# Lewes Astronomical Society

## Newsletter - October 2023

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# Astronomy News

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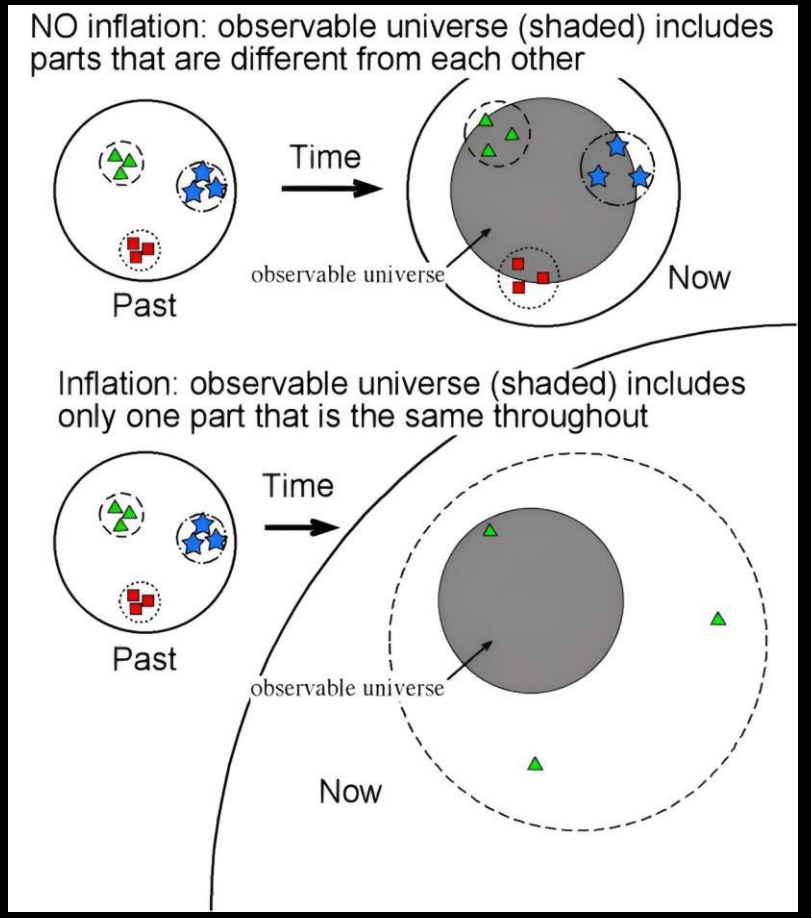
# Do we live in a small universe? (1)

- The earliest detectable light originates from Cosmic Microwave Background Radiation (CMB). It has been travelling towards us for nearly 13.8 billion years, from the edge of the observable universe. Because of cosmic expansion, the distance across the observable universe is about 46 billion light years
- Based on the models developed over the last 50 years, the observable universe is only a very small part of the overall universe.
- There are 3 compelling reasons for this idea:

1. The distribution of galaxy clusters is the same whichever way we look; if the observable universe was all there is, clusters would feel a gravitational pull towards the centre and be asymmetrically clustered




Inflation would make the CMB temperature uniform
Credit: Nick Strobel

# Do we live in a small universe? (2)

2. Spacetime is flat, otherwise distant galaxies would appear to be distorted. This suggests the cosmos is at least 400 times larger than the observable universe
3. The CMB is almost a perfect blackbody. The temperature fluctuations are much smaller and more uniform than they should be. To account for this the theory of inflation was proposed where there was a brief period of tremendous expansion that lasted between $10^{-36}$ and $10^{-32}$ seconds after the Big Bang

- While there is no direct evidence to support inflation, the model solves many of the cosmological problems and is widely accepted. If it is correct, then the Universe is of the order of $10^{26}$ times larger than the observable universe
- However, there are cosmologists who believe we don't live in a 4-D (3 space, 1 time) universe, but a multi-dimensional one, premised on String Theory
- Most String Theory models don't look like the Universe, but one has now been developed that doesn't involve inflation, matches observations and is only about a thousand times larger than the observable universe

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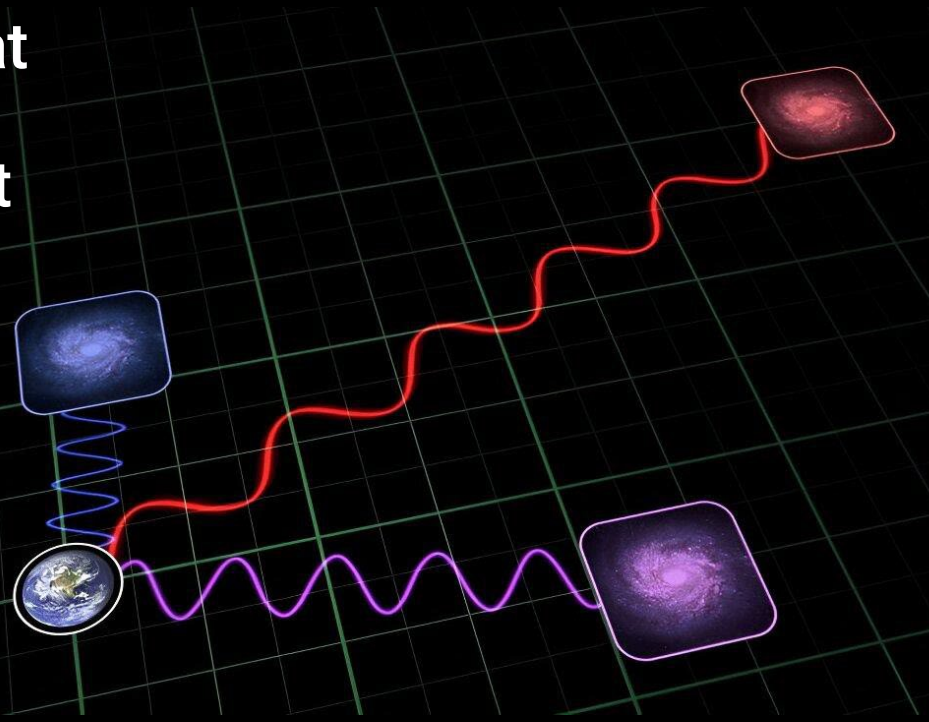
# Rate of expansion of the Universe: Redshift (1)

- One hundred years ago, Edwin Hubble showed that the Universe was expanding and that there was a correlation between galactic distance and redshift
- Space itself is expanding and the rate of this expansion is known as the Hubble Constant
- The current value is around 70 km/s per megaparsec (roughly 3 million light years). So, a galaxy 2 megaparsecs away is moving away from us at 140 km/s
- However, different methods of measuring the Hubble Constant come up with different answers; the so-called Hubble Tension. Trying to resolve it is difficult as we can only measure the current expansion rate



Cosmological redshift depends upon a galaxy's distance
Credit: NASA/JPL-Caltech/R. Hurt (Caltech-IPAC)

# Rate of expansion of the Universe: Redshift (2)

- Is cosmic expansion is due to general relativity or a more subtle extension of Einstein's model?
- Each year, as the Universe continues to expand, it is a little more distant, causing the redshift to grow larger
- This drift is extremely small; the apparent speed of a galaxy 12 billion light-years away would be about 95% of the speed of light, while its drift would be just 15cm/s each year – far too small to currently measure
- But the new Extremely Large Telescope (ELT), due to start operating in 2027, should be able to view this drift over a period of time, say between 5 and 10 years of precise observations. With that much data it should be able to see drifts as small as 5 cm/s. For more on the ongoing debate about Hubble Tension see: https://phys.org/news/2023-09-early-dark-energy-hubble-tension.html?utm_source=nwletter&utm_medium=email&utm_campaign=daily-nwletter

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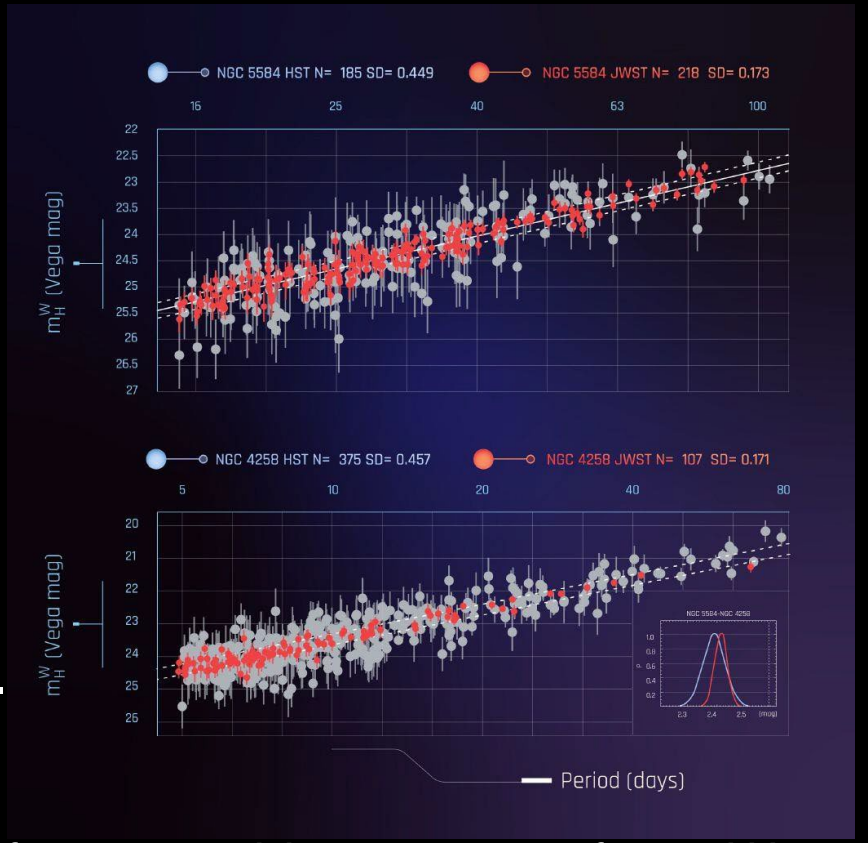
# Expansion and the Hubble Tension (1)

- The rate of expansion of the Universe has been measured using two different methods: from the Cosmic Microwave Background (using Planck), and from observations of distant supernovae (Hubble)
- Unfortunately, the two methods do not give the same result; they differ by about 10%. The latest estimates for the Hubble Constant ($H_0$) from Planck are 67.4 ± 0.5 (km/s)/Mpc, and from Hubble, 73.0 ± 1.0 (km/s)/Mpc
- Recently, JWST has stepped in the resolve the issue – only it seems to have made the mystery even murkier




Comparison of Cepheid period-luminosity relations used to measure distances. The red points are from JWST and the grey points are from Hubble. The top panel is for NGC 5584, the Type Ia supernova host, with the inset showing image stamps of the same Cepheid seen by each telescope. The bottom panel is for NGC 4258, a galaxy with a known geometric distance, with the inset showing the difference in distance moduli between NGC 5584 and NGC 4258, as measured with each telescope
Credit: NASA, ESA, CSA, J. Kang (STScI). Science: A. Riess (STScI))

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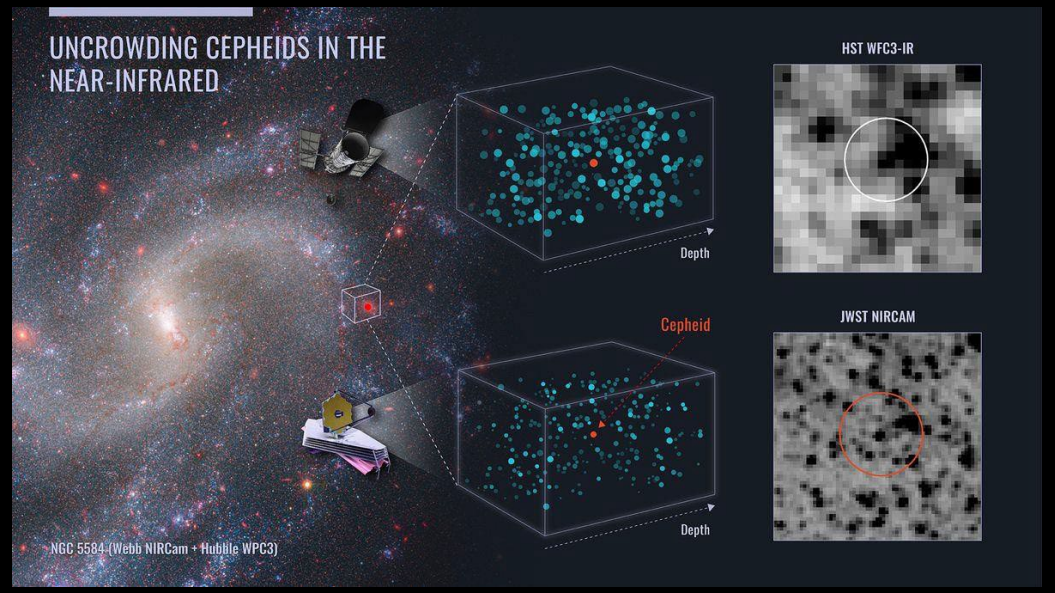
# Expansion and the Hubble Tension (2)

- Thirty years earlier, the Hubble Space Telescope, with its ability to measure stellar brightness with incredible precision, was called upon to measure the Hubble Constant
- To do this required the creation of an accurate stepladder out into the Cosmos. So, if the distance to Cepheid Variables could be measured, not just in the Milky Way, but in far off galaxies up to 100 million light years away, this would create a rung in the ladder towards measuring even more distant Supernovae Type 1a. Prior to 1990 the expansion rate couldn't be measured accurately, and the age of the Universe was estimated to be between 10 and 20 billion years




This diagram illustrates the combined power of the Hubble and Webb space telescopes in nailing down precise distances to a special class of variable star, which is used in calibrating the expansion rate of the universe
Credit: NASA, ESA, CSA, J. Kang (STScI). Science: A. Riess (STScI))

# Expansion and the Hubble Tension (3)

- Unfortunately, Hubble has some limitations. It is excellent at resolving the blue end of the spectrum, but less so at the red end (and into the near infrared). Light is shifted more towards the red end as the Universe expands, and is also affected by dust (unless it is infrared). This means that a Cepheid partially obscured by a dust cloud will appear fainter than it actually is. To account for this light blending, scientists used statistical modelling. This was held up by detractors of the Cepheid/Supernova method as being a reason why the Hubble Constant differed from the CMB
- Now, JWST has checked observations made by Hubble and looked at the same Cepheids by firstly observing Cepheids in a galaxy with a known geometric distance for calibration purposes. That galaxy was NGC 4258. The second step was to observe Cepheids in the host galaxies of recent Type 1a supernovas. In essence, JWST has confirmed the Hubble measurements
- The two corners are still resolutely apart - and the Hubble Tension continues!

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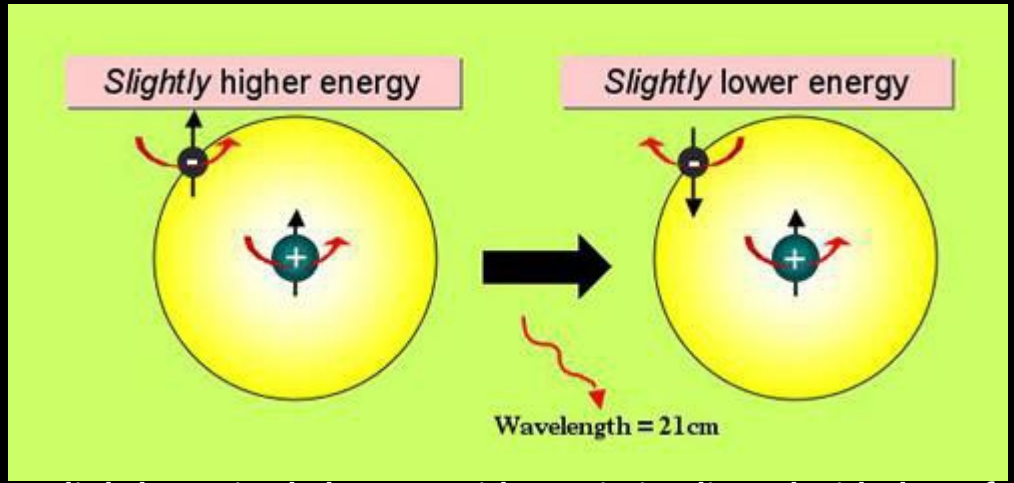
# HERA, 21cm and WIMPS (1)

- The Universe is filled with hydrogen, which makes up 90% of all the normal matter. It has a nice trait which makes it easy to spot; a faint emission line of radio at a wavelength of 21cm, known as the H1 hydrogen line
- Hydrogen consists of a single electron bound to a single proton. When the spins of these two are aligned in the same way, hydrogen has slightly higher energy than when the spins are oppositely directed




A slightly excited electron with a spin is aligned with that of the proton will eventually flip its spin to enter a lower energy state. The energy emitted is very small and equivalent to a wavelength of 21cm
Credit: Swinburne University of Technology

- Matter likes to occupy the lowest energy level possible. This means that the electron will often spin-flip and release a bit of energy as a photon of light at a wavelength of 21cm, with clouds of hydrogen emitting 21cm radio light. This can happen spontaneously, the hydrogen doesn't need to be ionised or superheated

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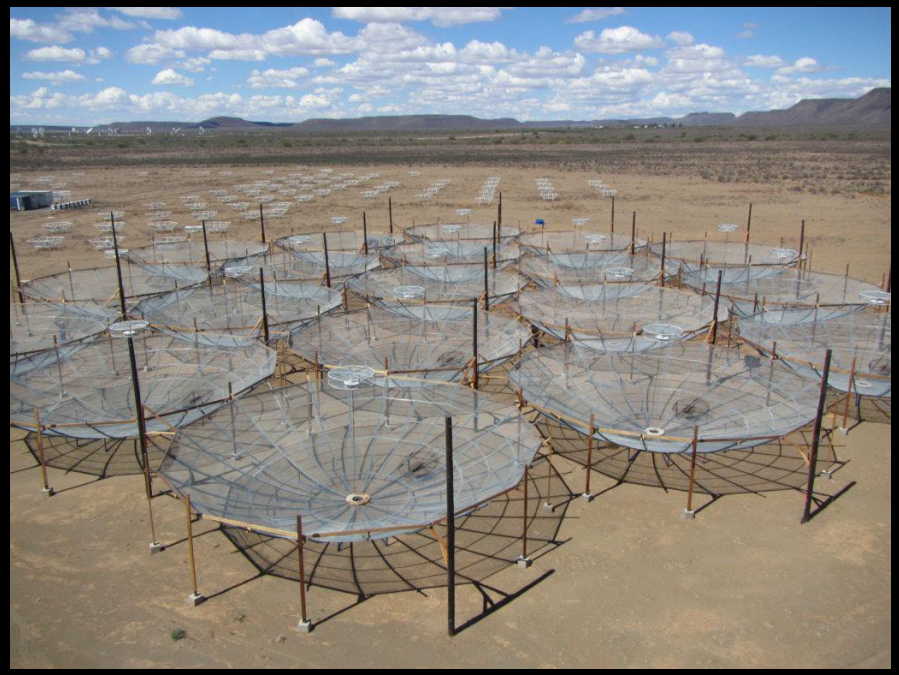
# HERA, 21cm and WIMPS (2)

- Being a very specific wavelength, it can be used to measure the relative motion or cosmological redshift of hydrogen. It was this trick that Vera Rubin used to discover dark matter
- A new study shows how the 21cm line might give us the first evidence of dark matter particles
- The study focuses on the Hydrogen Epoch of Reionization Array (HERA), which is a radio telescope in South Africa particularly suited for observing hydrogen in the early Universe
- HERA is due to be fully commissioned soon, and will map the large-scale structure of hydrogen during the cosmic dark ages and cosmic dawn period (the time between Big Bang and the first stars)



The HERA Observatory
Credit: National Research Foundation (NRF)/South African Radio Astronomy Observatory (SARAO)

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# HERA, 21cm and WIMPS (3)

- In this period, the Universe was filled with warm clouds of hydrogen gas and dark matter. If dark matter doesn't interact with ordinary matter (apart from gravitationally), then the only light emitted will be at 21cm
- The current model for dark matter involves heavy particles known as WIMPs (Weakly Interacting Massive Particles). These are expected to occasionally decay into ordinary matter and create bursts of positrons, electrons, or protons and anti-protons. Such decay particles would interact with 21cm light
- WIMPs are currently hypothetical but, if they do exist, they would have extremely long half-lives; possibly more than a trillion years
- Despite WIMPs having such long half-lives, HERA would be able to detect the effect on the 21cm line, and could even have enough evidence in just 1,000 hours of observation time
- Even if WIMPs are not detected by HERA, the ruling out of some WIMP models will help to unravel what dark matter really is

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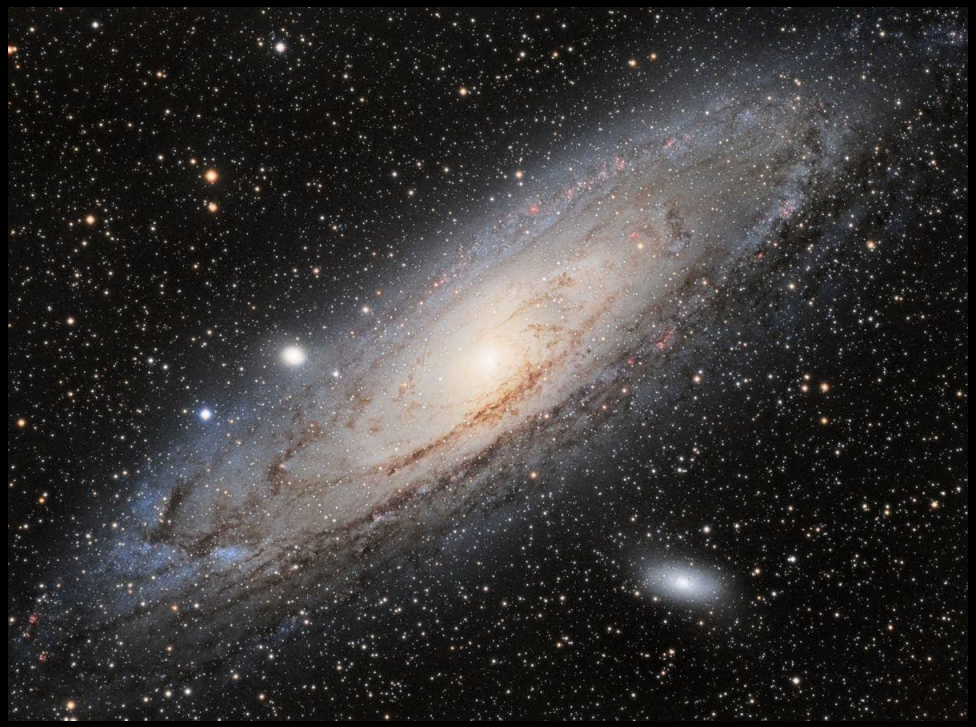
# Studying dark energy in our own backyard

- Dark energy makes up over 68% of the Universe, and scientists are already observing distant galaxies in an effort to study it
- However, researchers now think that the interaction between the Milky Way and the Andromeda Galaxy, as well as their combined mass, may set an upper limit on the cosmological constant; the simplest model of dark energy
- As the two galaxies get closer they will very slowly start to orbit each other(a single orbit will take 20 billion years). Before this happens, huge gravitational forces will cause them to begin to merge



The Andromeda Galaxy
Credit: André van der Hoeven

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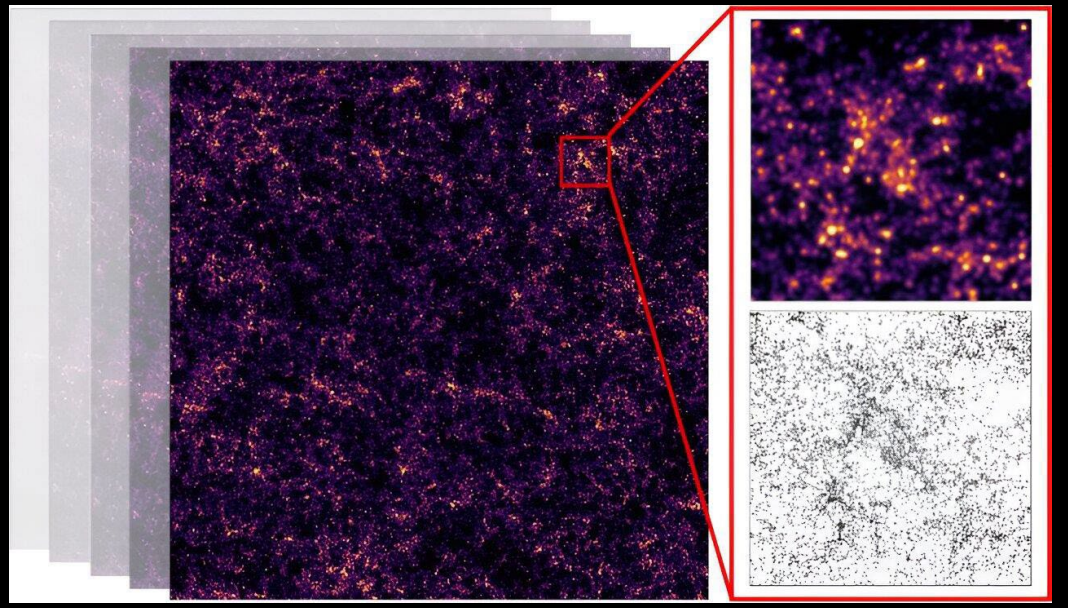
# Where other telescopes can’t go

- JWST has revolutionised the study of the Universe by peering back to within a few hundred million years after the Big Bang
- But, within a billion years, there were just too many galaxies and clusters, meaning that JWST “can’t see the wood for the trees”
- In order to study the whole universe, a different technique is needed – Line Intensity Mapping (LIM) – to map galaxies that are too far away for traditional surveys



A line intensity image appears smeared compared to traditional galaxy survey images
Credit: Patrick Breysse

- LIM uses a low-resolution telescope to study the sum of radiation emitted from a collection of galaxies. As a result, intensity mapping images appear smeared compared to traditional galaxy survey images. Combining these smeared images with the colour of the light tells us how far away the aggregates are

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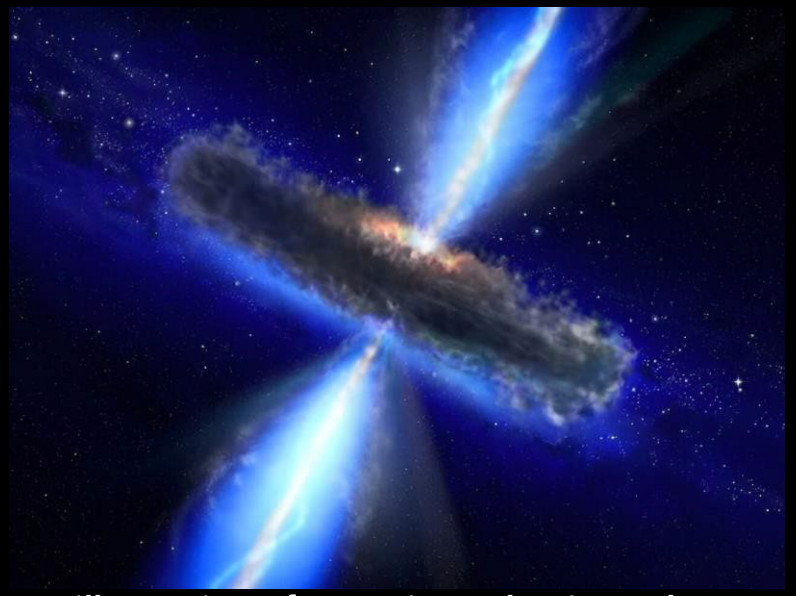
# Fewer Supermassive Black Holes revealed

- A JWST survey has revealed active galactic nuclei (AGN - supermassive black holes that are rapidly increasing in size) are rarer than many astronomers previously assumed
- This suggests that our universe may be a bit more stable than was supposed
- With JWSTs increased boost in power, it was thought that more AGNs would be located than in past surveys, but very few new ones were found

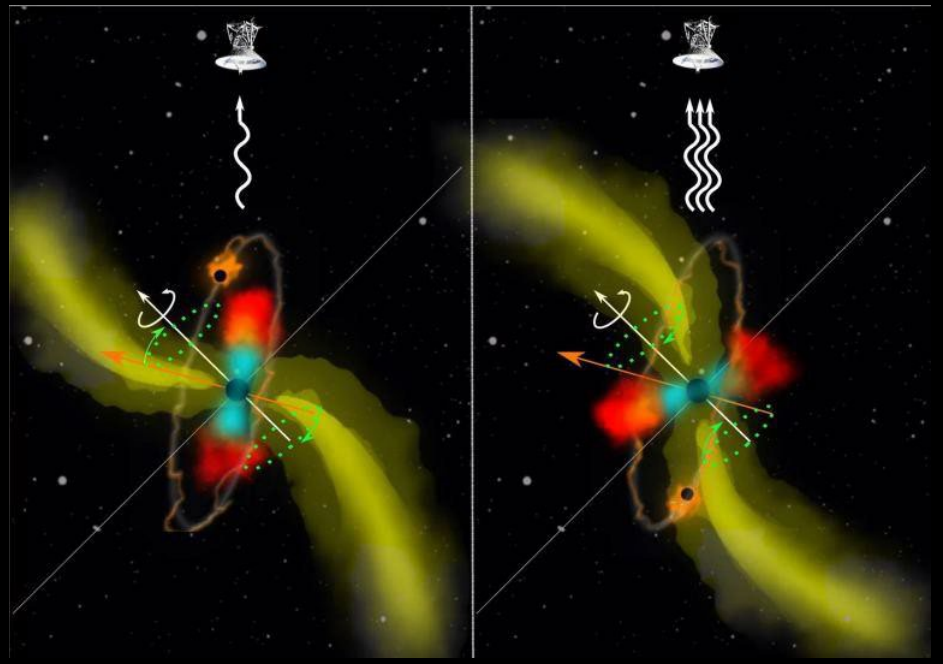


An illustration of an active galactic nucleus
Credit: ESA/NASA/AVO/Paolo Padovani

- This suggests that these black holes are likely to be growing at a slower pace than previously believed and not significantly impacting on their host galaxies
- Another surprise was that many smaller galaxies, similar in size and appearance to the Milky Way, lacked lots of dust. Could this mean that the SBMH in the Milky Way was never active or went through an AGN phase?

# Other galaxies have two SMBHs

- Blazers are bright active galactic nuclei (AGN) which blast out cosmic rays, are bright in radio emission, and which sport huge jets of material travelling in our direction at nearly the speed of light
- Studies of blazers with wandering jets have led astronomers to propose that they may be the result of binary black holes
- One particular galaxy, OJ287, seems to have two black holes at its core. As the black holes orbit each other, one black hole emits the jet and the other one's gravitational influence affects the appearance and behaviour of the jet



A magnetized radio jet (yellow), precessing due to a pair of supermassive black holes. The larger one is (black) at the centre of the accretion disk. It contains warmer (blue) and cooler (red) gas. The white arrow indicates the spin of the larger black hole. The second black hole orbits (orange) around the central SMBH
Credit: Michal Zajacek/Dept of Theoretical Physics and Astrophysics, Masaryk University, Brno, Czech Republic (UTFA MUNI)

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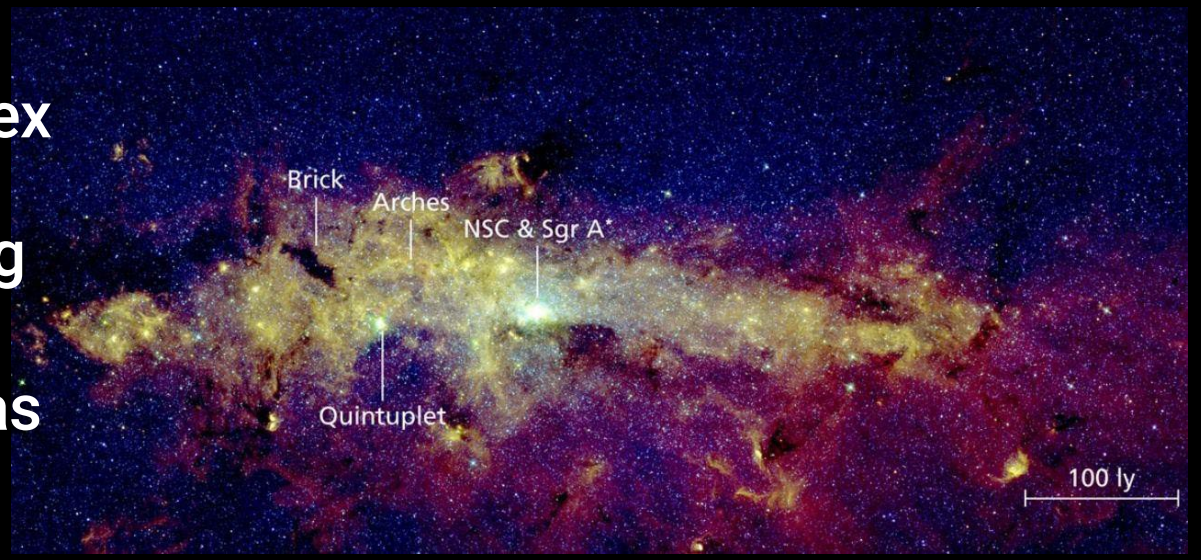
# The “Brick” at the heart of the Milky Way

- Around the heart of the Milky Way lies the Central Molecular Zone; a massive complex of dense, turbulent and dark molecular clouds where new stars are born, equalling some 60 million solar masses
- One such dark molecular cloud is known as the “Brick” which, unlike other areas, lags behind with very low star formation (although at least 56,000 stars are in it). But why? Too young? Too turbulent?




The Central Molecular Zone; the Heart of the Milky Way
Credit: Dr Jonathan Henshaw, Max Planck Institute for Astronomy, Heidelberg, Germany

- To study this, astronomers looked at Carbon Monoxide (CO). JWST has found that there is more CO ice than previously thought, which is gaseous at the Brick’s surface but frozen in the interior. In spite of the ice, the gas inside the Brick is actually warmer than other clouds (CO is a coolant), and this may be inhibiting star formation

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# Astronomy News in Brief (1)

- Hoʻoleilana: a relic of the birth of the Universe – astronomers at the University of Hawaii have found an immense bubble 820 million light years from Earth, believed to be a fossil-like remnant of the birth of the universe. These massive structures are predicted by the Big Bang theory to be the result of 3D ripples found in the material of the early universe, known as Baryon Acoustic Oscillations (BAO). The very large diameter of one billion light years is beyond theoretical expectations. If its formation and evolution are in accordance with theory, this BAO is closer than anticipated, implying a high value for the expansion rate of the universe. See a short video about the discovery at: https://youtu.be/OktWFI09NmI
- Early galaxy found by not seeing it – researchers have discovered a new galaxy dating back 11 billion years using Hubble, not by the light it emits, but by the light it absorbs. The galaxy itself evades observations, but has at least one nearby companion. In this case, the hidden galaxy is absorbing light from a more distant bright source, most likely a quaser

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# Astronomy News in Brief (2)

- Large early galaxies light on heavy elements – it has long been believed that galaxies live in equilibrium throughout their lives. As they grow, the amounts of heavy elements increases in a well-known relationship. Now, JWST has revealed that a number of very large but early galaxies, which are in the process of being formed, have up to four times less heavy elements, compared to what you'd expect from their stellar masses and the numbers of new stars they have produced
- Early “Milky Ways” – galaxies from the early universe are more like our own Milky Way than previously predicted, flipping the entire narrative of how scientists think about structure formation in the universe. Using JWST, researchers discovered that galaxies like our own Milky Way dominate throughout the universe, and are surprisingly common

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# Astronomy News in Brief (3)

- El Gordo challenges ΛCDM (Lambda cold dark matter) – the Standard Model of Cosmology dictates that galaxies form first and only later combine into larger clusters of galaxies. Thus, galaxy clusters should take a lot of time to appear on the cosmic scene. However, El Gordo ("The Fat One") is a cluster formed by a collision of two massive clusters of galaxies, which occurred when the Universe was half its current age. The mass of El Gordo has been confirmed by Hubble using weak lensing (which agrees with JWST estimate). This has allowed models to be created of what the precursor clusters would have looked like and at what speed they would have collided – these cannot be reconciled with ΛCDM, which would have predicted a much slower collision
- Cosmic structure growth being supressed – during the early period of the Universe when dark and visible matter held the whip hand, cosmic structures (such as clusters) developed as gravity took a hold. Dark energy then started to gain in dominance and slowed the growth of cosmic structures. Researchers believe this growth suppression is a relatively late phenomenon

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# Astronomy News in Brief (4)

- Fast-moving black holes – when two smaller black holes collide and generate gravitational waves, the ensuing recoil causes the newly-merged larger black hole to hurtle in the opposite direction at great speeds. Now, mathematical modelling is suggesting that some black holes may be travelling at up to 10% the speed of light
- Black Hole repeatedly snacking on star – in a galaxy 500 million light years away, a white dwarf named Swift J0230 is being stripped of material equal to the mass of 3 Earths every time it passes near to a small black hole, roughly once a month. For about a week the material is sucked into the black hole and is accompanied by a strong flash of light. The partial shredding is known as a tidal disruption event and so far about 100 are known. However, all the others occur on either a very short time span (approximately once a day) or much longer time period (about once a year). The black hole is estimated to be about 10,000 to 100,000 the mass of the Sun

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# Astronomy News in Brief (5)

- Spotting a supernova before we see it – the new Jiangmen Underground Neutrino Observatory in China is built to look for supernovae and should see first light later this year. If all goes well, it will be able to detect a burst of neutrinos coming from a core-collapse supernova before we can see the flash of radiation. As a star implodes, energy piles up inside the star, but the neutrinos can freely escape, arriving seconds earlier than the radiation. The observatory will have a range of 3,000 light-years for pre-supernova neutrino detections and 1.2 million light-years for post-supernova detection
- The Milky Way is warped – astronomers have measured the Milky Way's shape and found that the disk is warped; different to the flat spiral we see in many other galaxies. It was assumed a collision with another galaxy in the ancient past caused this warping. Observations have shown that the galactic stellar halo is tilted in relation to the galactic plane, and a new theory proposes that the dark matter halo is tilted too

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# Astronomy News in Brief (6)

- Polaris behaving oddly – Polaris, the Pole Star, lies about 434 light years from Earth. It is only the 48th brightest star; if it wasn't within 1% of the north celestial pole it would not be very remarkable. It is a binary system with a F-type yellow supergiant (Polaris Aa) and a smaller main-sequence yellow dwarf (Polaris B) in an orbital period of about 30 years. Polaris Aa is also a Cepheid variable. Over the past 150 years, observations have revealed that the pulsation period of Polaris Aa is about 4 days, and that it has been increasing by about 5 seconds a year. Now, that process has been reversed. No one is quite sure why, but it is thought it could be that the companion star (Polaris B) is disturbing it whenever they make a close pass of each other
- Hidden Earth twin – a pair of Japanese astrophysicists believe they have found evidence for an Earth-sized planet residing in the Kuiper Belt. In their work, the researchers found that some of the objects in the Kuiper Belt behave in a way that suggests that there is a small planet amongst them. It is believed to be about 500 AU from the Sun, with a mass 1.5 to 3 times that of the Earth

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# Spaceflight News

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# Communicating with a satellite (1)

- JWST and Euclid are sitting at Lagrange Point 2 ($L_2$), about a million miles from Earth. How do we send them instructions and receive data back, including all those wonderful images?
- The Deep Space Network (DSN) uses three sites around the world: Goldstone in California, Canberra in Australia and Madrid in Spain. These provide 24-hour continuous coverage for any satellite
- For JWST it is in contact two or three times a day and each contact period is scheduled to ensure communication is not compromised with other missions, all handled by negotiation (after the initial 8 weeks, which are fixed)

Goldstone Complex
Credit: Lara Hartley

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# Communicating with a satellite (2)

- Each DSN has three antennae: 70m, 34m and 26m. Each DSN supports different radio frequencies, such as S-band and Ka-band. S-band has lower bandwidth, so is used for commands and telemetry information while Ka-band is used to downlink stored data. JWST has a high-gain antenna for Ka-band and a medium-gain antenna for S-band
- Currently, the DSN supports 40 missions
- For more about the DSN go to: https://www.nasa.gov/directorates/heo/scan/services/networks/deep_space_network/about
- And for what the DSN is communicating with: https://eyes.nasa.gov/dsn/dsn.html

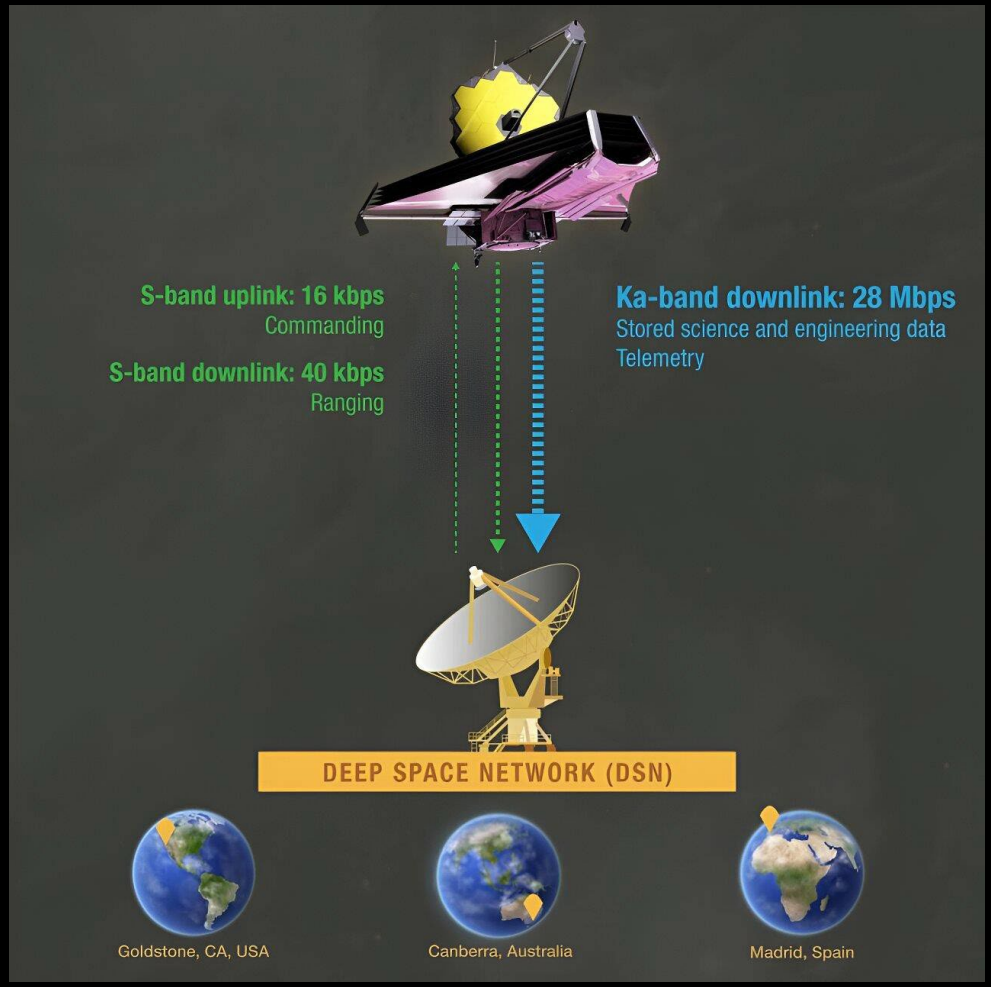


Diagram of links from DSN to JWST Credit: STScI

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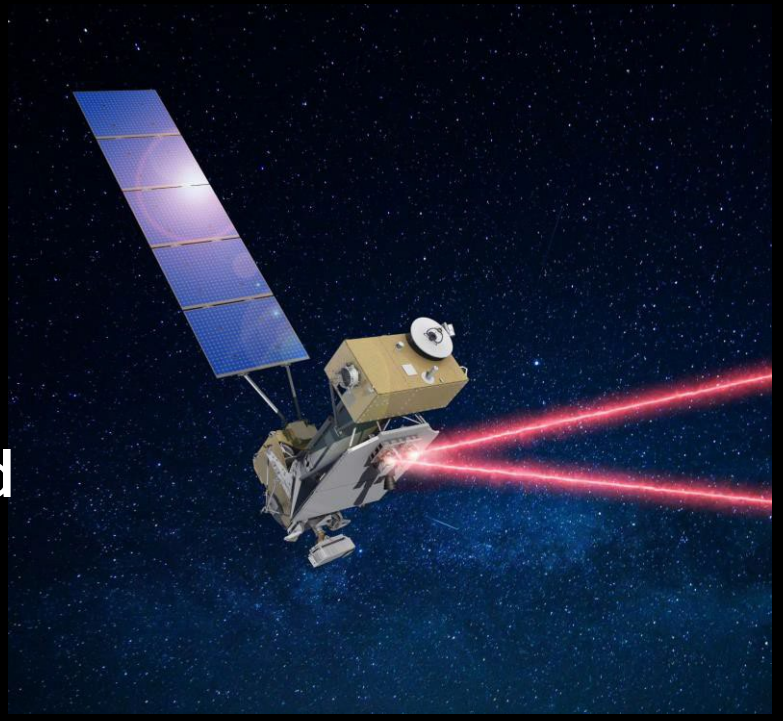
# Communicating with a satellite (3)

- Later this year the SpaceX CRS-29 mission, due to launch on 1st November, will deliver the ILLUMA-T: 2023 module to the International Space Station
- NASA's Integrated LCRD Low-Earth Orbit User Modem and Amplifier Terminal will provide the ISS with laser end-to-end communications to the LCRD (Laser Communications Relay Demonstration) payload onboard the STPSat-6 satellite, for direct link to ground stations on Earth
- Up until now, communication with the ISS has relied on radio waves, but the new powerful and much lighter communications system will be able to handle 1.2 GB/sec. Lasers, being of much shorter wavelength, can transmit more information simultaneously than radio



The Laser Communications Relay Demonstration payload on STPSat-6
Credit: NASA's Goddard Space Flight Center

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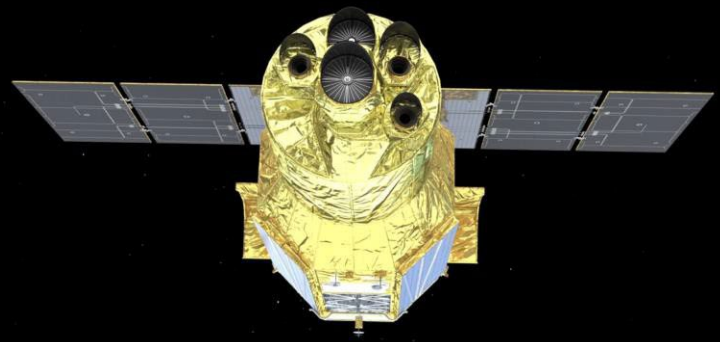
# XRISM (X-ray Imaging and Spectroscopy Mission)

- The XRISM spacecraft will study the universe's hottest regions, largest structures, and objects with the strongest gravity
- It is a collaboration between the Japanese Space Agency JAXA (lead), NASA, ESA and CSA. XRISM was successfully launched from the Tanegashima Space Center in Japan on 6th September, on board a Japanese H2-A rocket
- To collect the x-rays, XRISM has 3,200 curved individual nested mirrors, with each mirror assembly about 45 centimetres across, and has a resolution of just over 1 arcminute. These will be used by Xtend, a soft X-ray imager, using four CCD detectors that extend the field of the observatory to 38 arcmin on a side over the energy range 0.4-13 keV



Artist's concept of face-on view of XRISM
Credit: NASA's Goddard Space Flight Center Conceptual Image Lab

Watch an animation of the microcalorimeter array at: https://youtu.be/J5mzhK9in_I

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# PSYCHE

- The new spacecraft is due to be launched by a SpaceX Falcon Heavy rocket from Launch Complex 39A at the Kennedy Space Center, Cape Canaveral on 12th October
- In preparation for this, the spacecraft has been mated with its huge solar panels. After testing, the panels were refolded in readiness for the launch to the asteroid, Psyche, which is in the main asteroid belt
- The giant solar panels will produce 20kW of power when near Earth, but this will fall to 2kW by the time the spacecraft arrives at Psyche in July 2029
- For more about the Psyche mission go to: https://youtu.be/y__vwRQ3PVg

NASA's Psyche spacecraft, undergoing final tests in a clean room at a facility near Florida's Kennedy Space Center
Credit: NASA/Frank Michaux

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# India: the Sun and Moon in one month (1)

- Following its successful landing within 300m of the target point, the Indian Lunar Rover (Pragyan – “Wisdom”) was successfully deployed from the lander and spent nearly two weeks exploring the surrounding area. During this time, the Vikram lander performed a short hop, taking off to a height of about 40cm, and landing again about 30cm away
- During its explorations, the rover confirmed the presence of sulphur and detected several other elements, but there is no word about signs of frozen water on the surface. One instrument recorded the surface temperature at 50°C and -10°C a few millimetres below the surface


India’s Pragyan rover left its mark on the lunar surface
Credit: Indian Space Research Organisation (ISRO)

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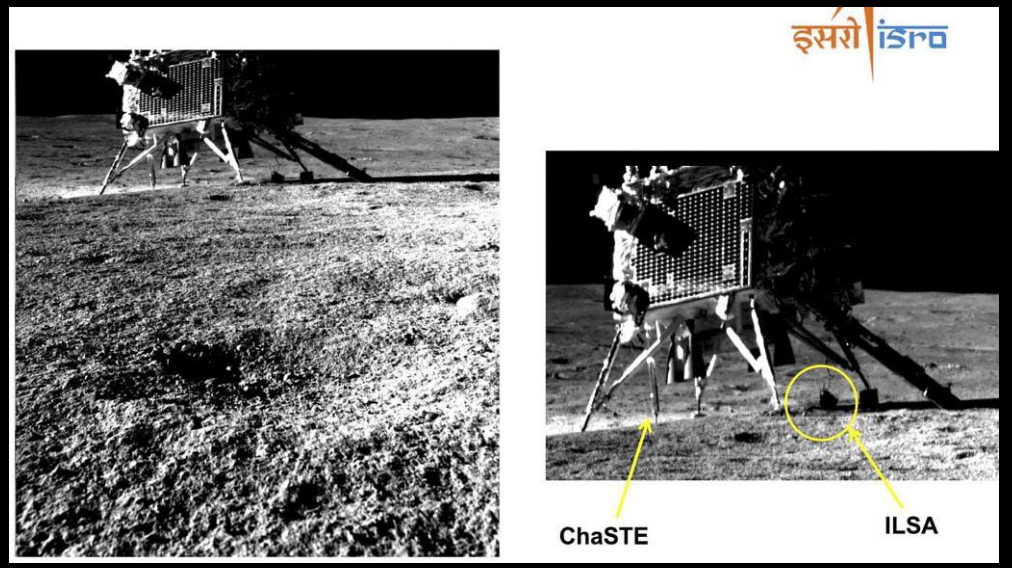
# India: the Sun and Moon in one month (2)

- With daylight in the Moon's south pole coming to an end, the rover and the lander, both with fully charged up batteries, have entered sleep mode until 22nd September, when the Sun returns
- It was hoped that, once warmed up again, both could resume operations, although the electronics on board the Indian moon mission weren't designed to withstand very low temperatures, which reach less than -120°C during the nighttime on the moon. So far, all attempts to wake up both the rover and lander have failed
- For a clip of the rover rolling off the lander go to: https://youtu.be/rEoDdzCJFGM and of it doing a 360° turn: https://t.co/d4XBbG9VXU




Indian Vikram lander with two of the instruments highlighted. Photo taken from the Pragyan rover
Credit: Indian Space Research Organisation (ISRO)

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# India: the Sun and Moon in one month (3)

- On 2nd September, the Aditya-L1 spacecraft blasted off from Satish Dhawan Space Centre in Sriharikota atop a Polar Satellite Launch Vehicle (PSLV). Aditya-L1 is a solar observatory operated by the Indian Space Research Organisation (ISRO). The Aditya-L1 spacecraft will travel to Lagrangian Point $L_1$, from where it will study the Sun. During the five-year mission it will investigate the Sun's atmosphere (the corona) and its surface (the photosphere)

Launch of Aditya L-1 Solar Observatory
"Aditya" is Sanskrit for "The Sun"
Credit: Indian Space Research Organisation (ISRO)

- It carries seven scientific instruments, including a Magnetometer, a Visible Emission Line Coronagraph, and a Solar Ultraviolet Imaging Telescope
- Watch the Sky News report of the launch and India's increasing influence in outer space at: https://www.youtube.com/watch?v=I4ZAP3uOkII

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# Spaceflight News and Updates (1)

- SLS “unaffordable” – NASA officials have told the U.S. Government Accountability Office (GAO), “…that at current cost levels, the SLS program is unaffordable”. The GAO’s audit report states that the Space Launch System (SLS) moon rocket program's cost "exceeds what NASA officials believe will be available for its Artemis missions”. To date, the SLS program has cost $11.8 million; an additional $11.2 million has been allocated in the 2024 Federal Budget Request. NASA plans to use these funds to develop core stages, rocket engines and other components for SLS, ultimately, to increase the vehicle's efficiency as well as the amount of cargo that can be delivered to the moon for Artemis. However, the baseline costs and schedules for this future work have not been established despite GAO's nearly decade-long concerns
- Moon Sniper – also along on the XRISM launch was the Smart Lander for Investigating the Moon (SLIM). The small-scale exploration lander is designed to achieve a “pinpoint” landing at a specific location to within 100 metres, rather than the typical kilometre range, using high-precision landing technology

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# Spaceflight News and Updates (2)

- OSIRIS-Rex – the samples gathered by the OSIRIS-REx spacecraft in October 2020 from the asteroid Bennu, were successfully returned to Earth on 24th September. The capsule, containing about 250 grams gathered from the asteroid, survived re-entry at a speed of 27,000+ miles per hour to touch down at a more modest 10mph in the deserts of western Utah. The recovered capsule was taken to a clean room in nearby Dugway before being transferred to the Johnson  Space Center in Houston, where analysis of some of the sample will take place. Small specimens will be distributed to research teams across the globe
- Space Debris – an old Soviet-era satellite has apparently disintegrated approximately 1,400 km above Earth, probably due to a space debris hit. It is thought it could be either Kosmos-2143 or Kosmos-2145 that was hit. In a separate event, the ISS had to fire its thrusters to avoid space debris

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# Spaceflight News and Updates (3)

- Nuclear powered rockets to Mars – NASA has selected Lockheed Martin to develop a nuclear-powered rocket with a target of launching as soon as 2027. The DRACO Program (Demonstration Rocket for Agile Cislunar Operations) envisages faster speeds using less propellant than a chemically-powered rocket, with a typical journey coming down from 6-9 months to 45-100 days. The propellant, liquid hydrogen, will be pumped through a nuclear reactor core, converting it to a gas which will then be forced out through a nozzle to create the thrust; the technology is called Nuclear-Thermal Propulsion (NTP). For safety reasons, the nuclear reactor will not be turned on until the rocket is in a high orbit
- Watch the “Revolutionising Nuclear Propulsion with DRACO” video at: https://youtu.be/LSIlLUKiiGE and “Earth to Mars in 100 days?” video at: https://youtu.be/q_Zoxpv9b3w

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## Spaceflight News and Updates (4)

- Solar Sails to Mars – using aerographite solar sails for traveling to Mars and interstellar space could dramatically reduce both the time and fuel required for such missions, researchers claim. Depending upon which trajectory is used, simulations show that a solar sail could reach Mars in 26 days (outward transfer method) and 126 days (inward transfer method). Watch “What’s a Solar Sail?” at: https://youtu.be/Xe6yoGfTZOk
- Ingenuity – the small 1.8kg helicopter has now made 58 flights. In doing so it notched up in excess of 100 minutes flying time
- Australian moon rover – Australia is currently the next country with deep space ambitions, and is building a rover which could be launched on Artemis 3, as soon as 2026. Watch a short video on the mission at: https://youtu.be/sRzZHLuCSiM

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# Spaceflight News and Updates (5)

- A busy month for SpaceX – there are 10 Falcon 9 (Block 5) launches planned this month. 6 will carry Starlink satellites (groups 6-21/22/23, 7-4/5/6), each launch putting either 21 or 22 v2 mini satellites into orbit. The other 4 launches will carry:

1. O3b mPOWER 5 & 6 (communication satellites) for SES-owned O3b Networks
2. SARah 2&3 (passive-antenna synthetic aperture radar satellites) for the German military
3. WorldView Legion 1&2 (Earth observation satellites) for private US commercial organisation, Maxar
4. NROL-69 (a classified mission for the National Reconnaissance Office)

- As of 26th September, SpaceX has made 68 orbital launches this year (the majority Falcon 9)—a new record—and 5,178 Starlink satellites are now orbiting the Earth, of which 4,797 are working. With a further 35 launches planned before the end of this year, SpaceX will break its “100 launches in 2023” target, a significant increase from the 61 launches it achieved in 2022

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# Spaceflight News and Updates (6)

- A busy month for SpaceX launches – these launches are in addition to the Psyche launch on a Falcon Heavy, and the possible test of the Starship-Super Heavy. Apart from the Starship-Super Heavy Booster (from Boca Chica, Texas), all SpaceX launches are from either:
  Cape Canaveral, Brevard County, Florida
    Kennedy Space Launch Complex 39 (LC-39A)
    Space Launch Complex 40 (SLC-40)
  Vandenberg Space Launch Centre, Santa Barbara, California
    Complex 4 (SLC-4E)
    Complex 6 (SLC-6)
- Meanwhile, the current Falcon 9 Block 5 rocket completed 200 successful launches on 24th September. Two Falcon 9 first stage boosters (B1058 & B1060) also set records by being launched 17 times after recovery

Falcon 9 Block 5 Credit: Jose Davila, Space Launch 30 Public Affairs

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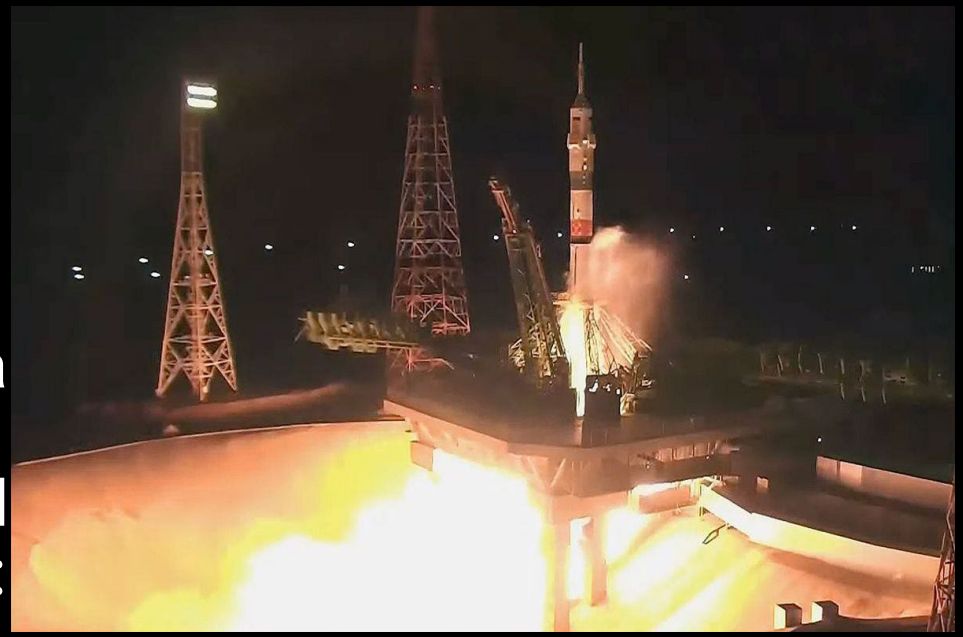
# Spaceflight News and Updates (7)

- Rocket Lab launch failure – the launch of a synthetic aperture radar (SAR) spacecraft for the California company Capella Space on 19th September went wrong shortly after separation of the Electron rocket's second stage. It appears that the Rutherford engine failed to kick in. The first stage was successfully recovered, but the Earth-observation satellite was lost. See the launch at: https://cdn.jwplayer.com/previews/K45gF0sZ
- Soyuz MS-24 Mission – a Soyuz 2.1a rocket was launched on 15th September from Launch Complex 21 at the Baikonur Cosmodrome, in Kazakhstan, with the crew of Oleg Kononenko and Nikolai Chub of Roscosmos, and Loral O'Hara of NASA, relieving crewmembers delayed onboard the ISS for more than six months beyond their scheduled return to Earth. See the launch at: https://cdn.jwplayer.com/previews/SvQePJ0x



Soyuz 2.1a rocket launch Credit: NASA TV

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# Spaceflight News and Updates (8)

- Ariane 6 – a hot-fire test of the new upper stage engines (Vinci and the smaller Auxiliary Power Unit (APU)) on ESA's next generation Ariane 6 rocket was successfully completed on 1st September. This simulated the way the two will have to operate in flight. Vinci, fed by liquid hydrogen and oxygen, can be stopped and restarted multiple times — to place satellites into different orbits and then de-orbit the upper stage, so it is not left behind as hazardous debris in space. The APU makes it possible for Vinci to restart in space
- Launched in 27 hours – Firefly Aerospace launched the Victus Nox mission, with a Millenium Space Systems payload, for the US Space Force just 27 hours after being given the order. Launched from Vandenberg Space Force Base on an Alpha rocket on 14th September, it comes two weeks after Firefly and Millenium entered the mission's "hot standby" phase; a six-month period during which they could receive a launch-alert notice at any time. From receipt of that notice, Millenium and Firefly had 60 hours to get the satellite from Millenium's facilities to Vandenberg, fuel it up, and mate it to the Alpha rocket's payload adapter

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# Observational Highlights

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# October 2023 dates

- 8th October – Draconid meteor shower peak
- 12th October – Comet 103P/Hartley at perihelion (1.06 AU)
- 18th October – Dwarf planet (136199) Eris is at opposition
- 22nd October – Orionid meteor shower peak
- 22nd October – Comet 2P/Encke at perihelion (0.34 AU)
- 23rd October – Venus at greatest western elongation (46° from the Sun)
- 28th October – Partial lunar eclipse between 20:36 and 21:53 BST. Maximum eclipse (12%) is at 21:15

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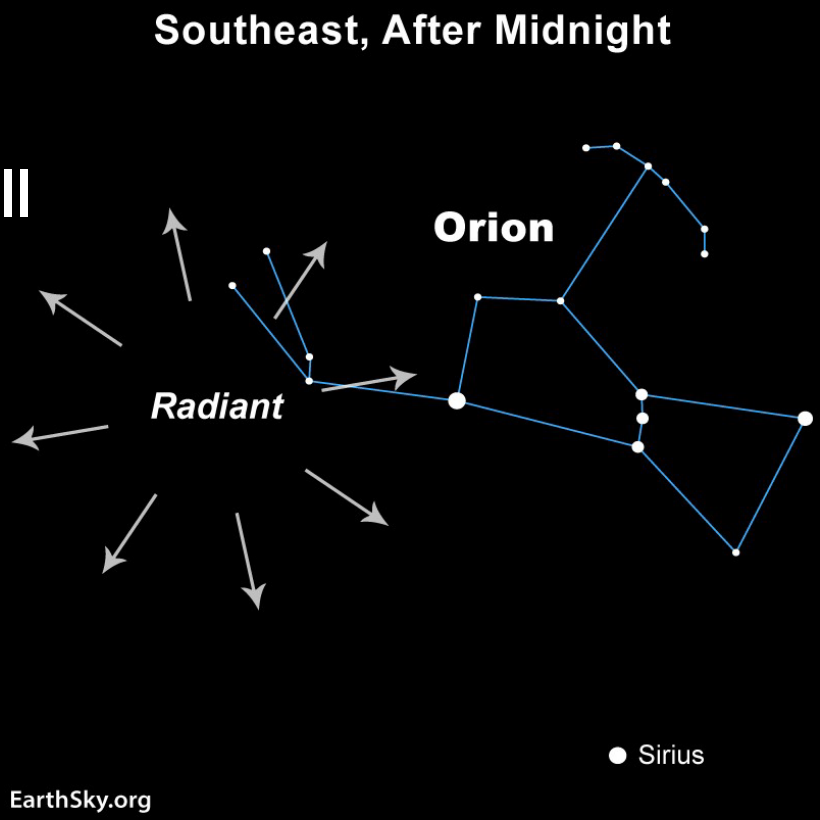
# The Orionids meteor shower

- One of the major meteor showers of the year peaks around 21st/22nd October
- Best to view after midnight, as the first quarter Moon will have set by then
- The meteor radiant is located slightly closer to Gemini than Orion and is situated between Betelgeuse and Alhena (gamma) γ-Geminorium. The radiant rises after 22:00, climbing to about 30° above the eastern horizon by 01:00
- The meteor shower is caused by the debris left behind by Halley's Comet (1P/Halley)
- Fast meteor shower (41 miles/sec) with 10–20 meteors per hour



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# Jupiter approaching opposition

- Jupiter is close to opposition and is coming to its best for the year
- Shining at -2.8 it is the brightest object in the evening sky. At the beginning of the month, it rises at 19:51 and climbs to 30° by 23:15, culminating at 53° at 03:10
- By the end of the month, as opposition approaches it will be at an altitude of 30° or more for up to 8 hours
- With even a small telescope the Great Red Spot, and even the belts should be visible in clear dark skies
- Binoculars will be able to pick out the four Galilean moons, although a telescope will be needed to see one of the moon’s shadows on the planet

Credit: NASA, ESA, A. Simon (Goddard Space Flight Center), and M.H. Wong (University of California, Berkeley)

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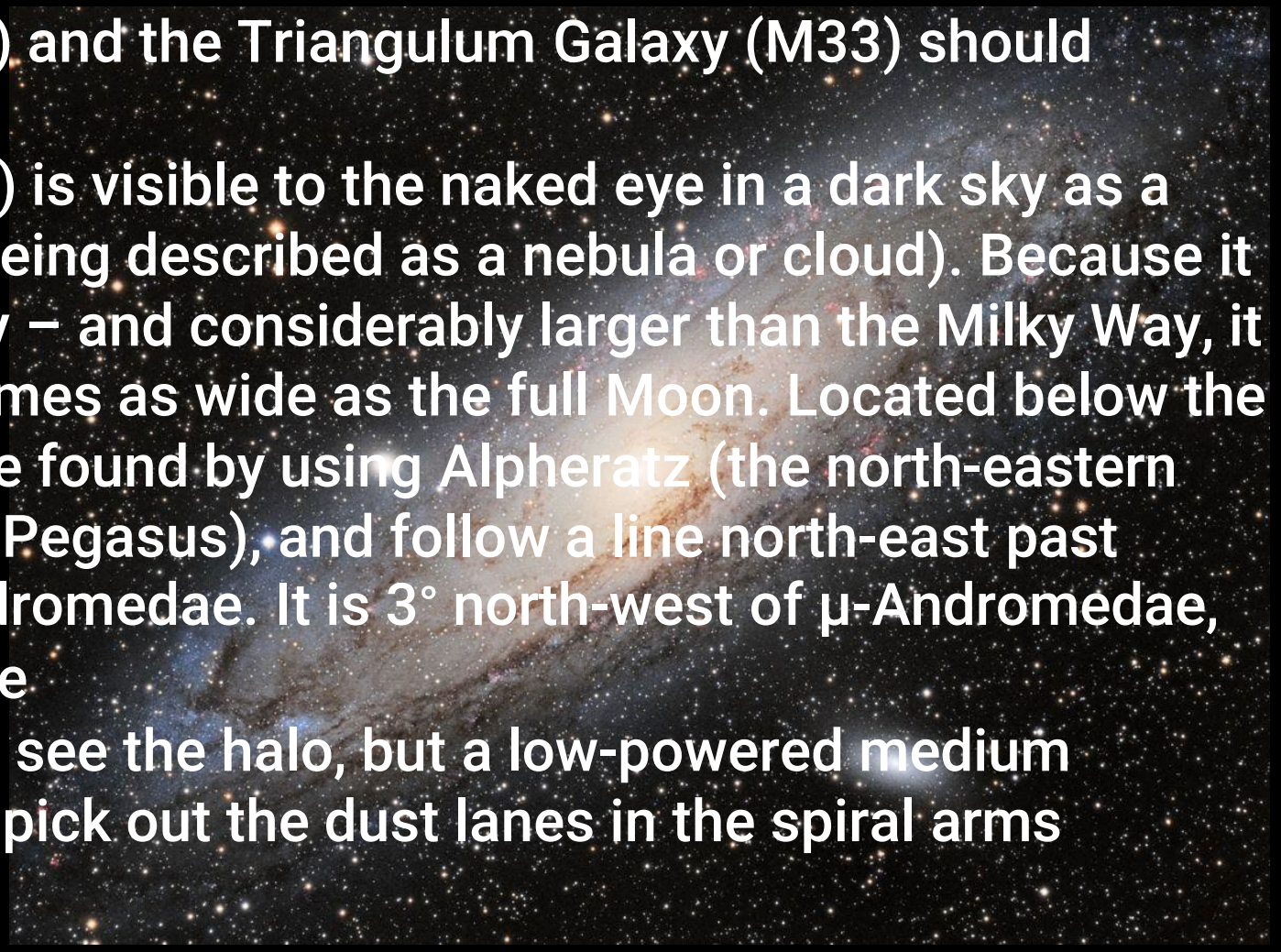
# Two Autumn nebula stand out - Andromeda

- Both the Andromeda Galaxy (M31) and the Triangulum Galaxy (M33) should provide superb viewing
- Andromeda (Messier 31/NGC 224) is visible to the naked eye in a dark sky as a smudge or misty patch (hence it being described as a nebula or cloud). Because it is our nearest neighbouring galaxy – and considerably larger than the Milky Way, it spans 3° x 1° which makes it six times as wide as the full Moon. Located below the famous “W” in Cassiopeia it can be found by using Alpheratz (the north-eastern corner star of the Great Square of Pegasus), and follow a line north-east past (pi)π-Andromedae, and (mu)μ-Andromedae. It is 3° north-west of μ-Andromedae, and just west of (nu)v-Andromedae
- Binoculars will really be needed to see the halo, but a low-powered medium telescope can, in clear dark skies, pick out the dust lanes in the spiral arms



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# Two Autumn nebula stand out - Triangulum

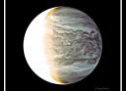
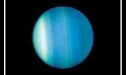
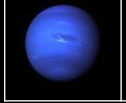
- M33, the Triangulum Galaxy, is another close neighbour located in the local group of galaxies. It lies between the constellations of Triangulum and Pisces, 4.3° west-northwest of Mothallah (+3.4, (alpha)α-Trianguli)
- Half the size of the Milky Way and further away than Andromeda, it is harder to find and see than M31
- Although it has a magnitude of +5.8, it suffers from low surface brightness as it is spread out over a large area as it is a face-on galaxy. So a small telescope really is needed

Credit: Astronomy Magazine

# Lewes Astronomical Society



# Planets (for evening of 1st/morning of 2nd October)

| | Planet | Rises | Sets | Highest | Direction | Altitude | Magnitude | Visible |
|---|---|---|---|---|---|---|---|---|
|  | MERCURY | 05:35 | 18:24 | 11:57 | East | 9° ▫ | -1.03 | YES |
|  | VENUS | 03:02 | 16:59 | 09:59 | South-East | 32° ▫ | -4.51 | YES |
|  | MARS | 08:22 | 19:06 | 13:43 | | | +1.67 | NO |
|  | JUPITER | 19:51 | 10:29 | 03:10 | South | 53° | -2.81 | YES |
|  | SATURN | 17:34 | 03:33 | 22:34 | South | 26° | +0.56 | YES |
|  | URANUS | 20:03 | 11:20 | 03:42 | South | 57° | +5.67 | YES |
|  | NEPTUNE | 18:19 | 05:58 | 00:08 | South | 36° | +7.82 | YES |

* = Highest point at Dawn (05:39 - last visible sighting)

** = Highest point at Dusk (19:57 - first visible sighting)

◊ = Highest point when first visible

◊◊ = Highest point when first visible

▫ = Highest point when last visible (06:37)

▫▫ = Highest point when last visible

# Lewes Astronomical Society



# Deep Sky Objects 1 (for evening of 1st/morning 2nd October)

| Object | Name | Type | Rises | Sets | Highest | Direction | Alt | Mag |
|---|---|---|---|---|---|---|---|---|
| Cr50 | The Hyades (Taurus) | Open Cluster | 21:22 | 12:15 | 04:49 | South | 55° | +1.0 |
| M45 | The Pleiades (Taurus) | Open Cluster | 19:51 | 12:27 | 04:09 | South | 63° | +1.3 |
| M44 | Beehive Cluster (Cancer) | Open Cluster | 01:13 | 16:50 | 09:01 ▫ | East | 40° | +3.1 |
| M31 | Andromeda Galaxy (Andromeda) | Galaxy | *** | *** | 01:05 | West | 42° | +3.4 |
| M42 | Orion Nebula (Orion) | Open Cluster | 00:20 | 11:34 | 05:57 * | South | 33° | +4.0 |
| NGC1977 | Running Man Nebula (Orion) | Open Cluster | 00:17 | 11:36 | 05:57 * | South | 33° | +4.2 |
| IC4665 | Open Cluster (Ophiuchus) | Open Cluster | 11:34 | 00:37 | 18:06 ** | South-West | 39° | +4.2 |
| C14 | Double Cluster (Perseus) | Open Cluster | *** | *** | 02:42 | North | 83° | +4.3 |
| NGC6633 | Open Cluster (Ophiuchus) | Open Cluster | 12:11 | 01:22 | 18:46 ** | South-West | 43° | +4.6 |
| IC4756 | Graff's Cluster (Serpens Cauda) | Open Cluster | 12:27 | 01:29 | 18:58 ** | South | 42° | +4.6 |
| M33 | Triangulum Galaxy (Triangulum) | Galaxy | 16:43 | 11:09 | 01:56 | South | 69° | +5.8 |
| M13 | Great Globular Cluster (Hercules) | Globular Cluster | 06:30 | 03:33 | 17:01 ** | West | 55° | +5.8 |
| M12 | Globular Cluster (Ophiuchus) | Globular Cluster | 11:13 | 23:01 | 17:07 ** | South-West | 25° | +6.1 |
| M3 | Globular Cluster (Canes Venatici) | Globular Cluster | 05:11 | 22:54 | 14:02 ** | West | 22° | +6.3 |
| M15 | Globular Cluster (Pegasus) | Globular Cluster | 14:43 | 04:54 | 21:49 | South | 51° | +6.3 |

* = Highest point at Dawn (05:39 - last visible sighting) ** = Highest point at Dusk (19:57 - first visible sighting)
▫ = Bright object last visible sighting (05:44) ▫▫ = Bright object last visible sighting *** = circumpolar

# Lewes Astronomical Society



# Deep Sky Objects 2 (for evening of 1st/morning 2nd October)

| Object | Name | Type | Rises | Sets | Highest | Direction | Alt | Mag |
|---|---|---|---|---|---|---|---|---|
| M92 | Globular Cluster (Hercules) | Globular Cluster | *** | *** | 17:37 ** | West | 65° | +6.5 |
| M2 | Globular Cluster (Aquarius) | Globular Cluster | 15:53 | 03:52 | 21:52 | South | 38° | +6.6 |
| M10 | Globular Cluster (Ophiuchus) | Globular Cluster | 11:33 | 23:00 | 17:17 ** | South-West | 25° | +6.6 |
| M81 | Bode's Galaxy (Ursa Major) | Galaxy | *** | *** | 10:16 * | North-East | 53° | +6.9 |
| NGC2232 | Open Cluster (Monoceros) | Open Cluster | 01:09 | 12:29 | 06:49 * | South | 32° | +7.0 |
| M101 | Pinwheel Galaxy (Ursa Major) | Galaxy | *** | *** | 14:23 ** | North-West | 42° | +7.9 |
| M94 | 'Spiral' Galaxy (Canes Venatici) | Galaxy | *** | *** | 13:11 ** | North-West | 24° | +8.2 |
| M51 | Whirlpool Galaxy (Canes Venatici) | Galaxy | *** | *** | 13:50 ** | North-West | 33° | +8.4 |
| M1 | The Crab Nebula (Taurus) | Planetary Nebula | *** | *** | 05:39 * | South | 61° | +8.4 |
| M57 | The Ring Nebula (Lyra) | Planetary Nebula | *** | *** | 19:57 ** | South-West | 70° | +8.8 |
| NGC2403 | 'Spiral' Galaxy (Camelopardalis) | Galaxy | *** | *** | 07:58 * | North-East | 62° | +8.9 |

Twilight ends (1st), Twilight starts (2nd)
Sunset (1st), Sunrise (2nd)
Moon rises (1st), Moon sets (2nd)

| | Twilight | Civil | Naut | Astro |
|---|---|---|---|---|
| | Ends | 19:12 | 19:50 | 20:29 |
| | Starts | 06:24 | 05:46 | 05:06 |

| | Rises | Sets |
|---|---|---|
| Sun | 06:57 | 18:39 |
| Moon | 19:07 | 09:36 |

* = Highest point at Dawn (05:39 - last visible sighting)  ** = Highest point at Dusk (19:57 - first visible sighting)
▫ = Bright object last visible sighting (05:44)  ▫▫ = Bright object last visible sighting  *** = circumpolar

# Lewes Astronomical Society

## Brown Lunation Numbers

numbered from first New Moon in 1923

# Phases of the Moon


| Phase | Date | Time | Lunation |
|---|---|---|---|
| FULL MOON | 28th October | 21:24 | 1247 |
| LAST QUARTER | 6th October | 14:47 | 1246 |
| NEW MOON | 14th October | 18:55 | 1247 |
| FIRST QUARTER | 22nd October | 04:29 | 1247 |

Credit: Sean Smith/NASA

# Lewes Astronomical Society

**Wednesday 4th October 2023, 7:30–9:30pm**
*"Stellar Nucleosynthesis"*
Hal Sosabowski , Lewes Town Hall, visitors welcome

**Friday 13th October 2023, 8:00–10:00pm**
Observing Evening
Arlington Village Hall, strictly members only

**Thursday 2nd November 2023, 7:30–9:30pm**
*"Arrokoth and the Sentinels"*
Greg Smye-Rumsby, Lewes Town Hall, visitors welcome

www.lewesas.org.uk