Lewes Astronomical Society

Newsletter - September 2024

Astronomy News, Spaceflight News, and Observational Highlights

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Astronomy News

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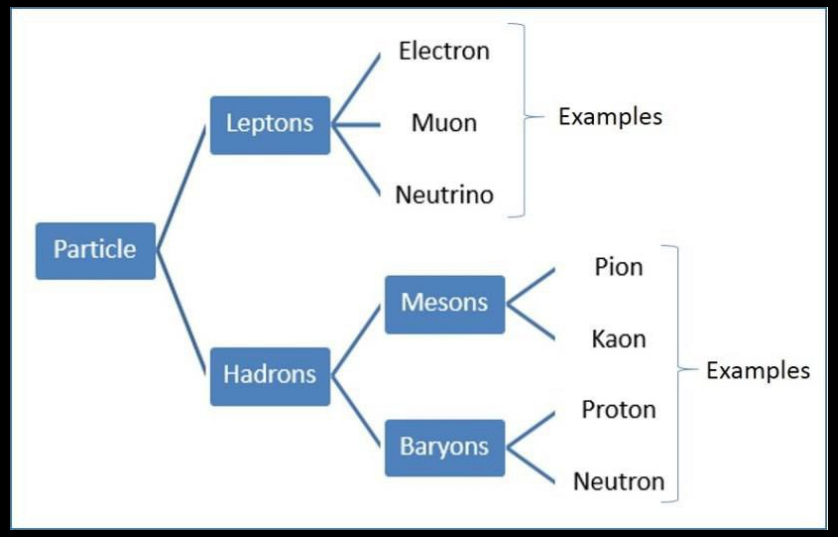
Matter in the early Universe (1)



Classification of Particles based on mass, type of interaction, and electrical charge.

- A lot happened within the first second of the Big Bang, including the formation of hadrons (the heaviest particles), such as protons and neutrons, which make up everyday matter. However, since the early universe was 250,000 times hotter than the core of our Sun, conditions were theoretically too hot for these subatomic particles to form.
- Protons and neutrons are made up of quarks: the fundamental building blocks of matter, and gluons: the “glue” that holds quarks together through the strong nuclear force.
- For a brief moment, or up until 0.000001 seconds after the Big Bang, the extremely hot and dense state of the universe was characterised by a quark-gluon plasma. This plasma soup rapidly expanded, somewhat like a fireball, within an incredibly short timescale; faster than it takes for light to cross a single atom.

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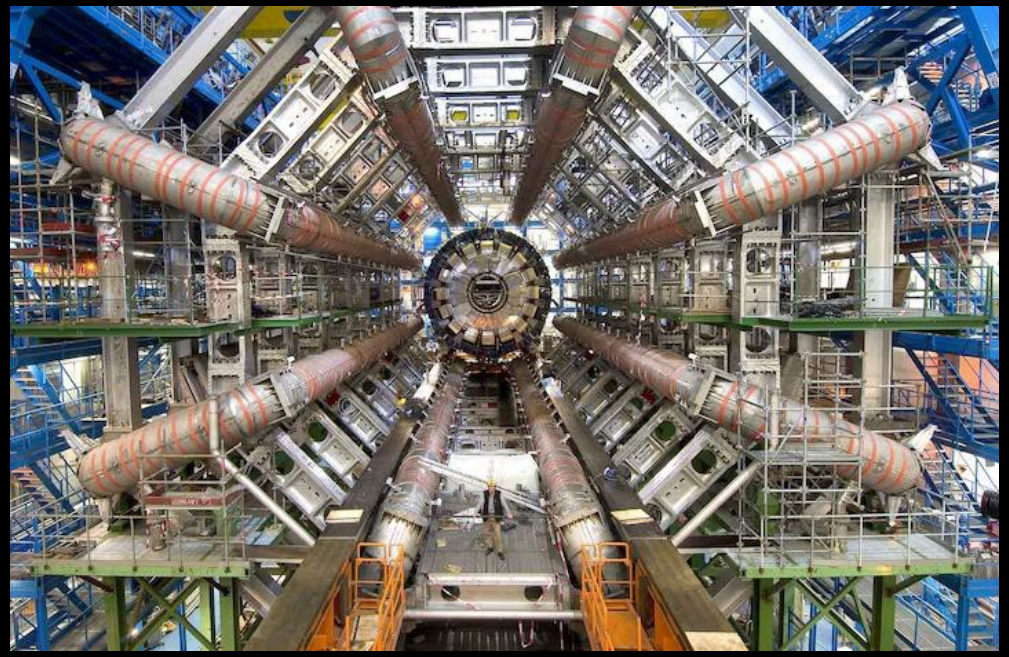
Matter in the early Universe(2)

- After 0.000001 seconds, as the universe expanded and cooled, the temperature had dropped enough for quarks and gluons to form protons, neutrons, and other particles. Scientists have previously estimated that most matter was produced within this timeframe, including the more complex particles, such as charmonium.
- By smashing atoms together in particle accelerators at nearly the speed of light, scientists aim to recreate the conditions of the early universe and to understand how matter formed; how much was formed within the first few fractions of a second; and how much was formed during later reactions, as the universe expanded.



The ATLAS particle detector – part of the Large Hadron Collider – was used to find the Higgs Boson. Credit: Rex Features Via Associated Press

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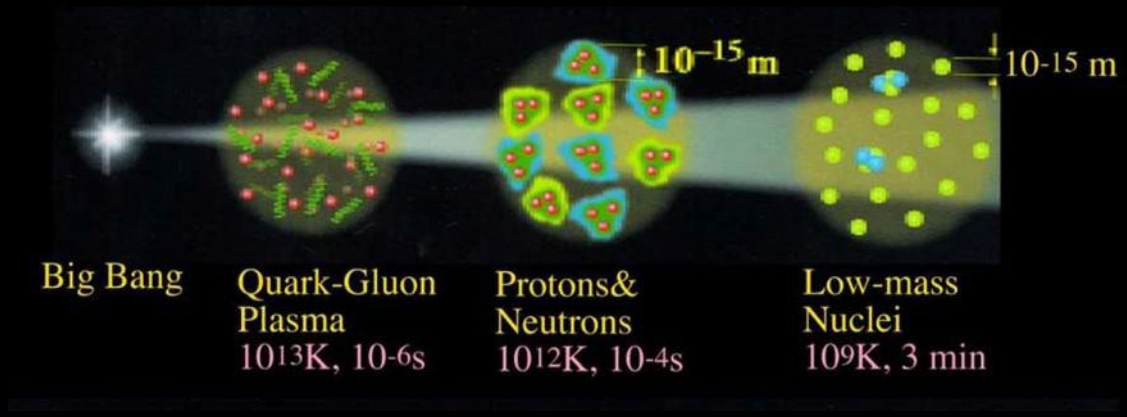
Matter in the early Universe(3)



Timeline of the formation of matter

- Recent experiments have provided data on how particles such as charmonium formed within later reactions. Using the data, physicists at Yale University and Duke University have calculated that more than 70% of the charmonium measured could be formed in later reactions through collision.
- This result suggests that the specific details of the expansion may not be as critical for understanding the formation of some particles as was previously thought and that a significant number of particles could still have been formed through later collisions, bringing us one step closer to understanding the origins of matter.

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Could the Higgs field alter the Laws of Physics? (1)

- The Higgs boson gives mass to particles through the Higgs field, which is uniform across the universe, meaning that we observe the same masses and interactions across the entire cosmos. However, the Higgs field isn't likely to be in its lowest energy state, meaning that it could potentially change its state and drop to a lower energy in a certain location. This would dramatically alter the laws of physics.
- Recent measurements of particle masses from the Large Hadron Collider (LHC) suggest that it is possible for such a phase transition, which would create low-energy bubbles of space. In these bubbles, the mass of electrons and their interactions with other particles would suddenly change, and protons and neutrons would suddenly dislocate, creating completely different laws of physics.

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Could the Higgs field alter the Laws of Physics? (2)

- The research theorises that primordial black holes (hypothetical black holes which may have formed within the first second of the universe's existence) could have started this phase transition early on due to increased hot spots from Hawking radiation, which would have caused the Higgs field to bubble. The fact the universe still exists suggests that these black holes may never have existed themselves.
- If new evidence were to come to light confirming the existence of these early black holes, it would indicate that there may be something we don't know about the Higgs, or that there are brand new particles or forces at play.

An artistic impression of the Brout-Englert-Higgs field. Credit: D Dominguez/CERN

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Alfvén Wings created by solar disturbance (1)

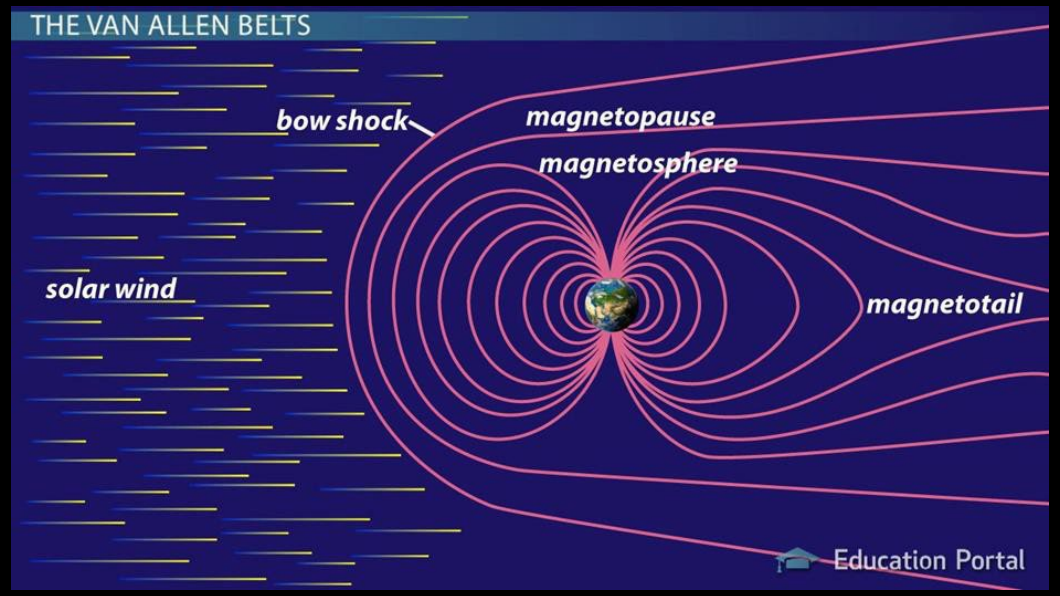

Diagram of Earth's Magnetosphere

- A rare phenomenon, created during a coronal mass ejection (CME) on 24th April 2023 was observed by NASA's Magnetospheric Multiscale Million (MMS) spacecraft, with research into the event offering new insights on how Alfvén wings form and evolve.
- A continuous stream of charged particles (mostly electrons and protons), flow out from the Sun's corona in all directions, bombarding the Earth and curving around the magnetosphere (magnetic field) to form a sunward side front called a bow shock, and stretching into a windsock shape with a long tail on the nightside. This is known as solar wind.

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Alfvén Wings created by solar disturbance (2)

- CMEs are large-scale releases of plasma and magnetic fields from the Sun’s corona into space, and typically eject billions of tons of material at between 250 to 3,000km per second. They are associated with solar flares and other activity, but can happen independently, often when the Sun’s magnetic fields become twisted and suddenly realign, releasing enormous amounts of energy and plasma.
- Solar flares are intense bursts of radiation caused by the release of magnetic energy from the Sun’s atmosphere and are distinct from CMEs in that they emit electromagnetic radiation, such as X-rays and UV light, rather than plasma.
- Both CMEs and solar flares can trigger solar wind disturbances which, in turn, can alter the structure and dynamics of Earth’s magnetosphere.
- The Alfvén speed represents the speed at which magnetic disturbances, such as waves, travel through a magnetised plasma, and can be used to determine whether a CME can generate shock waves in space; if a CME travels faster than the local Alfvén speed, it can create a shock wave, leading to space weather effects.

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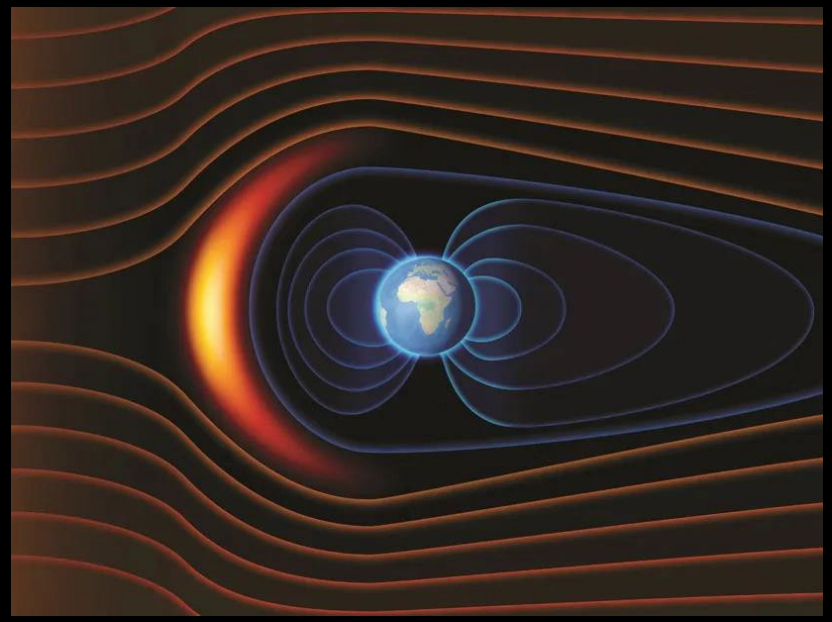
Alfvén Wings created by solar disturbance (3)

- Typically, solar winds travel faster than the Alfvén speed, creating a stable bow shock. However, on the date in question, the Alfvén speed during the strong CME was even faster.
- This high Alfvén speed caused Earth's bow shock to temporarily disappear, increasing our vulnerability to geometric storms and other space weather effects. The windsock tail was replaced by structures called Alfvén wings; structures that form when a magnetised object interacts with flowing plasma. These connected Earth's magnetosphere to the recently erupted region of the Sun and acted as a highway, transporting plasma between the two.



The dayside magnetosphere and its surroundings play host to an almost bewildering array of intercoupled phenomena extending across spatial and temporal scales. Credit: © Naeblys/Shutterstock

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Alfvén Wings created by solar disturbance (4)

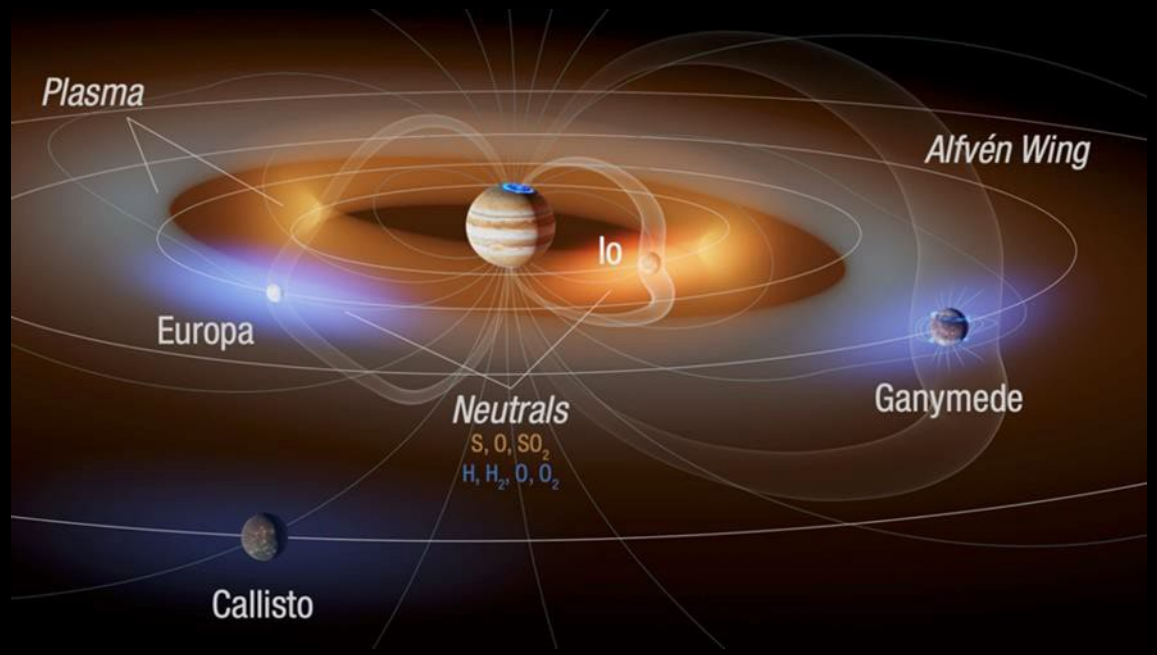

Diagram of how Alfven wings connect Jupiter with its moons.
Credit: Szalay, J. R., et al. (2022)

- This event has offered new insights into how Alfvén wings form and evolve, and may allow us to further investigate how similar processes could occur around other magnetically active bodies in our Solar System, influencing the behaviour of moons, planets, and even man-made spacecraft.
- Jupiter's relationship with its moon, Io, is a classic example of Alfvén wings, which connect Io to Jupiter's magnetic field and even induce auroras at Jupiter's poles.

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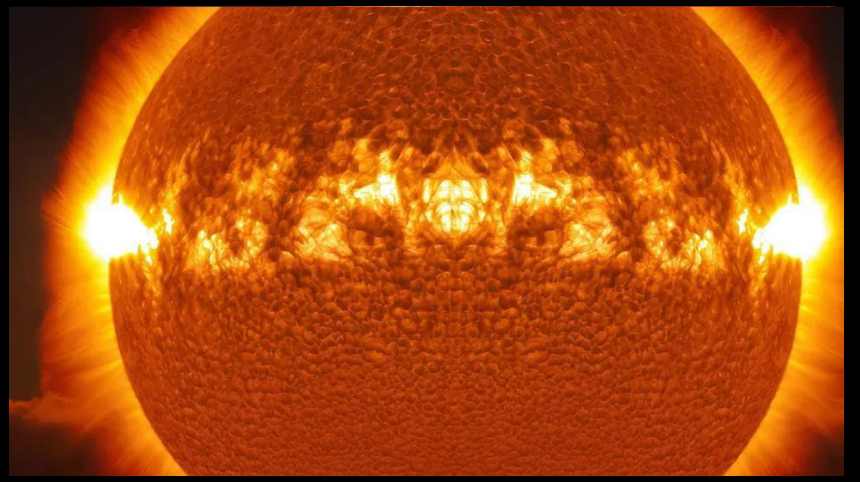
New insight into the evolution of stars (1)

- Research into a recently discovered star, J0524-0336, approximately 30 times the size of the Sun, has provided new insights into star evolution and the formation of chemical elements, suggesting a new stage within stars' growth cycles.
- Using a method called spectroscopy, researchers at the University of Florida have measured J0524-0336's elemental composition by filtering the star's light into its constituent rainbows and identifying dark spots.
- It is normally thought that, as stars burn, they lose lighter elements such as lithium in exchange for heavier elements, such as carbon. However, although J0524-0336 is in the later stages of its life and is beginning to grow unstable, its lithium content was found to be higher than the normal level for any star at any age; containing 100,000 times more than the Sun does at its current age.



An illustration showing a star more massive than the sun. Credit: Robert Lea

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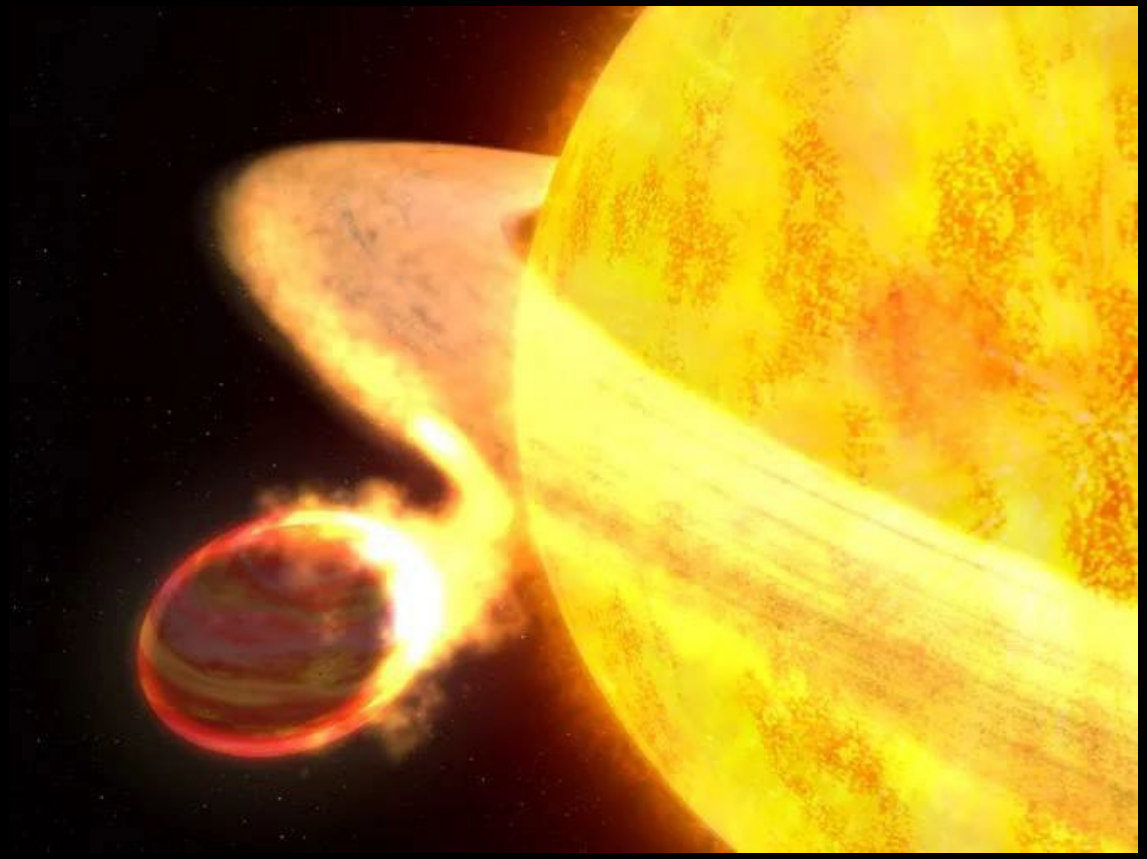
New insight into the evolution of stars (2)



Conceptual image of a star consuming a planet
Credit: NASA/ESA/G. Bacon

- This suggests that there could be a previously unknown mechanism for lithium production or retention in stars. However, it could also indicate that the star is currently in a previously unobserved phase in the evolutionary cycle of stars, or that the star may have gained the element from a recent interaction with another celestial body, such as through the consumption of planets and neighbouring stars.
- Further observations of the star's compositional changes will hopefully shed more light on the chemical evolution of J0524-0335, and to reveal how it currently has such high lithium content.

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Dark matter seen through a forest (1)

- The Lyman-Alpha Forest is a pattern observed in spectrograms, where light from distant cosmic sources shows dark bands at specific wavelengths, representing the absorption of light by hydrogen atoms encountered along the way.
- Hydrogen gas falls into regions with strong gravitational potential caused by dark matter, which allows scientist to map out dark matter concentrations by tracking hydrogen particles.
- Simeon Bird, a physicist at UC Riverside, and his colleagues have been researching discrepancies between theoretical predictions and observations of the universe, which were discovered by analysing the Lyman-Alpha Forest spectrograms.
- Models of the universe, particularly those based on the Lambda Cold Dark Matter (ΛCDM) model, predict a higher number of dwarf galaxies with low redshifts (meaning that they are relatively close to Earth), with higher distribution in the universe.

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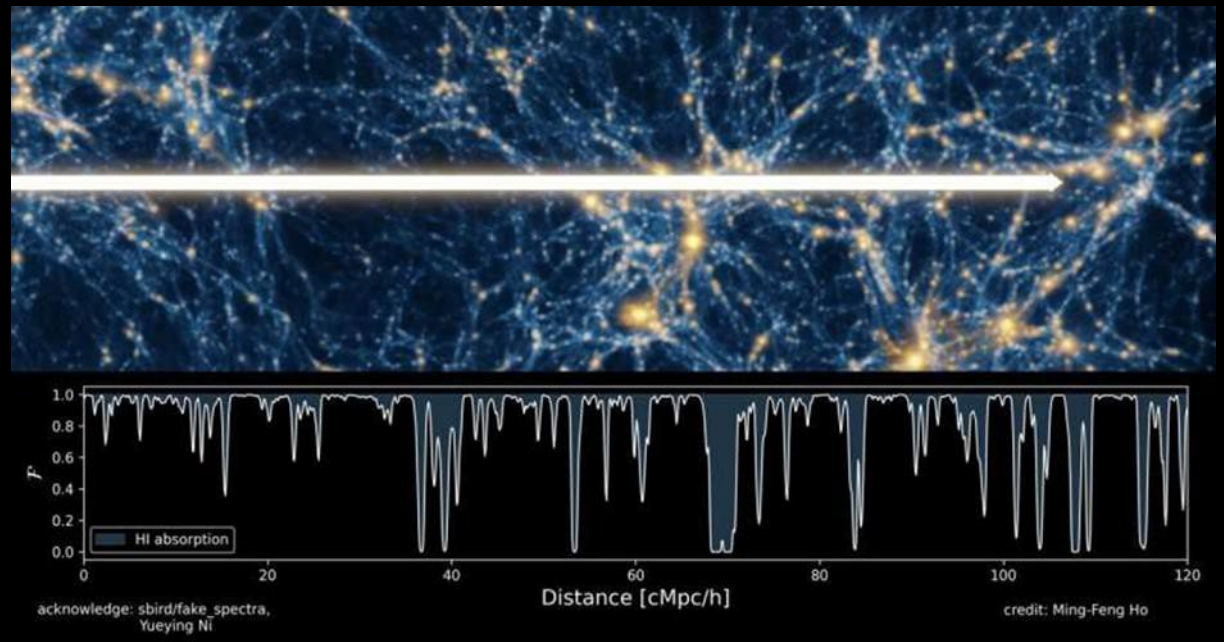
Dark matter seen through a forest (2)

- However, observations have found that far fewer small galaxies exist than the model predicts, especially in regions closer to Earth.
- This discrepancy suggests either the existence of unknown particles or forces, or that supermassive black holes play a more significant role in galaxy formation than was previously anticipated.
- Further research is required to determine whether the discrepancy is caused by a new particle or new physics, or if it is due to black holes interfering with calculations.



Example of PRIYA Simulations. Credit: UC Riverside.

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Scientists pinpoint dino-killing asteroid's origin (1)

Artist's impression of the Chicxulub impact crater soon after its creation. Credit: Detlev van Ravensway/Science Source

- The Chicxulub Impactor, located in what is present-day Mexico's Yucatan Peninsula, is known as the dinosaur-killing asteroid which slammed into Earth 66 million years ago, causing the world's most recent mass extinction event.
- New findings, based on analysis of sediment samples formed at the time of the asteroid's impact; between the Cretaceous and Paleogene eras, have shed more light on the asteroid's origins.
- By measuring isotopes of the element ruthenium, which is common on asteroids but extremely rare on Earth, scientists have been able to inspect geological layers from the debris at Chicxulub and confirm that the element came 100% from the asteroid.

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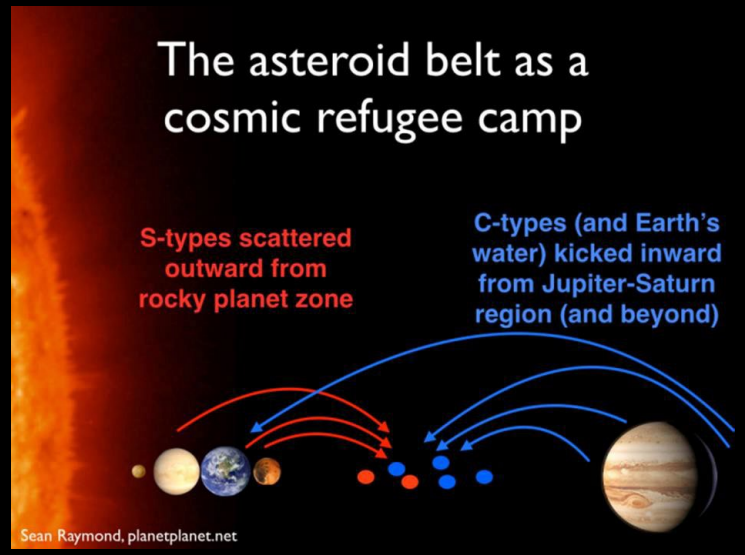
Scientists pinpoint dino-killing asteroid's origin (2)



Artist's impression of how the Asteroid Belt could have become filled with C-type and S-type asteroids over time. Credit: Sean Raymond/planetplanet.net

- This identifies the asteroid as a C-type, or carbonaceous asteroid, which are formed in the outer solar system, beyond Jupiter, and is distinguished from S-type silicate asteroids which originate from the inner solar system, nearer to the Sun. Most meteorites that fall to Earth are S-types, making these findings quite striking.
- This conclusion had previously reached by studies carried out in the early 2000s, but with far less certainty than has been attained via the most recent research.
- Researchers have also dismissed the claim that the impactor was a comet (an amalgam of icy rock from the very edge of the solar system), due to it being very different in composition from samples of other meteorites, believed to be comets in the past.
- Scientists believe that by studying past asteroids we may be able to determine how water arrived on Earth and may also be able to prepare for future C-type asteroids on an Earth-crossing orbit.

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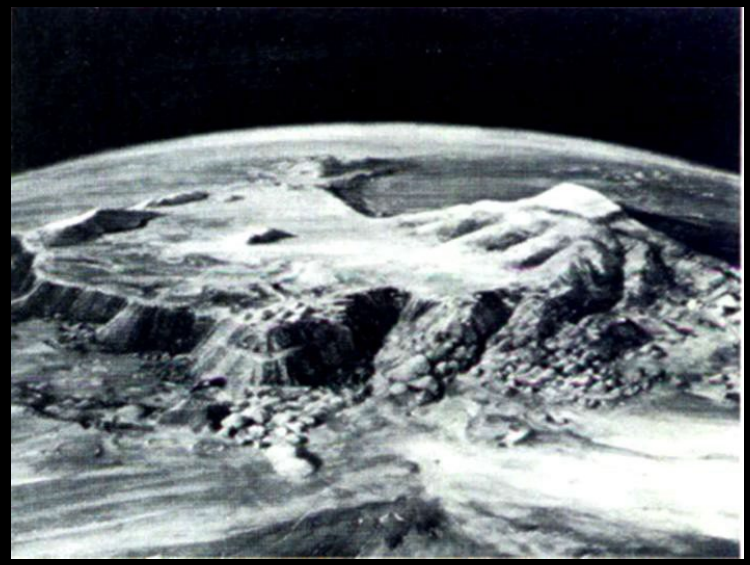
Surprising Earth-Venus link discovered

- Earth’s rebellious twin, Venus, could potentially have a close link in its geological history to our own planet.
- An exciting new study has challenged the ideas about planetary evolution and shown that Venus, despite its extreme 460°c surface temperature and lack of plate tectonics, may have a more complex geological history than we previously thought.
- Researchers, using computer simulations and data from NASA’s Magellan spacecraft, have modelled the formation of Venus’ Ishtar Terra and concluded that Venus’ vast plateaus, known as tesserae, could have risen from the planet’s hot interior in a similar process to that which created the Earth continents billions of years ago.



Venus’ Ishtar Terra; bordered by mountain rangers on the east, northwest, and north.

- This research could offer clues about the evolution of rocky planets, and underscores the importance of upcoming Venus missions, such as DAVINCI, VERITAS, and EnVision, all of which will investigate Venus’ geological history.

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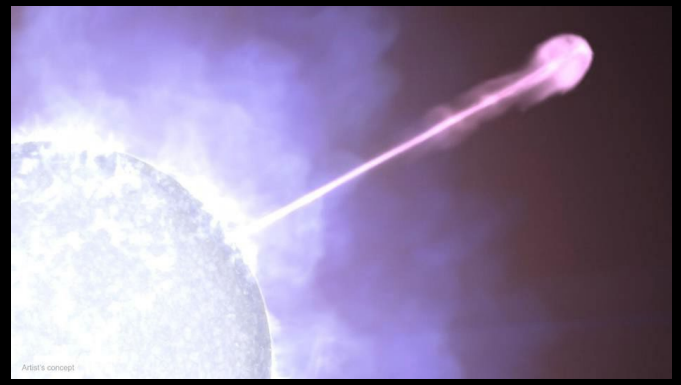
Brightest of All Time: Gamma-ray burst (GRB) investigated (1).



Artist’s concept of particles moving at nearly the speed of light, bursting out of a massive star. Credit: NASA’s Goddard Space Flight Centre Conceptual Image Lab.

In October 2022, GRB 221009A, the “Brightest of All Time” (BOAT) shocked astronomers, saturating many gamma-ray detectors due to its extreme brightness, and representing the most intense gamma-ray burst (GRB) detected in over 10,000 years.

- Gamma-ray bursts are the most powerful explosions in the cosmos and mainly arise from the deaths of massive stars. In the case of most GRBs, and as is the case with BOAT, the core of the star runs out of fuel and collapses, creating a black hole in the centre. Matter swirls into the black hole before a portion is thrown out along two jets, moving close to the speed of light and blasting out of the star into space.
- We see gamma-ray bursts when one of these jets points towards Earth, and the more directly we view it, the brighter it appears. BOAT was exceptional in that its narrow jet shot head-on towards Earth, causing it to be intensely bright.

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Brightest of All Time: Gamma-ray burst (GRB) investigated (2)

- Two separate research teams; one led by the institute of High Energy Physics (IHEP) of the Chinese Academy of Sciences, using two space gamma-ray monitors named GECAM-C and Fermi/GBM; and an international team, also using NASA's Fermi Gamma-ray Space Telescope, have analysed the signal and published their results.
- The IHEP team used GECAM-C's accurate measurement of the low energy band spectrum and Fermi's coverage of the high energy band, where the gamma-ray showed up. The Fermi detector suffered data loss due to the intense brightness of the burst, so GECAM-C data was used to correct it.
- From this data, the team identified gamma-ray lines up to 37 million electron-volts (MeV) from this GRB, making it the highest energy spectral line ever detected from a celestial object.
- They found that the energy of the gamma-ray line changes in a predictable pattern over time, while the relationship between the line's width and its energy stays pretty much the same. These patterns strongly confirm that these gamma-ray lines are real and that they come from the gamma-ray burst itself.

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Brightest of All Time: Gamma-ray burst (GRB) investigated (3)

- Five minutes into the event, scientists found an emission line; a narrow band of enhanced brightness in light spread out in a spectrum. This lasted 40 seconds and was the first one ever seen with high confidence during a burst, giving scientists insight into where the gamma-rays come from within the jet.
- The gamma-rays are likely produced by electrons and their anti-matter twins, positrons, colliding and annihilating within the jet to produce a pair of gamma-rays. Two gamma-rays can also collide to produce an electron and a positron. Both processes are occurring in the jet environment, so there are plenty of particles.
- The gamma-rays had to be shifted to higher energies by their motion, similar to how a siren rises in pitch as it approaches, and predictions state that the particles must have been moving at 99.9% the speed of light. Scientists know little about the processes occurring within these jets, but Fermi has now given us a brief glimpse inside.

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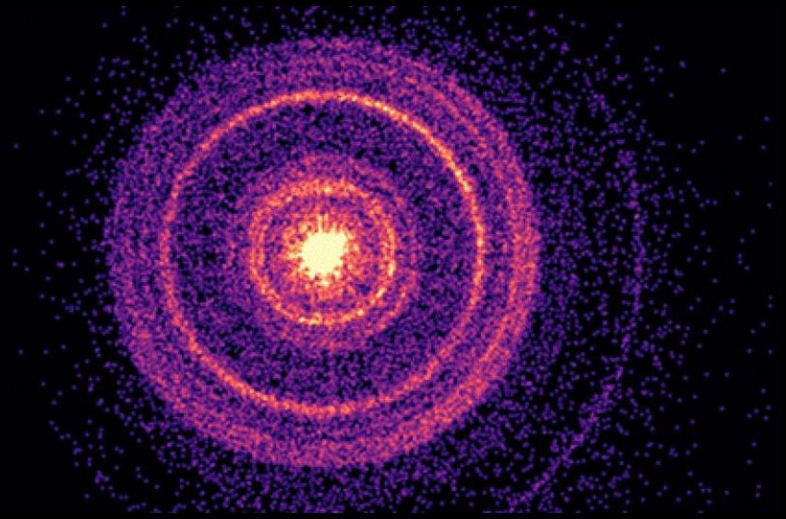
Brightest of All Time: Gamma-ray burst (GRB) investigated (4)



Satellites captured images of how the gamma blast lit up dust rings in space. Credit: NASA/SWIFT/A. Beardmore (University of Leicester).

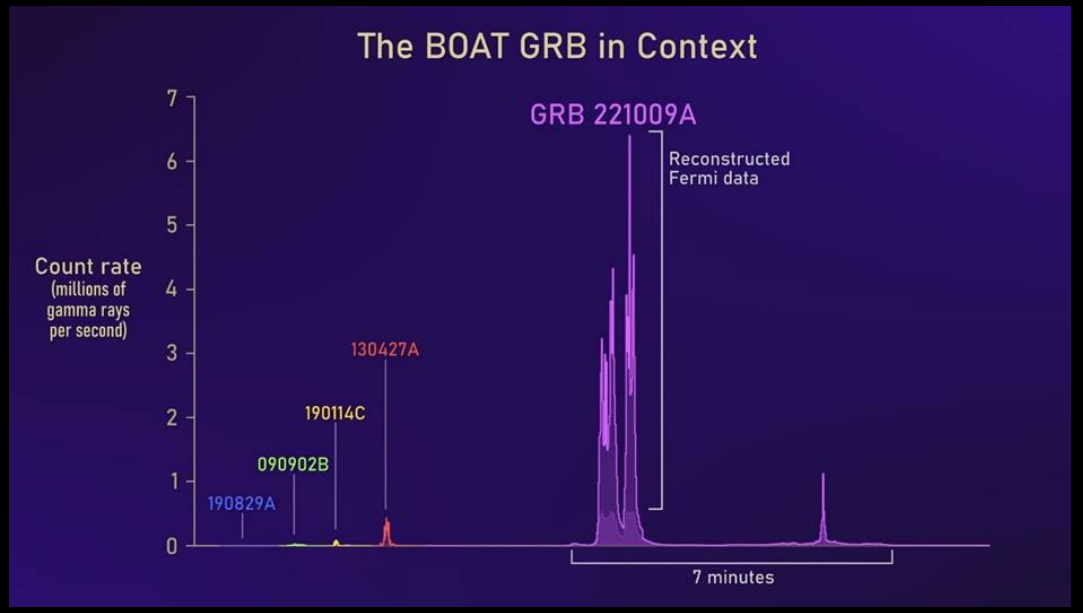


Chart comparing the BOAT emission to that of five precious record-holding long gamma-ray bursts. Credit: NASA's Goddard Space Flight Centre and Adam Goldstein (USRA)

- By integrating these findings, we can see how GRB 221009A set new records for gamma-ray bursts and provided a unique opportunity to observe and analyse high-energy spectral lines, deepening our understanding of the extreme physics driving these cosmic explosions.

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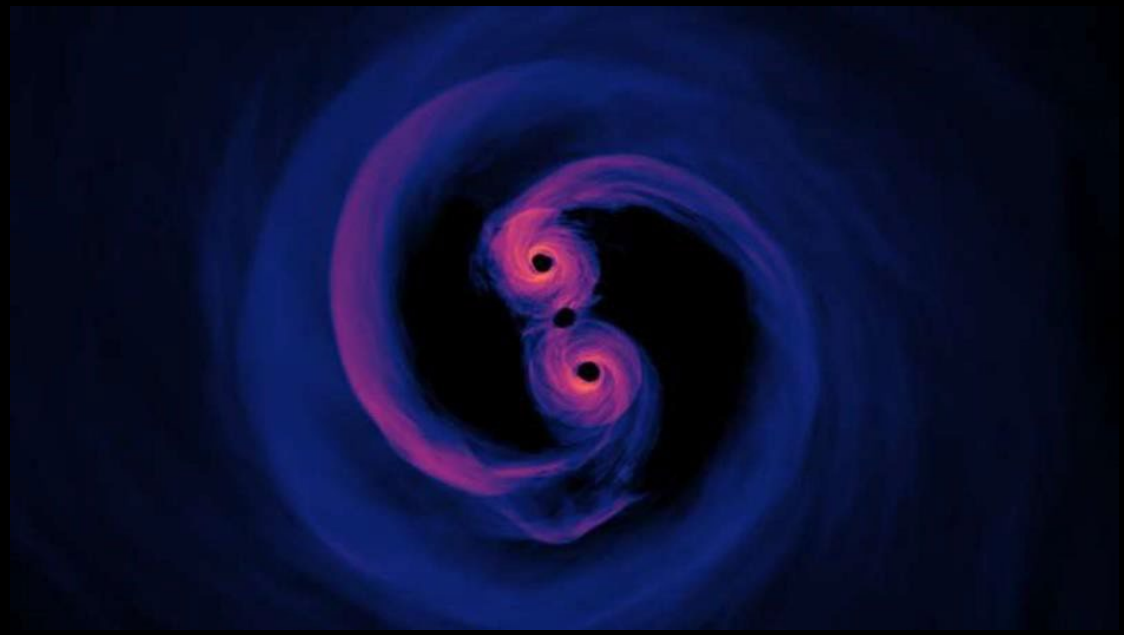
Could dark matter solve the Final Parsec Problem? (1)

- A new solution to the final parsec problem grants insight into supermassive black hole (SMBH) mergers, as well as the nature of dark matter.
- In 2023, astrophysicists announced the detection of a “hum” of gravitational waves penetrating the universe, theorised to be caused by millions of merging pairs of SMBHs, billions of times more massive than our Sun.
- This was proposed to occur when SMBHs fall into orbit around each other and, as they revolve, become slowed by the tug of nearby stars, losing rotational energy and causing them to spiral inward towards a merger.



Simulation of light emitted by a supermassive black hole binary system. Credit: NASA’s Goddard Space Flight Centre/Scott Noble; simulation data, d’Ascoli et al. 2018

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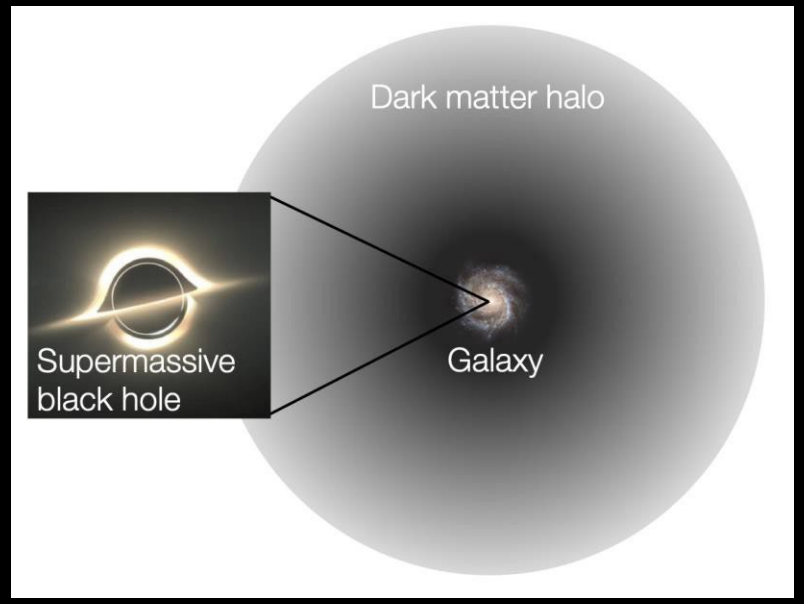
Could dark matter Solve the Final Parsec Problem? (2)



Schematic of a galaxy with a supermassive black hole at its center, surrounded by a halo of dark matter (not to scale). (Credit: M. Powell.)

- However, an issue was encountered during theoretical simulations which showed that, as the giant bodies spiral closer together, they stall at about three light years (or one parsec) apart, preventing any merger. This meant that SMBHs may not be the source of the gravitational wave background, and that lesser massive black holes may not combine to become supermassive.
- Previous merger models also suggested that SMBHs begin to interact with the dark matter cloud or halo in which they are embedded, throwing dark matter particles clear of the system, resulting in energy not being drawn from the pair and the stagnation of their reducing mutual orbits.

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Could dark matter Solve the Final Parsec Problem? (3)

- A new model, published by collaborating physicists from McGill University in Montreal and Cern, highlight a previously overlooked effect of dark matter, which shows that the particles interact with each other in such a way that they are not dispersed, meaning that the density of the dark matter halo remains high enough for interactions to continue degrading the SMBH's orbits, and present the way through to a merger.
- This prediction is backed up by data from the Pulsar Timing Array, which reveals gravitational waves by measuring minute variations in signals from pulsars and displays softening at low frequencies; this could be a result of dark matter particles interacting with each other and producing gravitational waves that have a particular pattern.
- Interactions between dark matter particles within the model also explain the shapes of galactic dark matter halos.
- The researchers state that "the final parsec problem can only be solved if dark matter particles interact at a rate that can alter the distribution of dark matter on galactic scales".

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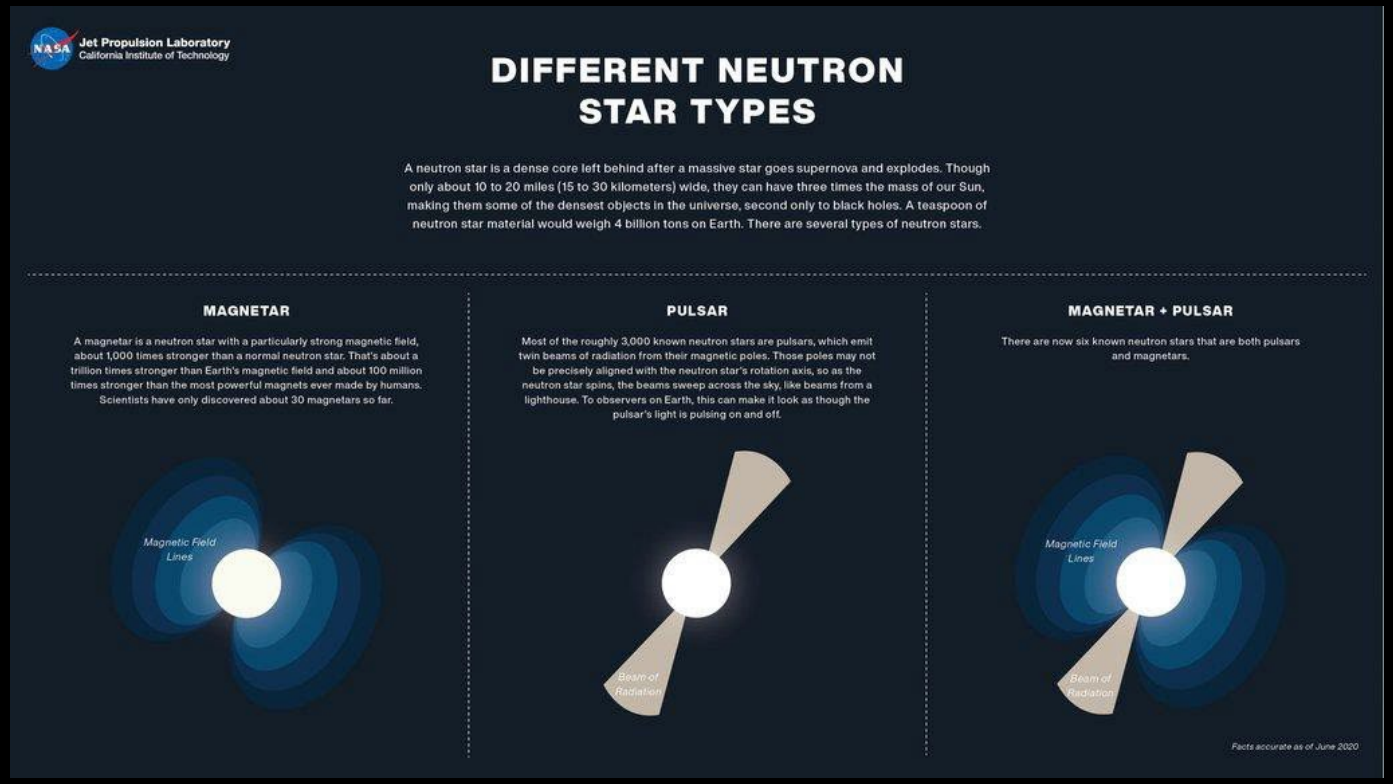
The cosmic origin of magnetars (1)



Credit: NASA/JPL-Caltech

- Neutron stars are born from the supernova of high-mass stars and exist as superdense objects, often spinning very rapidly and shining out beams of light, like a lighthouse. When these beams are aligned in a way which makes them visible from Earth, the star is also called a pulsar. When the neutron star forms with a fast, pulsar-like spin and a magnetic field thousands of times stronger than that of a typical neutron star, it is dubbed a magnetar, with roughly double the mass of the Sun condensed down to the size of a city.

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The cosmic origin of magnetars (2)

- A team of astronomers led by Hao Ding of the Mizusawa VLBI Observatory, National Observatory of Japan, using the U.S. National Science Foundation (NSF) National Radio Astronomy Observatory's (NRAO) Very Long Baseline Array (VLBA), have been investigating what conditions cause magnetars to evolve along such distinct paths.
- Over the previous three years, the team have used the NSF VLBA to collect data on the position and velocity of the magnetar Swift J1818.0-1607, located in the constellation Sagittarius on the other side of the central galactic bulge, only 22,000 light years away within the Milky Way. The star is one of only 30 confirmed magnetars in the universe and one of eight similar enough to be relevant for this study.
- It is believed to be the youngest magnetar discovered so far at only a few hundred years old and has the fastest rotation, with a spin period of only 1.36 seconds. Magnetars are supposed to be a relatively short-lived phenomenon due to their bright x-ray emissions requiring an extremely high energy outflow, which only the rapid decay of its intense magnetic field can explain.

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The cosmic origin of magnetars (3)

- Magnetars can also emit at the low end of the electromagnetic spectrum; in radio wavelengths, which are likely powered by synchrotron radiation (electromagnetic radiation that occurs when charged particles, like electrons or positrons, are accelerated in a magnetic field and travel in curved paths) from their rapid spin.
- Swift J1818.0-1607’s transverse velocity (perpendicular to the galaxy’s plane), was easier to measure than its radial velocity (along the line of sight), and this helps astronomers differentiate between the formation processes of regular neutron stars, pulsars, and magnetars.
- By using the precise measurements of transverse velocity, researchers determined that the magnetar has a low transverse velocity, suggesting that the conditions under which magnetars are formed are distinct from those of other neutron star types. This could mean that they are born from more extreme conditions, such as the collapse of a more massive star, or in environments with intense magnetic fields.
- Further research into how fast the magnetar was moving with it was just born is required to grow our understanding of the mysterious formations of these powerful objects.

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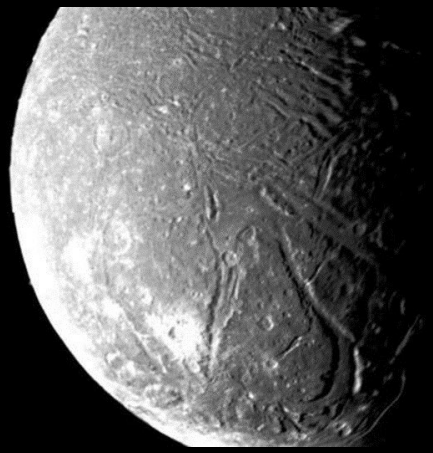
Has JWST discovered hidden oceans on Ariel? (1)

- Uranus' moon, Ariel, has been found to have a significant amount of carbon dioxide ice on its surface, particularly on the trailing hemisphere side that faces away from its direction of orbital motion.
- The discovery has surprised scientists because, even in the cold environment of the Uranian system, the carbon dioxide is expected to turn into gas and escape into space.
- Initially, scientists believed that interactions between Ariel's surface and charged particles from Uranus' magnetosphere could create carbon dioxide through a process called radiolysis: where molecules are broken apart through exposure to ionizing radiation, such as X-rays, gamma radiation, or fast electrons from accelerators.



An image mosaic of Uranus' moon Ariel, taken by the narrow-angle camera on Voyager 2 on Jan 24, 1986. Credit: NASA/Jet Propulsion Laboratory.

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Has JWST discovered hidden oceans on Ariel? (2)

- Using the James Webb Space Telescope (JWST), a research team, led by Richard Cartwright from the Johns Hopkins Applied Physics Laboratory (APL) in Laurel, Maryland, found that the carbon dioxide may be emerging from within Ariel from a subsurface liquid ocean. This supports recent theories that four of Uranus' largest moons, including Ariel, could contain an ocean layer between their cores and icy crusts.
- Unexpected traces of carbon monoxide on Ariel's surface also shouldn't be stable at the observed temperatures, indicating that it must be continually replenished.
- This theory is boosted further by evidence that Ariel's surface may also contain carbonate minerals, which only form through interactions between liquid water and rocks, also suggesting geological activity.

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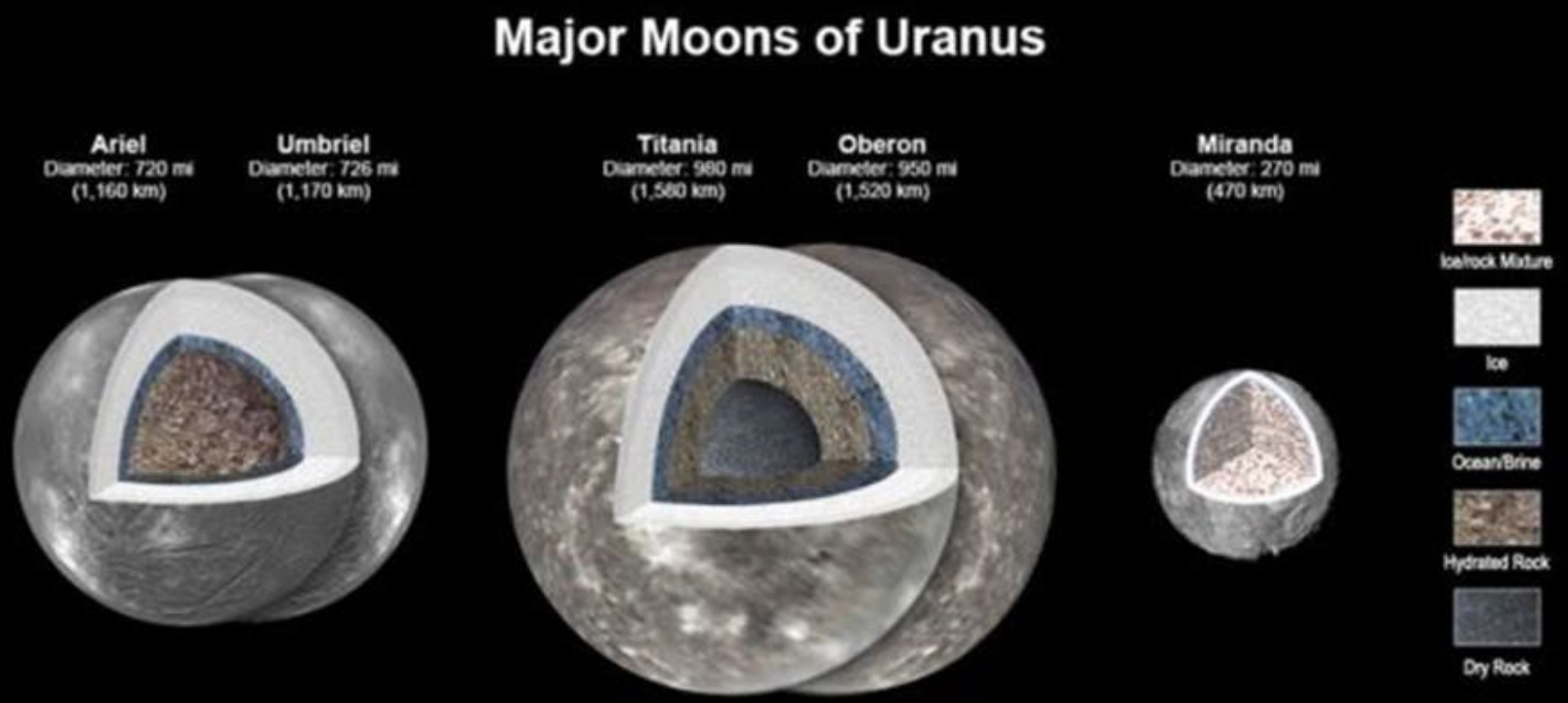
Has JWST discovered hidden oceans on Ariel? (3)

- Future missions to Uranus could provide more detailed observations and help to confirm whether any of the moons are ocean worlds, offering more valuable insights into the formation of the solar system and for similar ocean-bearing moons around other stars.



The makeup of the four largest moons of Uranus, according to a previous study. Credit: NASA/JPL-Caltech.

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Caltech observatory is removed from controversial site (1)

Credit: NOIRLab/NSF/AURA/T. Matsopoulos

- The Caltech Submillimeter Observatory was first designed to detect some of the most unexplored wavelengths of light; between a third of a millimetre and one millimetre.
- Over the previous three decades, the telescope has played a key role in several scientific breakthroughs in astrophysics, including mapping interstellar dust and the discovery that the Earth is bathed in light from excited molecules in space.
- The telescope was located on Maunakea in Hawaii, a place revered by native Hawaiians as a sacred site, serving their spiritual connection to the heavens.

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Caltech observatory is removed from controversial site (2)

- The site is a prime location for astronomical observatories; due to its high altitude at nearly 14,000 feet above sea level placing it above much of Earth's atmosphere; its remote location removing it from sources of light pollution; its low humidity; its stable atmospheric conditions; and its geographic location near to the equator, which allowed the telescope to observe a larger portion of both the northern and southern skies.
- Following the removal of a University of Hawaii observatory a month earlier, the Caltech Submillimeter observatory was decommissioned in July and has now been totally removed from the site, returning it to pristine conditions. The telescope will be given new instruments, moved to a non-sacred site in Chile, and given a new name; the Leighton Chajnantor Telescope.
- 11 telescopes remain on Maunakea, and so the debate continues. While the observatories do contribute to Hawaii's economy and support science and engineering on the islands, locals remain divided over the issue.

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Astronomy News in Brief (1)

- **Astronomers discover two new super-Earths orbiting nearby stars** – Using NASA's Transiting Exoplanet Survey Satellite (TESS), an international team of astronomers have detected two new super-Earth exoplanets orbiting nearby M-dwarf stars, designated TOI-6002 b and TOI-5713 b. TOI-6002 b is estimated to be nearly four times more massive than the Earth, with a radius of 1.65 Earth radii, and orbits its host star every 10.9 days at a distance of 0.006 AU. TOI-5713 is estimated to be about 4.3 Earth masses, is 77% larger than the Earth, and orbits its star approximately every 10.44 days at a distance of 0.06 AU. Both planets are just outside of the inner edge of the habitable zone and have unknown compositions, although it is thought they could be rocky or water-rich worlds.
- **Research finds evidence of hydration on the asteroid Psyche** – Using data from JWST, a Southwest Research Institute-led team has identified hydroxyl molecules on the surface of the metallic asteroid Psyche, suggesting that it has a complex history. Psyche is one of the largest objects in the asteroid belt between Mars and Jupiter at around 140 miles in diameter, and is a dense, largely metallic object, potentially existing as a remnant of a planetary core. Hydration could result from external impacts or be native and understanding Psyche's composition could provide insight into the evolution of our solar system and potential life-supporting water distribution. NASA launched the Psyche spacecraft on 13th October 2023. It will cover 2.2 billion miles to arrive at the asteroid in August 2029.

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Astronomy News in Brief (2)

- Early riser: The Sun is already starting its next solar cycle – despite being halfway through its current one – The current solar cycle is expected to continue for another six years, but astronomers have detected early indicators of the next cycle through subtle changes in the sun's internal rotation patterns. They can spot bands that rotate a bit faster or slower, moving towards the Sun's equator and poles as its activity changes, and these faster-moving bands often appear just before a new solar cycle starts. This data is similar to a feature spotted in 2017, at the beginning of the current solar cycle. However, the current cycle, cycle 25, is still ongoing and at its peak, and the data doesn't mean that the new cycle is starting prematurely
- Scientists pin down the origins of the Moon's tenuous atmosphere – The Moon has a thin atmosphere, called an "exosphere", primarily formed by "impact vaporization". Using lunar soil samples from NASA's Apollo missions to analyse isotopes of potassium and rubidium, scientists from MIT and the University of Chicago have identified that, over its 4-5-billion-year history, the Moon's surface has been bombarded by meteorites and that the impacts vaporize the atoms that form the exosphere. It is estimated that around 70% of the Moon's atmosphere is caused by impact vaporization, while solar wind (ion sputtering) contributes around 30%. Understanding this process helps explain the Moon's history and could apply to other moons and asteroids.

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Astronomy News in Brief (3)

- **Discovery of ancient stars on the stellar thin disk of the Milky Way –** An international team led by astronomers from the Leibniz Institute for Astrophysics Potsdam (AIP) have used Gaia mission data to study stars in the solar neighbourhood, finding many ancient stars in thin disk orbits. Some of these are over 13 billion years old and show a wide range of metal content, indicating rapid metal enrichment in the early Milky Way. This suggests that the Milky Way's thin disk formation started 4-5 billion years earlier than previously believed, aligning with timelines observed in high-redshift galaxies. Similar techniques will be applied to analyse data from the upcoming 4MOST telescope, starting in 2025.
- **New massive eccentric brown dwarf discovered** – A new brown dwarf, designated TOI-2490 b, has been reported by an international team of astronomers using TESS. The object is about 74 times more massive than Jupiter and orbits a sun-like star in a highly eccentric orbit; completing one orbit every 60.33 days, at a distance of approximately 0.31 AU. It has a high orbital eccentricity of 0.78, indicating that it is highly elliptical, rather than circular, with a fluctuating temperature between 545 to 1,552 K as it travels around its orbit. The brown dwarf is likely to have formed via stellar formation mechanisms and is assumed to have a similar metallicity and age to its host star, which as massive as our Sun and estimated to be 7.9 billion years old.

Lewes Astronomical Society

Astronomy News in Brief (4)

- A new study shows how the sun could permanently capture rogue planets – Interest in interstellar objects (ISOs) surged after Oumuamua and 2I/Borisov passed through our Solar System, confirming that ISOs are common and regularly visit us. A recent study identifies a region in the Solar System where ISOs can be permanently captured by the Sun’s gravity, allowing them to remain in orbit indefinitely without colliding with the Sun. This research suggests that the Sun could capture various objects, including rogue planets, so influencing the orbits of other bodies in the Solar System. These findings have significant implications for future ISO studies and potential space missions.
- Gaia spots possible moons around hundreds of asteroids - ESA's Gaia mission has identified potential moons around 352 asteroids that were not previously known to have companions, nearly doubling the number of known binary asteroids. Gaia's ultra-accurate astrometric data enabled these "blind" discoveries, highlighting its ability as a powerful asteroid explorer. The mission has also provided precise data on asteroid positions, motions, and compositions, significantly improving our understanding of these objects. Gaia's contributions will continue with future data releases, including insights into binary asteroid systems, which will be further explored by ESA's upcoming Hera mission.

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Astronomy News in Brief (5)

- **Elliptical orbits could be essential to the habitability of rocky planets -** Kepler's discovery of elliptical orbits was crucial for aligning astronomical models with observations. A recent study by astronomers from the University of Leeds suggests that orbital eccentricity (how elliptical a planet's orbit is) may be vital for the emergence of life. Using climate simulations, the study found that planets with highly eccentric orbits could have more habitable land area than those with circular orbits. These findings could impact the search for habitable exoplanets, especially as next-generation telescopes like PLATO and the ELT will be better equipped to detect eccentric Earth-like planets.
- **Are Andromeda and the Milky Way doomed to collide?** Maybe not - Astronomers have long believed that the Milky Way and Andromeda galaxies will merge, but new research from the University of Helsinki suggests there's only a 50% chance this will happen in the next 10 billion years. The uncertainty stems from the gravitational influences of other galaxies in the Local Group, like the Triangulum galaxy (M33) and the Large Magellanic Cloud, which complicate the dynamic between the Milky Way and Andromeda. The study highlights the difficulty in making precise predictions due to the complex interactions and uncertainties involved. While the future collision remains uncertain, if it occurs, it will happen long after the Sun has burned out, potentially offering future humans access to an additional galaxy's resources.

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Spaceflight News

Lewes Astronomical Society

Deep water found on Mars (1)

- Geophysicists, using NASA's InSight lander's seismic data analysis and rock physics models (similar to those used on Earth for mapping underground aquifers), have detected a large underground reservoir of liquid water on Mars, potentially enough to cover the planet to a depth of 1–2 km.
- This discovery is important for understanding Mars' geological history and water cycle and suggests a potential habitat for life.
- It also helps to explain what happened to Mars' water after its surface oceans disappeared over 3 billion years ago, revealing that much of it may have filtered into the crust rather than evaporating into space.
- Since the water is located in tiny cracks and pores within the Martian crust about 11.5–20 km below the surface, it will be challenging to access it for future Mars colonies. However, the discovery still helps to improve our understanding of the planet's potential to support life and informs future exploration missions.

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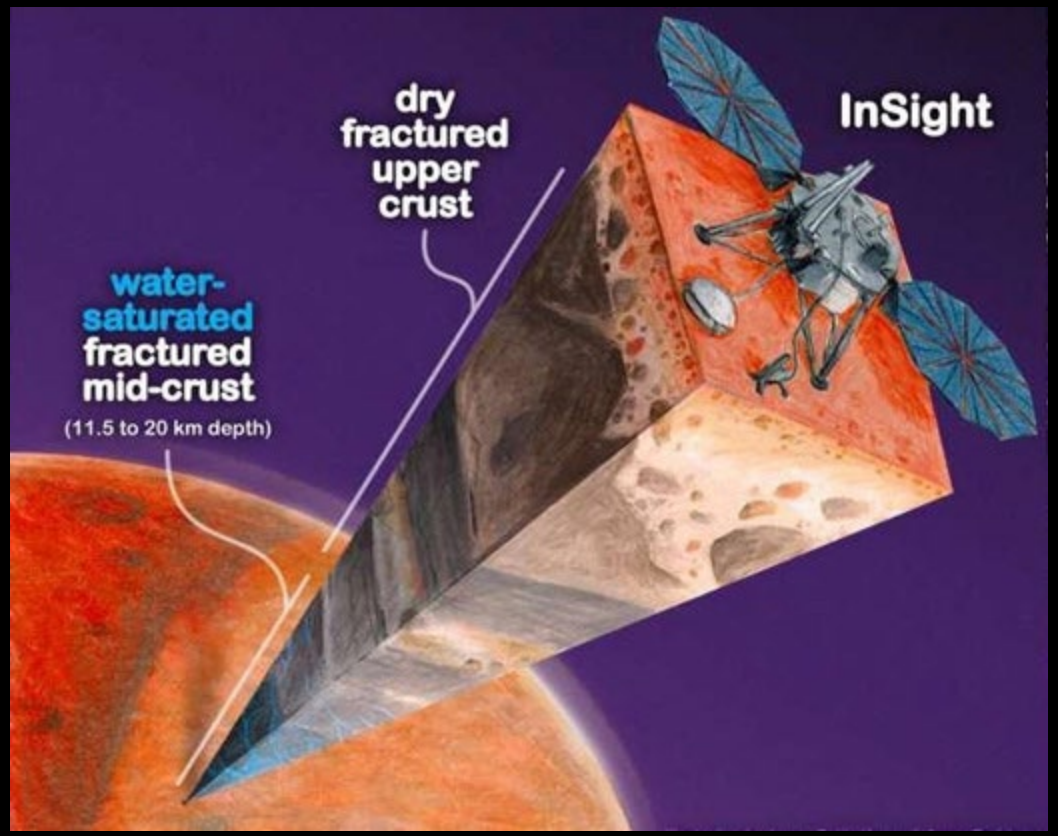
Deep water found on Mars (2)

- A cutout of the Martian interior beneath NASA's Insight lander. The top 5 kilometres of the crust appear to be dry, but a new study provides evidence for a zone of fractured rock 11.5–20 km below the surface that is full of liquid water—more than the volume proposed to have filled hypothesized ancient Martian oceans.



Credit: James Tuttle Keane and Aaron Rodriquez, courtesy of Scripps Institute of Oceanography

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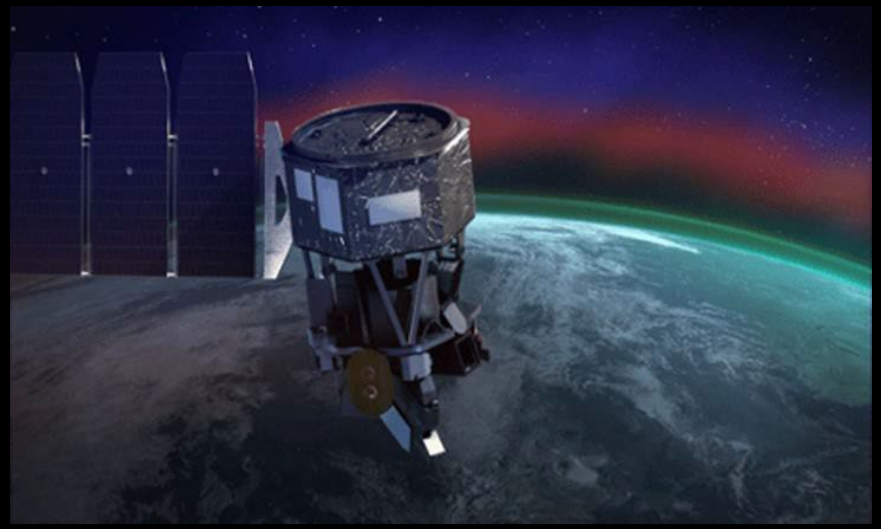
NASA’s ICON Mission comes to an end (1)

- The Ionospheric Connection Explorer (ICON) launched in October 2019. Its original two-year mission was extended by a further year. Now, its final mission has come to an end as, despite best efforts, communication could not be re-established since being lost in November 2022.
- ICON studied the boundary between Earth’s atmosphere and space - the ionosphere, located 55 miles to 360 miles above Earth’s surface - and provided critical insights into the interactions between terrestrial and space weather.
- The mission captured unprecedented data, including direct measurements of ionized particles and airglow (created by a process similar to what creates the aurora), thus enhancing our understanding of the ionosphere’s dynamics and structure.



Artist’s Impression of ICON in Orbit. Credit: NASA

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NASA’s ICON Mission comes to an end (2)

Credit: NASA GSFC/Mary Pat Hrybyk-Keith

- It also provided the first concrete observation of winds fuelling the ionospheric dynamo; a process influencing space weather and affecting technology where unpredictable terrestrial winds move plasma around the ionosphere, sending the charged particles shooting out into space or plummeting toward Earth. Complex electric and magnetic fields are created due to the electrically charged tug-of-war between the ionosphere and the Earth’s electromagnetic field, which has never been observed before.
- ICON’s legacy includes breakthrough discoveries and a vast dataset that will continue to inform future scientific research.

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NASA streams first 4K video to space station (1)

- Historically, NASA has relied on radio waves to send information to and from space.
- Now, a team at NASA's Glen Research Center in Cleveland has streamed 4K video footage from an aircraft to the International Space Station (ISS) and back for the first time using optical (laser) communications.
- Glenn engineers worked together with the Air Force Research Laboratory and NASA's Small Business Innovation Research program to install a portable laser terminal on the underside of a Pilatus PC-12 aircraft.

From left to right, Kurt Blankenship, research aircraft pilot, Adam Wroblewski, instrument operator, and Shaun McKeehan, High-Rate Delay Tolerant Networking software developer, wait outside the PC-12 aircraft, preparing to take flight. Credit: NASA/Sara Lowthian-Hanna

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NASA streams first 4K video to space station (2)

A graphic representation of a laser communications relay between the International Space Station, the LCRD, and the Earth. Credit: NASA/Dave Ryan

- Flying over Lake Erie, they sent the data from the aircraft to an optical ground station in Cleveland, where it was then sent over an Earth-based network to NASA's White Sands Test Facility in Las Cruces, New Mexico.
- Scientist then used infrared light signals to send the data, which travelled 22,000 miles to an orbiting experimental platform – NASA's Laser Communications Relay Demonstration (LCRD).
- The LCRD relayed the signals to the ILLUMA-T (Integrated LCRD LEO User Modem and Amplifier Terminal), mounted on the orbiting laboratory, which then sent data back to Earth. A new system developed at Glenn – the High-Rate Delay Tolerant Networking (HDTN) – helped the signal to penetrate cloud coverage more effectively.
- Laser communications use infrared light to transmit 10 to 100 times more data faster than radio frequency systems, making this an excellent achievement and signalling a new dawn for communications with the Space Station.

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NASA smashes spacecraft into asteroid update (1)

DART's last complete image of Dimorphos, about 12km from the asteroid and 2 seconds before impact. Credit: NASA/Johns Hopkins APL

- NASA's Double Asteroid Redirection Test, or DART mission, launched on 24th November 2021, was humanity's first real-world planetary defence mission. The aim was to test our ability to alter the trajectory of an asteroid, and to gather data on potential impacts from such objects.
- On 26th September 2022, DART smashed into the companion "moon" of a small asteroid at 6.1km/s, 11 million kilometres from Earth. The asteroid is named "Didymos" and the moon "Dimorphos".
- The impact was a surprising success and shortened the orbit of Dimorphos around Didymos by more than half an hour.

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NASA smashes spacecraft into asteroid update (2)

- Since our planetary defence relies upon understanding not only the composition of asteroids, but of how they're put together, research has been carried out to understand how many asteroids are solid objects, or loosely bundled piles of rubble.
- Since the chosen asteroid and its moon are what's known as a binary asteroid system, they presented a perfect target for the DART mission, allowing the effects of the impact to be measured in changes to the moon's orbit. Researchers may also gain insight into how binary asteroid systems form.
- In a new study, a team from the Johns Hopkins University in the U.S. used images from DART and LICIACube to estimate the age of the system. By looking at the surface roughness and crater records, they found that Didymos is roughly 12.5 million years old and that Dimorphos, its moon, formed less than 300,000 years ago, making it much younger than expected.

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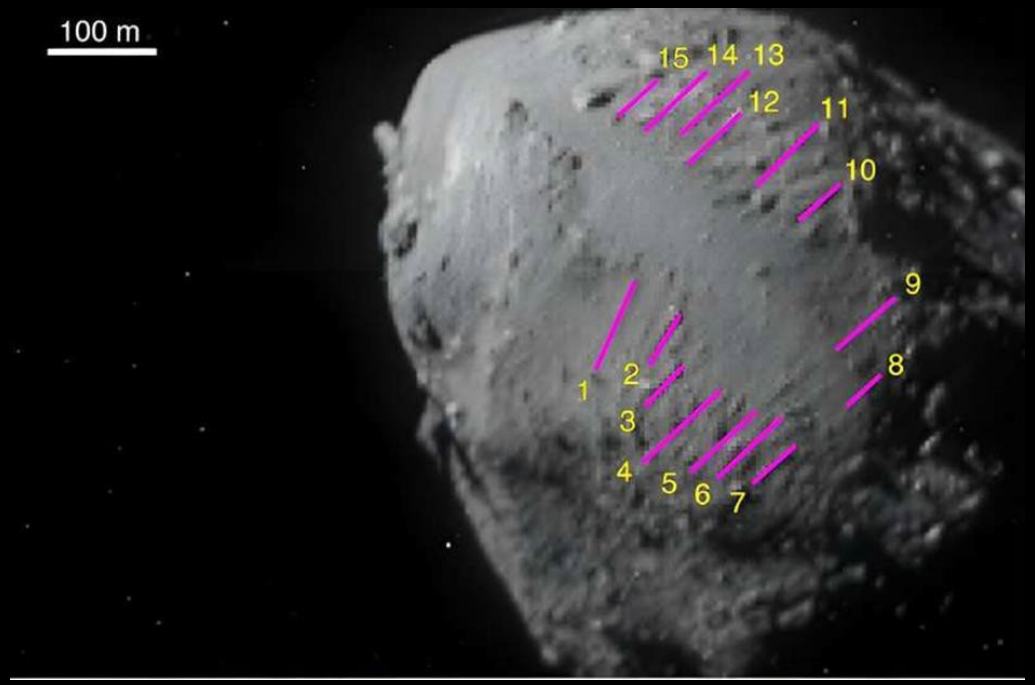
NASA smashes spacecraft into asteroid update (3)

- Dimorphos is not a solid rock, but a rubble pile of boulders. As sunlight caused Didymos to spin, its shape became squashed and bulged in the middle. This caused large pieces to roll off from the main body and slowly created a ring of debris around the asteroid which, over time, started coalescing to become the small moon.
- Another new study suggested that boulders on all asteroids that space missions have so far visited were likely shaped in the same way, but that the excess of large boulders on the Didymos system could be unique to binaries.



The locations of 15 suspected boulder tracks on the surface of Didymos. Credit: Bigot, Lombardo et al., (2024)/Image taken by DRACO/DART (NASA)

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NASA smashes spacecraft into asteroid update (4)

Artist impression of scene pre-asteroid impact. Credit: ESA

- Lastly, a final study showed that this type of asteroid is more susceptible to cracking, which occurs due to the heating-cooling cycles between day and night. This suggests that if a spacecraft were to make impact, there would be much more debris thrown out, but that there may be more solid matter beneath.
- From here, ESA's Hera mission, due to be launched in October 2024, will perform a detailed post-impact survey of Dimorphos, turning the grand-scale experiment into a well-understood and repeatable planetary defence technique.

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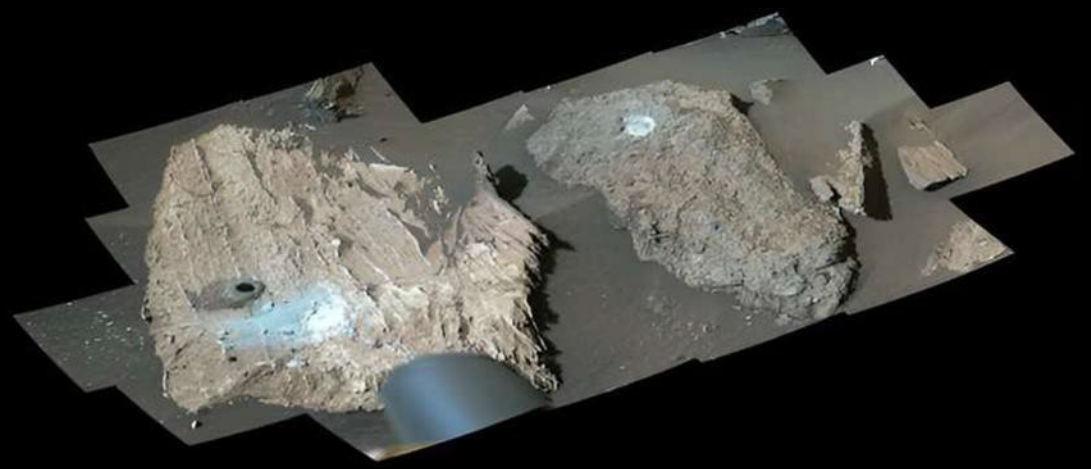
Perseverance rocks Mars' world (1)



Cheyava Falls is named after a site in Arizona. Credit: NASA/JPL-Caltech

- NASA's Perseverance Mars Rover may have made its most remarkable discovery yet: potential signs of ancient life on Mars. In the Neretva Vallis, an ancient river valley within the Jezero Crater, the rover discovered a rock named "Cheyava Falls," which might contain fossilized microbes dating back billions of years.
- On 21st July 2024, the rover drilled into the rock to collect a core sample, which will eventually be sent back to Earth for detailed analysis. The rock features calcium sulphate veins, indicating that water once flowed through it. Between these veins lies a reddish area rich in organic compounds, detected by the rover's SHERLOC instrument.

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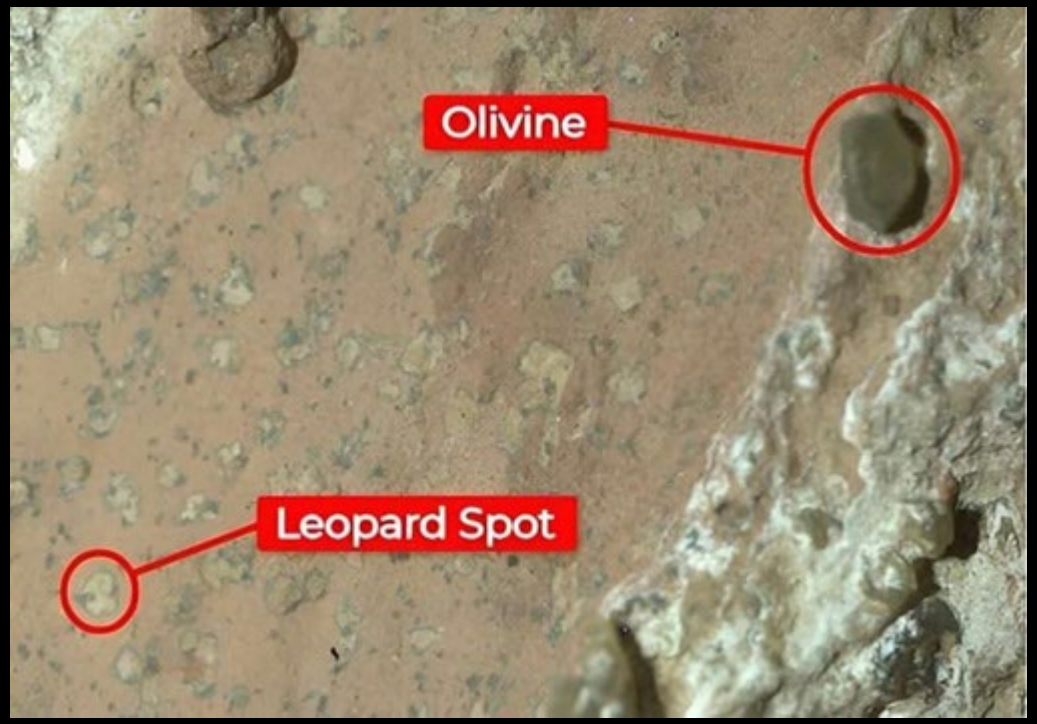
Perseverance rocks Mars' world (2)

- The rock also has tiny off-white splotches surrounded by black rings, containing chemicals that suggest possible energy sources for ancient microbes. On Earth, similar features are often linked to fossilised microbes that utilized oxidised iron as an energy source, much like humans use oxygen from the air.
- However, the veins are also filled with olivine crystals, a mineral typically formed from magma. This raises the question: was the olivine and sulphate introduced at temperatures too high for life, and could the white splotches have formed through non-biological processes?



Reduction spots can be produced by microbial activity on Earth, but there are other explanations. Credit: NASA/JPL-Caltech

- The true test will come when these rock samples are returned to Earth, as part of the Mars Sample Return Program, a collaboration between NASA and ESA, slated for the 2030s. This will allow scientists to study what really occurred in the Martian River valley.

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Fly-around observation images of debris released

- The Japan Aerospace Exploration Agency (JAXA) has released images of space debris, captured during “Fly-around observation”, under its Commercial Removal of Debris Demonstration (CRD2) Phase I project.
- The fly-around observation is the third out of four services required during phase I and involves pointing a camera at the target debris and maintaining a constant distance, while orbiting around to capture images from different directions.
- The high-quality images reveal detailed information about the debris, including surface features and potential degradation, and marks the progression toward achieving CRD2’s two objectives: improving debris removal technology and enhancing Japanese on-orbit services competitiveness.
- To watch the video of the “Fly-Around Observation”, please click the following link: JAXA Space Debris Video

Images of the target space debris taken during the fly-around observation on 16th July 2024. The order of the images progresses from top left to bottom right. (H-IIA upper stage, which launched Greenhouse Gases Observing Satellite (GOSAT), also known as Ibuki in 2009, H2A R/B, International Designator: 2009-002J, Catalog Number: 33500, the bottom of the image is toward the nadir direction). Credit: JAXA

Lewes Astronomical Society

Spaceflight News and Updates (1)

- **Senegal's first satellite successfully launched –** Senegal's first satellite, GAINDSEAT-1A, was launched into orbit from California's Vandenberg base at 18:56 GMT Friday 16th August 2024. President Bassirou Diomaye Faye hailed the achievement as a significant step toward the country's "technological sovereignty", after five years of effort by Senegalese engineers, in collaboration with the French Montpellier University Space Centre. The satellite, launched via a Falcon 9 rocket, will gather data for various state agencies, including those managing water resources and meteorology.
- **Spacecraft swung by Earth and moon on path to Jupiter –** ESA's JUICE probe was launched in April 2023 on a mission to determine the life hosting capabilities of Jupiter's icy moons Ganymede, Callisto, and Europa. It completed a world-first lunar-Earth flyby on 19th–20th August, with flight controllers guiding the spacecraft. The gravity of the moon and Earth changed JUICE's speed and direction, sending it on a shortcut to Jupiter via Venus. It is expected to reach Jupiter in July 2031.

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Spaceflight News and Updates (2)

- **Experiment on photosynthesis is heading to the space station to explore effects of microgravity –** an experiment by scientists at the Department of Energy's Pacific Northwest National Laboratory (PNNL) will study how two types of grass grow in space aboard a NASA mission, launched in early August. The study, led by biologist Pubudu Handakumbra, will compare photosynthesis in a microgravity environment on the ISS with identical plants grown at the Kennedy Space Centre. This research aims to understand plant growth in space, which is crucial for deep space exploration. Astronauts will monitor 288 plants photosynthesis before returning them to Earth for further analysis.
- **NASA, JAXA bounce laser beam between moon's surface and lunar orbit -** NASA's Lunar Reconnaissance Orbiter (LRO) successfully transmitted and received laser signals from a retroreflector aboard JAXA's SLIM lander on the Moon twice during orbits on 24th May 2024. This achievement is significant because the retroreflector, a small device designed to reflect laser signals, was not in an optimal position, with its top facing sideways instead of upward. LRO engineers, working with JAXA, calculated the best timing and trajectory to hit the retroreflector despite its challenging orientation. This success demonstrates the resilience of these devices, which can last for decades on the Moon's surface and aid future missions, including guiding Artemis astronauts.

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Spaceflight News and Updates (3)

- China launches rocket carrying new constellation of satellites – China claimed that it launched a rocket at the end of July, carrying a constellation of a reported 18 satellites as part of efforts to assert its presence in space. The satellites were carried into orbit aboard a Long March-6 carrier rocket from the Taiyun Satellite Launch Center in north China's Shanxi Province. Official Xinhua News Agency said that rocket had reached its pre-programmed orbit without incident.
- NASA decides to keep two astronauts in space until February – NASA have made the decision to delay the return of two of its astronauts from the ISS due to safety concerns with Boeing's Starliner capsule. The mission was initially intended to be a weeklong test flight but will now be extended to over eight months. Due to multiple thruster failures and helium leaks, the astronauts, Butch Wilmore and Suni Williams, will return to Earth aboard a SpaceX Dragon spacecraft next February. The Dragon spacecraft will arrive at the ISS in September carrying just two astronauts instead of the usual four in order to make space for Wilmore and Williams on the return trip. Prior to the Dragon's arrival, the unmanned Starliner capsule will be undocked and an attempted landing made in the New Mexico desert. Despite this setback, NASA remains committed to Boeing's Starliner, aiming for another crew flight in the future.

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Spaceflight News and Updates (4)

- **Debris concerns cause SpaceX to shift Dragon capsule landings from Florida to California** – starting in 2025 due to concerns about debris from the capsule's trunk, which detaches before re-entry. Initially, models predicted that the trunk would fully burn up upon re-entry, but debris has since been discovered in various locations, including Australia and North Carolina. SpaceX will now keep the trunk attached until after the deorbit burn, ensuring it lands in unpopulated areas of the Pacific. Recovery operations will be based out of the Port of Long Beach.
- **SpaceX announces new private mission on 1st human polar orbit spaceflight** – SpaceX has announced a private mission, Fram2, set to launch from Florida by the end of 2024, marking its first human spaceflight into polar orbit. Using SpaceX's Crew Dragon capsule, the mission aims to explore polar regions from space, study aurora-like light emissions, and conduct groundbreaking research, including the first human X-ray images in space. The mission will last 3–5 days and fly at altitudes between 264 to 279 miles.
- **SpaceX knocks out company's 50th Space Coast launch of the year** – SpaceX successfully launched three Falcon 9 rockets over the weekend after the FAA lifted a grounding; imposed due to a July incident involving a liquid oxygen leak. The first launch carried 23 Starlink satellites from the Kennedy Space Centre, marking SpaceX's 50th launch from the Space Coast in 2024.

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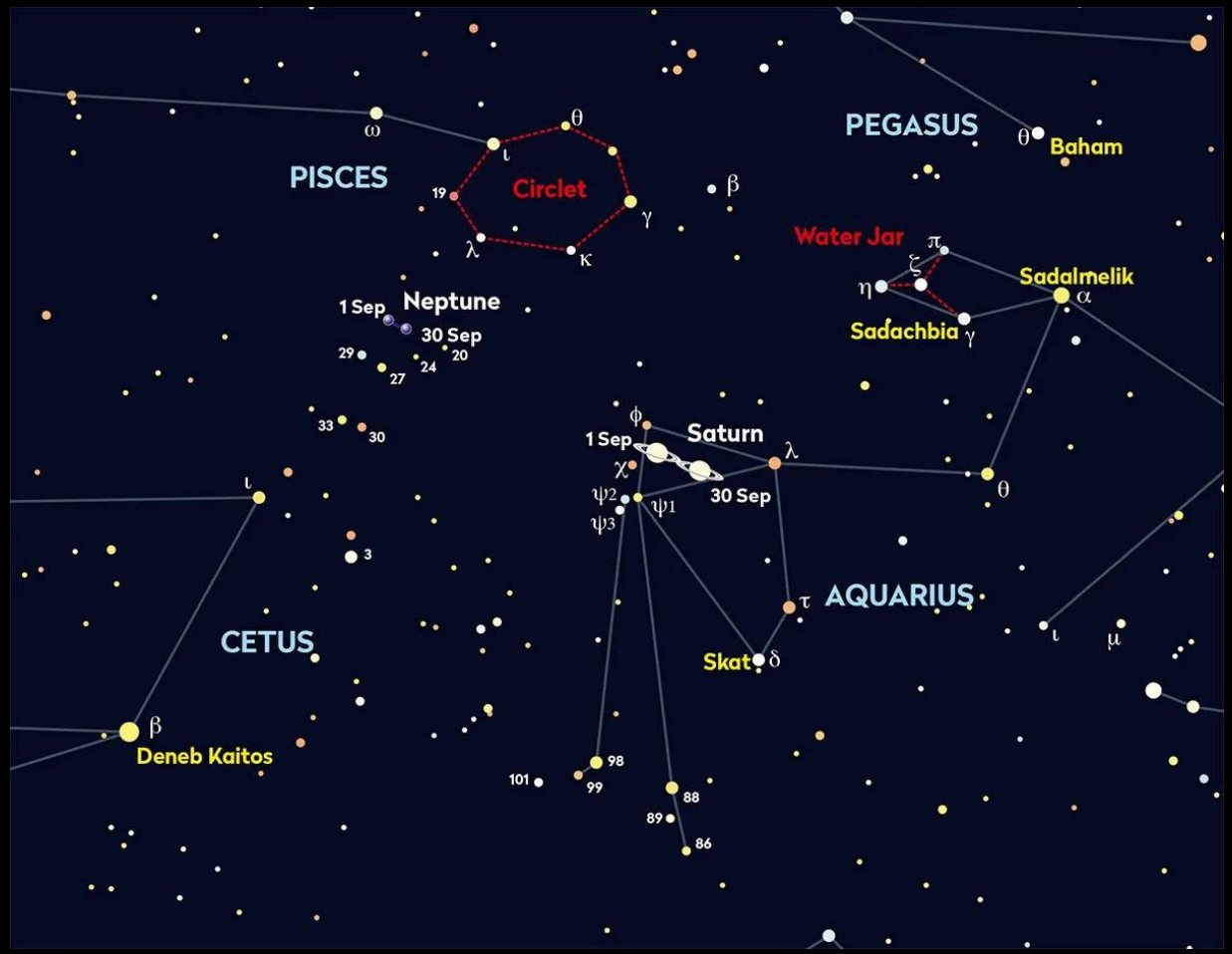
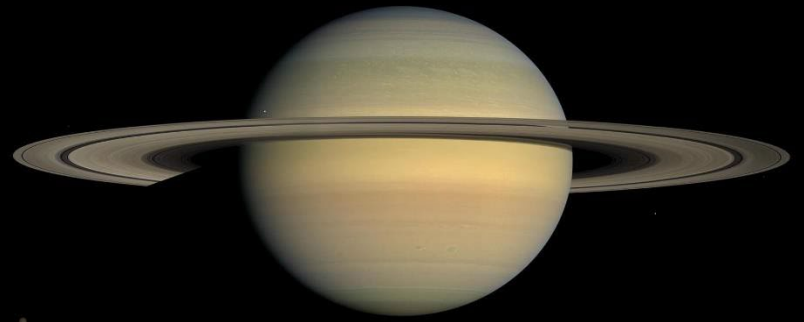
Observational Highlights

Lewes Astronomical Society

Saturn at opposition



Credit: Pete Lawrence/BBC Sky at Night magazine



Credit: NASA

- Saturn will be at opposition on Sunday 8th September (05:27 BST/04:27 GMT).
- It will lie in the constellation of Aquarius, reaching its highest point at 01:01 BST, 31° above the southern horizon.
- It will be 8.66 AU from Earth, which makes it relatively close, and brighter and larger than normal
- However, as the rings are almost side on (tilted by only 3.7°) and therefore not reflecting sunlight back to Earth, its apparent brightness is only +0.66.

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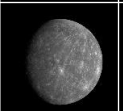
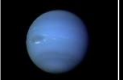
Planets (information for 1st September)

	Planet	Rises	Sets	Highest	Direction	Altitude	Magnitude	Visible
	MERCURY	04:40	19:01	11:51			+0.49	NO
	VENUS	08:23	20:30	14:26			-3.84	NO
	MARS	23:52	16:17	08:05	South-East	48° ▫	+0.74	YES
	JUPITER	23:22	15:33	07:27	South-East	55° ▫▫	-2.28	YES
	SATURN	20:03	06:57	01:30	South	31°	+0.62	YES
	URANUS	22:10	13:41	05:55	South-East	55° *	+5.71	YES
	NEPTUNE	20:19	08:10	02:15	South	37°	+7.82	YES

* = Highest point at Dawn (04:47 - last visible sighting)

** = Highest point at Dusk (21:08 - first visible sighting)

▫ = Highest point when last visible (05:27)

◊ = Highest point when first visible

▫▫ = Highest point when last visible (05:50)

◊◊ = Highest point when first visible

Lewes Astronomical Society

100 Deep Sky Objects - 1 (Information for 1st September)

Object	Name	Constellation	Type	↗	↘	Highest	Direction	Alt	Mag
Cr70	Orion's Belt	Orion	Open Cluster	01:54	05:29	05:29 ◊	South-East	29°	+0.6
Cr50	The Hyades	Taurus	Open Cluster	23:17	05:23	05:23 ◊	South-East	51°	+1.0
Mel20	The Alpha Persei Cluster	Perseus	Open Cluster	20:36	05:20	05:20 ◊	South-East	86°	+1.2
Cr39	Collinder 39	Perseus	Open Cluster	20:36	05:20	05:20 ◊	South-East	86°	+1.2
M45	The Pleiades	Taurus	Cluster with Nebulosity	21:46	05:19	05:19 ◊	South-East	61°	+1.3
Mel111	The Coma Star Cluster	Coma Berenices	Open Cluster	20:44	23:13	20:44 ◊◊	West	19°	+1.8
Cr256	Collinder 256	Coma Berenices	Open Cluster	20:44	23:12	20:44 ◊◊	West	19°	+1.8
NGC1980	Open Cluster	Orion	Cluster with Nebulosity	02:17	05:02	05:02 ◊	South-East	22°	+2.5
C33	The Eastern Veil Nebula	Cygnus	Nebula	21:08	04:47	23:10	South	70°	+2.7
Cr69	The Lambda Orionis Cluster	Orion	Open Cluster	00:58	04:48	04:48 ◊	South-East	35°	+2.8
Mel186	Melotte 186	Ophiuchus	Open Cluster	21:01	02:34	21:01 ◊◊	South	41°	+3.0
Cr359	Collinder 359	Ophiuchus	Open Cluster	21:01	02:33	21:01 ◊◊	South	41°	+3.0
Cr65	Collinder 65	Orion	Open Cluster	00:17	04:55	04:55 ◊	South-East	41°	+3.0
M31	Andromeda Galaxy	Andromeda	Galaxy	21:08	04:48	04:48 ◊	West	69°	+3.4
Cr439	The Elephant Trunk	Cepheus	Cluster with Nebulosity	21:08	04:47	23:53	North	83°	+3.5

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◊ = Bright object last visible sighting after dawn ◊◊ = Bright object first visible sighting before dusk

Lewes Astronomical Society

100 Deep Sky Objects - 2 (Information for 1st September)

Object	Name	Constellation	Type	↗	↘	Highest	Direction	Alt	Mag
Cr399	Brocchi's Cluster	Vulpecula	Open Cluster	21:08	03:29	21:39	South	59°	+3.6
M42	Orion Nebula	Orion	Cluster with Nebulosity	02:15	04:47	04:47 *	South-East	21°	+4.0
NGC2264	The Christmas Tree Cluster	Monoceros	Cluster with Nebulosity	02:04	04:47	04:47 *	East	24°	+4.1
Cr62	Collinder 62	Auriga	Open Cluster	00:03	04:47	04:47 *	East	58°	+4.2
Cr464	Collinder 464	Camelopardalis	Open Cluster	21:08	04:47	04:47 *	North-East	58°	+4.2
Cr349	Open Cluster	Ophiuchus	Open Cluster	21:08	02:32	21:08 **	South-West	42°	+4.2
NGC1977	Running Man Nebula	Orion	Open Cluster	02:12	04:47	04:47 *	South-East	21°	+4.2
NGC1981	Open Cluster	Orion	Open Cluster	02:10	04:47	04:47 *	South-East	22°	+4.2
C14	The Perseus Double Cluster	Perseus	Open Cluster	21:08	04:47	04:37	North	83°	+4.3
M39	Open Cluster	Cygnus	Open Cluster	21:08	04:47	21:08 **	East	64°	+4.6
Cr106	Collinder 106	Monoceros	Open Cluster	02:20	04:47	04:47 *	East	22°	+4.6
NGC6633	Open Cluster	Ophiuchus	Open Cluster	21:08	03:17	21:08 **	South	45°	+4.6
M24	Delle Caustiche	Sagittarius	Asterism	21:08	00:58	21:08 **	South	20°	+4.6
M25	Open Cluster	Sagittarius	Open Cluster	22:27	22:48	23:38	South	20°	+4.6
Cr386	Graff's Cluster	Serpens Cauda	Open Cluster	21:08	03:24	21:08 **	South	44°	+4.6

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◊ = Bright object last visible sighting after dawn ◊◊ = Bright object first visible sighting before dusk

Lewes Astronomical Society

100 Deep Sky Objects - 3 (Information for 1st September)

Object	Name	Constellation	Type	↗	↘	Highest	Direction	Alt	Mag
NGC2244	Open Cluster	Monoceros	Open Cluster	02:20	04:47	04:47 *	East	22°	+4.8
NGC1499	The California Nebula	Perseus	Bright Nebula	21:08	04:47	04:47 *	South-East	67°	+5.0
M35	Open Cluster	Gemini	Open Cluster	00:06	04:47	04:47 *	East	40°	+5.1
Cr107	Collinder 107	Monoceros	Open Cluster	02:27	04:47	04:47 *	East	21°	+5.1
NGC6871	Open Cluster	Cygnus	Open Cluster	21:08	04:47	22:20	South	74°	+5.2
M34	The Spiral Cluster	Perseus	Open Cluster	21:29	04:47	04:47 *	North-East	81°	+5.2
NGC869	h Per Cluster	Perseus	Open Cluster	21:08	04:47	04:36	North	83°	+5.3
NGC2281	Open Cluster	Auriga	Open Cluster	01:49	04:47	04:47 *	North-West	45°	+5.4
Cr97	Collinder 97	Monoceros	Open Cluster	02:15	04:47	04:47 *	East	23°	+5.4
NGC7686	Open Cluster	Andromeda	Open Cluster	21:08	04:47	04:47 *	West	61°	+5.6
M37	The Auriga Salt-and-Pepper	Auriga	Open Cluster	22:35	04:47	04:47 *	East	49°	+5.6
NGC752	Open Cluster	Andromeda	Open Cluster	21:23	04:47	04:15	East	71°	+5.7
Cr89	Collinder 89	Gemini	Open Cluster	00:20	04:47	04:47 *	East	38°	+5.7
M5	Globular Cluster	Serpens Caput	Globular Cluster	21:08	23:47	21:08 **	South-West	23°	+5.7
NGC6882	Open Cluster	Vulpecula	Open Cluster	21:08	04:18	22:26	South	65°	+5.7

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◊ = Bright object last visible sighting after dawn
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100 Deep Sky Objects - 4 (Information for 1st September)

Object	Name	Constellation	Type	↗	↘	Highest	Direction	Alt	Mag
M13	Great Globular Cluster	Hercules	Globular Cluster	21:08	05:28	21:08 **	West	62°	+5.8
M11	Wild Duck Cluster	Scutum	Open Cluster	21:08	02:38	21:08 **	South	32°	+5.8
M33	Triangulum Galaxy	Triangulum	Galaxy	21:39	04:47	03:51	South	69°	+5.8
NGC2169	The "37" Cluster	Orion	Open Cluster	01:10	04:47	04:47 *	East	32°	+5.9
Cr29	Collinder 29	Perseus	Open Cluster	21:08	04:47	04:47 *	North	84°	+5.9
M36	The Pinwheel Cluster	Auriga	Open Cluster	21:59	04:47	04:47 *	East	52°	+6.0
IC405	The Flaming Star Nebula	Auriga	Nebula	21:36	04:47	04:47 *	East	55°	+6.0
NGC7000	The North American Nebula	Cygnus	HII Region	21:08	04:47	21:08 **	East	68°	+6.0
M17	The Omega Cluster	Sagittarius	Open Cluster	21:08	01:16	21:08 **	South	22°	+6.0
M16	The Eagle Nebula	Serpens Cauda	Open Cluster	21:08	01:27	21:08 **	South	24°	+6.0
NGC6605	Open Cluster	Serpens Cauda	Open Cluster	21:08	01:18	21:08 **	South	23°	+6.0
NGC7160	Open Cluster	Cepheus	Open Cluster	21:08	04:47	00:11	North	78°	+6.1
M12	Globular Cluster	Ophiuchus	Globular Cluster	21:08	00:56	21:08 **	South-West	30°	+6.1
Cr350	Collinder 350	Ophiuchus	Open Cluster	21:08	02:13	21:08 **	South	38°	+6.1
NGC884	chi Per Cluster	Perseus	Open Cluster	21:08	04:47	04:39	North	83°	+6.1

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Lewes Astronomical Society

100 Deep Sky Objects - 5 (Information for 1st September)

Object	Name	Constellation	Type	↗	↘	Highest	Direction	Alt	Mag
NGC1746	Open Cluster	Taurus	Open Cluster	23:05	04:47	04:47 *	South-East	49°	+6.1
NGC1545	Open Cluster	Perseus	Open Cluster	21:08	04:47	04:47 *	East	72°	+6.2
M3	Globular Cluster	Canes Venatici	Globular Cluster	21:08	00:49	21:08 **	West	28°	+6.3
M15	Globular Cluster	Pegasus	Globular Cluster	21:08	04:24	23:44	South	51°	+6.3
NGC6940	Open Cluster	Vulpecula	Open Cluster	21:08	04:47	22:48	South	67°	+6.3
M38	The Starfish Cluster	Auriga	Open Cluster	21:25	04:47	04:47 *	East	54°	+6.4
NGC457	The Dragonfly Cluster	Cassiopeia	Open Cluster	21:08	04:47	03:37	North	82°	+6.4
NGC7243	Open Cluster	Lacerta	Open Cluster	21:08	04:47	04:47 *	North-West	50°	+6.4
NGC1662	Open Cluster	Orion	Open Cluster	00:06	04:47	04:47 *	South-East	41°	+6.4
NGC1528	Open Cluster	Perseus	Open Cluster	21:08	04:47	04:47 *	East	73°	+6.4
NGC1647	Open Cluster	Taurus	Open Cluster	23:18	04:47	04:47 *	South-East	48°	+6.4
Cr26	The Heart Nebula	Cassiopeia	Cluster with Nebulosity	21:08	04:47	04:47 *	North	79°	+6.5
Cr34	The Soul Nebula	Cassiopeia	Cluster with Nebulosity	21:08	04:47	04:47 *	North	79°	+6.5
NGC129	Open Cluster	Cassiopeia	Open Cluster	21:08	04:47	02:47	North	80°	+6.5
NGC654	Open Cluster	Cassiopeia	Open Cluster	21:08	04:47	04:01	North	78°	+6.5

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Lewes Astronomical Society

100 Deep Sky Objects - 6 (Information for 1st September)

Object	Name	Constellation	Type	↗	↘	Highest	Direction	Alt	Mag
M92	Globular Cluster	Hercules	Globular Cluster	21:08	02:50	21:08 **	West	71°	+6.5
NGC6604	Open Cluster	Serpens Cauda	Open Cluster	21:08	01:34	21:08 **	South	26°	+6.5
M2	Globular Cluster	Aquarius	Globular Cluster	21:08	03:17	23:47	South	38°	+6.6
M29	The Cooling Tower	Cygnus	Open Cluster	21:08	04:47	22:38	South	77°	+6.6
M10	Globular Cluster	Ophiuchus	Globular Cluster	21:08	00:55	21:08 **	South-West	29°	+6.6
NGC1444	Open Cluster	Perseus	Open Cluster	21:08	04:47	04:47 *	East	77°	+6.6
NGC6709	Open Cluster	Aquila	Open Cluster	21:08	04:01	21:08 **	South	49°	+6.7
NGC1027	Open Cluster	Cassiopeia	Open Cluster	21:08	04:47	04:47 *	North	79°	+6.7
NGC7789	The Caroline's Rose	Cassiopeia	Open Cluster	21:08	04:47	02:15	North	84°	+6.7
NGC1342	Open Cluster	Perseus	Open Cluster	21:08	04:47	04:47 *	South-East	72°	+6.7
NGC7023	The Iris Nebula	Cepheus	Nebula	21:08	04:47	23:15	North	72°	+6.8
NGC6811	The Hole in a Cluster	Cygnus	Open Cluster	21:08	04:47	21:08 **	South-East	81°	+6.8
NGC2175	Open Cluster	Orion	Cluster with Nebulosity	00:32	04:47	04:47 *	East	37°	+6.8
NGC1502	Open Cluster	Camelopardalis	Open Cluster	21:08	04:47	04:47 *	North-East	72°	+6.9
M52	The Cassiopeia Salt-and-Pepper	Cassiopeia	Open Cluster	21:08	04:47	01:42	North	79°	+6.9

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100 Deep Sky Objects - 7 (Information for 1st September)

Object	Name	Constellation	Type	↗	↘	Highest	Direction	Alt	Mag
M81	Bode's Galaxy	Ursa Major	Galaxy	21:08	04:47	04:47 *	North	40°	+6.9
NGC1857	Open Cluster	Auriga	Open Cluster	00:41	04:47	04:47 *	North-West	58°	+7.0
NGC225	The Sailboat Cluster	Cassiopeia	Open Cluster	21:08	04:47	03:01	North	79°	+7.0
NGC7635	The Bubble Nebula	Cassiopeia	HII Region	21:08	04:47	01:38	North	79°	+7.0
NGC6960	The Western Veil Nebula	Cygnus	Supernova Remnant	21:08	04:47	23:00	South	69°	+7.0
NGC7063	Open Cluster	Cygnus	Open Cluster	21:08	04:47	23:38	South	75°	+7.0
Cr111	Collinder 111	Monoceros	Open Cluster	02:17	04:47	04:47 *	East	22°	+7.0
NGC1582	Open Cluster	Perseus	Open Cluster	23:25	04:47	04:47 *	East	68°	+7.0
NGC1807	Open Cluster	Taurus	Open Cluster	23:58	04:47	04:47 *	South-East	43°	+7.0
NGC663	Open Cluster	Cassiopeia	Open Cluster	21:08	04:47	04:03	North	79°	+7.1

Twilight	Civil	Naut	Astro		Rises	Sets
Ends	20:19	21:01	21:47	Sun	06:11	19:45
Starts	05:37	04:55	04:08	Moon	03:56	19:34

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Phases of the Moon

Brown Lunation Numbers

numbered from first New Moon in 1923

Phase	Date	Time	Lunation
NEW MOON	3rd September	02:55	1258
FIRST QUARTER	11th September	07:05	1258
FULL MOON	18th September	03:34	1258
LAST QUARTER	24th September	19:49	1258

Credit: Vito Technology, Inc.

Credit: NASA
Data credit: Time and Place

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September Star Guide

On the 1st, look northeast 30 minutes before sunrise to see the super thin crescent Moon and Mercury close together. On the 4th, the Moon joins brilliant Venus shining in the western sky after sunset.

Saturn will appear at its best when it's at opposition with the Sun on the 8th, but will be visible most of the night throughout the month.

In the early hours of the 18th, the full Moon will be partially eclipsed as it moves into the shadow of the Earth. Between 3:12 and 4:17am it will appear to have a small bite taken out of it. The maximum eclipse is at 3:44am.

The autumnal equinox occurs on the 22nd. The Sun passes over the equator from north to south, so day and night are roughly of equal length. The Sun will rise due east and set due west.

Autumn is a wonderful time to observe the Milky Way (shown in grey). It's amazing how many stars you can see using binoculars.

The chart shows the night sky at 10pm at the start of September, or just after sunset at the end of the month, and the position and phase of the Moon on the 10th, 12th, and 18th September.