

# Lewes Astronomical Society

Newsletter - December 2023

**Lewes Astronomical Society**

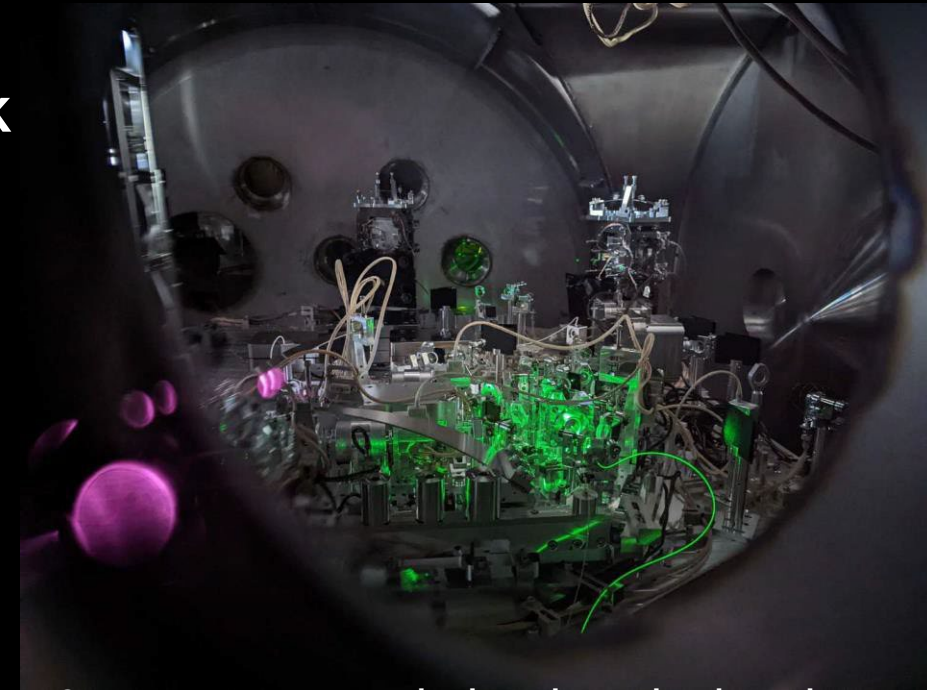
**December 2023**

**Astronomy News**

# Lewes Astronomical Society

## Beyond the quantum limit with LIGO

- For nearly ten years, LIGO has been detecting the gravitational waves caused by the merging of black holes and of neutron stars
- The ripples cause spacetime to stretch and compress, and LIGO can measure this down to 10 thousand trillion times smaller than the width of a human hair, although quantum noise limits how small these measurements can go
- Researchers have found a workaround: frequency-dependent squeezing. Light can be squeezed at different frequencies, which bypasses the quantum limit. This means LIGO can probe further and detect more mergers
- For more on squeezing, see: <https://youtu.be/j2oH9bq-FAE>

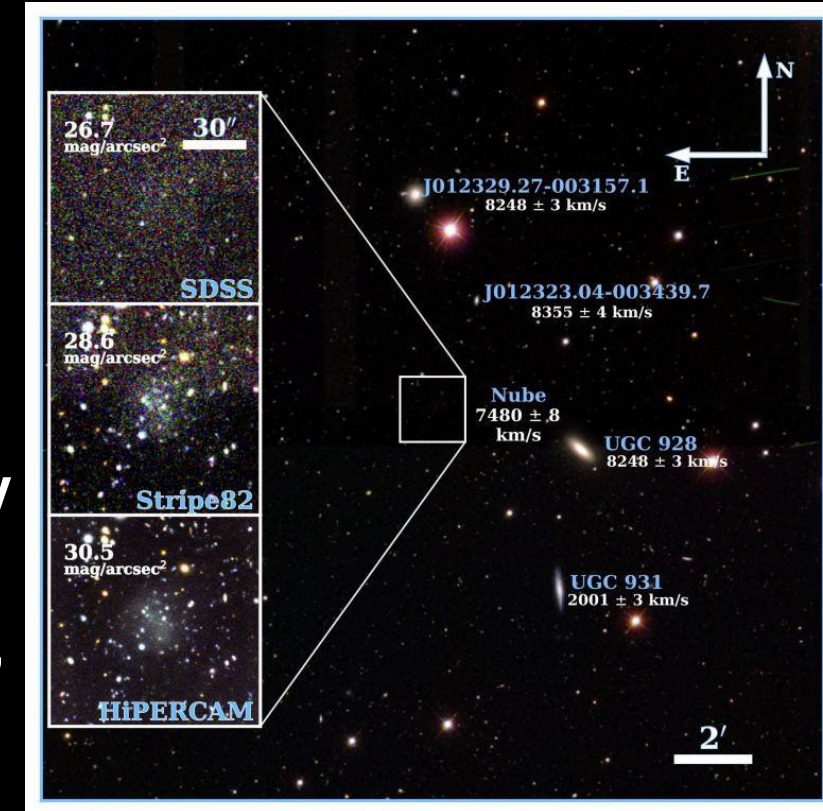


Quantum squeezer: a look at the technology that creates squeezed light in LIGO's vacuum chamber. The picture was taken from one of the chamber's viewports at a time when the squeezer was operational and pumped with green light  
Credit: Georgia Mansell/LIGO Hanford Observatory

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## Almost dark galaxies

- Galaxies contain billions of stars, causing them to shine brightly
- Some have very low surface brightness, with a central surface brightness fainter than  $26 \text{ mag/arcsec}^2$ , and are generally known as "almost dark galaxies"
- Another new rare type of galaxy has been found. Dubbed "Nube", it is about 350 million light years away and has a surface brightness of  $26.7 \text{ mag/arcsec}^2$
- At about the same size as the Small Magellanic Cloud, Nube is believed to have a low metallicity of  $-1.1$ , which allows us to estimate that it is around 10 billion years old, and completely composed of dark matter
- It is also the most massive and extended galaxy found, being 10 times fainter and 3 times as large than other ultra-diffuse galaxies (UDGs) with similar stellar masses



Credit: Mireia Montese (Instituto de Astrofísica de Canarias, La Laguna (IAC), et al

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## Oldest Milky Way-type galaxy found

- In the past few years, as telescopes like the JWST have peered further back through time to the early universe, astronomers have been astonished to find large galaxies existing less than a billion years after the Big Bang
- However, large barred spiral galaxies, like the Milky Way, are thought to take a much longer time to evolve as they require settled conditions, which certainly did not exist in the early Universe
- Bars were thought to only occur when a galaxy reaches full maturity
- Now, that theory has been turned on its head, with the JWST discovery of ceers-2112: a 2 billion years old galaxy with a redshift of 3. Either the region around the galaxy was a lot more stable than predicted, or a new hypothesis is required

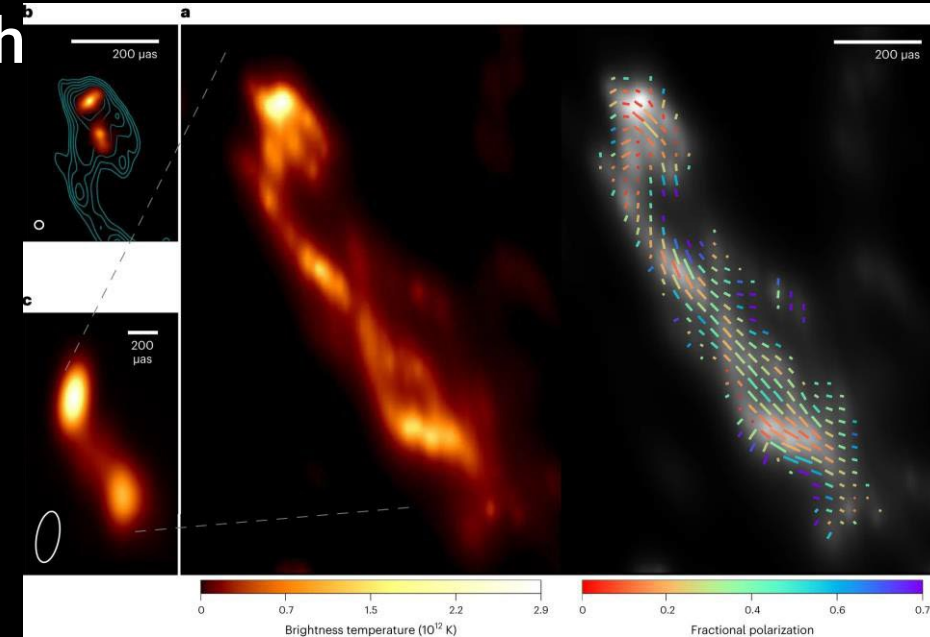


Artistic representation of the spiral barred galaxy ceers-2112, observed in the early universe  
Credit: Luca Costantin/CAB/CSIC-INTA

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## Blazer's plasma jets revealed

- Active Galactic Nuclei (AGN) are large galaxies with a powerful supermassive black hole at the centre, which accretes material from a surrounding disk. About 10% of all AGNs are Quasars, in that they produce relativistic (close to the speed of light) plasma jets. Blazars are quasars, with plasma jets pointing directly towards Earth, and are the brightest and most powerful source of electromagnetic radiation in the Universe
- Here, the jet is twisted into two helical filaments of plasma stretching more than 570 light years from the black hole. The twisting is probably caused by instabilities in the forces surrounding the black hole, and a magnetic field constrains the jet, which is travelling at 99.7% the speed of light



The filamentary structure of the jet in 3C 279 revealed by RadioAstron. A: total intensity (left) and linearly polarized (right) RadioAstron image at 1.3 cm obtained on 10 March 2014. B: the 1:1 scale 1.3 mm EHT image obtained in April 2017. C: the 7 mm VLBA-BU-BLAZAR program image obtained on 25 February 2014

Credit: <https://www.nature.com/articles/s41550-023-02105-7>

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## Hubble and JWST combine efforts (1)

- The two space telescopes have combined to study the galaxy cluster, MACS0416
- MACS0416 is about 4.6 billion light years away, and is a pair of colliding galaxy clusters that will eventually merge

To create the image, the shortest wavelengths of light were represented in blue, the longest in red, and the intermediate wavelengths in green.

This cluster magnifies the light from more distant background galaxies through gravitational lensing. The bluest galaxies are relatively nearby and often show intense star formation, as best detected by Hubble, while the redder galaxies tend to be more distant, or else contain copious amounts of dust, as detected by JWST

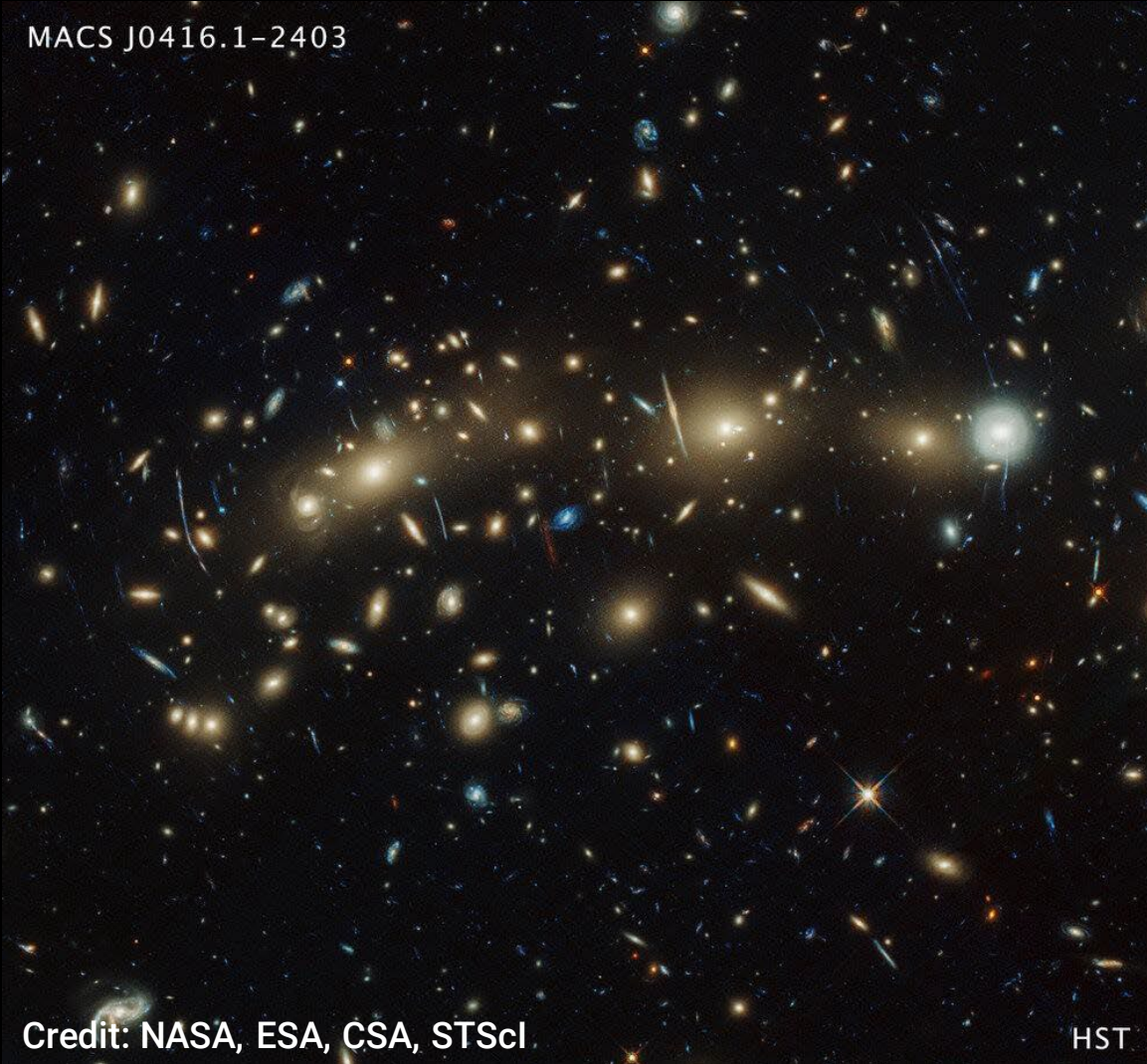
Credit: NASA, ESA, CSA, STScI, Jose M. Diego (IFCA), Jordan C. J. D'Silva (UWA), Anton M. Koekemoer (STScI), Jake Summers (ASU), Rogier Windhorst (ASU), Haojing Yan (University of Missouri)



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## Hubble and JWST combine efforts (2)

MACS J0416.1-2403



Credit: NASA, ESA, CSA, STScI

HST

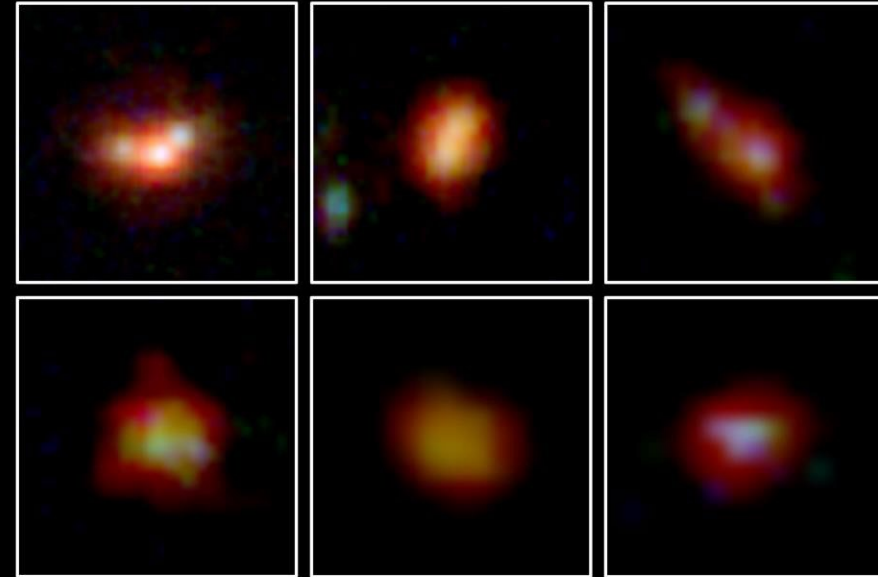


JWST



## Oxygen rapidly increases in early Universe

- The Big Bang produced only three elements: hydrogen, helium and lithium (although the latter in only very small amounts). These are the three lightest elements and all the others have been formed either through nuclear fusion or events such as supernova explosions
- Analysis by researchers of 138 galaxies that existed in the first 2 billion years, has revealed that the amount of oxygen present was similar in abundance to current levels
- Six earlier galaxies, around 500-700 million years after the Big Bang showed levels of oxygen at only half that of slightly younger galaxies
- The rapid increase in oxygen indicates the presence of Population III stars, short-lived massive stars that were able to produce oxygen (and other elements) quickly



JWST infrared images of the six early galaxies  
Credit: NASA, ESA, CSA, K. Nakajima et al

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## How close is too close to a kilonova? (1)

- Different and violent explosions happen in the Universe
- A Nova explosion occurs when a white dwarf in a binary system steals material from its companion star which, at a certain point, triggers a surface explosion, increasing its brightness up to a million times. This can happen repeatedly
- Larger still is a Supernova explosion, which have two main types: type I supernovae follow the nova process of the white dwarf, but become runaway, ending with a cataclysmic explosion destroying the star completely
- Type II supernovae involve the death of a much larger star (at least 8 times the mass of the Sun), occurring when the nuclear fusion process runs out and the outward pressure can no longer prevent gravity collapsing, leaving behind either a neutron star or black hole. The star's outer layers rebound in a shockwave that is relativistic



Artist's impression of merging neutron stars creating a kilonova  
Credit: NOIRLab/NSF/AURA/J. da Silva/Spaceengine

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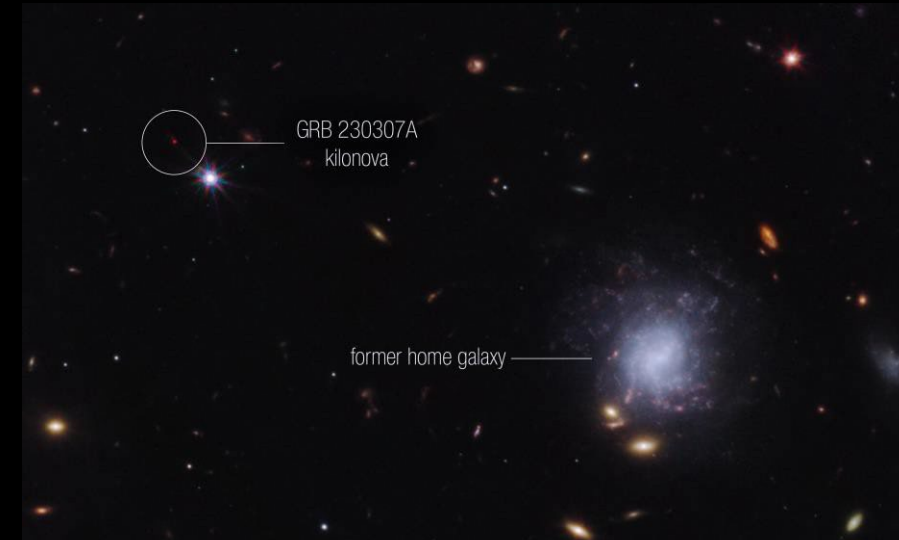
## How close is too close to a kilonova? (2)

- The nearest star to Earth that is likely to go supernova is Betelgeuse but, at 650 light years away, it is too far away to cause any harm
- Now there is a 'Kilonova': the result of a merger of two neutron stars, which produces a tremendous number of high-energy particles. Though not as bright as a supernova, they can still outshine a nova by a thousand times with massive gamma ray bursts. Beams of X-rays stream from the poles and from the equatorial region, with particles, accelerated by the explosion itself, becoming cosmic rays
- But how far do you need to be away from a kilonova explosion to be safe? Recent calculations, based on the neutron star merger in 2017, suggest that X-rays would pose a threat up to 5 parsecs (or 16 light years) away. The gamma rays would be scattered by other interstellar particles and would lose their effect after 4 parsecs (13 light years). Both X-rays and gamma rays would travel at the speed of light
- However, the shockwave, which travels much slower and would take hundreds or thousands of years to reach Earth, could be lethal up to 36 light years away

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## A kilonova caught making heavy elements

- The merger of two neutron stars, 120,000 light years away, caused a kilonova and the second brightest gamma ray burst ever recorded
- GRB230307A, a long duration blast lasting over 200 seconds, was observed by numerous ground-based telescopes and the space-based JWST, Fermi Gamma-ray and Neils Gehrels Swift Observatories. It briefly outshone the whole Milky Way by over a million times
- Now, researchers have discovered the heavy element, tellurium, in the aftermath of the explosion. Iodine, thorium and other heavy elements are also likely to have been formed
- See how a new kilonova was discovered at: <https://youtu.be/wnwMhvdDcfl>

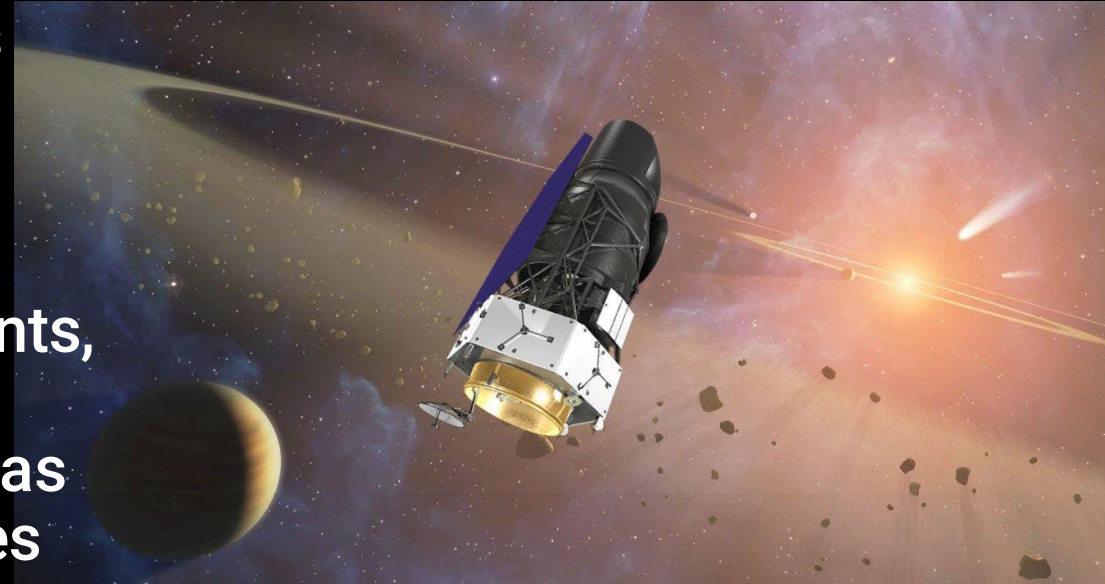


A team of scientists has used NASA's James Webb Space Telescope to observe an exceptionally bright gamma-ray burst, GRB 230307A, and its associated kilonova. The highly sensitive infrared capabilities of JWST helped scientists identify the home address of the two neutron stars that created the kilonova  
Credit: NASA, ESA, CSA, STScI, Andrew Levan (IMAPP, Radboud University, The Netherlands)

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## A new view on the heart of the Milky Way

- The Nancy Grace Roman Space Telescope is due to launch in May 2027
- Unlike Hubble or JWST, it is a survey observatory, and will be able to study huge areas of the sky to look for microlensing events, helping us to spot black holes and transiting exoplanets. Its image quality will be as good as Hubble's, but its field of view will be 100 times larger. It has a similar-sized mirror (2.4m)
- During its primary mission, it will use its ability to repeatedly look at large areas to do Time Domain Astronomy. In particular, it will perform the Galactic Bulge Survey of the centre of the Milky Way in infrared light. To do this, it will take a new image every 2 minutes for 62 days, and then repeat this over five years, giving 400 days of coverage. Any discoveries can then be followed up by JWST. See a video about the new Nancy Grace Roman Space Telescope at: [https://youtu.be/R\\_jZsUPqiCY](https://youtu.be/R_jZsUPqiCY)



Credit: NASA/Goddard Space Flight Center/Jet Propulsion Lab

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## First pictures from EUCLID Mission (1)

- The first five science images have been released by the EUCLID Mission on November 7<sup>th</sup>

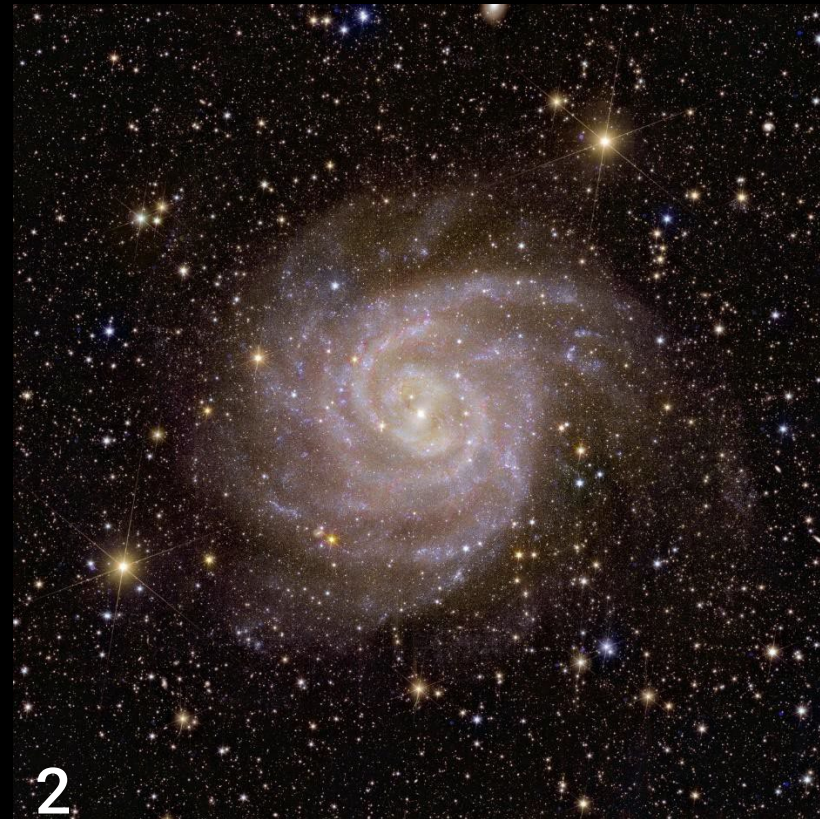
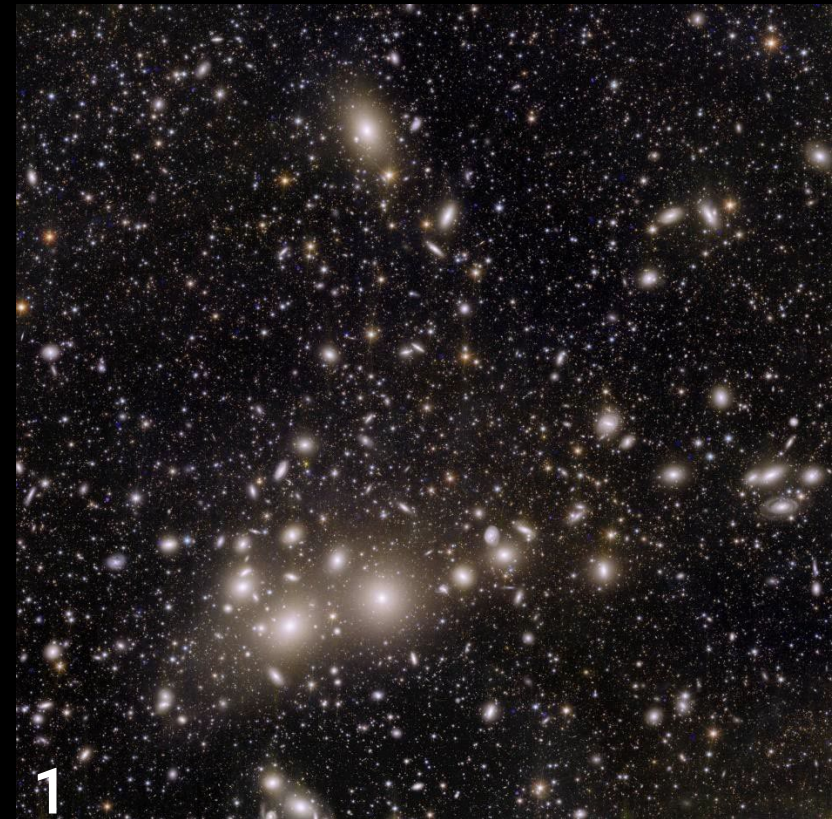


Image 1 – The Perseus Cluster

Image 2 – Spiral Galaxy IC 342

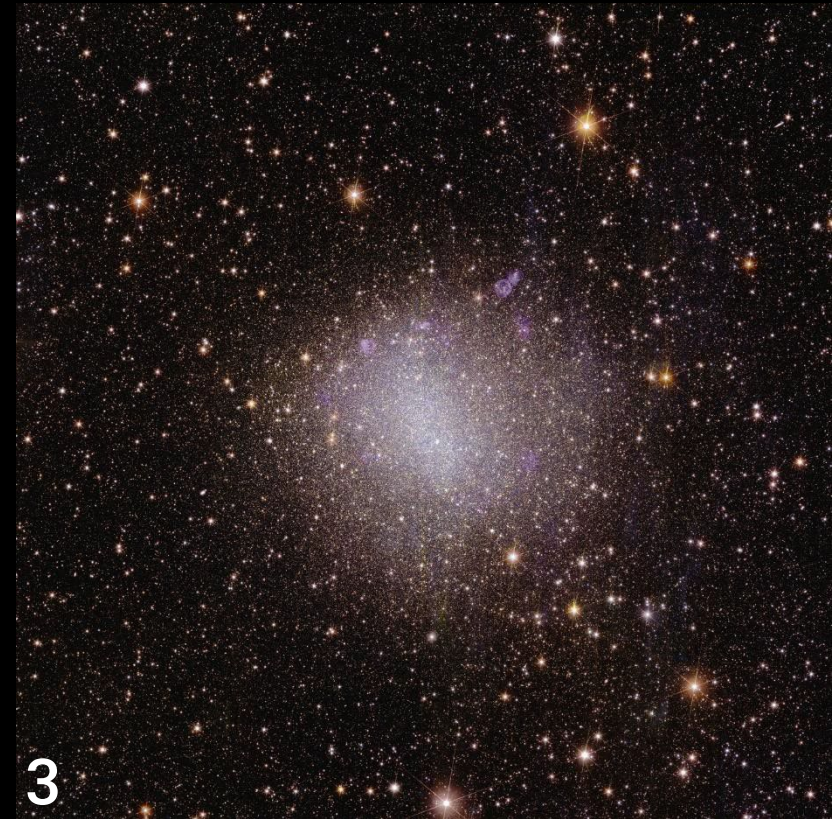
Image 3 – Galaxy NGC 6822

Image 4 – The Horsehead Nebula

Image 5 – Globular Cluster NGC 6397

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## First pictures from EUCLID Mission (2)



Credit: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi; CC BY-SA 3.0 IGO (all five images)

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## JWST view of the Crab Nebula (1)

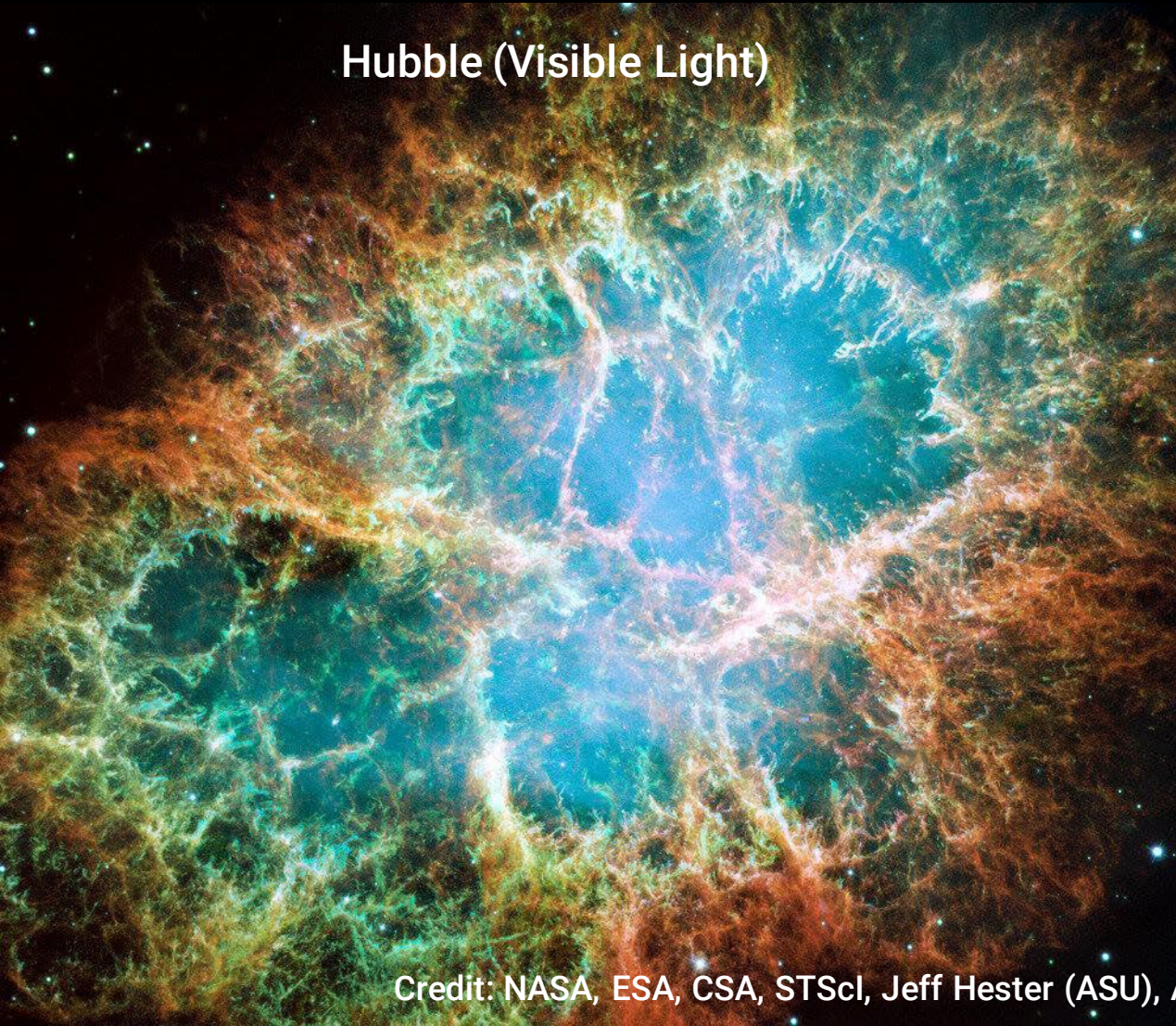
- The Crab Nebula, a supernova remnant first observed by the Chinese in 1054, is situated 6,500 light years from Earth in the constellation Taurus
- Although having been imaged and studied often over many years, it provides a very close-by example that can be used to develop our understanding of the after effects of a supernova
- Now, using JWST's NIRCam (Near-Infrared Camera) and MIRI (Mid-Infrared Instrument), researchers hope to discover more about the Crab Nebula's origins
- The image on the next slide shows a Hubble view, taken in 2005 in visible light (left) with the new JWST image taken this year (right)
- In the Hubble image, hydrogen shows up in orange, oxygen in blue, singly-ionised sulphur in red, and doubly-ionised sulphur in green. The bright glow in the centre is the nebula's pulsar
- In the JWST image, the fluffy red-orange filaments are doubly-ionised sulphur, whereas the milky white areas are synchrotron radiation



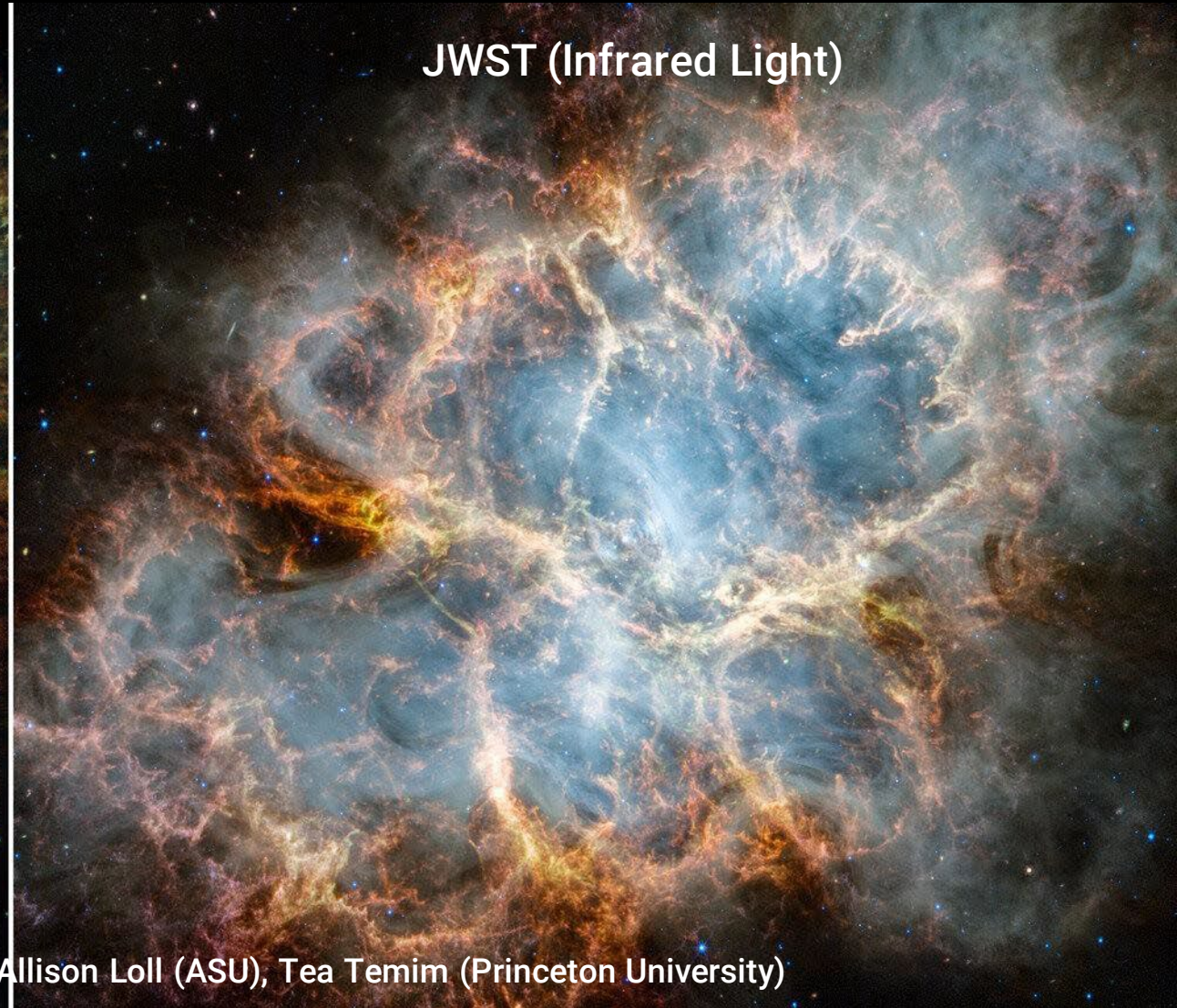
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## JWST view of the Crab Nebula (2)

Hubble (Visible Light)



JWST (Infrared Light)

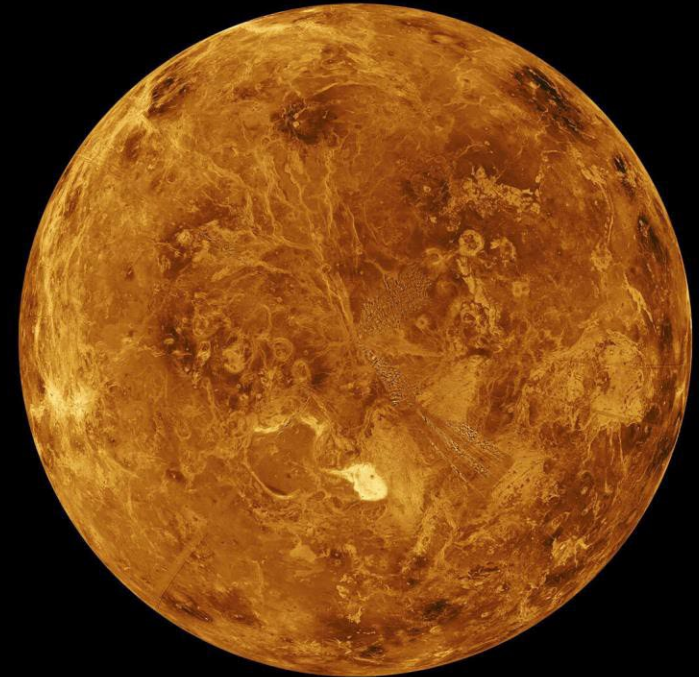


Credit: NASA, ESA, CSA, STScI, Jeff Hester (ASU), Allison Loll (ASU), Tea Temim (Princeton University)

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## Tectonic plates on Venus

- Computer modelling and data from studies of Venus' atmosphere strongly suggest that, billions of years ago, it once had tectonic plates
- Whilst these have tended to become more pronounced on Earth, Venus went in the opposite direction. Venus then exhibited what is now termed, "stagnant lid": having only one plate with very minimal give and movement
- Could Venus have started to develop microbial life before this was snuffed out?
- Further simulations suggest that planets may transit in and out of different tectonic states and that Earth is unusual, although Jupiter's moon, Europa, is thought to have plate tectonics similar to the Earth's



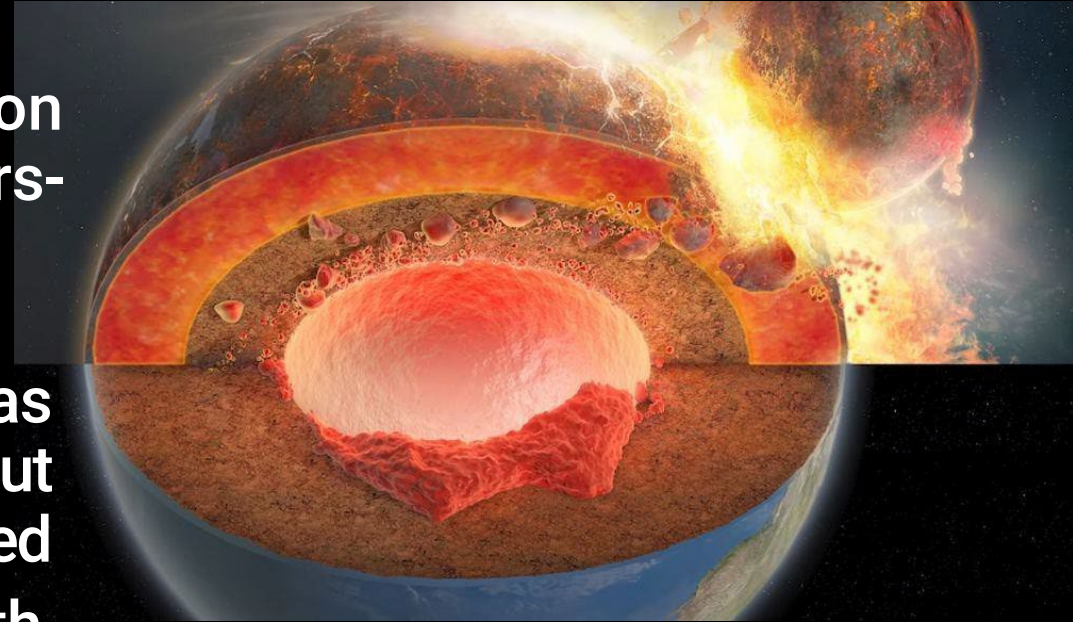
Venus, now a scorching desert of a planet according to astronomers, may have once had tectonic plate movements similar to those that may have occurred on early Earth, a new study found

Credit: NASA/Jet Propulsion Lab

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## Theia + Gaia = The Earth and the Moon (1)

- It has long been believed that the Moon was formed from the debris left over after a collision between the primordial Earth (Gaia) and a Mars-sized proto-planet (Theia), about 4.5 billion years ago
- Simulations had suggested that the Moon was principally made from material from Theia, but the Earth was only partially cross-contaminated
- New research suggests that the effect on Earth was far more dramatic; the Moon and Earth are much more similar than previously supposed
- Using computational fluid dynamics, researchers believe the upper mantle region, which at the point of the collision was still molten, is a thorough mixing of both Gaian and Theian material, whilst the lower mantle, which has remained relatively solid, is almost completely Gaian. The core remained untouched

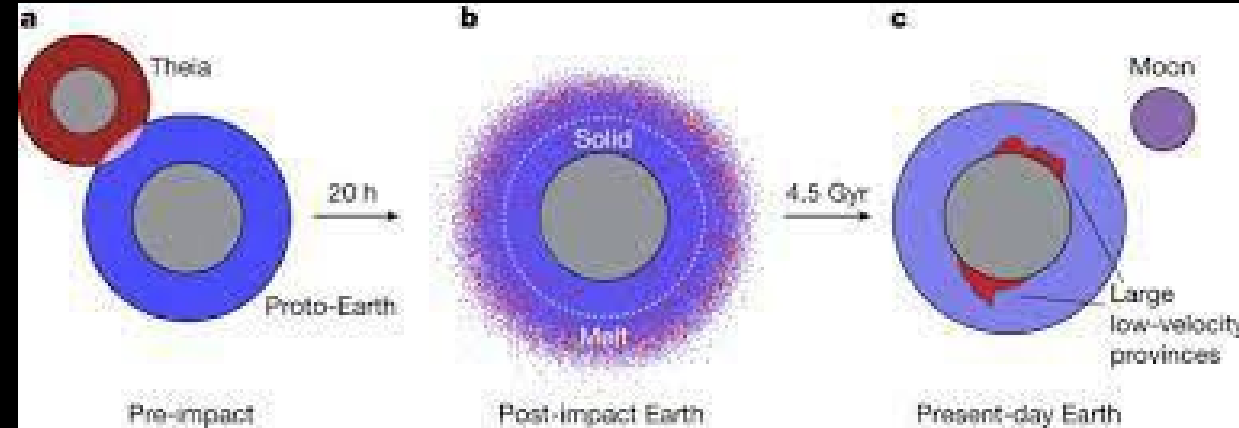


During an ancient collision, the proto-planet named Theia slammed into Earth, leading to the creation of the Moon, but it left some of the remains inside Earth. Credit: CalTech

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## Theia + Gaia = The Earth and the Moon (2)

- When Theia slammed into Earth, it released an enormous amount of energy. The collision sprayed molten material from both planets into orbit around Earth. Some escaped, but much of it then coalesced to form the Moon, with some of it remaining inside the Earth's molten form



Formation of Earth and Moon diagram

Credit: <https://www.nature.com/articles/s41586-023-06589-1/Dr>  
Yuan Qian, California Institute of Technology

- Studies of two massive continent-sized anomalies, which are buried deep in the Earth and are known as Large Low-Shear-Velocity Provinces (LLSVPs), suggest that a substantial amount of Theian material has reached the lower mantle, as it is enriched with iron and therefore denser than the Gaian material. The LLSVPs make up about 8% of the Earth's mantle volume and about 6% of the Earth's total volume

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## STEVE and the Auroras (1)

- STEVE has been in the news recently
- STEVE is the acronym for Strong Thermal Emission Velocity Enhancement. It is a phenomenon that is often seen accompanying auroras, but it isn't an aurora
- Both are the result of the same space weather
- Auroras occur when energised particles from the Sun, are directed via the magnetic fields, down through the atmosphere at the poles
- The particles excite gases such as oxygen and nitrogen and they lose this energy by giving off photons. Green light is associated with oxygen, pink with nitrogen
- STEVE occurs when streams of hot plasma from the Sun heat the gases in the upper atmosphere, and that what is seen – glowing magenta-coloured hot gas. It occurs at an altitude of 100-200km, and can reach lower latitudes than auroras



Credit: NASA (with the permission of Megan Hoffman)

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## STEVE and the Auroras (2)



Aurora borealis

Credit: ESA



STEVE

Credit: NASA/Goddard Space Flight Center/Courtesy of Krista Trinder

- For a short clip about STEVE go to: <https://youtu.be/wRHwGD-is9U>

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## Astronomy News in Brief (1)

- **Betelgeuse – the super red giant has been behaving strangely over the past few years; increasing in brightness and then dimming more than expected. A recent brightening this year may not be due to its imminent end as a supernova, but the possible consumption of a companion star**
- **Misaligned binary systems and rogue planets – the recent discovery of unattached, or rogue, planets in the Orion system has led to a new theory being developed to explain how this could have happened. The new paper proposes that misaligned binary systems, when young, are inherently unstable, and this allows larger planets to kick smaller planets out into interstellar space**
- **Saturn-like planet orbiting an M-dwarf star – NASA's Transiting Exoplanet Survey Satellite (TESS) has discovered a Saturn-like exoplanet orbiting an M-class dwarf star (TOI-5344) approximately 440 light years distant. The exoplanet, TOI-5344b, is nearly 10 times bigger and 135 times heavier than the Earth. The planet orbits its star every 3.8 days, at a rough distance of 0.04 AU, and with a mean temperature of 679K**

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## Astronomy News in Brief (2)

- Vera Rubin and interstellar objects – so far two interstellar objects (ISO), 'Oumuamua and 21/Borisov, have been discovered. But it is likely that many hundreds could be crossing the Solar System at any one time. The new Vera Rubin Observatory is due to become operational in 2025, and simulations suggest that it may help discover up to 70 ISOs a year. Using its 8.4m Simonyi Survey Telescope, attached to a 3,200-megapixel camera (the highest resolution in the world), and equipped with the largest fish-eye lens yet made, the telescope will be able to scan the whole Southern Hemisphere, every few days. With this ability, the telescope will be able to spot and track any object that is moving against the background star field. The main focus of the Vera Rubin Observatory will be to gather data on more than 5 million asteroid belt objects, 300,000 Jupiter Trojans, 100,000 near-Earth objects, and more than 40,000 Kuiper belt objects



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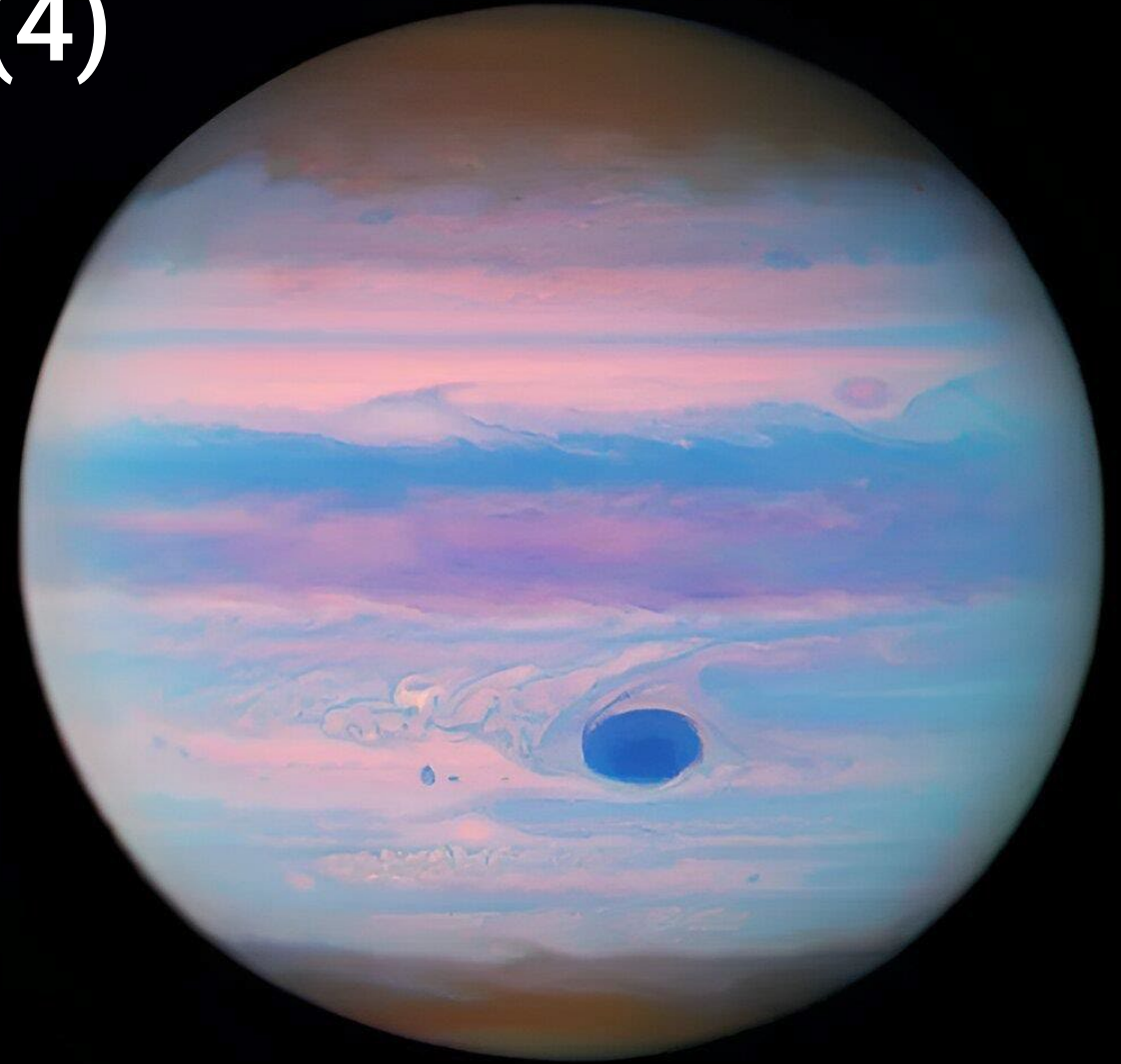
## Astronomy News in Brief (3)

- **Dimorphos and Didymos – just over a year ago, the space probe, DART, was deliberately smashed into Dimorphos: the small rock orbiting the much larger Didymos asteroid, in an attempt to alter the former's orbit. The test was successful. One of the outcomes now is the discovery that the pair of asteroids were once a single larger object. The trail of dust left behind by the impact has been analysed by the IRTF telescope in Hawaii and was found to match the spectroscopic signature of Didymos. As they are both, in effect, piles of rubble held loosely together by gravity, it is likely that they broke apart due to being fast spinning**
- **Fleeing stars – the Milky Way is shedding stars into intergalactic space. Up to 10 million stars are currently being ejected from the galaxy in a process that is not yet well understood. Many of the stars so far discovered are massive O-type stars**

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## Astronomy News in Brief (4)

- Jupiter – NASA has released a newly-taken composite image of Jupiter taken in UV light



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## Astronomy News in Brief (5)

- **Sun Cycle** – the current Solar Cycle (25) is now expected to peak one year earlier (between January and October 2024), and to be much stronger, lasting longer than previously estimated
- **Old Moon** – continuing studies of Moonrock brought back by the Apollo astronauts has indicated that the Moon is 40 million years older than previously thought
- **Satellite glints** – what may hamper Vera Rubin and other survey telescopes is the sheer number of satellites. Although they can be easily tracked and accounted for, what is less easy to eliminate is the fact that as they change orientation, any flat surface can reflect sunlight very briefly (tens to hundreds of milliseconds) as a flash or glint. Using the latest data, astronomers estimate that satellites currently give off 80,000 glints an hour

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**December 2023**

**Spaceflight News**

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## Nighttime test of Ariane 6

- ESA's new replacement for the now-retired Ariane 5, took a step closer to its first test flight with a nighttime wet rehearsal, on 24<sup>th</sup> October
- The thirty-hour test involved fuelling and then draining the rocket, as well as a systems integration. The rocket holds 180 tons of liquid hydrogen and oxygen propellant. The nighttime test made use of the cooler ambient temperatures
- This followed the first test on 18<sup>th</sup> July, and a main engine test on 5<sup>th</sup> September
- The next test, at the end of November, should be a full 8-minute firing of the main engines



Credit: European Space Agency

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## Japanese spacecraft to land on Phobos (1)

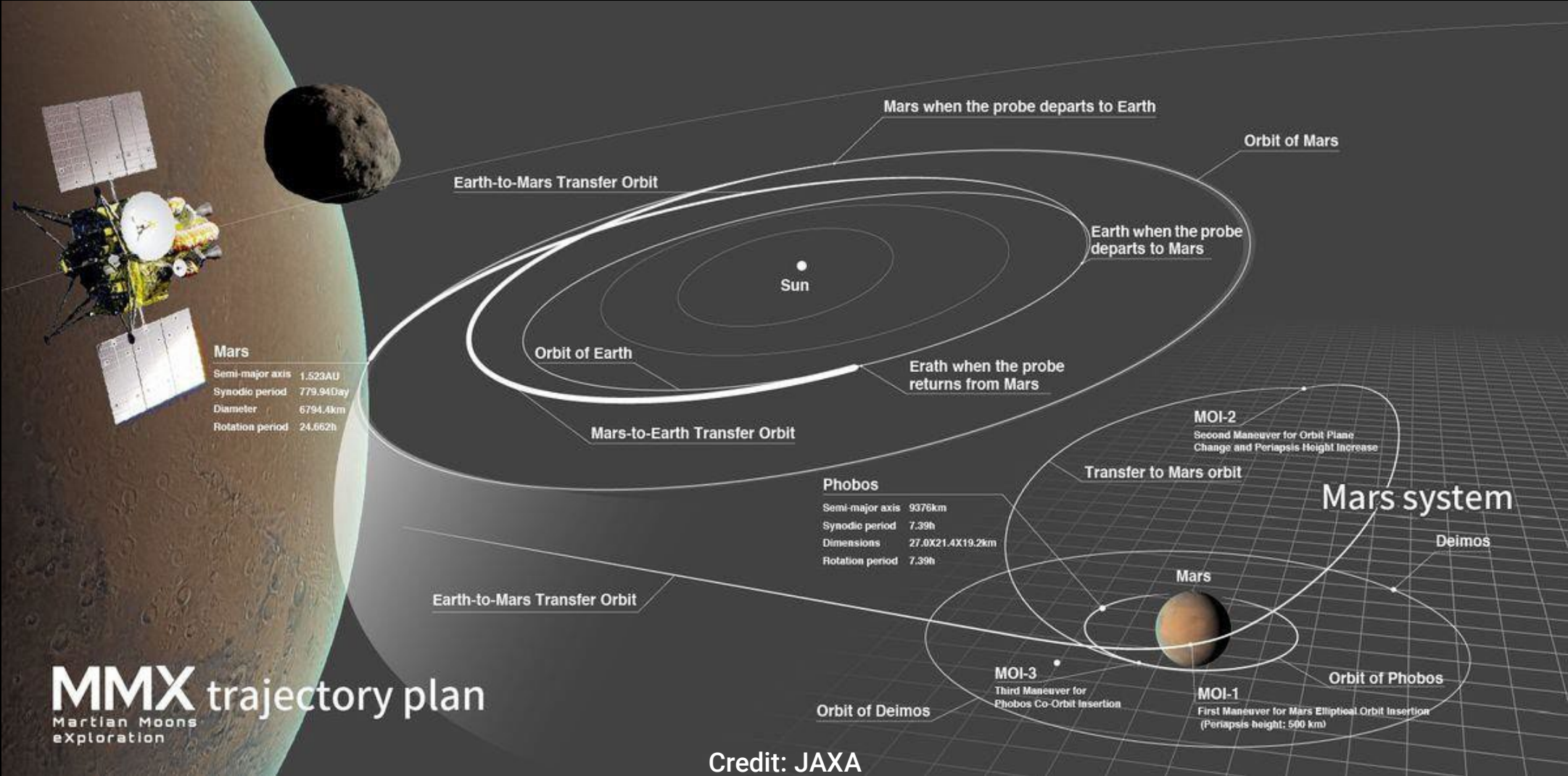
- The Japanese MMX mission to Mars, which is due to launch in 2024, will also land on the moon of Phobos to drill and collect a sample, before returning it to Earth
- Both Phobos (the larger of the two moons at 27x22x18 km) and Demos are thought to be captured asteroids, although there is a possibility that they are leftovers from the formation of Mars
- Apart from the sample collection, the MMX mission will also carry a joint Franco-German lander



Credit: JAXA

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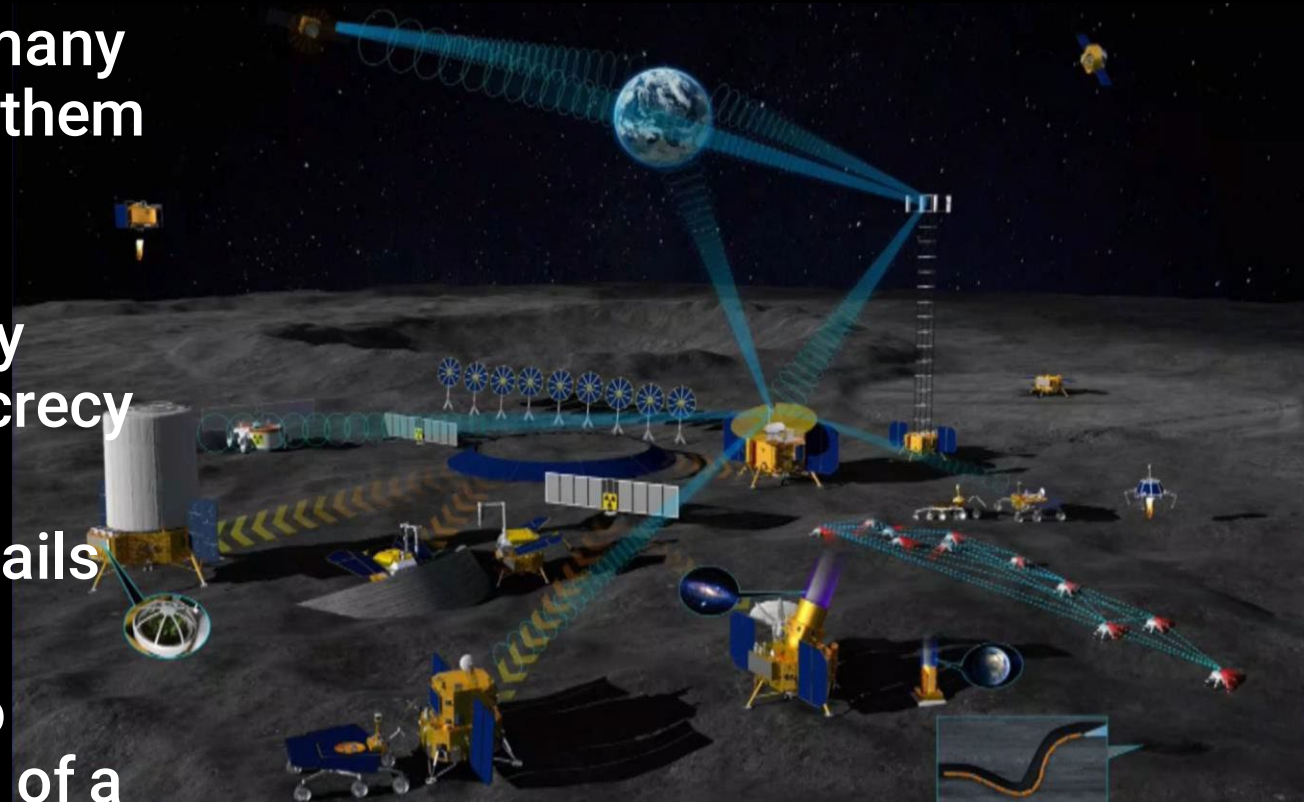
# Japanese spacecraft to land on Phobos (2)



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## China's lunar ambitions

- China is now able to rival America in many fields, space exploration being one of them
- But apart from the official reports on projects such as the Tiangong Space Station, and the idea of a lunar base by 2030, future plans are shrouded in secrecy
- Now an unofficial video has surfaced which purports to give many more details
- It shows spacecraft docking with an orbiting lunar space station (similar to NASA's Lunar Gateway), with mention of a Cislunar Transportation Facility in addition to the Long-term Support Facility on the Moon's surface



A render depicting phase 3 of the ILRS roadmap Credit: CNSA

See it at: [https://youtu.be/\\_j2PeM5kuWM](https://youtu.be/_j2PeM5kuWM)

(although it is in Mandarin and the translation is poor)



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## Apollo 8 astronaut Frank Borman dies (1)

- Former Apollo and Gemini astronaut, Frank Borman, has died at the age of 95 on November 7<sup>th</sup>
- Borman, a former US Air Force pilot, instructor and test pilot, joined NASA in 1962 as part of the “Next Nine” group of astronauts, following the “Mercury Seven”
- Selected as the commander of Gemini 7, he and his co-pilot, Jim Lovell, spent 14 days in space in December 1965. During the mission, they rendezvoused with Gemini 6, coming within 30cm of the other craft
- After the devastating and tragic fire onboard Apollo 1, Borman served on the Accident Review Board, and he was a key reason why the Apollo Program survived. He worked with North American Aviation to make improvements to the Apollo capsule



Credit: NASA

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## Apollo 8 astronaut Frank Borman dies (2)

- Borman was selected to command Apollo 9, due to fly in Spring 1969, testing the new lunar module in medium-Earth orbit, following Apollo 8's low-Earth orbit test. However, Apollo 8's lunar module was not ready in time. To save the mission, NASA proposed sending Apollo 8 around the Moon. The Apollo 8 commander (Jim McDivitt) declined the offer, preferring to test the lunar module, so the two crews swapped
- The Apollo 8 mission successfully completed 10 orbits of the Moon at Christmas 1968. The mission was broadcast and during one orbit the crew took turns to read out excerpts from the Book of Genesis. Borman finished with the lines "And from the crew of Apollo 8, we close with good night, good luck, a Merry Christmas, and God bless all of you—all of you on the good Earth"

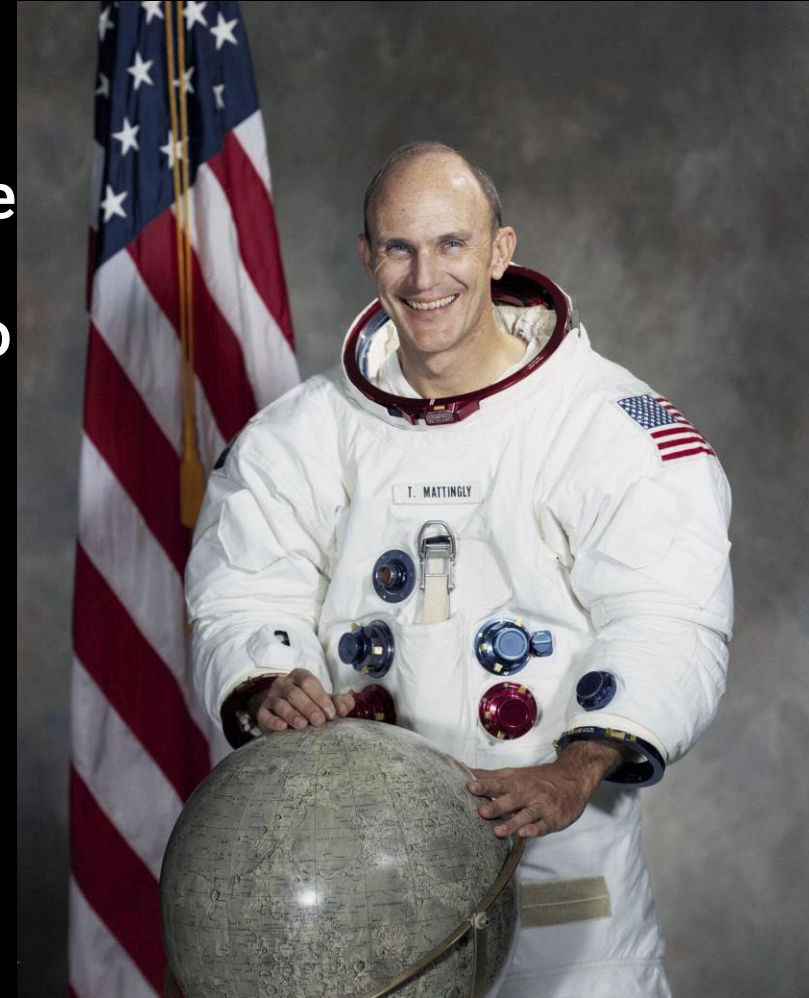


Prime crew for the Apollo 8 mission  
(Bill Anders – lunar module pilot,  
Jim Lovell – command module pilot,  
Frank Borman – commander)  
Credit: NASA

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## Apollo 16 astronaut Ken Mattingly dies

- Former Apollo astronaut, Ken Mattingly, has died at the age of 87 on 31<sup>st</sup> October
- Mattingly, a US Navy test pilot, was selected to fly as the Command Module Pilot, on Apollo 13, but was removed a few days before the launch as he had been exposed to German Measles (he didn't contract the disease). He was replaced by John (Jack) Swigert Jr.
- When an explosion in the service module on the way to the Moon put the Apollo 13 astronauts (Jim Lovell, Fred Haise, and Jack Swigert) lives in danger, Mattingly helped the engineers back in Houston, developing solutions to bring them back safely
- He was the Command Module Pilot on Apollo 16 and carried out a spacewalk to retrieve film



Credit: NASA via AP

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## Spaceflight News and Updates (1)

- **Vulcan Centaur** – United Launch Alliance's new rocket, the Vulcan Centaur, is due to make its first flight on 24<sup>th</sup> December. The first flight will carry the cremated remains of a number of people associated with the original Star Trek series, and a lunar lander. It is the next generation rocket, replacing the Atlas 5 series
- **Voyager 1 & 2** – after 46 years in space both probes have received updates to keep them in working order for another 5 years. One software patch will help Voyager 1 correct telemetry data, which has been routing through a defunct computer, becoming garbled. The other will help prevent fuel residue building up on the probes' thrusters, which could cause them to become blocked
- **Curiosity** – NASA's Martian rover, Curiosity, has completed 4,000 Martian solar days exploring the surface, since arriving in the Gale Crater in August 2012 and is still going strong

# Lewes Astronomical Society

## Spaceflight News and Updates (2)

- Lucy encounters first (and second) asteroid – the Lucy spacecraft, on a 12-year mission to the Trojan asteroids of Jupiter, has swept past the first of up to 10 asteroids. Speeding by at 16,000kph, the spacecraft came within 435km of the small 1km sized asteroid, Dinkinesh. It is situated about 480 million kms from the main asteroid belt. It now turns out that Dinkinesh has a very small and previously unknown companion
- UK Astronauts on Axiom Flight – the UK Space Agency has signed an agreement with Axiom Space to put 4 British astronauts on a 2-week mission to the ISS. If, and when this comes off, NASA rules must be followed, including having a former agency astronaut in command of the mission. In which case it is possible that Tim Peake will come out of retirement to lead the mission

# Lewes Astronomical Society

## Spaceflight News and Updates (3)

- Norway inaugurates new spaceport – nine months after Sweden set up the Esrange Spaceport, Norway has joined the race to launch satellites by inaugurating the Andoya Spaceport on the island of Andoya, north of the Arctic Circle. The first launch could happen in under a year's time
- ESA's cargo ship competition – the European Space Agency is to hold a competition to build a ship capable of carrying cargo to the ISS. The project will require "transport, docking and re-entry capability, something Europe does not possess today", said ESA chief Josef Aschbacher. He also said "the service vehicle could later evolve to a crew vehicle and serve other destinations beyond low Earth orbit". The aim is to have a spacecraft ready by 2028

# Lewes Astronomical Society

## Spaceflight News and Updates (4)

- How to 3D print an engine nozzle – engine nozzles are complicated things to make: often made up of hundreds of separate parts which need to be welded together. Because of the heat involved in conventional rocket nozzle manufacture, they can't be made of aluminium. Now, NASA has tested a rocket nozzle made out of aluminium by the Additive Manufacturing (AM) process, otherwise known as 3D printing. Working with a leading specialist AM company, Elementum 3D, and RPM Innovations, and using a new technique, RAMFIRE, a much quicker, cheaper and lighter nozzle was made. Now two RAMFIRE nozzles have now completed a series of 22 hot-fire tests, firing for over 10 minutes. Watch the tests at: <https://youtu.be/CZgl622kYng>

**Lewes Astronomical Society**

**December 2023**

**Observational Highlights**



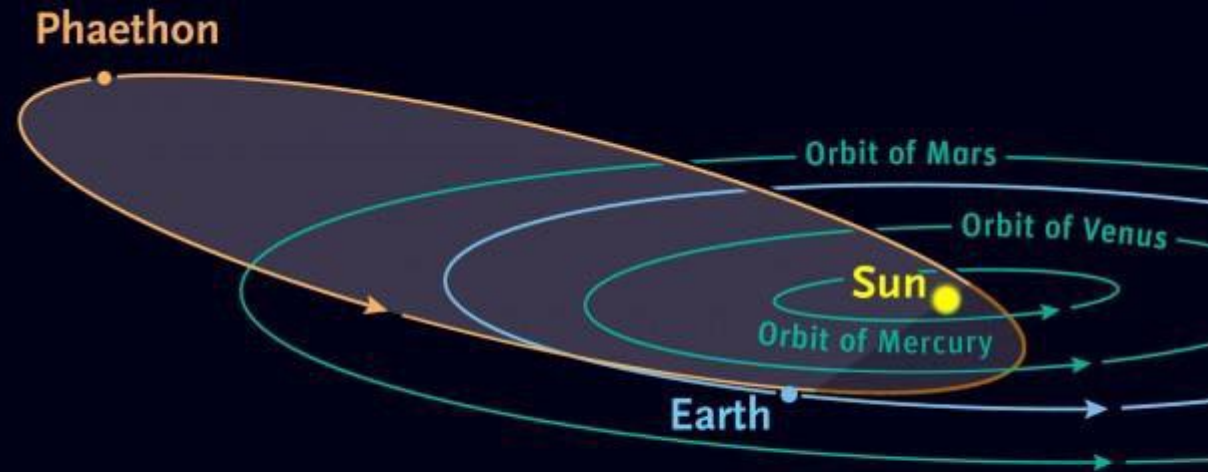
## December 2023 dates

- 13<sup>th</sup> December – earliest sunset of the year
- 14<sup>th</sup>/15<sup>th</sup> December – Geminid meteor shower. Radiant point in Gemini, 120 meteors per hour, associated with asteroid 3200 Phaethon. Highest point 72° 02:00 GMT, due South
- 22<sup>nd</sup> December – Winter Solstice (03:27 GMT)
- 22<sup>nd</sup>/23<sup>rd</sup> December – Ursid meteor shower. Radiant point in Ursa major, 10 meteors per hour, associated with 8P/Tuttle comet. Highest point 65° just before dawn, due North
- 30<sup>th</sup> December – latest sunrise of the year
- 31<sup>st</sup> December – Mercury visible one hour before dawn above the south-east horizon

# Lewes Astronomical Society

## The Geminid meteor shower

- Possibly the best meteor shower of the year, reaching its maximum on 14<sup>th</sup>/15<sup>th</sup>
- December
- The meteor radiant is located slightly close to Castor in Gemini. The radiant ascends above 25° in the West shortly after 20:00, climbing to 72° at 02:00 due South before setting in the East at dawn
- Most of the meteors will be white but some may appear to be red, yellow, blue or green. There will be no interference from the already set Moon
- The meteor shower is caused by the debris left behind by an asteroid (3200 Phaethon) which orbits the Sun every 1.4 years. Fast meteor shower (50-80 miles/sec) with between 120 and 150 meteors per hour



Credit: Sky & Telescope diagram

## Planets (information for 1<sup>st</sup> December)

	<u>Planet</u>	<u>Rises</u>	<u>Sets</u>	<u>Highest</u>	<u>Direction</u>	<u>Altitude</u>	<u>Magnitude</u>	<u>Visible</u>
	MERCURY	09:36	16:34	13:15			-0.51	NO
	VENUS	03:32	14:22	08:57	South-East	27° ◻	-4.36	YES
	MARS	07:19	15:39	11:29			+1.48	NO
	JUPITER	14:31	04:45	21:38	South	51°	-2.90	YES
	SATURN	12:33	22:32	17:33	South	26°	+0.77	YES
	URANUS	14:54	06:04	22:29	South	56°	+5.63	YES
	NEPTUNE	13:13	00:48	19:01	South	35°	+7.84	YES

\* = Highest point at Dawn (06:11 - last visible sighting)

\*\* = Highest point at Dusk (17:24 - first visible sighting)

◊ = Highest point when first visible

◊◊ = Highest point when first visible

◻ = Highest point when last visible (07:14)

◻◻ = Highest point when last visible

## 100 Deep Sky Objects - 1 (Information for 1<sup>st</sup> December)

Object	Name	Type	↗ Visible ↘		Highest	Direction	Alt	Mag
Cr50	The Hyades (Taurus)	Open Cluster	17:43	05:47	23:45	South	55°	+1.0
M45	The Pleiades (Taurus)	Cluster with Nebulosity	16:54	05:45	23:05	South	63°	+1.3
NGC1980	Open Cluster (Orion)	Cluster with Nebulosity	21:07	04:46	00:57	South	33°	+2.5
C33	The Eastern Veil Nebula	Nebula	17:24	01:39	17:24 **	South-West	67°	+2.7
M44	Beehive Cluster (Cancer)	Open Cluster	22:08	06:16	04:01	South	58°	+3.1
M31	Andromeda Galaxy (Andromeda)	Galaxy	17:23	03:52	20:01	South	80°	+3.4
IC1396	The Elephant Trunk (Cepheus)	Cluster with Nebulosity	17:24	06:11	17:24 **	North-West	82°	+3.5
M42	Orion Nebula (Orion)	Cluster with Nebulosity	21:26	04:27	00:57	South	33°	+4.0
NGC2264	The Christmas Tree Cluster (Monoceros)	Cluster with Nebulosity	21:09	06:11	02:02	South	49°	+4.1
IC4665	Open Cluster (Ophiuchus)	Open Cluster	17:24	19:38	17:24 **	West	20°	+4.2
NGC1977	Running Man Nebula (Orion)	Open Cluster	19:17	06:11	00:57	South	33°	+4.2
NGC1981	Open Cluster (Orion)	Open Cluster	21:23	04:30	00:57	South	34°	+4.2
NGC2232	Open Cluster (Monoceros)	Open Cluster	02:18	05:20	01:49	South	36°	+4.2
C14	Double Cluster (Perseus)	Open Cluster	17:24	06:11	21:38	North	83°	+4.3
M47	Open Cluster (Puppis)	Open Cluster	00:48	05:08	02:58	South	24°	+4.4

\* = Highest point at Dawn (06:11 - last visible sighting)

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## 100 Deep Sky Objects - 2 (Information for 1<sup>st</sup> December)

Object	Name	Type	↗ Visible ↘		Highest	Direction	Alt	Mag
IC4756	Graff's Cluster (Serpens Cauda)	Open Cluster	17:24	20:29	17:24 **	South-West	27°	+4.6
M39	Open Cluster (Cygnus)	Open Cluster	17:24	01:18	17:24 **	West	84°	+4.6
NGC6633	Open Cluster (Ophiuchus)	Open Cluster	17:24	20:23	17:24 **	South-West	26°	+4.6
NGC1499	The California Nebula (Perseus)	Bright Nebula	17:24	06:11	23:21	South	75°	+5.0
M35	Open Cluster (Gemini)	Open Cluster	19:41	06:11	01:31	South	63°	+5.1
M34	The Spiral Cluster (Perseus)	Open Cluster	17:24	05:30	22:00	South	81°	+5.2
NGC6871	Open Cluster (Cygnus)	Open Cluster	17:24	01:44	17:24 **	South-West	63°	+5.2
NGC869	h Per Cluster (Perseus)	Open Cluster	17:24	06:11	21:38	North	83°	+5.3
NGC2281	Open Cluster (Auriga)	Open Cluster	18:54	06:11	02:10	South	80°	+5.4
M37	The Auriga Salt-and-Pepper	Open Cluster	18:50	06:11	01:14	South	71°	+5.6
NGC7686	Open Cluster (Andromeda)	Open Cluster	17:24	03:00	18:49	South	88°	+5.6
NGC752	Open Cluster (Andromeda)	Open Cluster	17:24	04:07	21:16	South	77°	+5.7
M13	Great Globular Cluster (Hercules)	Globular Cluster	17:24	22:33	17:24 **	West	32°	+5.8
M33	Triangulum Galaxy (Triangulum)	Galaxy	17:24	03:04	20:52	South	69°	+5.8
M48	Open Cluster (Hydra)	Open Cluster	00:36	06:11	03:35	South	33°	+5.8

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## 100 Deep Sky Objects - 3 (Information for 1<sup>st</sup> December)

Object	Name	Type	↗ Visible ↘		Highest	Direction	Alt	Mag
M50	The Heart-Shaped Cluster (Monoceros)	Open Cluster	23:47	05:01	02:24	South	30°	+5.9
NGC2169	The "37" Cluster (Orion)	Open Cluster	20:36	06:11	01:26	South	53°	+5.9
IC405	The Flaming Star Nebula (Auriga)	Nebula	18:10	06:11	00:38	South	73°	+6.0
M36	The Pinwheel Cluster (Auriga)	Open Cluster	18:31	06:11	00:58	South	73°	+6.0
NGC2301	Open Cluster (Monoceros)	Open Cluster	22:36	05:50	02:13	South	39°	+6.0
NGC7000	The North American Nebula (Cygnus)	HII Region	17:24	23:46	17:24 **	South-West	77°	+6.0
M46	Open Cluster (Puppis)	Open Cluster	01:42	04:24	03:03	South	24°	+6.1
NGC1746	Open Cluster (Taurus)	Open Cluster	18:50	06:01	00:25	South	62°	+6.1
NGC7160	Open Cluster (Cepheus)	Open Cluster	17:24	06:11	17:24 **	North	78°	+6.1
NGC884	chi Per Cluster (Perseus)	Open Cluster	17:24	06:11	21:38	North	83°	+6.1
NGC1545	Open Cluster (Perseus)	Open Cluster	17:24	06:11	23:39	South	89°	+6.2
M15	Globular Cluster (Pegasus)	Globular Cluster	17:24	23:54	17:24 **	South	50°	+6.3
M3	Globular Cluster (Canes Venatici)	Globular Cluster	00:11	06:11	06:11 *	East	50°	+6.3
NGC6940	Open Cluster (Vulpecula)	Open Cluster	17:24	00:44	17:24 **	South-West	61°	+6.3
M38	The Starfish Cluster (Auriga)	Open Cluster	18:15	06:11	00:50	South	75°	+6.4

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## 100 Deep Sky Objects - 4 (Information for 1<sup>st</sup> December)

Object	Name	Type	↗ Visible ↘		Highest	Direction	Alt	Mag
NGC1528	Open Cluster (Perseus)	Open Cluster	17:24	06:11	23:33	North	89°	+6.4
NGC1647	Open Cluster (Taurus)	Open Cluster	18:54	05:21	00:08	South	58°	+6.4
NGC1662	Open Cluster (Orion)	Open Cluster	19:36	04:44	00:10	South	50°	+6.4
NGC457	The Dragonfly Cluster (Cassiopeia)	Open Cluster	17:24	06:11	20:38	North	82°	+6.4
NGC7243	Open Cluster (Lacerta)	Open Cluster	17:24	01:44	17:34	South	89°	+6.4
IC1805	The Heart Nebula (Cassiopeia)	Cluster with Nebulosity	17:24	06:11	21:59	North	79°	+6.5
IC1848	The Soul Nebula (Cassiopeia)	Cluster with Nebulosity	17:24	06:11	22:09	North	80°	+6.5
M92	Globular Cluster (Hercules)	Globular Cluster	17:24	19:56	17:24 **	West	42°	+6.5
NGC129	Open Cluster (Cassiopeia)	Open Cluster	17:24	06:11	19:48	North	80°	+6.5
NGC2539	Open Cluster (Puppis)	Open Cluster	01:42	05:21	03:32	South	26°	+6.5
NGC654	Open Cluster (Cassiopeia)	Open Cluster	17:24	06:11	21:02	North	78°	+6.5
M2	Globular Cluster (Aquarius)	Globular Cluster	17:24	22:52	17:24 **	South	37°	+6.6
M29	The Cooling Tower (Cygnus)	Open Cluster	17:24	03:24	17:24 **	South-West	68°	+6.6
NGC1444	Open Cluster (Perseus)	Open Cluster	17:24	06:11	23:07	North	88°	+6.6
NGC1027	Open Cluster (Cassiopeia)	Open Cluster	17:24	06:11	22:01	North	79°	+6.7

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## 100 Deep Sky Objects - 5 (Information for 1<sup>st</sup> December)

Object	Name	Type	↗ Visible ↘		Highest	Direction	Alt	Mag
NGC1342	Open Cluster (Perseus)	Open Cluster	17:24	05:34	22:50	South	76°	+6.7
NGC2129	Open Cluster (Gemini)	Open Cluster	19:49	06:11	01:23	South	62°	+6.7
NGC2343	Open Cluster (Monoceros)	Open Cluster	00:15	04:44	02:29	South	28°	+6.7
NGC2423	Open Cluster (Puppis)	Open Cluster	01:23	04:34	02:58	South	25°	+6.7
NGC6709	Open Cluster (Aquila)	Open Cluster	17:24	21:06	17:24 **	South-West	33°	+6.7
NGC7789	The Caroline's Rose (Cassiopeia)	Open Cluster	17:24	06:11	19:16	North	84°	+6.7
NGC2175	Open Cluster (Orion)	Cluster with Nebulosity	20:11	06:11	01:31	South	59°	+6.8
NGC6811	The Hole in a Cluster (Cygnus)	Open Cluster	17:24	22:38	17:24 **	West	65°	+6.8
NGC7023	The Iris Nebula (Cepheus)	Nebula	17:24	06:11	17:24 **	North-West	73°	+6.8
M52	The Cassiopeia Salt-and-Pepper	Open Cluster	17:24	06:11	18:43	North	79°	+6.9
M67	Open Cluster (Cancer)	Open Cluster	23:34	06:11	04:12	South	50°	+6.9
M81	Bode's Galaxy (Ursa Major)	Galaxy	17:24	06:11	06:11 *	North-East	86°	+6.9
NGC1502	Open Cluster (Camelopardalis)	Open Cluster	17:24	06:11	23:26	North	78°	+6.9
NGC6960	The Western Veil Nebula (Cygnus)	Supernova Remnant	17:24	06:11	17:24 **	South-West	64°	+7.0
NGC7635	The Bubble Nebula (Cassiopeia)	HII Region	17:24	06:11	18:39	North	79°	+7.0

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## 100 Deep Sky Objects - 6 (Information for 1<sup>st</sup> December)

Object	Name	Type	↗ Visible ↘		Highest	Direction	Alt	Mag
M103	Open Cluster (Cassiopeia)	Open Cluster	17:24	06:11	20:52	North	80°	+7.4
M27	Apple Core Nebula (Vulpecula)	Planetary Nebula	17:24	23:27	17:24 **	South-West	52°	+7.4
NGC6888	The Crescent Nebula (Cygnus)	HII Region	17:24	03:01	17:24 **	West	66°	+7.5
M53	Globular Cluster (Coma Berenices)	Globular Cluster	00:54	06:11	06:11 *	South-East	46°	+7.7
M101	The Pinwheel Galaxy (Ursa Major)	Galaxy	17:24	06:11	06:11 *	North-East	61°	+7.9
M78	Reflection Nebula (Orion)	Reflection Nebula	21:33	04:43	01:18	South	39°	+8.0
NGC246	The Skull Nebula (Cetus)	Planetary Nebula	18:05	22:06	20:05	South	27°	+8.0
M110	Galaxy (Andromeda)	Galaxy	17:24	03:08	19:59	South	80°	+8.1
M94	'Spiral' Galaxy (Canes Venatici)	Galaxy	01:05	06:11	06:11 *	East	67°	+8.2
NGC7009	The Saturn Nebula (Aquarius)	Planetary Nebula	17:24	21:30	17:24 **	South	26°	+8.3
M1	The Crab Nebula (Taurus)	Planetary Nebula	19:29	06:11	00:56	South	61°	+8.4
M49	Galaxy (Virgo)	Galaxy	01:07	06:11	06:11 *	South	42°	+8.4
M51	Whirlpool Galaxy (Canes Venatici)	Galaxy	01:03	06:11	06:11 *	East	63°	+8.4
M56	Globular Cluster (Lyra)	Globular Cluster	17:24	23:44	17:24 **	West	52°	+8.4
M71	Globular Cluster (Sagitta)	Globular Cluster	17:24	22:56	17:24 **	South-West	48°	+8.4

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## 100 Deep Sky Objects - 7 (Information for 1<sup>st</sup> December)

Object	Name	Type	↗ Visible ↘		Highest	Direction	Alt	Mag																														
			Starts	Ends																																		
M82	The Cigar Galaxy (Ursa Major)	Galaxy	17:24	06:11	06:11 *	North-East	80°	+8.4																														
NGC1245	Open Cluster (Perseus)	Open Cluster	17:24	06:11	17:24 **	North-East	41°	+8.4																														
M64	The Black Eye Galaxy (Coma Berenices)	Galaxy	00:16	06:11	06:11 *	South-East	51°	+8.5																														
M104	The Sombrero Galaxy (Virgo)	Galaxy	02:55	06:11	06:11 *	South-East	23°	+8.6																														
M63	The Sunflower Galaxy (Canes Venatici)	Galaxy	01:24	06:11	06:11 *	East	63°	+8.6																														
M57	The Ring Nebula (Lyra)	Planetary Nebula	17:24	23:52	17:24 **	West	51°	+8.8																														
M60	Galaxy (Virgo)	Galaxy	01:02	06:11	06:11 *	South-East	44°	+8.8																														
NGC6543	The Cat's Eye Nebula (Draco)	Planetary Nebula	17:24	06:11	17:24 **	North-West	52°	+8.8																														
M66	Galaxy (Leo)	Galaxy	23:31	06:11	06:11 *	South	51°	+8.9																														
M73	Nebula (Aquarius)	Nebula	17:24	21:18	17:24 **	South	24°	+8.9																														
M77	Galaxy (Cetus)	Galaxy	18:26	01:35	22:31	South	39°	+8.9																														
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2"></th> <th>Twilight</th> <th>Civil</th> <th>Naut</th> <th>Astro</th> <th colspan="2"></th> <th>Rises</th> <th>Sets</th> </tr> </thead> <tbody> <tr> <td colspan="2"></td> <td>Ends</td> <td>16:36</td> <td>17:17</td> <td>17:57</td> <td colspan="2">Sun</td> <td>07:37</td> <td>15:57</td> </tr> <tr> <td colspan="2"></td> <td>Starts</td> <td>06:59</td> <td>06:17</td> <td>05:38</td> <td colspan="2">Moon</td> <td>19:19</td> <td>11:47</td> </tr> </tbody> </table>											Twilight	Civil	Naut	Astro			Rises	Sets			Ends	16:36	17:17	17:57	Sun		07:37	15:57			Starts	06:59	06:17	05:38	Moon		19:19	11:47
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# Lewes Astronomical Society

## Brown Lunation Numbers

numbered from first New Moon in 1923

# Phases of the Moon



<u>Phase</u>	<u>Date</u>	<u>Time</u>	<u>Lunation</u>
LAST QUARTER	5 <sup>th</sup> December	05:49	1248
NEW MOON	12 <sup>th</sup> December	23:32	1249
FIRST QUARTER	19 <sup>th</sup> December	18:39	1249
FULL MOON	27 <sup>th</sup> December	00:33	1249



Credit: Sean Smith/NASA

# Lewes Astronomical Society

**Friday 1<sup>st</sup> December 2023, 8:00–10:00pm**

Observing Evening

Arlington Village Hall, members only

**Wednesday 6<sup>th</sup> December 2023, 7:30–9:30pm**

*“A Whistle-Stop Tour of the Inner Planets”*

William Joyce, Lewes Town Hall, visitors welcome

**Wednesday 3<sup>rd</sup> January 2024, 7:30–9:30pm**

A selection of short talks by several speakers

Lewes Town Hall, visitors welcome

[www.lewesas.org.uk](http://www.lewesas.org.uk)