Lewes Astronomical Society

Newsletter - May 2023

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Astronomy & Space News

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The Early Universe: more questions than answers (1)

- The current Standard Model of Cosmology is based on the assumption that it all started with the Big Bang from pure energy about 13.8 billion years ago
- It is based on three components:
  - Dark Energy (68%)
    - (Λ – Cosmological Constant)
  - (Cold) Dark Matter (27%)
  - Normal Matter (5%)
- It also presumes that Einstein's Theory of General Relativity is the accepted theory for gravity on the scale of the Universe
- It is sometimes called the LAMBDA CDM

Credit: Terry Gilliam

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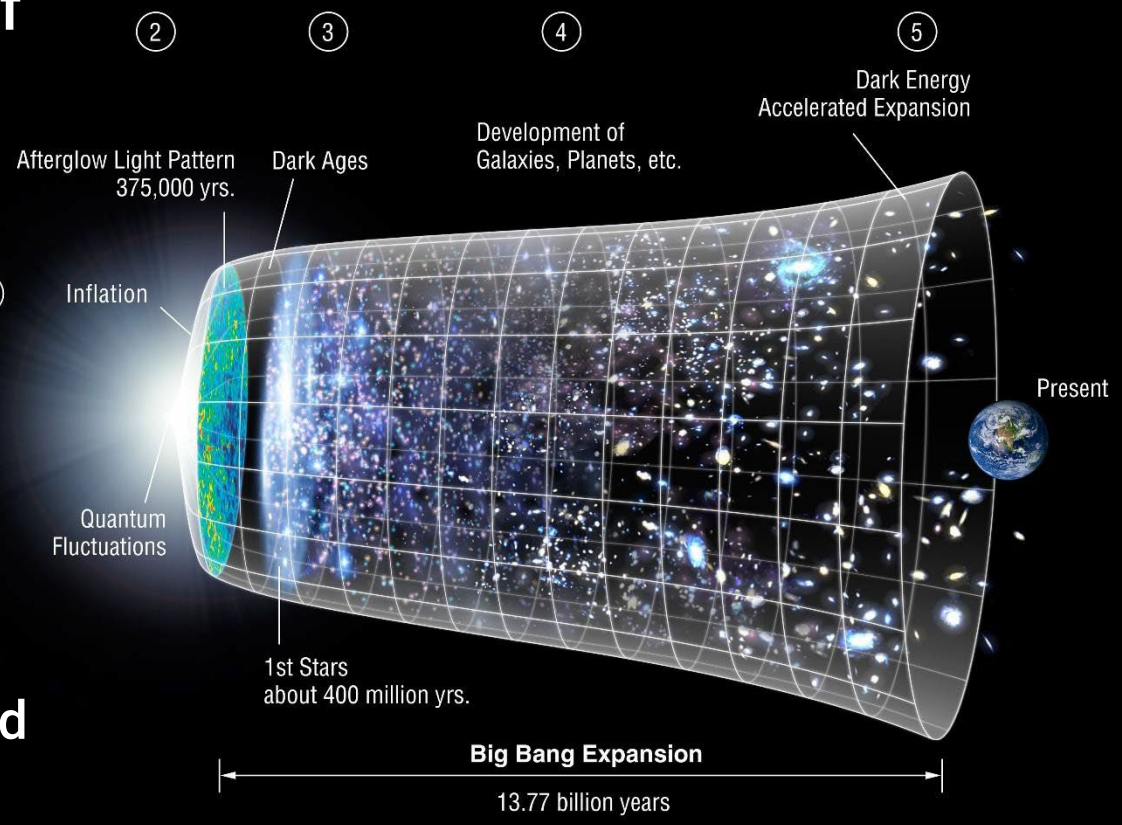
The Early Universe: more questions than answers (2)

- The Model gives a good approximation of the following properties of the Cosmos

1. The existence and structure of the Cosmic Microwave Background (CMB)
2. The distribution of galaxies and clusters and the Universe on a large scale
3. The observed composition of the Universe – the proportions of hydrogen, helium and lithium
4. The accelerating expansion of the Universe as seen by the light of distant galaxies and measured using supernovae

- But the Model is not perfect and recent discoveries are highlighting issues



Credit: NASA/LAMBDA Archive/WMAP Science Team

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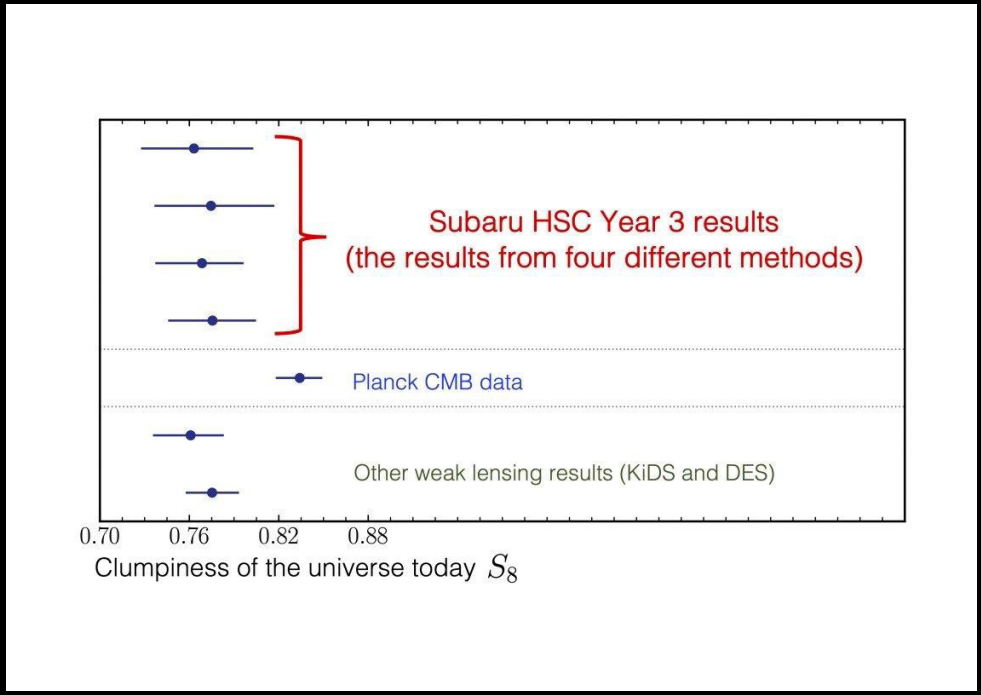
The Early Universe: more questions than answers (3)

- In three areas pressure is now being put on the Model:

1. Galaxies formed earlier and are larger, more developed and complex than predicted – as observed by JWST and ALMA as they push back the boundaries of distance

2. Measurement of the "clumpiness" of Dark Matter – (known as S8). Derived from the CMB it is 0.83 but a gravitational lens survey of 25 million galaxies, using the Hyper Suprime Camera, gives a value of 0.78

3. The Hubble Constant (H_0) is being reassessed. Based on CMB and measured by the Planck satellite, it is 67.4 ±0.5 km/sec/Mpc. But, having looked at supernovae, and now Cephid Variables, and measured by the Gaia satellite, it is 73.0 ±0.9 km/sec/Mpc



S8 measurement based on gravitational lensing data on 25 million galaxies from the Hyper-Suprime Camera (HSC) on the Subaru Telescope in Hawaii

Credit: Kavli IPMU

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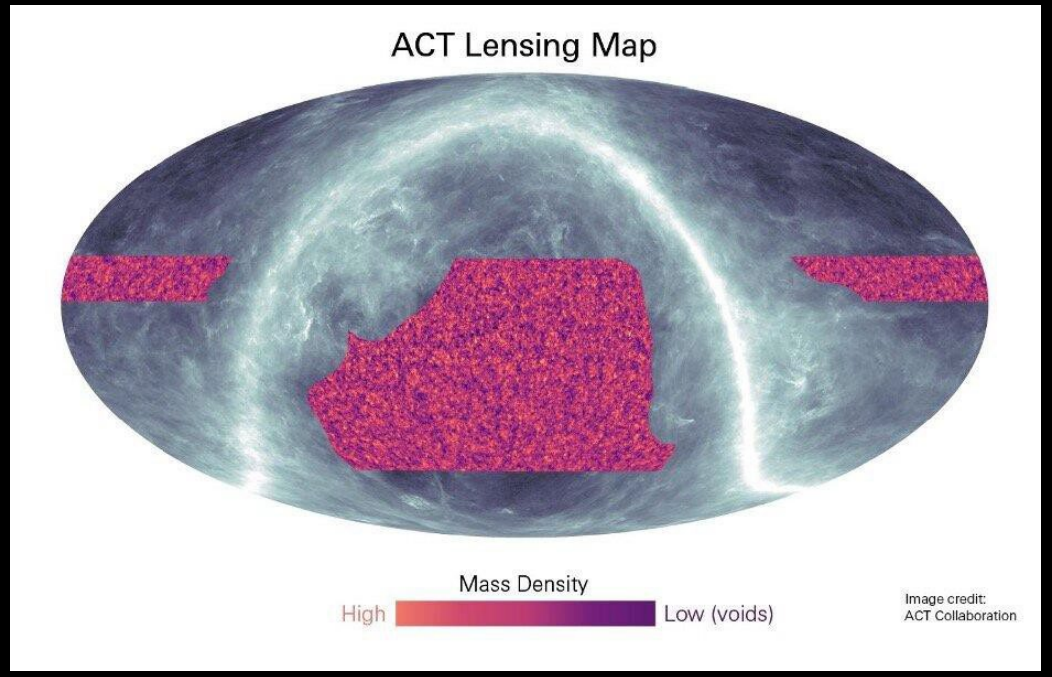
The Early Universe: more questions than answers (4)

- As more questions are raised, new supporting evidence is coming in from the Atacama Cosmology Telescope (ACT) Collaboration
- They have produced the most detailed map of the distribution of Dark Matter across the whole Universe
- Studying how large structures and Dark Matter warp the CMB over the course of its almost 14-billion year journey to us, it seems to confirm the current Standard Model of Cosmology
- The vast clumps of Dark Matter seen in the image from ACT are exactly the right size as predicted by Einstein's Theory



A new map of dark matter compiled by the Atacama Cosmology Telescope. The orange regions show where there is more mass; purple where there is less or none. The grey-white regions show where contaminating light from dust in our Milky Way galaxy, measured by the Planck satellite, obscures a deeper view. Typical features in the map are hundreds of millions of light-years across.
Credit: ACT Collaboration

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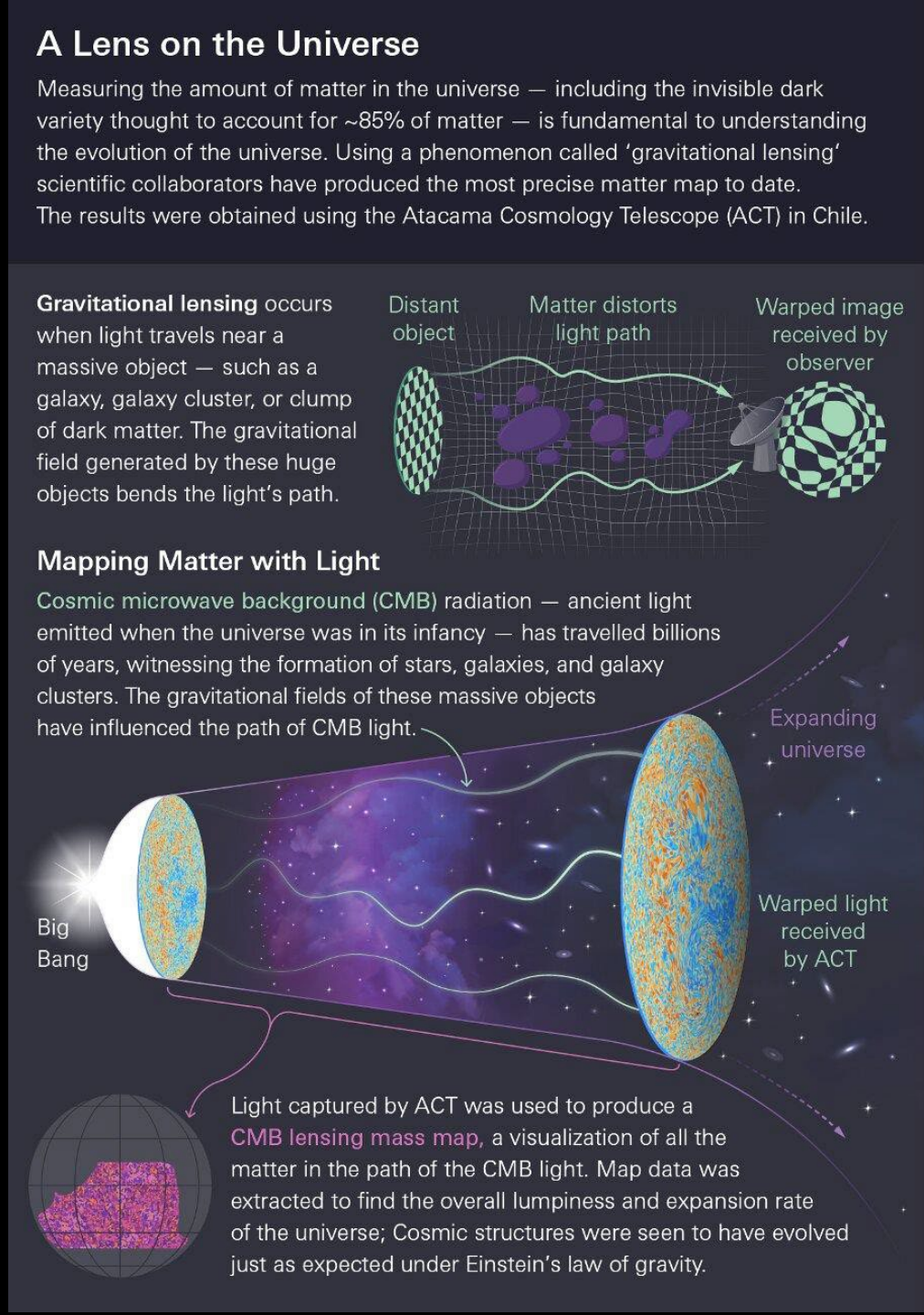
The Early Universe: more questions than answers (5)

- The results from ACT do contradict some of the other studies. However, it can be argued that the two methods will never agree as the light from the CMB is quite different than the light from stars in galaxies
- Meanwhile, proponents of modified gravity theory are suggesting new ways to test their model. It seems that seismic waves travelling through the Earth would do so at different rates and ways under modified gravity; could seismic data be used?
- For more on the issues around Dark Matter visit: https://youtu.be/qm0dYbs5Dkc

Credit: Lucy Reading-Ikkanda, Simons Foundation



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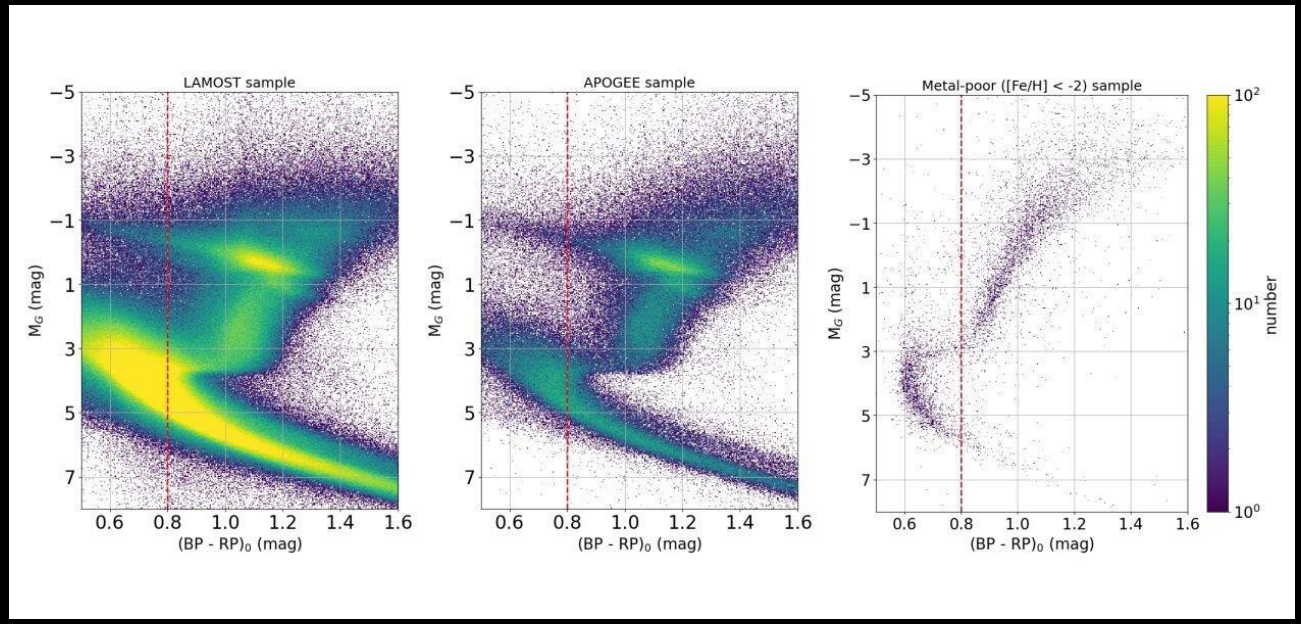
Many more early stars found in Milky Way

- Our current thinking suggests that stars formed in the early universe would have contained almost nothing but hydrogen and helium
- Elements larger and heavier than either hydrogen or helium are known as “metals”. So, first generation stars are “metal-poor”
- Metal-poor stars have iron abundances [Fe/H] below -2. The most metal-poor star (SMSS J0313–6708) has an index of -7.3
- Data from Gaia, together with LAMOST and APOGEE surveys, suggest that of the 210 million stars investigated, up to 180,000 are possibly metal-poor



Colour-magnitude diagram. The horizontal axis is the Gaia intrinsic colour and the vertical axis is the Gaia absolute magnitude
Credit: Yupeng Yao (University of Chicago, USA) et al, 2023

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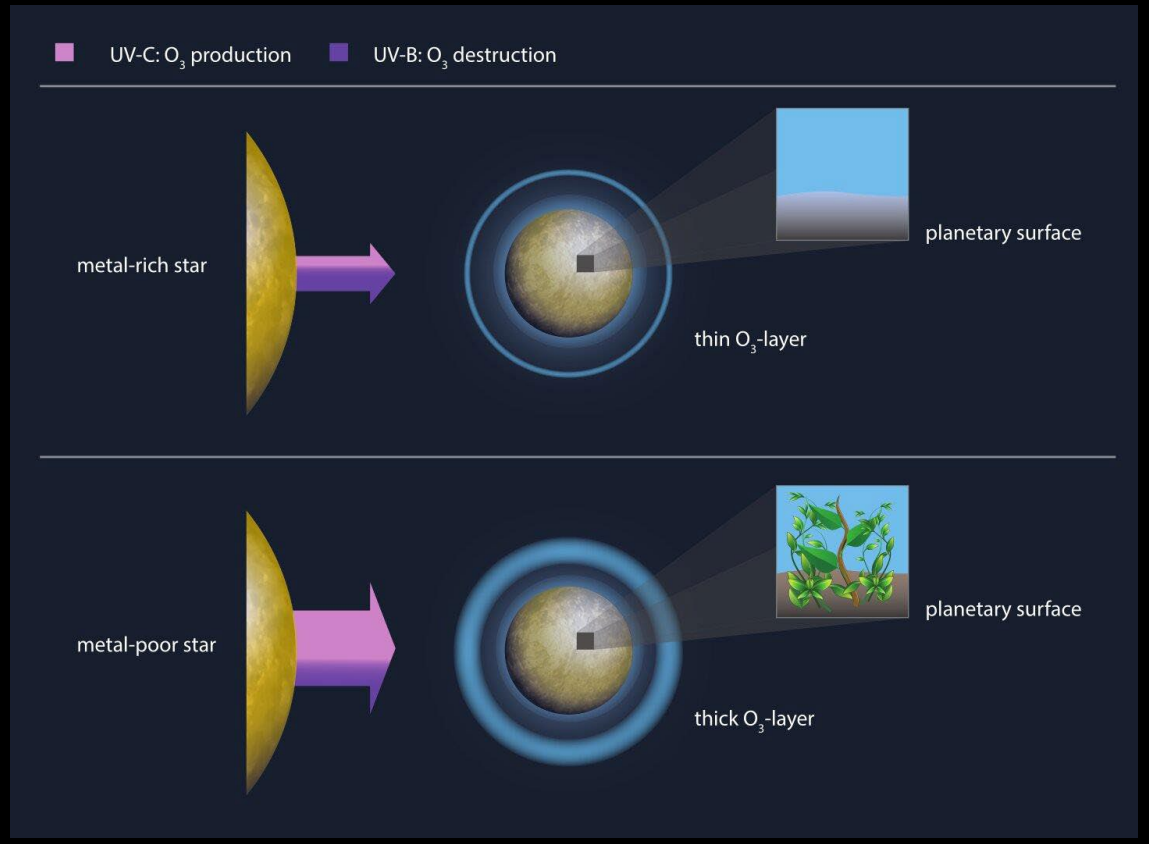
Metal-Poor Stars – more life friendly?

- About half the stars that have known exoplanets are sun-like. They have surface temperatures between 5,000 and 6,000° Celsius
- Such stars are often very variable in brightness producing large amounts of ultraviolet radiation. There are two sorts: UV-B (long-wave) and UV-C (short-wave). The former destroys life-protecting ozone (O3), the latter helps produce it
- Metal-poor stars, whilst producing more overall radiation, have a much higher UV-C/UV-B ratio than metal-rich stars, such as the Sun



Credit: MPS/hormesdesign.de

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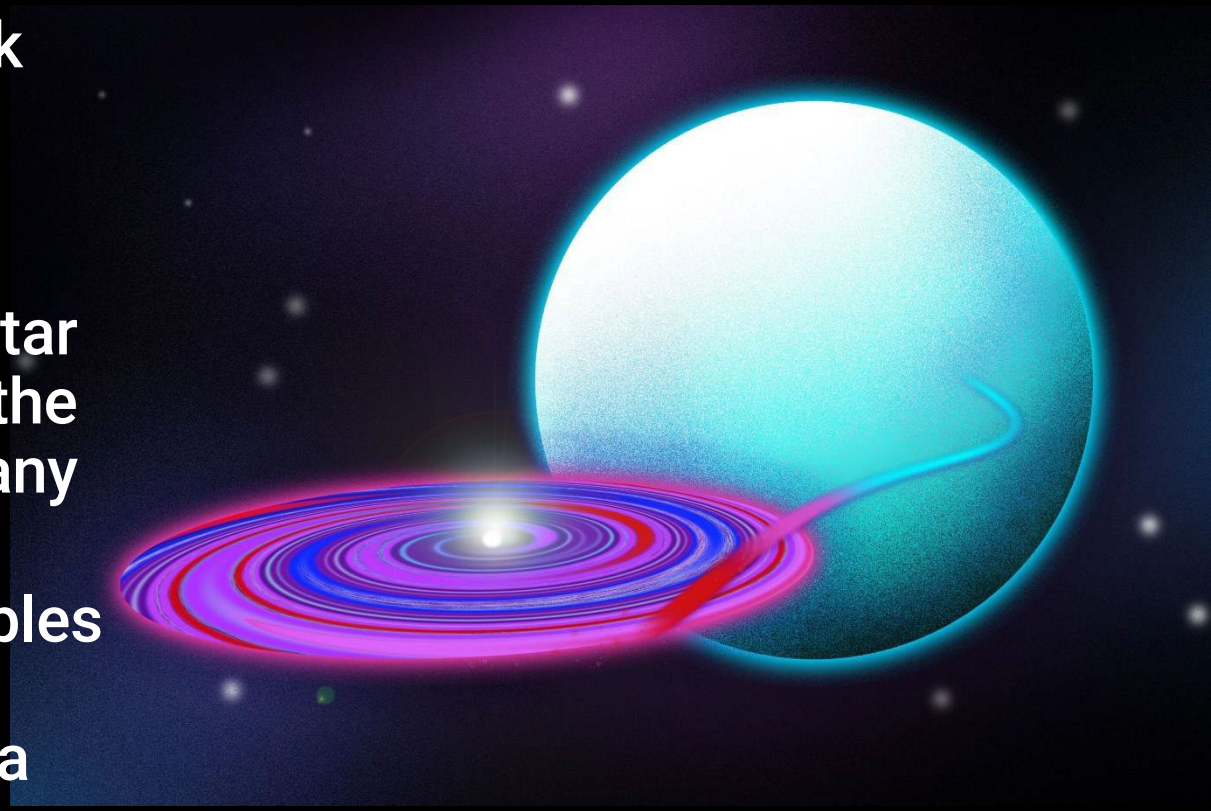
Disk Winds from a Neutron Star

- When a neutron star (or stellar-sized black hole) is in a binary system, the intense gravity can draw off material from the companion star
- This material swirls around the neutron star in an accretion disk. The speed at which the material moves causes it to heat up to many millions of degrees through friction
- Hercules X-1 is a neutron star which wobbles over a 35-day period. This causes the accretion disk to move up and down (like a vinyl record on a turntable) and this produces wind which can blow off streams of plasma and x-ray protons across many light years



Credit: D Klochkov, European Space Agency

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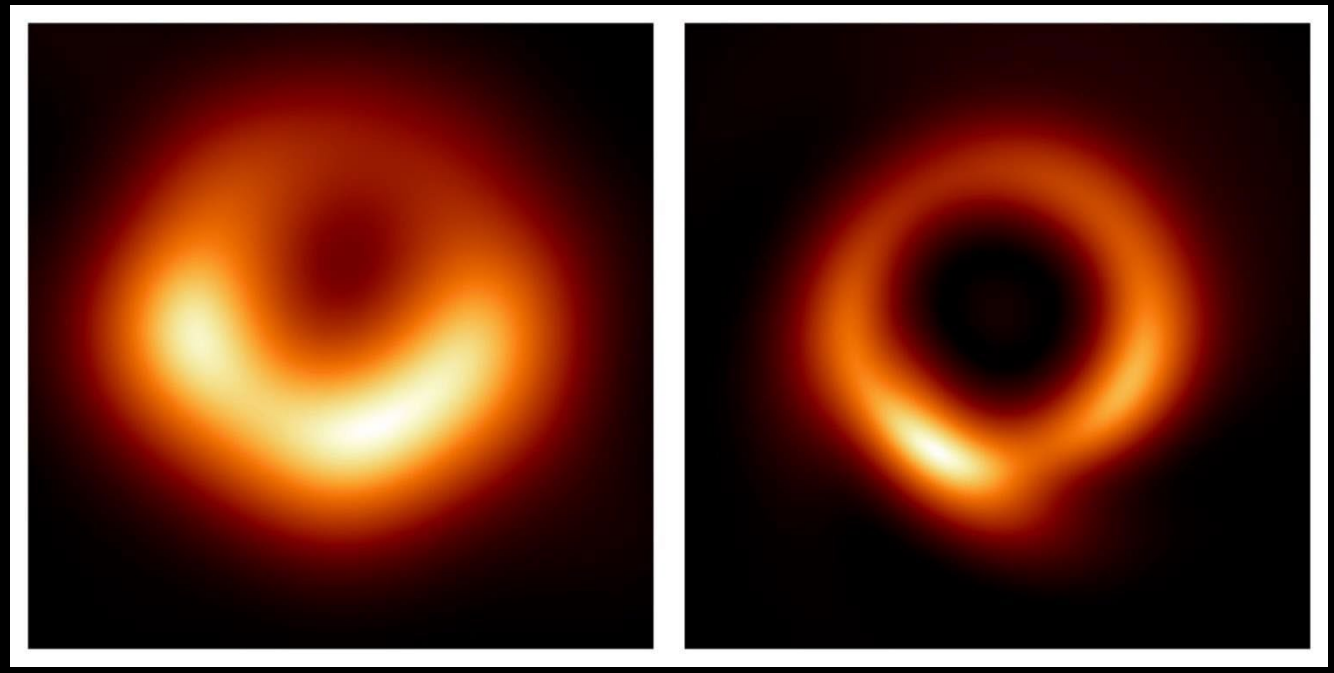
The Supermassive Black Hole inside M87

- A few years ago, the world was astounded by the first pictures of the black hole at the heart of the M87 galaxy, 57 million light years away in the Virgo constellation
- The image was developed using the 7 radio telescopes of the Event Horizon Telescope Collaboration, spread around the planet, and this allowed the overall “telescope” to have a baseline the size of the Earth



Credit: Lia Medeiros, Institute for Advanced Study

- Unfortunately, the distribution of the radio telescopes left gaps in the coverage. Now, using a machine learning technique, PRIMO, researchers have refined and enhanced the data to produce a new image (right). Watch what would happen if we fell into a black hole: https://youtu.be/4rTv9wvvat8 (15 minutes)

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Astronauts for first trip to Moon named

- The four astronauts, who will go around the Moon onboard Artemis II in November 2024, have been named

1. Reid Wiseman – mission commander and US Navy aviator. He has spent six months on the ISS (Expedition 40/41) in 2014. Carried out 2 spacewalks
2. Christina Koch – is the most experienced female astronaut and was on the ISS (Expedition 59/60/61) in 2019-20. She holds the longest spaceflight by a woman (328 days) record and has carried out 6 spacewalks (3 all-women)
3. Victor Glover – US Navy aviator. He was on the second crewed SpaceX Dragon spacecraft and on the ISS (Expedition 64 with 4 spacewalks) in 2020-21
4. Jeremy Hansen – Canadian Air Force (first space flight)

Credit: NASA

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Starship Super Heavy Rocket Launch (1)

- The Starship Super Heavy Rocket from SpaceX is the largest (at 119m high) and most powerful launcher (75.9 MN/17,100,00 lbs if thrust) ever built
- It is made up of a first stage Super Heavy booster and second stage Starship. The second stage is a fully containable spacecraft. It is designed to be fully reusable
- It is expected to be able to lift up to 150 tonnes into low-Earth orbit (in reusable mode) or 250 tonnes if expended. It could take up to 100 astronauts to Mars. The payload bay alone is 17m tall by 8m in diameter, a volume of 1,000m^3

Credit: SpaceX

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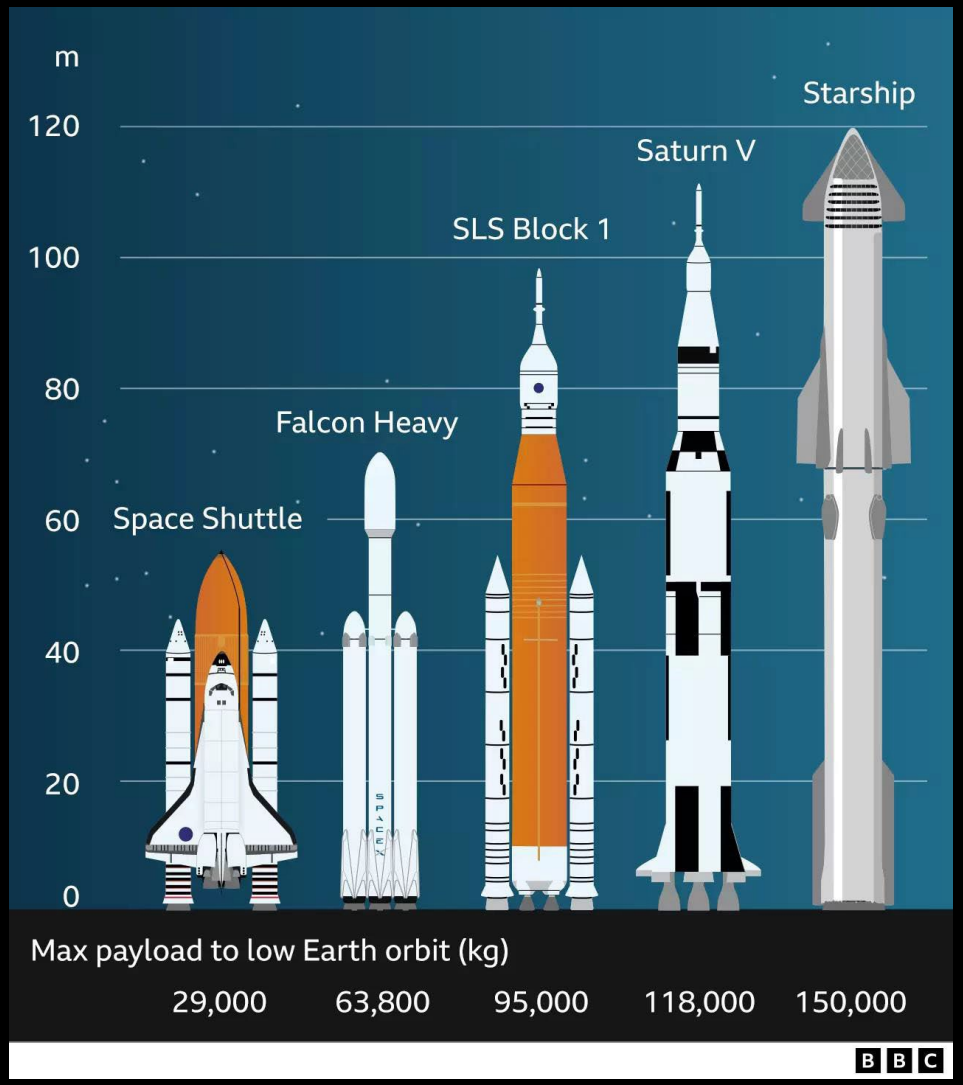
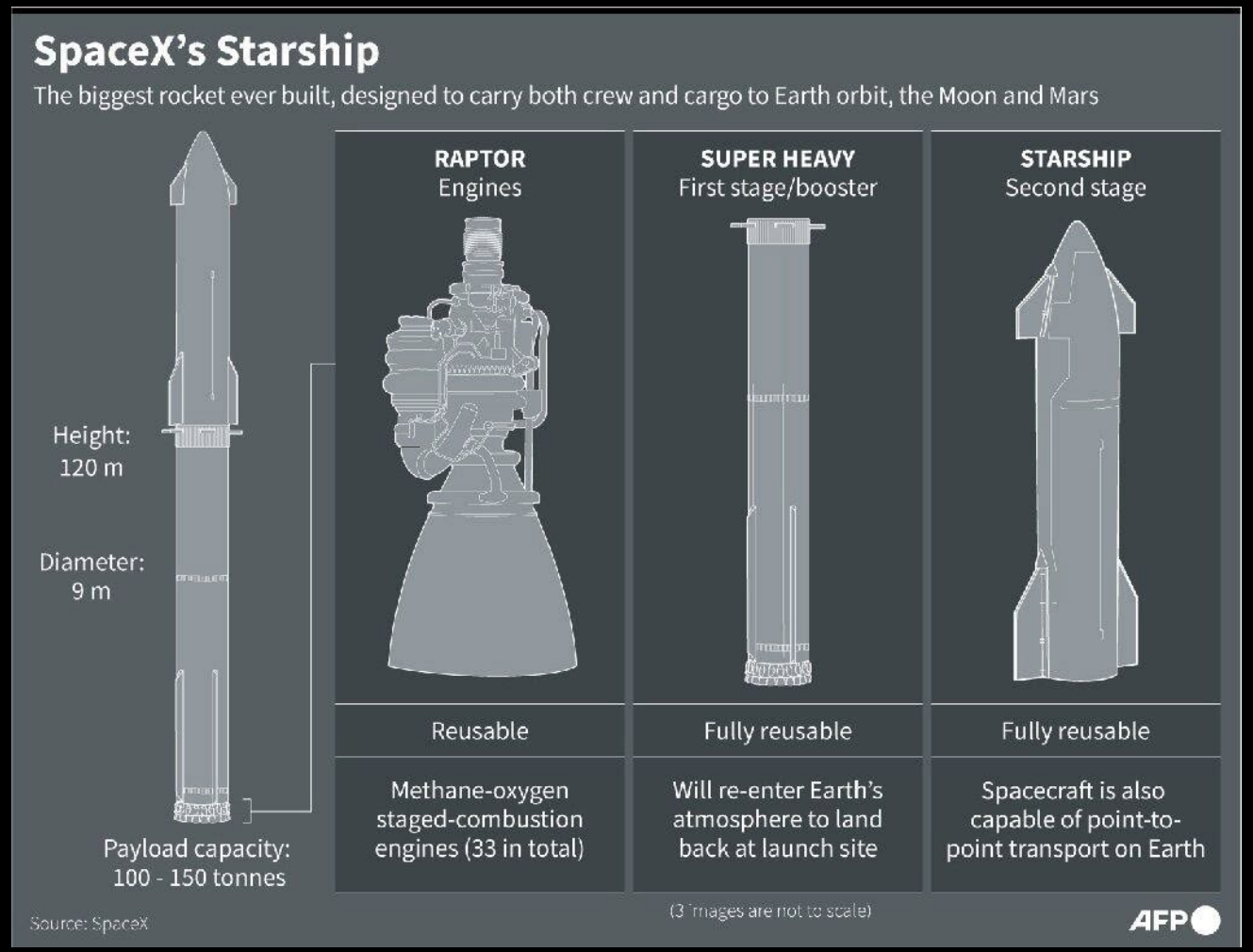
Starship Super Heavy Rocket Launch (2)





Credit (left): BBC

Credit: (above): AFP

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Starship Super Heavy Rocket Launch (3)

- After a cancellation on Monday 17th April due to a frozen valve, the test launch took place at 13:33 BST on Thursday 20th April
- The rocket cleared the tower and climbed to an attitude of 39 km, with speeds in excess of 2,000 km/hour, in just over 3 minutes
- At this point, the rocket was due to flip over for stage separation but instead, carried on slowly tumbling and no separation occurred

Credit: Patrick T. Fallon/AFP/Getty Images

- It appears that at least 8 engines flamed-out causing a loss of power and instability. On-board computers detonated the rocket on the 4-minute mark
- Although SpaceX had stated that they regarded just clearing the tower as a success, it was obviously clearly disappointing. SpaceX and the FAA will study the huge amount of data collected before deciding on when the next launch is

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Starship Super Heavy Rocket Launch (4)

At least 8 out of 33 engines flameout
Credit: AP Photo/Eric Gay

Tumbling out-of-control 3 minutes 50 seconds
Credit: Patrick T. Fallon/AFP/Getty Images

Rocket detonation at 4 minutes
Credit: Patrick T. Fallon/AFP/Getty Images

- Watch the launch at: https://youtu.be/ZnA-6rkt_HU (6 minute presentation)
- There are longer programmes at: https://youtu.be/rVLp8nKcOCg (32 minutes) and https://youtu.be/-1wcilQ58hI (53 minutes)

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Starship Super Heavy Rocket Launch (5)

Credit: social media post

Credit: social media post

Credit: social media post

- Aftermath of launch – a scene of desolation
- Debris blasted over 400 metres from launch site as dust covered town 5km away
- Concrete pad left shattered with huge crater formed, months to repair
- No water-cooling system or flame trench installed
- Massive water-cooled steel plate wasn’t completed in time

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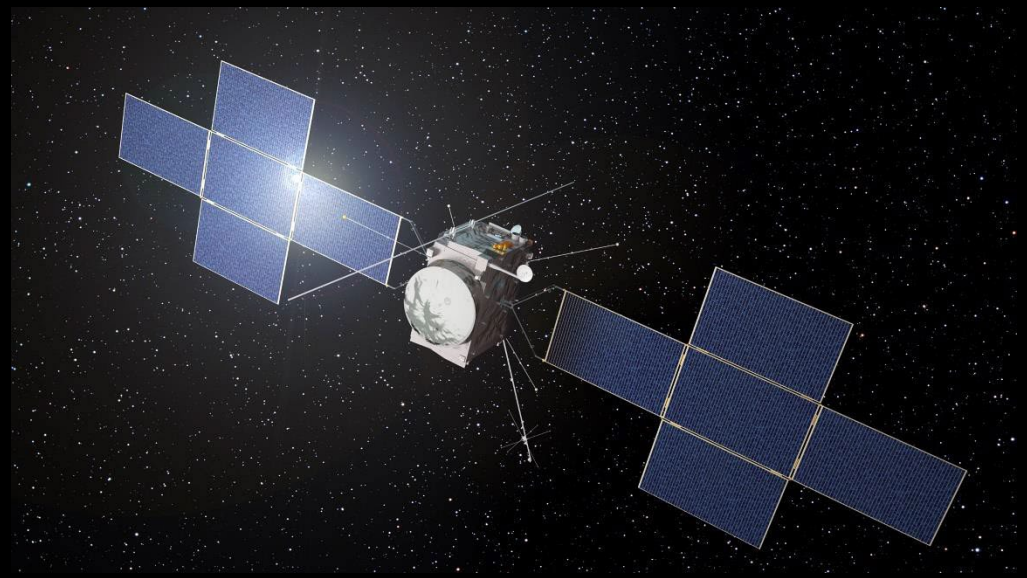
JUICE (1)

- The JUpiter ICy Moons Explorer (JUICE) Mission is the third major one to the Jovian system. Although primarily an ESA mission, both NASA and JAXA have made important contributions
- It follows in the footsteps of Galileo and Juno but its primary mission is to survey 3 of the 4 Galilean moons: Europa, Ganymede and Callisto
- The journey will take 8 years, with a couple of swing-bys of Venus and Earth to pick up additional speed
- It will be joined by NASA's Europa Clipper spacecraft (launching next year)



Credit: European Space Agency

Watch an animation of the launch and moon flybys at: https://cdn.jwplayer.com/previews/kU8Wmajz

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JUICE (2)

- The Ariane 5 rocket was launched at 13:14 BST on Friday 14th April from Kourou in French Guiana
- There was a 1 second window where the planetary alignments helped with the trajectory and allows the spacecraft to save as much fuel as possible for later manoeuvres when it reaches Jupiter
- The 2.42 metric tonnes spacecraft carries 3.65 metric tonnes of fuel in its tanks
- Watch the mission timeline at: https://cdn.jwplayer.com/previews/rVNJu9QB

Credit: ESA

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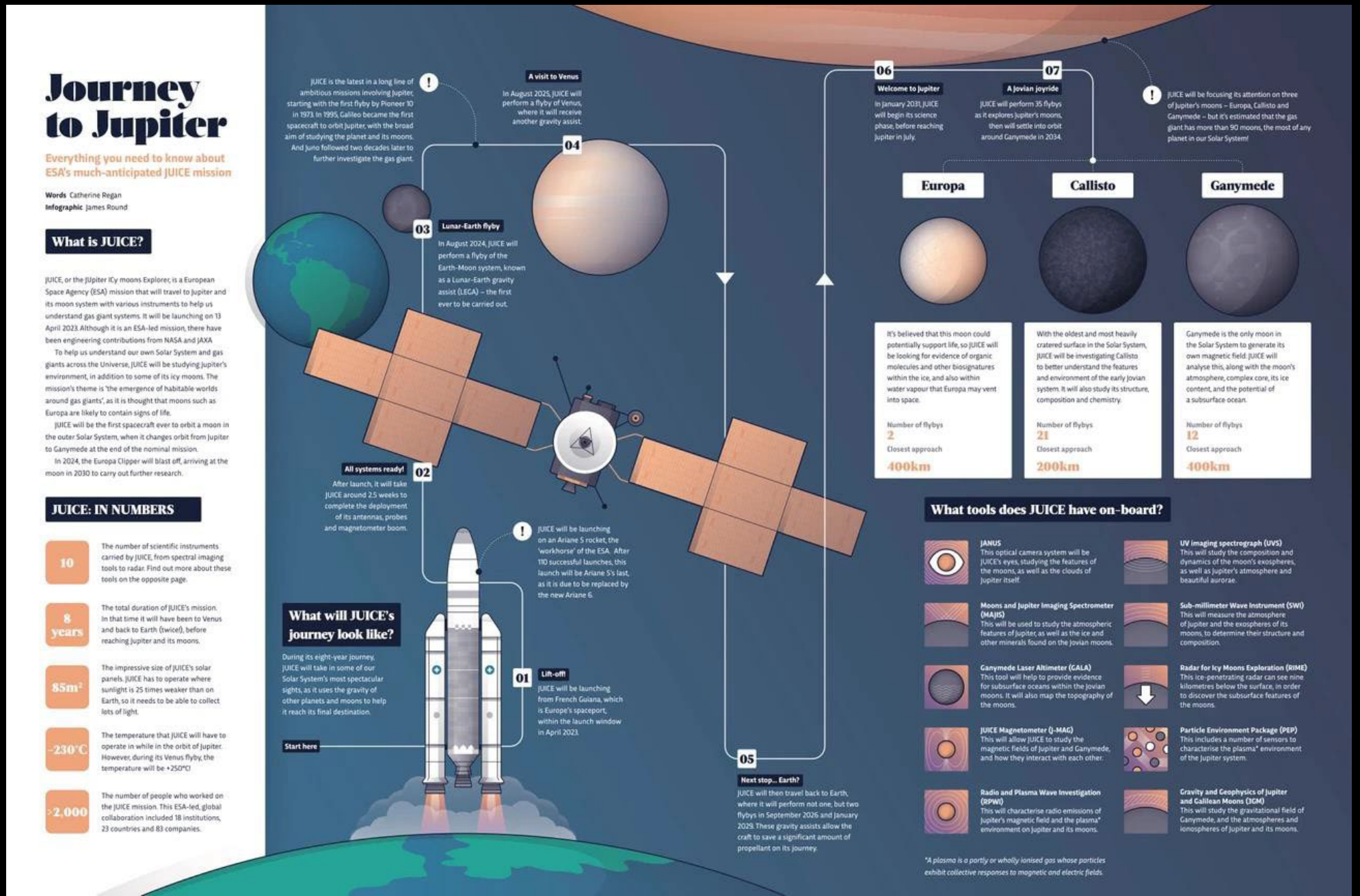

Credit: James Round/ BBC Science Focus

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What tools does JUICE have on-board?

JANUS
This optical camera system will be JUICE's eyes, studying the features of the moons, as well as the clouds of Jupiter itself.

UV imaging spectrograph (UVS)
This will study the composition and dynamics of the moon's exospheres, as well as Jupiter's atmosphere and beautiful aurorae.

Moons and Jupiter Imaging Spectrometer (MAJIS)
This will be used to study the atmospheric features of Jupiter, as well as the ice and other minerals found on the Jovian moons.

Sub-millimeter Wave Instrument (SWI)
This will measure the atmosphere of Jupiter and the exospheres of its moons, to determine their structure and composition.

Ganymede Laser Altimeter (GALA)
This tool will help to provide evidence for subsurface oceans within the Jovian moons. It will also map the topography of the moons.

Radar for Icy Moons Exploration (RIME)
This ice-penetrating radar can see nine kilometres below the surface, in order to discover the subsurface features of the moons.

JUICE Magnetometer (J-MAG)
This will allow JUICE to study the magnetic fields of Jupiter and Ganymede, and how they interact with each other.

Particle Environment Package (PEP)
This includes a number of sensors to characterise the plasma* environment of the Jupiter system.

Radio and Plasma Wave Investigation (RPWI)
This will characterise radio emissions of Jupiter's magnetic field and the plasma* environment on Jupiter and its moons.

Gravity and Geophysics of Jupiter and Galilean Moons (3GM)
This will study the gravitational field of Ganymede, and the atmospheres and ionospheres of Jupiter and its moons.

**A plasma is a partly or wholly ionised gas whose particles exhibit collective responses to magnetic and electric fields.*

Credit: James Round/
BBC Science Focus

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Sundancer Concept

Technology Demonstration Mission (TDM) Design objectives

* A/m ratio > 50m^2/kg
* Achieve 6-8 AU/year exit velocity
* Survive perihelion of 0.2 AU
* Low cost and manufacturable
* Capabilities-based and no development
* Rideshare combatible

TDM Design features

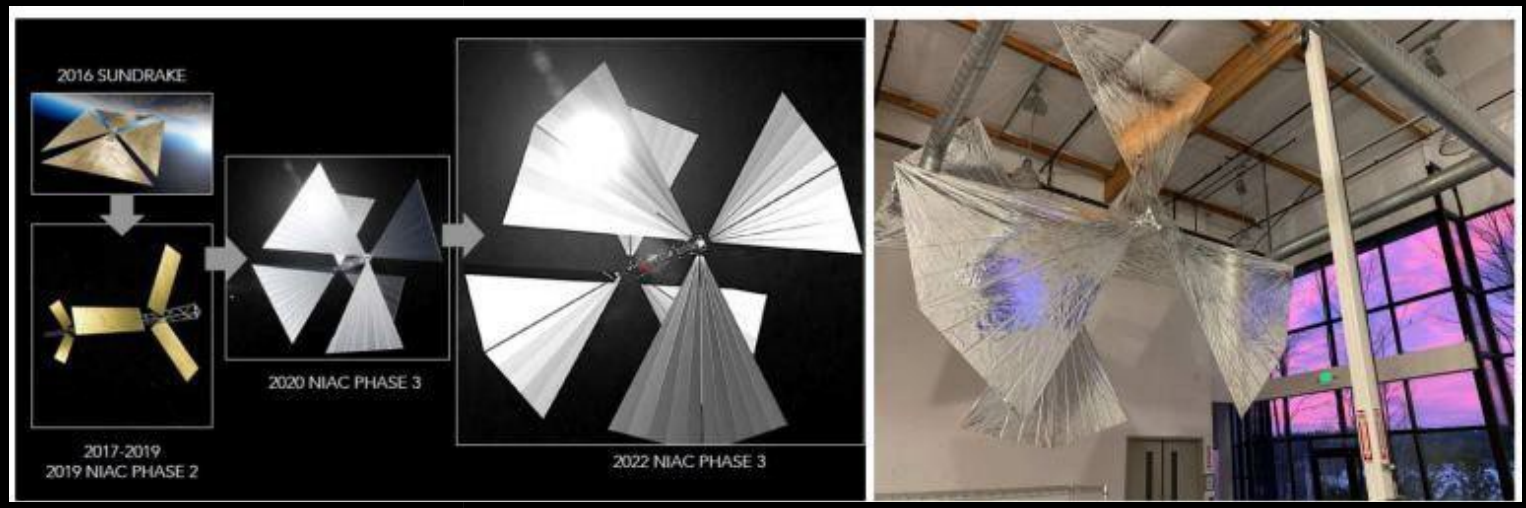
* A/m ratio 22.3m^2/kg
* 6 x 20m^2 vanes
* Carbon fibre truss (120g)

Avionics and GNC leverages

* 500g for X-band SRD, 3 wheels, 2 star trackers, battery
* 100g for shape memory motors

Total Mass

* 5.37kg (86% mass in vanes)



Credit: James Round/
BBC Science Focus

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Brief One-liners

- Supernova explosions damage planets atmospheres up to 160 light years away
- Quaoar, minor planet and TNO has two rings
- 2 super-Earth exoplanets found on edge of habitable zone of M dwarf TOI-2095
- New type of star masquerading as a black hole
- World's 1st mid-infrared solar observation telescope nearing trials in China
- 3D-printed rocket, Terran 1, is no more; replaced by bigger Terran R, due 2026
- Next generation space telescopes to have flexible mirrors
- Ingenuity helicopter completes 50th flight on Mars
- ESA's Solar Orbiter makes nearest approach to Sun (29% distance)
- New Horizon mission may be changed from KBOs to Heliospheric Science
- Moon possible place to mine and store rocket fuel
- Martian moon Deimos photographed by UAE space probe "Amal"

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Deimos

Credit: UAE Space Agency via AP

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Hybrid Solar Eclipse: 20th April, Australia & South Pacific

Credit: Mohamad Sol

Credit: Patrick Poitevin

- Watch the youTube video at: https://youtu.be/S2U3a1xXv8k (2 hours 32 mins)

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Finally: Aftermath of a launch

- Another successful rocket launch. Boosters and lower stages fall to Earth (hopefully to be reused). Upper stages burn up in the atmosphere. Payload safely placed in orbit
- But sometimes the rocket carries a small amount of excess fuel – and that needs to be jettisoned, usually at high altitude
- On April 15th SpaceX conducted a night-time polar launch from the Vandenberg Space Force Base in California. Three hours later in Alaska residents were treated to the spectacle of a blue spiral in the light of the Aurora as the excess fuel froze and reflected sunlight in the upper atmosphere

Credit: Todd Salat via AP

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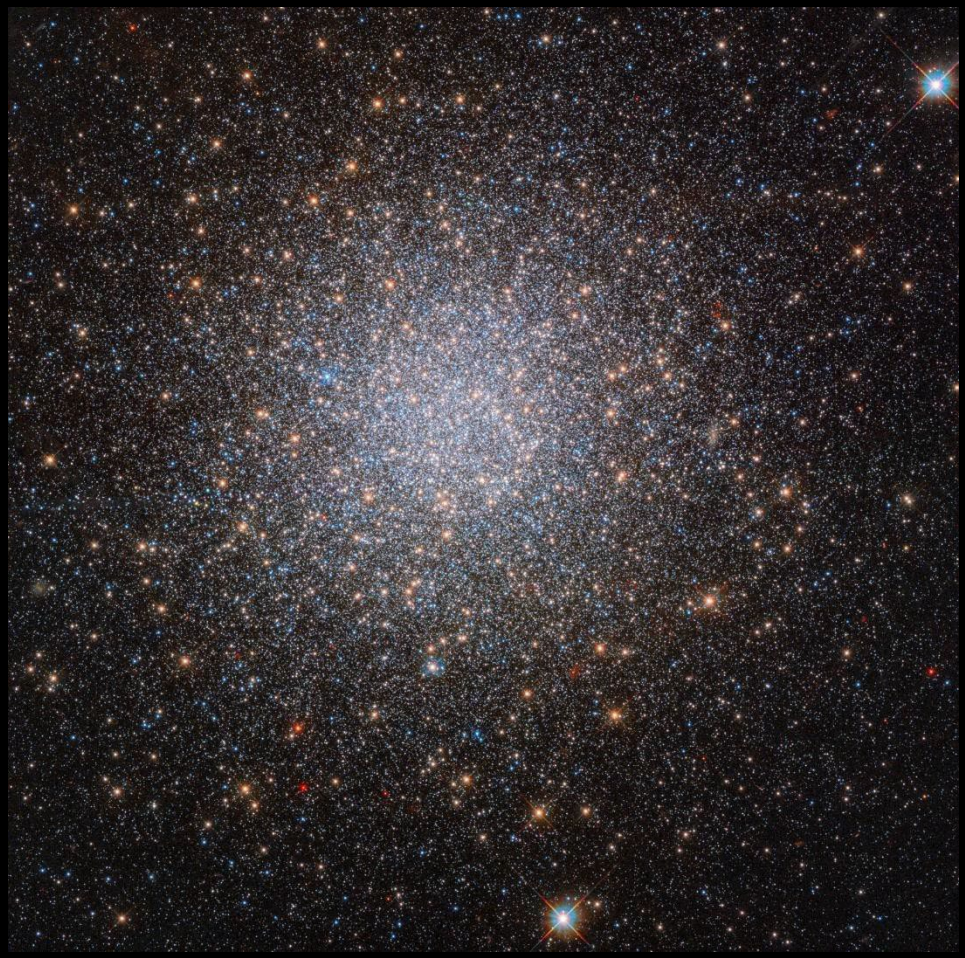
JWST and Hubble latest photos (1)

- This is Globular Cluster NGC 2419 (Caldwell 25) which is situated 300,000 light years from Earth in the Lynx constellation
- Further away than the Magellanic Clouds but is still considered to be part of the Milky Way
- It takes 3 billion years to orbit the Milky Way
- Unusually, it has two different populations of Red Giants, one is richer in helium and nitrogen and these stars orbit nearer the centre
- Could two separate globular clusters have merged in the distant past?
- The Globular Cluster M92, 26,740 light years away in the Hercules constellation is similar



Credit: ESA/Hubble/NASA/S. Larsen et al

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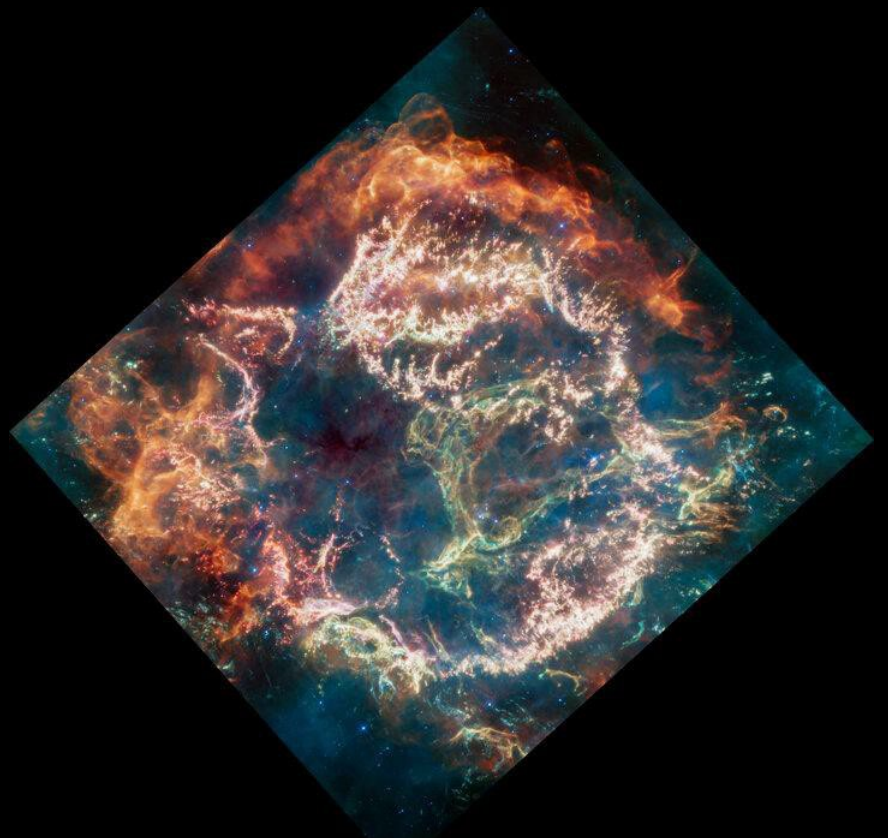
JWST and Hubble latest photos (2)

- JWST recently took this image of the supernova remnant (SNR) Cassiopeia A
- It lies about 11,000 light years from Earth and can be seen (with the aid of a 12” telescope and suitable filters) to the right of the last stoke of the ‘W’ of Cassiopeia. It is about 10 light years across
- Said to be the last known Milky Way supernova seen with the naked eyes but accounts vary (John Flamsteed possibly catalogued it as the star 3 Cassiopeiae on 16th August 1680)
- It is the brightest radio source above 1GHz in the sky



Credit: NASA, ESA, CSA, D. Milisavljevic (Purdue), T. Temim (Princeton), I. De Looze (Ghent University). Image Processing: J. DePasquale (STScI)

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JWST and Hubble latest photos (3)

- The Hubble Ultra Deep Field image of 2004 is one of the most iconic deep sky pictures ever taken, even surpassing the amazing 1995 first Deep Field image
- In October 2022, JWST imaged the same area using its NIRCam (1.8 – 4.8 microns wavelength). Taken over a period of 20 hours (Hubble took over 11 days to produce the original) the recently released image reveals previously unseen red galaxies

Hubble UDF (exposure time: 11.3 days)


Webb (exposure time: 0.83 days)

Credit: NASA/ESA/CSA/STScI, C. Williams (University of Arizona)
Image processing: J. DePasquale (STScI)

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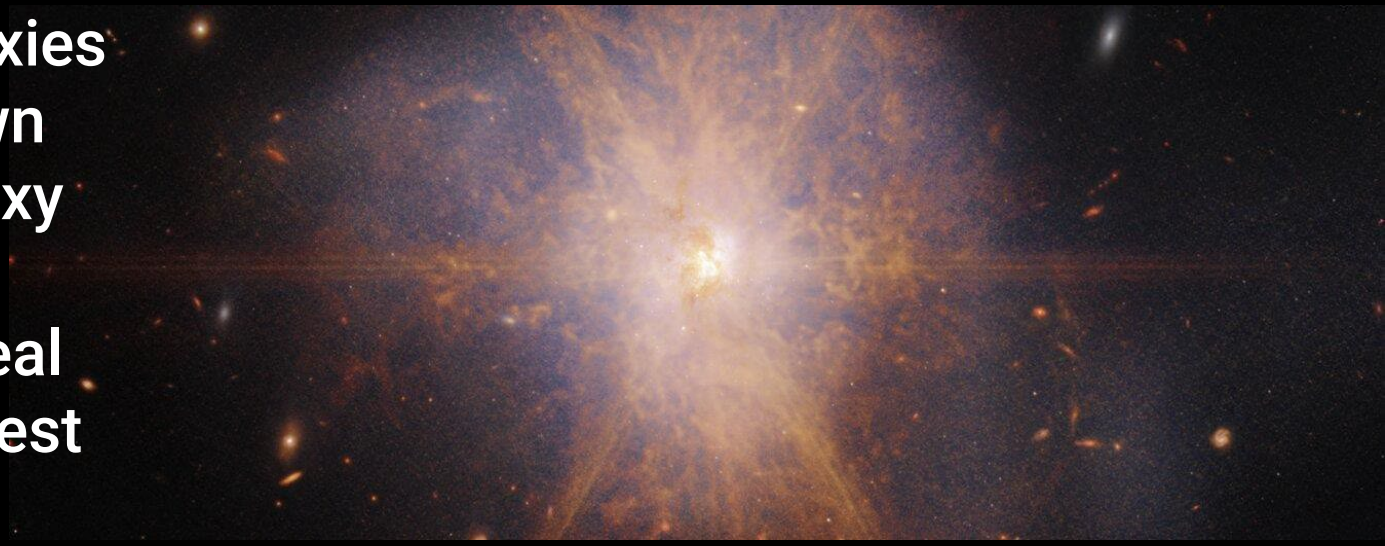
JWST and Hubble latest photos (4)

- In the constellation, Serpens, 2 galaxies are in the process of merging. Known as ARP 220, the new combined galaxy is 250 million light years away
- It glows in infrared light (so is an ideal candidate for JWST) and is the closest ULIRG (Ultra-Luminous Infrared Galaxy) to Earth



Credit: NASA, ESA, CSA, STScI, Alyssa Pagan (STScI)

- This is the result of a massive increase in star formation triggered by the merger, which started 700 million years ago
- About 200 huge star clusters are packed into an area only 5% the width of the Milky Way (5,000 light years). The amount of gas and dust in this small area is the same as that found in the entire Milky Way

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Observational Highlights

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May 2023 dates

- 6th May – peak of Eta Aquariid meteor shower. Best seen after midnight and before dawn although Full Moon will affect visibility. Meteors will be quite low near eastern horizon (best seen from Southern Hemisphere). Under ideal conditions up to 50 meteors per hour could be observed. Medium speed – 40 miles per second. The shower is associated with comet Halley (as is the Orionid Meteor Shower in October)
- 29th May – Mercury reaches greatest western elongation
- Venus remains a magnificent sight during May. It will become visible at 20:45 at the beginning of the month, 29° above the western horizon, shining at magnitude 4.13. By mid-May it will become visible at 21:08, 28° above the western horizon at 4.19. On the 31st May it will become visible at 21:29, 24° above the western horizon, brightening to -4.28

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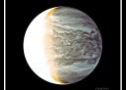
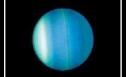
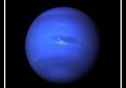
Planets (for evening of 1st/morning of 2nd May)

	Planet	Rises	Sets	Highest	Direction	Altitude	Magnitude	Visible
	MERCURY	05:28	20:18				-0.65	NO
	VENUS	07:20	00:20	15:50	West	29° ◊	-4.13	YES
	MARS	09:27	01:59	17:43	South-West	48° ◊◊	+1.19	YES
	JUPITER	05:09	18:48				-2.04	NO
	SATURN	03:41	13:59				+1.02	NO
	URANUS	05:51	20:54				+5.87	NO
	NEPTUNE	04:17	16:00				+7.94	NO

◊ = Highest point when first visible (20:45)

◊◊ = Highest point when first visible (21:21)

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

Object	Name	Type	Rises	Sets	Highest	Direction	Alt	Mag
M44	The Beehive Cluster (Cancer)	Open Cluster	12:06	03:42	21:57 **	South-West	44°	+3.1
M31	Andromeda Galaxy (Andromeda)	Galaxy	***	***	03:56 *	North-East	22°	+3.4
C14	Double Cluster (Perseus)	Open Cluster	***	***	03:56 *	North-East	25°	+3.7
IC4665	Open Cluster (Ophiuchus)	Open Cluster	22:31	11:34	03:56 *	South	44°	+4.2
NGC6633	Open Cluster (Ophiuchus)	Open Cluster	23:07	12:19	03:56 *	South	44°	+4.6
IC4756	Graff's Cluster (Serpens Cauda)	Open Cluster	23:24	12:25	03:56 *	South	42°	+4.6
M5	Globular Cluster (Serpens Caput)	Globular Cluster	20:21	08:49	01:40	South	41°	+5.7
M13	Great Globular Cluster (Hercules)	Globular Cluster	17:26	14:29	03:03	South	75°	+5.8
M12	Globular Cluster (Ophiuchus)	Globular Cluster	22:09	09:57	03:08	South	37°	+6.1
M3	Globular Cluster (Canes Venatici)	Globular Cluster	16:07	09:50	00:04	South	67°	+6.3
M15	Globular Cluster (Pegasus)	Globular Cluster	01:40	15:51	03:56 *	East	28°	+6.3
M92	Globular Cluster (Hercules)	Globular Cluster	***	***	03:56 *	South-West	81°	+6.5
M10	Globular Cluster (Ophiuchus)	Globular Cluster	22:30	09:57	03:18	South	35°	+6.6
M81	Bode's Galaxy (Ursa Major)	Galaxy	***	***	21:55	North	69°	+6.9
M101	Pinwheel Galaxy (Ursa Major)	Galaxy	***	***	00:25	North	86°	+7.9

* = Highest point at Dawn (03:56 - last visible sighting) ** = Highest point at Dusk (21:57 - first visible sighting)
*** = circumpolar

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

Object	Name	Type	Rises	Sets	Highest	Direction	Alt	Mag
M94	'Spiral' Galaxy (Canes Venatici)	Galaxy	***	***	21:57 **	South-East	74°	+8.2
M51	Globular Cluster (Hercules)	Globular Cluster	***	***	21:57 **	East	71°	+8.4
M104	Sombrero Galaxy (Virgo)	Galaxy	18:48	04:58	22:58	South	27°	+8.6
M57	The Ring Nebula (Lyra)	Planetary Nebula	***	***	03:56 *	South-East	67°	+8.8
NGC2403	'Spiral' Galaxy (Camelopardalis)	Galaxy	***	***	21:57 **	North	57°	+8.9

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

Twilight	Civil	Naut	Astro			Rises	Sets
Ends	21:00	21:48	22:48		Sun	05:31	20:22
Starts	04:53	04:05	03:06		Moon	16:37	04:48

* = Highest point at Dawn (03:56 - last visible sighting) ** = Highest point at Dusk (21:57 - first visible sighting)
*** = circumpolar

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Brown Lunation Numbers

numbered from first New Moon in 1923

Phases of the Moon

Phase	Date	Time	Lunation
FULL MOON	5th May	18:34	1241
LAST QUARTER	12th May	15:28	1241
NEW MOON	19th May	16:53	1242
FIRST QUARTER	27th May	16:22	1242

Credit: Sean Smith/NASA

Lewes Astronomical Society

Wednesday 7th June 2023

"A beginner's guide to cosmology and the insights gained from studying the cosmic microwave background"

Kate Land, Lewes town hall, guests welcome

The 2023-24 season starts on Wednesday 6th September 2023

More details at our AGM which precedes our talk next month

These slides are available as a newsletter at

www.lewesas.org.uk/newsletters/LAS-May-23.pdf