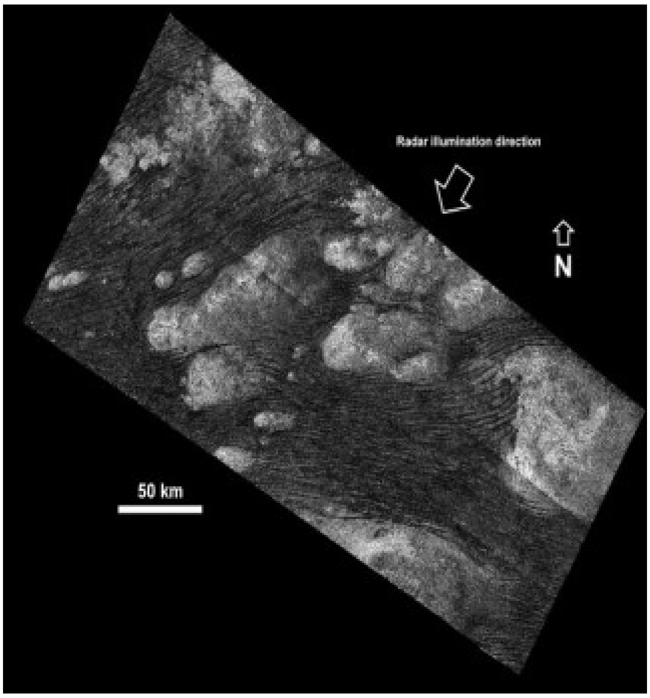
As they indicate in their paper, the mere presence of sand dunes can be used to infer what conditions exist on the surface of an astronomical body. Specifically, they considered the two criteria that need to be satisfied for sand-dune formation. These include the presence of loose sediment that is sufficiently strong to survive collisions and winds that are fast enough to transport these grains across the surface. As Gunn explained in an article with *The Conversation*, this is similar to habitability studies – where surface conditions are inferred on an exoplanet based on how close it orbits to its parent star:

"For dunes to even exist, there are a pair of "Goldilocks" criteria that must be satisfied. First is a supply of erodible but durable grains. There must also be winds fast enough to make those grains hop across the ground – but not fast enough to carry them high into the atmosphere."

"So far, the direct measurement of winds and sediment has only been possible on Earth and Mars. However, we have observed wind-blown sediment features on multiple other bodies (and even comets) by satellite. The very presence of such dunes on these bodies implies the Goldilocks conditions are met."

For their study, Gunn and Jerolmack focused on Venus, Earth, Mars, Titan (Saturn's largest moon), Triton (Neptune's largest moon), and Pluto. In all cases, scientists have noted the presence of dune-like features and indications that the surfaces of these bodies are dynamic (they move over time). These observations have been the subject of debate for decades because of how remarkably different these planetary environments are. For instance, Triton and Pluto both have extremely tenuous atmospheres that are believed to be incapable of moving grains.

Mars has a denser atmosphere, but scientists still consider it to be too whispy to generate the wind speeds required to create its massive dust storms and an extensive system of dunes. On the other hand, Titan has an abundance of hydrocarbon "grains" on its surface and a dense atmosphere capable of generating stronger winds. During its descent into the atmosphere, the Huygens lander clocked wind speeds of up to 120 m/s (430 km/h; 267 mi) in the upper atmosphere. Wind speeds closer to the surface were relatively gentle (just a few m/s) but still strong enough to transport grains.



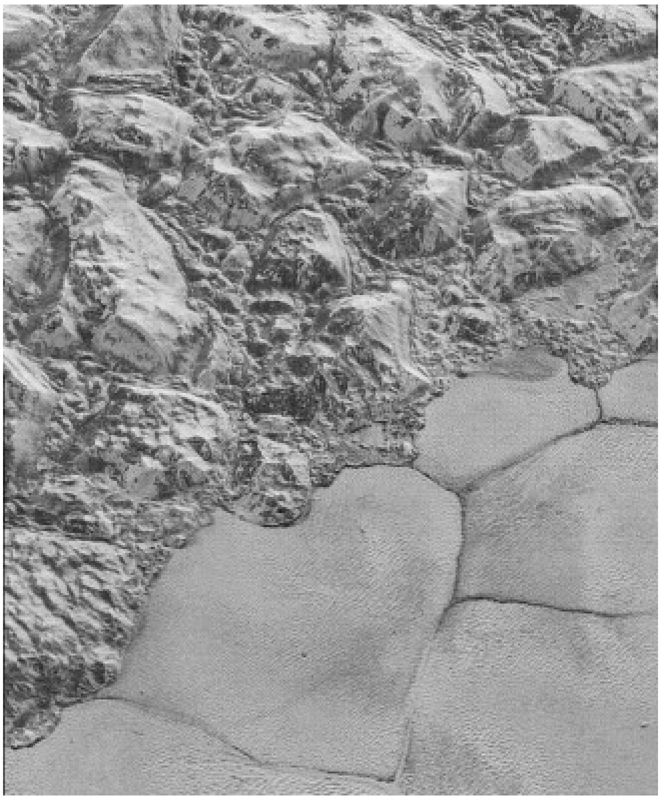
The Shangri-La Sand Sea on Titan, as imaged by the Cassini orbiter. Credit: NASA/JPL-Caltech/ASI

Venus, meanwhile, has a stiflingly dense atmosphere (100 times that of Earth) and average surface temperatures that are hot enough to melt lead. And yet, it also has extensive dunes that indicate an ability to move sediment on its surface the same way wind and water do on Earth. To help resolve the debate on how sand dunes can exist in such exotic and different environments, Gunn and Jerolmack created a model that predicts the required wind speed to move sediment on these bodies and how easily it would break apart in those winds.

This model resulted from previous studies examining the contact, rarefied gas, and statistical and adhesion mechanics of dune features on these bodies. These studies were based on data obtained by numerous robotic missions like the *Mars Reconnaissance Orbiter* (MRO), the *Cassini-Huygens* mission, and the *New Horizons* mission – which conducted the first-ever flyby of Pluto on July 14th, 2015. They then tested these predictions against experimental data and observations of these bodies to account for variables like gravity, atmospheric composition, surface temperature, and the strength of sediments.

As Gunn explained, previous studies into extraterrestrial sand dunes have either examined the wind speed thresholds required to move sand on these bodies and the strength of sediment particles – but not both. Therefore, their study is unique in how it combines these two factors and how they work together in different planetary environments. Their analysis could shed light on the atmospheric and environmental dynamics on many Solar System bodies. Said Gunn:

"[W]e know Titan's equator has sand dunes – but we aren't sure of what sediment encircles the equator. Is it pure organic haze raining down from the atmosphere, or is it mixed with denser ice? As it turns out, we discovered loose aggregates of organic haze would disintegrate upon collision if they were blown by the winds at Titan's equator. This implies Titan's dunes probably aren't made of purely organic haze. To build a dune, sediment must be blown around in the wind for a long time (some of Earth's dune sands are a million years old)."



The Mountainous Shoreline of Sputnik Planum on Pluto. Great blocks of Pluto's water-ice crust appear jammed together in the informally named al-Idrisi mountains. Credit: NASA/JHUAPL/SwRI

Their results also revealed that wind-blown sands generate more dust on Mars than on Earth, which could mean that the model does not effectively capture Mars' "katabatic" winds. These strong gusts of cold wind occur at night on Mars and are responsible for blowing sediment down hillsides. As for Pluto, they found that wind speeds would have to be excessively fast to transport grains (which are thought to be composed of methane or nitrogen ice), which could mean that the features spotted in Pluto's Sputnik Planitia (shown above) might be sublimation waves rather than dunes.

The results of this study could have significant implications for future research into planets and natural satellites. For example, data obtained by the *Galileo* spacecraft revealed dune-like features on Jupiter's volcanic moon Io. Here too, scientists were skeptical since the atmosphere is too thin to accommodate anything but the weakest winds. However, a recent study showed that a volcanic mechanism was responsible for their formation.

These studies show the effectiveness of combining advanced simulations with astronomical observations. By creating a model that can predict wind and grain transport on other bodies, Gunn and Jerolmack's study will benefit from the many robotic missions that will explore these bodies in the coming years. For instance, Mars will be visited by the ESA's *Rosalind Franklin* rover, India's *Mangalyaan 2* orbiter, JAXA's *Mars Exploration of Life and Organism Search* (MELOS), and the NASA-ESA *Sample Return Mission* (SRM) before the decade is over.

These results could also inform the crewed missions to Mars that NASA and China hope to mount by the early 2030s. NASA's *Dragonfly* mission will launch in 2027 and arrive on Titan by 2034 to explore its surface, atmosphere, and methane lakes. In the recently-released Planetary Science and Astrobiology Decadal Survey (2023-2032), an orbiter mission was considered to study the Neptune-Triton system (but was passed over in favor of a mission to study Uranus). This overall aim, however, is clear: the exotic locations of the Solar System are on the agenda, and the secret they hold won't remain secret forever.

Hubble Sees Two Spiral Galaxies Together

Two peculiar spiral galaxies are in the latest image release from the Hubble Space Telescope. The two galaxies, collectively known as Arp 303, are located about 275 million light-years away from Earth. IC 563 is the odd-shaped galaxy on the bottom right while IC 564 is a flocculent spiral at the top left.

Fittingly, these two oddball galaxies are part of the Atlas of Peculiar Galaxies, which is a catalog of unusual galaxies produced by astronomer Halton Arp in 1966. He put together a total of 338 galaxies for his atlas, which was originally published in 1966 by the California Institute of Technology.

Two spiral galaxies, collectively known as Arp 303, are seen in this image from the Hubble Space Telescope. Credit: NASA, ESA, K. Larson (STScI), and J. Dalcanton (University of Washington); Image Processing: G. Kober (NASA Goddard/Catholic University of America).

What Arp wanted to do in his catalog was provide examples of the different kinds of peculiar structures found among galaxies. While most of the entries in the catalog consist of single galaxies, some of the objects were entered as interacting galaxies, and others as groups of galaxies.

Interacting galaxies usually have a distorted shape, while galaxy groups are simply gravitationally bound to each other but not necessarily close enough to each other to induce major structural changes.

While the two galaxies in Arp 303 aren't exceptionally close to each other, they do look distorted. Therefore, Arp entered Arp 303 as "unclassified." Objects 298–310 in his atlas are considered unclassified, and they are mostly interacting galaxy pairs.

Another unusual Arp pair, Arp 299 (parts of it are also known as IC 694 and NGC 3690) is a pair of colliding galaxies approximately 134 million light-years away in the constellation Ursa Major. Credit: NASA/ESA/Hubble Heritage team.

Since the Hubble Space Telescope is able to zoom in on the individual galaxies with its multiple instruments, this image is actually created from two separate Hubble observations of Arp 303. The first used Hubble's Wide Field Camera 3 (WFC3) to study the pair's clumpy star-forming regions in infrared light. The Hubble team said that galaxies like IC 563 and IC 564 are very bright at infrared wavelengths and host many bright star-forming regions.

The second observation was taken with Hubble's Advanced Camera for Surveys (ACS) to take quick looks at bright, interesting galaxies across the sky. The observations filled gaps in Hubble's archive and looked for promising candidates that Hubble, the James Webb Space Telescope, and other telescopes could study further.

Source: NASA

Voyager 1 is Sending Home Strange Telemetry Data

Old computer systems have a lot of wacky ways to fail. Computers that are constantly blasted by radiation have even more wacky ways to fail. Combine those two attributes, and eventually, you're bound to have something happen. It certainly seems to have with Voyager 1. The space probe, which has been in active service for NASA for almost 45 years, is sending back telemetry data that doesn't make any sense.

At this point in the probe's journey, that's surprisingly not that big of a deal. Telemetry data helps position Voyager's science instruments and its high-gain antenna that allows it to talk to Earth continually. Both of those systems seem to still be in working order, as the data science instruments are sending back good readings, and those readings are getting to Earth, which shows that the antenna is still pointed in the right direction.

What might be causing this strange data is a mystery at this point. Engineers are trying to narrow down the problem. Their first step is to determine whether whatever is causing the randomized data is in the attitude and articulation control system (AACS) or some other sub-system that feeds data into it.

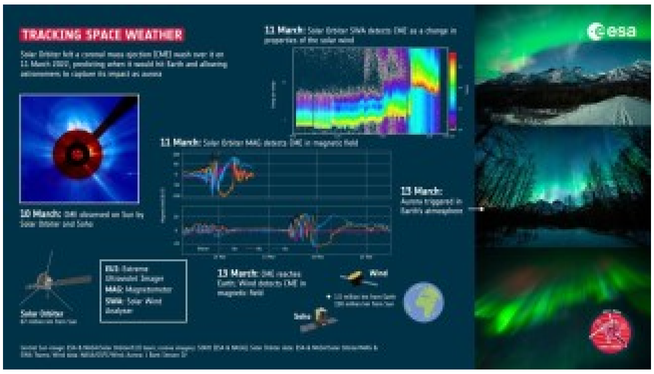
UT video looking back on the success of the Voyager missions.

One thing the bogus data hasn't done is trigger any of the "safe mode" operating systems for the probe, which could have shut down much of its functionality. Other than the won-

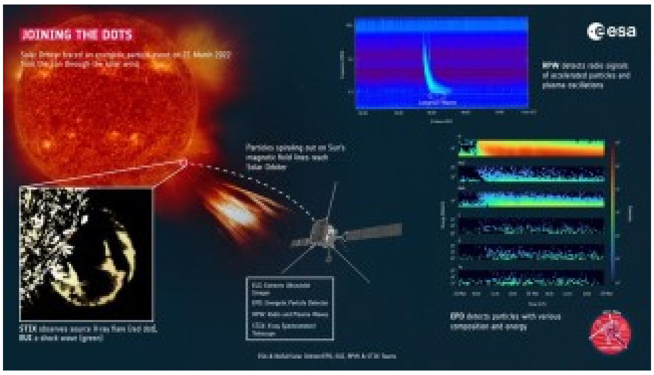
ky data, Voyager 1 is operating normally and continues to send valuable scientific data from 14.5 billion miles away. It and its sister craft, Voyager 2, are our only probes to have currently gone outside of the solar system and are able to collect data where no one has gone before.
Voyager 2 seems to be acting fine as well, returning normal telemetry and other data from 12.1 billion miles away. That points to something specifically going wrong with Voyager 1's systems. Potential solutions include software changes or switching to a redundant hardware system typically used for backup.
This wouldn't be the first time Voyager's engineers would bring up a backup system. In 2017, the probe's main thrusters began to fail, so the flight engineers switched to thrusters that were initially used to maneuver the probe around planets back in the 70s. They worked like a charm, even though they hadn't been used in 37 years.
UT looking ahead to the future of the Voyager missions.
There is a longer-term problem, though – every year, the reactor that has been powering Voyager all this time produces four fewer watts per year. Over time this has caused the mission team to turn off some of the craft's subsystems in an effort to direct the power where it is needed most. Eventually, all of them will have to be powered off. Still, until that time, which seems to be later than 2025 at least, the mission team will keep getting as much invaluable data as possible from the most distant ambassador of our species.

Solar Orbiter's Pictures of the Sun are Every Bit as Dramatic as You Were Hoping

On March 26th, the ESA's Solar Orbiter made its closest approach to the Sun so far. It ventured inside Mercury's orbit and was about one-third the distance from Earth to the Sun. It was hot but worth it.
The Solar Orbiter's primary mission is to understand the connection between the Sun and its heliosphere, and new images from the close approach are helping build that understanding.
According to the ESA, the Solar Orbiter is the most complex scientific laboratory ever sent to the Sun. It carries a robust suite of instruments, including a Magnetometer, an Extreme Ultraviolet Imager, a Solar Wind Plasma Analyzer, and others. Its broad range of instruments allows it to observe solar events in multiple ways.
The spacecraft benefits from getting as close to the Sun as it can. But close approaches make the Solar Orbiter hot. The spacecraft's first line of defence is its heat shield. It's a multi-layered titanium device mounted on a honeycomb aluminum support, with carbon fibre skins designed to shed heat. Between all that and the spacecraft's body, there are another 28 layers of insulation. During this approach, its heat shield reached 500 Celsius (932 F.)
Protected from the heat, the Solar Orbiter gathered a lot of data in its approach. Scientists need more time to work with it and understand it, but the images and videos are immediately engaging.
One of the Sun's features that caught everyone's attention is the "space hedgehog."
The intriguing feature in the bottom third of the image, below the centre, has been nicknamed the solar hedgehog. No one knows exactly what it is or how it formed in the Sun's atmosphere. The image was captured on 30 March 2022 by the Solar Orbiter's Extreme Ultraviolet Imager. Image Credit: ESA.
Thanks to a bit of luck, the Sun put on a show during the Solar Orbiter's approach. There were solar flares, and even a coronal mass ejection (CME) directed toward Earth. The Solar Orbiter has several remote sensing instruments, and scientists used them to forecast when the CME would reach Earth. They released their forecast on social media, and 18 hours later, Earthly observers were prepped to witness the resulting aurora. ESA released a graphic to explain how that played out.



This graphic shows the Solar Orbiter's role in detecting a CME and forecasting aurora when the CME struck Earth. On 10 March, a solar flare produced a coronal mass ejection (CME) directed at Earth. The cameras on the ESA/NASA mission SOHO (Solar and Heliospheric Observer) recorded the event at around 22:06 UT. Solar Orbiter also observed it from its viewpoint about 67 million km from the Sun. <Click to enlarge.> Image Credit: Central Sun image: ESA & NASA/ Solar Orbiter/EUI team; corona imagery: SOHO (ESA & NASA); Solar Orbiter data: ESA & NASA/Solar Orbiter/MAG & SWA Teams; Wind data: NASA/GSFC/Wind Aurora: J Bant Sexson IV
The following video features images of the flares and the CME from three of the Solar Orbiter's instruments: the Extreme Ultraviolet Imager, the Metis coronagraph, and SoloHI, the Solar Orbiter Heliospheric Imager.
The awesome energy of the Sun can be readily appreciated in this sequence of images combining data from three instruments on the ESA/NASA Solar Orbiter spacecraft. It shows the way a solar flare on 25 March 2022, one day before the Solar Orbiter's closest approach to the Sun, created a massive disturbance in the Sun's outer atmosphere, the solar corona, leading to an enormous quantity of the gas being hurled into space in a coronal mass ejection.
The ESA created an infographic that helps explain what the video shows.



This graphic helps explain how the Solar Orbiter imaged the event with different instruments. <Click to enlarge.> Image Credit: ESA & NASA/Solar Orbiter/EPD, EUI, RPW & STIX Teams
The Orbiter also gave us our highest-resolution image of the Sun's south pole.
Scientists are interested in the Sun's poles because of how the Sun's magnetic fields work. The magnetic fields create the powerful but temporary active regions on the Sun's surface, and the fields get swept up and down to the poles before being swallowed by the Sun again. Scientists think that they somehow act as seeds for the next solar activity. The detailed images from the Sun's south pole should help researchers understand how this all works.
The ESA/NASA Solar Orbiter spacecraft saw the Sun's south pole on 30 March 2022, just four days after the spacecraft passed its closest point yet to the Sun. These images were recorded by the Extreme Ultraviolet Imager (EUI) at a wavelength of 17 nanometers. Credit: ESA & NASA/Solar Orbiter/ EUI, Metis and SoloHI Teams

In the video of the Sun's south pole, the lighter regions are mostly magnetic loops rising from the Sun's interior. They're called closed magnetic field lines because particles have difficulty crossing them. Instead, the particles become trapped and emit extreme ultraviolet radiation, which the Solar Orbiter's Extreme Ultraviolet Imager (EUI) is poised to capture.

The darker regions in the video are where the Sun's magnetic field lines are open. Instead of being closed to particles and trapping them, gasses can escape into space from these darker regions. That creates solar wind.

The Orbiter also captured images and data of a March 2nd solar flare. The spacecraft's Extreme Ultraviolet Imager (EUI) and the X-ray Spectrometer/Telescope (STIX) instruments captured the flare as solar atmospheric gases reached temperatures of about one million degrees C (1,8000,000 F) and emitted extreme ultraviolet energy and x-rays.

In the gif below, lower-energy X-rays are displayed in red, and higher-energy X-rays are in blue.

Image Credit: ESA & NASA/Solar Orbiter/EUI & STIX Teams

There's a lot more to come from the Solar Orbiter. Over the next four years, the spacecraft will encounter Venus for a fourth and fifth time. Each time it does so, it'll increase its inclination, giving it more direct views of the Sun's poles. By December 2026, it'll be orbitally inclined at 24 degrees, marking the start of the spacecraft's "high-latitude" mission.

Solar Orbiter's journey around the Sun. Credit: *ESA/ATG medialab*.

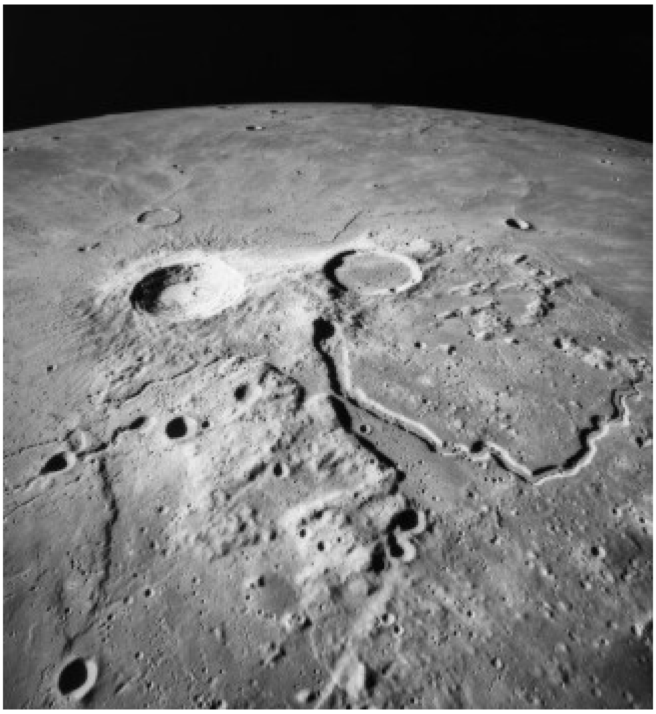
Those high-latitude observations will give scientists line-of-sight views of the poles. The ESA says those views are crucial to disentangling the Sun's complex magnetic polar environment. That could help unravel the mystery of the Sun's 11-year cycles.

"We are so thrilled with the quality of the data from our first perihelion," said Daniel Müller, ESA Project Scientist for Solar Orbiter. "It's almost hard to believe that this is just the start of the mission. We are going to be very busy indeed."

The Moon's Ancient Volcanoes Could Have Created Ice Sheets Dozens of Meters Thick

Everyone loves looking at the Moon, especially through a telescope. To see those dark and light patches scattered across its surface brings about a sense of awe and wonder to anyone who looks up at the night sky. While our Moon might be geologically dead today, it was much more active billions of years ago when it first formed as hot lava blanketed hundreds of thousands of square kilometers of the Moon's surface in hot lava. These lava flows are responsible for the dark patches we see when we look at the Moon, which are called mare, translated as "seas", and are remnants of a far more active past.

In a recent study published in *The Planetary Science Journal*, research from University of Colorado Boulder (CU Boulder) suggests that volcanoes active billions of years ago may have left another lasting impact on the lunar surface: sheets of ice that dot the Moon's poles and, in some places, could measure dozens or even hundreds of meters (or feet) thick.



Scientists believe that the moon's snakelike Schroeter's Valley was created by lava flowing over the surface. (Credit: NASA Johnson)

"We envision it as a frost on the Moon that built up over time," said Andrew Wilcoski, lead author of the new study and a graduate student in the Department of Astrophysical and Planetary Sciences (APS) and the Laboratory for Atmospheric and Space Physics (LASP) at CU Boulder.

The researchers used computer models to try to recreate conditions on the Moon long before complex life arose on Earth. They discovered that ancient moon volcanoes spewed huge amounts of water vapor, which then settled onto the surface—forming stores of ice that may still be hiding in lunar craters. If any humans had been alive at the time, they may even have seen a sliver of that frost near the border between day and night on the Moon's surface.

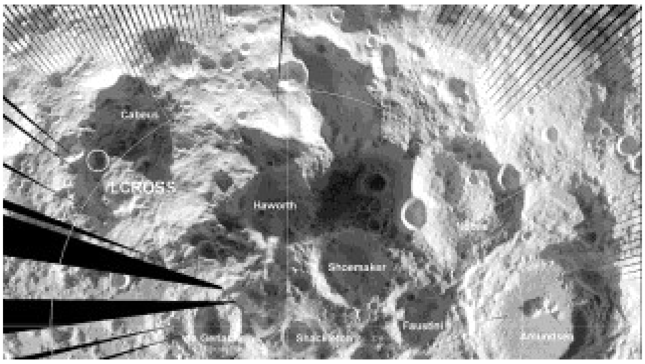
The new study adds to a growing body of evidence suggesting that the Moon may be awash in a lot more water than scientists once believed. In a 2020 study, Hayne and his colleagues estimated that nearly ~40,000 square kilometers (~25,000 square miles) of the lunar surface could be capable of trapping and hanging onto ice—mostly near the Moon's north and south poles. However, where all the water came from is still unclear.

It's a potential bounty for future moon explorers who will need water to drink and process into rocket fuel, said study co-author Paul Hayne, who is also an assistant professor in APS and LASP.

What Hayne is inferring with rocket fuel is that future astronauts on the Moon could do what is known as electrolysis of water, as water consists of the molecule H20, or two hydrogen atoms for every oxygen atom. Electrolysis is the process of using electricity to split water into hydrogen and oxygen. While oxygen can be used for breathing, the hydrogen can be used for fuel for return trips to Earth or even to venture farther out into the solar system.

As stated, it is hypothesized that most of the trapped ice is near the Moon's north and south poles. This is because the moon's axial tilt is only 1.5 degrees, compared to the Earth's axial tilt of 23.5 degrees. As a result, there are craters in both the north and south poles of the Moon that might receive constant sunlight or none at all. This could mean that ice might be present within craters in what's known as permanently shadowed regions (PSRs), which are designated as areas near the north or south poles of the Moon that never receive direct sunlight and are thus extremely cold (-248°C to -203°C; -415°F to -334°F).

One crater of interest is Shackleton Crater located at the lunar south pole. Shackleton 21 km (13 mi) in diameter and 4.2 km (2.6 mi) deep. What makes Shackleton so intriguing is that while its rim is almost entirely bathed in permanent sunlight, the inside of the crater is permanently shadowed, leaving open the possibility for ice deposits to be present deep within the crater itself. Several missions from three space-faring nations have examined Shackleton using cameras, radar, sensors, and even physically smashed by an impactor, all in hopes of learning it literal dark secrets.



The Diviner instrument aboard the Lunar Reconnaissance Orbiter imaged the temperatures of the south polar region, shown here. (Credit: NASA*)*

All of this research regarding water on the Moon is in preparation for the eventual return of humans to the lunar surface, which has been devoid of us Earthlings since Apollo 17 in 1972. These incredible missions belong to NASA's Artemis program, which aims to land the first woman and person of color on the surface of our nearest celestial neighbor. Using as much ice on the Moon as possible will mean astronauts won't have to rely as much on Earth for resupplies, which can be very expensive.

How much ice is on the Moon? How much ice is within Shackleton Crater? Will we be able to utilize this ice for future astronauts in lunar settlements? Only time will tell, and this is why we science!

As always, keep doing science & keep looking up!

Spacesuits are Leaking Water and NASA is Holding off any Spacewalks Until They can Solve the Problem

NASA's spacesuits are getting old. The extra-vehicular mobility units – EMUs for short – were designed and built for spacewalks outside NASA's space shuttles, which flew for the last time in 2011. Nowadays, the EMUs are an integral part of maintaining and upgrading the International Space Station (ISS) exterior, providing the crew with the ability to live and work in the vacuum of space for extended periods of time (spacewalks regularly last from 6 to 8 hours). However, at the end of the most recent spacewalk on March 23, NASA astronaut Kayla Barron discovered water in the helmet of German astronaut Matthias Maurer while she helped him remove the suit.

In microgravity, water can bead up in clumps and cling to the face and eyes, causing serious danger to the astronaut inside a leaking suit. As a precaution and preventative measure, future spacewalks have been put on hold.

At a press conference on May 17, NASA officials shared details of the decision to pause upcoming Extravehicular Activities (EVAs). "Until we understand better what the causal factors might have been during the last EVA with our EMU, we are no-go for nominal EVA," said Dana Weigel (Deputy Manager, Space Station Program). "We won't do a planned EVA until we've had a chance to really address and rule out major system failure modes."

There were four upcoming EVAs scheduled for 2022, two each in August and November. These spacewalks were meant to carry out upgrades to the station's power systems, but now will only go ahead after careful inspection of the malfunctioning suit.

So far, they've yet to find the cause of the problem. "We're looking for any obvious signs of contamination or fouling or something else that might have gotten into our system. We're not seeing that yet," said Wiegel.

New spacesuit designs are in the works, but these are tailored towards EVAs on the lunar surface for the upcoming Artemis program. And with the ISS due for retirement in the next decade (currently set for 2031), the likelihood of new EMUs for the ISS is small. According to a 2017 Office of the Inspector General report, eighteen EMUs were manufactured during the shuttle era, and of these, eleven remain, four of which are on the station, while the rest are used on the ground for testing and training.

NASA unveils its Artemis Spacesuit design in 2019.

That doesn't mean we won't see any more EVAs in the near future. Further testing might find the source of the fault, and additional precautions could enable the EVA schedule to proceed. Water samples from the failed suit will be returned to Earth for analysis – any identifiable contaminants they find will help determine where the leak originated.

In the last decade, there have already been several upgrades to the EMUs to protect against water, which is required in the suits for both drinking and cooling. An absorbent pad was added to the back of the astronaut's head in 2014, as well as a breathing tube, for use in the event that water covers the astronaut's mouth and nostrils. These changes were instigated by a close call in 2013, when astronaut Luca Parmitano found his helmet filling with water, making it difficult to see and breathe. He had to cut his spacewalk short and return to the safety of the station to deal with the dangerous situation before it cut off his airways.

Surface tension causes water to adhere to surfaces in zero gravity, making it a dangerous hazard in the event of a leak inside the helmet of a spacesuit. Image Credit: NASA: https://www.youtube.com/watch?v=9ZEdApyi9Vw

For the near future, while the investigation proceeds, NASA says it would consider using the EMUs if necessary in an emergency situation.

"Depending upon what has failed and what the risk is to the spacecraft and to the mission overall, we'll look at where we are with the investigation, where we are with the additional mitigations that we're putting in place and we'll specifically make a call based on the contingency and where we are at the given moment," Wiegel said.

In addition, the Sokol spacesuits used by Russian crew members aboard the ISS still function (Russian cosmonauts last performed an EVA on April 28), providing a secondary option in case the need for an emergency EVA arises.

Additional absorption pads for installation into the EMU helmets arrived at the ISS aboard the Boeing Starliner last week, which made its first-ever successful docking with the ISS during an uncrewed test flight on May 20th.

What additional EMU upgrades are required will become clear as the investigation continues.

The “Doorway on Mars” is More Like a Dog Door

Mars Curiosity rover took a panorama of this rock cliff during its trip across Mount Sharp on Mars. Circled is the location of a so-called “doorway on Mars.” Courtesy NASA/JPL/Mars Curiosity team.

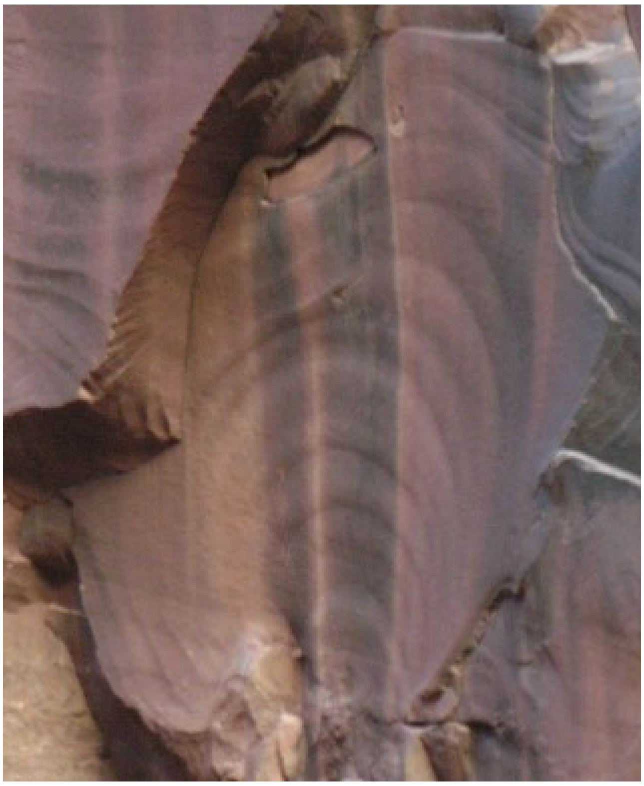
Remember all the fuss about the “doorway on Mars” from just last week? Well, this week, NASA issued some more information about the rock mound where the Curiosity rover snapped a pic showing a fracture hole in the rock. It looks like a door, but it’s not.

This discovery came as Curiosity was investigating an area on Mount Sharp for clues to the existence of water early in Martian history. It turns out this odd-shaped opening isn’t much bigger than a dog door here on Earth. Does that mean Mars is occupied by canines that can squeeze through openings 30 by 40 centimeters (12 x 16 inches)? Wouldn’t that be cool? But no, it’s not. But, that knowledge is not enough to keep the “Mars aliens” enthusiasts from promoting their favorite ideas about ancient civilizations on the Red Planet.

Debunking the Doorway on Mars Idea

In last week’s article about Curiosity’s find, we pointed out that this hole in the rocks isn’t a mysterious opening to a subterranean world on Mars. Instead, it turns out to be one of many little naturally occurring rock fractures that are pretty common on the planet. We even see similar types of fractures here on Earth.

As you can see from the main panorama posted from the rover and the Earth sandstone in the scene below, the break in the rocks is fairly typical of sandstones and bedrock. If you look closely, you can see individual layers in the rocks. The scene is pretty familiar to anyone who’s hiked in desert regions and seen desiccated sandstones or along the Front Range of the Rocky Mountains and seen layers of sandstone near the mountains. In the case of the Rockies, sandstone layers got fractured and upended when the central part of the mountain range jutted out to form the Continental Divide. For millions of years before that, the region was covered by an ancient ocean. The sea bottom and shorelines were layered in fine sands, which hardened to become rock.



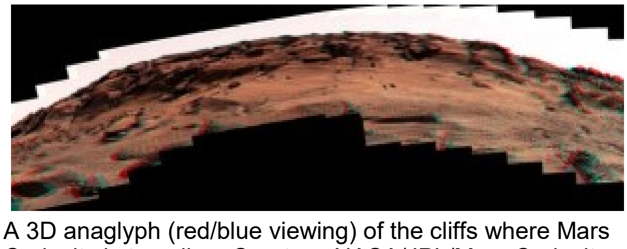
A view of a fractured sandstone formation on Earth. This type of rock can shatter easily under erosion or other forces. The concentric circles etched on the rock are “plumose” (plume-like) structures that formed when the rock fractured. Courtesy AWickert. CC BY-SA 3.0.

We see similar rocks in various locations on Earth where lakes, oceans, and riverbeds have deposited layers of sand. It even happens as a result of wind-driven sand and dust. That action creates sand layers and dunes that eventually harden into rock. So, it’s no surprise to see similar features on Mars, given what we know about its surface. And, as on Earth, sandstone on Mars can erode and break pretty easily.

The existence of the shattered rock cliff region where Curiosity is exploring comes as no surprise. And, we shouldn’t be surprised to see fracture “holes” where bits and pieces of rock have broken away over time. The same forces at work on Mars also happened on Earth. That’s why so much of Mars looks so familiar to us.

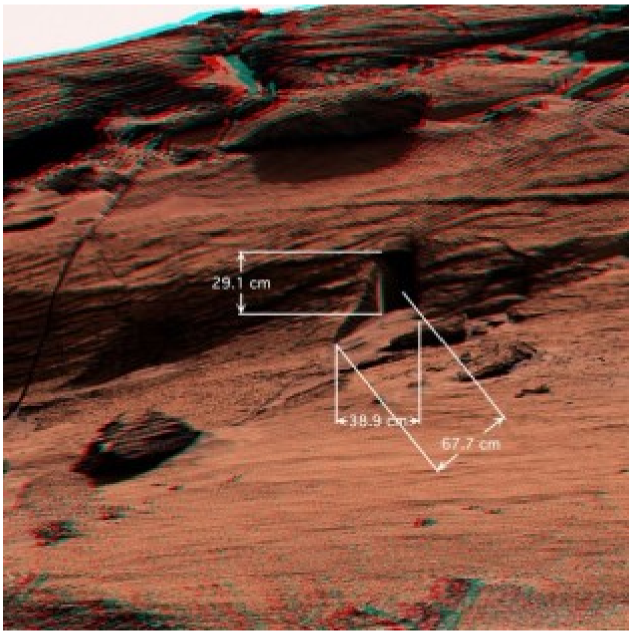
Viewing the “Dog Doorway on Mars” in 3D

NASA released some analysis images of Curiosity’s Mastcam view of the East Cliffs region to give a good idea of the sizes of the rock layers and what’s now coming to be known as the “dog door.” The Curiosity imaging team created a 3D anaglyph (viewable with red/blue 3D glasses for those of you playing along at home). Take some time to explore it; chances are you’ll find it very familiar-looking.

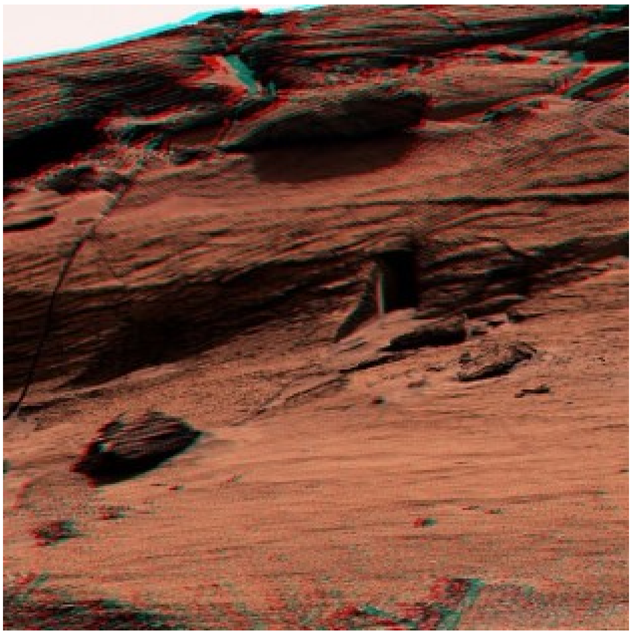


A 3D anaglyph (red/blue viewing) of the cliffs where Mars Curiosity is traveling. Courtesy NASA/JPL/Mars Curiosity team.

The team also zeroed in on the region of the “door” and created two images from that. The first is just the close-up, also in 3D anaglyph. Then, they put some size and scale markings on to give you a good idea of what we’re really looking at here. No doubt it, this open fracture is intriguing. Not because it's a door to another Martian dimension, but because of what it represents. There are millions of years of Martian geologic history in this image. Mars scientists are studying it closely to understand how this rock formed and what conditions were like when it did.



Zeroing in on the Dog Doorway on Mars, with scale markings to show its approximate shape and size. Courtesy NASA/JPL/Mars Curiosity team.



The same view as above, but without scale markings. Courtesy NASA/JPL/Mars Curiosity team.

Where Is Curiosity?

The spacecraft is exploring special regions of Gale Crater on Mars in an effort to find evidence for Mars's watery past. Currently, it's on a rock mound studying the chemistry of the rocks on this section of Mount Sharp (the shroud around Aeolis Mons, the central peak of the crater). As this is written, Curiosity's next two days (Sols 3480-3482) will be spent checking out some "gnarly looking" rocks, analyzing what it finds, and doing a full panoramic imaging sweep specially timed for another spectacular Martian sunset view.

Plants can grow in lunar regolith, but they're not happy about it

NASA is sending astronauts back to the Moon by the end of this decade, and hope to send humans to Mars sometime in the 2030s. Growing food in space using in-situ resources is vital if astronauts are to survive on both the Moon and Mars for the long-term. Growing plants in space using Earth soil is nothing new, as this research is currently ongoing onboard the International Space Station (ISS). But recent research carried out on Earth has taken crucial steps in being able to grow food in space using extraterrestrial material that we took from the Moon over 50 years ago.

In a recent study published in *Communications Biology*, researchers have made a remarkable first step in helping future astronauts on the Moon grow their own food using lunar regolith instead of Earth soil. This is an extraordinary discovery as this could help future astronauts on the Moon and Mars grow their own food using in-situ resources as opposed to relying on resupplies from Earth to help them survive. What makes this research even more amazing is it was accomplished using lunar regolith that was returned from the Moon over 50 years ago by samples from Apollo 11, 12, and 17.

Rob Ferl, left, and Anna-Lisa Paul looking at the plates filled part with lunar soil and part with control soils, now under LED growing lights. At the time, the scientists did not know if the seeds would even germinate in lunar soil. (Credit: UF/IFAS photo by Tyler Jones)

"This research is critical to NASA's long-term human exploration goals as we'll need to use resources found on the Moon and Mars to develop food sources for future astronauts living and operating in deep space," said NASA Administrator Bill Nelson. "This fundamental plant growth research is also a key example of how NASA is working to unlock agricultural innovations that could help us understand how plants might overcome stressful conditions in food-scarce areas here on Earth."

Earth's soil is rich in vital nutrients ideal for growing plants, to include minerals (45%), water (25%), air (25%), and organic matter (5%). For Lunar regolith, 99% of the mass consists of water (41-45%), Silicon (Si), Aluminum (Al), Calcium (Ca), Iron (Fe), Magnesium (Mg), and Titanium (Ti), and nearly all of the remaining 1% consists of Manganese (Mn), Sodium, (Na), Potassium (K), and Phosphorous (P).

"Here we are, 50 years later, completing experiments that were started back in the Apollo labs," said Robert Ferl, a professor in the Horticultural Sciences department at the University of Florida, Gainesville, and a co-author on the study. "We first asked the question of whether plants can grow in regolith. And second, how might that one day help humans have an extended stay on the Moon."

For the study, the team grew the well-studied *Arabidopsis thaliana*, which is native to Eurasia and Africa, and is a relative of mustard greens and other cruciferous (cabbage family) vegetables such as broccoli, cauliflower, and Brussel sprouts. Due to its small size and ease of growth, it is one of the most studied plants in the world. Because of this, scientists already know what its genes look like, how it behaves in different circumstances, and even how it grows in space.

Anna-Lisa Paul, left, and Rob Ferl, working with the lunar soils in their lab.
(Credit: UF/IFAS photo by Tyler Jones)

Using samples from Apollo 11, 12, and 17, the research team used only a gram of regolith for each plant. They then added water and seeds to the samples. They then put the trays into terrarium boxes in a clean room, and a nutrient solution was added daily. After only a couple of days, the results seemed promising.

“After two days, they started to sprout!” said Anna-Lisa Paul, who is a professor in Horticultural Sciences at the University of Florida, and first author on the paper. “Everything sprouted. I can’t tell you how astonished we were! Every plant – whether in a lunar sample or in a control – looked the same up until about day six.” It was only after day six that the research team realized the plants growing in the regolith were not as robust as the control group plants growing in volcanic ash. To make matters worse, the regolith plants were growing differently depending on which type of sample they were in. They grew more slowly and had stunted roots; additionally, some had stunted leaves and sported reddish pigmentation.

After 20 days, just before the plants started to flower, the team harvested the plants, ground them up, and studied the RNA. This showed that the plants were indeed under stress and had reacted the way researchers have seen *Arabidopsis* respond to growth in other harsh environments, such as when soil has too much salt or heavy metals. As stated, the regolith used in this study came from three Apollo samples, all collected at three different sites on the Moon. It was revealed that plants grown in the Apollo 11 samples were not as robust as the plants in the Apollo 12 and 17 samples.

By day 16, there were clear physical differences between plants grown in the volcanic ash lunar simulant, left, compared with those grown in the lunar soil, right. (Credit: UF/IFAS photo by Tyler Jones)

While the plants ultimately did not turn out as was hoped, this research nonetheless opens the door to not only growing plants in habitats on the Moon, but it also opens the door for additional studies as well. This includes understanding which genes plants need to adjust to growing in regolith, gauging how different materials from the Moon are more conducive in growing plants than others, and studying lunar regolith to help us better understand Mars regolith, as well.

“Not only is it pleasing for us to have plants around us, especially as we venture to new destinations in space, but they could provide supplemental nutrition to our diets and enable future human exploration,” said Sharmila Bhattacharya, program scientist with NASA’s Biological and Physical Sciences (BPS) Division. “Plants are what enable us to be explorers.”

Lunar Sample Laboratory Facility

While the samples used in this research are 50 years old, this research was able to be carried out because of the Lunar Sample Laboratory Facility at Johnson Space Center in Houston, TX. The purpose of this facility is to maintain lunar samples in pristine condition to allow for current and future studies by scientists and educators from around the world. A portion of the facility is devoted to long-term storage of lunar samples to study them later as research technology improves.

Ceres Probably Formed Farther out in the Solar System and Migrated Inward

When Sicilian astronomer Giuseppe Piazzi spotted Ceres in 1801, he thought it was a planet. Astronomers didn’t know about asteroids at that time. Now we know there’s an enormous quantity of them, primarily residing in the main asteroid belt between Mars and Jupiter.

Ceres is about 1,000 km in diameter and accounts for a third of the mass in the main asteroid belt. It dwarfs most of the other bodies in the belt. Now we know that it’s a planet—albeit a dwarf one—even though its neighbours are mostly asteroids.

But what’s a dwarf planet doing in the asteroid belt?

A new research article provides the answer: Ceres didn’t form in the asteroid belt. It formed further out in the Solar System and then migrated to its current position. This isn’t the first study to reach that conclusion, but it adds weight to the idea.

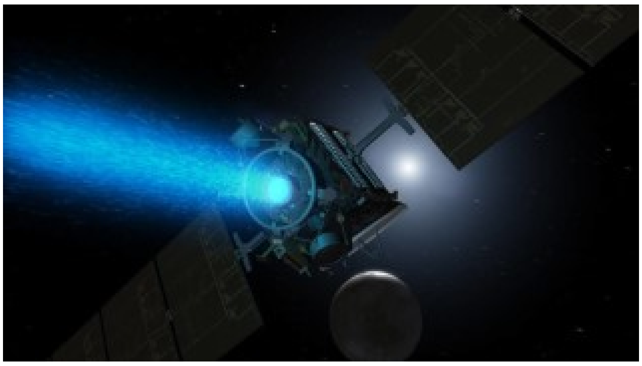
The article is “Dynamical Origin of the Dwarf Planet Ceres,” and it’s published in the journal Icarus. The lead author is Rafael Ribeiro de Sousa, a physics professor at Sao Paulo State University in Brazil. Other co-authors come from the same university and France and the US.

(Note: Ceres is called a dwarf planet, a protoplanet, and sometimes an asteroid. No point getting hung up on it. It was officially classified as a dwarf planet in 2006.)

Ceres is one of three dwarf planets or protoplanets in the asteroid belt. The other two are Vesta and Pallas. A fourth large body, Hygiea, is 434 km in diameter and may also be a dwarf planet. These four largest bodies make up half the mass of the asteroid belt.

These are the four largest objects in the asteroid belt. Ceres is the only one massive enough for self-gravity to maintain a spheroid shape. Image Credit: ESO/M. Kornmesser/Vernazza et al./MISTRAL algorithm (ONERA/CNRS)

Most of what we know about Ceres comes from NASA’s Dawn mission. Dawn was the first spacecraft to visit two extraterrestrial bodies and the first to orbit a dwarf planet. Dawn visited both Vesta and Ceres before the spacecraft ran out of fuel in October 2018. Now it’s a derelict in a stable orbit around Ceres.

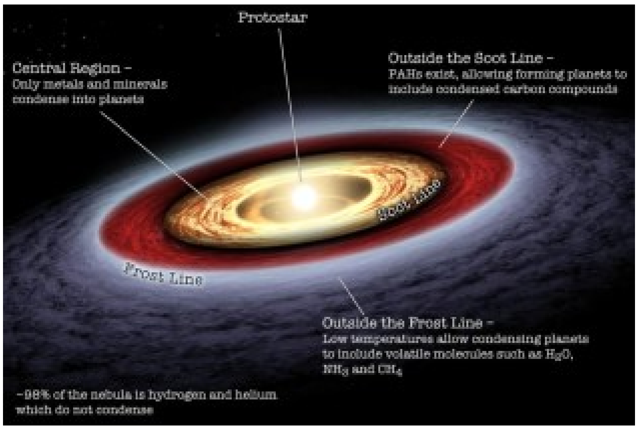


An artist's illustration of NASA's Dawn spacecraft with its ion propulsion system approaching Ceres. Image: NASA/ JPL-Caltech.

The terminology and descriptions of the largest objects in the asteroid belt can be confusing, but Ceres stands apart from the other three. Ceres is the only body in the belt that's massive enough to maintain a spheroid shape.

Ceres also has a transient atmosphere called an exosphere. Sunlight sublimes water ice and ammonia ice into vapour, but the dwarf planet's gravity is too weak to hold onto it. This is an important clue to Ceres' origins because asteroids don't typically emit vapour.

The presence of ammonia is also a clue.

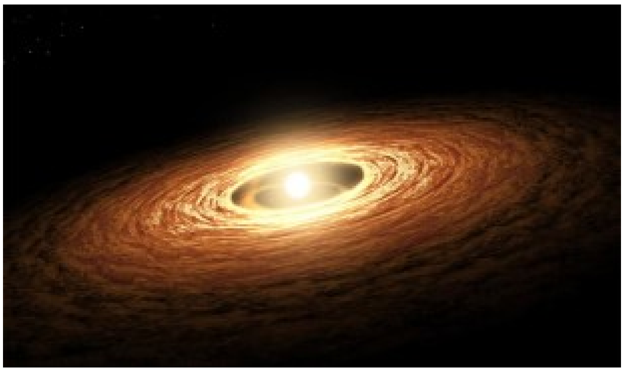


Compounds like ammonia condense beyond the Solar System's frost line. Since Ceres contains ammonia, it likely formed beyond the frost line. Image Credit: NASA / JPL-Caltech, InvaderXan of http://supernovacondensate.net/.

Comets contain volatile ices like ammonia that sublime when the Sun heats them. That's what creates the comet's tail and coma. But comets come from the cold outer regions of the Solar System where they would've accreted the volatile ices. Since Ceres has frozen volatiles like a comet, it suggests that it also originated in the colder regions of the Solar System.

"The presence of ammonia ice is strong observational evidence that Ceres may have been formed in the coldest region of the Solar System beyond the Frost Line, in temperatures low enough to cause condensation and fusion of water and such volatile substances as carbon monoxide [*CO*], carbon dioxide [CO_2] and ammonia [NH_3]," Ribeiro de Sousa said in a press release.

The boundary between the colder outer Solar System and the warmer inner Solar System is called the Frost Line. There are specific frost lines for different volatiles which freeze at different temperatures, but astrophysicists speak of a single frost line for simplicity. The frost line is close to Jupiter's orbit now, but it hasn't always been there. It's moved as the Solar System evolved. The solar nebula was opaque in the early days, and the Sun's warmth didn't reach as far. The Sun was also less energetic then, so the frost line was closer to the Sun.



An artist's illustration of a young, sun-like star encircled by its disk of gas and dust. Image Credit: NASA/JPL-Caltech/T. Pyle

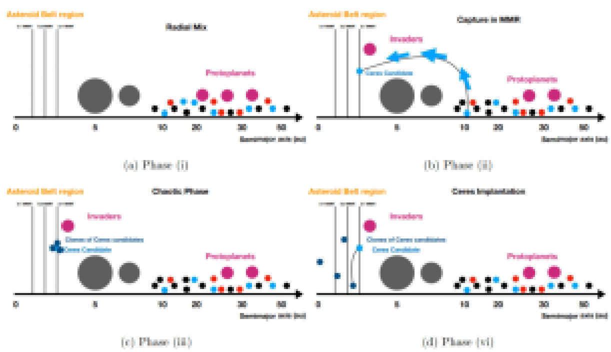
The growth of the giant planets also affected the position of the frost line. "The intense gravitational disturbance produced by the growth of these planets may have changed the density, pressure and temperature of the protoplanetary disk, displacing the Frost Line. This disturbance in the protoplanetary gas disk may have led the expanding planets to migrate to orbits closer to the Sun as they acquired gas and solids," co-author Ernesto Vieira Neto said.

"In our article, we propose a scenario to explain why Ceres is so different from neighbouring asteroids. In this scenario, Ceres began forming in an orbit well beyond Saturn, where ammonia was abundant. During the giant planet growth stage, it was pulled into the asteroid belt as a migrant from the outer Solar System and survived for 4.5 billion years until now," Ribeiro de Sousa said.

The team ran a large number of computer simulations to test the idea. They simulated the formation of giant planets inside the Sun's protoplanetary disk, including Jupiter and Saturn. They also included some embryonic planets to serve as precursors to Uranus and Neptune. Then they added a group of objects with compositions and sizes similar to Ceres. Their inclusion is based on the assumption that Ceres is one of the Solar System's early planetesimals, objects on their way to becoming full-fledged planets.

"Our main finding was that in the past there were at least 3,600 Ceres-like objects beyond Saturn's orbit. With this number of objects, our model showed that one of them could have been transported and captured in the Asteroid Belt, in an orbit very similar to Ceres's current orbit."
Rafael Ribeiro de Sousa, lead author, Sao Paulo State University.

"Our simulations showed that the giant planet formation stage was highly turbulent, with huge collisions between the precursors of Uranus and Neptune, ejection of planets out of the Solar System, and even invasion of the inner region by planets with masses greater than three times Earth's mass. In addition, the strong gravitational disturbance scattered objects similar to Ceres everywhere. Some may well have reached the region of the Asteroid Belt and acquired stable orbits capable of surviving other events," Ribeiro de Sousa said.



This figure from the study shows the four steps required to implant an object like Ceres into the asteroid belt. Image Credit: de Sousa et al. 2022.

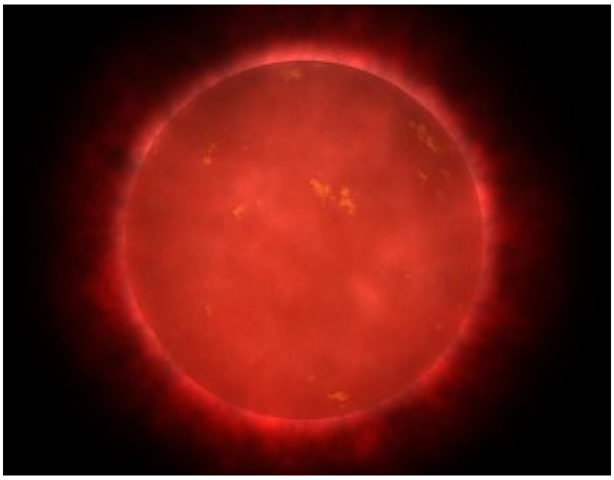
The researchers say there are four steps involved in a Ceres-like object becoming implanted in the asteroid belt. The first is a fast radial mixing phase in the position of the planetesimals in the outer planetesimal disk. The second is when the Ceres candidate gets captured in mean-motion resonance with giant planets. The third step is a chaotic phase, where the Ceres-like object can encounter other "invaders" that can increase or decrease its eccentricity and scatter the object into more stable regions in the inner asteroid belt. The chaotic phase also includes gas drag and gaseous dynamical friction that can change the Ceres candidate's eccentricity and inclination and implant it into its current position. The fourth phase is where the gas is removed from the protoplanetary disk, invaders are removed, Ceres is removed from mean-motion resonance, and the implantation becomes stable.

The team's simulations also showed that Ceres is only one of many objects like it that existed in the Solar System's early days. "Our main finding was that in the past, there were at least 3,600 Ceres-like objects beyond Saturn's orbit. With this number of objects, our model showed that one of them could have been transported and captured in the Asteroid Belt, in an orbit very similar to Ceres's current orbit," Ribeiro de Sousa said.

This image of Ceres approximates how the dwarf planet's colours would appear to the eye. Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA

These aren't the first researchers to come up with a number like 3,600 Ceres-like objects. Others have studied craters and the number of objects beyond Saturn and in the Kuiper Belt to come up with their results. This study confirms previous results and supports our understanding of how the Solar System formed and evolved. "Our scenario enabled us to confirm the number and explain Ceres's orbital and chemical properties. The study reaffirms the accuracy of the most recent models of the formation of the Solar System," he said.

Carbon-12 is an Essential Building Block for Life and Scientists Have Finally Figured Out How it Forms in Stars



Artist's impression of a red giant star. Their cores are cauldrons where carbon-12 is produced. Credit:NASA/ Walt Feimer

Each of us is, as it says in Max Ehrmann's famous poem "Desiderata", a child of the universe. It speaks metaphorically about our place in the cosmos, but it turns out to be a very literal truth. Our bodies contain the stuff of stars and galaxies, and that makes us children of the cosmos. To be more precise, we are carbon-based life forms. All life on Earth is based on the element carbon-12. It turns out this stuff is a critical gateway to life. So, how did the universe come up with enough of it to make you and me and all the life on our planet? Astrophysicists and nuclear physicists think they have an answer by using a supercomputer simulation of what happens to create carbon. As it turns out, it's not very easy.

The recipe for carbon-12 requires a pressure cooker and a lot of source material. The environment inside a star or during a stellar collision or an explosion provides the pressure cooker. The ingredients inside are helium-4 atoms and a theoretically forbidden nucleus of something called beryllium-8 (^{8}Be). Put them all together and eventually, you get carbon-12. Sounds simple, right?

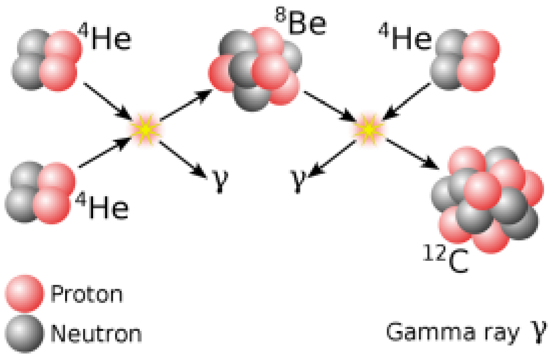
Well, not exactly. There's no way to replicate this recipe in the lab to test it and prove the process. That's because you need temperatures and pressures that exist only inside stars. To understand why we can't reproduce the birth of carbon, here's a simple outline of a complex process that astrophysicists think is happening.

Diving into Stars

The cores of stars engage in a process called nucleosynthesis. That's a fancy term for "cooking up new elements." So, for most of its life, a star is a giant sphere of hydrogen. Inside, the conditions are just right for it to fuse hydrogen atoms to make helium atoms. Take it a step further, and fuse two helium nuclei together, and you get that ^{8}Be. There's a problem though: the beryllium isotope should not exist. So, we're at an impasse. If these things can't be made, you don't get carbon, and life maybe doesn't get to exist. What's the solution? Not silicon-based life forms (as we often hear about in science fiction), or, we still wouldn't exist. (At least not in our current form.)

Getting to Carbon-12

So, carbon is important. It's everywhere. Carbon is the fourth most abundant element after hydrogen, helium, and oxygen. The Big Bang created hydrogen and helium. Stars make oxygen and carbon. Older stars such as red giants are prodigious producers of carbon and they are everywhere. So, obviously, it happens. How? It turns out that things are fast and furious inside a star. The "forbidden" ^{8}Be actually can exist, even if only for brief moments. However, it decays in a few nanoseconds.



A graphical look at the triple-alpha process that produces carbon-12. Image credit: Borb, CC BY-SA 3.0.

So, there isn't much time to create carbon-12. But, it happens, or we wouldn't be here to talk about it. Here's how. There's a chemical reaction involving three helium nuclei called "alpha particles" and the very short-lived ^{8}Be. If conditions are just right inside the star, the alpha particles and the ^{8}Be can fuse together. This forms the basis for carbon-12 production. This is the "triple alpha" process and occurs inside these older stars with extremely hot interiors (like above 10^8 K).

Modeling the Formation of Carbon-12

We can't look inside an old red giant star to see what happens inside. Nor can we send a probe into a stellar collision. No spacecraft can go through a stellar explosion to witness elemental creation in those events. So, how do we know that this process is the correct one to explain the creation of carbon-12? As is often the case in astrophysics, researchers turn to computer models. Scientists at Iowa State University and the University of Tokyo created a complex supercomputer model of how alpha particles (the helium-4 atoms) and the ^{8}Be nuclei combine to form much heavier atoms. In their model, this reaction created an unstable, excited carbon-12 state called a Hoyle state. (Named for astrophysicist Fred Hoyle who predicted this state in 1953.)

First, the researchers created a robust simulation of the environment and processes responsible for creating carbon-12 inside stars. Then, they ran it on the Fugaku supercomputer at the RIKEN Center for Computational Science in Kobe, Japan. The team also developed new techniques in computational artificial intelligence that would reveal alpha clustering in the Hoyle state implicated in the creation of carbon-12.

"There's a lot of sublety—a lot of beautiful interactions going on in there," said James Vary of Iowa State University. He is the first author of the resulting research paper. The research team points that alpha-particle clustering "is a very beautiful and fascinating idea and is indeed plausible because the (alpha) particle is particularly stable with a large binding energy."

Ideas to Pursue in the Future

Now that the basic question of carbon-12 production seems to be answered by the simulations, Vary raises other questions about it. "Was carbon production mostly the result of internal processes in stars?" he asked. Or, could it also be in supernova explosions? Could it happen in the collisions of neutron stars? Recent studies show that such mergers create gold and platinum. So, were conditions ripe for carbon-12 to come about?

There are still many details to be worked out before researchers have a complete understanding of the carbon-12 process. But, understanding the role of nucleosynthesis is a prime goal. "his nucleosynthesis in extreme environments produces a lot of stuff," Vary said, "including carbon."

Merging Supermassive Black Holes Gives us a New Way to Measure the Universe

The study of black holes has advanced immensely in the past few years. In 2015, the first gravitational waves were observed by scientists at the Laser Interferometer Gravitational-Wave Observatory (LIGO). This finding confirmed what Einstein predicted a century before with General Relativity and offered new insight into black hole mergers. In 2019, scientists with the Event Horizon Telescope (EHT) Collaboration shared the first image of a supermassive black hole (SMBH), which resides at the center of the M87 galaxy.

Earlier this month, the EHT announced that they had also acquired the first image of Sagittarius A*, the black hole at the center of the Milky Way Galaxy. And just in time for Black Hole Week (May 2nd to May 6th), a pair of researchers from Columbia University announced a new and potentially easier way to study black holes. In particular, their method could enable the study of black holes smaller than M87* in galaxies more distant than the M87 galaxy.

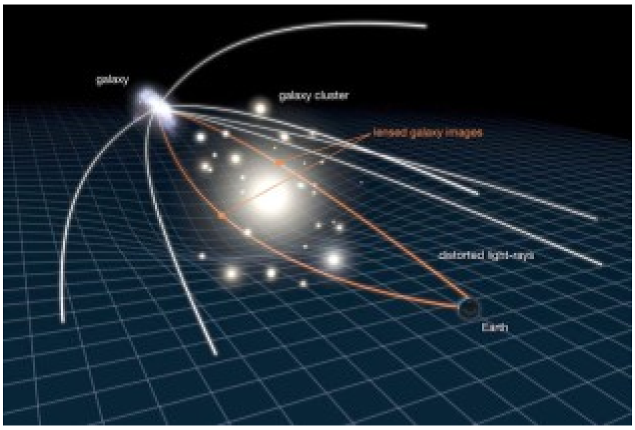
This new imaging method was developed by Zoltán Haiman (a professor of astronomy at Columbia University) and Jordy Davelaar, a theoretical astrophysicist at Columbia, the Flatiron Institute in New York, and a member of the EHT Collaboration. Their method was outlined in complementary studies that recently appeared in *Physical Review Letters* and *Physical Review D*. As they indicate in these papers, their technique combines two techniques – interferometry and Gravitational Lensing.

The former technique involves using multiple instruments to capture light from distant sources, then combining it to create a composite image. This technique allowed the EHT Collaboration to capture images of the bright rings surrounding M87* and Sagittarius A* (among other objects). In the latter case, the gravitational force of a massive object (such as a black hole or galaxy) is used to magnify and enhance the light of a more distant object.

As Haiman and Davelaar explain, viewing a binary black hole system edge-on as one passes in front of the other (aka. transits), astronomers will be able to use the gravitational force of the closest BH to magnify the bright disk of the more distant one. However, these observations will also reveal another interesting feature. As two BHs pass in front of each other, said Haiman and Davelaar, there will be a distinctive dip in brightness corresponding to the "shadow" of the more distant black hole.

Depending on how massive the black holes are and how closely their orbits are entwined, these dips can last from a few hours to a few days. The length of the dip can also be used to estimate the size and shape of the shadow cast by the BHs event horizon, the point at which nothing can escape its gravitational force (not even light). As Davelaar explained in a recent Columbia News release:

"It took years and a massive effort by dozens of scientists to make that high-resolution image of the M87 black holes. That approach only works for the biggest and closest black holes—the pair at the heart of M87 and potentially our own Milky Way. [W]ith our technique, you measure the brightness of the black holes over time, you don't need to resolve each object spatially. It should be possible to find this signal in many galaxies."



In gravitational lensing, the gravity of a large object is used to bend, brighten, and distort the light of other objects behind it. Credit: NASA/ESA/L. Calcada

As Haiman added, the shadow of a black hole is its most mysterious and informative feature. "That dark spot tells us about the size of the black hole, the shape of the space-time around it, and how matter falls into the black hole near its horizon," he said. Haiman and Davelaar became interested in this phenomenon after Haiman and a team of colleagues detected a suspected pair of supermassive black holes ("Spikey") in 2020 at the center of a galaxy that existed during the early Universe.

The discovery occurred when the team was examining data from the *Kepler Space Telescope* to monitor distant stars for tiny dips in brightness, which is used to confirm the presence of transiting exoplanets (aka. the Transit Method). Instead, the *Kepler* data showed indications that the flaring effect was caused by a pair of transiting black holes that were visible edge-on. The nickname was due to the spikes in brightness triggered by the suspected lensing effect of the black holes as they passed in front of each other.

To learn more about the flare, Haiman enlisted the help of his postdoc (Davelaar) to construct a model for this flaring effect. While the model confirmed the spikes, it also revealed a periodic dip in brightness that they could not explain. After eliminating the possibility that this resulted from errors in the model, they determined that the signal was real and began looking for a physical mechanism that could explain it. Eventually, they realized that each dip closely corresponded to the time it took for the BHs to make transits relative to the observer.

The detection of this shadow could have immense implications for astrophysicists and quantum physicists alike. Astrophysicists have been looking for these shadows as part of an ongoing effort to test General Relativity under the most extreme conditions and environments. These tests could lead to a new understanding of how gravity and quantum forces interact, which would allow physicists to finally resolve how the four fundamental forces of nature work together – electromagnetic, weak nuclear forces, strong nuclear forces, and gravity.

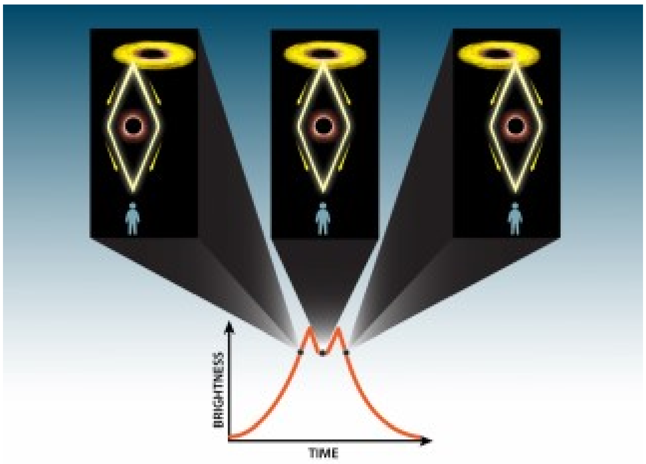


Illustration of the lensing effect allows light from transiting black holes to become magnified. Credit: Nicoletta Baroloini

For decades, scientists have understood how three of the forces that govern all matter-energy interactions work. While General Relativity describes how gravity (the weakest of the four forces) works on its own, all efforts to find a way to explain it in quantum terms have failed. As a result, a theory of "quantum gravity," or Theory of Everything (ToE), has eluded even the greatest scientific minds. This includes Einstein and Stephen Hawking, who dedicated the better part of his scientific career to finding one.

In the meantime, Haiman and Davelaar are currently looking for other telescope data to confirm the *Kepler* observations and verify that "Spikey" really is harboring a pair of merging black holes. If and when their technique is confirmed, it is likely to be applied to the roughy 150 pairs of merging SMBHs that have been observed but are still awaiting confirmation. In the coming years, next-generation telescopes will be coming online that will allow for more opportunities to test this technique. Examples include the Vera C. Rubin Observatory, a massive telescope in Chile scheduled to open later this year. Once operational, Rubin will conduct the 10-year Legacy Survey of Space and Time (LSST) that will include the observation of more than 100 million SMBHs. By 2030, NASA's Laser Interferometry Space Antenna, a space-based gravitational wave detector, will also come online and enable even more opportunities to study merging black holes. With so many candidates available for study, scientists shouldn't have to wait too long for a breakthrough.

"Even if only a tiny fraction of these black hole binaries has the right conditions to measure our proposed effect, we could find many of these black hole dips," said Davelaar.

Astronomers Find a Star That Contains 65 Different Elements

Have you ever held a chunk of gold in your hand? Not a little piece of jewelry, but an ounce or more? If you have, you can almost immediately understand what drives humans to want to possess it and know where it comes from.

We know that gold comes from stars. All stars are comprised primarily of hydrogen and helium. But they contain other elements, which astrophysicists refer to as a star's metallicity. Our Sun has a high metallicity and contains 67 different elements, including about 2.5 trillion tons of gold. Now astronomers have found a distant star that contains 65 elements, the most ever detected in another star. Gold is among them.

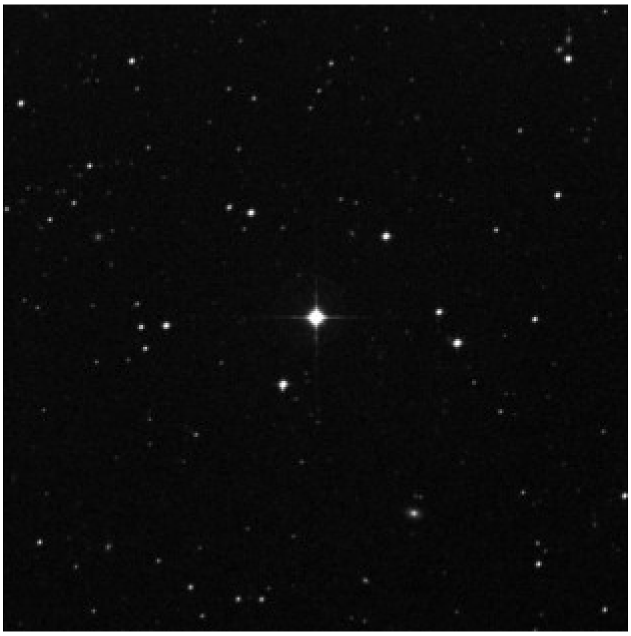
There's a fairly bright star in our neighbourhood of the Milky Way named HD 222925. It's close to the southern sky's Tucana (Toucan) constellation. Astronomers are calling it the "gold standard" star because it's their best opportunity to study how stars create some of the heavy elements in the Universe. That process is called the r-process, or rapid neutron capture process.

A new paper presents a chemical inventory for HD 222925 of all the elements produced by the r-process. The paper is "The R-Process Alliance: A Nearly Complete R-Process Abundance Template Derived from Ultraviolet Spectroscopy of the R-Process-Enhanced Metal-Poor Star HD 222925." It's available online at the pre-press site arxiv.org and will be published in the Astrophysical Journal Supplement Series. The lead author is Ian Roederer, an astronomer at the University of Michigan.

HD 222295 is an r-process enhanced but metal-poor star. It has high metallicity, meaning it contains many elements other than hydrogen and helium, but not much of those elements by mass. It's not the first one discovered. That distinction belongs to CS 22892–052, also known as Sneden's star, after the scientist who first identified 53 chemical elements in it. But HD 222295 is much brighter in UV than Sneden's star, making it much easier to observe spectroscopically. That's how the researchers were able to identify 65 different elements.

"To the best of my knowledge, that's a record for any object beyond our Solar System. And what makes this star so unique is that it has a very high relative proportion of the elements listed along the bottom two-thirds of the periodic table. We even detected gold," Roederer said in a press release. "These elements were made by the rapid neutron capture process. That's really the thing we're trying to study: the physics in understanding how, where and when those elements were made."

The star HD 222925 is a ninth-magnitude star located to



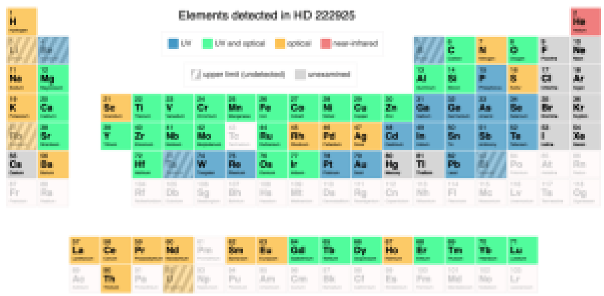
ward the southern constellation Tucana. Astronomers detected 65 different chemical elements in the star, the most detected in a star other than the Sun, containing 67 different elements. Image Credit: The STScI Digitized Sky Survey

There are two types of neutron capture: the slow neutron capture process, or s-process, and the r-process. The s-process is reasonably well-understood, but scientists still have significant questions about the r-process. Astrophysicists have a good theoretical understanding of the r-process, but it wasn't observed directly until 2019 when observers saw strontium in the wreckage of a kilonova explosion.

Rapid neutron capture allows an atomic nucleus to capture neutrons quicker than the neutrons can decay, creating heavy elements. The r-process begins with elements lighter than iron. In an environment with lots of neutrons and lots of energy, these lighter elements can capture neutrons since they're neutral and have no charge. When an atom captures a neutron, it emits an electron, converting the neutron into another proton. That raises the atomic number, and the lighter element becomes a heavier element.

These heavier elements—including precious gold—are rarely detected in stars because the astrophysical sites that foster the r-process are rare. "You need lots of neutrons that are free and a very high energy set of conditions to liberate them and add them to the nuclei of atoms," Roederer said. "There aren't very many environments in which that can happen—two, maybe."

This rarity makes the r-process challenging to study, and also what makes the heavier elements, like gold, rare. It's what makes HD 222295 the gold standard.



This periodic table from the study shows the elements examined in HD 222925. Elements with no long-lived isotopes are indicated using a light gray font. Helium was previously detected in near-infrared spectra. Image Credit: Roederer et al. 2022.

Neutron star mergers and the resulting kilonova explosions are one of the environments that foster the r-process. Supernovae explosions of massive stars are the other. Nailing down the astrophysical environments that allow the r-process is critical in understanding the r-process. Now astrophysicists want to study the process in more detail.

"That's an important step forward: recognizing where the r-process can occur. But it's a much bigger step to say, 'What did that event actually do? What was produced there?'" Roederer said. "That's where our study comes in."

HD 222295 didn't produce the heavy elements it contains. They were produced earlier in the Universe and then spread into space by either supernovae or kilonovae. Then they were taken up in another generation of star formation, in this case by HD 222295.

"We now know the detailed element-by-element output of some r-process event that happened early in the universe," said study co-author Anna Frebel. Frebel is a physics professor at MIT. "Any model that tries to understand what's going on with the r-process has to be able to reproduce that," she said.

Scientists know that the r-process is one of the main ways stars and their remnants produce heavier elements with atomic numbers greater than 30. Recent observations confirmed that the r-process occurs in neutron star mergers and the resulting kilonova explosions. But there are still some open questions that have persisted for a long time, like which elements it produces and in what abundances?

In 2019, European researchers found signatures of strontium formed in a neutron-star merger. This artist's impression shows two tiny but dense neutron stars when they merge and explode as a kilonova. In the foreground, we see a representation of freshly created strontium. Image Credit: ESO/L. Calçada/M. Kornmesser

Those questions led to the creation of the R-Process Alliance, a group of scientists trying to find answers. Some of the authors of this new study are members of the Alliance. This is the second paper published by members of the Alliance that focuses on HD 222295. The researchers think that HD 222295 is one of a group of stars that formed in an environment enriched by the r-process. The star's metallicity is higher than most known stars enriched by the r-process. That suggests that multiple supernovae enriched it. HD 222295 likely didn't form as part of the Milky Way but was captured by our galaxy at some point in the past.

"HD 222925 exhibits no remarkable characteristics in its chemical abundance pattern, other than the overall enhancement of r-process elements," the authors write. "Thus, it may be considered as reflecting the yields of the dominant r-process source(s) in the early universe."

Now that astrophysicists have identified a bright star containing elements from the r-process, it can act as a proxy for what supernovae and kilonovae produce. As researchers create models of the r-process inside these events that creates the heavy elements, those models must have the same signature as HD 222295. Hence, it's the gold standard.

Gold has always held a certain mystique for humanity. It's unique among the elements and made regular appearances in the world's myths. In ancient Greece, the Gods dressed in gold and golden apples conferred mortality on those who ate them if they could get past the dragon that guarded them. In Hindu mythology, gold is the source of power and can transmit divine consciousness. It's also the soul of the world itself.

The ancients treasured gold, but they couldn't have guessed at its origins. These are images of King Tut's mask (l) and his inner coffin (r). The inner coffin is solid gold and weighs almost 243 pounds. Image Credits: Mask: By Roland Unger – Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=48168958. Inner Coffin: Egyptian Museum, Cairo.

Those beliefs are wiped away now, lost to time. But the science that replaces them is even more fascinating. The ancients could never have imagined that their myths would be replaced by science and that stars could explode and create gold and other elements. They could never have envisioned gigantic mountain-top telescopes that peer vast distances into space. They could never have imagined that we could cut up a star's light and determine that the star holds gold.

And they could never have guessed that our own Sun contains 2.5 trillion tons of gold.

Scouring Through old Hubble Images Turned up 1,000 new Asteroids

Researchers have found over 1,700 asteroid trails in archived Hubble data from the last 20 years. While many of the asteroids are previously known, more than 1,000 are not. What good are another 1,000 asteroids? Like all asteroids, they could hold valuable clues to the Solar System's history.

As time passes and more and more telescopes perform more and more observations, their combined archival data keeps growing. Sometimes discoveries lurk in that data that await new analytical tools or renewed efforts from scientists before they're revealed. That's what happened in an effort called the Hubble Asteroid Hunter.

In 2019 a group of astronomers launched the Hubble Asteroid Hunter. It's a citizen science project on the Zooniverse platform. Their goal was to comb through Hubble data to find new asteroids.

"The amount of data in astronomy archives increases exponentially and we wanted to make use of this amazing data."

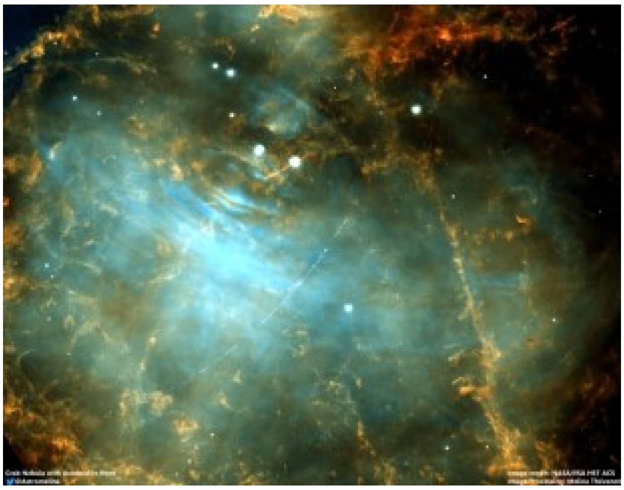
Sandor Kruk, Max Planck Institute for Extraterrestrial Physics.

The astronomers released the results of their project in a new paper titled "Hubble Asteroid Hunter I. Identifying asteroid trails in Hubble Space Telescope images." The study is online in the journal Astronomy and Astrophysics. The lead author is Sandor Kruk from the Max Planck Institute for Extraterrestrial Physics.

"One astronomer's trash can be another astronomer's treasure," Kruk said in a press release. The data they searched for was largely discarded from other observational efforts not focused on asteroids. In many cases, the data would have appeared as "noise" and was removed to make different elements stand out. But all of this secondary, unexamined data is still archived and available.

"The amount of data in astronomy archives increases exponentially, and we wanted to make use of this amazing data," said Kruk.

The project examined more than 37,000 composite Hubble images. They were taken between 30 April 2002 and 14 March 2021 with the Advanced Camera for Surveys and the Wide Field Camera 3 onboard the Hubble Space Telescope. Most images are 30-minute long exposures, so asteroid trails appear as curved streaks.

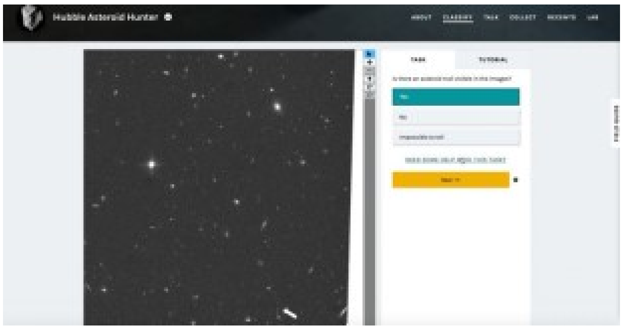


In this Hubble observation taken on 5 December 2005, the Main Belt asteroid 2001 SE101 passes in front of the Crab Nebula. Image Credit: NASA/ESA HST, Image processing: Melina Thévenot.

The streaks go to the heart of the problem: computers struggle to detect them. That's where the Zooniverse platform and citizen scientists come in.

"Due to the orbit and motion of Hubble itself, the streaks appear curved in the images, which makes it difficult to classify asteroid trails – or rather it is difficult to tell a computer how to automatically detect them," explained Sandor Kruk. "Therefore, we needed volunteers to do an initial classification, which we then used to train a machine-learning algorithm."

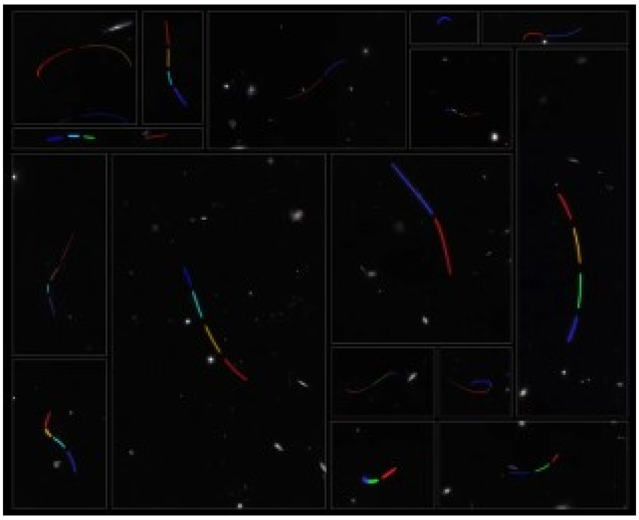
The volunteers delivered. 11,482 citizen scientists took part in classifying the images. The Hubble Asteroid Hunter page at Zooniverse had over 2 million clicks, and the volunteers provided 1488 positive classifications in about 1 % of the images.



This image shows the Hubble Asteroid Hunter interface as used on Zooniverse. Citizen Scientists were asked to mark the beginning and end of asteroid trails in Hubble images. Image Credit: Zooniverse/Hubble Asteroid Hunter.

The work of the citizens who took part trained a machine-learning algorithm to search the rest of the images quickly and accurately. The algorithm exists in the Google Cloud, and once it was trained, it contributed another 900 detections for a total of 2487 potential asteroid trails in the Hubble data.

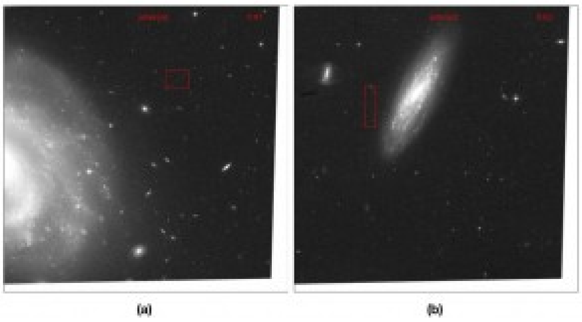
Then the professional scientists played their role. Three of the paper's authors, including lead author Sandor Kruk, went over the results. They excluded things like cosmic rays and other objects, which resulted in 1701 trails found in 1316 Hubble images. About one-third of them were known asteroids, leaving 1031 unidentified asteroid trails.



This mosaic consists of 16 different data sets from the NASA/ESA Hubble Space Telescope studied as part of the Asteroid Hunter citizen science project. Each of these datasets was colour-assigned based on the time sequence of exposures, whereby the blue tones represent the first exposure that the asteroid was captured in and the red tones represent the last. Image Credit: ESA/Hubble & NASA, S. Kruk (ESA/ESTEC), Hubble Asteroid Hunter citizen science team, M. Zamani (ESA/Hubble)

Follow-up observations will confirm how many of them are newly-discovered asteroids and determine their orbits. Some of 1031 will likely not be confirmed, but the rest will help flesh out our understanding of our Solar System's asteroid population.

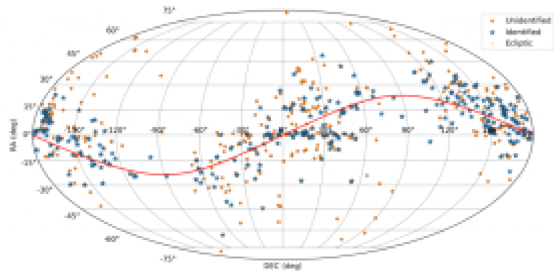
These asteroids have escaped detection because they're fainter and likely much smaller than most asteroids detected from the ground. This paper is the first one released as part of the Hubble Asteroid Hunter project. In subsequent papers, the authors will use the curved shape of the asteroid trails to determine their orbits and their distances.



This image from the paper shows two asteroids found in Hubble images by the team's machine learning tool, called Auto ML. The red numbers in the upper right corners are Auto ML's confidence classifications for each image. Image Credit: Hubble Asteroid Hunter

All asteroids are remnants from the Solar System's early days, mostly from before the planets formed. They're like nature's time capsules, and they preserve the conditions in the early system. That's why astronomers are so interested in them and why we've sent spacecraft to collect samples from asteroids like Bennu and Ryugu.

"The asteroids are remnants from the formation of our Solar System, which means that we can learn more about the conditions when our planets were born," Kruk explained.



This image from the study is a sky-map of the Solar System Objects (SSOs) identified in the Hubble archived images. The blue stars show the identified, known asteroids. The orange circles show the location of objects for which the team did not find any associations with SSOs. The ecliptic is shown in red. The two gaps in this plot correspond to the Galactic plane, which HST did not observe. Image Credit: Hubble Asteroid Hunter

More and more researchers are making use of archival data like this. It's economical to scour existing images for new discoveries, and it bears fruit. "The use of archival data produced by imaging campaigns whose primary science goals lie outside the Solar System is common practice in asteroid science. Several groups have used various image archives to find and characterize SSOs." For example, in 2019, researchers used archival images from exoplanet surveys to identify over 1800 asteroids, with 182 potential new discoveries.

Astronomers want a complete understanding of the Solar System's asteroid population because it helps clarify the Solar System's history. "A detailed description of the small bodies in the Solar System puts constraints on the different Solar System formation scenarios, which make

concrete predictions on the size and orbit distribution of objects as a function of time," the authors explain. "In particular, both the giant planets' migrations and collisional cascades have effects on the asteroids' size and orbital distributions that could be detectable with specially purposed observational surveys."
But specially purposed surveys are expensive and time-consuming. Observing proposals also face stiff competition from other researchers with other foci. "We instead decided to produce such a survey from a large archival dataset," the authors write.
Kruk hinted at things in the data other than asteroids. "But there were other serendipitous finds in the archival images as well, which we are currently following up." He also said that their approach is a game-changer, and they intend to use it again. "Using such a combination of human and artificial intelligence to scour vast amounts of data is a big game-changer, and we will also use these techniques for other upcoming surveys, such as with the Euclid telescope."
As far as the "… other serendipitous finds…" in the images, Kruk declined to share what those other finds might be. He told Universe Today that the findings are "… not related to unusual asteroids but to other findings in the data. We will report them in follow-up publications and announcements soon, so stay tuned!"
We certainly will.

This is it! Meet the Supermassive Black Hole at the Heart of the Milky Way

On April 10th, 2019, the international consortium known as the Event Horizon Telescope (EHT) announced the first-ever image of a supermassive black hole (SMBH). The image showed the bright disk surrounding the black hole at the center of the M87 galaxy (aka. Virgo A). In 2021, they followed up on this by acquiring an image of the core region of the Centaurus A galaxy and the radio jet emanating from it. Earlier this month, the European Southern Observatory (ESO) announced that the EHT would be sharing the results from its latest campaign – observations of Sagittarius A*!
This supermassive black hole resides at the center of the Milky Way Galaxy, roughly 27,000 light-years from Earth, 44 million km (27.34 million mi) in diameter, and has a mass of 4.31 million Suns. The campaign's results were shared in an ESO press release and a series of live-streamed press conferences worldwide, including the ESO Headquarters in Munich, Germany. The team's results (which were shared in six papers) were also published today in a special issue of *The Astrophysical Journal Letters*.
Since the 1970s, astronomers have speculated about the existence of SMBHs, which were believed to be why massive galaxies had such energetic core regions. Also known as Active Galactic Nuclei (AGNs), or "quasars," these regions are known to temporarily outshine all of the stars contained in their disks. In some cases, jets of superheated material (relativistic jets) have also been found emanating from them at a fraction of the speed of light.
The study of SMBHs has led to new theories about how galaxies formed and evolved in our Universe and has allowed astronomers to test the laws of physics under the most extreme conditions (i.e., Einstein's Theory of General Relativity). Until 2019 the study of these massive black holes was confined to observing their effect on the surrounding environment. In particular, astronomers have noted how the gravitational forces of SMBHs cause gas and dust to fall in around their outer edges (the Event Horizon).
This matter is then accelerated to relativistic speed and slowly be accreted onto the faces of the black hole, releasing the tremendous amounts of energy that allow AGNs to outshine their galactic disks. However, visualizing these massive objects in telescopes is extremely difficult because they are nestled within the tightly packed group of stars at the galaxy's center (aka. the "galactic bulge"), which produces a tremendous amount of light interference.
But thanks to a technique known as Very Long Baseline Interferometry (VLBI), where telescopes worldwide combine light to achieve high-resolution imaging, astronomers at the EHT Collaboration created a virtual telescope with an aperture equivalent in size to the Earth. When concentrated on an object that is difficult to resolve, this telescope can gather light over time and reconstruct an image of what it looks like (similar to a long exposure time with a camera).
This allowed the EHT team to image the bright Event Horizon around the M87 supermassive black hole (M87*) for the first time and has led to new insights on several other SMBHs. For example, the EHT also observed Sgr A* on multiple nights in 2017 and collected data for several hours straight. The latest image shows the Event Horizon of Sagittarius A* (Sgr A* for short) and is the first definitive evidence of this SMBHs existence.

The Atacama Large Millimeter/submillimeter Array (ALMA) looking up at the Milky Way and the location of Sagittarius A, the supermassive black hole at our galactic center. Credit: ESO*

Geoffrey Bower, an EHT Project Scientist from the Academia Sinica's Institute of Astronomy and Astrophysics, spoke of the results in an ESO press release. "We were stunned by how well the size of the ring agreed with predictions from Einstein's Theory of General Relativity," he said. "These unprecedented observations have greatly improved our understanding of what happens at the very center of our galaxy and offer new insights on how these giant black holes interact with their surroundings."
As noted, the EHT Collaboration is an international effort that includes facilities worldwide, which includes the ESO's Atacama Large Millimeter/submillimeter Array (ALMA) and Atacama Pathfinder EXperiment (APEX) in northern Chile. ESO Director General Xavier Barcons was also part of the press conference and expressed his support for the Collaboration and its latest results.
"It is very exciting for ESO to have been playing such an important role in unraveling the mysteries of black holes, and of Sgr A* in particular, over so many years," he said. "ESO not only contributed to the EHT observations through the ALMA and APEX facilities but also enabled, with its other observatories in Chile, some of the previous breakthrough observations of the Galactic center."
While the image of Sagittarius A* looks remarkably similar to M87*, there are some significant differences between the two. For one, our galaxy's SMBH is more than a thousand times smaller and less massive than M87* – about 6.5 billion times as massive as our Sun. However, the edges of both black holes look very similar, which the team concludes is the result of General Relativity govern-

ing these objects up close. At the same time, differences seen further away are due to differences in the material surrounding them.

Furthermore, imaging Sgr A* was far more difficult than imaging M87*, despite being much closer to Earth. As EHT scientist Chi-kwan Chan, from the Steward Observatory and the University of Arizona Data Science Institute (UoA DSI), explained:

“The gas in the vicinity of the black holes moves at the same speed – nearly as fast as light – around both Sgr A and M87*. But where gas takes days to weeks to orbit the larger M87*, in the much smaller Sgr A* it completes an orbit in mere minutes. This means the brightness and pattern of the gas around Sgr A* were changing rapidly as the EHT Collaboration was observing it – a bit like trying to take a clear picture of a puppy quickly chasing its tail.”*

In short, M87* was a steadier target than Sgr A*, where nearly all of the images acquired looked the same because its rapid velocity created the appearance of uniformity. In contrast, the images of Sgr A* the team extracted were markedly different, owing to the slower velocity of matter in the accretion disk. The EHT researchers had to develop new tools to account for this and provide an average of all the different images.

To achieve this, the team worked rigorously for five years, using supercomputers to combine and analyze their data and creating an unprecedented library of simulated black holes to compare with the observations. Because of this,s scientists will now have images of two black holes with very different sizes and offers, which offers opportunities to test the laws of physics under different domains. Scientists have already begun to use the data to test theories and models of how gas behaves around SMBHs.

While this process is not yet well-understood, it is thought to play a key role in the formation and evolution of galaxies. Said EHT scientist Keiichi Asada from the Academia Sinica’s Institute of Astronomy and Astrophysics in Taipei:

“Now we can study the differences between these two supermassive black holes to gain valuable new clues about how this important process works. We have images for two black holes – one at the large end and one at the small end of supermassive black holes in the Universe – so we can go a lot further in testing how gravity behaves in these extreme environments than ever before.”

The results of the EHT Collaboration’s observation campaign (contained in six studies) were also shared in a special issue of *The Astrophysical Journal Letters*. Whereas the first paper presents a summary of their overall findings, papers II, III, and IV demonstrate how the lower mass and shorter dynamical scale of Sgr A* led to complexity with the imaging and data analysis. In Paper V, researchers combine the EHT results with extensive multi-wavelength constraints to explore the accretion and outflow physics of Sgr A*.

In Paper VI, researchers present infrared measurements of stellar orbits around Sgr A* to constrain the mass, distance, and ring diameter of Sgr A* to approximately 1% accuracy, enabling precision explorations of gravitational physics. Additional papers not performed by the EHT collaboration are also provided that address the possibility of dynamical VLBI imaging, a new analysis of the data obtained by the 2017 campaign, evaluating simulated images of black holes, and black-hole image reconstruction.

These results were made possible thanks to the over 300 scientists and 80 institutions worldwide that make up the EHT Collaboration. These include the Caltech Submillimeter Observatory (CSO) on the summit of Manua Kea, Hawaii; the Combined Array for Research in Millimeter-wave Astronomy (CARMA) in California; the Kitt Peak National Observatory (KPNO), and the ARO Submillimeter Telescope (SMT) in Arizona; and the Gran Telescopio Milimétrico Alfonso Serrano in Mexico.

Beyond North America, there’s also the NSF’s South Pole Telescope (SPT) at the Amundsen–Scott South Pole Station, Antarctica, and the Institute Radioastronomie Millimetrique‘s (IRAM) 30-meter telescope and NOrthern Extended Millimeter Array (NOEMA) radio telescopes in Spain and France. Additional support is provided by the Max Planck Institute for Radio Astronomy in Germany, which relies on its supercomputer to combine EHT data from multiple observatories.

A Giant Galaxy has been Unwinding its Neighbour for 400 Million Years

The interacting galaxy pair NGC 1512 and NGC 1510 take center stage in this image from the Dark Energy Camera, a state-of-the art wide-field imager on the Víctor M. Blanco 4-meter Telescope at Cerro Tololo Inter-American Observatory. Courtesy NOIRLab.

Sometimes you have to just sit back and marvel at a particularly gorgeous view of a galaxy interaction. When these giant space cities merge with each other, wild and crazy things happen—a sort of “Galaxies Gone Wild” scenario. Take this pair, for example. We see them locked together in a cosmic dance that has lasted for not quite a half-billion years. With each turn on the intergalactic dance floor, they change each other permanently. Eventually, they’ll combine to make one giant galaxy.

NGC 1512 (left) is the larger of the two galaxies. It’s a barred spiral that looks like it’s unwinding as the interaction plays out. Its smaller companion is a dwarf lenticular galaxy (to its lower right) called NGC 1510. They both lie in the direction of the constellation Horologium, and are about 60 million light-years away from us. The Victor M. Blanco 4-meter telescope in Chile caught this view of the pair’s galaxy interaction.

What Happens in a Galaxy Merger?

Galaxies lie far apart in space, but they interact with each other throughout cosmic time. The dances they do are how they grow and change. This includes our own Milky Way. In fact, our galaxy is currently gobbling up some smaller dwarf galaxies, adding their distinctive stars to the larger population of the Milky Way.

The galaxy interaction of NGC 1510 and NGC 1512 is a good example of what happens during the merger process. Their gravitational attraction to each other spurred great waves of star formation, particularly in the outer spiral arms of the larger galaxy. That created what astronomers call “starbursts” and splashed long blue strings of hot young stars out to space. Galaxy mergers often spur bouts of star formation. Someday, these massive stars will explode as supernovae and add a bit of a fireworks display to the long galactic dance.

In addition, NGC 1512’s smaller gravitational pull has pulled gas, dust, and stars away from its larger neighbor, creating wispy tendrils extending out through space. It also looks like it’s “unwinding” the spiral arms on the more-massive neighbor.

A cropped view of the main image shows the tendrils of hot young stars created during the starburst phase of the galaxy interaction. Courtesy NOIRLab.

NGC 1510 affects its small companion, pulling tendrils of gas and dust away. The interaction is also distorting the shapes of both galaxies. Things will only get worse for both of them as time goes by. Ultimately, they'll merge completely with each other to form a giant galaxy, probably an elliptical one. But, that's way far in the future.

Capturing the View

This galactic dance scene is part of a larger image captured by the Blanco Telescope, outfitted with the Dark Energy Camera (DECam). The DECam was built for use by the Dark Energy Survey. That's a project to map hundreds of millions of galaxies and detect supernovae. Ultimately, the idea is to look for patterns in cosmic structure that give clues to the nature of dark energy. That's a mysterious "something" that is accelerating the expansion of the universe. The survey lasted six years. During that time, the DECam recorded information about 300 million galaxies across 5,000 square degrees of the southern skies.

While we can't see dark energy directly, we can appreciate the survey's incredibly detailed images of galaxies like this one and the results of such a fantastic galaxy interaction. If you look closely at this wide-field view, you can see even more distant galaxies forming a backdrop to the two interacting ones.

A wide-field view from the DECam. Courtesy NOIRLab.

The Victor C. Blanco facility is part of the NOIRlab. This collection of observatories includes the Cerro Tololo Inter-American Observatory, the Community Science and Data Center, Gemini Observatory, Kitt Peak National Observatory, and the Vera C. Rubin Observatory. The lab itself is funded by the U.S. National Science Foundation.

The Víctor M. Blanco 4-meter Telescope dome appears under the Milky Way at Cerro Tololo Inter-American Observatory. Courtesy NOIRLAb.

E Mails Viewings Logs and Images from Members.

Viewing Log for 4th of May

I started the evening at Hackpen Hill watching a sunset and hopefully finding Mercury after the sun had gone? Mercury is the one planet I have not seen many times over the years I have been doing astronomy, I remember the first time finding the inner most planet while I was out in Oman during the mid -90's, think I have seen the planet less than 10 times since yet all the other planets must be close to or past the 100 mark? About 20 minutes after the sun had set, I managed to find the planet using my 15x70 binoculars when it was about 7 ° above the horizon. While I was hunting for the planet, I noticed a couple of people setting up a telescope in the car park, I went across to them and said the car park was not a good place to do any viewing due to car lights coming and going. I said, I had a telescope in the back of my car and would be setting it up once Mercury had gone and if they wish they could come along to my viewing place as it would not be affected by cars as the road was still close.

With the two people in tow I arrived at my usual viewing place and had my Meade LX90 set up and ready by 22:14, with a temperature of 11 °C and no wind the conditions should be good? As usual, I would be using my trusted 14 mm WX Pentax eye piece. But before I could start I noticed the power jack was bent, what! Lucky for me, the wires were still connected, with the outer cover of the jack straighten and strapped to the plug of the hand controller (so it could not move and lose power for the scope) I could carry on. As I was showing two newbies the sky, I asked what they would like to see, started with the Double Cluster (Caldwell 14) which is always great to look at. Had to slew from one to the other as my field of view was too narrow to view them both at the same time. Explained about the colour of stars and the temperatures to go with them, so I went off to Vega in Lyra, this star is a blue-tinged white star and fifth brightest star in the whole sky. Going up one place to number four is Arcturus, a red giant star in Bootes. Off to globular clusters (G C) and Messier (M) 13 in Hercules, this was good to look at and could make out a few stars on the edge of the cluster. Tried to get Albireo (for double stars) but it was too low to view so I tried Castor in Gemini, this is a tight double to look at but is actually a six star system! On to another open cluster and M 44, the Beehive in Cancer, this was best viewed with the finderscope as it is too big to be viewed with the eye piece. Went back to Hercules and had a look at the often over looked G C in M 92. This is much smaller and duller than M 13 but still good to look at. Final object for the evening was M 3 in Canes Venatici, this is another wonderful G C to look at. M 3 would give M 13 a good run for its money being nearly as good, in my view.

With the time being 23:35, it was time to pack up, hopefully the two people who I had for the session managed to learn sometime from me? I did inform them about Swindon Stargazers and they meet in Liddingham and hopefully they might go there, all clubs like to have new members once in a while.

Clear skies.

Peter Chappell

Viewing Log for 27th of May

Chris Brooks had arranged a WAS viewing session at Lacock with a starting time of around 22:00 with a solar session beforehand, if people were interested. I could not make the solar session as I was playing golf in the late afternoon. Once home and had something to eat, I headed off to Hackpen Hill to catch the sunset before heading to Lacock afterwards. I left Hackpen Hill around 21:30 and arrived at Lacock just after 22:00.

To my surprise only Chris and Andy Burns were in the field, so I joined them and had my Meade LX90 GOTO telescope with a Pentax XW 14 mm eye piece set up and ready by 22:19, with a temperature of 12 °C it should be a pleasant session? With thin high cloud to keep us company it might affect some of the objects we wished to view? I had brought along my step ladder so the light sensor could be covered but for some reason the light was not working, great!

While I was doing my set up the ISS came over with a maximum height of 32 ° and covered about two thirds of the sky before going into Earth's shadow. So, with the ISS pass finish it was time to start viewing, my first object was Messier (M) 57, the Ring Nebula but I could not find it at all yet both Andy and Chris were making comments about this planetary nebula (P N) with their equipment. Strange I thought? So I tried going to other targets with no success, tried a star but was way out! Turns out when I was doing my star alignment I had not started with Polaris, not dark enough. So, after doing a reset, I managed to find M 57, it was okay to look at, not being that dark did not help. Nearby is the globular cluster (G C) M 56 in Lyra, this was no better than a fuzzy blob (F B) to view. It got even worst with M 27, the Dumbbell nebula. I made this out as a faint fuzzy blob (F F B), viewing this P N for a while it did show some detail. The open cluster near the star Sadr in Cygnus is M 29 and one of my favourite objects to look at but tonight the six stars that make up the main components of the cluster were dim. Battling the clouds we went to Leo, starting to set in the western sky and M 65 and 66 in the same field of view, both were F F B's to look at. By now Andy had packed up his equipment and gone, this just left the two of us to carry on. By now my star sign (Scorpius) had cleared the trees, in the claws of this constellation is M 80, a G C which is small but had a bright core. Lower down near the star Antares is M 4 a large G C which unfortunately was very dim, really too low to view and just cleared the trees! Told Chris about M 92 in Hercules is often over looked by M 13, so we went off to this G C. Managed to see some stars around the edge of this G C. Going directly south we came across M 10 in Ophiuchus, this G C was good to look at. A bit further west is another G C and M 12, this was a bit dimmer than M 10. The same could be said about M 14, also in Ophiuchus.

We noticed it had got much cooler by now and not having my winter gear with me, we decided it was time to pack up (00:03) and go home. That will probably be my last viewing session until mid-August at best due to the skies not getting dark enough?

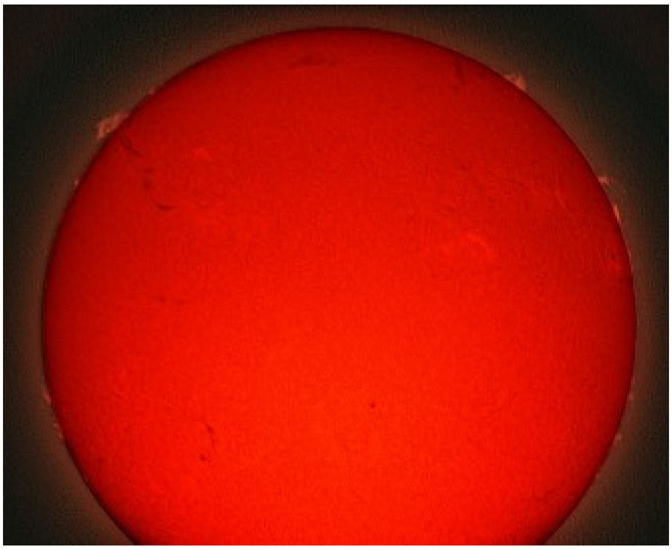
Clear skies.

Peter Chappell

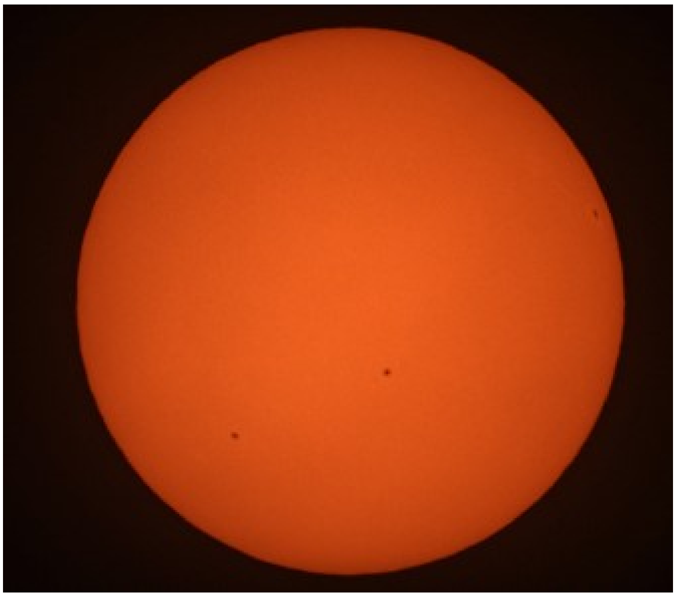
PS After we had packed up our equipment and having a chat in the car park we noticed the skies had cleared of cloud and now looked very good. Oh, British astronomy at times!

Some of the Solar Views from the month of May.

Andy Burns.



Hydrogen alpha shot.

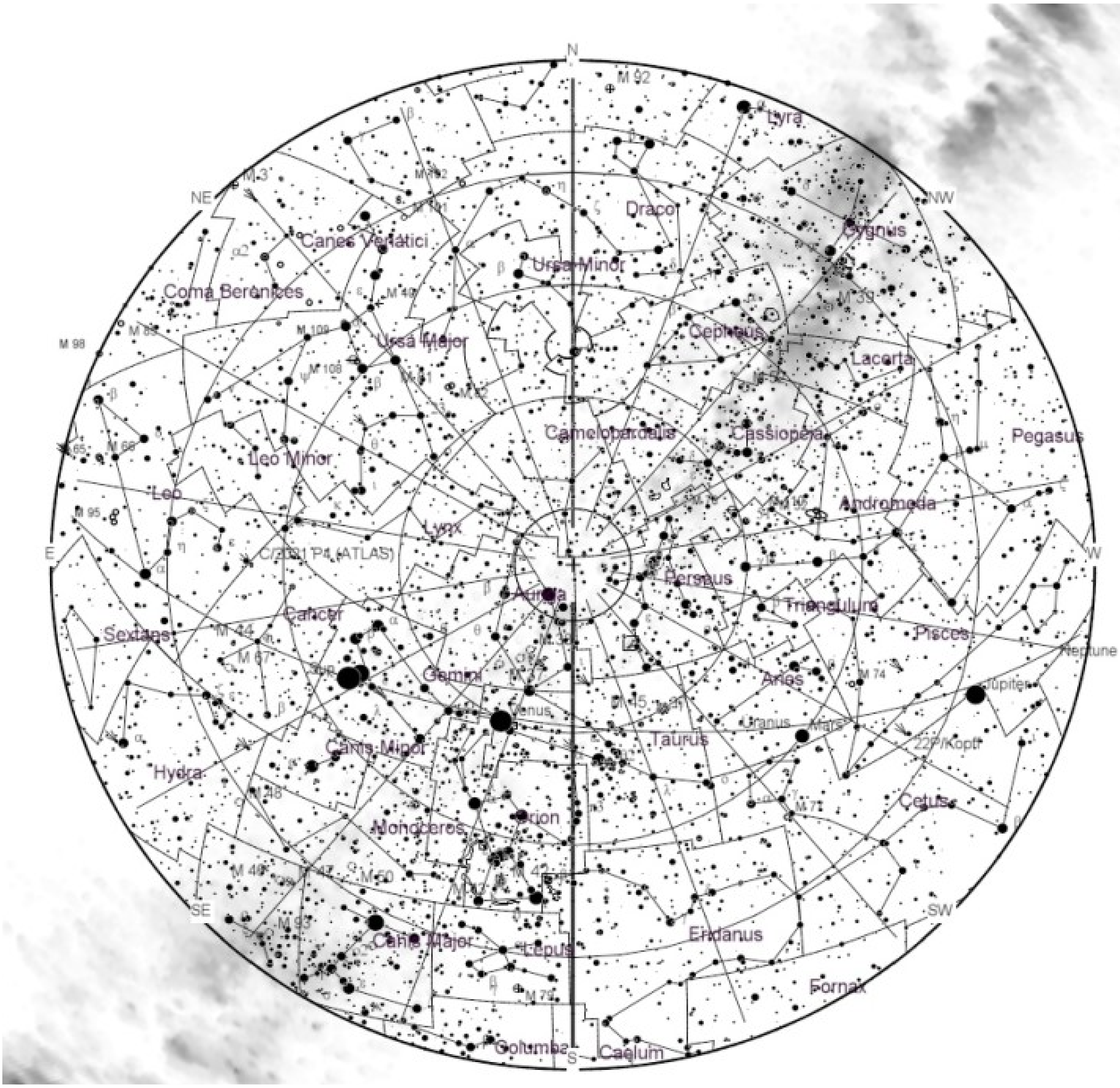


White light from bridge camera and thousand oaks filter. Below is 3 weeks later with a huge sunspot group.

Series of lunar shots.

North of the Mare Imbrium on 11 day lunation. Sinus Iridium, Plato crater and the Alpine rift.

Copernicus crater and the bottom of Mare Imbrium. The Carpathia mountains run from the north of the deep crater.



I have chosen the star chart to show the skies at the middle of July and 10:30. The Milky Way will be twisting across the south horizon as the hour gets later or through August. The darker skies as the summer short nights expand should enhance this even more.

Throughout June and July keep an eye above the northern horizons for the sparkling electric blue clouds of Noctilucent clouds. Capella is a good guide for te right place to look in the evenings or mornings an hour after sunset or an hour before sunrise.

June 14 - **Full Moon, Supermoon.** The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This phase occurs at 11:52 UTC. This full moon was known by early Native American tribes as the Strawberry Moon because it signaled the time of year to gather ripening fruit. It also coincides with the peak of the strawberry harvesting season. This moon has also been known as the Rose Moon and the Honey Moon. This is also the first of three supermoons for 2022. The Moon will be near its closest approach to the Earth and may look slightly larger and brighter than usual.

June 16 - **Mercury at Greatest Western Elongation.** The planet Mercury reaches greatest western elongation of 23.2 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 morning sky. Look for the planet low in the eastern sky just before sunrise.

June 21 - **June Solstice.** The June solstice occurs at 09:05 UTC. The North Pole of the earth will be tilted toward the Sun, which will have reached its northernmost position in the sky and will be directly over the Tropic of Cancer at 23.44 degrees north latitude. This is the first day of summer (summer solstice) in the Northern Hemisphere and the first day of winter (winter solstice) in the Southern Hemisphere.

June 29 - **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 02:53 UTC. This is the best time of the month to observe faint objects such as galaxies and star clusters because there is no moonlight to interfere.

July 13 - **Full Moon, Supermoon.** The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This phase occurs at 18:38 UTC. This full moon was known by early Native American tribes as the Buck Moon because the male buck deer would begin to grow their new antlers at this time of year. This moon has also been known as the Thunder Moon and the Hay Moon. This is also the second of three supermoons for 2022. The Moon will be near its closest approach to the Earth and may look slightly larger and brighter than usual.

July 28 - **New Moon.** The Moon will located on the same side of the Earth as the Sun and will not be visible in the night sky. This phase occurs at 17:55 UTC. This is the best time of the month to observe faint objects such as galaxies and star clusters because there is no moonlight to interfere.

July 28, 29 - **Delta Aquarids Meteor Shower.** The Delta Aquarids is an average shower that can produce up to 20 meteors per hour at its peak. It is produced by debris left behind by comets Marsden and Kracht. The shower runs annually from July 12 to August 23. It peaks this year on the night of July 28 and morning of July 29. This is a great year for this shower because the new moon means dark skies for what should be an excellent. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Aquarius, but can appear anywhere in the sky.

August 12 - **Full Moon, Supermoon.** The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This phase occurs at 01:36 UTC. This full moon was known by early Native American tribes as the Sturgeon Moon because the large sturgeon fish of the Great Lakes and other major lakes were more easily caught at this time of year. This moon has also been known as the Green Corn Moon and the Grain Moon. This is also the last of three supermoons for 2022. The Moon will be near its closest approach to the Earth and may look slightly larger and brighter than usual.

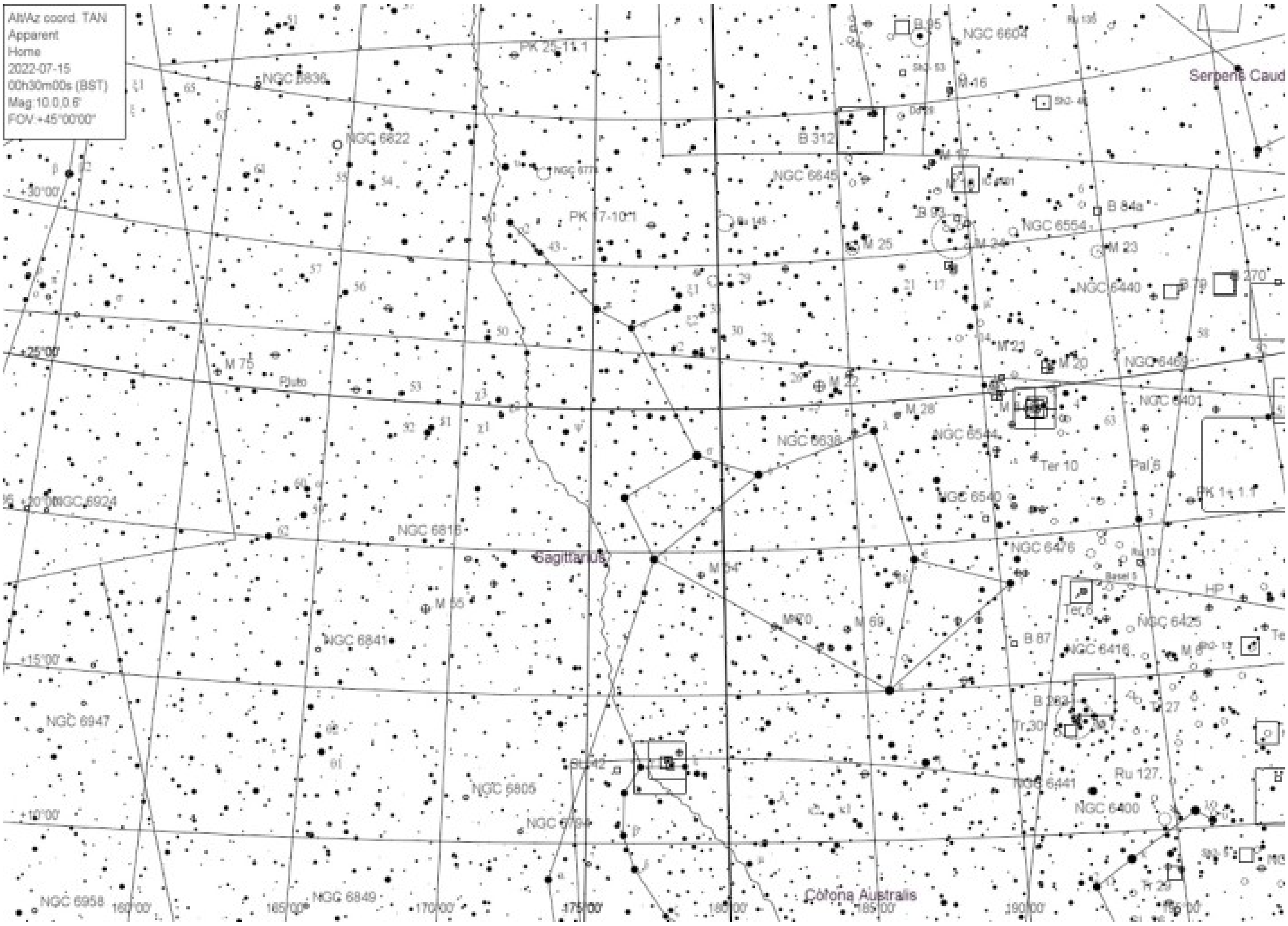
August 12, 13 - **Perseids Meteor Shower.** The Perseids is one of the best meteor showers to observe, producing up to 60 meteors per hour at its peak. It is produced by comet Swift-Tuttle, which was discovered in 1862. The Perseids are famous for producing a large number of bright meteors. The shower runs annually from July 17 to August 24. It peaks this year on the night of August 12 and the morning of August 13. Unfortunately the nearly full moon this year will block out l but the brightest meteors. But the Perseids are so bright and numerous that it could still be a decent show. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Perseus, but can appear anywhere in the sky.

August 14 - **Saturn at Opposition.** The ringed planet will be at its closest approach to Earth and its face will be fully illuminated by the Sun. It will be brighter than any other time of the year and will be visible all night long. This is the best time to view and photograph Saturn and its moons. A medium-sized or larger telescope will allow you to see Saturn's rings and a few of its brightest moons.

August 27 - **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 08:17 UTC. This is the best time of the month to observe faint objects such as galaxies and star clusters because there is no moonlight to interfere.

August 27 - **Mercury at Greatest Eastern Elongation.** The planet Mercury reaches greatest eastern elongation of 27.3 degrees from the Sun. This is the best time to view Mercury since it will be at its highest point above the horizon in the evening sky. Look for the planet low in the western sky just after sunset

CONSTELLATIONS OF THE MONTH: SAGITTARIUS



Sagittarius

The zodiacal constellation of Sagittarius resides on the ecliptic plane and was one of the original 48 constellations charted by Ptolemy to be later adopted as a modern constellation by the IAU. It spans 867 square degrees of sky and ranks 15th in constellation size. It has 7 primary stars in its main asterism and 68 Bayer Flamsteed designation stars within its confines. Sagittarius is bordered by the constellations of Aquila, Scutum, Serpens Cauda, Ophiuchus, Scorpius. Corona Australis, Telescopium, Indus, Microscopium and Capricornus. It is visible to all observers located at latitudes between +55° and ?90° and is best seen at culmination during the month of August.

The easily recogniged “tea pot” shape of Sagittarius was well known in mythology as being represented by the half-man, half-horse – the Centaur. According to some legends, he was the offspring of of Philyra and Saturn. Named Chiron, he turned himself into a horse to hide from his jealous wife and was eventually immortalized in the stars. He is often depicted as an archer as well, with his arrow pointed directly at the red heart of the Scorpion – Antares. Sagittarius may represent the son of Pan, who invented archery and was sent to entertain the Muses who threw a laurel wreath at his feet. No matter what identity you choose, one thing is for certain – there’s no mistaking the presence of the nearby Sagittarius arm of the Milky Way!

(Since the constellation of Sagittarius is simply slopping over with deep sky objects, creating a small, workable chart here would be very confusing. For this reason, I have only chosen a few of my favorite objects to highlight and I hope you enjoy them, too!)

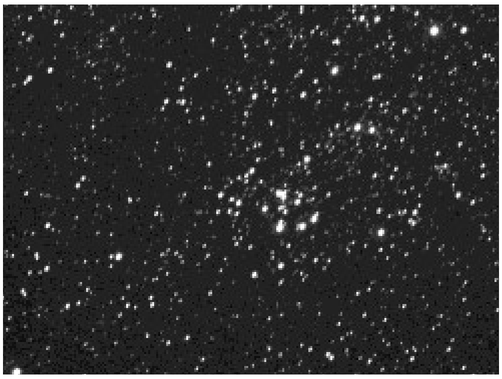
Let’s begin our binocular tour of Sagittarius with its alpha star – the “a” symbol on our map. Located far south in the constellation, Alpha Sagittarii is far from being the brightest of its stars and goes by the traditional name of Rukbat – the “knee of the Archer”. It’s nothing special. Just a typical blue, class AB dwarf star located about 170 light years from Earth, but it often gets ignored because of its position. Have a look at Beta while you’re there, too. It’s the “B” symbol on our map. That’s right! It’s a visual double star and its name is Arkab – the “hamstring”. Now, power up in a telescope. Arkab Prior is the westernmost and it truly is a binary star accompanied by a 7th magnitude dwarf star and seperated by about 28 arcseconds. It’s located about 378 light years from Earth. Now, hop east for Arkab Posterior. It is a spectral type F2 giant star, but much closer at 137 light years in distance.

Now turn your attention towards Epsilon Sagittarii – the backwards “3” symbol on our chart. Kaus Australis is actually the brightest star in the bottom righthand corner of the teapot and the brightest of all the stars in Sagittarius and the 36th brightest in the night sky. Hanging out in space some 134 light years from our solar system, this A-class giant star is much hotter than most of its main sequence peers and spinning over 70 times faster on its axis than our Sun. This rapid movement has caused a shell to form around the star, dimming its brightness… But not nearly as dim as its 14th magnitude companion! That’s right… Epsilon is a binary star. The disparate companion is well seperated at 32 arc seconds, but will require a larger telescope to pick away from its bright companion!

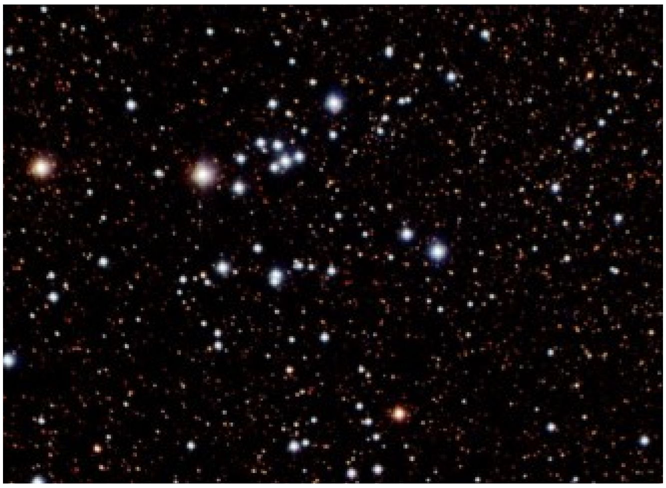
Ready for more? Then have a look at Gamma – the “Y” symbol on our map. Alnasl, the “arrowhead” is two star systems that share the same name. If you have sharp eyes, you can even split this visual double star without aid! However, take a look in the telescope… Gamma-1 Sagittarii is a Cepheid 1500 light year distant variable star in disguise. It drops by almost a full stellar magnitude in just a little under 8 days! Got a big telescope? Then take a closer look, because Gamma-1 also shows evidence of being a close binary star, as well has having two more distant 13th magnitude companions, W Sagittarii B, and C separated by 33 and 48 arcseconds respectively. How about Gamma-2? It's just a regular type-K giant star – but it's only 96 light years from Earth!

Located just slightly more than a fingerwidth above Gamma Sagittarii and 5500 light-years away, NGC 6520 (RA 18 03 24 Dec -27 53 00) is a galactic star cluster which formed millions of years ago. Its blue stars are far younger than our own Sun, and may very well have formed from what you don't see nearby – a dark, molecular cloud. Filled with dust, Barnard 86 literally blocks the starlight coming from our galaxy's own halo area in the direction of the core. To get a good idea of just how much light is blocked by B 86, take a look at the star SAO 180161 on the edge. Behind this obscuration lies the densest part of our Milky Way! This one is so dark that it's often referred to as the "Ink Spot." While both NGC 6520 and B 86 are about the same distance away, they don't reside in the hub of our galaxy, but in the Sagittarius Spiral Arm. Seen in binoculars as a small area of compression, and delightfully resolved in a telescope, you'll find this cluster is on the Herschel "400" list and many others as well.

Are you ready for a whirlwind tour of the Messier Catalog objects with binoculars or a small telescope? Then let's start at the top with the "Nike Swoosh" of M17.
Easily viewed in binoculars of any size and outstanding in every telescope, the 5000 light-year distant Omega Nebula was discovered by Philippe Loys de ChÃ©seaux in 1745-46 and later (1764) cataloged by Messier as object 17 (RA 18 20 26 Dec -16 10 36). This beautiful emission nebula is the product of hot gases excited by the radiation of newly born stars. As part of a vast region of interstellar matter, many of its embedded stars don't show up in photographs, but reveal themselves beautifully to the eye at the telescope. As you look at its unique shape, you realize many of these areas are obscured by dark dust, and this same dust is often illuminated by the stars themselves. Often known as "The Swan," M17 will appear as a huge, glowing check mark or ghostly "2" in the sky – but power up if you use a larger telescope and look for a long, bright streak across its northern edge with extensions to both the east and north. While the illuminating stars are truly hidden, you will see many glittering points in the structure itself and at least 35 of them are true members of this region, which spans up to 40 light-years and could form up to 800 solar masses. It is awesome…



Keeping moving south and you will see a very small collection of stars known as M18, and a bit more south will bring up a huge cloud of stars called M24. This patch of Milky Way "stuff" will show a wonderful open cluster – NGC 6603 – to average telescopes and some great Barnard darks to larger ones. M24 is often referred to as the "Small Sagittarius Star Cloud". This vast region is easily seen unaided from a dark sky site and is a stellar profusion in binoculars. Telescopes will find an enclosed galactic cluster – NGC 6603 – on its northern border. For those of you who prefer a challenge, look for Barnard Dark Nebula, B92, just above the central portion.



Now we're going to shift to the southeast just a touch and pick up the M25 open cluster. M25 is a scattered galactic cluster that contains a cephid variable – U Sagittarii. This one is a quick change artist, going from magnitude 6.3 to 7.1 in less than seven days. Keep an eye on it over the next few weeks by comparing it to the other cluster members. Variable stars are fun! Head due west about a fist's width to capture the next open cluster – M23. From there, we are dropping south again and M21 will be your reward. Head back for your scope and remember your area, because the M20 "Triffid Nebula" is just a shade to the southwest. Small scopes will pick up on the little glowing ball, but anything from about 4″ up can see those dark dust lanes that make this nebula so special. The "Trifid" nebula appears initially as two widely spaced stars – one of which is a low power double – each caught in its own faint lobe of nebulosity. Keen eyed observers will find that the double star – HN 40 – is actually a superb triple star system of striking colors! The 7.6

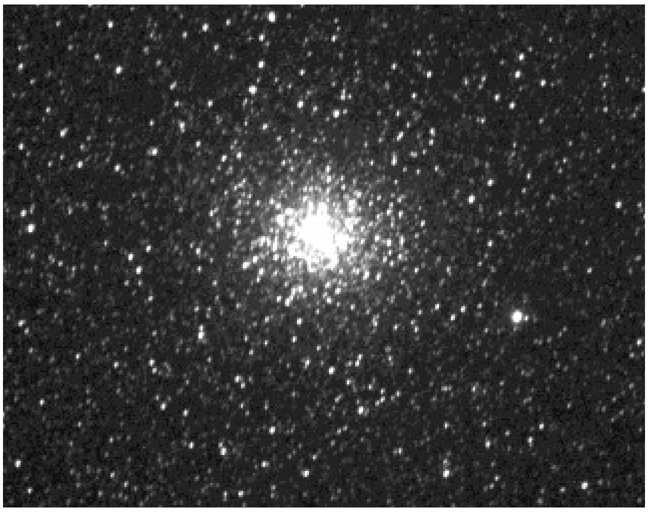
magnitude primary appears blue. Southwest is a reddish 10.7 magnitude secondary while a third companion of magnitude 8.7 is northwest of the primary.

Described as "trifid" by William Herschel in 1784, this trilobed pattern of faint luminosity broken by a dark nebula – Barnard 85 – is associated with the southern triple. This region is more brightly illuminated due to the presence of the star cluster and is suffused with a brighter, redder reflection nebula of hydrogen gas. The northern part of the Trifid (surrounding the solitary star) is fainter and bluer. It shines by excitation and is composed primarily of doubly ionized oxygen gas. The entire area lies roughly 5000 light-years away. What makes M20 the "Trifid" nebula, are the series of dark, dissecting dust lanes meeting at the nebula's east and west edges, while the southernmost dust lane ends in the brightest portion of the nebula. With much larger scopes, M20 shows differences in concentration in each of the lobes along with other embedded stars. It requires a dark night, but the Trifid is worth the hunt. On excellent nights of seeing, larger scopes will show the Trifid much as it appears in black and white photographs!

You can go back to the binoculars again, because the M8 "Lagoon Nebula" is south again and very easy to see. Easily located about three finger-widths above the tip of the teapot's spout (Al Nasl), M8 is one of Sagittarius' premier objects. This combination of emission/reflection and dark nebula only gets better as you add an open cluster. Spanning a half a degree of sky, this study is loaded with features. One of the most prominent is a curving dark channel dividing the area nearly in half. On its leading (western) side you will note two bright stars. The southernmost of this pair (9 Sagittarii) is thought to be the illuminating source of the nebula. On the trailing (eastern) side, is brightly scattered cluster NGC 6530 containing 18 erratically changing variables known as "flare stars." For large scopes, and those with filters, look for small patches of dark nebulae called "globules." These are thought to be "protostar" regions – areas where new stars undergo rapid formation. Return again to 9 Sagittarii and look carefully at a concentrated portion of the nebula west-southwest. This is known as the "Hourglass" and is a source of strong radio emission.

This particular star hop is very fun. If you have children who would like to see some of these riches, point out the primary stars and show them how it looks like a dot-to-dot "tea kettle." From the kettle's "spout" pours the "steam" of the Milky Way. If you start there, all you will need to do is follow the "steam" trail up the sky and you can see the majority of these with ease.

At the top of the "tea kettle" is Lambda. This is our marker

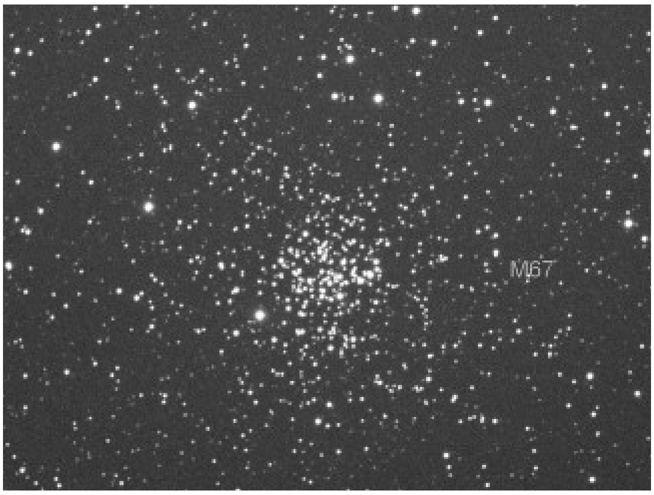


for two easy binocular objects. The small M28 globular cluster is quite easily found just a breath to the north/northwest. The larger, brighter and quite wonderful globular cluster M22 is also very easily found to Lambda's north-east. Ranking third amidst the 151 known globular clusters in total light, M22 is probably the nearest of these incredible systems to our Earth, with an approximate distance of 9,600 light-years. It is also one of the nearest globulars to the galactic plane. Since it resides less than a degree from the ecliptic, it often shares the same eyepiece field with a planet. At magnitude 6, the class VII M22 will begin to show individual stars to even modest instruments and will burst into stunning resolution for larger aperture. About a degree west-northwest, mid-sized telescopes and larger binoculars will capture the smaller 8th magnitude NGC 6642 (RA 18 31 54 Dec -23 28 34). At class V, this particular globular will show more concentration toward the core region than M22. Enjoy them both!

Now we're roaming into "binocular possible" but better with the telescope objects. The southeastern corner of the "tea kettle" is Zeta, and we're going to hop across the bottom to the west. Starting at Zeta, slide southwest to capture globular cluster M54. Keep heading another three degrees southwest and you will see the fuzzy ball of M70. Just around two degrees more to the west is another globular that looks like M70's twin. The small globular M55 is out there in "No Man's Land" about a fist's width away east/south east of Zeta .

Ready for a big telescope challenge? Then try your hand at one the sky's most curious galaxies – NGC 6822. This study is a telescopic challenge even for skilled observers. Set your sights roughly 2 degrees northeast of easy double 54 Sagittarii, and have a look at this distant dwarf galaxy bound to our own Milky Way by invisible gravitational attraction…

Named after its discoverer (E. E. Barnard – 1884), "Barnard's Galaxy" is a not-so-nearby member of our local galaxy group. Discovered with a 6″ refractor, this 1.7 million light-year dis-



tant galaxy is not easily found, but can be seen with very dark sky conditions and at the lowest possible power. Due to large apparent size, and overall faintness (magnitude 9), low power is essential in larger telescopes to give a better sense of the galaxy's frontier. Observers using large scopes will see faint regions of glowing gas (HII regions) and unresolved concentrations of bright stars. To distinguish them, try a nebula filter to enhance the HII and downplay the star fields. Barnard's Galaxy appears like a very faint open cluster overlaid with a sheen of nebulosity, but the practiced eye using the above technique will clearly see that the "shine" behind the stars is extragalactic in nature.

Now look less than a degree north-northwest to turn up pale blue-green NGC 6818 – the "Little Gem" planetary. Easily found in any size scope, this bright and condensed nebula reveals its annular nature in larger scopes but hints at it in scopes as small as 6″. Use a super wide field long-focus eyepiece to frame them both!

Be sure to get a good star chart and enjoy the constellation of Sagittarius to its fullest potential – there's lots more out there!

Sources:
SEDS
Chandra Observatory
Wikipedia

ISS PASSES For MAY 2022

from Heavens Above website maintained by Chris Peat.

Date	Brightn	Start	Highest point	End						
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
29 Jun	**-1.7**	**03:50:50**	**10°**	**S**	**03:53:03**	**17°**	**SE**	**03:55:16**	**10°**	**E**
30 Jun	-1.3	03:03:36	10°	SSE	03:04:38	11°	SE	03:05:40	10°	ESE
01 Jul	-2.7	03:49:15	11°	SSW	03:52:08	31°	SSE	03:55:10	10°	E
02 Jul	-2.2	03:02:12	17°	S	03:03:36	22°	SE	03:06:17	10°	E
03 Jul	-1.8	02:15:06	16°	SE	02:15:06	16°	SE	02:17:10	10°	ESE
03 Jul	-3.5	03:48:00	10°	WSW	03:51:18	55°	SSE	03:54:36	10°	E
04 Jul	-3.2	03:00:47	21°	SW	03:02:39	41°	SSE	03:05:51	10°	E
05 Jul	-2.8	02:13:34	28°	SSE	02:14:02	29°	SSE	02:17:00	10°	E
05 Jul	-3.8	03:47:09	10°	WSW	03:50:30	82°	SSE	03:53:52	10°	E
06 Jul	-2.1	01:30:21	21°	SE	01:30:21	21°	SE	01:32:20	10°	E
06 Jul	-3.8	03:03:12	14°	WSW	03:06:01	70°	SSE	03:09:23	10°	E
07 Jul	-1.2	00:43:14	11°	ESE	00:43:14	11°	ESE	00:43:25	10°	ESE
07 Jul	-3.7	02:16:05	28°	SW	02:17:33	55°	SSE	02:20:52	10°	E
07 Jul	-3.7	03:50:53	10°	W	03:54:15	85°	N	03:57:38	10°	E
08 Jul	-3.4	01:28:54	40°	SSE	01:29:07	41°	SSE	01:32:20	10°	E
08 Jul	-3.8	03:02:22	10°	W	03:05:44	89°	N	03:09:07	10°	E
09 Jul	-2.5	00:41:34	26°	ESE	00:41:34	26°	ESE	00:43:43	10°	E
09 Jul	-3.9	02:14:25	14°	WSW	02:17:13	82°	S	02:20:36	10°	E
09 Jul	-3.8	03:50:37	10°	W	03:54:00	88°	S	03:57:22	10°	E
09 Jul	-1.7	23:54:02	15°	ESE	23:54:02	15°	ESE	23:54:58	10°	E
10 Jul	-3.9	01:26:51	24°	WSW	01:28:43	68°	SSE	01:32:05	10°	E
10 Jul	-3.8	03:02:05	10°	W	03:05:28	86°	N	03:08:50	10°	E
10 Jul	-1.4	23:05:58	10°	ESE	23:05:58	10°	ESE	23:05:59	10°	ESE
11 Jul	-3.7	00:38:43	27°	SW	00:40:14	53°	SSE	00:43:32	10°	E
11 Jul	-3.8	02:13:33	10°	W	02:16:56	85°	N	02:20:18	10°	E
11 Jul	-3.8	03:50:19	10°	W	03:53:39	63°	SSW	03:57:00	10°	ESE
11 Jul	-3.3	23:48:38	10°	SW	23:51:47	39°	SSE	23:54:57	10°	E
12 Jul	-3.8	01:25:01	10°	W	01:28:22	90°	NW	01:31:45	10°	E
12 Jul	-3.9	03:01:47	10°	W	03:05:09	78°	SSW	03:08:31	10°	ESE
12 Jul	-2.9	23:00:27	10°	SSW	23:03:22	28°	SSE	23:06:18	10°	E
13 Jul	-3.9	00:36:28	10°	WSW	00:39:50	80°	SSE	00:43:12	10°	E
13 Jul	-3.8	02:13:13	10°	W	02:16:36	89°	S	02:19:59	10°	E
13 Jul	-3.2	03:50:03	10°	W	03:53:11	37°	SSW	03:56:19	10°	SE
13 Jul	-2.4	22:12:28	10°	SSW	22:14:58	20°	SE	22:17:30	10°	E
13 Jul	-3.9	23:47:59	10°	WSW	23:51:18	66°	SSE	23:54:39	10°	E
14 Jul	-3.8	01:24:40	10°	W	01:28:02	85°	N	01:31:25	10°	E
14 Jul	-3.6	03:01:26	10°	W	03:04:43	50°	SSW	03:07:59	10°	SE
14 Jul	-3.6	22:59:33	10°	SW	23:02:48	50°	SSE	23:06:05	10°	E
15 Jul	-3.8	00:36:06	10°	W	00:39:28	85°	N	00:42:51	10°	E
15 Jul	-3.9	02:12:52	10°	W	02:16:13	66°	SSW	02:19:32	10°	ESE
15 Jul	-2.4	03:50:00	10°	W	03:52:32	20°	SW	03:55:04	10°	SSE

15 Jul	-3.8	23:47:32	10°	W	23:50:54	89°	SSE	23:54:16	10°	E
16 Jul	-3.9	01:24:18	10°	W	01:27:40	80°	SSW	01:31:02	10°	ESE
16 Jul	-2.9	03:01:11	10°	W	03:04:08	28°	SSW	03:07:04	10°	SSE
16 Jul	-3.9	22:58:58	10°	WSW	23:02:20	78°	SSE	23:05:42	10°	E
17 Jul	-3.9	00:35:43	10°	W	00:39:05	90°	NNW	00:42:26	10°	E
17 Jul	-3.2	02:12:30	10°	W	02:15:11	36°	SW	02:15:11	36°	SW
17 Jul	-3.8	22:10:27	10°	WSW	22:13:46	63°	SSE	22:17:06	10°	E
17 Jul	-3.8	23:47:08	10°	W	23:50:30	85°	N	23:53:52	10°	E
18 Jul	-3.7	01:23:54	10°	W	01:27:05	53°	SSW	01:27:05	53°	SSW
18 Jul	-3.8	22:58:32	10°	W	23:01:54	86°	N	23:05:16	10°	E
19 Jul	-3.9	00:35:18	10°	W	00:38:38	68°	SSW	00:39:29	45°	SE
19 Jul	-3.8	22:09:56	10°	W	22:13:18	88°	SSE	22:16:40	10°	E
19 Jul	-3.9	23:46:42	10°	W	23:50:03	82°	SSW	23:52:04	22°	ESE
20 Jul	-1.9	01:23:34	10°	W	01:24:55	19°	WSW	01:24:55	19°	WSW
20 Jul	-3.8	22:58:05	10°	W	23:01:27	88°	N	23:04:47	10°	E
21 Jul	-3.1	00:34:52	10°	W	00:37:37	38°	SW	00:37:37	38°	SW
21 Jul	-3.7	22:09:28	10°	W	22:12:50	85°	N	22:16:12	10°	E
21 Jul	-3.7	23:46:14	10°	W	23:49:32	55°	SSW	23:50:24	40°	SSE
22 Jul	-3.8	22:57:36	10°	W	23:00:57	71°	SSW	23:03:13	19°	ESE
23 Jul	-1.8	00:34:38	10°	W	00:36:05	18°	WSW	00:36:05	18°	WSW
23 Jul	-3.8	22:08:59	10°	W	22:12:21	84°	S	22:15:42	10°	ESE
23 Jul	-2.9	23:45:49	10°	W	23:48:51	31°	SSW	23:48:57	31°	SSW
24 Jul	-3.3	22:57:07	10°	W	23:00:20	43°	SSW	23:01:51	25°	SSE
25 Jul	-3.6	22:08:27	10°	W	22:11:45	58°	SSW	22:14:47	12°	ESE
25 Jul	-1.7	23:45:47	10°	W	23:47:39	16°	SW	23:47:39	16°	SW
26 Jul	-2.3	22:56:48	10°	W	22:59:32	24°	SW	23:00:37	20°	S
27 Jul	-2.7	22:07:58	10°	W	22:11:02	33°	SSW	22:13:37	13°	SSE
28 Jul	-1.4	22:57:14	10°	WSW	22:58:34	12°	SW	22:59:32	11°	SSW
29 Jul	-1.7	22:07:48	10°	W	22:10:08	18°	SW	22:12:28	10°	S
25 Aug	-1.2	05:02:50	10°	S	05:04:37	14°	SE	05:06:23	10°	ESE
27 Aug	-2.2	05:00:49	13°	SSW	05:03:14	26°	SSE	05:06:06	10°	E
28 Aug	-1.8	04:13:55	18°	SSE	04:14:31	19°	SE	04:16:56	10°	E
29 Aug	-1.0	03:26:59	11°	ESE	03:26:59	11°	ESE	03:27:23	10°	ESE
29 Aug	-3.2	04:59:51	19°	SW	05:01:57	47°	SSE	05:05:12	10°	E
30 Aug	-2.9	04:12:52	34°	SSE	04:13:09	34°	SSE	04:16:14	10°	E
31 Aug	-1.5	03:25:52	18°	ESE	03:25:52	18°	ESE	03:27:11	10°	E
31 Aug	-3.8	04:58:44	22°	WSW	05:00:46	75°	SSE	05:04:07	10°	E
01 Sep	-3.7	04:11:43	58°	S	04:11:54	59°	SSE	04:15:12	10°	E
01 Sep	-3.7	05:45:13	10°	W	05:48:34	85°	N	05:51:56	10°	E
02 Sep	-1.8	03:24:41	24°	E	03:24:41	24°	E	03:26:15	10°	E
02 Sep	-3.8	04:57:33	21°	W	04:59:38	87°	N	05:03:00	10°	E
03 Sep	-4.0	04:10:33	79°	SW	04:10:42	85°	S	04:14:03	10°	E
03 Sep	-3.8	05:44:05	10°	W	05:47:27	85°	S	05:50:48	10°	ESE

END IMAGES, OBSERVING AND OUTREACH

AT the end of May I was asked to stand in at Dark Sky Wales teaching session in the Brecon Beacons. To show the Milky Way to visitors I set up a wide angle (20mm lens) on the Nikon D 810 at various ISO so I could show immediate views of the Milky Way as it trailed onto and behind Pen Y Fan. Unfortunately about 15 miles to the south is the large conglomeration around Merthyr.casting its light above the mountains. But this shows what the Milky Way will be like in the evenings of July and August, as this was at 2am. Andy Burns

Observing Sessions and Covid19 - Update

Proposed Observation Sessions for 2021-2022

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:

August 12th Possible Perseid Meteor Watch. Bring comfortable chair!

NEW SEASON T DATES O BE ANNOUNCED

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

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.