NWASNEWS

Volume27 Issue 6

February 2022

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

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Shorter Warmer nights are coming

Through January the James Webb Telescope has been working its way though the space within the solar system out to a point of neutral gravitational pull about 4 times the distance of the Moon. This Langran (L) 2 orbiting point has equal pull from other objects so it requires little fuel to keep it at this point. On the million mile journey it has deployed the critical multiple layer sun shields and has deployed the mirrors for the telescope. A lot more adjustment and testing to go, but has so far functioned very well. I know this month's speaker will be delighted with the progress made so far.

After a dreary December for weather January did bring us some clear skies and opportunities for viewing, even if some were around full Moon. Peter Chappell has provided three viewing logs this month.

It is still winter and the nights can be cold. Keeping equipment warm and dew free can be hard to do. Yes, expensive custom made dew heaters can be purchased with specific instruments in mind, but for field use this can be clumsy. I have find hand warmers put round lenses with hair bands/ elastic bands can be very effective. Some even come with power outlet batteries that supply low voltage for phones, computers cameras and the like.

Theend of February is also the opportunity to join in with the sky quality survey run by the Campaign to Protect Rural England CPRE and I have included their details on page 32 of this bumper newsletter.. From your normal viewing sites wait for a Moonless night with clear cloudless, mist free skies. Wait 20-30 minutes to be dark adapted and use glasses if you usually need them to correct your vision.Look for Orion, and count the stars you can see withinh the boundaries of the 4 body stars, Betelgeuse, Bellatrix, Rigel and Saiph. Don't include these four stars in the count..

Good luck and enjoy.

Zoom meeting details

Dr David Southwood: Local puzzles in Cosmic Magnetism

Very appropriate with recent findings in our Milky Way.

Time: Feb 1, 2022 07:45 PM London

Join Zoom Meeting

Meeting ID: 859 2008 4062

Passcode: 540970

Clear skies Andy

Orion's Sword
The groups of stars hanging down in the asterism we know as Orion's sword. Even under binocular view the fuzzy central patch catches the eye, and under higher magnification greater nebulosity can be seen, along with some very bright stars in the centre known as the trapezium. These are are stars born in the nebula. Photo imaging brings out the complexities withinh this 100 light year wide patch of nebula. It also brings colour (I have seen through a 14" Maksutov telescope. But the nebula extends up to the running man and below the Messier 42 cloud. 60 second exposure Nikon D810a on 5" refractor..

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

1st Feb Prof David Southwood Local Puzzles in Cosmic Magnetism (Zoom)
1st Mar Martin Griffiths Dark Energy and Matter (Zoom)
5th Apr Pete Williamson Herschel to Hawkwind, Astronomy & Music & How each other influence each other
3rd May Andrew Lound The Moon at Christmas: The Epic Voyage of Apollo 8
7th Jun Prof Matt Griffin The hazards of Asteroid Impacts on the Earth – Should we worry?

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.

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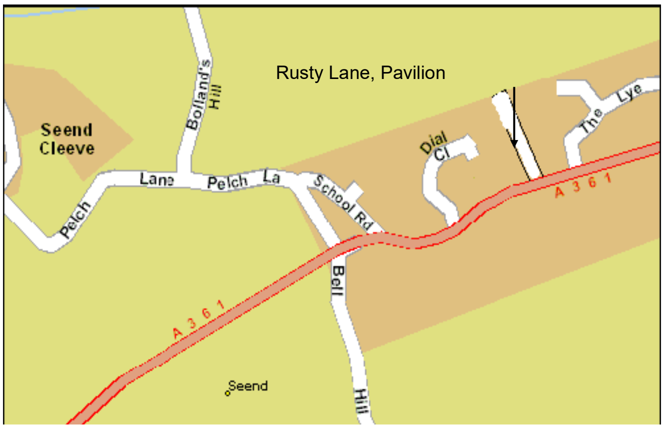
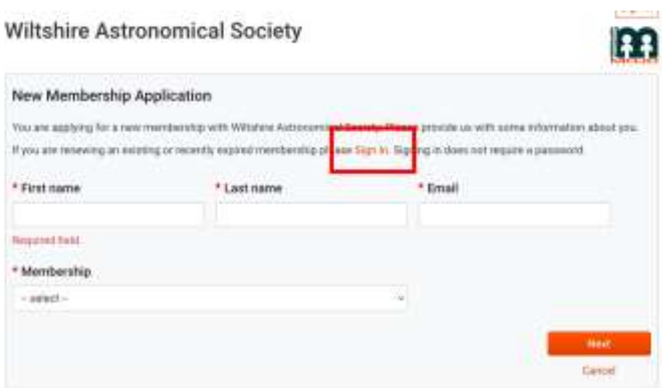


Observing Sessions see back page



Professor David Southwood CBE.

is a British space scientist who holds the post of Senior Research Investigator at Imperial College London. He was the President of the Royal Astronomical Society from 2012–2014, and earlier served as the Director of Science and Robotic Exploration at the European Space Agency. Southwood's research interests have been in solar–terrestrial physics and planetary science, particularly magnetospheres. He built the magnetic field instrument for the Cassini Saturn orbiter.

He conducted post-doctoral research at the University of California, Los Angeles, working on magnetometer data from the ATS-1 spacecraft. He then returned to Imperial College in 1971, where he produced a theory of field-line resonances in the Earth's magnetosphere which now underpins most work on geomagnetic pulsations.

In 1982 Southwood founded what became the Space and Atmospheric Physics Group and together with André Balogh decided to focus the group's experimental work on space magnetometers. This led to Imperial's involvement in a series of missions including Ulysses, Mars 96, Cluster, Cassini, Rosetta, BepiColombo, and Solar Orbiter. His magnetometer on the Cassini Saturn orbiter found the first signatures that led to the discovery of geysers on the moon Enceladus.

During this time he also was a co-investigator on the magnetometer team led by Margaret G. Kivelson for the Galileo mission to Jupiter. The magnetic field measurements made by this magnetometer led to several discoveries concerning the magnetism of the Galilean moons and asteroid Gaspra. From 1994 to 1997 Southwood was head of the Blackett Laboratory at Imperial College

Commander of the Order of the British Empire (CBE) in the 2019 Birthday Honours for services to space science and industry.

Swindon's own astronomy group

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

Next meeting: Prof. Matt Griffin

Professor Matt Griffin is Head of the Astronomy Instrumentation Group at Cardiff University. His research work is in infrared astronomy and instrumentation, and involves developing instruments for both ground-based and satellite-borne observatories. He was Principal Investigator for the SPIRE instrument on board the European Space Agency's Herschel Space Observatory and is currently working with

the international consortium developing the Ariel exoplanet characterisation space mission.

Talk summary:

"The hazards of asteroid impacts on the Earth - what me worry?"

The Earth is bombarded by meteorites all the time. Most of them go unnoticed, but occasionally a larger one makes a bigger impact, such the Chelyabinsk event in 2013. Even those ones don't present any major danger to life and civilisation. But sooner or later a much bigger object will come our way, with potentially drastic consequences. How likely is it to happen soon? How much warning would we have? What could we do about it? Should we worry?

Ad-hoc viewing sessions postponed

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

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

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

Friday, 18 Feb 19.30 onwards

Programme: Prof Matt Griffin: The Hazards of Asteroid Impacts on the Earth - should we worry?

Friday, 18 Mar 19.30 onwards

Programme: AGM

Friday, 22 April 19.30 onwards

Programme: Jon Gale - The Herschel 400

Friday, 20 May 19.30 onwards

Programme: Hugh Allen - Binary Stars - A history of making waves

Friday, 17 June 19.30 onwards

Programme: Steve Tonkin - Journey Into Space

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

Dear Local Astronomy Society,
I was hoping to invite your members to our free Astronomy lectures in 2022 by Professor Katherine Blundell and Professor Roberto Trotta.
You can register for any of these lectures by clicking the link.
I have listed the lectures below by month in case you share information with your members in this way.
JANUARY
Structures in the Universe by Professor Katherine Blundell
Wednesday, January 19, 2022 6:00 PM gres.hm/structures-universe
Museum of London/ Online Or watch later
How did the cosmos transition into space characterised by galaxies in a plethora of different shapes of great beauty? This lecture will consider what happens when groups of galaxies interact with one another and what happens when these galaxies collide and merge.
The Broken Cosmic Distance Ladder by Professor Roberto Trotta
Monday, January 31, 2022 1:00 PM gres.hm/cosmic-distance
Barnard's Inn Hall/ Online Or watch later
Measuring distances to astronomical objects outside our Galaxy is a surprisingly hard challenge: it wasn't until 1929 that Edwin Hubble obtained proof that Andromeda is indeed a galaxy in its own right. Today, astronomers extend distance measurements in the cosmos to the edge of the visible Universe, building up a 'cosmic distance ladder' made of several rungs. This talk will explore a major conundrum of contemporary astronomy: as observations have become more precise, the distance ladder appears today to be broken.
FEBRUARY
Magnetic Universe by Professor Katherine Blundell
Wednesday, February 23, 2022 6:00 PM gres.hm/magnetic-universe
Museum of London / Online Or watch later
Magnetic fields have mysterious effects that can be dramatically counterintuitive, and they are ubiquitous throughout the Universe and can have influence on large scales. This lecture will explore how some of the exotic and energetic phenomena in the Universe can only be explained in terms of these magnetic fields that pervade space.
MARCH
Planetary Universe by Professor Katherine Blundell
Wednesday, March 30, 2022 6:00 PM gres.hm/planetary-universe
Museum of London / Online Or watch later
How can new worlds be discovered, and how many exo-planets might be out there? What does today's technology in astronomical observatories now enable, and what is it that holds us back from finding what is actually out there? What hinders us from pushing forwards the frontiers of space science?
MAY
The Future of Life on Earth by Professor Roberto Trotta
Monday, May 9, 2022 1:00 PM gres.hm/future-life
Barnard's Inn Hall/ Online Or watch later
Although life is probably widespread in the universe, our pale blue dot, Earth, is the only known place harbouring intelligent life. Even if we manage to stave off extinction by climate change, avoid a nuclear apocalypse and the dangers of runaway AI, biological life on our planet will eventually come to an end in about 5 billion years' time. What are the astrophysical dangers to life on Earth, and the prospects for life's survival into the distant future? 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

REVISION PAGE
The Electro Magnetic Spectrum

The four fundamental forces of nature

By Jeremy Rehm , Ben Biggs published December 23, 2021

Facts about the four fundamental forces that describe every interaction in nature.

The four fundamental forces of nature are at the root of every interaction in the universe, including the Coalsack nebula, Caldwell 99 (Image credit: NASA, ESA, and R. Sahai)

The four fundamental forces act upon us every day, whether we realize it or not. From playing basketball, to launching a rocket into space, to sticking a magnet on your refrigerator - all the forces that all of us experience every day can be whittled down to a critical quartet: Gravity, the weak force, electromagnetism, and the strong force. These forces govern everything that happens in the universe.

Gravity

Gravity is the attraction between two objects that have mass or energy, whether this is seen in dropping a rock from a bridge, a planet orbiting a star or the moon causing ocean tides. Gravity is probably the most intuitive and familiar of the fundamental forces, but it's also been one of the most challenging to explain.

Isaac Newton was the first to propose the idea of gravity, supposedly inspired by an apple falling from a tree. He described gravity as a literal attraction between two objects. Centuries later, Albert Einstein suggested, through his theory of general relativity, that gravity is not an attraction or a force. Instead, it's a consequence of objects bending space-time. A large object works on space-time a bit like how a large ball placed in the middle of a sheet affects that material, deforming it and causing other, smaller objects on the sheet to fall toward the middle.

Though gravity holds planets, stars, solar systems and even galaxies together, it turns out to be the weakest of the fundamental forces, especially at the molecular and atomic scales. Think of it this way: How hard is it to lift a ball off the ground? Or to lift your foot? Or to jump? All of those actions are counteracting the gravity of the entire Earth. And at the molecular and atomic levels, gravity has almost no effect relative to the other fundamental forces.

The weak force

The weak force, also called the weak nuclear interaction, is responsible for particle decay. This is the literal change of one type of subatomic particle into another. So, for example, a neutrino that strays close to a neutron can turn the neutron into a proton while the neutrino becomes an electron.

Physicists describe this interaction through the exchange of force-carrying particles called bosons. Specific kinds of bosons are responsible for the weak force, electromagnetic force and strong force. In the weak force, the bosons are charged particles called W and Z bosons. When subatomic particles such as protons, neutrons and electrons come within 10^-18 meters, or 0.1% of the diameter of a proton, of one another, they can exchange these bosons. As a result, the subatomic particles decay into new particles, according to Georgia State University's HyperPhysics website.

The weak force is critical for the nuclear fusion reactions that power the sun and produce the energy needed for most life forms here on Earth. It's also why archaeologists can use carbon-14 to date ancient bone, wood and other formerly living artifacts. Carbon-14 has six protons and eight neutrons; one of those neutrons decays into a proton to make nitrogen-14, which has seven protons and seven neutrons. This decay happens at a predictable rate, allowing scientists to determine how old such artifacts are.

The weak force is critical for the nuclear fusion reactions that power the sun and produce the energy needed for most life forms here on Earth. This significant solar flare peaked at 10:29 a.m. EDT on July 3, 2021 (Image credit: NASA)

Electromagnetic force

The electromagnetic force, also called the Lorentz force, acts between charged particles, like negatively charged electrons and positively charged protons. Opposite charges attract one another, while like charges repel. The greater the charge, the greater the force. And much like gravity, this force can be felt from an infinite distance (albeit the force would be very, very small at that distance).

As its name indicates, the electromagnetic force consists of two parts: the electric force and the magnetic force. At first, physicists described these forces as separate from one another, but researchers later realized that the two are components of the same force.

The electric component acts between charged particles whether they're moving or stationary, creating a field by which the charges can influence each other. But once set into motion, those charged particles begin to display the second component, the magnetic force. The particles create a magnetic field around them as they move. So when electrons zoom through a wire to charge your computer or phone or turn on your TV, for example, the wire becomes magnetic.

Electromagnetic forces are transferred between charged particles through the exchange of massless, force-carrying bosons called photons, which are also the particle components of light. The force-carrying photons that swap between charged particles, however, are a different manifestation of photons. They are virtual and undetectable, even though they are technically the same particles as the real and detectable version, according to the University of Tennessee, Knoxville.

The electromagnetic force is responsible for some of the most commonly experienced phenomena: friction, elasticity, the normal force and the force holding solids together in a given shape. It's even responsible for the drag that birds, planes and even Superman experience while flying. These actions can occur because of charged (or neutralized) particles interacting with one another. The normal force that keeps a book on top of a table (instead of gravity pulling the book through to the ground), for example, is a consequence of electrons in the table's atoms repelling electrons in the book's atoms.

The force that keeps a book on top of a table (instead of gravity pulling the book through to the ground), is a consequence of the electromagnetic force: Electrons in the table's atoms repel electrons in the book's atoms. (Image credit: NASA/ Shutterstock)

The strong nuclear force

The strong nuclear force, also called the strong nuclear interaction, is the strongest of the four fundamental forces of nature. It's 6 thousand trillion trillion trillion (that's 39 zeroes after 6!) times stronger than the force of gravity, according to the HyperPhysics website. And that's because it binds the fundamental particles of matter together to form larger particles. It holds together the quarks that make up protons and neutrons, and part of the strong force also keeps the protons and neutrons of an atom's nucleus together.

Much like the weak force, the strong force operates only when subatomic particles are extremely close to one another. They have to be somewhere within 10^-15 meters from each other, or roughly within the diameter of a proton.

The strong force is odd, though, because unlike any of the other fundamental forces, it gets weaker as subatomic particles move closer together. It actually reaches maximum strength when the particles are farthest away from each other, according to Fermilab. Once within range, massless charged bosons called gluons transmit the strong force between quarks and keep them "glued" together. A tiny fraction of the strong force called the residual strong force acts between protons and neutrons. Protons in the nucleus repel one another because of their similar charge, but the residual strong force can overcome this repulsion, so the particles stay bound in an atom's nucleus.

Unifying nature

The outstanding question of the four fundamental forces is whether they're actually manifestations of just a single great force of the universe. If so, each of them should be able to merge with the others, and there's already evidence that they can.

Physicists Sheldon Glashow and Steven Weinberg from Harvard University with Abdus Salam from Imperial College London won the Nobel Prize in Physics in 1979 for unifying the electromagnetic force with the weak force to form the concept of the electroweak force. Physicists working to find a so-called grand unified theory aim to unite the electroweak force with the strong force to define an electronuclear force, which models have predicted but researchers have not yet observed. The final piece of the puzzle would then require unifying gravity with the electronuclear force to develop the so-called theory of everything, a theoretical framework that could explain the entire universe.

Physicists, however, have found it pretty difficult to merge the microscopic world with the macroscopic one. At large and especially astronomical scales, gravity dominates and is best described by Einstein's theory of general relativity. But at molecular, atomic or subatomic scales, quantum mechanics best describes the natural world. And so far, no one has come up with a good way to merge those two worlds.

Many physicists aim to unite the fundamental forces under a single, unified theory — a theoretical framework that could explain the entire universe. (Image credit: Shutterstock)

Physicists studying quantum gravity aim to describe the force in terms of the quantum world, which could help with the merge. Fundamental to that approach would be the discovery of gravitons, the theoretical force-carrying boson of the gravitational force. Gravity is the only fundamental force that physicists can currently describe without using force-carrying particles. But because descriptions of all the other fundamental forces require force-carrying particles, scientists expect gravitons must exist at the subatomic level — researchers just haven't found these particles yet.

Further complicating the story is the invisible realm of dark matter and dark energy, which make up roughly 95% of the universe. It's unclear whether dark matter and energy consist of a single particle or a whole set of particles that have their own forces and messenger bosons.

The primary messenger particle of current interest is the theoretical dark photon, which would mediate interactions between the visible and invisible universe. If dark photons exist, they'd be the key to detecting the invisible world of dark matter and could lead to the discovery of a fifth fundamental force. So far, though, there's no evidence that dark photons exist, and some research has offered strong evidence that these particles don't exist.

The **electromagnetic spectrum** is the range of frequencies (the spectrum) of electromagnetic radiation and their respective wavelengths and photon energies.

The electromagnetic spectrum covers electromagnetic waves with frequencies ranging from below one hertz to above 10^{25} hertz, corresponding to wavelengths from thousands of kilometers down to a fraction of the size of an atomic nucleus. This frequency range is divided into separate bands, and the electromagnetic waves within each frequency band are called by different names; beginning at the low frequency (long wavelength) end of the spectrum these are: radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays at the high-frequency (short wavelength) end. The electromagnetic waves in each of these bands have different characteristics, such as how they are produced, how they interact with matter, and their practical applications. There is no known limit for long wavelengths, while it is thought that the short wavelength limit is in the vicinity of the Planck length.[4] Extreme ultraviolet, soft X-rays, hard X-rays and gamma rays are classified as *ionizing radiation* as their photons have enough energy to ionize atoms, causing chemical reactions.

In most of the frequency bands above, a technique called spectroscopy can be used to physically separate waves of different frequencies, producing a spectrum showing the constituent frequencies. Spectroscopy is used to study the interactions of electromagnetic waves with matter.[5] Other technological uses are described under electromagnetic radiation.

HISTORY and DISCOVERY

Humans have always been aware of visible light and radiant heat but for most of history it was not known that these phenomena were connected or were representatives of a more extensive principle. The ancient Greeks recognized that light traveled in straight lines and studied some of its properties, including reflection and refraction. Light was intensively studied from the beginning of the 17th century leading to the invention of important instruments like the telescope and microscope. Isaac Newton was the first to use the term *spectrum* for the range of colours that white light could be split into with a prism. Starting in 1666, Newton showed that these colours were intrinsic to light and could be recombined into white light. A debate arose over whether light had a wave nature or a particle nature with René Descartes, Robert Hooke and Christiaan Huygens favouring a wave description and Newton favouring a particle description. Huygens in particular had a well developed theory from which he was able to derive the laws of reflection and refraction. Around 1801, Thomas Young measured the wavelength of a light beam with his two-slit experiment thus conclusively demonstrating that light was a wave.

In 1800, William Herschel discovered infrared radiation. He was studying the temperature of different colors by moving a thermometer through light split by a prism. He noticed that the highest temperature was beyond red. He theorized that this temperature change was due to "calorific rays", a type of light ray that could not be seen. The next year, Johann Ritter, working at the other end of the spectrum, noticed what he called "chemical rays" (invisible light rays that induced certain chemical reactions). These behaved similarly to visible violet light rays, but were beyond them in the spectrum.[7] They were later renamed ultraviolet radiation.

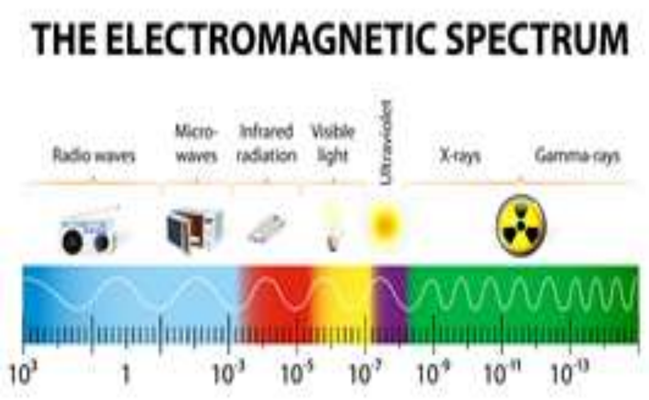
The study of electromagnetism began in 1820 when Hans Christian Ørsted discovered that electric currents produce magnetic fields (Oersted's law). Light was first linked to electromagnetism in 1845, when Michael Faraday noticed that the polarization of light traveling through a transparent material responded to a magnetic field (see Faraday effect). During the 1860s, James Clerk Maxwell developed four partial differential equations (Maxwell's equations) for the electromagnetic field. Two of these equations predicted the possibility and behavior of waves in the field. Analyzing the speed of these theoretical waves, Maxwell realized that they must travel at a speed that was about the known speed of light. This startling coincidence in value led Maxwell to make the inference that light itself is a type of electromagnetic wave. Maxwell's equations predicted an infinite range of frequencies of electromagnetic waves, all traveling at the speed of light. This was the first indication of the existence of the entire electromagnetic spectrum.

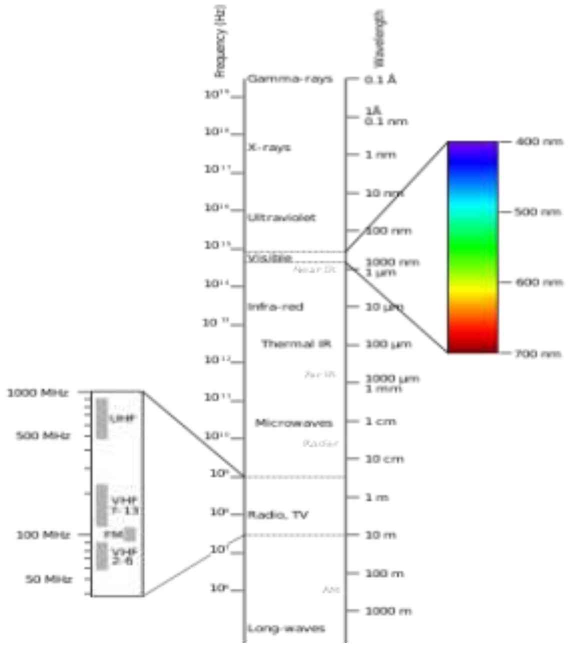
Maxwell's predicted waves included waves at very low frequencies compared to infrared, which in theory might be created by oscillating charges in an ordinary electrical circuit of a certain type. Attempting to prove Maxwell's equations and detect such low frequency electromagnetic radiation, in 1886, the physicist Heinrich Hertz built an apparatus to generate and detect what are now called radio waves. Hertz found the waves and was able to infer (by measuring their wavelength and multiplying it by their frequency) that they traveled at the speed of light. Hertz also demonstrated that the new radiation could be both reflected and refracted by various dielectric media, in the same manner as light. For example, Hertz was able to focus the waves using a lens made of tree resin. In a later experiment, Hertz similarly produced and measured the properties of microwaves. These new types of waves paved the way for inventions such as the wireless telegraph and the radio.

In 1895, Wilhelm Röntgen noticed a new type of radiation emitted during an experiment with an evacuated tube subjected to a high voltage. He called this radiation "x-rays" and found that they were able to travel through parts of the human body but were reflected or stopped by denser matter such as bones. Before long, many uses were found for this radiography.

The last portion of the electromagnetic spectrum was filled in with the discovery of gamma rays. In 1900, Paul Villard was studying the radioactive emissions of radium when he identified a new type of radiation that he at first thought consisted of particles similar to known alpha and beta particles, but with the power of being far more penetrating than either. However, in 1910, British physicist William Henry Bragg demonstrated that gamma rays are electromagnetic radiation, not particles, and in 1914, Ernest Rutherford (who had named them gamma rays in 1903 when he realized that they were fundamentally different from charged alpha and beta particles) and Edward Andrade measured their wavelengths, and found that gamma rays were similar to X-rays, but with shorter wavelengths.

The wave-particle debate was rekindled in 1901 when Max Planck discovered that light is only absorbed in discrete "quanta", now called photons, implying that light has a particle nature. This idea was made explicit by Albert Einstein in 1905, but never accepted by Planck and many other contemporaries. The modern position of science is that electromagnetic radiation has both a wave and a particle nature, the wave-particle duality. The contradictions arising from this position are still being debated by scientists and philosophers.





The types of electromagnetic radiation are broadly classified into the following classes (regions, bands or types)

- Gamma radiation
- X-ray radiation
- Ultraviolet radiation
- Visible light
- Infrared radiation
- Microwave radiation
- Radio waves

This classification goes in the increasing order of wavelength, which is characteristic of the type of radiation.

There are no precisely defined boundaries between the bands of the electromagnetic spectrum; rather they fade into each other like the bands in a rainbow (which is the sub-spectrum of visible light). Radiation of each frequency and wavelength (or in each band) has a mix of properties of the two regions of the spectrum that bound it. For example, red light resembles infrared radiation in that it can excite and add energy to some chemical bonds and indeed must do so to power the chemical mechanisms responsible for photosynthesis and the working of the visual system.

The distinction between X-rays and gamma rays is partly based on sources: the photons generated from nuclear decay or other nuclear and subnuclear/particle process are always termed gamma rays, whereas X-rays are generated by electronic transitions involving highly energetic inner atomic electrons.[11][12][13] In general, nuclear transitions are much more energetic than electronic transitions, so gamma rays are more energetic than X-rays, but exceptions exist. By analogy to electronic transitions, muonic atom transitions are also said to produce X-rays, even though their energy may exceed 6 megaelectronvolts (0.96 pJ),[whereas there are many (77 known to be less than 10 keV (1.6 fJ)) low-energy nuclear transitions (*e.g.*, the 7.6 eV (1.22 aJ) nuclear transition of thorium-229m), and, despite being one million-fold less energetic than some muonic X-rays, the emitted photons are still called gamma rays due to their nuclear origin.

The convention that EM radiation that is known to come from the nucleus is always called "gamma ray" radiation is the only convention that is universally respected, however. Many astronomical gamma ray sources (such as gamma ray bursts) are known to be too energetic (in both intensity and wavelength) to be of nuclear origin. Quite often, in high-energy physics and in medical radiotherapy, very high energy EMR (in the > 10 MeV region)—which is of higher energy than any nuclear gamma ray—is not called X-ray or gamma ray, but instead by the generic term of "high-energy photons".

The region of the spectrum where a particular observed electromagnetic radiation falls is reference frame-dependent (due to the Doppler shift for light), so EM radiation that one observer would say is in one region of the spectrum could appear to an observer moving at a substantial fraction of the speed of light with respect to the first to be in another part of the spectrum. For example, consider the cosmic microwave background. It was produced when matter and radiation decoupled, by the de-excitation of hydrogen atoms to the ground state. These photons were from Lyman series transitions, putting them in the ultraviolet (UV) part of the electromagnetic spectrum. Now this radiation has undergone enough cosmological red shift to put it into the microwave region of the spectrum for observers moving slowly (compared to the speed of light) with respect to the cosmos.

Cosmic questions about cosmic magnets

My own research has two focuses. First, what do galactic magnets look like? Where are all the north and south poles in our Milky Way, and in the millions of other galaxies scattered throughout the universe?

Second, and more importantly, where did all these magnets come from? How did the first cosmic magnets come into existence billions of years ago, and how have they survived through to the present day?

These questions are not quite as esoteric as they sound.

Magnetism is vital for stars like our sun to form. The Earth's magnetism protects our atmosphere from harmful radiation. And cosmic magnets generate energetic high-speed particles which, on arrival at Earth, can cause random genetic mutations and hence drive evolution.

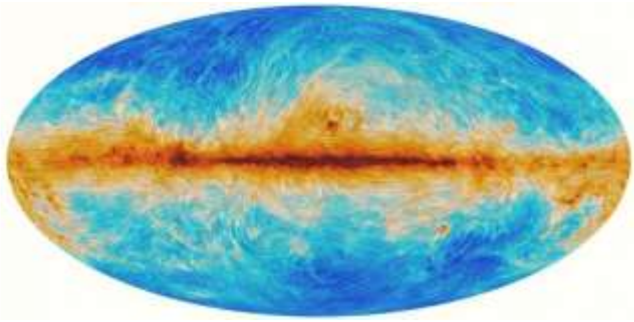
On the other hand, the answers are elusive. The big challenge is that magnetism is invisible: point a powerful telescope at a cosmic magnet, and you won't see it. Instead, we use indirect approaches, relying on the fact that background light is subtly changed as it passes through magnetic regions of foreground gas. I think of it as trying to do the ultimate cryptic crossword puzzle, but blindfolded and with your hands tied behind your back.

A magnetic sixth sense

Of course, one can't spend one's whole life just thinking about cosmic magnets. Every scientist has a secret unfulfilled ambition: a completely different scientific career that perhaps, if things had been different, they would have pursued instead.

So what's my secret alternative vocation?

In a parallel universe, I would still be obsessed with magnets. But I would not be an astronomer. Instead I would study "magnetoreception."



The magnetic field of our Milky Way galaxy as seen by the Planck satellite. Darker regions correspond to stronger polarized emission, and the striations indicate the direction of the magnetic field projected on the plane of the sky. Credit: ESA and the Planck Collaboration, CC BY

Magnetoreception is the ability of some animals to respond or react to magnetism: a "sixth sense" that allows them to see the unseen. The best-known examples are birds, some species of which navigate using the Earth's magnetic field during their spectacular globe-spanning migrations.

But in recent years, scientists have found that a whole host of other species can sense magnetism. Perhaps the most extraordinary case is that of magnetic cows. Using images from Google Earth, researchers have claimed that cows around the world tend to align their bodies with the Earth's magnetic field whenever they are grazing or resting.

Other studies, covering everything from the swimming patterns of sea turtles to the directions dogs face when they defecate, have similarly revealed that animals can somehow sense magnetism.

Even humans might have some vestigial sensitivity to magnets. Vision quality seems to depend on whether you're facing north–south or east–west. Dreams are more likely to be mundane rather than bizarre when the Earth's magnetism is going through a period of high activity.

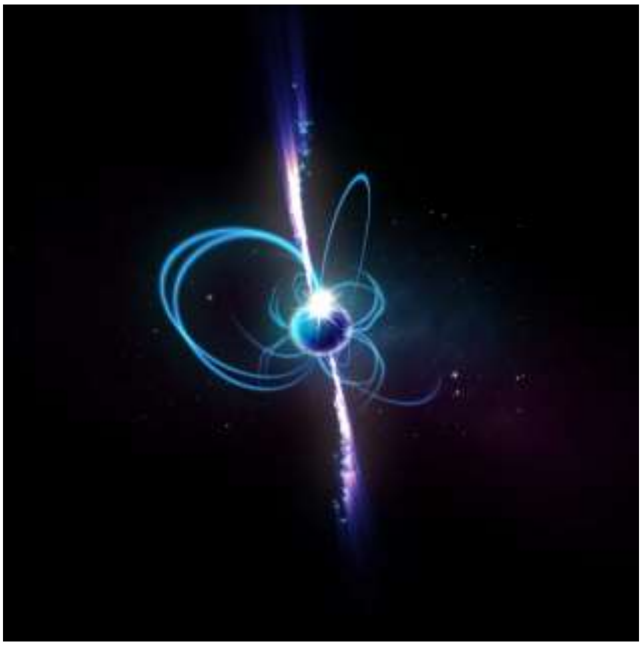
Well-known but so mysterious

It's now been around 2,600 years since the Greek philosopher Thales noticed that magnets attract iron. We understand almost completely how magnets work, right down to the detailed atomic level. Once a curiosity, magnetism is now at our beck and call, and underpins our entire modern world of convenience and technology.

SPACE NEWS TO FEBRUARY 22

Astronomers Discover a Mysterious Star That Flashes Every 20 Minutes. But What is it?

Just 4,000 light-years from Earth is a strange, star-sized object. It's been observed by radio telescopes, but astronomers aren't sure what it is. They call it a long period transient. Transients are objects in the sky that change over some period of time. Fast transients are things such as pulsars, which emit a bright flash over a period of seconds or milliseconds. Slow transients are objects such as supernovae, which grow to extreme brightness over days or months. This new object is transient three times an hour. About every 18 minutes, it becomes one of the brightest radio objects in the sky, with its flash lasting anywhere from half a second to nearly a minute. Its long period and extreme brightness are what makes it so unusual. One idea is that the object is a hypothetical object known as an ultra-long period magnetar. Magnetars are neutron stars, the same as pulsars, but magnetars have much stronger magnetic fields. Most magnetars are thought to rotate as quickly as pulsars, but their strong magnetic fields could interact with surrounding ionized gas in a way that causes it to slow down significantly. This would turn it into a kind of slow rotating pulsar. The problem with this idea is that astronomers have thought ultra-long period magnetars wouldn't be nearly so bright. Another idea is that the object is a strange type of white dwarf, but it isn't clear how a white dwarf could become so radio bright.



An artist view of the object as a magnetar. Credit: ICRAR

Based on observations, we do know the object has an intense magnetic field. The radio light we see from the object is highly polarized. Charged particles emit highly polarized light when they interact with a strong magnetic field. We also know the transient can't simply be a standard pulsar effect. Pulsars emit regular flashes because their rotation sweeps a beam of intense radio light across the sky. We see a radio flash every time the beam sweeps our way, similar to the flash of a lighthouse. This object would flash about every 18 minutes, but these flashes would only happen over the course of a few hours. The team saw the object shift between active and quiet periods during their observation runs. So some strange happenings are going on.

Of course, the most exciting idea is that the transient object is something we don't expect. Perhaps a newly formed black hole, or a hypothetical quark star. With only one example, it's difficult to narrow down the possibilities. So the team is searching for similar objects in order to solve the mystery they never expected to find.

Reference: Hurley-Walker, N., et al. "A Radio Transit with Unusually Slow Periodic Emission." *Nature* 601 (2022): 526-530.

It Turns out, We Have a Very Well-Behaved Star

Should we thank our well-behaved Sun for our comfy home on Earth?

Some stars behave poorly. They're unruly and emit powerful stellar flares that can devastate life on any planets within range of those flares. New research into stellar flares on other stars makes our Sun seem downright quiescent.

NASA's TESS (Transiting Exoplanet Survey Satellite) is a planet hunter. Its primary task is to watch stars for any regular dips in light. Those dips can signal the presence of a planet as it passes between us and the star. TESS is very successful at finding planets.

But TESS does more than identify exoplanet candidates. TESS's keen-eyed cameras reveal a lot about the stars the planets are orbiting. One of the mission's objectives is to study about 1,000 M-dwarf (red dwarf) stars closest to us. Red dwarfs are the most plentiful stars in our galaxy, so most exoplanets are probably orbiting red dwarfs. About 75% of the stars in the Milky Way are M-dwarfs and many of them host planets in their habitable zones.

But red dwarfs are complicated stars. On the one hand, they're the longest-lived stars, so planets orbiting them can count on stable conditions for a long time. That long-lived stability is good for the development of life.

On the other hand, red dwarfs can emit powerful flares. Stellar flares can be hard on planets and can severely limit the possibility of life on planets around red dwarfs.

This is an artist's conception of a violent stellar flare erupting on the red dwarf Proxima Centauri, our nearest neighbour. Our Sun seems relatively calm compared to red dwarfs. Credit: NRAO/S. Dagnello.

This puts planet-hunting in a new light. Planet hunting's over-arching goal is finding planets in a star's habitable zone where liquid water could exist on the surface. But our growing knowledge of flaring may make our understanding of habitable zones outdated.

A new study presents a statistical analysis of stellar flaring on hundreds of stars. The study is "No Such Thing as a Simple Flare: Substructure and QPPs Observed in a Statistical Sample of 20 Second Cadence TESS Flares." The authors are Ward Howard, a post-doc researcher at the University of Colorado, Boulder, and Meredith MacGregor, assistant professor of astrophysical and planetary sciences at CU Boulder. The Astrophysical Journal will publish the study.

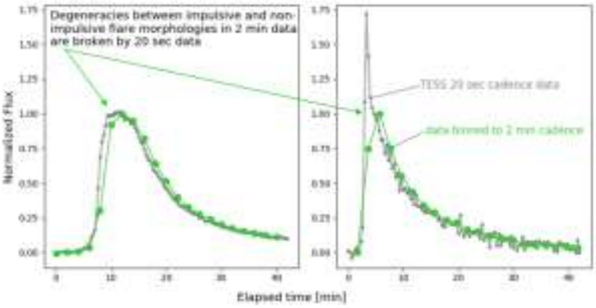
The study is the first large-scale analysis of stellar flaring. It's based on data collected at 20-second intervals, a rapid cadence for observations. The faster cadence gathers more granular data.

Our Sun emits flares, which can disrupt electronic systems on Earth and in satellites. The Sun is nothing compared to the stars in this study, even though red dwarfs are smaller than the Sun.

"The sun is very well behaved," lead author Howard said in a press release. "Many of these red dwarf stars can emit flares 1,000 times larger than those from the Sun, and you can only imagine what that might do to a planet or to life on the surface."

TESS is in its extended mission now. The 20-second observation intervals are more rapid than the two-minute intervals used in TESS's primary mission. The rapid intervals give astrophysicists a better window into flares. They can watch as flares develop and measure the radiation more accurately. Howard and MacGregor discovered that flares are more complicated than thought, and some can burst multiple times.

"They have all sorts of weird structure in the light curves, which indicates that some of them are bursting multiple times," co-author MacGregor said.



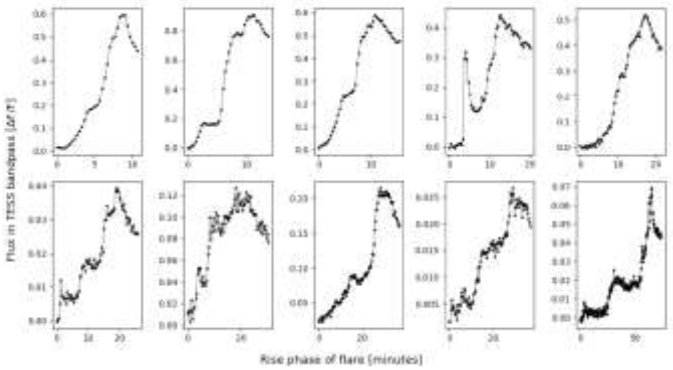
This figure from the study shows the difference between 20-second intervals and 2-minute intervals. The left panel shows both intervals binned to 2-minute intervals. The right panel shows how the 20-second cadence reveals more detail in the flares. Image Credit: Ward and MacGregor 2022.

"The new 20-second cadence mode reveals significant substructure in large flares that would have been missed at 2 min cadence," the authors write in their paper. "Higher-cadence observations also remove degeneracy present at 2 min cadence between significantly different flare morphologies," they say when discussing the above figure.

"We have historically had a very simple picture of stellar activity, where one loop breaks and we have one outburst of energy, and then it slowly dies away, and then we think about the frequency of that," MacGregor continued. "That's the model that's been fed into everything we think about stars and their impact on planets, and it's clearly just flat-out wrong."

"It allows us to kind of have a statistical understanding of how often do certain things occur," Howard said, adding that scientists have never before been able to determine how much radiation reaches planets during the peak of the superflares and how much complexity the flares have.

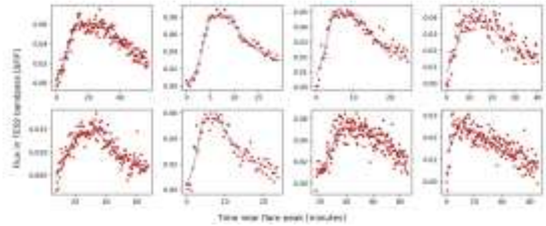
Astrophysicists describe stellar flares in two phases: the rise phase between the beginning of the flare and peak brightness and the decay phase. "Many large flares exhibit complex substructure during the rise phase," the authors write, and the 20-second cadence helps reveal the complexity, while the slower cadence doesn't. "We find 46% of the large flares in our sample exhibit complex structure in the rise phase (201 out of 440 flares), making this a common phenomenon at the 20-second cadence."



This figure shows the rise phases of ten of the flares in the study—nearly half of the flares show complex substructures during the rise phase. Although exceptions exist, a greater degree of complexity generally correlates with longer rise times. Resolving the complex substructure in the rise phases of large M-dwarf flares is more difficult in lower-cadence observations. Image Credit: Ward and MacGregor 2022.

The study also found other flare morphologies that the authors describe as unusual yet frequently-occurring. One is the peak-bump flare. This type of flare has an initial highly-impulsive peak followed by a less-impulsive second peak. About 17% of the flares exhibit this morphology.

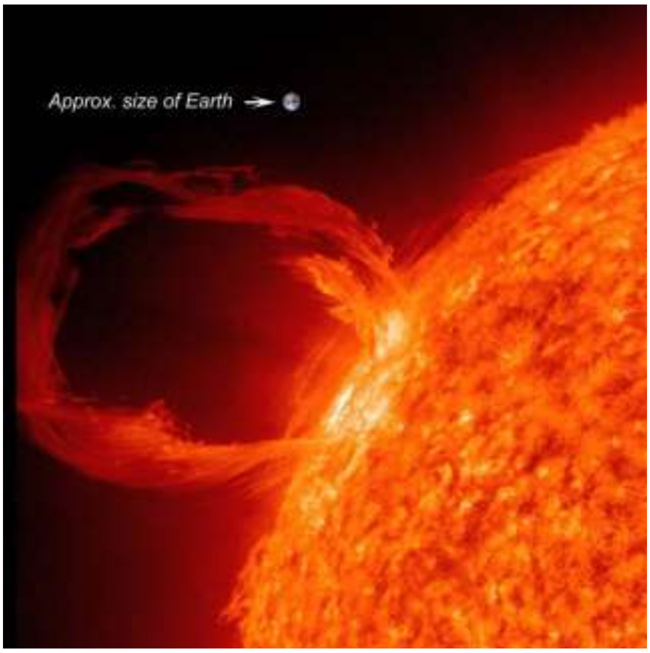
Another unusual type is the flat-top flare. Most flares have a very powerful impulsive peak, but flat-top flares have more constant emission levels at their peak. Previous studies show that these flat-top flares can peak for almost one hour, though the longest-lasting peak in this study was 26 minutes. 24 of the flares in this study—about 5%—are flat-top flares.



This figure from the study shows eight flat-top flares. The 20-second cadence observations helped identify these types of flares. Image Credit: Ward and MacGregor 2022.

Red dwarfs flare differently than our Sun. But the basics are the same. All stars have powerful magnetic fields, and sometimes those fields become entangled. The entanglement spawns powerful bursts of radiation and charged particles. The result is beautiful, looping, solar prominences. Prominences remain anchored to the Sun but extend thousands of kilometres into space.

"Our sun does this, and we can get beautiful images where you see these loops of emission protruding out of the surface of the sun, and then they break and stream out into space," MacGregor said.



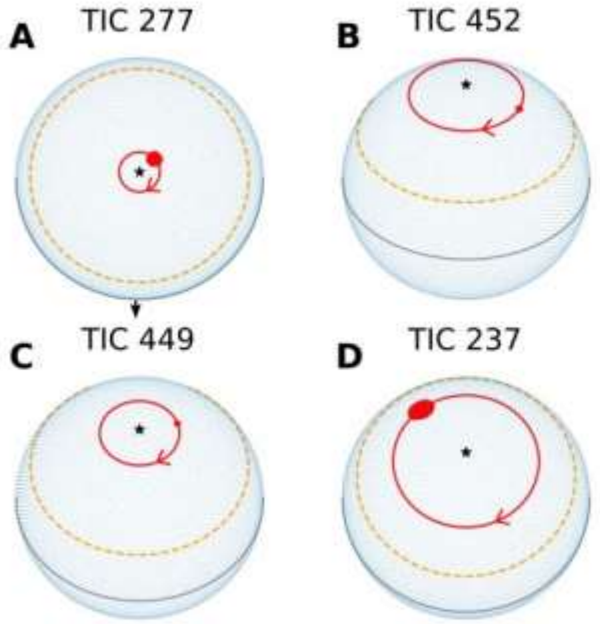
This is a solar eruptive prominence seen in extreme UV light on March 30, 2010, with Earth superimposed for a sense of scale. Credit: NASA/SDO

When a solar prominence breaks free from the Sun, it's a flare. Most flares are accompanied by coronal mass ejections (CME), masses of solar plasma and magnetic fields. When the Sun emits a CME toward Earth and strikes our planet's magnetosphere, we get beautiful light shows: the aurorae. We also get geomagnetic storms, and if they're powerful enough, they can damage electrical grids and satellites. But that's rare.

"So we see beautiful lovely green lights," MacGregor said. "What we're actually observing is the effect of our sun splitting apart molecules in our atmosphere and then the release of energy from that splitting of things like ozone and water."

Things play out differently on red dwarfs.

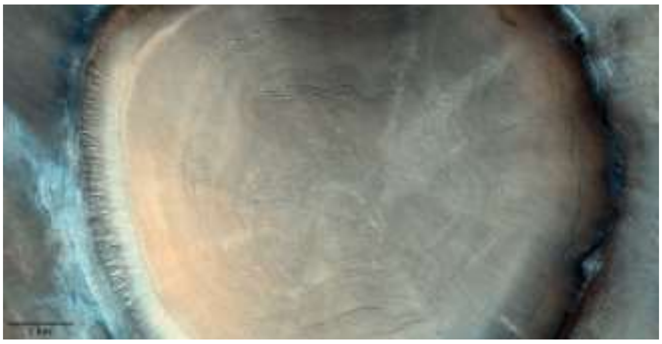
Red dwarfs are smaller than stars like our Sun. But they can rotate more rapidly than larger stars, so they can have more powerful magnetic fields. This creates more powerful flares, and sometimes what astrophysicists call superflares. Superflares can be up to 30 times more powerful than our Sun's flares—maybe even more potent than that.
That much energy can shred a planet's atmosphere. Most planets orbiting in a red dwarf's habitable zone are likely tidally locked. This paints an ugly picture for life. One side of a world would be regularly blasted by powerful flares, while the other remained dark. Could life survive there?
Maybe it could. Some evidence shows that red dwarfs emit their flares from higher latitudes and poles. But planets orbit their stars in the ecliptic, which might spare them from the worst effects.



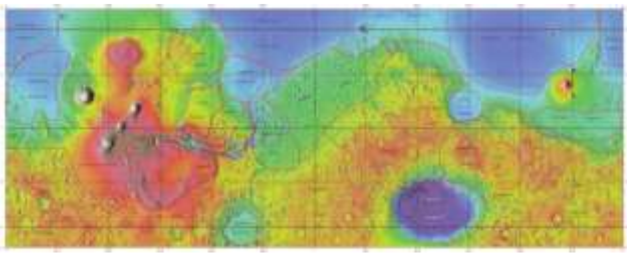
This figure is from a 2021 study showing that red dwarfs emit flares from their polar regions. The black star marks the star's pole. The red circle shows the flare latitude, and the red dot marks the active flaring. The yellow dashed line marks the maximum typical solar flare latitude. Planets orbiting in these stars' ecliptics likely escape the worst effects of powerful flares. Image Credit: Ilin et al. 2021.
There are no firm measurements of how much radiation from red dwarf flares would reach any planets around the stars. The authors discuss this in their paper but can't reach solid conclusions. Scientists work with a survival concept called D90—the UV dose needed to kill 90% of a hardy bacterium called D. Radiodurans. The authors find that "… 1/3 of our 10^{34} erg flares reach this limit during the 20-second peak epoch." They also found that none of the flares were powerful enough to kill 100% of D. Radiodurans.
These numbers are preliminary, and there are assumptions behind them. The hypothetical planets subjected to the flares are unmagnetized and have no significant atmospheres. Magnetospheres of differing strengths and different types of atmospheres could strongly affect how much UV radiation from flares would reach a planet's surface.
Our understanding of red dwarfs and their flaring is in the early stages. This study removes some guessing and conjecture and replaces it with some of our most detailed knowledge of flaring yet.
"It allows us to kind of have a statistical understanding of how often do certain things occur," Howard said, adding that scientists have never before been able to determine how much radiation reaches planets during the peak of the superflares and how much complexity the flares have.
It doesn't paint a pretty picture, though.
These results put our own neighbourly Sun in a pretty good light. The Sun's flares are relatively calm and gentle compared to some powerful bursts from red dwarfs.
Complex life on Earth is only possible because of many variables that turned out just right. It looks like we can add the Sun's relatively quiescent flaring to the list.

Rings Inside a Martian Crater Reveal its Ancient History

Is this a closeup look at a tree stump, or an orbital view of an impact crater? At first glance, it might be hard to tell. But this image of a crater on Mars provides planetary scientists almost the same kind of climate history data about the Red Planet as tree rings provide to climate scientists here on Earth.
This picture was taken by the Colour and Stereo Surface Imaging (CaSSIS) camera onboard the ESA/Roscosmos ExoMars Trace Gas Orbiter (TGO), which arrived at Mars in 2016 and began its full science mission in 2018.
This unnamed crater is located in the vast northern plains of Acidalia Planitia. This plain is north of Valles Marineris, and the region contains the famous Cydonia region (where the "Face on Mars" butte is (it aoesn't actually look like a face), and well as heavily cratered highland terrain.
So, why does this crater look so unusual? Scientist from the ExoMars mission say the interior of the crater is likely composed of ice-rich material, and the quasi-circular and polygonal patterns of fractures could be the result of seasonal changes in temperature that cause cycles of expansion and contraction of those materials, eventually leading to the development of fractures.
Along the crater rim on the left, possible gullies are also visible.



An unusual crater on Mars, as seen by the CaSSIS camera onboard the ESA/Roscosmos ExoMars Trace Gas Orbiter (TGO) on 13 June 2021 in the vast northern plains of Acidalia Planitia. Credit: ESA/Roscosmos/CaSSIS.
Any water-ice rich soil would have been laid down during an earlier time in Mars' history when the inclination of the planet's spin axis allowed such deposits to form at lower latitudes than it does today. Just like on Earth, Mars' tilt gives rises to seasons, but unlike Earth its tilt has changed dramatically over long periods of time.
"Understanding the history of water on Mars and if this once allowed life to flourish is at the heart of ESA's ExoMars missions," say mission scientists. "The spacecraft is not only returning spectacular images, but also providing the best ever inventory of the planet's atmospheric gases with a particular emphasis on geologically and biologically important gases, and mapping the planet's surface for water-rich locations."



This topographical map of Mars from the Mars Global Surveyor laser altimeter instrument shows the various regions on

Mars. Acidalia Planitia can be see at the top near the center. Credit: MGS/MOLA.

The ExoMars orbiter will also provide data relay services for the second ExoMars mission which has the Russian built Kazachok lander that will bring the Rosalind Franklin rover to the surface of Mars. That mission is scheduled to launch in September of 2022. When it arrives on Mars in 2023, the rover will explore another region of Mars – not yet disclosed — thought once to have hosted an ancient ocean, and will search underground for signs of life.

Source: ESA

The Scientific Debate Rages on: Is there Water Under Mars' South Pole?

There's no surface water on Mars now, but there was a long time ago. If you ask most people interested in Mars, what's left of it is underground and probably frozen.

But some previous evidence shows there's a lake of liquid water under the planet's South Pole Layered Deposits (SPLD). Other evidence refutes it. So what's going on? Science, that's what.

Is there a lake under Mars' southern polar cap? Two new studies released concurrently tackled the question, and each one arrived at a different answer. One confirms the liquid lake; another refutes it. What are people to make of this?

It might look like scientists don't know what they're doing, but the opposite is true. This back-and-forth is the scientific method playing out in real-time.

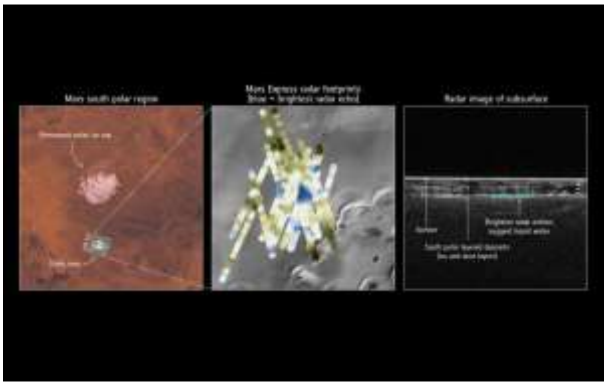
We're accustomed to simple yes or no answers, but that's not how things are. We all know that the Earth is round, right? But it wasn't always this way. Everyone had the same evidence, but it took a lot of discussions and arguing before people established that the Earth is a sphere. And even that isn't exactly correct: Earth is an oblate spheroid. Things aren't always straightforward, and nature hides the truth.

"I'd really like to know if brines do or do not exist under the SPLD, but uncertainty rules the day!"

Dr. David Stillman, Geophysicist, Southwest Research Institute.

The question around Mars' underground lakes is vexing because we can't go there and look. We have to rely on orbiters with remote sensing to gather evidence. And that data has to be interpreted. The interpretation is where it gets tricky.

In 2018, radar data from the ESA's Mars Express spacecraft hinted at an underground lake below the ice near Mars' south pole. A team of Italian researchers reported the discovery in the journal *Science*. Data showed a 20 km (12.5 miles) long reflective subsurface zone, and the scientists concluded that it was water, or more accurately, brines.



Radar data collected by ESA's Mars Express point to a pond of liquid water buried under layers of ice and dust in the south polar region of Mars. <Click to enlarge.> Credit: ESA

The purported lake is buried about 1.5 km below the surface, and it's briny, which makes it resist freezing. It's analogous to lakes found in northern Canada, and NASA previously found the necessary salts on Mars that could keep the lake from freezing. So there were reasons to believe the findings were plausible.

The discovery prompted some skepticism. Jeffrey Plaut, a planetary scientist at NASA's Jet Propulsion Laboratory, said, "It's not quite a slam dunk yet." There were calls for more supporting evidence.

Then in 2020, another study confirmed the presence of the lake—and found additional lakes. Or what they interpreted to be lakes. They were more buried reflective surfaces. This study generated more excitement, not just because there were lakes, but because they, or something like them on Mars, might support simple life.

Then a 2021 study showed that the reflective surfaces could be clays. The scientific back and forth was in full swing.

Where does the issue sit now?

Two new studies released only days apart come to separate conclusions. Will one of them bring this issue to a satisfactory end?

A new research letter published in the journal Earth and Planetary Science Letters says that the original 2018 discovery of liquid water under Mars' south pole could still be correct. Its title is "Assessing the role of clay and salts on the origin of MARSIS basal bright reflections." The first author is Elisabetta Mattei from the Department of Mathematics and Physics at Roma Tre University. Mattei and co-authors were also authors of the original 2018 paper showing the presence of liquid water under Mars' southern polar region. This letter is a scientific response to other published findings against their initial discovery of a subsurface lake.

The issue boils down to the reflectivity detected by an instrument on the Mars Express orbiter. The device is MARSIS (Mars Advanced Radar for Subsurface and Ionosphere Sounding.) It measures the subsurface composition of Mars and searches for frozen water. In a nutshell, liquid water and frozen water return different signals; liquid water is more reflective than frozen water.

An artist's illustration of the Mars Express Orbiter above Mars. Image Credit: Spacecraft: ESA/ATG medialab; Mars: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO

MARSIS data is the basis of the 2018 paper announcing the presence of buried liquid water. It's also the basis for the papers that arrive at different explanations for the measured reflectivity. The data isn't in doubt, just the interpretations and other scientific inquiry around the data.

The research concluding that there is no liquid water says that other things cause the reflectivity.

Nathaniel Putzig is a senior scientist with the Planetary Science Institute. Putzig is one of the authors of a paper presenting other explanations for the reflectivity in MARSIS data. In a press release, Putzig said, "It is not necessary to invoke liquid water at the base of the polar cap to explain the results of the MARSIS observations. Alternatives include clays, some metallic minerals, and salty ice."

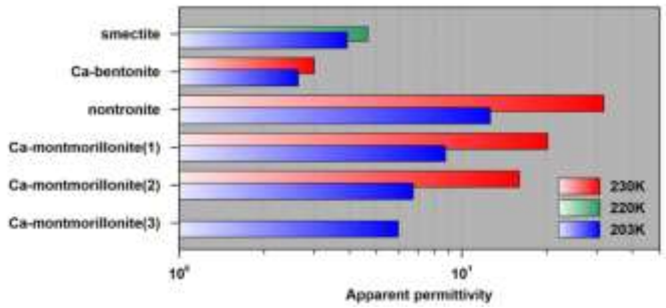
But the new research letter doesn't agree. The authors acknowledge the counter-explanations for the MARSIS signal, but they offer counter-counter-explanations. They discount clays, metallic minerals and salty ice as explanations. "Combining previous published data, simulations, and new laboratory measurements, we demonstrate that the dielectric properties of these materials do not generate strong basal reflections at MARSIS frequencies and Martian temperatures," they write. "Only brines can generate such high dielectric contrast at low basal temperature," they add.

The new research letter favouring water is partly based on lab experiments done by a scientist at the Southwest Research Institute (SwRI.) Geophysicist David Stillman, a co-author of the new research letter, conducted laboratory experiments on ice-brine mixtures at low temperatures.

"Lakes of liquid water actually exist beneath glaciers in Arctic and Antarctic regions, so we have Earth analogs for finding liquid water below the ice," said Stillman, a specialist in detecting water in any format — liquid, ice or absorbed — on planetary bodies. "The exotic salts that we know exist on Mars have amazing 'antifreeze' properties allowing brines to remain liquid down to -103 degrees Fahrenheit. We studied these salts in our lab to understand how they would respond to radar."

"The research showed that we don't have to have lakes of perchlorate and chloride brines, but that these brines could exist between the grains of ice or sediments and are enough to exhibit a strong dielectric response. This is similar to how seawater saturates grains of sand at the shoreline or how flavouring permeates a slushie but at -103 degrees Fahrenheit below a mile of ice near the South Pole of Mars," Stillman said.

Temperature is a critical factor in this issue. We don't know what the temperature is one-and-a-half kilometres below the Martian surface. It's too low for liquid water, but it can remain liquid at lower temperatures if the water is briny. The temperature also affects the permittivity of different materials and the data that MARSIS gathers.



This figure from the study shows the effect that temperature can have on the permittivity of different clays on Mars. Image Credit: Stillman et al. 2022.

The paper is a detailed examination of the different types of clays on Mars and how they appear different in MARSIS data at different temperatures. "Temperature has a dominating effect on the dielectric properties of clay and clay sediments," the authors write. "The drastic effect of temperature on the dielectric behaviour of clays is confirmed by our set of measurements conducted on clay sediments at different water content, clay content, and different mineralogy. Very low temperatures, such as those commonly inferred at the base of the SPLD (~200 K), are totally inconsistent with the hypothesis that clay sediments can generate a dielectric contrast with the SPLD large enough to obtain bright basal echoes."

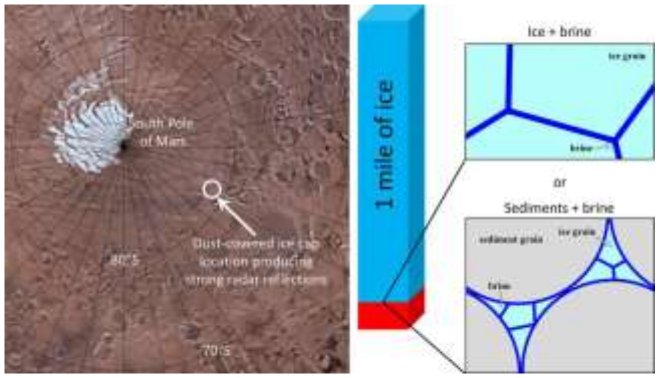
"Our dielectric measurements on Mg(ClO4)2 and CaCl2 brines at Martian subglacial conditions rule out also salty ice as the cause for MARSIS bright reflections," they write in their paper's conclusion.

In some of the lab experiments, Dr. Stillman subjected clay samples to extremely low temperatures. "For example, the 100 mM Mg(ClO4)2 (magnesium perchlorate) sample was held at 193 K for 72 hours and never fully froze, until the temperature was reduced to 188 K," the paper says.

Dr. Stillman talked about the temperature problem with Universe Today.

"The temperature behind the SPLD is critical. Our understanding of this temperature is poor," Stillman said. "The <Sori and Bramson> paper we reference is a lower bound assumption assuming the SPLD is a single piece of nearly pure ice. It is likely not a single sheet of ice, but much more complex."

Scientists also don't know how conductive the SPLD is, which affects temperature uncertainty.



Dr. Stillman from SwRI studied the antifreeze properties of exotic salts that exist on Mars, which could allow brines to remain liquid down to -103 degrees Fahrenheit. The studies show how a mile below the Martian south polar cap, brines between the grains of ice or sediments could produce the strong reflections detected by the radar instrument aboard ESA's Mars Express orbiter. Image Credit: NASA/JPL-Caltech/USGS/SwRI

So are there lakes below Mars' south pole? We don't know yet. If there is something there, it might be more slush than a lake, and it might not be anything like buried lakes on Earth. This back-and-forth shows the power of the scientific method. Nobody's saying the data's wrong; they're just engaging with the evidence and reaching different conclusions.

"This is how the scientific method works. It is frustrating to see papers that came out within a week of each other coming to vastly different conclusions," Stillman said. (Dr. Stillman refers to a paper led by Cyril Grima, a planetary scientist at the University of Texas Institute for Geophysics. Universe Today will cover that paper in a separate article.)

COVID plays a role, too. In more normal times, scientists would discuss issues like this at conferences and share ideas and lines of inquiry. While face-to-face discussions at conferences don't guarantee consensus, they are a part of the scientific process.

"I think some of this is because of the much lower interaction of scientific groups due to the lack of in-person conferences due to COVID," Stillman said. "This is also occurring because different science groups make different assumptions," Stillman said, referring to estimates of the underground temperature.

"Honestly, I do not know which assumptions are correct because we are studying a planet so far away with very limited data."

This discussion will continue for a while, and we need better data before there is widespread agreement. It's frustrating for researchers and the rest of us interested in Mars, water, habitability, and the host of issues that ride shotgun alongside Martian water.

But it's also a fascinating look at the scientific method playing out as intended.

"I'd really like to know if brines do or do not exist below the SPLD, but uncertainty rules the day! I still think partially saturated brines are the most correct answer, but I cannot be positive," Stillman said. "I look forward to debating this in the literature and at in-person conferences. I mean, this is what makes science fun!"

Webb Has Arrived Successfully at L2

It's really happening. The James Webb Space Telescope has successfully reached its orbital destination in space, 1.5 million km (1 million miles) from Earth. A final 5-minute thruster firing on January 24, 2022 put JWST in its halo orbit at the Sun-Earth Lagrange 2 (L2) point. The formal commissioning process can now begin.

"We're excited to announce today that Webb is officially on station at its L2 orbit, capping off a remarkable 30 days," said Webb's commissioning manager Keith Parrish in a January 24 news conference. "It's an incredible achievement by our team."

Arianespace's Ariane 5 rocket launches with the James Webb Space Telescope onboard, Saturday, Dec. 25, 2021, from Europe's Spaceport at the Guiana Space Centre in Kourou, French Guiana. The James Webb Space Telescope (sometimes called JWST or Webb) is a large infrared telescope with a 21.3 foot (6.5 meter) primary mirror. The observatory will study every phase of cosmic history—from within our solar system to the most distant observable galaxies in the early universe. Photo Credit: (NASA/Bill Ingalls)

Since it launched on December 25, Webb has been undergoing the nail-biting and complicated unfolding and deploying while cruising through space. Everything so far has gone perfectly.

"During the past month, JWST has achieved amazing success and is a tribute to all the folks who spent many years and even decades to ensure mission success," said Bill Ochs, Webb project manager at NASA's Goddard Space Flight Center, in a blog post. "We are now on the verge of aligning the mirrors, instrument activation and commissioning, and the start of wondrous and astonishing discoveries."

Parrish reiterated how efficient the launch by the Ariane 5 rocket and the course correction maneuvers have been, potentially giving the JWST mission twice the lifetime as originally announced, as long as 20 years.

"We used a tiny amount of fuel in today's maneuver," he said, "We're very, very happy with our estimated lifetime, and it's going to extensively exceed our 10 year estimate. Everybody's thrilled by it. It's just a degree of how thrilled."

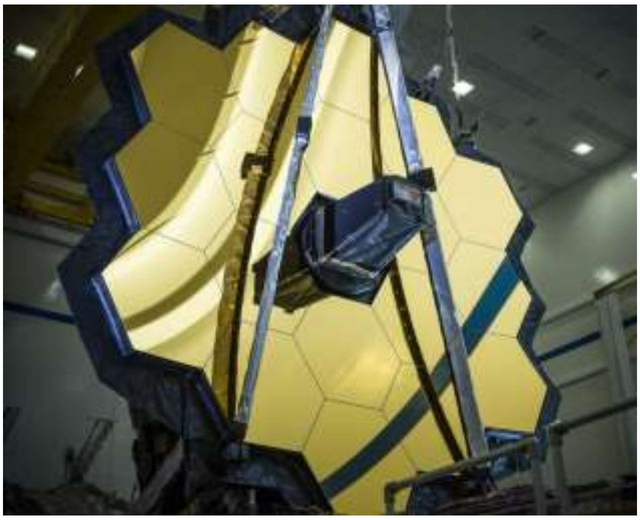
Parrish added that the team will review the data and put an exact number on that lifetime over the next few months.

Parrish said approximately once every 21 days, the telescope's orbit around L2 will need to be tweaked by briefly firing JWST's thrusters.

The telescope team will now begin the months-long process of calibrating its mirrors and turning on the science instruments.

Lee Feinberg, JWST's Optical Telescope Element Manager said the 3-month process of aligning the 18 mirror segments to act as one large 6.5 meter telescope will begin in about a week, after the primary near-infrared camera, NIRCam, is cold enough to turn on. That instrument will help align the mirrors.

"We'll look at a bright, isolated star," Feinberg said, "and we'll get 18 different images — which will all be blurry because the individual mirror won't be aligned. Then we can begin the slow process that we call phasing, which will align the mirrors to work as one."



Shown with its primary mirror fully deployed, NASA's James Webb Space Telescope is the largest and most technically complex space science telescope NASA has ever built. Credit: NASA/Chris Gunn

Feinberg said the mirrors will be aligned to within 1/5000th the width of a human hair. He also revealed the identity of the star they will use: HD 84406, a G-type main sequence star that is a lot like our own Sun.

"It's a Ursa Major near the bowl of the Big Dipper," he said noting that the star is not visible to the naked eye, but it can be seen with binoculars.

While everything has gone well so far, there is still a lot of work to get the telescope ready for action.

"We're a month in and the baby hasn't even opened its eyes yet," said Jane Rigby of NASA Goddard Space Flight Center. "Everything we're doing is about getting the observatory ready to do transformative science. That's why we're here."

The Moon's Crust was Formed From a Frozen Slushy Magma

Scientists' detailed study of the Moon dates back to the Apollo missions when astronauts brought rock samples from the lunar surface back to Earth for analysis. Apollo 11 gathered samples from the lunar highland regions, the pale areas on the Moon's surface easily seen from Earth. The highlands are made of a relatively light rock called anorthosite, which formed early in the history of the Moon, between 4.3 and 4.5 billion years ago.

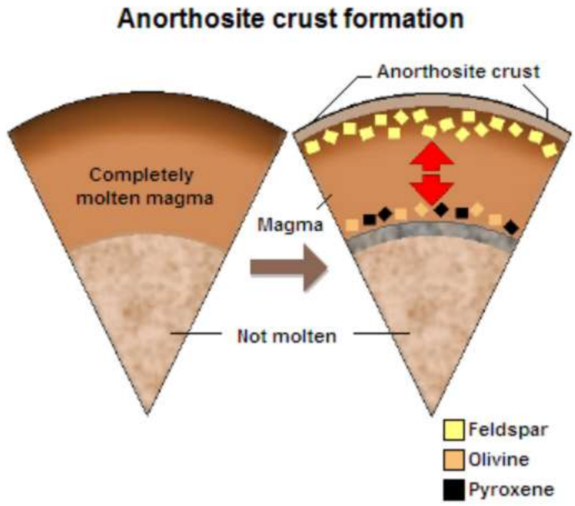
There's some mystery involved in the anorthosite formation on the Moon. The age of the anorthosite highlands doesn't match how long it took for the Moon's magma ocean to cool. But scientists behind a new study think they've solved that mystery.

Geologists are interested in lunar anorthosites because of the uncertainty surrounding their formation. Their formation involves fractional crystallization, where anorthite mineral crystals are removed from magma as they form, with lighter crystals rising to the surface. But some of the details of their formation are still unclear.

(*Note: The anorthosite is the rock that forms the highlands. Anorthite is a mineral (plagioclase). So anorthosites are rocks that are very rich in anorthite.*)

A collision between two protoplanets created the Moon. One of the protoplanets became the Earth, and the smaller one became the Moon. After the crash, the Moon heated up so much that the entire mantle was molten. Geologists call this a magma ocean.

When scientists studied the Apollo 11 samples from the lunar highlands, the evidence seemed to confirm that the anorthosites on the lunar highlands were formed by fractional crystallization. Light anorthite crystals rose to the top of the magma oceans comprising the highlands, and heavier crystals sank. The Highlands is more than 90% anorthite.



This figure shows the older model of anorthosite crust formation on the Moon. But the new research suggests a different formation mechanism. The new model can solve an age discrepancy that the older model can't. Image Credit: By Titoxd at the English-language Wikipedia, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=19535063

But there are problems with that explanation, and a pair of scientists think they have a better answer. They've presented their work in a paper titled "Formation of the Lunar Primary Crust From a Long-Lived Slushy Magma Ocean." The A.G.U.'s Geophysical Letters published the paper by researchers Chloé Michaut and Jerome A. Neufeld.

"Since the Apollo era, it has been thought that the lunar crust was formed by light anorthite crystals floating at the surface of the liquid magma ocean, with heavier crystals solidifying at the ocean floor," said co-author Chloé Michaut from Ecole normale supérieure de Lyon. "This 'flotation' model explains how the lunar Highlands may have formed."

But that conclusion is based on samples from Apollo11, and present-day researchers have more tools and evidence at their disposal. Analysis of lunar meteorites and deeper analysis of the Moon's surface contradict the earlier conclusion. The lunar anorthosites appear to be more heterogeneous instead of highly fractionated. Anorthites are spread throughout the rock, but the surface is especially rich in anorthites. These findings suggest that our understanding of the lunar magma ocean isn't complete.

So what happened in the ancient magma ocean to create these heterogenous anorthosites in the lunar highlands? One of the clues to what happened is the disparity between the age range in the anorthosites and how long it took the magma ocean to cool. The anorthosites are over 200 million years old, but the ocean solidified in about 100 million years.

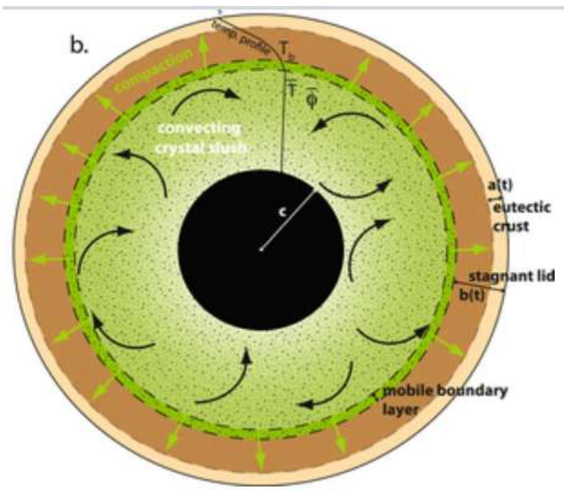
The lunar highlands are pale-coloured, and the darker areas are called maria, Latin for "seas." The maria are volcanic features created by basaltic lava flows. The highlands are older and formed when the lunar magma ocean cooled and solidified. Image Credit: By Gregory H. Revera, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=11901243

"Given the range of ages and compositions of the anorthosites on the Moon, and what we know about how crystals settle in solidifying magma, the lunar crust must have formed through some other mechanism," said co-author Professor Jerome Neufeld from Cambridge's Department of Applied Mathematics and Theoretical Physics.

Michaut and Neufeld developed a mathematical model to identify this mechanism. Their model shows that it's difficult for heavier crystals to settle to the bottom in the Moon's lower gravity. The convective currents in the magma ocean also discourage settling. The pair of researchers found that the ocean could have formed a kind of slurry, where crystals remain suspended rather than settling or rising. They also found that there's a critical threshold. When the crystal content in the slurry is above this threshold, the slurry becomes more viscous, and deformation slows down.

In their paper, the authors say that "On reaching this critical crystal fraction, the mixture viscosity dramatically increases which may result in a prolongated mushy magma ocean stage."

In this scenario, the surface of the slurry cools faster than the interior. The result is the anorthite-rich crust we see in the lunar highlands and a more well-mixed, slushy interior.



This figure from the study illustrates the new model of highland formation on the Moon. The stagnant lid is the anorthite-rich crust found in the highlands, and the green area is the still-convecting crystal slush. Eutectic means a homogeneous composition of materials that solidifies at the same time. The eutectic crust is 90% anorthite. Image Credit: Michaut and Neufeld, 2022.

"We believe it's in this stagnant 'lid' that the lunar crust formed, as lightweight, anorthite-enriched melt percolated up from the convecting crystalline slurry below," said Neufeld. "We suggest that cooling of the early magma ocean drove such vigorous convection that crystals remained suspended as a slurry, much like the crystals in a slushy machine."

The press release goes on to say that "Enriched lunar surface rocks likely formed in magma chambers within the lid, which explains their diversity."

This research explains the discrepancy between the age of the anorthosites and the understood length of time it took for the magma ocean to solidify. Rather than taking 100 million years to cool, the magma ocean was a slushy mix that took over 200 million years to cool, matching the age of the anorthosites in the lunar highlands.

Even Tiny Mimas Seems to Have an Internal Ocean of Liquid Water

Data from the Cassini mission keeps fuelling discoveries. The latest discovery is that Saturn's tiny moon Mimas may have an internal ocean. If it does, the moon joins a growing list of natural satellites in our Solar System that may harbour liquid water under their surfaces.

Worlds with interior oceans are called Interior Water Ocean Worlds (IWOWs). If the new paper announcing this discovery is correct, tiny Mimas will join worlds like Europa, Enceladus, Titan—and maybe Pluto—on the growing list of IWOWs in our Solar System. How did scientists discover that Mimas is a potential IWOW?

It's all thanks to the Cassini mission to Saturn, a collaboration between NASA, the ESA, and the Italian Space Agency. That mission ended with a plunge into Saturn in 2017, called the Grand Finale. But before it concluded its mission with a purposeful plunge into the gas giant's atmosphere, the spacecraft's instruments detected an unusual libration in Mimas' rotation.

Librations like the one found in Mimas' rotation are often indicators of a geologically active world with a subsurface ocean.

A new paper published in the journal Icarus explains the findings. Its title is "The case for an ocean-bearing Mimas from tidal heating analysis," and it's available online at Science Direct. The authors are Alyssa Rose Rhodena and Matthew E. Walker. Rhodena is an expert in the geophysics of icy satellites at the Southwest Research Institute, and Walker is an Associate Research Scientist at the Planetary Science Institute.

If Mimas is an IWOW, it would be different from others in the Solar System like Europa and Enceladus. Those ocean-bearing moons show geological activity that Mimas lacks. The authors point out that the physical librations Cassini sensed "… can be explained by either a non-hydrostatic core or a global, liquid water ocean beneath a 24–31 km thick ice shell."

The moons Enceladus (L), Europa (M), and Mimas (R,) not to scale. While the surfaces of Enceladus and Europa show clear signs of geological activity like fractures and troughs, Mimas' surface is different. It's covered in craters and shows no signs of activity. Image Credits: Enceladus: By NASA/JPL/Space Science Institute. Europa: By NASA/JPL/DLR. Mimas: By NASA / JPL-Caltech / Space Science Institute.

"If Mimas has an ocean, it represents a new class of small, 'stealth' ocean worlds with surfaces that do not betray the ocean's existence," said SwRI's Dr. Alyssa Rhoden in a press release. Rhoden studies the geophysics of icy satellites, particularly those containing oceans, and the evolution of giant planet satellites systems.

The word 'stealth' certainly applies to Mimas compared to other IWOWs like Enceladus and Europa. Mimas' cratered surface gives no hint of an ocean underneath, though researchers suspected it might be a large chunk of ice rather than rock. Its density is too low to be all rock, though it may contain some rock.

"Because the surface of Mimas is heavily cratered, we thought it was just a frozen block of ice," Rhoden said. "IWOWs, such as Enceladus and Europa, tend to be fractured and show other signs of geologic activity. Turns out, Mimas' surface was tricking us, and our new understanding has greatly expanded the definition of a potentially habitable world in our solar system and beyond."

Mimas is close enough to massive Saturn to be shaped by the planet's powerful gravity. Saturn's gravity is strong enough to stretch the small moon into an ellipsoidal shape. Those same tidal forces cause heating, along with heating from rotational energy. There's a delicate balance here; the heating must be powerful enough to melt the interior into liquid but not so powerful that the surface melts.

The researchers developed numerical models based on tidal heating models to develop a plausible explanation for the librations that Cassini sensed. They concluded that an icy shell 24 km to 32 km (14 to 20 miles) thick covers Mimas' interior ocean. Compare that to Europa's icy shell, which is probably 10–30 km (6–19 miles) thick, and to Enceladus' which is probably 30 to 40 km (19 to 25 miles) thick.

"Most of the time, when we create these models, we have to fine tune them to produce what we observe," Rhoden said. "This time evidence for an internal ocean just popped out of the most realistic ice shell stability scenarios and observed librations."

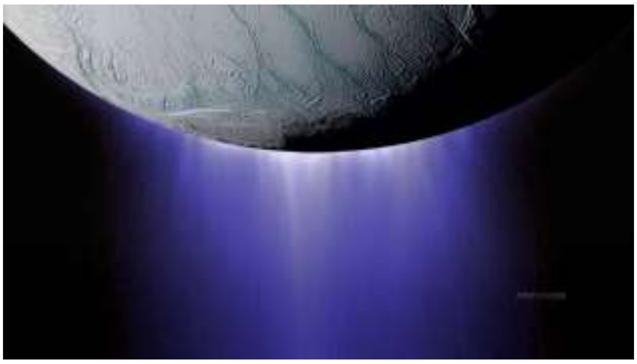
This is still a preliminary discovery, and a visit from a spacecraft can confirm it. It needn't visit Mimas itself; a visit to any IWOW would clarify the critical issue of heat flow against ice shell thickness. From the press release: "The team also found that the heat flow from the surface was very sensitive to the thickness of the ice shell, something a spacecraft could verify. For instance, the Juno spacecraft is scheduled to fly by Europa and use its microwave radiometer to measure heat flows in this Jovian moon."

NASA's Juno will perform a flyby of Europa near the end of 2022 at a distance of about 320 kilometres (200 miles). Data from the flyby will help researchers understand how heat flow affects icy shells. The dynamics between heat flow and frozen shells on IWOWs will grow in importance when NASA's Europa Clipper mission launches in 2024. The spacecraft will reach the Jovian system in April 2030 and enter a long looping orbit around Jupiter, performing repeated flybys of Europa.

The Europa Clipper will study Europa in detail, and its findings will tell us a lot about IWOWs. Will data from that mission help scientists understand Mimas better? Probably. But for now, the data from the Cassini mission is what scientists have to work with. According to Rhoden, there are still some unreconciled aspects in that data regarding Mimas. If Rhoden and other researchers can reconcile some of the challenges in the data, they'll learn more about other ocean moons and the systems they belong to. It's like facing a locked door. Behind the door is a greater understanding of IWOWs, and Mimas is the key that unlocks it.

"Although our results support a present-day ocean within Mimas, it is challenging to reconcile the moon's orbital and geologic characteristics with our current understanding of its thermal-orbital evolution," Rhoden said. "Evaluating Mimas' status as an ocean moon would benchmark models of its formation and evolution. This would help us better understand Saturn's rings and mid-sized moons, as well as the prevalence of potentially habitable ocean moons, particularly at Uranus. Mimas is a compelling target for continued investigation."

Uranus has five large moons, and images from Voyager 2's flyby in 1986 showed that they're roughly equal parts ice and rock. Voyager 2 didn't have the same capable instruments as Cassini, so more detailed data isn't available. But the images did show evidence of cryovolcanism, where liquid erupts through the surface and then freezes. Enceladus has the same eruptions, sending plumes of material from the subsurface ocean out into space.



This image is a false-colour artist's illustration of the cryovolcanic plumes erupting from Saturn's moon Enceladus. Image Credit: NASA/ESA

The Solar System's gas giants might all have IWOWs. The outer giant planets could have enough mass to induce tidal heating in their moons, and that's something scientists are keen to examine. Neptune has 14 moons, with Triton by far the most massive. Triton's crust is mostly water ice, and the moon is geologically active like Europa and Enceladus. It's likely a captured Kuiper Belt Object (KBO.) When Voyager 2 approached the moon in 1989, it saw geyser-like plumes 8 km (5 miles) high.

These are three images of a cryovolcanic plume on Triton taken about 45 minutes apart, from left to right, by Voyager 2 on August 26th, 1989. They show the geyser-like volcanic plume spewing an 8km (5 miles) tall cloud of fine, dark particles into Triton's thin atmosphere. The cloud is drifting downwind to the right for a distance of roughly 150 kilometres (about 100 miles). Image Credit: NASA/JPL

Each time scientists discover another IWOW, it brings up the possibility of life. For life to start, evidence shows that there needs to be an active interface between water and rock. Mimas' density suggests it could have a rocky core. If there's heat, then interactions between water and rock can supply the necessary ingredients for life.

Mimas is small, with a surface area about the size of Spain. It's only 396 kilometres (246 mi) in diameter, and it's the smallest known body that's rounded due to self-gravity. If a world this small can harbour a subsurface ocean, then that expands the list of other objects that could have them, and our understanding of potentially habitable worlds will grow, too.

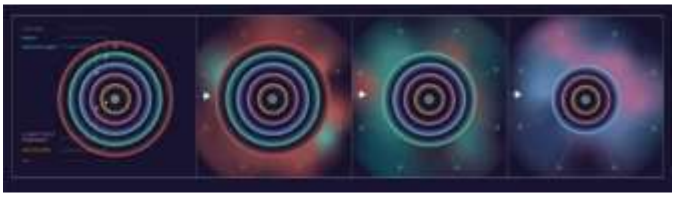
Does Mimas have an ocean? Could it harbour life? Are IWOWs far more common than we expected?

For now, we don't know.

A new Kind of Supernova has Been Discovered

We often think of supernova explosions as inevitable for large stars. Big star runs out of fuel, gravity collapses its core and BOOM! But astronomers have long thought at least one type of large star didn't end with a supernova. Known as Wolf-Rayet stars, they were thought to end with a quiet collapse of their core into a black hole. But a new discovery finds they might become supernovae after all.

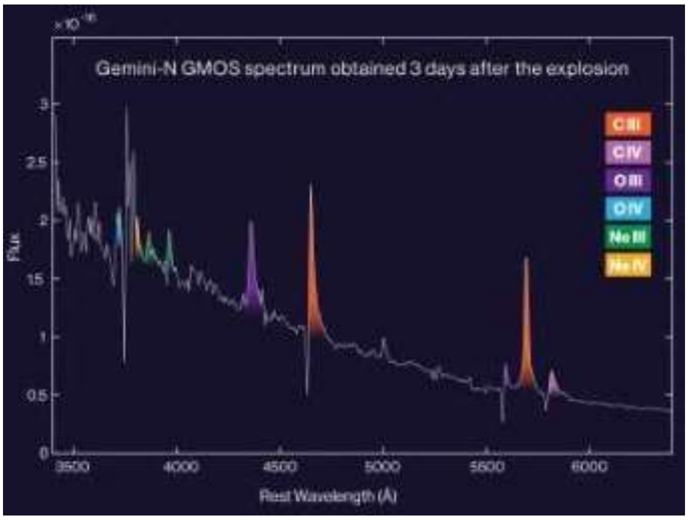
Wolf-Rayet stars are among the most massive stars known. They are at the end of their short lives, but rather than simply running out of fuel and exploding, they push out their outer layers with an extremely powerful stellar wind. This produces a surrounding nebula rich in ionized helium, carbon, and nitrogen, but almost no hydrogen. The surface temperature of the remaining star can be over 200,000 K, making them the most luminous stars known. But because most of that light is in the ultraviolet range, they are not particularly bright to the naked eye.



In a large star, different elements are in layers before the star explodes. Credit: Itai Raveh

Even with the outer layers of a Wolf-Rayet star cast off, the central star is still much more massive than the Sun. So you'd figure it's only a matter of time before it becomes a supernova. No matter how far up the periodic table fusion occurs, it will eventually run out of fuel, leading to a core-collapse supernova. But we can see the spectra of elements within a supernova, and we'd never seen a spectrum that matched a Wolf-Rayet star. As our discovery of supernovae became commonplace, some astronomers began to wonder if Wolf-Rayet stars had a quiet death instead. The idea was that they would cast off enough outer layers that the remaining core would eventually just collapse directly into a black hole. No giant explosion needed. A silent death to a massive star.

This latest study shows that at least some Wolf-Rayet stars do become supernovae. The team looked at the spectrum of a supernova known as SN 2019hgp, which was discovered by the Zwicky Transient Facility (ZTF). The supernova's spectrum had bright emission light indicating the presence of carbon, oxygen, and neon, but not hydrogen or helium. When the team looked at the data more closely, they found these particular emission lines weren't caused by elements of the supernova directly. Instead, they were part of a nebula expanding away from the star at more than 1,500 km/s.



A spectra from SN 2019hgp. Credit: Itai Raveh

In other words, before the supernova occurred, the progenitor star was surrounded by a nebula rich in carbon, nitrogen, and neon, while lacking the lighter elements of hydrogen and helium. The expansion of the nebula must have been driven by strong stellar winds. This matches the structure of a Wolf-Rayet star extremely well. So it looks like SN 2019hgp is the first example of a Wolf-Rayet supernova. Since then, similar supernovae have also been detected.

Because this supernova was identified by spectra of the surrounding nebula, it isn't clear whether the explosion was a simple supernova, or whether it was a more complex hybrid process where the upper layer of the star exploded while the core collapsed directly to a black hole. It will take more observations to determine the details. What's clear is that at least some Wolf-Rayet stars do not go silently into the night.

Reference: Gal-Yam, A., et al. "A WC/WO star exploding within an expanding carbon–oxygen–neon nebula." *Nature* 601.7892 (2022): 201-204.

Space Flight Destroys Your Red Blood Cells

It's really true: space wants to kill us. And this time, space is trying to kill us from the inside out.

A new study on astronauts living on board the International Space Station shows that while in space, the astronauts' bodies destroyed 54 percent more red blood cells than they normally would on Earth. Even one year after their flight and back on Earth, the symptoms of "space anemia" persisted in the 14 astronauts tested.

Anemia in astronauts has been known as an issue, even since some of the first human missions to space. Medical experts haven't been sure, however, about the mechanisms contributing to anemia in space. For quite some time, it was thought that space anemia was part of the fluid shift in astronauts when they arrive in space due to the zero-gravity conditions.

Upon entry into microgravity, body fluids tend to migrate away from the legs toward the upper body and head, with the usual result of nasal congestion, a feeling of fullness in the head and faces that look puffy. This fluid shift has also been part of the studies of why astronauts' vision degrades while in space.

Previous studies showed that astronauts lose 10 percent of the liquid in their blood vessels while their bodies adapt to being in space. From those studies, it was thought vascular systems in the space environment rapidly destroyed 10 percent of the red blood cells to restore the balance, and that red blood cell control was back to normal after 10 days in space.

Astronaut Tim Peake's first blood draw completed in space. The sample was taken as part of the anemia study. Credit: NASA.

Instead, a team led by Dr. Guy Trudel from the Ottawa Hospital and University of Ottawa, found that the red blood cell destruction was a primary effect of being in space, not just caused by fluid shifts. Plus, the rate of red blood cell destruction persisted, albeit at a lower rate, for at least a year following the astronauts' six-month expeditions in space.

"Here, we show that space flight is associated with persistently increased levels of products of hemoglobin degradation, carbon monoxide in alveolar air and iron in serum, in 14 astronauts throughout their 6-month missions onboard the International Space Station," Trudel and his team wrote in their paper, published in Nature Medicine. "One year after landing, erythrocytic effects persisted, including increased levels of hemolysis, reticulocytosis and hemoglobin."

These findings, the team said, suggest that the destruction of red blood cells, called hemolysis, is a primary effect of microgravity in space flight and support the hypothesis that the anemia associated with space flight is a hemolytic condition that should be considered in the screening and monitoring of both astronauts and space tourists.

Red blood cell destruction happens all the time in our bodies. On Earth, our bodies create and destroy 2 million red blood cells every second. The researchers found that astronauts' bodies were destroying 54 percent more red blood cells during the six months they were in space, or 3 million every second. These results were the same for both female and male astronauts.

But the effects of this type of anemia aren't evident until the astronauts return to Earth.

"Thankfully, having fewer red blood cells in space isn't a problem when your body is weightless," said Trudel, in a press release. "But when landing on Earth and potentially on other planets or moons, anemia affecting your energy, endurance, and strength can threaten mission objectives. The effects of anemia are only felt once you land, and must deal with gravity again."

Astronaut David Saint-Jacques collecting breath, ambient air, and blood samples for the MARROW experiment. Credit: NASA

In this study, five out of 13 astronauts were clinically anemic when they landed—one of the 14 astronauts did not have blood drawn on landing. While the researchers found that the anemia slowly improved after a few months, even one year after astronauts returned to Earth, red blood cell destruction was still 30 percent above preflight levels. The team said these results suggest that structural changes may have happened to the astronaut while they were in space that changed red blood cell control for up to a year after long-duration space missions.

What does this mean for future space travelers? Trudel's team said that everyone going to space should be screened for existing blood or health conditions that are affected by anemia. But also, since the study showed that the longer the space mission, the worse the anemia, this could impact long-duration missions to the Moon and Mars, since it is unclear at this point how long the body can withstand the higher rate of destruction and production of red blood cells. The researchers suggest an adapted diet for astronauts to try to counteract the anemia.

As with most physiological studies in space, these findings are applicable to people on Earth. Trudel wants to study this correlation in future studies.

"If we can find out exactly what's causing this anemia, then there is a potential to treat it or prevent it, both for astronauts and for patients here on Earth," said Trudel.

Now we Know why Spaceflight Affects Your Eyes

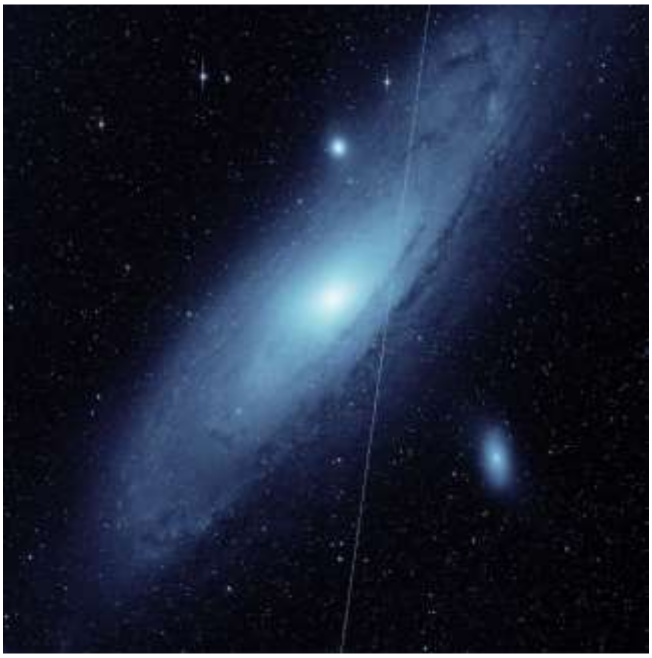
70% of astronauts who spend time on the International Space Station (ISS) experience swelling at the back of their eyes, causing blurriness and impaired eyesight both in space and

when they return to Earth. Sometimes, it's permanent. Understanding the way microgravity affects the eyes, and the human body as a whole is an essential part of preparations for future long-duration spaceflights to the Moon and Mars. In an effort to understand the cause of these eye problems, researchers at the Medical University of South Carolina used MRI scans of twelve ISS astronauts to measure the intracranial venous system (veins that circulate blood to the brain) before and after flight. They've determined that there is a strong connection between the swelling of these veins and the onset of eye trouble.
Poor eyesight is just one of the medical challenges facing humans in space. When not having to fight against Earth's gravity, muscles become weak and bone density decreases, while the high radiation environment of space threatens to cause long-term diseases like cancer. The ISS is largely designed as a microgravity laboratory, and many of the experiments carried out there are medical in nature, with astronauts themselves as willing test subjects – everything learned from these studies helps keep them and their peers safe. As a result, a wealth of medical data has been gathered that will reduce the risk to future spacefarers.
The effect of spaceflight on the eyes is known as spaceflight-associated neuro-ocular syndrome (SANS). SANS is so common, according to Dr. Mark Rosenberg, one of the study's authors, that "it's gotten to the point where astronauts actually carry extra pairs of glasses when they go into space. They know that their vision is going to be deteriorating up there, and they've even started calling them space anticipation glasses."

NASA astronaut Chris Ferguson has his eyes imaged using ultrasound at the Johnson Space Center Flight Medicine Clinic, 2011, in Houston. Credit: NASA.
The physical changes in the eyes include flattening of the globes, injury to the retinas, and the swelling of nerves in the eyes. For some astronauts, the eyes recover within weeks of returning to Earth, but the healing process can sometimes take much longer.
The root cause of SANS, according to the paper Rosenberg and his colleagues produced, seems to be correlated with veins swelling behind the eyes. Weightlessness causes the distribution of blood in the body to change, with fluid moving towards the head and eyes more than is usual on Earth, where gravity reduces the flow to these areas.
These results imply "individuals with increased venous sinus compliance may be at increased risk of developing SANS," and therefore pre-screening can help astronauts understand the risks to their eyes before they ever leave the Earth.
There is still, of course, more to learn. For one thing, the team hopes to do more research on how SANS risks might differ between men and women, using a larger sample size of astronauts (the current research is based on 2 female and ten male astronauts). They'd also like to install a mobile MRI machine on the ISS, which would allow them to do brain scans in space. The post-flight scans used in the current research leaves open the possibility that the changes they see in the intracranial venous system occur on return to Earth, rather than in orbit, and the team would like the opportunity to rule out that possibility. The team also believes their research will useful for understanding eye disorders for humans here on Earth. What is learned in space has applications in medical science right here at home.

20% of Twilight Observations Contain Satellite Passes

With the rapid expansion of commercial space, there is a growing number of satellites in orbit around our planet. Most of these are in low-Earth orbit, which is becoming increasingly crowded. This has led some to be concerned about a catastrophic rise of space debris, as well as a growing frustration by astronomers due to the number of satellite sky trails. Currently, the biggest player is the SpaceX Starlink project, which currently has more than 1,700 satellites in low-Earth orbit. They have become notorious for creating bright streaks in astronomical images. But Starlink will soon be followed by other projects, such as OneWeb and Amazon's Project Kuiper. The goal of all of these projects is to provide easily accessible Internet across the globe, which is a noble goal. But the visibility of these satellites will also pose serious challenges to critical astronomy. While the impact of these satellites on astronomy isn't serious yet, it will be soon, as a recent study shows.



A Starlink satellite trail seen across the Andromeda Galaxy. Credit: Caltech Optical Observatories/IPAC
Published in *Astrophysical Journal Letters*, the study looks at the number of Starlink trails seen in images captured by the Zwicky Transient Facility (ZTF) at Palomar Observatory. They found that from November 2019 to September 2021 there were more than 5,300 streaks seen in ZFT images. Most of the streaks were seen in twilight images taken near dusk or dawn. In 2019 only half a percent of twilight images had streaks, but they are now seen in about 1 of every 5 twilight images. This is concerning because twilight images are the most critically important to the search for near-Earth asteroids. The potential meteor strikes that pose the greatest threat to us are those that are the most difficult to find because they come from a trajectory near the Sun's position in the sky.
The authors point out that this number of streaks isn't high enough to significantly affect the search for potential asteroid collisions. But as the number rises to 10,000 or 15,000, astronomers will start to miss some asteroids. Given current trends, that number will be reached within a year or so. There are ways to mitigate the effect of these streaks. Painting the satellites and adding reflective panels could reduce their

brightness, particularly at infrared wavelengths that are important for near-Earth asteroid detection. But the study points out that the mitigation strategy currently proposed by Starlink won't be sufficient to avoid an impact on astronomy.

It is clear we will soon need to make some difficult choices about satellite Internet. While it could broaden human connection to even the poorest and most remote regions of the world, it could also destroy our ability to view the heavens and more deeply understand the universe we call home. If we do not set our priorities and guidelines soon, SpaceX, Amazon, and other mega-companies will make the decision for us.

Reference: Mróz, Przemek, et al. "Impact of the SpaceX Starlink Satellites on the Zwicky Transient Facility Survey Observations." *The Astrophysical Journal Letters* 924.2 (2022): L30.

Remember When Life was Found in a Martian Meteorite? Turns out, it was Just Geology

The Alan Hills meteorite is a part of history to Mars aficionados. It came from Mars and meteorite hunters discovered in Antarctica in 1984. Scientists think it's one of the oldest chunks of rock to come from Mars and make it to Earth.

The meteorite made headlines in 1996 when a team of researchers said they found evidence of life in it.

Did they?

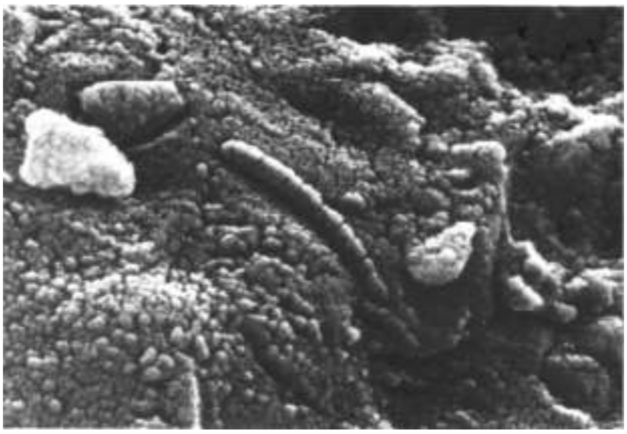
The Alan Hills meteorite (ALH84001) is a precious scientific object and part of Mars lore now. Twelve years after its discovery, a team of scientists claimed to find evidence of microscopic bacterial fossils in the meteorite.

From that paper's abstract: "The carbonate globules are similar in texture and size to some terrestrial bacterially induced carbonate precipitates. Although inorganic formation is possible, the formation of the globules by biogenic processes could explain many of the observed features, including the PAHs (polycyclic aromatic hydrocarbons.) The PAHs, the carbonate globules, and their associated secondary mineral phases and textures could thus be fossil remains of a past martian biota."

That was controversial, and it was huge news. So huge that then-President Bill Clinton saw fit to make a speech about it. Clinton was suitably circumspect when he said, "Like all discoveries, this one will and should continue to be reviewed, examined and scrutinized. It must be confirmed by other scientists."

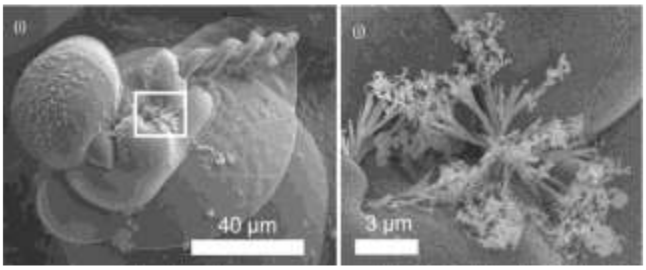
Other scientists have studied it many times, and they've concluded that the strange, organic-seeming morphologies inside the meteorite were not biological in origin.

So what created them?



Electron microscope images of the Martian meteorite ALH84001 showed chain-like structures that resembled living structures. Image: NASA

There are a lot of false positives when it comes to fossilized evidence of microscopic life. Purely geological structures can mimic organic structures. So it's easy to see how scientists interpreted the Alan Hills meteorite as evidence of life in 1994. But now we know that a host of geological processes can produce organic-looking structures. Scientists call these microscopic structures "chemical gardens."



These images show structures called carbonate-silica biomorphs that appear biological but aren't. The image on the left shows blob structures, sheet structures, and helical structures, which all appear biological. The image on the right is the blown-up area in the white rectangle on the left, showing what looks like a branching, flowering organism. Image Credit: P. Knoll and O. Steinbock (Florida State University)

Anybody who saw these images could easily assume that they were organic. And the idea that they could be biological had to be examined. But now we know they're not biological; they're geological.

In a new study, a team of researchers took a deeper look into the microscopic organic-looking structures in ALH84001. Their goal was to understand the geological processes that created them and learn something new about Earth and Mars.

The paper's title is "Organic synthesis associated with serpentinization and carbonation on early Mars." The team published their paper in the journal Science, and the lead author is Andrew Steele. Steele is a Senior Staff Scientist at Carnegie University's Geophysical Laboratory.

Interactions between water and rock don't produce life directly. But those interactions are likely a precursor to habitability on both Earth and Mars. They produce organic molecules and create the mineralogical diversity necessary for life. The scientists who found evidence of life in the Alan Hills meteorite were incorrect, but they were onto something.

"The search for life on Mars is not just an attempt to answer the question 'Are we alone?'"

Andrew Steele, lead author, Carnegie University.

Now that the Perseverance Rover is on Mars, a deeper understanding of geological interactions is gaining importance. Perseverance is searching for fossilized evidence of life in the Jezero Crater. By understanding the geological interactions and the false positives they can create, scientists are better positioned to understand the evidence Perseverance gathers. The Alan Hills meteorite can play a role in this.

"Analyzing the origin of the meteorite's minerals can serve as a window to reveal both the geochemical processes occurring early in Earth's history and Mars' potential for habitability," Steele said in a press release. Steele has extensively researched organic material in Martian meteorites and is a member of both the Perseverance and Curiosity rovers' science teams.

Mars rovers have found organic compounds in ancient rocks on Mars. And both rovers and orbiters have detected methane, which can have a biological source. Organic compounds containing carbon, oxygen, hydrogen, nitrogen, sulphur, and other elements are associated with living processes. But non-biological processes can also produce them. Those processes are called abiotic organic chemistry. The Alan Hills meteorite contains organic carbon, and its presence poses a question: What process produced the organic carbon?

There are different hypothetical answers to that question, including volcanic activity, hydrological exposure, and impact events on Mars. Living processes are also a hypothetical answer. Ancient Martian life could've created them, or Earthly life post-impact.

The Allan Hills 84001 meteorite courtesy of NASA/JSC/ Stanford University.

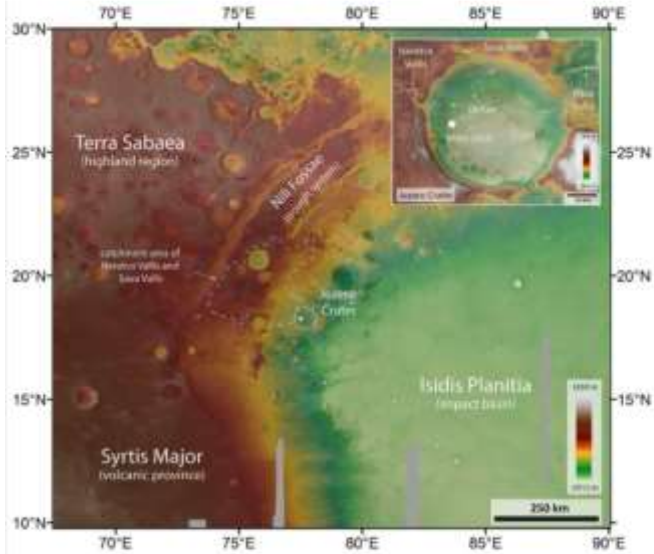
Scientists have new investigative techniques at their disposal now. One of them is nanoscale imaging. Nanoscale imaging wasn't available to researchers studying the Alan Hills meteorite in 1994, and recent breakthroughs have increased its power. In this new study, the researchers used nanoscale imaging along with spectroscopy and isotopic analysis to deepen their understanding of ALH84001. The team's evidence showed that the meteorite underwent two types of hydrological interactions.

One is called serpentinization, a name that brings organic activity to mind. But serpentinization is purely geochemical. It occurs when igneous rocks rich in iron or magnesium interact with low-temperature circulating water. Serpentinization produces hydrogen, and it also changes the mineralogy of the rocks. The rocks absorb large amounts of water, lowering their density and destroying their initial structure.

The second process is called carbonation. From Wikipedia: "Carbonation is the chemical reaction of carbon dioxide to give carbonates, bicarbonates, and carbonic acid." Carbonation is the reaction between rocks and slightly acidic water containing dissolved CO2.

The team's results show that these processes occurred rapidly in ALH84001. But they weren't able to determine if they occurred simultaneously or sequentially. From the paper: "We find complex refractory organic material associated with mineral assemblages that formed by mineral carbonation and serpentinization reactions. The organic molecules are colocated with nanophase magnetite; both formed in situ during water-rock interactions on Mars."

These reactions occurred about 3.9 to 4.1 billion years ago on Mars, during the Late Noachian period. The Late Noachian was a period of intense impacts on Mars, and the planet also likely had extensive surface water. It roughly coincides with the rise of Life on Earth. Surface geology from this time is prime hunting ground in the search for fossilized evidence of life. The Jezero Crater, where the Perseverance Rover is searching, dates from the Noachian period.



This image is a topographic map of the region around Jezero Crater, where the Perseverance Rover searches for fossilized evidence of ancient life. The terrain dates back to the Noachian Period when surface water was likely abundant. Image Credit: ESA/DLR/FU CC BY-SA 3.0 IGO

These new results are in line with other recent developments. A 2011 study showed that the carbonates in ALH84001 were formed during a period of surface water evaporation.

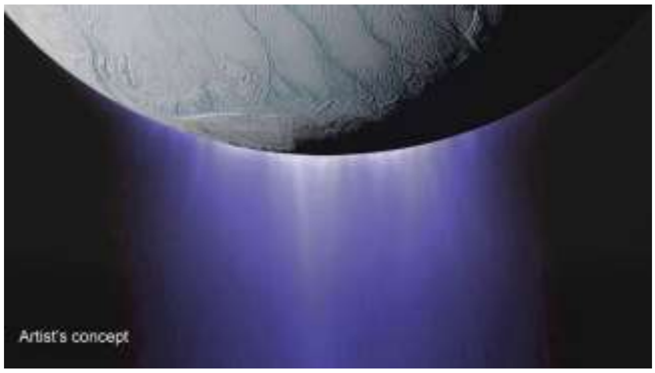
The mineralogical features caused by serpentinization and carbonation are rare in Martian meteorites. Orbital surveys of Mars found evidence of both processes on the planet's surface, and scientists have found carbonation in other Martian meteorites, all younger than ALH84001. But the Alan Hills meteorite is the first evidence of both processes occurring on ancient Mars.

Steele has found organic molecules in other Martian meteorites and on Mars with the SAM (Sample Acquisition at Mars) instrument on the Curiosity Rover. So scientists are reasonably sure that these abiotic processes have been at work on Mars for much of the planet's history.

Their presence indicates that Martian geology supplied some necessary materials for life to exist.

"These kinds of non-biological, geological reactions are responsible for a pool of organic carbon compounds from which life could have evolved and represent a background signal that must be taken into consideration when searching for evidence of past life on Mars," Steele concluded.

But the results extend beyond Mars. They tell us something about Earth, and maybe about Saturn's moon Enceladus.



This is an artist's impression of the plumes coming from Enceladus. The Cassini spacecraft detected complex macromolecular organic material in ice grains in the plumes. Image: NASA/JPL.

"Furthermore, if these reactions happened on ancient Mars, they must have happened on ancient Earth and could possibly explain the results we've seen from Saturn's moon Enceladus as well. All that is required for this type of organic synthesis is for a brine that contains dissolved carbon dioxide to percolate through igneous rocks. The search for life on Mars is not just an attempt to answer the question 'are we alone?' It also relates to early Earth environments and addresses the question of 'where did we come from?'"

Press Release: Martian Meteorite's Organic Materials Origin Not Biological, Formed By Geochemical Interactions Between Water And Rock

Nearby Supernovae Exploded Just a few Million Years Ago, Leading to a Wave of Star Formation Around the Sun

The Sun isn't the only star in this galactic neighbourhood. Other stars also call this neighbourhood home. But what's the neighbourhood's history? What triggered the birth of all those stars?

A team of astronomers say they've pieced the history together and identified the trigger: a series of supernovae explosions that began about 14 million years ago.

A series of stars in our neighbourhood exploded as supernovae starting about 14 million years ago. They created a vast bubble of gas about 1,000 light-years across called the Local Bubble. In the middle of that void sits the Sun. The Sun's neighbours formed on the edge of that bubble, and the preceding supernova explosions were the catalyst for their formation.

A new study published in the journal Nature presents the findings. The title is "Star formation near the Sun is driven by expansion of the Local Bubble." Catherine Zucker is the lead author and she's an astronomer and data visualization expert.

"We've calculated that about 15 supernovae have gone off over millions of years to form the Local Bubble that we see today."

Catherine Zucker, lead author, NASA Hubble Fellow at STScI.

Stars form from clouds of hydrogen gas called Giant Molecular Clouds (GMC.) For a star to form, enough of the gas has to gather in one spot. This happens when the density of the gas varies. Due to gravity, density begets more density, and if enough time passes and if conditions are right, sufficient gas clumps together to trigger fusion, and a star is born.

But stars can also form when supernovae explode. Supernova explosions release a tremendous amount of energy, and that energy travels outward in a shockwave. The shockwave pushes gas together into clouds and creates greater density. That can lead to new stars.

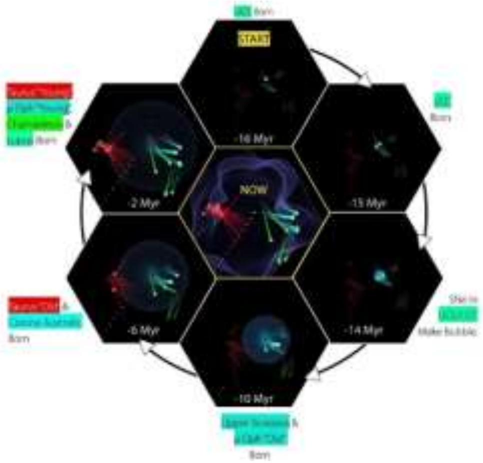
That's what happened in our neighbourhood, and it formed stars on the edge of the Local Bubble, which is also the edge of supernova shockwaves. Inside the Local Bubble, the density of the Interstellar Medium (ISM) is much lower than the density of the ISM throughout the Milky Way. The series of supernovae explosions pushed the gas aside, forming the edge of the bubble of dense ISM and driving star formation there.

"This is an incredible detective story, driven by both data and theory."

Alyssa Goodman, study co-author, CfA Professor.

The edge of the bubble has fragmented and collapsed over time into star-forming clouds. Its once-smooth edge is gone. The team reports that there are seven star-forming regions on the bubble's surface in the form of molecular clouds. These include Orion A and Orion B, both prominent parts of the Orion Molecular Cloud Complex. "Remarkably, we find that every well-known molecular cloud within ~200 pc of the Sun lies on the surface of the Local Bubble," the paper says. The exception might be the Perseus Molecular Cloud.

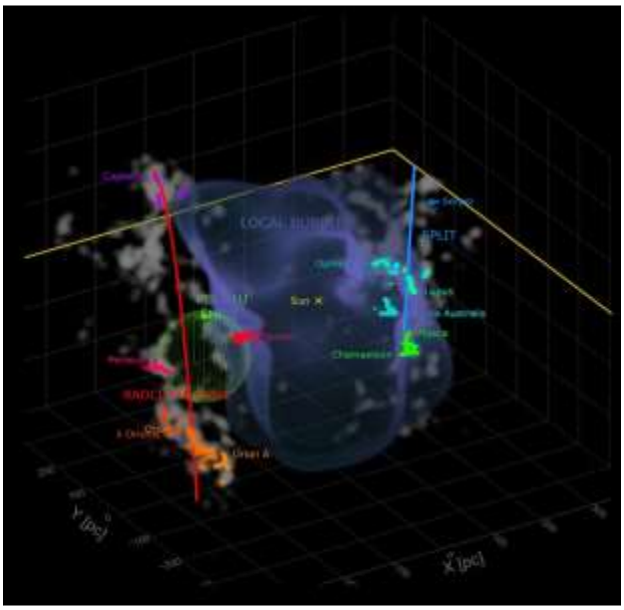
The star formation didn't happen all at once. In their paper, the authors point out that it happened in four distinct epochs: 10 Myr ago, 6 Myr ago, 4 Myr ago, and in the present age. They don't know exactly how many supernovae exploded to create the bubble, but they've constrained it between 8 and 26, settling on 15 as the most likely number. "We've calculated that about 15 supernovae have gone off over millions of years to form the Local Bubble that we see today," said Zucker, who is now a NASA Hubble Fellow at STScI.



This figure shows the evolution of the Local Bubble and sequential star formation at the surface of its expanding shell. Selected time snapshots (seen from a top-down projection) are shown here. The central figure shows the present day. Stellar cluster tracebacks are shown with the coloured paths. Prior to the cluster birth, the tracebacks are shown as unfilled circles meant to guide the eye, since the modelling is insensitive to the dynamics of the gas before its conversion into stars. After the cluster birth, the tracebacks are shown with filled circles and terminate in a large dot, which marks the cluster's current position. For time snapshots ? 14 Myr ago, we overlay a model for the evolution of the Local Bubble (purple sphere). The solar orbit is shown in yellow dots and indicates that the Sun entered the Local Bubble approximately 5 Myr ago. Image Credit: Zucker et al 2022.

"This is really an origin story; for the first time we can explain how all nearby star formation began," said Zucker, who completed the work during a fellowship at the CfA.

Zucker is a data visualization specialist, and visualizations are prominent in the study. Zucker and her colleagues created an interactive tool to explore the Local Bubble and its surroundings.



This is a static screen grab of the interactive tool Zucker and her colleagues created. Image Credit: Zucker et al 2022.

Universe Today readers might recognize some of the stars on the edge of the Local Bubble. For example, the red supergiant Antares is the brightest and most massive star in the Sco-Cen (Scorpius-Centaurus) association. Antares is the 15th brightest star in the sky, and one of the largest stars visible with the naked eye.

Zucker and her colleagues also created a video explaining their work.

This video describes new research linking an interstellar void known as the Local Bubble to nearby star-forming regions.

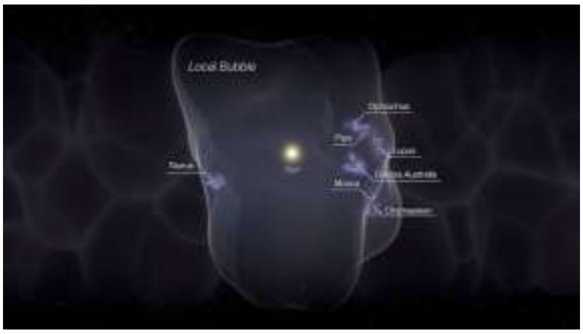
The Local Bubble isn't a static object: it's still slowly growing, like a car after you take your foot off the gas. "It's coasting along at about 4 miles per second," Zucker said. "It has lost most of its oomph though and has pretty much plateaued in terms of speed."

Like many other discoveries about our neighbourhood in the Milky Way, this work leaned heavily on the data from the ESA's Gaia spacecraft. Gaia created an ambitious 3D model of our galaxy based on the position and velocity measurements of about one billion stars.

The team traced back the motions of stars to paint a picture of the bubble's formation. "The clear implication of the observed geometry and motions is that all the well-known star-forming regions within 200 pc of the Sun formed as gas has been swept up by the Local Bubble's expansion," they explain in their paper.

"This is an incredible detective story, driven by both data and theory," said Harvard professor and Center for Astrophysics astronomer Alyssa Goodman, a study co-author and founder of glue, data visualization software that enabled the discovery. "We can piece together the history of star formation around us using a wide variety of independent clues: supernova models, stellar motions and exquisite new 3D maps of the material surrounding the Local Bubble."

The Sun is in the middle of the Local Bubble, but it hasn't always been. As Sol travelled through space, it entered the bubble. Now we find ourselves in the middle of it, where we've been since the dawn of humanity.

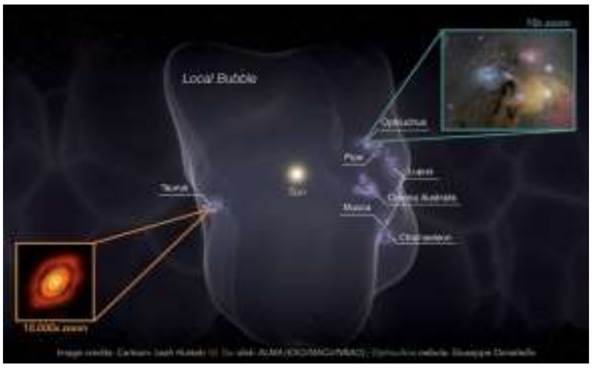


This is an artist's illustration of the Local Bubble with star formation occurring on the bubble's surface. Scientists have now shown how a chain of events beginning 14 million years ago with a set of powerful supernovae led to the creation of the vast bubble, responsible for the formation of all young stars within 500 light-years of the Sun and Earth. Credit: Leah Hustak (STScI).

"When the first supernovae that created the Local Bubble went off, our Sun was far away from the action," says co-author João Alves, a professor at the University of Vienna. "But about five million years ago, the Sun's path through the galaxy took it right into the bubble, and now the Sun sits — just by luck — almost right in the bubble's center."

What does it mean that we find ourselves right in the center of a bubble? That's statistically unlikely, so it implies that bubbles are not uncommon. In fact, astronomers have theorized for 50 years that these bubbles exist. "Now, we have proof — and what are the chances that we are right smack in the middle of one of these things?" asks Goodman.

What happened to all the supernovae after they exploded? When supernovae explode, the star isn't completely destroyed. They leave behind remnants. In their paper, the authors say the survivors of all these supernovae are likely contained in the Upper Centaurus Lupus (UCL) and Lower Centaurus Crux (LCC) clusters. "We find that 15-16 Myr ago, the Upper Centaurus Lupus (UCL) and Lower Centaurus Crux (LCC) clusters in the Sco-Cen stellar association were born about 15 pc apart and that the Bubble itself was likely created by supernovae whose surviving members belong to these clusters."



If we zoomed in on famous star-forming regions on the surface of the Local Bubble, what would we see? The two inset images (one of HL Tau, the other of the Ophiuchus nebula) show what astronomers call "plane of the sky" images, in that they are necessarily 2D projections taken from our vantage point near the Sun on Earth. If an astronomer on Earth looked in the direction of the Taurus star-forming region, with ALMA, they would see HL Tau (200 AU in size) if they zoomed in 10,000 times compared to the typical scale of the Taurus cloud. If an astronomer on Earth looked toward Ophiuchus (with a wide-field-of-view telescope on the ground) and zoomed in 10x compared to the typical size of the Ophiuchus cloud, they would see the beautiful Ophiuchus nebula. Image Credit: Leah Hustak, ALMA, Giuseppe Donatiello.

The discovery implies that the Milky Way has a sort of swiss-cheese morphology, where bubbles of thin ISM are pervasive. Now that the team of researchers has found one bubble they want to find more. Will our Local Bubble be special somehow? Or will it be run-of-the-mill?

There are other questions waiting to be addressed, too. "Where do these bubbles touch?" Zucker asked in a press release. "How do they interact with each other? How do superbubbles drive the birth of stars like our Sun in the Milky Way?"

To answer those questions, the team will have to wait for Gaia's third data release (Gaia DR3.) The ESA released some of that data already, but not all of it.

The team ends their paper with a look to the future. "The abundance of new stellar radial velocity data expected in Gaia DR3 should not only allow for more refined estimates of the Local Bubble's evolution but also enable similar studies farther afield, providing further observational constraints on supernova-driven star formation across our Galactic neighbourhood."

More:

Press Release: 1,000-Light-Year Wide Bubble Surrounding Earth is Source of All Nearby, Young Stars

Paper: Star formation near the Sun is driven by expansion of the Local Bubble

Nancy Grace Roman Telescope Will do its Own, Wide-Angle Version of the Hubble Deep Field

Remember the Hubble Space Telescope's Deep Field and Ultra-Deep Field images?

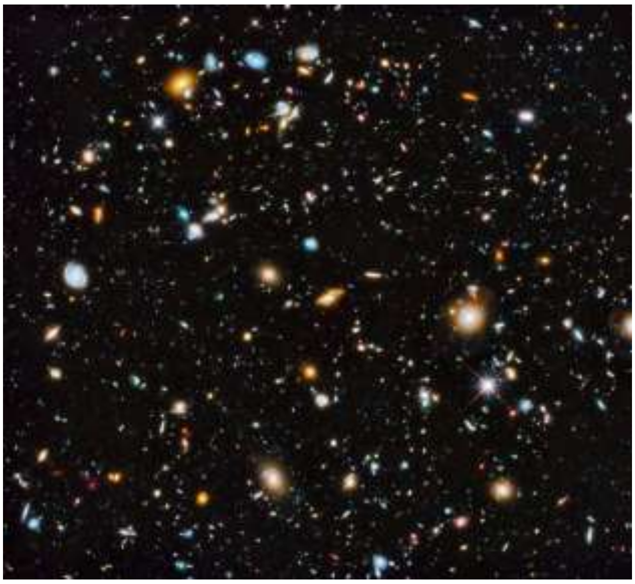
Those images showed everyone that what appears to be a tiny, empty part of the sky contains thousands of galaxies, some dating back to the Universe's early days. Each of those galaxies can have hundreds of billions of stars. These early galaxies formed only a few hundred million years after the Big Bang. The images inspired awe in the human minds that took the time to understand them. And they're part of history now.

The upcoming Nancy Grace Roman Space Telescope (NGRST) will capture its own version of those historical images but in wide-angle. To whet our appetites for the NGRST's image, a group of astrophysicists have created a simulation to show us what it'll look like.

The NGRST's previous name was WFIRST. That stands for Wide-Field Infrared Survey Telescope. NGRST will launch in the latter half of 2027 if everything goes according to plan. The Hubble launched in 1990, so there are almost 35 years between the two. Technology has progressed enormously in those intervening years, so the NGRST will be much more powerful and effective than the Hubble in many respects.

The Hubble Deep Field (HDF) and Hubble Ultra Deep Field (HUDF) images were mosaics of individual images. Hubble took 10 days in December 1995 to capture the 342 images comprising the Deep Field. The Ultra Deep Field was made of even more images captured with multiple instruments on the Hubble. Both images required painstaking efforts, with detailed planning and execution. The images took hundreds of hours to capture.

And they were worth it.

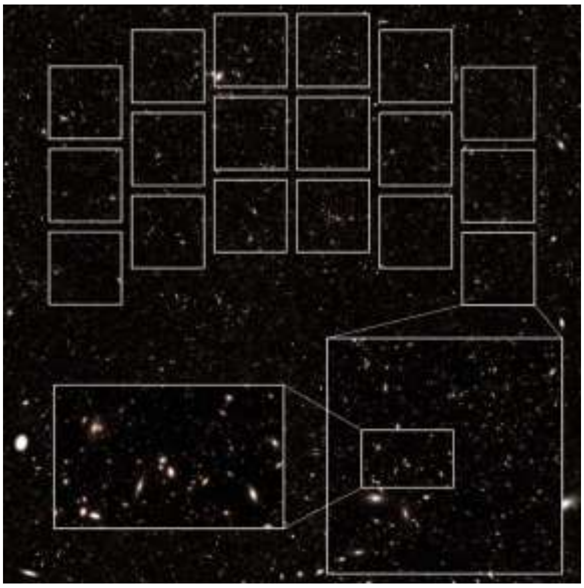


This image shows the Hubble Ultra Deep Field in ultraviolet, visible, and infrared light. Image Credit: NASA, ESA, H. Teplitz and M. Rafelski (IPAC/Caltech), A. Koekemoer (STScI), R. Windhorst (Arizona State University), and Z. Levay (STScI)

The NGRST is different than the Hubble in many ways. The main difference is the Roman's field of view (FOV.) The NGRST has a FOV 100 times larger than the Hubble's. That wider FOV is typical of survey telescopes. Survey telescopes image large swathes of the sky at once rather than individual targets. The Hubble has the Wide Field Camera 3 and the Advanced Camera for Surveys, but the Nancy Roman is superior to both of them. While Hubble's Ultra-Deep Field contains thousands of galaxies—up to 10,000 or more—the NGRST's deep field image will contain millions of galaxies, possibly up to 10 million. The Roman's strength lies in observing large sky areas at once. And when it eventually gets to work later this decade, its Ultra-Deep Field images will be extraordinary. This new simulated image will not only whet our appetites as astronomy "fans," it's part of a new study.

The study's title is "Deep Realistic Extragalactic Model (DREaM) Galaxy Catalogs: Predictions for a Roman Ultra-Deep Field." The lead author is Nicole Drakos, a postdoctoral scholar at the University of California, Santa Cruz. The Astrophysical Journal will publish the study.

"Roman has the unique ability to image very large areas of the sky, which allows us to see the environments around galaxies in the early universe," said Drakos in a press release. "Our study helps demonstrate what a Roman ultra-deep field could tell us about the universe while providing a tool for the scientific community to extract the most value from such a program."

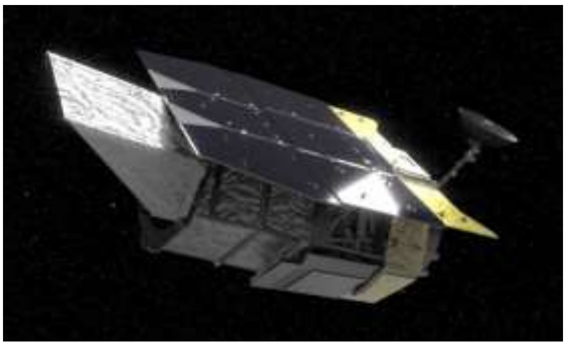


This synthetic image visualizes what a Roman ultra-deep field could look like. The 18 squares at the top of this image outline the area Roman can see in a single observation, known as its footprint. The inset at the lower-right zooms into one of the squares of Roman's footprint, and the inset at the lower-left zooms in even further. The image, which contains more than 10 million galaxies, was constructed from a simulation that produced a realistic distribution of the galaxies in the universe. Image Credit: Nicole Drakos, Bruno Villasenor, Brant Robertson, Ryan Hausen, Mark Dickinson, Henry Ferguson, Steven Furlanetto, Jenny Greene, Piero Madau, Alice Shapley, Daniel Stark, Risa Wechsler

It's a mistake to focus on just the size of the images and how many galaxies they contain. It's not a contest. It's the information about the Universe that's the intriguing part.

"The Hubble Ultra Deep Field gave us a glimpse of the universe's youth, but it was too small to reveal much information about what the cosmos was really like back then as a whole," said Brant Robertson, an astronomy professor at the University of California Santa Cruz and a co-author of the study. "It's like looking at a single piece of a 10,000-piece puzzle. Roman could give us 100 connected puzzle pieces, offering a much better picture of what the early universe was like and opening up new scientific opportunities."

The team behind the simulated image also created a website with a zoomable image to explore.



NASA released this rendering of the Nancy Grace Roman Telescope in May 2020. Image Credit: By NASA (WFIRST Project and Dominic Benford) – Adapted from https://www.nasa.gov/press-release/nasa-to-make-announcementabout-wfirst-space-telescope-mission, Public Domain, https://commons.wikimedia.org/w/index.php?curid=90474189

Camera owners know they have to choose between a wide-angle lens that captures wider FOV or a narrower angle lens to focus on individual subjects. A similar thing happens in astronomy. Powerful telescopes can capture deeper, more detailed images, requiring longer exposures. That's how the Hubble captured its DF and UDF images. That's not always easy to achieve because observing time at the world's observatories is a highly-coveted commodity.

But the Roman telescope is different.

Its enormously broad field of view, combined with its infrared capabilities, helps skirt around this problem.

The result of all this power will be an image that contains millions of galaxies of all ages. It'll show young, small galaxies just starting to form stars. Those galaxies are of great interest to astronomers, as is everything about the early Universe. Astronomers will compare these youngsters to more massive, modern galaxies that hardly form any new stars and learn about galaxy evolution from the comparison.

There are huge blank spots in our knowledge of galactic evolution, and the NGRST's wide-field power will show galaxies in their environments. Researchers will probe the galaxies and their surroundings to see how they affect galactic evolution and star formation.

One exciting part of this concerns the massive galaxies that no longer have much active star formation. They're called quiescent galaxies, and they're hard to find the further back in time astronomers search for them. "We're not sure whether we haven't detected very distant quiescent galaxies because they don't exist or simply because they're so difficult to find," Drakos said.

But Drakos and the other authors of the paper think that the Roman Telescope could change that. They're hopeful that they can find up to 100,000 of these quiescent galaxies and that some of them will be the furthest ever seen.

"It's amazing to think that no one knew for sure whether other galaxies existed until about a hundred years ago."

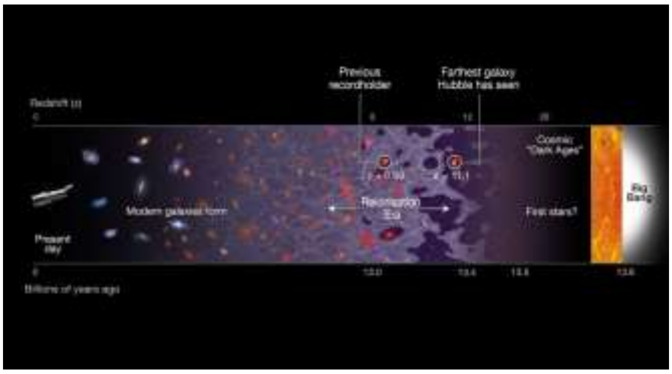
Bruno Villasenor, U of C Santa Cruz, study co-author.

The NGRST should also help astronomers address another burning question in astronomy concerning the Epoch of Reionization (EoR.)

After the Big Bang, the Universe was dense hot plasma, which was opaque to light. Astronomers sometimes refer to this early time in the Universe as the "Cosmic Dark Ages." As the Universe expanded and cooled, those dark ages ended. The EoR followed between 600 million and 900 million years after the Big Bang. Neutral hydrogen atoms could form now, and galaxies and quasars began to form during the EoR. There was light, and the dark ages ended.

Probing the Universe's early days is difficult. But astronomers think that ionizing radiation from the early galaxies caused the EoR and brought the dark ages to an end. Here's where the Roman telescope comes in.

If, like the authors of this paper predict, the NGRST can find up to 10,000 of these early galaxies and study them in their environments, they may be able to determine if early galaxies ionized the Universe and ended the dark ages.



This illustration shows the timeline of the Universe. Credit: NASA, ESA, and A. Feild (STScI)

"The EoR is the final frontier for galaxy surveys," the authors write in their paper. "Given the difficulty in measuring galaxies at high redshifts, this period in the universe's history is remarkably unconstrained. High-redshift low-mass galaxies were likely the major source of the ionizing photons in the EoR, and observations indicate that reionization was a "patchy" process. To fully understand the EoR, we need a complete census of galaxies and their ionizing photon contribution."

The Roman is so powerful that it may address the EoR problem quickly.

"Roman could shine a light on so many cosmic mysteries in just a few hundred hours of observing time," said Bruno Villasenor, a graduate student at the University of California Santa Cruz and a co-author of the study. "It's amazing to think that no one knew for sure whether other galaxies existed until about a hundred years ago. Now, Roman offers us the opportunity to observe thousands of the first galaxies that appeared in the very early universe!"

The NGRST won't be alone in addressing the dark ages and the EoR. The James Webb Space Telescope is on its way to its LaGrange Point, and it looks like the telescope's sun shields and mirrors have deployed successfully. Its infrared observing power will probe the early Universe and the EoR, so by the time the NGRST is operational, this early period in the Universe's history might be more tightly constrained.

However it ends up happening, it looks like we're about to make progress on one of cosmology's most pressing questions.

But we can also take a step back from all that in-depth science. We can simply enjoy the images from the Roman telescope. Hopefully, they'll ignite our sense of wonder.

Just like the Hubble did.

More:

Press Release: Simulated Image Shows How NASA's Roman Could Expand on Hubble's Deepest View

E Mails Viewings Logs and Images from Members.

Viewing Log for 5th of January

Wednesday evenings is normally my Chess time but as the Moon would be setting by 19:30 and the sky was clear, I thought I would have a viewing session instead astronomy beats Chess every time!

I got to my usual viewing place at Uffcott just off of the A4361 south of Swindon and had my Meade LX90 set up and ready to go by 19:50, I would be using a Delos 14 mm eye piece giving a magnification of about 143? With no wind and a temperature of 1 °C it should be good for viewing deep sky objects? While setting up I had the first car go past me so my eye sight was not really affected by it, just a case of turning away from the lights and closing my eyes until it has moved on. First object for the evening had to be Jupiter as it was getting very low on the western horizon. I could not make out the weather belts on the planet and could just make out one moon on either side of the gas giant planet, this was probably Calisto out to the east and Europa out to the west, and the other two moons were fairly close to Jupiter at that time. Next stop was Uranus, as usual, it was not in the eyepiece but within the finderscope, so had to do some adjusting to find this planet, there was a hint of blue coming from the planet. As for Neptune, the usual, could not find it at all!

So for a change, I thought I would let the hand controller decided what to look at this evening, there is a programme called 'Tonight's Best'. Only time will tell where it will take me? First object was Messier (M) 42 & 43, probably the best object to look at in the winter sky? This was brilliant as usual and the dust lanes showed up well, having no moon around does help! On to the first star for the evening and Mira, a red giant variable object. The hand controller in its information pack told me this star goes between magnitude (mag) 3 to 9 over a period of 331 days, having a guess I would have put it around mag 5 currently? Next object was the Double Cluster in Perseus, aka Caldwell (C) 14, both are large bright open clusters (O C) better seen with the finder scope than the current eye piece I was using. Having an attitude of 80 ° at time of viewing they would probably look their best with the lack of atmosphere for the light to go thru? On to Vega which was hiding in the nearby hedge, thru the finder scope all I could see was a large branch, with the eye piece there was a beam of light coming out either side of the star like from a lighthouse, too far down to view really! Climbing much higher in the sky and in the other direction we went off to M 45, the Pleiades in Taurus, looked very good in the finder scope, bright and clear. All I saw in the eye piece was the odd star, too much power for this object. Off to Orion and Betelgeuse, nice and bright shining at 0.5 mag, not far away is Aldebaran another giant red star and shining at 0.8 mag (13th brightest star in the night sky), this also was nice and bright to look at. Yet another star and Castor in Gemini, this blue/white double star (as seen with the eyepiece) is actually a 6 star system (according to the hand controller). Now back to the O C of Hyades (been in this part of the sky recently?), also called C 41. This O C is better seen with one's own eyes, too big even for the finder scope being 330' wide! Another large O C too big for the eyepiece was M 44, the Beehive cluster, large and dim in the finder scope, eyepiece only showed the odd star. Off to Auriga and M 37 a large and dense O C, probably the best O C in this constellation? Another two cars went past me within a couple of minutes while viewing this object. Not far away is M 38, another large but not as dense O C as M 37. Back into Perseus and M 34, a large and loose O C, surprised the hand controller did not do M 36 as it is right next door first? But to my surprise we did go off to M 36 next, a large and slightly dense O C. M 35 was next, this large and dense O C is in Gemini. Another car went past me which was the last for the evening, as usual keeping my eyes closed and turning away from the lights, my night vision was not too affected. Next object was Deneb, for some reason the light was being distorted in the eyepiece, strange? I noticed some dew on the eyepiece, so I changed over to the Pentax WX 14 mm eyepiece, now the star was clear and bright! M 82 was the next target in Ursa Major, this spiral galaxy (S G) is long and thin with a bright core. In the other direction we went off to M 79 in Lupus, this globular cluster is a bit of an oddball as there are not many glob's in this part of the sky, mainly summer visitors? This had a bright core but was small to look at, this is also a hard Messier object to see from Uffcott, does not climb that high and I have a hedge to deal with, tonight it was 12 ° high. The Andromeda galaxy or M 31 was the next object to look at, this S G is very large and has a bright core. Final object on the list (for the evening) was M 52 in Cassiopeia, a small and compact O C.

Time to do some of my own choices starting with M 41, a large and sparse O C, 4 ° below Sirius. Back into Orion and M 78, could make out the two main stars in this emission nebula and could make out some parts of the nebula, conditions must be good? Onto M 50 which is about a third of the way from Sirius to Procyon (line of sight), this O C is large with a compact centre. C 50, aka NGC 2244 or the Rosetta nebula is a very large and loose O C, final object for the evening was NGC 2261 or C 46 aka the Hubble's Variable nebula, this object was a faint fuzzy blob to look at.

Now 21:52 and with a nice coating of frost on the telescope (currently 0 °C) it was time to put everything away and go home for a hot drink, while at home everything used that night would have to be air dried before being stored away correctly.

Clear skies.

Peter Chappell

PS. Cannot understand why the hand controller took me all around the sky instead of starting in the west and going eastwards, poor old motors in the telescope had some work this evening!

Wiltshire AS monthly viewing session log for 7th January 2022

With the poor weather we had in early December going on until the end of the month, Chris Brooks decided to change the viewing session until the 7th of January, good thinking Chris!

Earlier in the day there was a lot of cloud, even at 16:00 there was total cloud cover but we were told by the weather people, the skies 'should' clear in the evening? Coming around to 18:15, the skies had actually started to break up and I could make out Jupiter shining in the western sky. What to take with me? Last time I just took my grab and go equipment as there might have been a chance of some rain but this time I decided I would take GOTO equipment.

I was the first to arrive at 19:00, first thing I did was to get my step ladder out of the car and cover the sensor for the security light, hopefully this would give us some darkness from lights around the area? By the time I had my Meade LX90 with Pentax 14mm WX eye piece set up and ready, I had been joined by Chris, it was now 19:13 with no wind and a temperature of 2° C, the Moon was in waxing crescent stage which I could look at any time I liked. First object of the evening had to be Jupiter as it was now getting quite low in the western sky. I could not make out the weather bands but noticed two moons out to the east (Calisto and Europa) with Ganymede out to the west, Io was behind the giant planet in eclipse? Off to Uranus, as usual it was not in the eye piece but in the finderscope, so I had to do some adjusting to get the seventh planet from the Sun into view, I thought it looked slightly greenish? By now we had been joined by four other people so we had some company for the evening. I started off with Messier (M) 42, the great Orion nebula, as usual this star forming factory was brilliant to look at? As my last viewing session had covered a lot of the winter objects I thought I would head back to the summer/autumn constellations and see what could be found. First object was M27, the Dumbbell nebula in Vulpecula, this object was a grey blob to look at which came and went, strange? Looking in the general direction I noticed a cloud bank rolling in! A bit higher in the sky was Cygnus, had a look at the open cluster (O C) of M29, it was okay to look at, this cloud was now starting to become a problem? Even higher in the sky is M39, this O C I was looking thru the object with the eye piece, really need lower eye piece for this object? Around to Ursa Major and M81, could make out a bright core in this spiral galaxy, no such luck with its neighbour in M82, cloud had now covered this object! By now it was a case of what parts of the sky were clear, quick look at M37 in Auriga, a large and dense O C before that object got filtered out. Only thing on view was M42, so slew around to this object again and have another look. After that, I could see no stars, so it was time to look at the Moon, this was shining thru some cloud so should not need a filter to view this object, the terminator was about halfway across Mare Tranquillitatis, crater Pitiscus (83 kms in diameter) and Hommel (126 kms in diameter) had just cleared the terminator near the South Pole, to the north, the crater Democritus (40 kms in diameter) was also in sunlight.

By 20:33 with only Chris and me around we decided to pack up as the cloud was now 100% cover, not even the Moon was on view! It was nice to get out and do some viewing as in December, I did not do one viewing session after doing four back in November.

Clear skies.

Peter Chappell

<u>Viewing Log for 29th of January</u>

We left Barnsley in South Yorkshire just after 13:00 with a brilliant clear sky and a very strong wind to keep us company! Clear sky would be great for astronomy but the strong wind would stop me as the telescope would bounce all over the place and anything I was viewing would not be stable? By the time we got back to Swindon (around 16:50), the sky was still clear and the wind had dropped a lot, I would make a final decision around 18:30 ish. At this time I went outside to still a clear sky and no wind at all, time to get ready for a session me thinks.

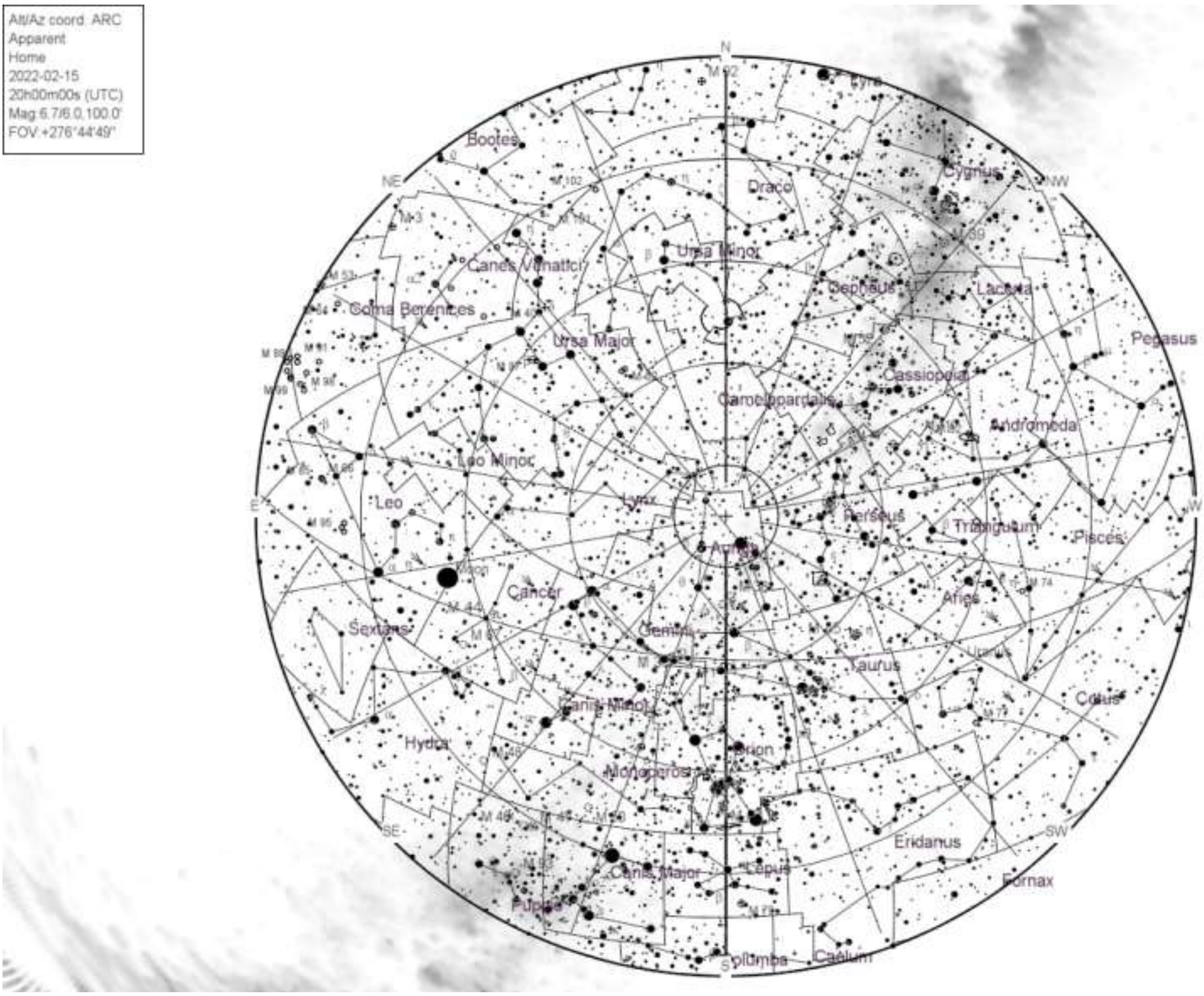
I arrived at my usual viewing spot near Uffcott and had my Meade LX90 set up and ready by 19:32, this time I would be using my Delos 17.3 mm eyepiece for a change, normally I use the 14 mm one. With a temperature of 6 °C and as said before, no wind it should be a reasonable evening. Not having viewed on a Saturday evening in several years (recently changed my shift to Sunday instead) I had no idea what traffic to expect to go past me. Had a pleasant surprise the hedge had been cut, so I could go a bit lower for viewing objects if needed. While doing the star set up I heard something hit the floor, I had left the spirit level on top of the telescope, doh! First object was Uranus, as usual it was not in the eye piece but in the finderscope, so I had to do some manual adjusting to get the seventh planet in the eyepiece, could make out a hint of blue and nothing else. Neptune was too low for viewing by now, only 8 ° above the horizon? For a change I thought I would have a good look at the constellation of Orion instead of the usual scan across the sky? There is a programme in the hand controller for constellations, so I be interested what it tells me and where it goes. First object was the star Betelgeuse, this red super giant has a magnitude (Mag) of 0.5 and is part of a five star system and a distance of 562 light years (L Y) from us. Rigel is actually the brightest star in the constellation (0.1 Mag) but is the Beta star with Betelgeuse being the Alpha star. This is a blue giant and is 250.7 L Y from us. Next was Bellatrix (Gamma), another blue star shining at 1.6 Mag and 112.5 L Y away. Onto Mintaka, the western most star in the belt, shining at 2.2 Mag and 232.8 L Y away, Alnilam, the middle star in the belt shines at 1.7 Mag and is 1630 L Y away. Next object was Zeta which is close to Alnitak, the eastern most star in the belt but was not mentioned in this tour (strange?), anyway Zeta shines at Mag 4.2 and is also another blue star and is 135.8 L Y from us. Nair Al Saif (Iota) is a star I have not heard of and is close to M 42, this star is an O giant which shines at 2.7 Mag and is 130.5 L Y away. Eta is another blue giant which shines at 3.3 Mag and is 465.7 L Y away. Final object in the constellation was Saiph (Kappa), another blue star which shines at 2.0 Mag and is 217.3 L Y away. Only objects on the data base were stars and NO deep sky objects? So now I would have a look at my sky atlas I brought out with me for objects to look at. Started with Messier (M) 42, as usual this was brilliant with the eyepiece, the dust lanes showed up well, even the trapezium stars were clear, maybe using a slightly lower power eyepiece helps with this object? Next door is M 43, a large grey blob to look at shining at 6.9 Mag it can be over looked with the brighter M 42 shining at 2.9 Mag. Even M 78 which is just above the eastern most belt star looked pretty good, as usual I could make out the two main stars in this Emission and Reflection nebula and for a change some grey around the stars. Now it would be a case of looking at the charts and picking something out. Started with NGC 1999, could not make anything out, this is a Diffused nebula which shines at Mag 20! This would also be the same answer with NGC 1788 and 2071. The open cluster (O C) NGC 1981 is very loose and sparse to look at? The Flame nebula (NGC 2024) I could make out, just with adverted vision, helps to put the star Alnitak out of view as it actually blinds the area with its brightness? With Orion finished I went south to M 79 in Lepus, this globular cluster is an odd ball, not many Glob's are in this area of the sky? This time it had a bright but small core. The first two cars went past me while I was viewing this object. With the hedge cut down I wondered how low I could view. Saw the star Furud in the atlas at – 30 ° declination (Dec), this star is well below Sirius in Canis Major. I slewed the telescope to this object, being a Mag 3 star it showed up well, so hopefully I might be able to pick up M 6 (lowest object in Messier list) at – 32 ° Dec later in the year? Some of the lesser Messier objects I look at are the O C's to the east of Sirius, so I started with M 41 which is just below Sirius. This is a large and loose O C, further east is M 46 and 47 (close together). Starting with M 47, a large and loose O C with some bright stars within this cluster. Another car just went past me. M 46 is large and much denser but dimmer to look at, the Planetary nebula NGC 2438 is in the cluster but I could not locate it? M 48 between Sirius and Procyon is very large and loose O C to look at. Another two cars went past me, starting to get a bit busy now! Onto M 50, a large O C which has a dense centre. Found the Cone Nebula (NGC 2264) in the atlas, so off I went to this object, this object is actually a star cluster which looks like a Christmas Tree and a dark nebula, managed to make out the tree and some of the nebula? NGC 2261 (Caldwell (C) 46) or Hubble's Variable Nebula was a fuzzy blob to look at. Final object for the evening was C 49 or NGC 2237, the Rosette Nebula, could make out the O C and some nebula this time.

The time was now 21:39 and some thin cloud had rolled in, so it was time to pack up and go home, the temperature had only dropped to 5 °C (yet in the morning there would be a ground frost) and very little dew on the gear used.

Clear skies.

Peter Chappell

Thank you Peter



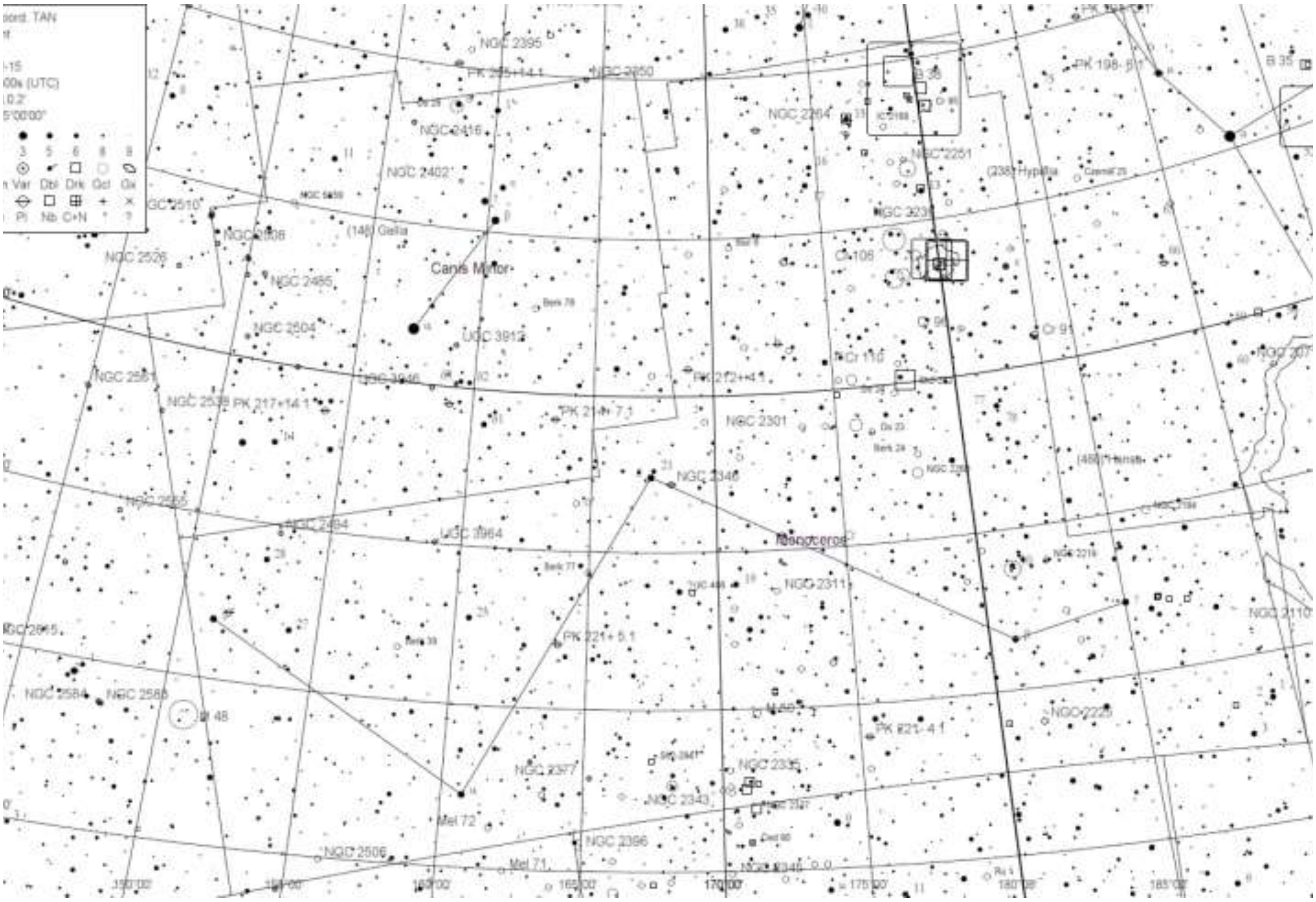
February 1 - **New Moon.** The Moon will located on the same side of the Earth as the Sun and will not be visible in the night sky. This phase occurs at 05:48 UTC. This is the best time of the month to observe faint objects such as galaxies and star clusters because there is no moonlight to interfere.

February 16 - **Full Moon.** The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This phase occurs at 16:59 UTC. This full moon was known by early Native American tribes as the Snow Moon because the heaviest snows usually fell during this time of the year. Since hunting is difficult, this moon has also been known by some tribes as the Hunger Moon, since the harsh weather made hunting difficult.

February 16 - **Mercury at Greatest Western Elongation.** The planet Mercury reaches greatest western elongation of 26.3 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 morning sky. Look for the planet low in the eastern sky just before sunrise.

March 2 - **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 17:38 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

CONSTELLATIONS OF THE MONTH: MONOCEROUS



Monoceros

The constellation of Monoceros was originally charted on a work done by Petrus Plancius in the early 1600s for its biblical references, but its first historical reference appears in Jakob Bartsch's star charts created of 1624 where it was listed as Unicornu. There is also a possibility, according to Heinrich Wilhelm Olbers and Ludwig Ideler's work with older astrological charts, that Monoceros could have been referred to as "the Second Horse" – while historian Joseph Justus Scaliger also makes reference to it in his (mid 1500s) work with Persian astrological records. Regards of its origins, Monoceros was adopted as one of the 88 modern constellations by the International Astronomical Union in 1930 and remains on the charts today. It is a relatively dim constellation that consists of 4 main stars in its primary asterism and contains 32 Bayer Flamsteed designated stars within its confines. Monoceros spans approximately 482 square degrees of sky and is bordered by the constellations of Canis Minor, Gemini, Hydra, Lepus, Orion and Puppis. It is visible to all observers located at latitudes between +75° and ?85° and is best seen at culmination during the month of February.

There is one annual meteor shower associated with Monoceros which peaks on or about December 10 of each year – the Monocerids: The radiant for this meteor shower occurs near the border of Gemini and averages about 12 meteors per hour at maximum fall rate. It is best viewed when there is little to no Moon to interfere with the faint streaks and activity is at its most when the constellation reaches the zenith.

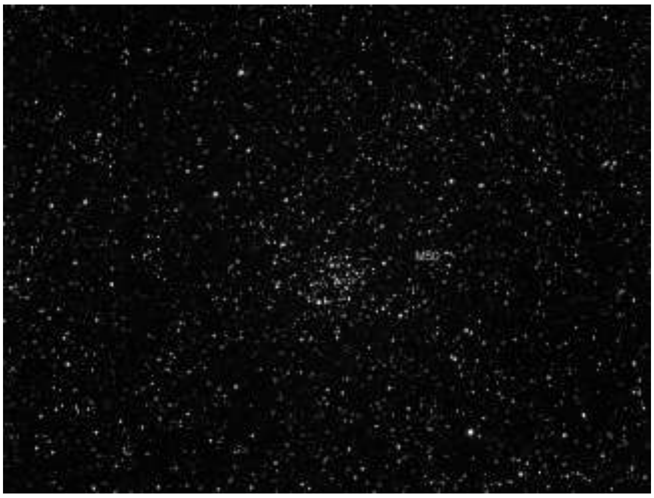
Because Monoceros is a relatively "new" constellation, there isn't any mythology associated with it – but the Unicorn itself has a long history of mystery. You'll not find this creature mention anywhere in mythology, but everywhere else! The unicorn is mention in the Bible, in accounts of natural history, in Chinese lore, Ethiopian artwork, medieval stories and religious art. It is depicted as a one-horned horse, thought to have existed somewhere at the edge of the known Earth.. and it still exists roaming the edges of the celestial sphere just between the northern and southern ecliptic plane. Fable or folklore? No matter which, it's filled with many great and starry delights!

Let's begin our binocular tour of Monoceros with its primary star – Alpha Monocerotis – the "a" symbol on our map. Hanging out in space some 144 light years from Earth, it's not the brightest star in the constellation, nor is it particular special. Alpha is just another orange/yellow helium-fusing giant star, not a whole lot different than ours. Averaging about 11 times larger than our Sun and putting out about 60 times more light, Alpha's hydrogen fuel tank went to empty about 250 million years ago. Now it just waits quiety, waiting for its helium shell to fade away… ready to spend the rest of its life as just another dense white dwarf star.

Now, take a look at Beta Monocerotis – the "B" symbol on our map. If you think it's slightly brighter – you're right. That's because Beta has some help from two other stars, too! Put your telescope Beta's way and discover what Sir William Herschel called "one of the most beautiful sights in the heavens". This fantastic triple star star system is located about 690 light years from our solar system. As you watch it slowly drift by the eyepiece, you'll know the names of the stars by which leave sight first… from west to east they are A, B and C. In this circumstance, it is believed the B and C stars orbit each other and the A star orbits this pair. All three are about 34 million years old and all three are dwarf stars. Close to each other in magnitude, this trio of hot, blue/white B3 stars each run a temperature of about 18,500 Kelvin and shine anywhere from 3200 down t0 1300 times brighter than our own Sun and spinning on their axis up to 150 times faster. A real triple treat!

For binoculars, have a look at visual double star Delta Monocerotis – the “8” symbol on our map. Located 115 light years from our solar system, this cool pair is worth stopping by – just to see if you can resolve it with your eyes alone! Don’t forget to try Epsilon Monocerotis, too. The backwards “3” on our map. Larger, steady binoculars may separate it and it’s easy for a smaller telescope. This is a very pretty gold and yellow combination binary star, seperated by about two magnitudes. You’ll find it on a number of observing lists. While there, take a look just two degrees northwest of Epsilon for T Moncerotis. This is a great Cepheid variable star with a period of 27 days and a magnitude range of 6.4 to 8.0. Those are the kinds of changes you can easily notice!

Our first deep sky binocular and telescope target will be magnificent Messier 50 (RA 07:03.2 Dec -08:20). This splendid open star cluster averages around magnitude 6 and was logged on April 5, 1772 by Charles Messier in his catalog on deep sky objects. Located about about 3,200 light years from Earth, it spans about 20 light years of space and contains about 200 stars. Inside this 78 million year old cloud is at least one red giant star – located just a



little bit south of central. Can you spot it? How about the smattering of yellows amid the blue/whites?

Now head for equally bright NGC 2301 (6:51.8 Dec +00:28). This easily resolvable chain of stars can be seen in binoculars, but requires a telescope to resolve its individual members. Smaller telescopes will notice at least 30 members, while larger aperture can detect many more from this 80 member galactic star cluster. Located about 2500 light years away, be sure to see if you notice color in the stars here, too. This intermediate age open cluster has

been studied for short-term variable stars and chemically peculiar stars. You’ll find this one on many challenging observing lists, too!

Time to hop to NGC 2244 (RA 6:32.4 Dec +04:52). The “Rosette Nebula” is a fine target for either telescopes or larger binoculars at a combined magnitude of 5. But, remember, combined magnitude isn’t true brightness! You’ll find the nebula here is quite faint and requires a good, dark, Moon-less sky. NGC 2244 is a star cluster embroiled in a reflection nebula spanning 55 light-years and most commonly called “The Rosette.” Located about 2500 light-years away, the cluster heats the gas within the nebula to nearly 18,000 degrees Fahrenheit,

causing it to emit light in a process similar to that of a fluorescent tube. A huge percentage of this light is hydrogen-alpha, which is scattered back from its dusty shell and becomes polarized. While you won’t see any red hues in visible light, a large pair of binoculars from a dark sky site can make out a vague nebulosity associated with this open cluster. Even if you can’t, it is still a wonderful cluster of stars crowned by the yellow jewel of 12 Monocerotis. With good seeing, small telescopes can easily spot the broken, patchy wreath of nebulosity around a well-resolved symmetrical concentration of stars. Larger scopes, and those with filters, will make out separate areas of the nebula which also bear their own distinctive NGC labels. No matter how you view it, the entire region is one of the best for winter skies.

Now for NGC 2264 (RA 6:41.1 Dec +09:53). Larger binoculars and small telescopes will easily pick out a distinct wedge of stars. This is most commonly known as the “Christmas Tree Cluster,” its name given by Lowell Observatory astronomer Carl Lampland. With its peak pointing due south, this triangular group is believed to be around 2600 light-years away and spans about 20 light-years. Look closely at its brightest star – S Monocerotis is not only a variable, but also has an 8th magnitude companion. The group itself is believed to be almost 2 million years old. The nebulosity is beyond the reach of a small telescope, but the brightest portion illuminated by one of its stars is the home

of the Cone Nebula. Larger telescopes can see a visible V-like thread of nebulosity in this area which completes the outer edge of the dark cone. To the north is a photographic only region known as the Foxfur Nebula, part of a vast complex of nebulae that extends from Gemini to Orion.

Northwest of the complex are several regions of bright nebulae, such as NGC 2247, NGC 2245, IC 446 and IC 2169. Of these regions, the one most suited to the average scope is NGC 2245 (RA 6:32.7 Dec +10:10), which is fairly large, but faint, and accompanies an 11th magnitude star. NGC 2247 is a circular patch of nebulosity around an 8th magnitude star, and it will appear much like a slight fog. IC 446 is

indeed a smile to larger aperture, for it will appear much like a small comet with the nebulosity fanning away to the southwest. IC 2169 is the most difficult of all. Even with a large scope a "hint" is all!

Now, get out there and capture NGC 2261 (RA 6:39.2 Dec +08:44). You'll find it about 2 degrees northeast of star 13 in Monoceros. Perhaps you know it better as "Hubble's Variable Nebula"? Named for Edwin Hubble, this 10th magnitude object is very blue in appearance through larger apertures, and a true enigma. The fueling star, the variable R Monocerotis, does not display a normal stellar spectrum and may be a proto-planetary system. R is usually lost in the high surface brightness of the "comet-like" structure of the nebula, yet the nebula itself varies with no predictable timetable – perhaps due to dark masses shadowing the star. We do not even know how far away it is, because there is no detectable parallax!

There are many other wonderful objects in Monoceros just waiting for you to discover them… So get a good star atlas and go hunting the Unicorn!

CAMPAIGN
CPRE STARCOUNT 2022

There's now just one month to go until Star Count!
A velvety black sky scattered with shining stars is a sight we should all have the opportunity to see. But too often, light pollution obscures our view of stars.
Our analysis of last year's Star Count showed that just 5% of people experienced 'truly dark skies', and 51% of us live in areas with severe light pollution.
That's why we need your help to map the nation's view of the stars, so we can better protect our dark skies in the countryside and our towns and cities.
By counting the number of stars you can see in the constellation of Orion, you'll be helping us build a better picture of our view of the stars. We base the time of Star Count around the new moon, the darkest natural time, and this time it's on 2 March.

Not sure how to take part? Follow our six simple steps below!
1) Find a good spot to do your Star Count which is south-facing.
2) If you're doing your Star Count from home, turn off all the lights in your home so it's as dark as possible and go outside.
3) Look south in the night sky (the way satellite dishes face) and find the constellation of Orion. Look out for Orion's belt (see image below).
4) Let your eyes adjust to the dark – the longer you wait, the better (we recommend at least 20 minutes). Count the number of stars you can see within the rectangle formed by the four corner stars. You count the 'belt', but not the corner stars.
5) Head to our website to submit your count and help us map the nation's view of the night sky.
6) Make a one off or regular donation to our work. Together, we can help our beautiful countryside thrive, for everyone's benefit - now and for generations to come.
Happy stargazing!
Emma
Emma Marrington
Dark skies campaigner

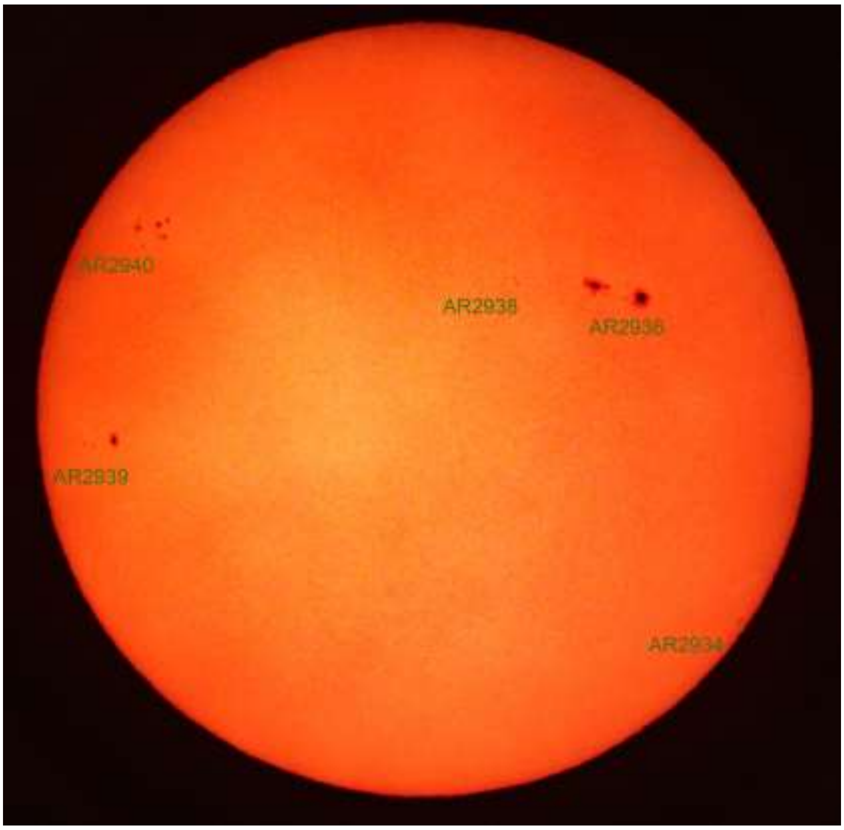
ISS PASSES For February and early March 2022

from Heavens Above website maintained by Chris Peat.

Date	Brightness	Start	Highest point	End						
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
01 Feb	-2.3	18:53:01	10°	W	18:56:03	32°	SSW	18:57:27	22°	SSE
02 Feb	-2.7	18:04:48	10°	W	18:08:01	44°	SSW	18:11:12	10°	SE
02 Feb	-0.8	19:42:58	10°	WSW	19:44:08	11°	SW	19:44:43	11°	SSW
03 Feb	-1.1	18:53:59	10°	W	18:56:13	17°	SW	18:58:27	10°	S
04 Feb	-1.5	18:05:29	10°	W	18:08:14	24°	SSW	18:10:59	10°	SSE
06 Feb	-0.5	18:06:55	10°	WSW	18:08:14	12°	SW	18:09:34	10°	SSW
21 Feb	-1.8	06:02:07	10°	SSW	06:05:00	27°	SSE	06:07:54	10°	E
22 Feb	-1.4	05:14:52	13°	S	05:16:48	19°	SE	05:19:16	10°	E
23 Feb	-1.0	04:28:41	13°	SE	04:28:41	13°	SE	04:30:17	10°	ESE
23 Feb	-3.0	06:01:36	10°	SW	06:04:47	49°	SSE	06:08:03	10°	E
24 Feb	-2.5	05:15:18	26°	SSW	05:16:28	36°	SSE	05:19:36	10°	E
25 Feb	-1.7	04:28:54	24°	SE	04:28:54	24°	SE	04:31:03	10°	E
25 Feb	-3.7	06:01:48	14°	WSW	06:04:38	77°	SSE	06:08:00	10°	E
26 Feb	-3.5	05:15:20	41°	SW	05:16:14	62°	SSE	05:19:34	10°	E
27 Feb	-2.3	04:28:48	35°	ESE	04:28:48	35°	ESE	04:31:07	10°	E
27 Feb	-3.8	06:01:41	14°	W	06:04:31	86°	N	06:07:53	10°	E
28 Feb	-0.5	03:42:13	12°	E	03:42:13	12°	E	03:42:36	10°	E
28 Feb	-3.8	05:15:06	44°	WSW	05:16:03	87°	S	05:19:25	10°	E
01 Mar	-2.7	04:28:29	45°	E	04:28:29	45°	E	04:30:58	10°	E
01 Mar	-3.8	06:01:23	13°	W	06:04:22	88°	N	06:07:44	10°	E
02 Mar	-0.6	03:41:51	15°	E	03:41:51	15°	E	03:42:29	10°	E
02 Mar	-3.8	05:14:44	39°	W	05:15:52	85°	N	05:19:14	10°	E
03 Mar	-3.0	04:28:05	53°	E	04:28:05	53°	E	04:30:45	10°	E
03 Mar	-3.7	06:00:59	11°	W	06:04:07	72°	SSW	06:07:29	10°	ESE
04 Mar	-0.8	03:41:26	16°	E	03:41:26	16°	E	03:42:14	10°	E
04 Mar	-3.8	05:14:20	35°	W	05:15:38	85°	S	05:19:00	10°	ESE
05 Mar	-3.3	04:27:42	59°	E	04:27:42	59°	E	04:30:29	10°	E
05 Mar	-3.2	06:00:35	10°	W	06:03:46	44°	SSW	06:06:58	10°	SE
06 Mar	-0.9	03:41:05	17°	E	03:41:05	17°	E	03:41:57	10°	E
06 Mar	-3.6	05:13:59	32°	W	05:15:18	59°	SSW	05:18:37	10°	ESE
07 Mar	-3.3	04:27:25	54°	SE	04:27:25	54°	SE	04:30:09	10°	ESE
07 Mar	-2.4	06:00:25	10°	W	06:03:12	24°	SSW	06:05:59	10°	SSE
08 Mar	-0.9	03:40:54	15°	E	03:40:54	15°	E	03:41:38	10°	E
08 Mar	-2.9	05:13:48	27°	WSW	05:14:47	34°	SSW	05:17:51	10°	SE
09 Mar	-2.6	04:27:23	33°	SSE	04:27:23	33°	SSE	04:29:34	10°	SE
09 Mar	-1.5	06:01:01	10°	WSW	06:02:26	12°	SW	06:03:52	10°	SSW
10 Mar	-0.6	03:41:05	10°	ESE	03:41:05	10°	ESE	03:41:08	10°	ESE
10 Mar	-2.1	05:14:00	18°	SW	05:14:06	18°	SW	05:16:27	10°	S
11 Mar	-1.4	04:27:49	14°	SSE	04:27:49	14°	SSE	04:28:31	10°	SSE

END IMAGES, OBSERVING AND OUTREACH

The Sun over the last week has put on a good display of sunspot growth I full view. Te Active Region AR2836 has developed from small spots like AR2940 to be two large spots 2-3 times the diameter of the Earth. Solar filter on P1000 zoom Nikon. Andy



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:**

- **Friday 4th February 2022**
- **Friday 25 February 2022**
- **Friday 25 March 2022 (Messier Marathon)**
- **Friday 29 April 2022**
- **Friday 27 May 2022**
- **Friday 03 June 2022 (limited sky darkness)**

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

OUTREACH

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

I have been asked to return to Westbury Leigh, but Covid has hit...

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.