NWASNEWS

Volume28 Issue6

February 2023

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

COMET HUBRIS and COLD WEATHER ASTRONOMY

Firstly may I welcome the return of our regular top echelon speaker, Professor David Southwood CBE.

I have including I Wikipedia sourced article about the JUICE mission. A probe due to launch this year(?) to the Icy moons of Jupiter. A lot of European equipment on board and due for launch on an Ariane rocket.

How more missions the UK will be involved with is up for question, and research cross fertilisation is being strangled at the moment/

Even the Virgin launch hit a failure to insert its first payload into orbit from Cornwall, though the Cornish bit had no problems, unless some pasty got stuck in the second phase rockets.

But most early rocket experiments do fail. It is a learning curve but the media with or without the consultation of experts will hype events before they happen and nail failures in a dreadful blame game cycle. There are no failures, only opportunities to learn and overcome.

The hype really hits the media mill when meteor showers and comets are the news. Not even the Moon can go about its billions of years ctivity without needing a 'super' or native tribe naming relating to monthly activities that have now basis over here.

Comets seemed to get dubbed'not seen for 50,000years, or 'rare' green comet. Most of the comets that star at or below naked eye visibility tend to be green. The current one is no exception. Just creeping into naked eye visibility (technically) because it occurred near full Moon so not really visible without binoculars or imaging. But the Zwicky telescope facility found it, it the man it was named after was never shy about upsetting those around him who dared to disagree… they get free world wide publicity.

Light pollution. February is the month for submitting star counts, hopefully between the 17th and 24th when the Moon is out of the way, count the stars in the rectangle made by Orion's main body stars, Betelgeuse, Bellatrix, Rigel and Saiph.

Register at the CPRE website and submit your findings.

This winter has already taken a sad toll on our members, and would dearly like to retire from Chair (again). At the end of the year. I will be over 70 and we really need younger blood leading the society into the future. I have some hints for taking over newsletter duties (Jonathon), but please try to think hard about the Chair roll...

Clear Skies

Andy

The Comet that was hyped to death.
Now dimming to below naked eye vision, if it ever got there . Comet 2022 E3 ZTF.
Here using the 5" refractor and Nikon D819a camera, 60 second exposures, though a good gibbous moon was within 90 degrees.
I took 45 exposures over 2 minutes apart, 60 second exposures. Cloud killed the last images, but in an hour I had detected the movement so stacked the first and last shoots with a middle shot, Stacked in Sequator for star tracking.
The result shows how far the comet travelled in an hour.
Andy Burns.

Wiltshire Society Page

Wiltshire Astronomical Society

Web site: www.wasnet.org.uk

Facebook members page: https://www.facebook.com/groups/wiltshire.astro.society/

Meetings 2020/2021.

HALL VENUE the Pavilion, Rusty Lane, Seend

Some Speakers have requested Zoom Meetings we will try to hold these at the hall

Meet 7.30 for 8.00pm start

SEASON 2022/23

6 Dec Martin Griffiths How the Moon was formed

2023

7 Feb Prof. David Southwood JUICE

7 Mar Mary McIntyre Shadows in Space & the stories they tell

4 Apr Chris Starr Heavy Metal World

2 May Dr Paul A Daniels The Mega-constellation threat

6 Jun Andrew Lound Venus, Paradise Lost

Professor David Southwood CBE.

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

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

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

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

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

Membership Meeting nights £1.00 for members £3 for visitors

Members can renew or new members sign up online via https://wasnet.org.uk/membership/ and also remind them they can pay in cash too on the door.

Wiltshire AS Contacts

Andy Burns Chair, anglesburns@hotmail.com

Andy Burns Outreach and newsletter editor.

Sam Franklin (Treasurer)

Rebecca Rowan (Hall coordinator)

??? (Teas and Projector)

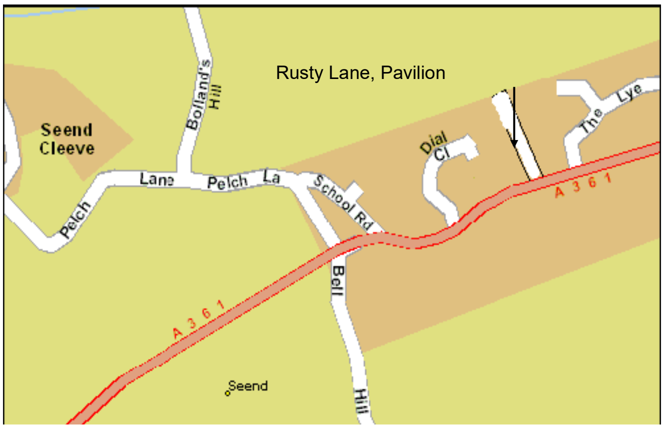
Peter Chappell (Speaker secretary) Retiring

Nick Howes (Technical Guru)

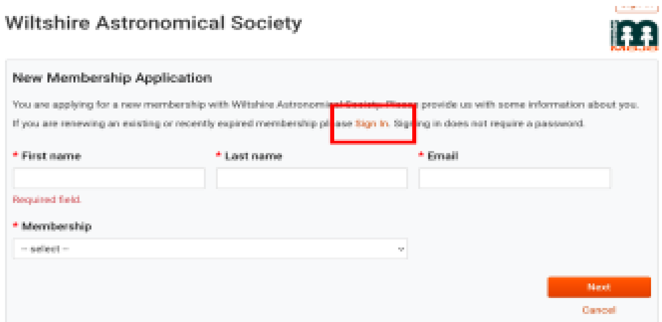
Observing Sessions coordinators: Chris Brooks, Jon Gale,

Web coordinator: Sam Franklin

Contact via the web site details.



Observing Sessions see back page



Swindon Stargazers

Swindon's own astronomy group

Physical meetings continuing!

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

Friday, 17 February - Simon Holbeche

Simon Holbeche was born and raised in Surrey and got his first good views of the night sky in the Surrey Hills. He joined Guildford Astronomical Society as he hit his teenage years. Initially training as an Aeronautical Engineer, today he is a project manager in software development.
In 2016, Simon joined the Herschel Society and discovered the Bath Astronomers in deep hibernation. The following year Simon became the groups coordinator and by November 2019, Bath Astronomers were reconstituted as a full society again with Simon Holbeche as Chair. Just three years later, the Bath Astronomers have 99 members and a robust outreach programme. Simon is targeting 100 hours of outreach as a STEM Ambassador this year.
In his spare time, other than visual observing, he is a stargazing guide at Bath Abbey and the Herschel Museum of Astronomy.

Frankenscope Reborn
The story of the discovery and restoration during Covid of a 7" Victorian telescope found in a dilapidated outhouse at a school near Bath.

Ad-hoc viewing sessions
Regular stargazing evenings are organised near Swindon. The club runs a WhatsApp group to notify members in advance of viewing sessions, usually at short notice. Anyone can call a meeting. To join these events please visit our website on the link below.

Information about our evenings and viewing spots can be found here:

http://www.swindonstargazers.com/noticeboard/noticeboard06.htm

Meetings at Liddington Village Hall, Church Road, Liddington, SN4 0HB – 7.30pm onwards

The hall has easy access from Junction 15 of the M4, a map and directions can be found on our website at:

http://www.swindonstargazers.com/clubdiary/directions01.htm

Meeting Dates For 2023

Friday, 17 February 19.30 onwards

Programme: Simon Holbeche: Frankenscope Reborn

Friday, 17 March 19.30

Programme: AGM + A Walk Through Astrophotography by Damian Ohara

Friday, 21 April 19.30 onwards

Programme: Prof Matt Griffin: Far Infrared Astronomy from Space

Friday, 19 May 19.30 onwards

Programme: Prof Nick Evans - Dark Energy - a cosmological overview of empty space and links to particle physics

Friday, 16 June 19.30 onwards

Programme: Bob Mizon MBE - Stars over the Nile - Ancient Egyptian Astronomy and star lore

------Summer Break-----

Friday, 15 September 19.30 onwards -

Programme: First Light Optics: Product trends / changes / news and upcoming products

Friday, 20 October 19.30 onwards Programme: Prof Martin Hendry MBE - The Science of Star Wars

Friday, 17 November 19.30 onwards Programme: Dr Lillian Hobbs: Eisa Esinga - The Planetarium in the Bedroom

Friday, 8 December 19.30 onwards Programme: Christmas Social

Website:
http://www.swindonstargazers.com

Chairman: Robin Wilkey

Tel No: 07808 775630
Email: robin@wilkey.org.uk
Address: 61 Northern Road
Swindon, SN2 1PD

Secretary: Hilary Wilkey
Email: hilary@wilkey.org.uk
Address: 61 Northern Road
Swindon, SN2 1PD

BECKINGTON ASTRONOMICAL SOCIETY

Society Details & Speakers programme can be found on our Website www.beckingtonas.org

General enquiries about the Society can be emailed to chairman@beckingtonas.org.

Our Committee for 2016/2017 is

Chairman: Steve Hill (email chairman@beckingtonas.org)
Treasurer: John Ball
Secretary: Sandy Whitton
Ordinary Member: Mike Witt

People can find out more about us at www.beckingtonas.org

Meetings take place in Beckington Baptist Church Hall in Beckington Village near Frome.

See the location page for details of how to find us on our website…………

Post Code for Sat Nav is BA11 6TB.

Our start time is 7.30pm No hall meetings.

STAR QUEST ASTRONOMY CLUB

This young astronomy club meets at the
Sutton Veny Village Hall.
Second Thursday of the Month.
Meet at Sutton Veny near Warminster.

BATH ASTRONOMERS

A friendly bunch of stargazers and enthusiastic astronomers who share experiences and know-how as well as offer an extensive outreach programme of public and young people's observing. As a partner to Bath Preservation Trust, they are the resident astronomers at the Herschel Museum of Astronomy, 19 New King Street, Bath, BA1 2BL and partner with Bath Abbey to showcase the skies above the city.

Gatherings and talks are held on the last Wednesday of each month at 7:30pm at the Herschel Museum of Astronomy (excluding December, July, and August) and are of 90 minutes duration or so.

Next Meetings:
Wednesday, 22nd February
Member's Night – a collection of small talks by Bath Astronomers members

Wednesday, 29th March
Herschel to Hawkwind – Pete Williamson brings a melodious interpretation to the history of Astronomy

More information and news is available via:
https://bathastronomers.org.uk
https://www.youtube.com/@bathastronomers
On Social Media (Facebook, Twitter, Instagram)
as **@BathAstronomers**

Public stargazing is scheduled twice a month on Saturday evenings as well as during school holidays to promote astronomy in Bath and Somerset area. Locations vary to bring telescopes to local communities. The February half-term, 13th to 17th Feb, will include nightly opportunities to discover the night sky.

Member's observing is conducted from the Monkton Combe Community Observatory using the 1860 Refractor and more modern telescopes. We try to avoid school nights but will run member's sessions when the clouds look like they'll recede long enough to align a Celestron Goto Scope.

Get in touch by email hello@bathastronomers.org.uk whether you'd like to find out more, pop in for a visit, share the stars, or have Bath Astronomers visit your school, young persons' group (rainbows, beavers, brownies, cubs, guides, scouts, rangers etc) or your community. The Coordination Team of Annie, Camilla, Jade, Jonathan, Meyrick, Mike, Prim and Simon will be happy to help you.

FORDINGBRIDGE AS

Our February meeting will be on Wednesday 15th February, starting at 7.30pm and we are delighted to welcome our very own **Mark Hardaker**, who will present "**A Visit to the Wabar Meteorite Craters in Saudi Arabia**". This will be followed by Duncan's **Pick of the Month**, Fordingbridge Astronomers' **Object of the Month** and especially **What to look out for in the sky this month**. There will be a short 10-15 minute break after Mark's talk to charge glasses and catch up with everyone.

We will be holding the meeting in our usual venue at The Elm Tree, Hightown, near Ringwood. The postcode to find the place is BH24 3DY. We'll be meeting in The Barn at the rear of the pub. There is plenty of parking for those who want to come along. There is a £2 charge for non-members attending the meeting.

We will also be holding the meeting on Zoom and the Zoom Invite details are below and will also be on Discord. If the technology lets us, we will start the Zoom meeting a little earlier to sort any gremlins out.

Fordingbridge Astronomers is inviting you to a scheduled Zoom meeting.
Topic: Fordingbridge Astronomers February Meeting
Time: Feb 15, 2023 07:00 PM London
Join Zoom Meeting
https://us06web.zoom.us/j/82861632140?pwd=amZhTzhkZzBoVWRzVHlUcnRWS3lvQT09
Meeting ID: 828 6163 2140
Passcode: 132885

For our new members who joined us in the last couple of months, do please try and come along. We'd love to meet you and make you welcome.
We hope you enjoy it! Please let me know if you have any questions.

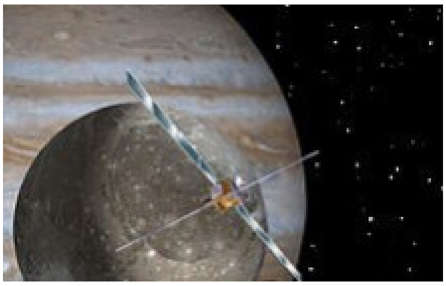
Jupiter Icy Moons Explorer

From Wikipedia, the free encyclopedia
For the proposed NASA spacecraft, see Jupiter Icy Moons Orbiter.

The Jupiter Icy Moons Explorer (JUICE) is an interplanetary spacecraft in development by the European Space Agency (ESA) with Airbus Defence and Space as the main contractor. The mission will study three of Jupiter's Galilean moons: Ganymede, Callisto, and Europa (excluding the volcanically active Io; Io is not an icy moon) all of which are thought to have significant bodies of liquid water beneath their surfaces, making them potentially habitable environments

The spacecraft is scheduled to launch in April 2023 and will reach Jupiter in July 2031 after four gravity assists and eight years of travel In December 2034, the spacecraft will enter orbit around Ganymede for its close up science mission, becoming the first spacecraft to orbit a moon other than the Moon of Earth. The selection of this mission for the L1 launch slot of ESA's Cosmic Vision science programme was announced on 2 May 2012 Its period of operations will overlap with NASA's *Europa Clipper* mission, launching in 2024.

HISTORY



A concept art for the Jupiter Ganymede Orbiter, the ESA component of the proposed Europa Jupiter System Mission – Laplace

The mission started as a reformulation of the Jupiter Ganymede Orbiter proposal, which was to be ESA's component of the cancelled Europa Jupiter System Mission – Laplace (EJSM-Laplace) It became a candidate for the first L-class mission (L1) of the ESA Cosmic Vision Programme, and its selection was announced on 2 May 2012

In April 2012, JUICE was recommended over the proposed Advanced Telescope for High Energy Astrophysics (ATHENA) X-ray telescope and a gravitational wave observatory (New Gravitational wave Observatory (NGO))

In July 2015, Airbus Defence and Space was selected as the prime contractor to design and build the probe, to be assembled in Toulouse, France. JUICE is expected to launch on Ariane 5 in April 2023.

TIMELINE

Launch and trajectory

JUICE will be launched between 14 April and 30 April 2023 on an Ariane 5 launch vehicle from the Guiana Space Centre Following the launch, there will be multiple planned gravity assists to put JUICE on a trajectory to Jupiter: a flyby of the Earth–Moon system in August 2024, Venus in August 2025, second flyby of Earth in September 2026, and a final third flyby of Earth in January 2029

JUICE will pass through the asteroid belt twice. A flyby of the asteroid 223 Rosa has been proposed, and would occur in October 2029

Arrival at the Jovian system

When it arrives in Jupiter's system in July 2031, JUICE will first perform a flyby of Ganymede in preparation for Jupiter orbital insertion ≈ 7.5 hours later. The first orbit will be elongated, with subsequent orbits gradually lowered over time, resulting in a circular orbit around Jupiter

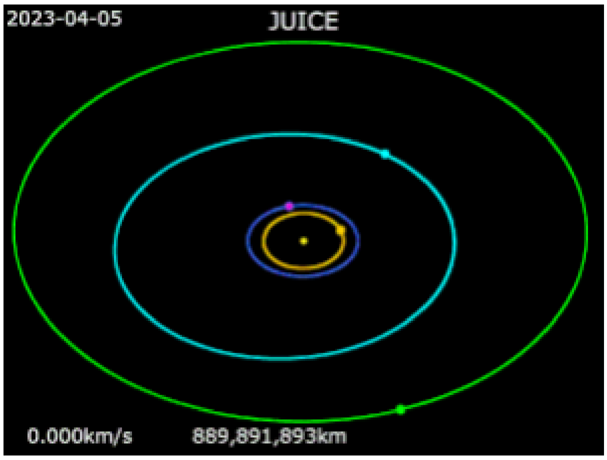
The first Europa flyby will take place in July 2032. JUICE will enter a high inclination orbit to allow exploration of Jupiter's polar regions and to study Jupiter's magnetosphere

Orbital insertion on Ganymede

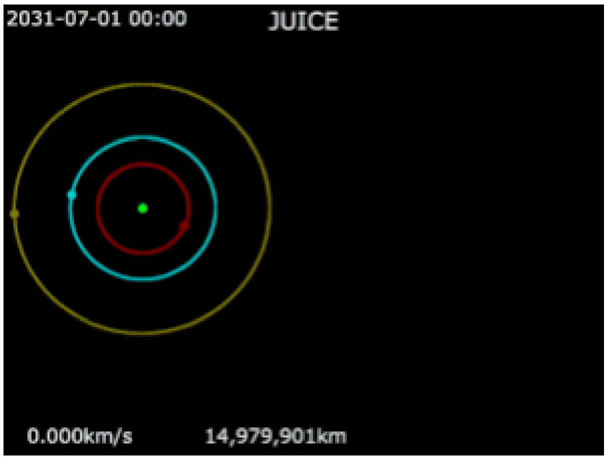
In December 2034, JUICE will enter an elliptical orbit around Ganymede, becoming the first spacecraft to orbit a moon other than Earth's Moon. The first orbit will be at a distance of 5,000 km (3,100 mi). In 2035, JUICE will enter a circular orbit 500 km (310 mi) above the surface of Ganymede. JUICE will study Ganymede's composition and magnetosphere among other things.

Planned deorbit on Ganymede
When the spacecraft consumes its remaining propellant, JUICE is planned to be deorbited and impact Ganymede at the end of 2035.

Trajectories of JUICE



Around the Sun



Around Jupiter

Around Ganymede

Science objectives

Ganymede view by Galileo

Section of Europa's icy surface

The *Jupiter Icy moons Explorer* orbiter will perform detailed investigations on Ganymede and evaluate its potential to support life. Investigations of Europa and Callisto will complete a comparative picture of these Galilean moons.[15] The three moons are thought to harbour internal liquid water oceans, and so are central to understanding the habitability of icy worlds.

The main science objectives for Ganymede, and to a lesser extent for Callisto, are:[15]

Characterisation of the ocean layers and detection of putative subsurface water reservoirs

Topographical, geological and compositional mapping of the surface

Study of the physical properties of the icy crusts

Characterisation of the internal mass distribution, dynamics and evolution of the interiors

Investigation of Ganymede's tenuous atmosphere

Study of Ganymede's intrinsic magnetic field and its interactions with the Jovian magnetosphere.

For Europa, the focus is on the chemistry essential to life, including organic molecules, and on understanding the formation of surface features and the composition of the non-water-ice material. Furthermore, JUICE will provide the first subsurface sounding of the moon, including the first determination of the minimal thickness of the icy crust over the most recently active regions.

More distant spatially resolved observations will also be carried out for several minor irregular satellites and the volcanically active moon Io.

DESIGN

The main spacecraft design drivers are related to the large distance to the Sun, the use of solar power, and Jupiter's harsh radiation environment. The orbit insertions at Jupiter and Ganymede and the large number of flyby manoeuvres (more than 25 gravity assists, and two Europa flybys) requires the spacecraft to carry about 3,000 kg (6,600 lb) of chemical propellant.

Gravity assists include

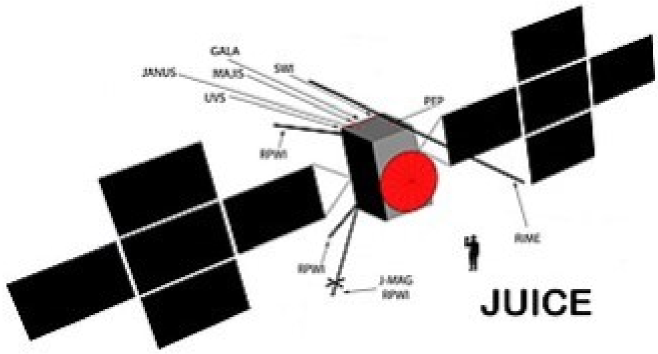
Interplanetary transfer (Earth, Venus, Earth, Mars, Earth)

Jupiter orbit insertion and apocentre reduction with multiple Ganymede gravity assists

Reduction of velocity with Ganymede–Callisto assists

Increase inclination with 10–12 Callisto gravity assists

Science instruments



JUICE scheme

On 21 February 2013, after a competition, 11 science instruments were selected by ESA, which are being developed by science and engineering teams from all over Europe, with participation from the US

Japan will also contribute several components for SWI, RPWI, GALA, PEP, JANUS and J-MAG instruments, and will facilitate testing

Jovis, Amorum ac Natorum Undique Scrutator (JANUS)

The name is Latin for "comprehensive observation of Jupiter, his love affairs and descendants. A camera system to image Ganymede and interesting parts of the surface of Callisto at better than 400 m/pixel (resolution limited by mission data volume). Selected targets will be investigated in high-resolution with a spatial resolution from 25 m/pixel down to 2.4 m/pixel with a 1.3° field of view. The camera system has 13 panchromatic, broad and narrow-band filters in the 0.36 μm to 1.1 μm range, and provides stereo imaging capabilities. *JANUS* will also allow relating spectral, laser and radar measurements to geomorphology and thus will provide the overall geological context.

Principal investigator: P. Palumbo, Parthenope University of Naples, Italy.

Co-investigator: J. Haruyama, JAXA, Japan.
Lead funding agency: ASI, Italy.

Moons and Jupiter Imaging Spectrometer (MAJIS)

A visible and infrared imaging spectrograph operating from 400 nm to 5.70 μm, with spectral resolution of 3–7 nm, that will observe tropospheric cloud features and minor gas species on Jupiter and will investigate the composition of ices and minerals on the surfaces of the icy moons. The spatial resolution will be down to 75 m (246 ft) on Ganymede and about 100 km (62 mi) on Jupiter.

Principal investigator: Y. Langevin, Institut d'Astrophysique Spatiale, France.
Lead funding agency: CNES, France.

UV Imaging Spectrograph (UVS)

An imaging spectrograph operating in the wavelength range 55–210 nm with spectral resolution of <0.6 nm that will characterise exospheres and aurorae of the icy moons, including plume searches on Europa, and study the Jovian upper atmosphere and aurorae. Resolution up to 500 m (1,600 ft) observing Ganymede and up to 250 km (160 mi) observing Jupiter.

Principal investigator: R. Gladstone, Southwest Research Institute, United States.

Lead funding agency: NASA, United States.

Sub-millimeter Wave Instrument (SWI)

A spectrometer using a 30 cm (12 in) antenna and working in 1080–1275 GHz and 530–601 GHz with spectral resolving power of ~10^7 that will study Jupiter's stratosphere and troposphere, and the exospheres and surfaces of the icy moons.

Principal investigator: P. Hartogh, Max Planck Institute for Solar System Research, Germany.

Co-investigator: Y. Kasai NICT, Japan.

Lead funding agency: DLR, Germany.

Ganymede Laser Altimeter (GALA)

A laser altimeter with a 20 m (66 ft) spot size and 10 cm (3.9 in) vertical resolution at 200 km (120 mi) intended for studying topography of icy moons and tidal deformations of Ganymede.

Principal investigator: H. Hussmann, DLR, Institute for Planetary Research, Germany.
Co-investigator: K. Enya, JAXA, Japan.
Lead funding agency: DLR, Germany.
Developer & Manufacturer: Hensoldt Optronics GmbH, Oberkochen, Germany.

Radar for Icy Moons Exploration (RIME)

An ice-penetrating radar working at frequency of 9 MHz (1 and 3 MHz bandwidth) emitted by a 16 m (52 ft) antenna; will be used to study the subsurface structure of Jovian moons down to 9 km (5.6 mi) depth with vertical resolution up to 30 m (98 ft) in ice.

Principal investigator: L. Bruzzone, University of Trento, Italy.

Lead funding agency: ASI, Italy.

JUICE-Magnetometer (J-MAG)

Will study the subsurface oceans of the icy moons and the interaction of Jovian magnetic field with the magnetic field of Ganymede using a sensitive magnetometer.

Principal investigator: Michele Dougherty, Imperial College London, United Kingdom.

Co-investigators A. Matsuoka, Kyoto University, Japan.
Lead funding agency: UKSA, United Kingdom.

Particle Environment Package (PEP)

A suite of six sensors to study the magnetosphere of Jupiter and its interactions with the Jovian moons. *PEP* will measure positive and negative ions, electrons, exospheric neutral gas, thermal plasma and energetic neutral atoms present in all domains of the Jupiter system from 1 meV to 1 MeV energy.

Principal investigator: S. Barabash, Swedish Institute of Space Physics, Sweden.

Co-princial investigators: P. Wurz, University of Bern, Switzerland; P. Brandt, JPL, United States.

Lead funding agency: SNSA, Sweden.

Radio and Plasma Wave Investigation (RPWI)

Will characterise the plasma environment and radio emissions around the spacecraft, it is composed of four experiments: GANDALF, MIME, FRODO and JENRAGE. *RPWI* will use four Langmuir probes, each one mounted at the end of its own dedicated boom, and sensitive up to 1.6 MHz to characterize plasma and receivers in the frequency range 80 kHz to 45 MHz to measure radio emissions. This scientific instrument is somewhat notable for using Sonic as part of its logo.[26][27]

Principal investigator: J.-E. Wahlund, Swedish Institute of Space Physics, Sweden.

Co-princial investigators: B. Cecconi, Obs. Paris, France; Y. Kasaba, Tohoku University, Japan; I. Müeller-Wodarg, ICL, UK; H. Rothkaehl, CBK, Poland; O. Santolik, IAP, Czech Republic.

Lead funding agency: SNSA, Sweden.

Gravity and Geophysics of Jupiter and Galilean Moons (3GM)

3GM is a radio science package comprising a Ka transponder and an ultrastable oscillator. 3GM will be used to study the gravity field – up to degree 10 – at Ganymede and the extent of internal oceans on the icy moons, and to investigate the structure of the neutral atmospheres and ionospheres of Jupiter (0.1 – 800 mbar) and its moons.

Principal investigator: L. Iess, Sapienza University of Rome, Italy.
Lead funding agency: ASI, Italy.

Planetary Radio Interferometer and Doppler Experiment (PRIDE)

The experiment will generate specific signals transmitted by JUICE's antenna and received by very-long-baseline interferometry to perform precision measurements of the gravity fields of Jupiter and its icy moons.

Principal investigator: L. Gurvits, Joint Institute for VLBI in Europe, Netherlands.

Lead funding agency: NWO and NSO, Netherlands.

SPACE NEWS TO JANUARY 23

Earth-Sized Planet Found At One of the Lightest Red Dwarfs

Astronomers have found another Earth-sized planet. It's about 31 light-years away and orbits in the habitable zone of a red dwarf star. It's probably tidally locked, which can be a problem around red dwarf stars. But the team that found it is optimistic about its potential habitability.

The prospect of finding Earth-like planets raises the prospect of finding life elsewhere. But they're difficult to spot. Of the approximately 5,200 exoplanets we know of, only a tiny minority can be described as Earth-like. NASA calls them terrestrial planets, and they range from half of Earth's mass to twice Earth's mass. But the designation only refers to their size and their composition.

An Earth-sized planet isn't Earth-like unless its star behaves well. And that's been a problem for planets orbiting red dwarfs. Red dwarfs are notorious for violent UV flaring. That can strip away the atmosphere of any planet in its habitable zone, Earth-like or not.

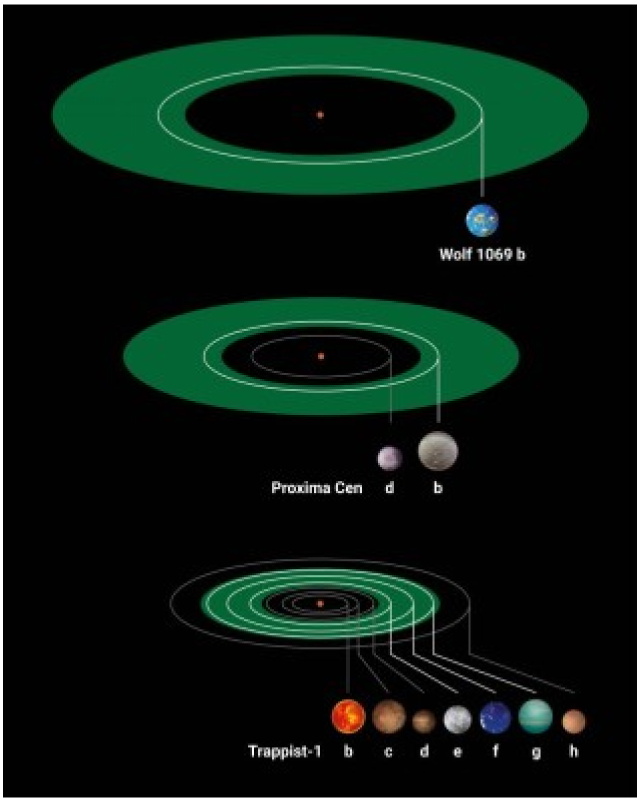
A team of astronomers from the Max Planck Institute for Astronomy think they've found a planet orbiting a red dwarf that might be an exception to the rule. Even though the planet is tidally locked, researchers think it could remain habitable across its dayside. They also think the planet is a good candidate to search for biosignatures on.

The researchers reported their findings in a paper titled "The CARMENES search for exoplanets around M dwarfs. Wolf 1069 b: Earth-mass planet in the habitable zone of a nearby, very low-mass star." The paper is published in the journal Astronomy and Astrophysics, and the lead author is Diana Kossakowski. Kossakowski is from the Department of Planet and Star Formation at the MPIA.

Low-mass planets like Earth are difficult to spot, especially around large stars. CARMENES stands for Calar Alto high-Resolution search for M dwarfs with Exo-earths with Near-infrared and optical Échelle Spectrographs. The instrument is a pair of spectrographs on the 3.5-meter telescope at the Calar Alto Observatory in Spain. CARMENES looked at hundreds of low-mass red dwarf stars and searched for low-mass planets in their habitable zones. CARMENES uses radial velocity to detect the tiny changes small planets induce in the small red dwarfs they orbit.

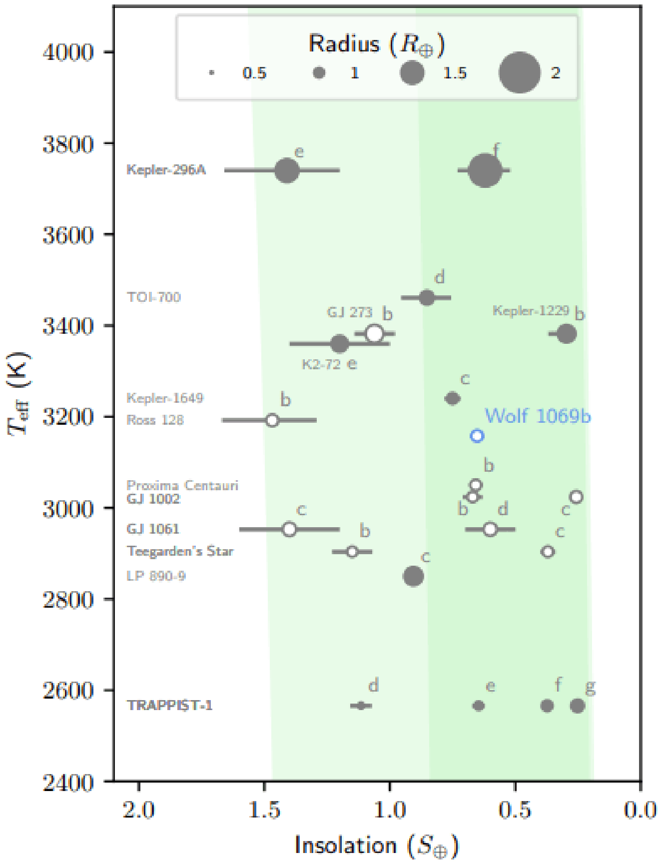
One of the stars found by CARMENES is called Wolf 1069. It's only 17% as massive as the Sun and only 18% the radius of the Sun. It hosts a single planet called Wolf 1069b. "When we analyzed the data of the star Wolf 1069, we discovered a clear, low-amplitude signal of what appears to be a planet of roughly Earth mass. It orbits the star within 15.6 days at a distance equivalent to one-fifteenth of the separation between the Earth and the Sun," said lead author Kossakowski.

Since Wolf 1069 is so much smaller and less energetic than a star like our Sun, its habitable zone is much closer. If Wolf 1069 b were orbiting our Sun at the same distance it orbits the red dwarf, it would be fried to a crisp. So even though Wolf 1069 b is so close to its star, the planet receives less energy than Earth does from the Sun, only about 65%. "As a result, the so-called habitable zone is shifted inwards," said Kossakowski.



This illustration compares three exoplanet systems of red dwarf stars hosting Earth-mass planets. The green rings indicate the individual habitable zones. Image Credit: MPIA graphics department/J. Neidel

"Wolf 1069 b, with a distance of 0.0672 ± 0.0014 au to the star, sits comfortably within the conservative HZ limits, namely, 0.056 au to 0.111 au, given the runaway-greenhouse and maximum greenhouse limits, respectively," the authors write in their paper.



This figure from the research shows planets around M-dwarf stars. The star's temperature is on the y-axis, and insolation is on the x-axis. The optimistic and conservative HZ regions for a one Earth-mass planet are shaded with light and dark green, respectively. Only the planets in either the conservative or optimistic HZ of each planetary system are shown. White-filled planets are non-transiting planets, and grey-filled are transiting exoplanets, and the size of the circle indicates planet radius. Wolf 1069b compares with our neighbour, Proxima Centauri b and with other rocky, Earth-sized exoplanets like Kepler 1649 c. Image Credit: Kossakowski et al. 2023.

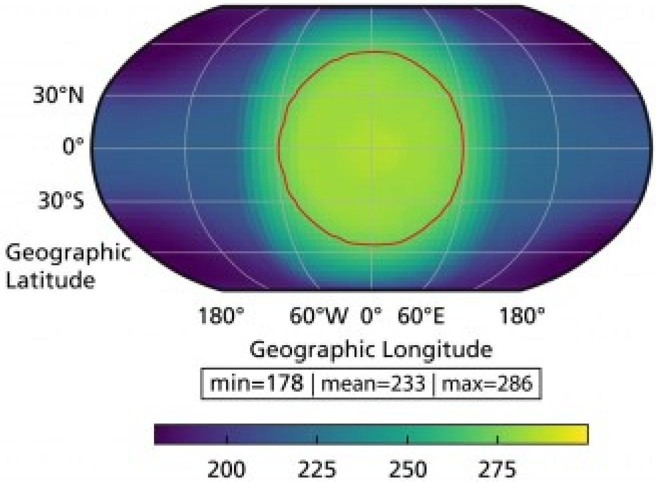
CARMENES excels at finding low-mass planets around low-mass stars because it uses radial velocity rather than the transit method. "The CARMENES survey is thus providing a comprehensive overview of planetary systems around nearby northern M dwarfs," the CARMENES website explains. "By reaching into the realm of Earth-like planets, it provides a treasure trove for follow-up studies probing their habitability."

Wolf 1069 b doesn't transit the star from our point of view, so without CARMENES, astronomers may never have found it.

"The CARMENES instrument was built for the very purpose of making it easier to discover as many potentially habitable worlds as possible," said study co-author Jonas Kemmer from Heidelberg University.

Habitable only means that the surface could sustain the presence of liquid water. But there would have to be an appropriate atmosphere for that to happen. The astronomers say that if Wolf 1069 b had an Earth-similar atmosphere, the temperature could be as high as 13 Celsius on the dayside. That would enable liquid water to exist over a large region of the planet. The researchers used computer modelling to show that the planet could sustain water over a wide variety of atmospheric types.

But the atmosphere does more than allow water to exist in liquid form. If it's there, it can fulfill another crucial role in habitability. It could help protect the planet from radiation and high-energy particles that would otherwise make the planet sterile. Red dwarfs are notorious for intense UV flaring that can strip away atmospheres.

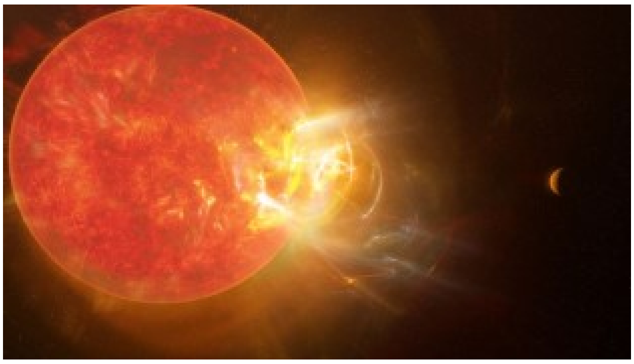


This figure shows the projected temperature across Wolf 1069 b's dayside in Kelvin if it has an Earth-like atmosphere. Image Credit: Kossakowski *et al.* 2023.

Proxima Centauri is the nearest star system to Earth, and it was big news when astronomers detected exoplanets there. Proxima Centauri b was discovered in 2016. It's just a little more massive than Earth and orbits the red dwarf in its habitable zone. But Proxima Centauri is a flare star, and that could mean the habitable zone is not habitable at all.

Wolf 1069 appears to lack the type of powerful flaring that other red dwarfs exhibit. If that's the case, then its habitable zone could actually be habitable. But flaring can be intermittent, and astronomers may not have seen any yet. So there's good reason to temper optimism.

On the other hand, red dwarfs don't flare at the same rate throughout their lives. When they're young, they're more energetic and likely to make it very difficult for nearby planets to hold onto an atmosphere. Depending on how early Wolf 1069 developed an atmosphere, if it did, it may still retain it to this day if the star's flaring is a thing of the past. It's even possible that the little planet has a magnetic field that could help shield it.



Artist's conception of a violent stellar flare erupting on our neighbouring star, Proxima Centauri. Credit: NRAO/S. Dagnello.

Wherever astronomers find exoplanets, they find them in groups. But this system appears to be different. Astronomers haven't found evidence of any siblings for Wolf 1069 b. Some computer modelling shows that low-mass stars can end up with just a single planet orbiting them, which appears to be the case here. "Our computer simulations show that about 5% of all evolving planetary systems around low-mass stars, such as Wolf 1069, end up with a single detectable planet," explained MPIA scientist Remo Burn, a team member of the study. The team can't completely rule out another planet in the system. But if one's there, it would have to be on a wide orbit well outside the habitable zone.

The simulations also explain that Wolf 1069 b could still have one of life's most precious commodities: a molten core. "The simulations also reveal a stage of violent encounters with planetary embryos during the construction of the planetary system, leading to occasional catastrophic impacts," Burn added. Impacts create an enormous amount of heat which might mean that Wolf 1069 went through a magma ocean phase like Earth did. If it did, then the planetary core should still be hot and liquid today and composed of dense iron and nickel. That could create a dynamo that produces a protective global magnetic field similar to Earth's.

Wolf 1069 b is only 31 light-years away, making it the sixth closest Earth-mass planet in its star's habitable zone. Its proximity, as well as its potential habitability, make it a star candidate for more detailed follow-up study. It's in the same class as Proxima Centauri b and TRAPPIST-1 e. All three are suitable candidates in the search for biosignatures. But since Proxima Centauri b and Wolf 1069 b were both found using the radial velocity method, they're not targets for the usual spectroscopy. They don't pass between us and their star, so there's no opportunity for the JWST or any other telescope to examine their atmospheres. Astronomers will have to wait for their opportunity.

"We'll probably have to wait another ten years for this," Kossakowski points out. "Though it's crucial we develop our facilities considering most of the closest potentially habitable worlds are detected via the RV method only." The ESO's Extremely Large Telescope (ELT) may be able to characterize the conditions of those planets using reflected light, but its first light is a few years away, hopefully in 2028. Until then, Kossakowski and her team look forward to finding more exciting candidates like Wolf 1069 b.

"To conclude," the researchers write, "Wolf 1069 b is a noteworthy discovery that will allow further exploration into the habitability of Earth-mass planets around M dwarfs, as well as case study in testing planetary formation theories."

JWST Unexpectedly Finds a Small Asteroid During 'Failed' Observations

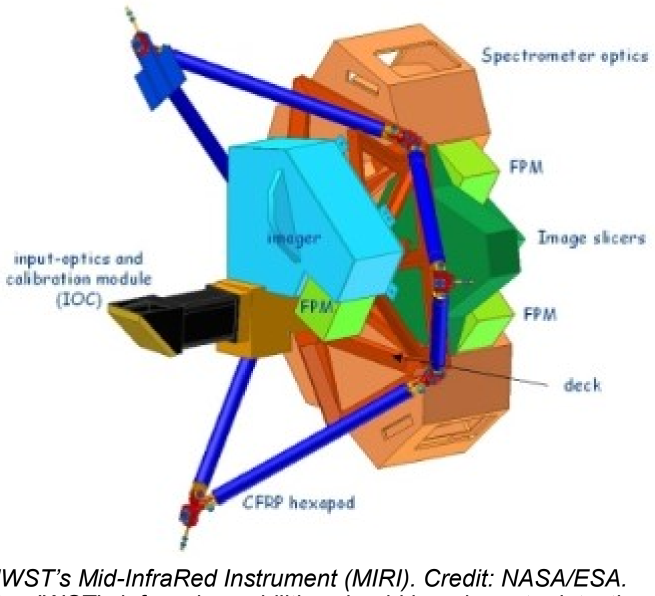
While astronomers and engineers were trying to calibrate one of the James Webb Space Telescope's instruments last summer, they serendipitously found a previously unknown small 100–200-meter (300-600 ft) asteroid in the main asteroid belt. Originally, the astronomers deemed the calibrations as a failed attempt because of technical glitches. But they noticed the asteroid while going through their data from the Mid-InfraRed Instrument (MIRI), and ended up finding what is likely the smallest object observed to date by JWST. It is also one of the smallest objects ever detected in our Solar System's main belt of asteroids.

"We — completely unexpectedly — detected a small asteroid in publicly available MIRI calibration observations," explained Thomas Müller, an astronomer at the Max Planck Institute for Extraterrestrial Physics in Germany, in a press release. "The measurements are some of the first MIRI measurements targeting the ecliptic plane and our work suggests that many, new objects will be detected with this instrument."

The asteroid is not yet named, as follow-up observations need to be done to confirm the discovery. Additionally, more observations will be done to better characterize this object's nature and properties.

This finding was unexpected because astronomers weren't sure JWST had the capability find asteroids this small. But this detection showed otherwise.

What's more, based on this finding, astronomers suspect that even short MIRI observations close to the plane of the Solar System will always include a few asteroids, most of which will be unknown objects. This is reminiscent of the early calibration images in March of 2022 where previously unseen background galaxies were showing up everywhere. Jane Rigby, JWST operations project scientist said, "Basically, everywhere ever we look, it's a Deep Field."

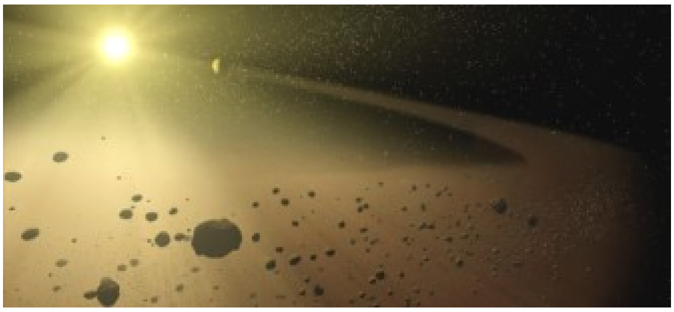


JWST's Mid-InfraRed Instrument (MIRI). Credit: NASA/ESA.

So, JWST's infrared capabilities should be a boon to detecting some of the hardest to find asteroids. Scientists estimate the asteroid belt has between 1.1 and 1.9 million asteroids larger than 1 kilometer (0.6 miles) in diameter, and millions of smaller ones. Most of the undiscovered asteroids are the smaller ones (less than 100 km across) which are more difficult to detect.

"This is a fantastic result which highlights the capabilities of MIRI to serendipitously detect a previously undetectable size of asteroid in the main belt," said Bryan Holler, Webb support scientist at the Space Telescope Science Institute. "Repeats of these observations are in the process of being scheduled, and we are fully expecting new asteroid interlopers in those images!"

The calibrations being performed while JWST was targeting another main-belt asteroid (10920) 1998 BC1, which astronomers discovered in 1998. The calibration team considered them to have failed for technical reasons due to the brightness of the target and an offset telescope pointing.



An artists impression of an asteroid belt. Credit: NASA

However, even the failure was a success in another way, because the team was able to test a new technique to constrain an object's orbit and to estimate its size. The validity of the method was demonstrated for asteroid 10920 using the MIRI observations combined with data from ground-based telescopes and ESA's Gaia mission.

"Our results show that even 'failed' Webb observations can be scientifically useful, if you have the right mindset and a little bit of luck," said Müller. "Our detection lies in the main asteroid belt, but Webb's incredible sensitivity made it possible to see this roughly 100-metre object at a distance of more than 100 million kilometers."

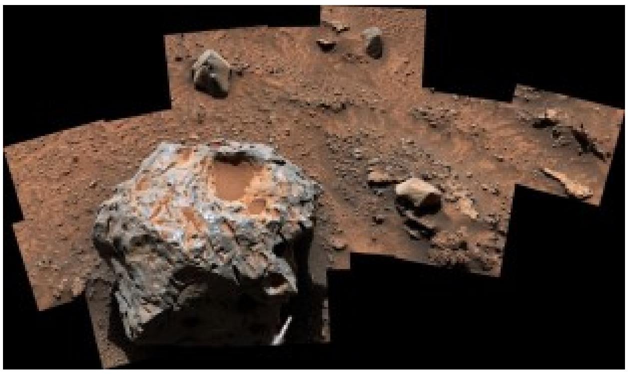
Curiosity Finds Another Metal Meteorite on Mars

MSL Curiosity is going about its business exploring Mars. The high-tech rover is currently exploring the sulphate-bearing unit on Mt. Sharp, the central peak in Mars' Gale Crater. Serendipity placed a metal meteorite in its path.

The meteorite is made mostly of nickel and iron, and it has a name: Cacao. (Chocolate comes from cacao.) Cacao isn't very large; it's only about 30 cm (1 ft.) across. Curiosity has come across several meteorites since landing in Gale Crater in August 2012.

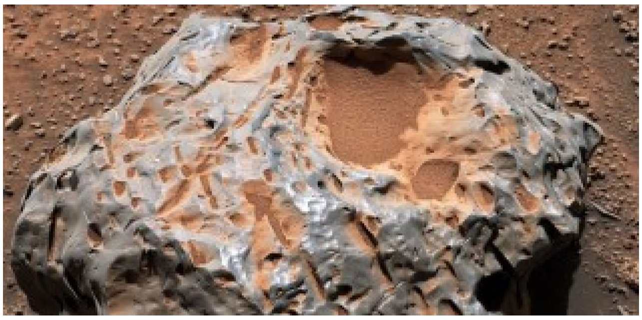
Cacao stands out visually from its surroundings. While the Martian surface is red from oxides, the meteorite is dark grey and metallic-looking. It's also smooth and rounded, obvious signs that it passed through an atmosphere.

The image is a composite of six individual images taken with the rover's Mastcam. Curiosity captured the images on Jan 27, 2023, the 3,724th Martian day, or sol, of the mission. The colours in the image have been corrected to match the lighting conditions as seen with human eyes on Earth.



A high-resolution TIFF is available at https://photojournal.jpl.nasa.gov/catalog/PIA25737 Credit: NASA/JPL-Caltech/MSSS

The grooves and pits are called *regmaglypts*. They're particularly interesting on iron meteorites. They formed when Cacao was travelling through the atmosphere. Even though Mars' atmosphere is much thinner than Earth's, it still creates enough friction to heat the meteorite's surface. The regmaglypts are likely created by vortices of hot gas that melted the rock as it travelled through the atmosphere.



MSL Curiosity found the iron-nickel meteorite “Cacao” on January 27th, 2023. Image Credit: NASA/JPL-Caltech/MSSS

The meteorite may have been on Mars’ surface for a long time, but nobody knows for sure.

This isn’t the first meteorite rovers have found on Mars. In 2016, MSL Curiosity found another metal meteorite about the size of a golf ball named “Egg Rock.” It examined that one with its ChemCam instrument to determine its composition. The grid pattern of five small white dots shows where the instrument’s laser struck the rock.

The dark, smooth-surfaced object at the center of this Oct. 30, 2016, image from the Mast Camera (Mastcam) on NASA’s Curiosity Mars rover was examined with laser pulses and confirmed to be an iron-nickel meteorite. Its surface is also marked with regmaglypts. Image Credit: NASA/JPL-Caltech/MSSS

Iron-nickel meteorites are the rarest type of meteorites, making up about 6% of witnessed falls. But because of their tell-tale visual appearance, they’re over-represented in collections. That’s because they’re more likely to survive passage through an atmosphere and are more resistant to weathering, even on Mars.

Most iron-nickel meteorites come from the cores of shattered planetesimals that formed in the early Solar System. Those objects were large enough to differentiate when they were molten. They formed a core of dense iron and nickel, much like Earth did. But life as a planetesimal was risky, and many of them were shattered into asteroids. That’s Cacao’s likely history.

Curiosity found this iron meteorite called “Lebanon” back in 2014. It’s about 2 yards or 2 meters wide (left to right, from this angle). The smaller piece in the foreground is called “Lebanon B.” This photo combines a series of high-resolution circular images across the middle taken by the Remote Micro-Imager (RMI). Credit: NASA/JPL-Caltech/LANL/CNES/IRAP/LPGNantes/CNRS/IAS/MSSS

That’s what makes meteorites, and especially metal ones, so scientifically interesting. They can date back billions of years to the beginning of the Solar System.

On Earth, meteorites like Cacao were humanity’s first source of iron. Long before smelting, people collected these meteorites when they could and made knives and other implements out of them. King Tut was buried with a dagger made of meteoric iron, and the Inuit people in the Arctic and in Greenland also used meteoric iron. They repeatedly visited one particularly large iron meteorite called the Cape York meteorite. They hammered off chunks of iron to shape into harpoon tips and started their own iron age without knowing anything about smelting. They even traded iron with other groups of people.

But only our robot explorers will ever set eyes on Cacao. Cacao is only an interesting oddity to MSL Curiosity. Curiosity’s job is to study Gale Crater, Mt. Sharp, and features like the sulphur-bearing unit. The unit is rich in salty minerals that formed in the presence of water. By researching the area, Curiosity is shedding light on Mars’ ancient history, and how it dried up to become the dessicated wasteland it is now. Finding Cacao is just a bonus.

Zooming into Cacao’s fascinating pits and ridges. Image Credit: NASA/JPL-Caltech/MSSS

Mars Ingenuity Kicks up a Surprising Amount of Dust Every Time it Lands

There’s no way to sugarcoat it: Mars has a “dust problem.” The surface of the Red Planet is covered in particulate matter consisting of tiny bits of silica and oxidized minerals. During a Martian summer in the southern hemisphere, the planet experiences dust storms that can grow to encompass the entire planet. At other times of the year, dust devils and dusty skies are a persistent problem. This hazard has claimed robotic explorers that rely on solar panels to charge their batteries, like NASA’s *Opportunity* rover and the *InSight* lander, which ended their missions in 2018 and 2022, respectively.

Martian dust has also been a persistent challenge for the *Ingenuity* helicopter, the rotorcraft that has been exploring Mars alongside NASA’s *Perseverance* rover since February 2021. Luckily, the way it has kicked up dust has provided vital data that could prove invaluable for rotorcraft sent to explore other extraterrestrial environments in the future. Using this data, a team of researchers (with support from NASA) has completed the first real-world study of Martian dust dynamics, which will support missions to Mars and Titan (Saturn’s largest moon) in this and the next decade.

The study was led by Mark T. Lemmon, a senior research scientist at the Space Science Institute’s (SSI) Center for Mars Science in Boulder, Colorado. He was joined by researchers from the Stevens Institute of Technology, the Johns Hopkins University Applied Physics Laboratory (JHUAPL), Aeolis Research, Cornell University, Arizona State University, the Centro de Astrobiologia (INTA-CSIC), and NASA’s Jet Propulsion Laboratory. The paper that describes their analysis recently appeared in the *Journal of*

Geophysical Research: Planets.

A Serpent Dust Devil on Mars, captured by the High-Resolution Imaging Science Experiment (HiRISE) aboard the *Mars Reconnaissance Orbiter (MRO). Credit: NASA/JPL/University of Arizona*

Studying dust dynamics on another planet is difficult, given the distances and communications delays involved. As a result, researchers rely on Computational Fluid Dynamics (CFD) to simulate how dust behaves in extraterrestrial environments based on the local conditions. Said Jason Rabinovitch, an assistant professor at the Stevens Institute of Technology and a co-author on the study:

"There's a reason that helicopter pilots on Earth prefer to land on helipads. When a helicopter lands in the desert, its downdraft can stir up enough dust to cause a zero-visibility 'brownout' – and Mars is effectively one big desert. Space is a data-poor environment. It's hard to send videos and images back to Earth, so we have to work with what we can get."

The Rabinovitch Research Group at Stevens investigates plume-surface interactions during the powered descent of spacecraft. They also model supersonic parachute inflation, small satellite hybrid rocket propulsion, and geophysical phenomena. This includes "yardangs," a feature found on Earth and Mars where protruding rocks are carved by the dual action of wind abrasion by dust and sand and the removal of loose material by wind turbulence (deflation). Rabinovitch has been working with NASA JPL and the Ingenuity program since 2014, creating the first theoretical models of dust kicked up by helicopters on Mars.

For the sake of their study, Rabinovich and his teammates used advanced image-processing techniques to extract information from the low-resolution videos of *Ingenuity*'s six helicopter flights captured by *Perseverance*. By identifying tiny variations between video frames and the light intensity of individual pixels, Rabinovich and his colleagues calculated the size and mass of dust clouds the helicopter kicked up during takeoff, hovering, and landing. The results were strikingly similar to the models he and his colleagues created in 2014.

Specifically, they estimate that Ingenuity kicked up about one-thousandth of its own mass (1.8 kg; 4 lbs) each time it flew. This is many times more dust than a rotorcraft of similar mass would generate here on Earth, a result of Martian gravity being roughly 40% that of Earth's and atmosphere pressure being less than half of a percent. However, given the remaining uncertainties, Rabinovich and his teammates are cautious about making direct comparisons.

"When you think about dust on Mars, you have to consider not just the lower gravity, but also the effects of air pressure, temperature, air density – there's a lot we don't yet fully understand," he said. Nevertheless, the fact that there is still much to be learned is part of what makes the research so interesting. "It was exciting to see the Mastcam-Z video from Perseverance, which was taken for engineering reasons, ended up showing Ingenuity lifting so much dust from the surface that it opened a new line of research," added Lemmon. This research will lead to a better understanding of Martian dust storms, which would help NASA extend future missions that rely on solar power. It could also help with Entry, Descent, and Landing (EDL) techniques whenever sensitive equipment needs to land on Mars' dusty surface – like the NASA/ESA Mars Sample Return (MSR) mission. It could also lead to a better understanding of the role dust storms play in meteorological phenomena that Earth and Mars share.

This will also prove useful for mission planners working on NASA's *Dragonfly* mission, a nuclear-powered quadcopter that will launch towards Titan (Saturn's largest moon) by 2027. For any celestial bodies that have atmospheres, wind-borne erosion, and plenty of particulate matter on their surfaces, these types of studies will be invaluable when it comes time to prep missions to explore them.

Further Reading: Stevens Institute of Technology, *JGR: Planets*

This Binary System is Destined to Become a Killernova

Kilonovae are extraordinarily rare. Astronomers think there are only about 10 of them in the Milky Way. But they're extraordinarily powerful and produce heavy elements like uranium, thorium, and gold.

Usually, astronomers spot them after they've merged and emitted powerful gamma-ray bursts (GRBs.) But astronomers using the SMARTS telescope say they've spotted a kilonova progenitor for the first time.

A kilonova explosion occurs when two neutron stars—or a neutron star and a black hole—merge. Neutron stars are the stellar remnants of massive stars that explode as supernovae. They're the smallest and densest astronomical objects we know of.

Astronomers spotted the progenitor kilonova stars about 11,400 light-years away. They're named CPD-29 2176 and were first spotted with NASA's Swift observatory. More observations with the SMARTS 1.5-meter Telescope at the Cerro Tololo Inter-American Observatory in Chile revealed more data.

The findings are in a paper titled "A high-mass X-ray binary descended from an ultra-stripped supernova." It's published in the journal Nature. The lead author is Noel D. Richardson, an assistant professor in the Physics and Astronomy Department at Embry-Riddle Aeronautical University.

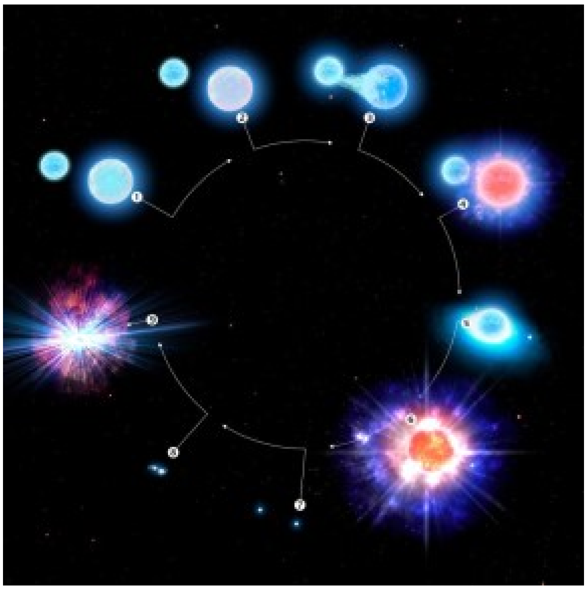
CPD-29 2176 isn't a pair of neutron stars, not yet. One of them is a neutron star, and the other is a massive star on its way to exploding as a supernova and leaving a neutron star behind. The stage is set for a kilonova about one million years from now, probably later.

But for the pair of neutron stars to merge as a kilonova in the future, the second star has to explode as a particular type of supernova called an *ultra-stripped supernova*. One of the reasons that kilonovae are so rare is that ultra-stripped supernovae are so rare. And if that's not rare enough, *the existing neutron star also had to explode* as an ultra-stripped supernovae.

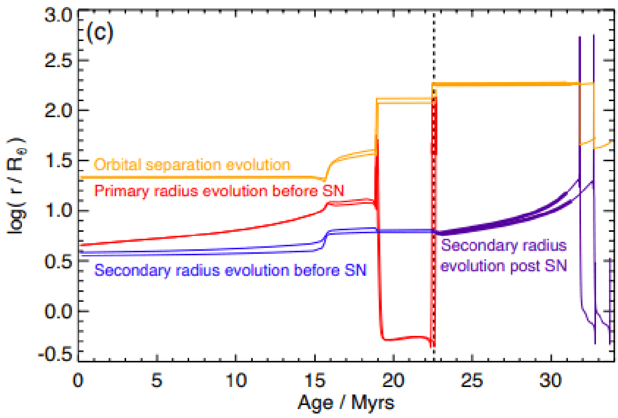
When a typical supernova (SN) explodes, it releases a tremendous amount of energy. The explosion can kick its neutron star companion out of the system, eliminating the pathway to a potential kilonova. Eventually, the SN will leave a neutron star behind, but it'll be alone, and there'll be no opportunity for two neutron stars to merge and explode as a kilonovae.

But an ultra-stripped supernova (USSN) is different. Ultra-stripped means the SN has experienced extreme mass loss prior to exploding. The mass is lost to its stellar companion, and without that mass, the SN explosion isn't powerful enough to kick out its companion when the SN explodes. These are important details because most stars massive

enough to explode as SN exist in binary pairs.
The interactions between the pair of stars prior to one exploding as a SN are critical to any eventual kilonova. Changes in mass, stellar rotation, and nuclear burning all determine the eventual core mass of the SN. Under the right but rare conditions, it creates an ultra-stripped supernova.
This is what's happening in CPD-29 2176, and the researchers doubt the SN will have enough energy when it explodes to eject its neutron star companion. Not only does the current massive star need to explode as a USSN, but the existing neutron star did, too, or else when it exploded as an SN, it would've kicked out its stellar companion. So two USSNs are necessary.
"The current neutron star would have to form without ejecting its companion from the system. An ultra-stripped supernova is the best explanation for why these companion stars are in such a tight orbit," said lead author Richardson. "To one day create a kilonova, the other star would also need to explode as an ultra-stripped supernova so the two neutron stars could eventually collide and merge." This explains why kilonovae are so rare. Mass stripping and weakened SN explosions are prerequisites.
The researchers explained how the system developed so far and what will likely happen in the future.
First, two massive blue stars form in a binary pair. Stars are never the same size; one is always more massive. As the more massive one approaches the end of its life and swells up, the smaller companion is able to siphon off some of the larger star's material and strip off a significant amount of its outer atmosphere. Then the larger star explodes as an ultra-stripped supernova, but without enough explosive power to kick out its companion, it leaves behind a neutron star.
The next stage is where CPD-29 2176 is now. There's the neutron star and the larger star that hasn't exploded yet. The neutron star is siphoning off the star's outer layers, causing significant mass loss. The tables are turned.



This infographic illustrates the evolution of the star system CPD-29 2176, the first confirmed kilonova progenitor. Stage 1, two massive blue stars form in a binary star system. Stage 2, the larger of the two stars nears the end of its life. Stage 3, the smaller of the two stars siphons off material from its larger, more mature companion, stripping it of much of its outer atmosphere. Stage 4, the larger star forms an ultra-stripped supernova, the end-of-life explosion of a star with less of a "kick" than a more normal supernova. Stage 5, as currently observed by astronomers, the resulting neutron star from the earlier supernova begins to siphon off material from its companion, turning the tables on the binary pair. Stage 6, with the loss of much of its outer atmosphere, the companion star also undergoes an ultra-stripped supernova. This stage will happen in about one million years. Stage 7, a pair of neutron stars in close mutual orbit now remain where once there were two massive stars. Stage 8, the two neutron stars spiral into toward each other, giving up their orbital energy as faint gravitational radiation. Stage 9, the final stage of this system as both neutron stars collide, producing a powerful kilonova, the cosmic factory of heavy elements in our Universe. Image Credit: CTIO/NOIRLab/NSF/AURA/P. Marenfeld
Sometime about a million years in the future, the remaining star will have lost much of its mass and will explode as an ultra-stripped supernovae. It won't be powerful enough to kick out its neutron star companion. It'll leave a neutron star behind, and the pair of neutron stars will orbit each other until they spiral inward and eventually merge.
"For quite some time, astronomers speculated about the exact conditions that could eventually lead to a kilonova," said NOIRLab astronomer and co-author André-Nicolas Chené. "These new results demonstrate that, in at least some cases, two sibling neutron stars can merge when one of them was created without a classical supernova explosion."
The odds against this happening are almost overwhelming. But since kilonovae do exist, circumstances must line up to produce them. So every time we witness a kilonova, we're witnessing a one-in-ten-billion event.
"We know that the Milky Way contains at least 100 billion stars and likely hundreds of billions more. This remarkable binary system is essentially a one-in-ten-billion system," said Chené. "Prior to our study, the estimate was that only one or two such systems should exist in a spiral galaxy like the Milky Way."
There's more to kilonovae than gravitational waves and a massive explosion. These events are also a source of the Universe's heavy elements. So studying them not only reveals details about the events leading up to them but it also helps untangle the history of nucleosynthesis.



This figure from the study shows the stellar radii (blue for the secondary star and red for the primary star) and the orbital radius in orange. The primary star's supernova event is shown as a vertical dashed line. Before exploding as an ultra-stripped supernova, the primary star's radius grew, then shrank as the secondary star siphoned off some of its mass. Eventually, the same thing will happen to the secondary star. Image Credit: Richardson *et al.* 2023.
But humanity will have to survive an awfully long time to see this kilonova event. It could take over a million years for the star to explode as an ultra-stripped supernova. And when it does, the two neutron stars will have to be close enough together before a kilonova can occur. That's a lot of time and a lot of circumstances.
Now that astronomers have spotted one of these potential kilonova progenitors, they might be in a better position to find more. Along the way, they'll learn more about ultra-stripped

supernovae.

"This system reveals that some neutron stars are formed with only a small supernova kick," said Richardson. "As we understand the growing population of systems like CPD-29 2176, we will gain insight into how calm some stellar deaths may be and if these stars can die without traditional supernovae."

How Can We Know if We're Looking at Habitable exo-Earths or Hellish exo-Venuses?

The differences between Earth and Venus are obvious to us. One is radiant with life and adorned with glittering seas, and the other is a scorching, glowering hellhole, its volcanic surface shrouded by thick clouds and visible only with radar. But the difference wasn't always clear. In fact, we used to call Venus Earth's sister planet.

Can astronomers tell exo-Earths and exo-Venuses apart from a great distance?

There are lots of terrestrial planets in the habitable zones of distant suns. Sometimes they're described as "Earth-like" just for being rocky and at the right distance from the star. But with scant information on their atmospheres and climates and with almost no information on other things like plate tectonics, can they really be accurately described as Earth-like? Could they just as easily be super-heated exo-Venuses?

Polarimetry could help us determine which exoplanets are more like Earth and which are more like Venus.

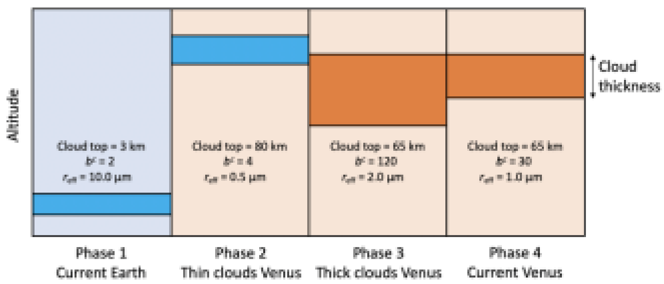
Polarimetry is the measurement of polarized light that's been affected by material that it passes through, reflects off, or is refracted or diffracted by. Polarimetry is also the interpretation of the measurements. A new paper models the polarisation of starlight that is reflected by different types of exoplanet atmospheres based on the evolution of Venus' atmosphere since its formation. The authors wanted to know if polarimetry could distinguish between Earth-like exoplanets and Venus-like exoplanets.

The paper is "From exo-Earths to exo-Venuses — Flux and Polarization Signatures of Reflected Light." It'll be published in the journal Astronomy and Astrophysics. The lead author is Gourav Mahapatra, an Atmospheric Physicist at the Netherlands Institute for Space Research.

Comparisons between Venus and Earth are instructive cases in planetary science. They're both the same age, they're about the same size, they're both rocky planets formed from the same materials, and they both have significant atmospheres. But astronomers are curious about habitability. And when it comes to habitability, the pair of planets are vastly different. Earth sings with the chorus of life while Venus is mute.

Scientists know that Earth's and Venus' atmospheres have both changed a lot over time. When astronomers study exoplanets searching for Earth-like planets, they can't know what phase of evolution they're in, so they need to model atmospheres at different stages of evolution. Since exo-Venuses can masquerade as exo-Earths, they need a method to tell the two apart.

Venus might've started out with a thin, Earth-like atmosphere. It may have had an ocean, too. But the planet suffered a runaway greenhouse effect. That drove the water into the atmosphere, creating an atmosphere enriched with water vapour. That took time, and the researchers modelled Venus' atmosphere in four different stages, mimicking what they might see when they find terrestrial exoplanets.



This figure from the study shows four evolutionary phases of the model planets. r_{eff} is the radius of the atmospheric particles, and b^c is the optical thickness of the clouds. In Phases 1 and 2, the clouds consist of liquid water droplets, and in Phases 3 and 4, of liquid sulfuric acid solution droplets. Image Credit: Mahapatra *et al.* 2023.

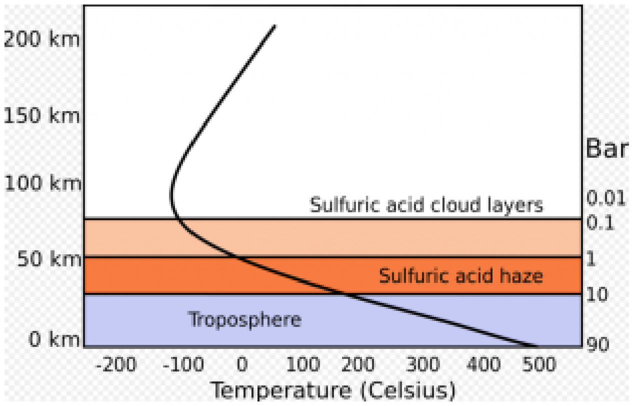
The researchers computed both the flux and the polarisation of light for atmospheres from different evolutionary stages of Venus' atmosphere. They varied atmospheric compositions from pure water to ones containing sulfuric acid, a signature gas in Venus' thick modern atmosphere. They wanted to find out how strong the polarisation difference is vs. the flux. If the polarization varied measurably, they were on to something.

In Phase 1, the atmosphere matches Earth's current atmosphere, aside from oxygen. Oxygen doesn't affect the results much, so the amount of oxygen in an exoplanet's atmosphere wouldn't be critical to polarimetry.

In Phase 2, the atmosphere is much more Venus-like and consists of almost pure CO2 gas. It has relatively thin liquid water clouds with $b^c = 4$, and with the cloud tops at 80 km. For this phase, the team used r_{eff} of 0.5 μm, which is smaller than the present-day value. The atmosphere was so hot that strong condensation couldn't take place, preventing particles from growing larger.

In Phase 3, the clouds are thick sulphuric-acid solution clouds. The $b^c = 120$, and the cloud tops are at 65 km because the atmosphere is cool enough to allow condensation and/or coalescence of saturated vapour over a large altitude range.

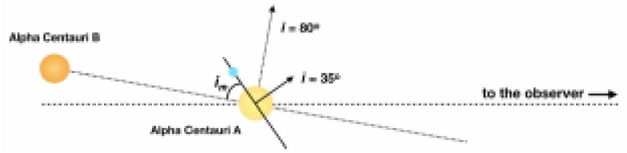
In Phase 4, the clouds are much like present-day Venus' clouds. The clouds aren't as thick with a $b^c = 30$, and the cloud tops are at 65 km.



This image shows the elevation and temperature of Venus' atmospheric layers. Image Credit: By Alexparent – Reproduction in SVG of http://en.wikipedia.org/wiki/File:Venusatmosphere2.GIF, Public Domain, https://commons.wikimedia.org/w/index.php?curid=6432901

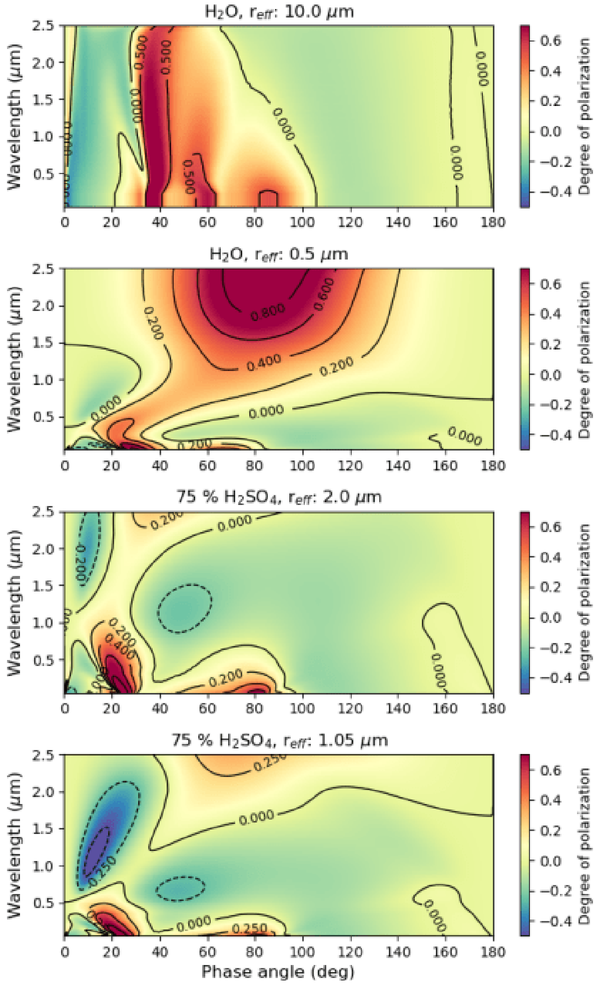
Since the researchers were looking at polarized light, the planetary phase angle is critical to their results. The phase angle is the angle between the light incident onto an observed object and the light reflected from the object. In this case, it's the angle between us (observer,) the exo-star, and the exoplanet.

In their paper, the researchers use a model planet in the Alpha Centauri system to help explain their work.

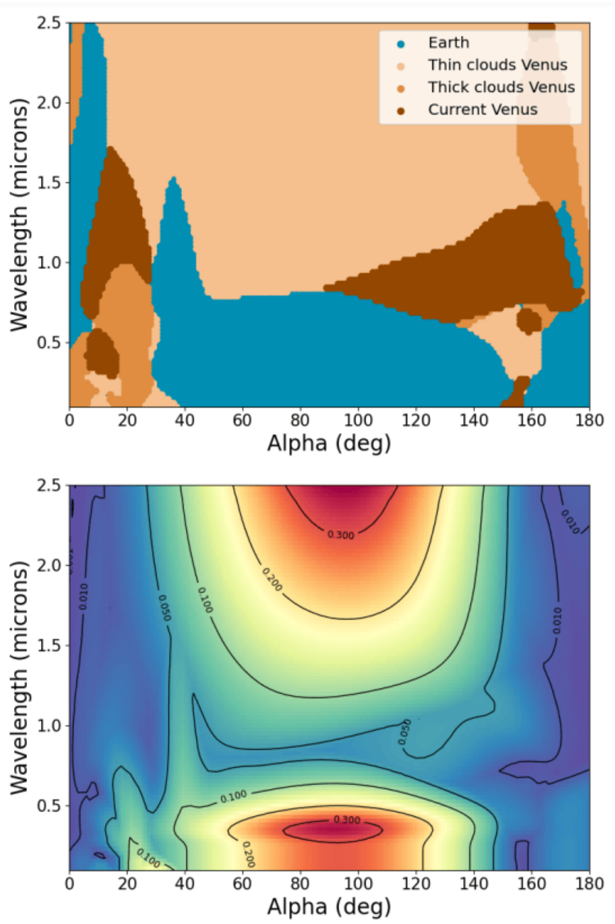


This sketch of the Alpha Centauri system from the study uses a blue dot for the modelled exoplanet. The orbital plane of the stars Alpha Centauri A and B is inclined by about $80^?$ with respect to the observer on Earth. In this sketch, the line of nodes of the planet's orbit was chosen to coincide with that of the stellar orbits. The inclination angle i_m of the planet's orbit with respect to the stellar orbital plane is $45^?$, and the inclination angle of the planet's orbit with respect to the observer is $80^? ? 45^? = 35^?$. The phase angles of the planet in this sketch would range from $90^? ? 35^? = 55^?$ to $90^? + 35^? =$

125?. Image Credit: Mahapatra et al. 2023.
So what did they find?
“The degree of polarization of the reflected starlight shows larger variations with the planetary phase angle and wavelength than the total flux,” they write. In visible light, the largest degree of polarization is for Earth-like atmospheres containing water vapour clouds. That’s partly because of Rayleigh scattering.
At NIR wavelengths, “a Venus-like CO2 atmosphere and thin water clouds shows the most prominent polarization features due to Rayleigh-like scattering by the small cloud droplets,” the authors write.



This figure from the research shows some of the results. The top panel is earliest Venus atmosphere, and the bottom panel is the current Venus atmosphere. Overall, the results show that early Venus shows more polarization than modern Venus. The types of atmospheric particles and their sizes work with phase angle to determine the degree of polarization. Image Credit: Mahapatra et al. 2023.
A problem astronomers face when studying exoplanet atmospheres is that they can’t control the phase angle of their observations. The orientation of a planet’s orbit determines that, and it changes over time. To account for that, the researchers combined all their modelling data into one image that shows which planetary models have the largest absolute degree of polarization.



Top: The planet models that yield the largest absolute degree of polarization over all phase angles and wavelengths: Phase 1 -‘ Current Earth’ (blue); Phase 2 -‘ Thin clouds Venus’ (light orange); Phase 3 ‘ Thick clouds Venus’ (dark orange); and Phase 4 -‘ Current Venus’ (brown). Bottom: The maximum values of degree of polarization of the four model planets. Image Credit: Mahapatra et al. 2023.
The researchers have modelled Venus in four evolutionary stages and shown how the polarity changes with atmospheric composition, particle size, and phase angle. So it seems that polarimetry can play a larger role in exoplanet studies. It’s already an important tool in astronomy and is used to study black holes, planet-forming disks around stars, hidden galactic nuclei, and other astronomical objects.
Astronomers have a lot of polarimeters at their disposal. The SPHERE instrument on the VLT and the HARPS instrument at La Silla both have polarimeters, as do many other telescopes. The problem is, while we can model polarity changes in exoplanets, that doesn’t mean they’re so prominent that we can detect them from a great distance.
“Current polarimeters appear to be incapable to distinguish between the possible evolutionary phases of spatially unresolved terrestrial exo-planets,” the authors write. Our current polarimeters aren’t up to the task. “A telescope/instrument capable of achieving planet-star contrasts lower than 10?9 should be able to observe the large variation of the planet’s resolved degree of polarization as a function of its phase angle and thus be able to discern an exo-Earth from an exo-Venus based on its clouds’ unique polarization signatures.
Polarimetry is becoming a more powerful tool in astronomy. The upcoming ELT will be the world’s most powerful optical light telescope for the foreseeable future. Its powerful EPICS instrument might be able to do the job, and so will future space telescopes. “Further, instruments such as EPICS on ELT and concepts for instruments on future space observatories such as HabEx and LUVOIR hold the promise for attaining contrasts of about 10?10,” the authors write.
The Thirty Meter Telescope’s proposed Planetary Systems

Imager could also do the job. But it's a second-generation instrument and won't be available at first light.

Artist's impression of the top view of the proposed Thirty Meter Telescope complex. Image Credit: tmt.org

Even though current polarimetric instruments might not be powerful enough yet, the authors believe that polarimetry will be able to tell the difference between truly Earth-like planets and Venus-like planets. We just need polarimeters with extreme contrasts.

"Reaching such extreme contrasts would make it possible to directly detect terrestrial-type planets and to use polarimetry to differentiate between exo-Earths and exo-Venuses."

It's probably only a matter of time.

The Historic Discussion of Ptolemy's Star Catalog

From the time of its writing in the 2nd century CE, Claudius Ptolemy's *Almagest* stood at the forefront of mathematical astronomy for nearly 1,500 years. This work included a catalog of 1,025 stars, listing their coordinates (in ecliptic longitude and latitude) and brightnesses. While astronomers within a few centuries realized that the models for the sun, moon, and planets all had issues (which we today recognize as being a result of them being incorrect, geocentric models relying on circles and epicycles instead of a heliocentric model with elliptical orbits), the catalog of stars was generally believed to be correct.

That was, until the end of the 16th century, when the renowned observation astronomer Tycho Brahe realized that there was a fundamental flaw with the catalog: the ecliptic longitudes were low by an average of 1 degree.

What's more, Brahe proposed an explanation for why. He suggested that Ptolemy had stolen the data from the astronomer Hipparchus some 250 years earlier, and then incorrectly updated the coordinates.

The question of whether this was a cosmic coincidence or the oldest case of scientific plagiarism is a question that historians of astronomy have argued for over 400 years.

The Accusation

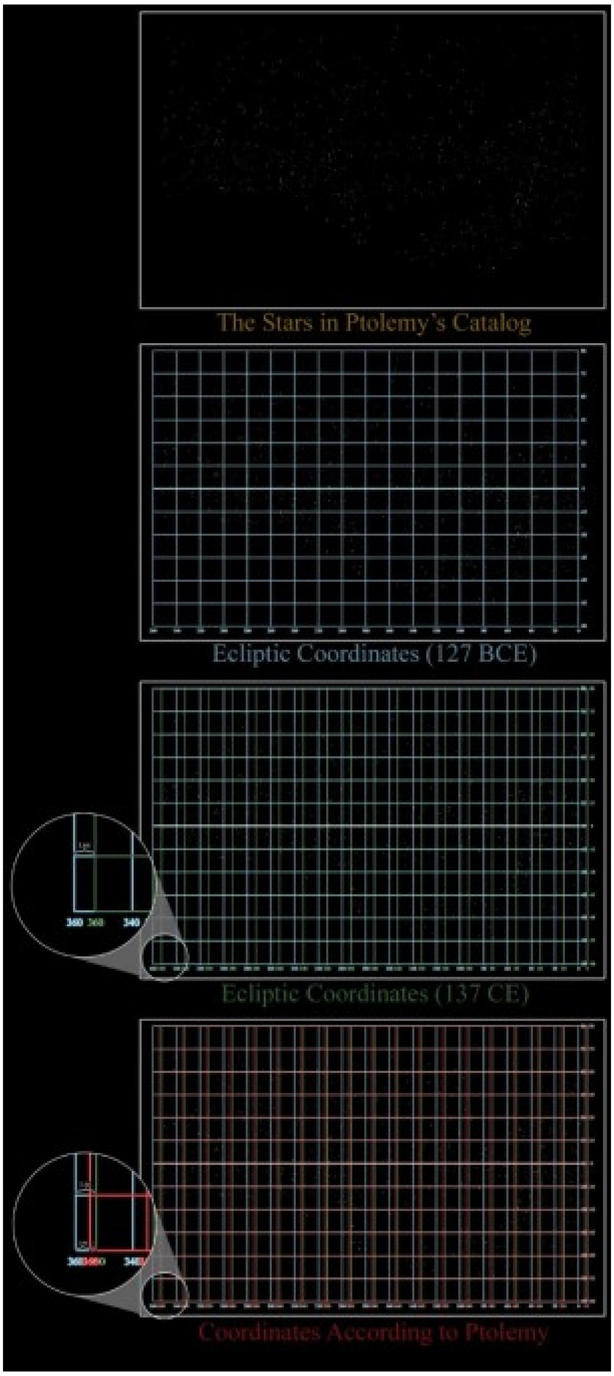
To understand why Brahe made this accusation, we must first understand the favored coordinate system of astronomers at the time: the ecliptic coordinate system.

In general, this system functions exactly like coordinates on earth, with a longitude and latitude. The difference is these are applied to the celestial sphere with the sun's path (the ecliptic) replacing the equator, and the position of the sun on the vernal equinox replacing Greenwich.

However, a phenomenon known as the precession of the equinoxes means that the position of the vernal equinox drifts slowly west, dragging the entire coordinate system with it. It does this at a rate of 1 degree every 72 years, or roughly 0.014 degrees per year.

In the Almagest, Ptolemy gives the time between Hipparchus and the year for which his star catalog was created as 265 years. In that amount of time, the coordinate system would have drifted by about 3 2/3 degrees.

However, Ptolemy had an incorrect value for the rate of precession. He estimated it at 1 degree per century. So by his estimation, the coordinate system would have only moved 2 2/3 degrees, leaving it short by exactly the amount by which Brahe discovered them to be. To astronomers of the time, this seemed to condemn Ptolemy as the observer for the catalog within the Almagest.



A depiction of the stars from Ptolemy's star catalog, with the actual placement of the ecliptic coordinate system for 127 BCE (Hipparchus), 137 CE (Ptolemy) and where Ptolemy claimed it was.

The Hipparchan Catalog

Before we get any further, it is a fair question to ask whether there is any evidence that Hipparchus had a star catalog which Ptolemy could have used. And indeed there is.

Pliny the Elder, circa 1st C. CE, records that Hipparchus did indeed create a star catalog because he had witnessed the birth of a new star, which was thought to be impossible. In response, Hipparchus allegedly set out to create a catalog of stars against which future astronomers could compare to determine how the heavens changed.

But if Hipparchus did have a catalog, why did historians have no other record of it? The answer is the *Almagest* itself. Ptolemy's work was so comprehensive that astronomers were no longer inclined to commission the tedious copying of other works. The *Almagest* was all they needed. Most prior astronomical works have been lost to time.

Indeed, the only surviving work of Hipparchus is a commentary he wrote criticizing two other natural philosophers, Aratus and Eudoxus.

Counting Stars

Towards the end of the 19th C., many historians were invigorated by the discovery and subsequent reinterpretation of medieval and ancient astrological manuscripts.

In 1892, Ernst Maas was put in charge of editing a codex from the 18th C. and discovered it contained a list of constellations. Based on the use of language, the text was attributed to Hipparchus, further supporting the notion that he may have had a star catalog.

Shortly thereafter, two more texts were discovered. The first was by Alessandro Olivieri in 1898 and the second by Franz Boll in 1901. These were also attributed to Hipparchus and, in addition to the names of the constellations, they also contained a count of stars in each constellation. However, the number of stars given was inconsistent with the number that Ptolemy provides in the *Almagest*. If these texts summarized a lost Hipparchan catalog, it would indicate that Ptolemy must have observed at least some of the stars in his catalog. But this did not free Ptolemy from the accusation that he stole some, if not most, of the data.

Dreyer's 1/4 Degree Stars

One of the oddities in Ptolemy's catalog surrounds the precision to which the coordinates are given. For the majority of stars, these seem to be given in increments of 1/6 of a degree. However, for a subset of stars, we find that they are given to a precision of 1/4 of a degree.

In 1917, the astronomer John Dreyer published a paper highlighting this fact and suggesting that this may be indicative of two instruments or two observers.

Statistical tests were done on this hypothesis by Gerd Grasshoff in his 1990 book *The History of Ptolemy's Star Catalogue*. There, he compared the error in the positions of each star as compared to their true positions as calculated by modern astronomical means. He separated the stars with 1/4 and 1/6 degree accuracy and examined the distributions of errors of each.

A notably different distribution would support Dreyer's hypothesis, but Grasshoff found that they were virtually indistinguishable making the test inconclusive.

Here Comes the Sun

One of the largest challenges to Brahe's assertion came from the famous French mathematician Pierre-Simon Laplace. Examining Ptolemy's work, he noticed that there was a minute error in the value Ptolemy used for the length of a year. It was *slightly* too long – by about 6.5 minutes (a 0.0012% error).

This becomes important because Ptolemy's solar model is, in fact, Hipparchus' solar model. While Ptolemy checked Hipparchus' values, he found them to be accurate and thus made no changes. Thus, the date for which the solar model was calibrated was actually during the epoch of Hipparchus.

If the error in the length of the year is compounded over the 265 years between the two astronomers, it results in the sun's average position lagging behind where it should have been by roughly 1 degree in the time of Ptolemy.

This matters because to determine the position of a star, historical astronomers would first have to determine the position of an object with known coordinates and measure from there.

For historic astronomers, this meant calculating the position of the sun (which would then be "known") and then observing the difference between the position of the sun just as it set, and the position of a bright star that was visible in the fading daylight. That star could then be used as a reference point from which to measure other stars. But ultimately, any error in the solar position would be imprinted on the coordinates of the stars.

Further evidence for this explanation is given in by Grasshoff. The Greeks knew that the sun's apparent motion sped up and slowed down throughout the year. Today, we recognize this as being due to our elliptical orbit but Ptolemy modeled it by placing the sphere on which the sun traveled slightly off of the earth. When the sun was closer, it would appear to move faster and vice-versa when it was further. However, this period motion would also be captured in the solar model and would affect the average error Laplace described by similarly increasing and decreasing the error throughout the year.

Grasshoff examined the error in the stellar positions as a function of ecliptic longitude and found that they had a sinusoidal pattern that matched the one from the solar model. Thus, the error in the solar model was an entirely plausible explanation for the discrepancy.

However, it did not fully absolve Ptolemy because the very same pattern would have been present if Hipparchus had been the original observer, but without the 1 degree error since the solar model was calibrated for his time.

Proper Motions

An interesting method to determine the era the star catalog was created involved the positions of the stars relative to one another. Although ancient astronomers believed the positions of the stars were fixed, they do move very slowly – a phenomenon known as proper motion.

In the late 1980's the astronomers Efremov and Pavlovskaya attempted to use this to date the star catalog. Their method was to consider the fastest moving stars in the catalog and determine what year the position of these fast moving stars were best described relative to the other stars in the same constellation.

Initially, they had trouble as the year varied wildly depending on which other stars they included to compare against. However, in 2000, Efremov and Dambis published a second paper claiming success and dating the star catalog to the era of Hipparchus.

This conclusion was swiftly rejected by Dennis Duke from the University of Florida who noted that the amount of proper motion over the 265 years between Hipparchus and Ptolemy was below the 1/6 degree precision for nearly every star. Only three stars moved more than 1/6 of a degree in that time period.

While Dambris and Efremov claimed to have sufficiently accounted for the inherent uncertainty from the instrumentation, Duke refuted this stating that, when properly accounted for, this method would not be able to distinguish between the era of Hipparchus and Ptolemy at all.

Recovering Hipparchus

With all of the tests that astronomers devised unable to answer the question, what would really be needed was a copy of Hipparchus' lost catalog. Sadly, the only text historians had available was the *Aratus Commentary*. This text was Hipparchus' response to a poem by Aratus entitled *The Phaenomena*, in which Aratus attempted to describe the stars that were rising, setting, or culminating (i.e., at their highest point) at the same time that other stars or points on the ecliptic were also rising, setting, or culminating.

Hipparchus criticized Aratus' descriptions and, first corrected them for the latitude of Aratus, and then provided pairings for his own longitude of Athens in an appendix.

Starting in the early 1900's, historians considered that, if these pairings had been calculated based on the lost Hipparchan catalog, it might be possible to reverse-calculate the coordinates from the catalog.

In 1925 Heinrich Vogt claimed to have successfully recovered the coordinates of 122 stars without "auxiliary hypotheses." Vogt first compared the positions for these stars to the ones given by Ptolemy. If the coordinates were the same, with the exception of a 2 2/3 offset, then it would support the hypothesis that Ptolemy used Hipparchus' data.

Vogt found that, by and large, the coordinates did not match. He went further, by comparing the error against the modern calculated position for both Hipparchus and Ptolemy and analyzed the distribution of errors. Again, he found that they were notably different. Only for a handful of stars did Vogt find that the coordinates for both the *Almagest* (after accounting for the 1 degree error) and the recovered Hipparchan catalog were off by similar amounts in the same direction. Theta Eridani, for example, was off by more than three degrees from its true position in both catalogs, again indicating that Ptolemy used at least some of Hipparchus' data.

However, Vogt's findings were not free from criticism. When Grasshoff reviewed Vogt's analysis, he questioned many of the underlying assumptions Vogt used. In particular, historians have recognized that different portions of the *Aratus Commentary* were written at different times during Hipparchus' life.

While Vogt says he accounted for this, he is unclear on which calculations were for which era. Similarly, the two portions of the text were given for different latitudes. Vogt's methods only ever mention Aratus' latitude raising doubt over whether or not he accounted for this at all.

Perhaps worst, some stars are given as part of multiple pairings allowing for their positions to be calculated in multiple ways. If the assumptions and methodology are sound they should match, but often they did not.

The combined result of these potential errors is that the coordinates in Vogt's reconstructed Hipparchan catalog could have been scrambled, making them not match when indeed they should have. And unfortunately, due to the unresolved questions about when various portions were written, it seemed unlikely this approach could ever be successful.

The *Phaenomena* of Ptolemy

But if attempts to reconstruct Hipparchus' catalog from the *Aratus Commentary* were unlikely to work, what would happen if we went the other way around, recreating the rising/setting/culminating descriptions of the *Aratus Commentary* using the data from the *Almagest*? This would remove the questionable assumptions in converting the phenomena described in the *Aratus Commentary* to standardized coordinates.

Grasshoff performed exactly these calculations and compared the phenomena described in the *Aratus Commentary* to what should be expected using modern astronomical theory to determine the error in the description for each star. He then did the same for the ones calculated from the *Almagest*. The error for each could then be plotted against one another. If both had the same, large error, it would be a strong indication of common origin.

When he did so, Grasshoff found that there were, indeed, a number of stars that showed a strong correlation in their errors (including Theta Eridani and three other stars that Vogt had also flagged as suspicious).

However, there were some that had notably *different* errors. This view supports the hypothesis that Ptolemy's catalog was only partially based on Hipparchus'.

Aratus Latinus

In the 8th C., this same *Aratus Commentary* had grown popular among scholars studying astronomy and it was translated into Latin. These texts became known collectively as *Aratus Latinus*. To supplement the work, they were often compiled with additional astronomical material. Among the works that became included in some, were passages containing descriptions of the boundaries of three constellations (Ursa Major, Ursa Minor, and Draco) by giving the distances of the bounding stars from the north celestial pole and their ecliptic longitude.

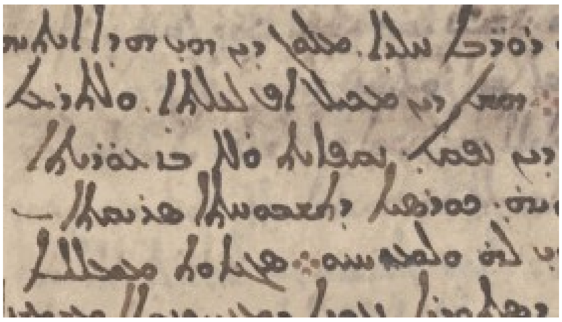
While these portions were originally attributed to Aratus, in the late 19th C., historians realized their descriptions and language better matched those of Hipparchus. It was further realized that the coordinates for Polaris exactly matched the value Hipparchus used according to Ptolemy in another of his works, *Geographia*.

Thus, historians now accept Hipparchus as the author of these portions, and these passages offered another way to recover the positions of some stars from the Hipparchan catalog.

Codex Climaci Rescriptus

In 2012, biblical scholar Peter Williams, gave his students several pages from a text found at a Greek Orthodox monastery in Egypt. These pages contained Christian texts, but were known to have been scraped clean before the Christian text was added, removing a previous text (a phenomenon known as palimpsest).

The students imaged the pages under numerous colors of light and used computer algorithms to attempt to recover the latent text beginning in 2017. They quickly realized that the texts were astronomical, containing star-origin mythos from Eratosthenes, but also segments of the *Aratus Latinus* and associated works. Among those associated works was the Hipparchan work, but this time included a new constellation: Corona Borealis.



How multispectral imaging reveals text. Credit: Museum of the Bible CC BY-SA 4.0

The researchers examined the coordinates for the stars of all four constellations and compared them with those of Ptolemy. The team found that they did not match. What's more, they compared the distribution of errors and found that Hipparchus' catalog was likely more accurate based on the limited selection of stars available.

Conclusions

When reviewing the 400+ year debate over the origin of Ptolemy's star catalog, the historian Noel Swerdlow remarked, "I am only too happy that I have never written anything on the subject myself that I might wish to defend."

Here, Swerdlow summarizes the ferocity of the debate on this subject, noting that there are convincing arguments in both directions. The startlingly similar errors for stars in both Ptolemy's catalog as in the *Aratus Commentary* seem to indicate that some data was most likely taken. But the independence of other stars in the *Aratus Latinus* collections suggests that much was not.

Thus, the general consensus among historians seems to be crystalizing around the notion that there is almost certainly a portion of the *Almagest*'s star catalog that is based on *Hipparchus*' data. In response, historians have been asking: How much?

Estimates have ranged wildly. Swerdlow concludes that the amount of overlap should be no more than 10%. Duke confidently declares it to be over 80%, and more likely over 90%.

But while this debate has raged for over four centuries, Swerdlow considers the question of whether it has been worth it:

"The labour and ingenuity that have been spent on this

question must far exceed the labour spent by Ptolemy in compiling the catalogue in the first place, however he may have done it, and perhaps it is time for a moratorium on the subject on the ground that life is too short to waste on questions that cannot be answered."
A more thorough discussion of each of the arguments here and more is available in Jon's blog.

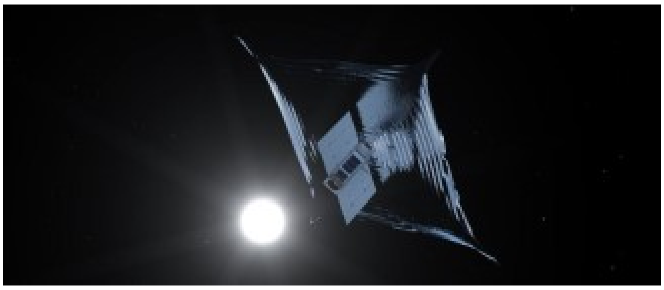
The First Stars May Have Weighed More Than 100,000 Suns

The universe was simply different when it was younger. Recently astronomers have discovered that complex physics in the young cosmos may have led to the development of supermassive stars, each one weighing up to 100,000 times the mass of the Sun.
We currently have no observations of the formation of the first stars in the universe, which is thought to have taken place when our cosmos was only a few hundred million years old. To understand this important epoch, astronomers turn to sophisticated computer simulations to test out models of how the first stars formed.
Over the years astronomers have wrestled with the key question of what is the typical size of the first stars. Some early estimates predicted that the first stars could be hundreds of times more massive than the Sun, while later simulation suggested that they would be more normally sized.
Recently a team of researchers have put together a new round of simulations and come to a very surprising conclusion. Their simulations specifically looked at a phenomenon known as cold accretion. To build large stars you have to pull a lot of material into a very small volume very quickly. And you have to do it without raising the temperature of the material, because warmer material will prevent itself from collapsing. So you need some method of removing heat from material as it collapses very quickly.

Earlier simulations had found the appearance of dense pockets within early galaxies that cool off rapidly from emitting radiation, but did not have the resolution needed to follow their further evolution. The new research takes it a step further by examining how the cold dense pockets that initially form in the early universe behave.
This simulations revealed that large flows of cold, dense matter can strike an accretion disk at the center of giant clumps of matter. When that happens a shockwave forms. That shockwave rapidly destabilizes the gas and triggers the instant collapse of large pockets of matter.
Those large pockets can be tens of thousands times more massive than the Sun, and in some cases even 100,000 times more massive than the Sun. With nothing to stop their collapse, they immediately form gigantic stars, known as supermassive stars.
The astronomers do not yet know if supermassive stars formed in the early universe. They hope that future observations with the James Webb Space Telescope will reveal clues as to the formation of the first stars and galaxies and determine if these monsters appeared in the infant universe.

Drag Sail Success! This Satellite Won't Turn Into Space Junk

The European Space Agency successfully tested a solar-sail-type device to speed up the deorbit time for a used cubesat carrier in Earth orbit. The so-called breaking sail, the Drag **A**ugmentation **Deo**rbiting System (ADEO) was deployed from an ION satellite carrier in late December 2022. Engineers estimate the sail will reduce the time it takes for the carrier to reenter Earth's atmosphere from 4-5 years to approximately 15 months.
The sail is one of many ideas and efforts to reduce space junk in Earth orbit.
"We want to establish a zero debris policy, which means if you bring a spacecraft into orbit you have to remove it," said Josef Aschbacher, ESA Director General.
Last year, China successfully deployed a similar sail from a Long March 2 rocket.
ESA says the sail provides a passive method of deorbiting by increasing the atmospheric surface drag effect and causing an accelerated decay in the satellite's orbital altitude. "The satellite will eventually burn-up in the atmosphere, providing a quicker, residue-free method of disposal."
This test was the final in-flight qualification flight needed to provide the technological proof-of-concept. A smaller 2.5 square meter sail was fitted onto the upper stage of the Electron launch vehicle in 2018. Previously, the ADEO sail was tested on several parabolic flights from 2019 to 2022. This larger orbital version was deployed from the Italian space company D-ORBIT's ION Satellite Carrier, which carries and deploys cubesats and weighs 160 kg (350 lb).



Artist impression of the Drag Augmentation Deorbiting System (ADEO) breaking sail. Credit: ESA

The sail membrane has a surface area of 3.6 square meters and is made of an aluminum-coated polyamide. It was packed inside an impressively small container, 10 x 10 x 10 cm. ESA says the sail's size can be scaled up for medium and large size satellites, or multiple sails can be used on larger pieces such as an upper rocket stage. Various sizes could be tailor-made, depending on the initial orbit, satellite mass and required de-orbiting time. The largest variation could be as large as 100 square meters, which could take up to 45 mins to deploy. The smallest sail available is just 3.5 square meters and deploy in just 0.8 seconds.
For the orbital test, cameras on ION captured the deployment of ADEO. ESA determined the satellite carrier immediately slowed to begin its deorbit process.

Astronomers Come Closer to Understanding How Mercury Formed

Simulations of the formation of the solar system have been largely successful. They are able to replicate the positions of all the major planets along with their orbital parameters. But current simulations have an extreme amount of difficulty getting the masses of the four terrestrial planets right, especially Mercury. A new study suggests that we need to pay more attention to the giant planets in order to understand the evolution of the smaller ones.
Of all the rocky inner planets of the solar system, Mercury is the strangest. Not only does it have the lowest mass, but compared to its size it has the biggest core. This presents a major challenge for planet formation simulations, because it's difficult to build such a large core without growing a proportionally larger planet along with it.
A team of astronomers recently investigated several possibilities to explain Mercury's strange properties by performing simulations of the formation of the solar system.
In the earliest days of the solar system, instead of a neat series of planets we instead had a protoplanetary disk made of gas and dust. Embedded in that disk were dozens of planetesimals which would eventually collide and merge and grow to become planets.

Astronomers believe that the inner edge of the protoplanetary disc was probably relatively lacking in material. Also in that young system the giant planets did not appear in their present day orbits. Instead they migrated from where they initially formed to their current positions. As those giant planets moved they destabilized the inner disk, potentially removing even more material.
Putting these ideas together, the astronomers were able to build a formation history of Mercury. Originally the inner protoplanetary disk contained a lot of planetesimals, but as the giant planets moved and migrated they pulled away a lot of the planet-building material with them. The remaining planetesimals collided together in a series of frequent collisions, which resulted in a lot of heavy metals being dumped into the innermost planet, creating the large core of Mercury.
While the models were able to capture the core size of Mercury, the simulations still couldn't get the overall mass of the planet right. The simulations generally produced a Mercury that was two to four times more massive than it really is.
It remains an open question as to how Mercury came to be. The astronomers suspect we need to pay more careful consideration to the chemical properties of the protoplanetary disk, especially focusing on how dust grains can stick together and survive the intense radiation environment at Mercury's orbit.

Don't Bother Trying to Destroy Rubble Pile Asteroids

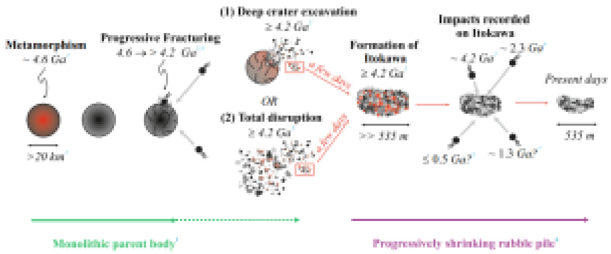
The asteroids in our Solar System are survivors. They've withstood billions of years of collisions. The surviving asteroids are divided into two groups: monolithic asteroids, which are intact chunks of planetesimals, and rubble piles, which are made of up fragments of shattered primordial asteroids.
It turns out there are far more rubble pile asteroids than we thought, and that raises the difficulty of protecting Earth from asteroid strikes.
The early days of planetary formation were marked by endless collisions that shattered countless planetesimals. The fragments populate the main asteroid belt and other regions in the inner Solar System. But some of those fragments reassembled into rubble pile asteroids, and surprisingly, they're more resistant to collisions and harder to destroy than their monolithic brethren.
Rubble-pile asteroids are detectable by their density, which is much lower than monolithic asteroids. Peanut-shaped Itokawa was the first confirmed rubble-pile asteroid, and astronomers think the well-known asteroids Bennu and Ryugu are both rubble-pile asteroids, too. When the Japanese spacecraft Hayabusa visited Itokawa in 2005, images showed that its surface was free of impact craters, a dead giveaway that it was a loose collection of rubble since a monolithic asteroid would most certainly show signs of impacts.
Hayabusa brought home some samples from Itokawa, and a new research article in the Proceedings of the National Academy of Sciences is based on those samples. The article is "Rubble pile asteroids are forever," and the lead author is Professor Fred Jourdan from the School of Earth and Planetary Sciences at Curtin University.
Itokawa is only about 500 meters long and is about 2 million km (1.2 million miles) from Earth. Hayabusa collected 1500 tiny grains of rock from the asteroid, and they were returned to Earth in June 2010. This research article is based on the study of three of those particles, and thanks to advanced analytical technologies, those three particles revealed a lot.
Scientists think that monolithic asteroids have a lifespan of a few hundred million years. For asteroids in the main belt, it's even shorter: a few hundred thousand years. There are so many opportunities for collisions in the main belt that few are likely to remain unscathed. But rubble piles aren't as brittle and can last much longer.
"Unlike monolithic asteroids, Itokawa is not a single lump of rock but belongs to the rubble pile family, which means it's entirely made of loose boulders and rocks, with almost half of it being empty space," Professor Jourdan said.

This image from JAXA's Hayabusa spacecraft shows a boulder on Itokawa's surface. Hayabusa's images were the first to show the existence of rubble pile asteroids. JAXA scientists wrote: "This is a very important clue to studying the asteroid's formation history. It is safe to assume that a larger celestial body originally existed before Itokawa. And on its destruction, a fragment from it became Itokawa as other finer fragments piled on the asteroid surface." Image Credit: JAXA
While monolithic asteroids can be shattered by collisions, rubble piles are more elastic and can more easily absorb kinetic energy. An impact can alter a rubble pile's shape without shattering it. The new research shows that Itokawa is extremely ancient—more than four billion years old. It wouldn't have survived this long unless it was a rubble pile.
"The survival time of monolithic asteroids the size of Itokawa is predicted to be only several hundreds of thousands of years in the asteroid belt," Jourdan said. "The huge impact that destroyed Itokawa's monolithic parent asteroid and formed Itokawa happened at least 4.2 billion years ago. Such an astonishingly long survival time for an asteroid the size of Itokawa is attributed to the shock-absorbent nature of rubble pile material."
"In short, we found that Itokawa is like a giant space cushion and very hard to destroy."
"Hence, such asteroids represent a major threat to Earth, and we really need to understand them better."

Fred Jourdan, lead author, School of Earth and Planetary Sciences at Curtin University.
One of the methods the researchers used to study the three Itokawa fragments is called Electron Backscattered Diffraction. It uses an electron microscope to study the crystallographic structure and orientation of the rocks. It can detect misalignment in the crystal structure that results from heat and shocks. Along with other analytical techniques, the analysis showed that the three fragments were "initially located deep in the monolithic parent asteroid," the paper states.
Deep inside the asteroid, they were protected from all the bombardment and shock heating in the Solar System's early, chaotic era. These particles were from the surface of Itokawa, and if they'd been there since the early days, they would've shown evidence of shock and heating. Collisions are far too plentiful for an asteroid to avoid them.

The particles show evidence of only weak shocks and heating. "In order to be affected or subsequently affectable by impact-related thermal events at ~4.2 Ga, the particles would need to be brought near the surface, either by total disruption of the parent body or by deep crater excavations," the authors explain in their paper.

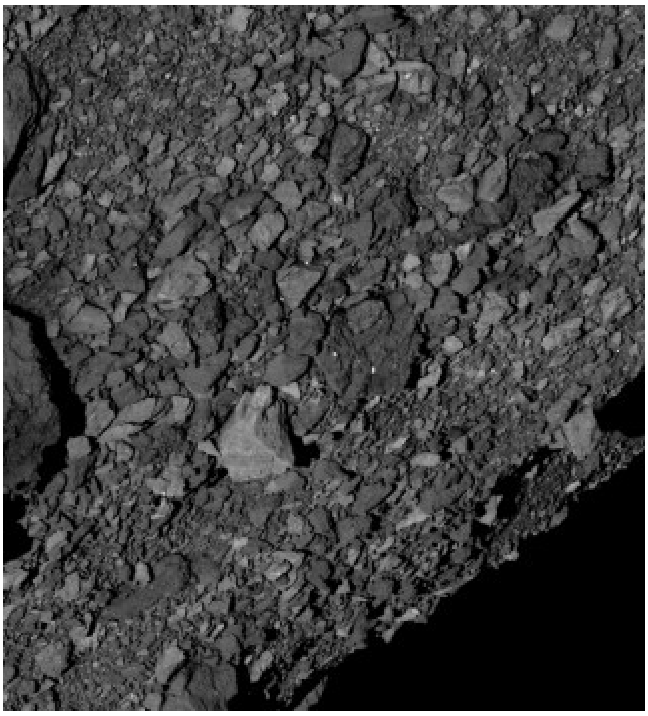
The research explains Itokawa's history. 4.6 billion years ago, a monolithic asteroid formed that was Itokaway's parent body. Between 4.6 and 4.2 billion years ago, successive impacts created progressive fracturing. Then 4.2 billion years ago, one of two things happened. Either an impact excavated a deep crater, or else it totally destroyed the asteroid. In a very short period of time, the debris reformed into Itokawa. Throughout its history since then, Itokawa's suffered many impacts, but the asteroid's rubble-pile nature allowed it to absorb those impacts without being cratered or destroyed.



This figure from the study explains Itokawa's history. Image Credit: Jourdan *et al.* 2023.

"Argon dating reveals the age of the particles as about 4.2 billion years. "Such a long survival time for an asteroid is attributed to the shock-absorbent nature of rubble pile material and suggests that rubble piles are hard to destroy once they are created," the authors write.

The results apply to more than only Itokawa. If they're so much harder to destroy, then there's likely a much higher population of rubble-pile asteroids than thought. We know that Bennu, Ryugu, and others are rubble-pile asteroids. That has implications for our ability to defend Earth from asteroid strikes.



This image shows Bennu's boulder-strewn surface. When NASA's OSIRIS-REx collected samples, the sampling arm sank much deeper into the asteroid than expected, indicating that it's a rubble-pile asteroid. Image Credit: NASA/University of Arizona.

"We set out to answer whether rubble pile asteroids are resistant to being shocked or whether they fragment at the slightest knock," Associate Professor and co-author Nicholas Timms said. "Now that we have found they can survive in the solar system for almost its entire history, they must be more abundant in the asteroid belt than previously thought, so there is more chance that if a big asteroid is hurtling toward Earth, it will be a rubble pile."

In an article in *The Conversation*, Jourdan emphasized the threat they pose. "In fact, they are very abundant, and since they are the shattered bits of monolithic asteroids, they are relatively small and thus hard to spot from Earth," he writes. "Hence, such asteroids represent a major threat to Earth, and we really need to understand them better."

The risk for us is that these asteroids can absorb a lot of kinetic energy. That means that kinetic impactors like in NASA's DART mission might not effectively direct them away from Earth. "Here, we showed that small rubble pile asteroids can survive billions of years against the ambient bombardment in the inner solar system due to their resistance to collisions and fragmentations. Therefore, more aggressive approaches (e.g., nuclear blast deflection) might have a higher chance of success against rubble pile asteroids," the authors write in their paper.

The Outer Solar System Supplied a Surprising Amount of Earth's Water

In a recent study published in *Science*, a team of researchers at Imperial College London examined 18 meteorites containing the volatile element zinc to help determine their origin, as it has been long hypothesized that Earth's volatiles materials, including water, were derived from asteroids closer to our home planet. However, their results potentially indicate a much different origin story.

"Our data show that about half of Earth's zinc inventory was delivered by material from the outer Solar System, beyond the orbit of Jupiter," Dr. Mark Rehkämper, a professor in the Department of Earth Science and Engineering at Imperial, and a co-author on the study, said in a statement. "Based on current models of early Solar System development, this was completely unexpected."

Approximately 4.5 billions years ago, our solar system formed from the collapsed cloud of interstellar gas and dust, whose collapse has been hypothesized to come from the supernova explosion of a nearby star. Upon its collapse, the cloud formed a swirling and spinning disk of material, a solar nebula. Over time, the gravity and pressure at the center of the nebula eventually forced hydrogen and helium atoms to fuse, which birthed our Sun. The remaining material in the nebula formed the planets and moons we see today, with the rocky planets comprising the inner part and the much larger gas planets forming in the outer parts.

Since the Earth formed in this inner part of the nebula, the long-standing hypothesis has been the majority of the Earth-forming materials also came from the inner portion, as well, so this most recent research could help reshape our understanding of both the formation and evolution of our own solar system.

"This contribution of outer Solar System material played a vital role in establishing the Earth's inventory of volatile chemicals.," Dr. Rehkämper said in a statement. "It looks as though without the contribution of outer Solar System material, the Earth would have a much lower amount of volatiles than we know it today – making it drier and potentially unable to nourish and sustain life."

For the study, the researchers examined 18 meteorites that originated from a variety of locales through our solar system, with 11 of the 18 coming from the inner solar system, and are known as non-carbonaceous meteorites. The remaining 7 of the 18 coming from the outer solar system and are known as carbonaceous meteorites.

The researchers discovered that while carbonaceous bodies accounted for only about 10 percent of Earth's entire mass, this same material is responsible for about 50 percent of Earth's zinc supply. The researchers say the high amount of zinc, along with other volatiles, could also contain a high amount of water, which could provide clues about the Earth's water supply, as well.

“We’ve long known that some carbonaceous material was added to the Earth, but our findings suggest that this material played a key role in establishing our budget of volatile elements, some of which are essential for life to flourish,” Rayssa Martins, who is a PhD Candidate in the Department of Earth Science and Engineering, and lead author of the study, said in a statement.

For next steps in their research, the team will examine Martian meteorites, for which there are currently five known on Earth, along with Moon rocks, with the Red Planet being of interest since it once possessed liquid water billions of years ago.

“The widely held theory is that the Moon formed when a huge asteroid smashed into an embryonic Earth about 4.5 billion years ago,” Dr. Rehkämper said in a statement. “Analyzing zinc isotopes in moon rocks will help us to test this hypothesis and determine whether the colliding asteroid played an important part in delivering volatiles, including water, to the Earth.”

As always, keep doing science & keep looking up!

Astronomers See Flashes on the Sun That Could be a Sign of an Upcoming Flare

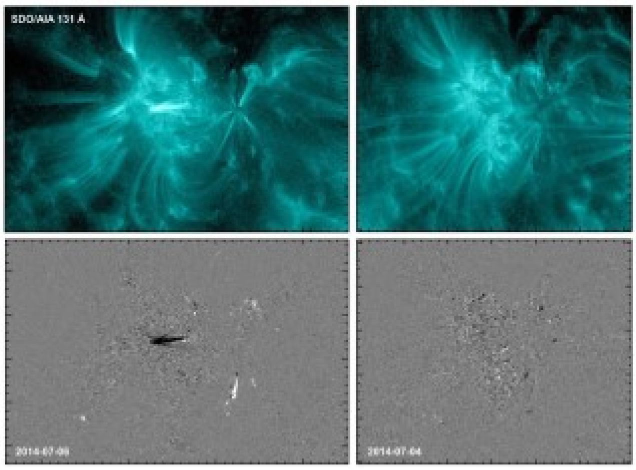
Using data from the Solar Dynamics Observatory, scientists have discovered new clues that could help predict when and where the next solar flare might blast from the Sun.

Researchers were able to identify small flashes in the upper layers of the corona – the Sun’s atmosphere – found above regions that would later flare in energetic bursts of light and particles released from the Sun. The scientists compared the flashes to small sparklers before the big fireworks.

“We can get some very different information in the corona than we get from the photosphere, or ‘surface’ of the Sun,” said KD Leka, lead author on the new study from Nagoya University in Japan, in a NASA press release. “Our results may give us a new marker to distinguish which active regions are likely to flare soon and which will stay quiet over an upcoming period of time.”

Since it launched in 2010, the Solar Dynamics Observatory has helped scientists understand better what causes solar flares. One of the main goals of the mission was to be able to create forecasts for predicting activity on the Sun.

Scientists have previously studied how changes in the Sun’s magnetic field can cause flares, helping them to predict when some flares would occure. Additionally, other teams have modeled how activity in lower layers of the Sun’s atmosphere – such as the photosphere and chromosphere – can indicate impending flare activity in active regions, which are often marked by groups of sunspots. The new findings, published in The Astrophysical Journal, add to that picture.



Two images of a solar active region (NOAA AR 2109) taken by SDO/AIA show extreme-ultraviolet light produced by million-degree-hot coronal gas (top images) on the day before the region flared (left) and the day before it stayed quiet and did not flare (right). The changes in brightness (bottom images) at these two times show different patterns, with patches of intense variation (black & white areas) before the flare (bottom left) and mostly gray (indicating low variability) before the quiet period (bottom right).

Credits: NASA/SDO/AIA/Dissauer et al. 2022

“With this research, we are really starting to dig deeper,” said Karin Dissauer from NorthWest Research Associates, or NWRA, who was instrumental in putting together an image database of the Sun’s active regions captured by SDO for the past eight years. “Down the road, combining all this information from the surface up through the corona should allow forecasters to make better predictions about when and where solar flares will happen.”

The new database makes it easier for scientists to use data from SDO’s Atmospheric Imaging Assembly (AIA) large statistical studies.

“It’s the first time a database like this is readily available for the scientific community, and it will be very useful for studying many topics, not just flare-ready active regions,” Dissauer said.

The NWRA team studied a large sample of active regions from the database, and their analysis revealed there are frequently small, intense brightness changes in the corona before the solar flares. These and other new insights will give researchers a better understanding of the physics taking place in these magnetically active regions, with the goal of developing new tools to predict solar flares.

The team said their methods could eventually help improve predictions of flares and space weather storms. Space weather can affect Earth in many ways: producing auroras, endangering astronauts, disrupting radio communications, and even causing large electrical blackouts.

Europe Will be Building the Transfer Arm for the Mars Sample Return Mission

Now that the Perseverance rover has dropped off ten regolith and rock sample tubes for a future sample return mission to retrieve, the plans for such a mission are coming together.

The mission is a joint venture between NASA and the European Space Agency, and ESA has agreed to build a 2.5-meter-long robotic arm to pick up tubes and then transfer them to a rocket for the first-ever Mars samples to be brought to Earth.

ESA says the Sample Transfer Arm (STA) will likely be autonomous, with a large range of movements and seven degrees of freedom. Cameras and sensors will assist the arm, which will have a hand-like gripper to handle the sample tubes. Perseverance has brought to Mars 43 6-inch-long (15.2 centimeters) titanium tubes.

The entire architecture for the sample return mission is not yet final, but it is surely one of the most ambitious missions ever attempted.

There will likely be a Mars orbiter that will send a lander to the planet’s surface. It will touch down somewhere near the Perseverance rover, and if Perseverance is still functioning and mobile, the rover itself could bring the samples to the lander. If the lander could set down close enough to some of the sample tubes, it might be able to reach them itself, but that seems quite ambitious and risky.

Helicopters, too

With the success of the Ingenuity helicopter – which has now made 40 flights on Mars — NASA has suggested sending along two small helicopters similar to Ingenuity, except the new helicopters would have small robotic arms. The helicopters would go retrieve sample tubes, pick them up with the robotic arms and then bring them to the lander.

ESA says the STA’s autonomous abilities would allow it to “see” the sample tubes, allowing it to either pick up the tubes from the ground (where the rover has now left them in Jezero Crater) or extract the tubes from Perseverance, or perhaps the helicopters.

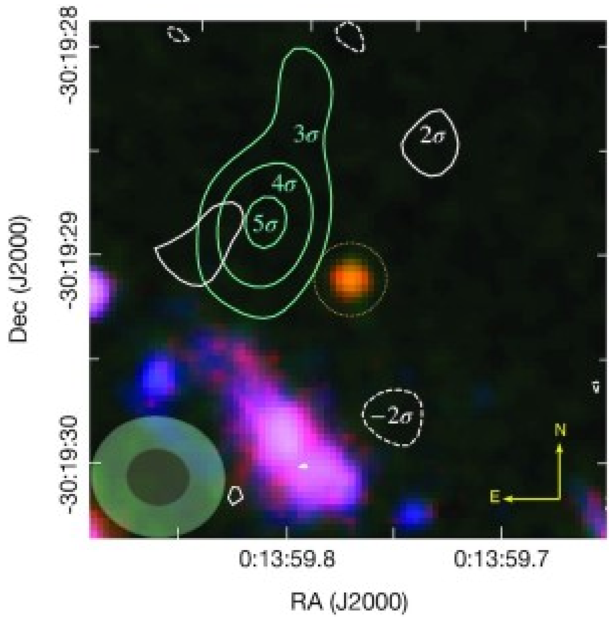
The plan is for a sample return container to blast off with a

small rocket from the surface of Mars and rendezvous with ESA's Earth Return Orbiter (ERO), which will leave orbit and bring the materials back to Earth.
Almost all of this plan has never been done before, so again, this is very ambitious. The goal is for the Martian samples to be back on Earth by 2033.
You can read more about ESA's plans and contributions to the sample return mission at their blog, To Mars and Back.

Astronomers Pin Down the Age of the Most Distant Galaxy: Seen 367 Million Years After the Big Bang

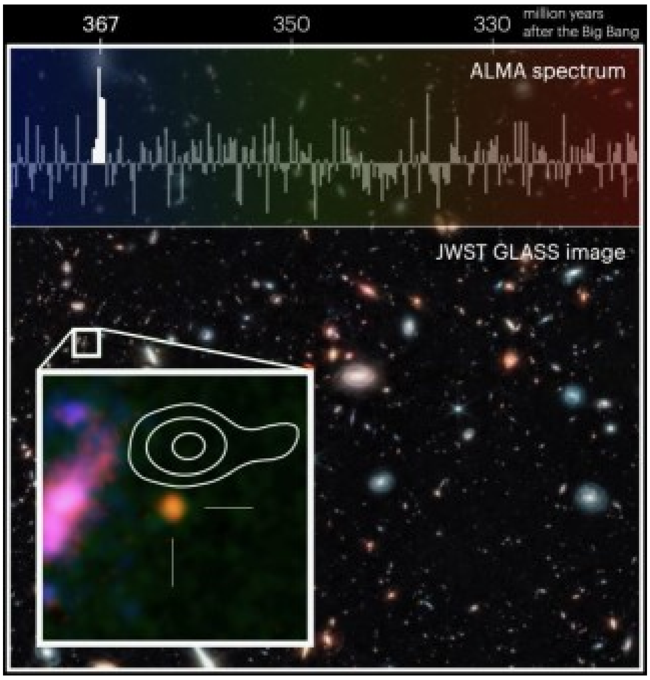
Staring off into the ancient past with a $10 billion space telescope, hoping to find extraordinarily faint signals from the earliest galaxies, might seem like a forlorn task. But it's only forlorn if we don't find any. Now that the James Webb Space Telescope has found those signals, the exercise has moved from forlorn to hopeful.
But only if astronomers can confirm the signals.
The James Webb Space Telescope (JWST) was built to peer back in time and identify the Universe's very first galaxies. Those observations are meant to forge a link between the ancient galaxies and the galaxies we see now, including our own. That link will help astronomers understand how galaxies like ours formed and evolved over billions of years.
The expansion of the Universe stretches the light emitted by ancient objects billions of years ago. The stretching shifts the light toward the red end of the visible light spectrum. The James Webb Space Telescope was built to see this light and identify the ancient galaxies that emitted it.
The telescope's GLASS Survey went to the heart of the issue. It used the galaxy cluster called Pandora's Cluster (Abell 2744) as a gravitational lens to magnify distant galaxies behind it and found 19 bright objects that appear to be early galaxies.

Other early-release science results from the JWST found more objects that appear to be ancient galaxies. Together, these findings are a cornucopia of scientific observations. Astronomers set out decades ago to build the JWST with these findings in mind. But there's a problem: our theories and models of galaxy formation suggest there shouldn't be so many of these earliest galaxies. The JWST's findings needed to be confirmed.
A team of researchers used the ESO's ALMA (Atacama Large Millimetre/sub-millimetre Array) to examine a candidate galaxy from GLASS and to try to confirm it. Their paper is titled "Deep ALMA redshift search of a z ~ 12 GLASS-JWST galaxy candidate," and it was published in the Monthly Notices of the Royal Astronomy Society. The lead author is Tom Bakx of Nagoya University.
Up until now, none of the JWST's candidate ancient galaxies have been confirmed. Until astronomers can confirm them, we're in a bind. In one of his *Starts With A Bang* articles at Big Think, astrophysicist Ethan Siegel made that point eloquently. "If all of these ultra-distant galaxy candidates were real, we'd have too many of them too early, forcing us to rethink how galaxies begin forming within the Universe," Siegel writes. "But we might be fooling ourselves completely, and we won't know for sure with only our current data. There's a tremendous difference between the light that a distant galaxy emits and the light that arrives at our eyes after journeying for billions of light-years across the Universe."
More observations were needed to confirm any of these ancient candidates, and that's what this team of researchers gathered. "The first images of the James Webb Space Telescope revealed so many early galaxies that we felt we had to test its results using the best observatory on Earth," lead author Bakx said in a press release.
They chose a galaxy named GHZ2/GLASS-z12, one of the brightest and most robust candidates at $z > 10$, according to the JWST observations. $z > 10$ means that the light from the galaxy has been travelling for over 13.184 billion years and has travelled a distance of at least 26.596 billion light-years. As Siegel pointed out in his article, a lot can happen to light that travels over 26 billion light-years before reaching us.
"Spectroscopy is needed to confirm the primeval nature of these candidates," the authors write in their paper. It's possible that the light from some of these galaxies is red due to dust rather than distance, and spectroscopy could help differentiate between the two. They turned to ALMA, the world's most expensive ground-based telescope currently operating.
They used it to look for an oxygen line (O III) in the spectroscopy at the same frequency found in the JWST observations. O III is doubly-ionized oxygen, and it's key because oxygen has a short formation time relative to other elements. Focusing on oxygen increased the likelihood of detection. Stars can generate oxygen on a short 50 Myr time scale. Other elements, like carbon, for example, take nearly 500 Myr to appear in a galaxy. This means that oxygen is generally the best redshift indicator, according to the authors, and is likely the brightest emission line in the early Universe.
Could ALMA find it?
ALMA's power didn't disappoint.
"The work of JWST has only just begun, but we are already adjusting our models of how galaxies form in the early Universe to match these observations."
Jorge Zavala, National Astronomical Observatory of Japan.



This figure from the study shows how the oxygen (O III) emission line (green contours) is shifted from the bright source the JWST detected (orange blur inside the yellow dotted line.) Image Credit: Bakx *et al*. 2023.
ALMA's confirmation wasn't instantaneous, though. There was a slight shift in the oxygen signal between the JWST observations and the ALMA observation.
"We were initially concerned about the slight variation in position between the detected oxygen emission line and the galaxy seen by Webb," author Tom Bakx notes, "but we performed detailed tests on the observations to confirm that this really is a robust detection, and it is very difficult to explain through any other interpretation."
The observations do more than confirm the galaxy's age, they also shed light on its metallicity. They show that enough stars had already lived and died by then to enrich the galaxy with elements like oxygen. "The bright line emission indicates that this galaxy has quickly enriched its gas reservoirs with elements heavier than hydrogen and helium. This gives us some clues about the formation and evolution of the first generation of stars and their lifetime," said co-lead author Jorge Zavala of the National Astronomical Observatory of Japan.
The observations hold another tantalizing clue, too. At least

some of the stars that lived and died and populated the galaxy with metals may have exploded as supernovae. “The small separation we see between the oxygen gas and the stars’ emission might also suggest that these early galaxies suffered from violent explosions that blew the gas away from the galaxy centre into the region surrounding the galaxy and even beyond,” added Zavala.



The image of galaxy GHZ2/GLASS-z12 with the associated ALMA spectrum. ALMA’s deep spectroscopic observations revealed a spectral emission line associated with ionized Oxygen near the galaxy, which has been shifted in its observed frequency due to the expansion of the Universe since the line was emitted.
NASA / ESA / CSA / T. Treu, UCLA / NAOJ / T. Bakx, Nagoya U.

Finding the Universe’s earliest galaxies was a prime motivation behind the JWST, and as this study shows, it’s making progress. There are a growing number of candidate early galaxies awaiting confirmation, and if more of them are confirmed, as expected, astronomers will have their work cut out explaining them and updating their models of galaxy formation.

But that’s a good thing, according to Zavala. When scientists are forced to update their models due to new evidence, our understanding grows. This work shows how ALMA and the JWST can work in tandem to advance our knowledge. “We conclude that ALMA and JWST are highly synergistic, and together they should revolutionize our understanding of early galaxy formation and evolution,” the authors conclude in their paper.

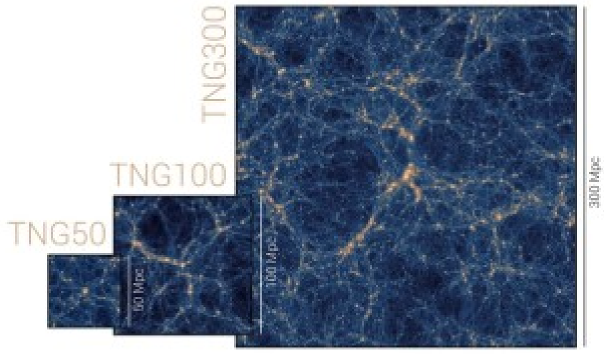
“These deep ALMA observations provide robust evidence of the existence of galaxies within the first few hundred million years after the Big Bang and confirm the surprising results from the Webb observations,” Zavala said. “The work of JWST has only just begun, but we are already adjusting our models of how galaxies form in the early Universe to match these observations. The combined power of Webb and the radio telescope array ALMA gives us the confidence to push our cosmic horizons ever closer to the dawn of the Universe.”

According to Simulations, the Milky Way is One in a Million

Humanity is in a back-and-forth relationship with nature. First, we thought we were at the center of everything, with the Sun and the entire cosmos rotating around our little planet. We eventually realized that wasn’t true. Over the centuries, we’ve found that though Earth and life might be rare, our Sun is pretty normal, our Solar System is relatively nondescript, and even our galaxy is one of the billions of spiral galaxies, a type that makes up 60% of the galaxies in the Universe.

But the Illustris TNG simulation shows that the Milky Way is special.

Illustris TNG is an ongoing series of large-scale simulations. The goal is to understand the mechanisms behind galaxy formation and evolution. The effort is a “series of large, cosmological magnetohydrodynamical simulations,” according to the Illustris TNG website. So far, the project has produced three primary runs, each one larger and higher resolution than the previous one: TNG 50, TNG 100, and TNG 300. Each run also focuses on various aspects of galaxy formation. TNG 300 is the largest, simulating a region of almost 300 million megaparsecs, over a billion light-years across, and containing millions of galaxies.

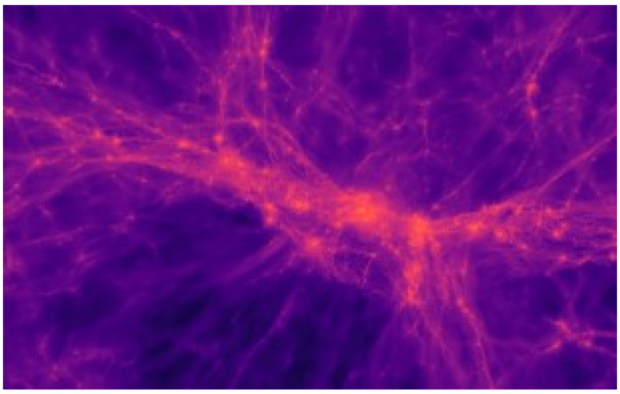


TNG 50, TNG 100, and TNG 300. Image: IllustrisTNG

New research based on Illustris TNG shows that the Milky Way is special. But it’s not special purely for its intrinsic qualities. It’s special in relation to its surroundings.

The findings are in a new paper based on Illustris TNG 300 published in the Monthly Notices of the Royal Astronomical Society. The title is “The unusual Milky Way-local sheet system: implications for spin strength and alignment.” The lead researcher is Miguel Aragón, a computational cosmologist and assistant professor at the National Astronomical Observatory, Universidad Nacional Autonoma de Mexico.

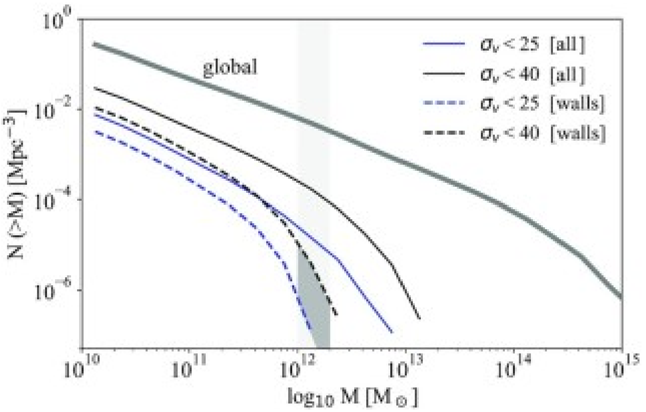
Illustris TNG simulates the large-scale structure of the Universe. It shows how galaxies are arranged on filaments of dark matter that weave their way through vast cosmic voids. Some of the features it shows are cosmological walls, also called galaxy walls. They’re enormous features, and one of them—a wall called the Hercules–Corona Borealis Great Wall—is the largest known structure in the Universe and is 10 billion light-years long.



This image from TNG 50 shows the large-scale structure of cosmic gas in the early Universe at redshift three. It shows a region of space 15 megaparsecs across, where the cosmic web of gas filaments come together to fuel galactic formation and growth. Image Credit: Illustris TNG 50.

Cosmological walls are made up of galaxies. They’re a subtype of filaments, but they’re flattened and have voids on either side. The voids seem to squash the walls into their flattened shape. The cosmological wall nearest the Milky

Way is called the Local Wall or Local Sheet.
The Local Sheet influences how the Milky Way and other nearby galaxies rotate on their axes. The Milky Way takes about 250,000,000 years to rotate, and the study shows that the rotation is more organized than if the galaxy wasn't near the Local Sheet.
The study also shows that the Milky Way is special. While typical galaxies tend to be much smaller in relation to walls, the Milky Way is surprisingly massive in relation to the Local Wall. According to the research, this is a rare cosmic occurrence.
This video is from Illustris TNG 50 and shows the formation of an elliptical galaxy. Credit: Illustris TNG
One characteristic that cosmologists study is velocity dispersion. It describes how much dispersal there is in the velocity of a group of astronomical objects. The velocities are dispersed around a mean velocity. The velocity of objects in the Milky Way/Local Wall neighbourhood has low dispersion, meaning they're not dispersed far from the mean.
This is unusual for a high-mass galaxy like the Milky Way in an environment like this, close to the Local Wall. To understand this better, the researchers looked for Milky Way Analogue (MWA) galaxies in Illustris TNG 300.
They found that MWAs in Local-Sheet analogues are rare. There was only one of them per 160–200?Mpc^3 of volume in the simulation. With their research, they showed that the cold environment around the Local Sheet is responsible. "We find that a Sheet-like cold environment preserves, amplifies, or simplifies environmental effects on the angular momentum of galaxies," they write in their paper.
Specifically, the Local Sheet affects the spin of the Milky Way. "… there are particularly strong alignments between the sheet and galaxy spins," they explain, adding that in the simulation, the galaxies near walls have low spin parameters.
This all affects how galaxies grow and merge over time, they think. It leads to lower-mass galaxies in these types of cosmic neighbourhoods. That's why the Milky Way, with its high mass, is so unusual and why the simulation found only one like it in up to 200 cubic megaparsecs of space.



This figure from the study shows how velocity dispersal relates to mass, with mass shown on the *x-axis*. The legend in the upper right shows how each line in the graph represents a different velocity dispersal (sigma $_v$.) The blue solid line is the mass function in cold (<25, high velocity dispersal) regions, and the black solid line is the mass function in warm (<40, low velocity dispersal) regions. The dotted lines are the same, but for regions near Cosmic Walls. It shows how lower velocity dispersal produces less massive galaxies near walls. There are also two shaded grey areas: light and dark grey. The light area represents the masses of Milky Way Analogues in the simulation, and the dark grey shows where the Milky Way actually is. Image Credit: Aragon *et al.* 2023.
The study reminds us of something critical: context is important. If we look at the Milky Way as a discrete object and compare it to other similar discrete objects, it doesn't appear to be exceptional. But in relation to its surroundings, it is.
"Our results highlight the importance of carefully characterizing the environment around our galaxy," the paper states.
"The effect of the geometry and coldness of Local Sheet environment on angular momentum processes may help us better understand current problems in galaxy formation…"
In a press release presenting the research, the authors refer to the *Copernican bias*. "This bias, describing the successive removal of our special status in the nearly 500 years since Copernicus demoted the Earth from being at the centre of the cosmos, would come from assuming that we reside in a completely average place in the Universe," the press release says. It shows the risk inherent in ignoring the environment of an object being studied.
This work also shows a potential flaw in how scientists use simulations like Illustris TNG. It's misleading to think that any point in the simulation is the same as any other point. Galaxies close to a Cosmic Wall can evolve quite differently than at other points.
"So, the Milky Way is, in a way, special," said research lead Miguel Aragón. "The Earth is very obviously special, the only home of life that we know. But it's not the centre of the Universe or even the Solar System. And the Sun is just an ordinary star among billions in the Milky Way. Even our galaxy seemed to be just another spiral galaxy among billions of others in the observable Universe."
"The Milky Way doesn't have a particularly special mass or type. There are lots of spiral galaxies that look roughly like it," Joe Silk, another of the researchers, said. "But it is rare if you take into account its surroundings. If you could see the nearest dozen or so large galaxies easily in the sky, you would see that they all nearly lie on a ring embedded in the Local Sheet. That's a little bit special in itself. What we newly found is that other walls of galaxies in the Universe like the Local Sheet very seldom seem to have a galaxy inside them that's as massive as the Milky Way."

Spiral galaxies are common. This image shows six spectacular spiral galaxies in images from the ESO's Very Large Telescope (VLT) at the Paranal Observatory in Chile. Credit: ESO
"You might have to travel half a billion light years from the Milky Way, past many, many galaxies, to find another cosmological wall with a galaxy like ours," Aragón said. He adds, "That's a couple of hundred times farther away than the nearest large galaxy around us, Andromeda."
So is it okay if we feel special again? We're obviously special just because we're alive, and most matter we can see isn't. But that doesn't necessarily tell us about how much other matter might be alive and if we're special. From a vantage point elsewhere in the Universe, there could be much more living matter. Before the rise of modern astronomy, we had no idea if there was life elsewhere or how special Earth might be. We're wise to be cautious with the word *special*, according to one of the authors.
"You do have to be careful, though, choosing properties that qualify as *'special,'*" Dr. Mark Neyrinck, another member of the team, said. "If we added a ridiculously restrictive condition on a galaxy, such as that it must contain the paper we wrote about this, we would certainly be the only galaxy in the

observable Universe like that. But we think this 'too big for its wall' property is physically meaningful and observationally relevant enough to call out as really being special."

A New Survey of the Milky Way Reveals Billions of Objects, Helping to Map Our Surroundings in Three Dimensions

The Dark Energy Camera Plane Survey 2 (DECaPS2) is out. This is the second data release from DECaPS, and the survey contains over 3 billion objects in the Milky Way. As the leading image shows, there are so many stars it appears as if there's no space between them.

Throughout most of human history, the nature of the Milky Way has confounded us. Aristotle thought that it resulted from the ignition of Earth's upper atmosphere, similar to how comets produce tails. The famous Persian scholar Al-Biruni thought the Milky Way was made up of countless fragments of nebulous stars. There are countless other ideas of what the Milky Way might have been.

Our modern understanding of the Milky Way is exquisitely detailed. Large-scale surveys of the galaxy have played a huge role in our growing understanding of the Milky Way. The ESA's Gaia mission, an ongoing survey of the Milky Way, has collected detailed data on over one billion stars, including their ages, masses, chemical compositions, colours, temperatures, and metal content.

Will DECaPS2 make a similar contribution? It might, based on raw data alone.

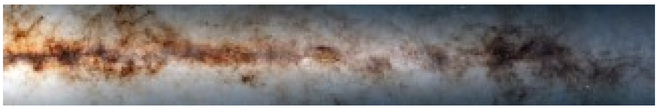
"When combined with images from Pan-STARRS 1, DECaPS2 completes a 360-degree panoramic view of the Milky Way's disk…"

Edward Schlafly, paper co-author, Space Telescope Science Institute.

A new paper in The Astrophysical Journal Supplement describes the new data release. It's titled "The Dark Energy Camera Plane Survey 2 (DECaPS2): More Sky, Less Bias, and Better Uncertainties." The lead author is Andrew K. Saydjari, a graduate student at Harvard University and a researcher at the Center for Astrophysics | Harvard & Smithsonian.

DECaPS2 contains 3.32 billion objects built from 34 billion detections. The detections are in 21,400 exposures which added up to 260 hours of open shutter time with the Dark Energy Camera (DECam) at the Cerro Tololo observatory. Of the 3.32 billion objects, about 2 billion are stars. It took two years and produced over 10 terabytes of data. The first data set was released in 2017, and it contained 2 billion objects, most of which were also stars.

The survey focuses on the galactic disk, where most of the galaxy's stars and dust are located. But the high density makes the region difficult to observe. The DECam Plane Survey overcomes this by performing "deep photometric surveys spanning a broad wavelength range (optical to NIR)."



Astronomers have released a gargantuan survey of the galactic plane of the Milky Way. The new dataset contains a staggering 3.32 billion celestial objects — arguably the largest such catalogue so far. The survey is here reproduced in 4000-pixel resolution to be accessible on smaller devices. Credit: DECaPS2/DOE/FNAL/DECam/CTIO/NOIRLab/NSF/AURA/E. Slawik Image processing: M. Zamani & D. de Martin (NSF's NOIRLab)

"One of the main reasons for the success of DECaPS2 is that we simply pointed at a region with an extraordinarily high density of stars and were careful about identifying sources that appear nearly on top of each other," said Saydjari. "Doing so allowed us to produce the largest catalogue ever from a single camera, in terms of the number of objects observed."

The two data releases combined cover 6.5 percent of the night sky and span 130 degrees in length. That's 13,000 times larger than the area of the full Moon. While 6.5 percent might not sound like a lot, it is. It's even more impressive when combined with other sky surveys.

"When combined with images from Pan-STARRS 1, DECaPS2 completes a 360-degree panoramic view of the Milky Way's disk and additionally reaches much fainter stars," says Edward Schlafly, a researcher at the AURA-managed Space Telescope Science Institute and a co-author of the paper. "With this new survey, we can map the three-dimensional structure of the Milky Way's stars and dust in unprecedented detail."

"Astronomers will be poring over this detailed portrait of more than three billion stars in the Milky Way for decades to come."

Debra Fischer, division director of Astronomical Sciences at NSF.

The galactic plane is difficult to observe. We're embedded in it, and when we look toward the center, we're looking through our arm of the Milky Way, through the central disk and beyond, into the spiral arms on the other side. It's not just that there are hundreds of millions of stars—maybe way more—in this view. This is where most of the dust is located, too.

The image shows how beautiful and intriguing the dark lanes of dust are, but they're also problematic. They absorb light from stars and can even block out faint stars entirely. There are many diffuse nebulae as well, and their light interferes with measurements of light from individual stars. The vast number of stars is also a challenge since they can overlap one another.

But understanding the central disk is critical to understanding the Milky Way. Observing in infrared helps overcome some of the challenges of observing the disk. Innovative data processing also helps. The team behind the survey came up with a way of predicting the background of each star. That made it easier to minimize the effects of overlapping stars and diffuse nebulae in the images.

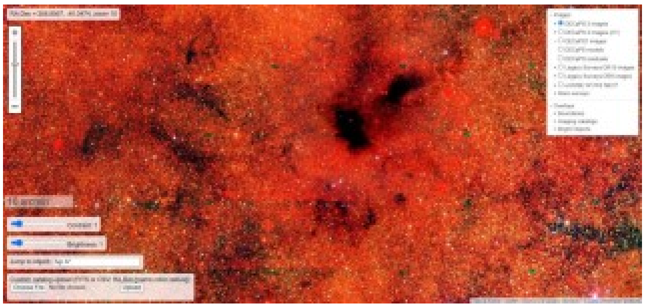
"This is quite a technical feat. Imagine a group photo of over three billion people, and every single individual is recognizable!" says Debra Fischer, division director of Astronomical Sciences at NSF, one of the agencies that operates DECam. "Astronomers will be poring over this detailed portrait of more than three billion stars in the Milky Way for decades to come. This is a fantastic example of what partnerships across federal agencies can achieve."

"Since my work on the Sloan Digital Sky Survey two decades ago, I have been looking for a way to make better measurements on top of complex backgrounds," said Douglas Finkbeiner, a professor at the Center for Astrophysics, co-author of the paper, and principal investigator behind the project. "This work has achieved that and more!"

You can explore the DECaPS data and images at the Legacy Survey Viewer <Click on image>. Image Credit: legacysurvey.org

A century ago, we didn't even know there were other galaxies. When astronomers saw the Andromeda galaxy and other spiral galaxies, they thought they were part of the Milky Way. They called them *spiral nebula*. Now we know better. We also know that the Milky Way is 90% dark matter and that the galaxy isn't flat; it's warped due to the Large and Small Magellanic Clouds tugging on it. We know that there's a behemoth black hole lurking in the galactic center called Sagittarius A-star. We also know that galaxies grow so large by consuming and merging with other galaxies. Large-scale astronomical surveys of the sky helped astronomers make some of these discoveries, and DECaPS promises to propel us to similar advancements. The first data release helped lead to some very interesting findings. One example is a 2018 paper that identified an old, metal-poor globular cluster in the galactic bulge. That was unusual since most globular clusters are in the galactic halo. Now, thanks to DECaPS and others, we know of many more globulars in the bulge.

The second data release will no doubt lead to many more discoveries and a filling-out of our knowledge about the galactic plane. "Combined with PS1, this completes comparable imaging of the entire Galactic plane essential for probing our Galaxy's stars, gas, and dust," the authors write. All of the data products from the survey "…should provide a rich, adaptable resource for the community, facilitating a variety of studies of the Milky Way," they explain.



Another screenshot from the Legacy Survey Viewer. <Click Image to Visit> Image Credit: legacysurvey.org

We're fortunate because our galaxy, the Milky Way, is a good model for understanding galaxies in general. About half of the stars in the Universe are in galaxies that are quite similar to ours. While nothing can be assumed, it's a reasonable assertion that much of what DECaPS tells us about the Milky Way will have some bearing on other galaxies.

Astronomers have strived to understand galaxies and how they formed and evolved. The most comprehensive way to study them is to perform large surveys of stars like this one. Who knows what researchers will find in all of this data?

Light Pollution is Obscuring the Night Sky. RIP Stargazing

A citizen science initiative called Globe at Night has some sobering news for humanity. Our artificial light is drowning out the night sky for more and more people. And it's happening more rapidly than thought.

Globe at Night is an international citizen science project run by the National Science Foundation's NOIRLab. It raises awareness about light pollution and how it's impacting our view of the night sky. A new research article based on observational data from Globe at Night shows that the average night sky grew 10% brighter each year in artificial light for the past eleven years. And as our artificial light becomes brighter, more stars are becoming obscured.

The paper is "Citizen scientists report global rapid reductions in the visibility of stars from 2011 to 2022," and it was published in the journal Science. The lead author is Christopher Kyba, a researcher at the German Research Centre for Geosciences.

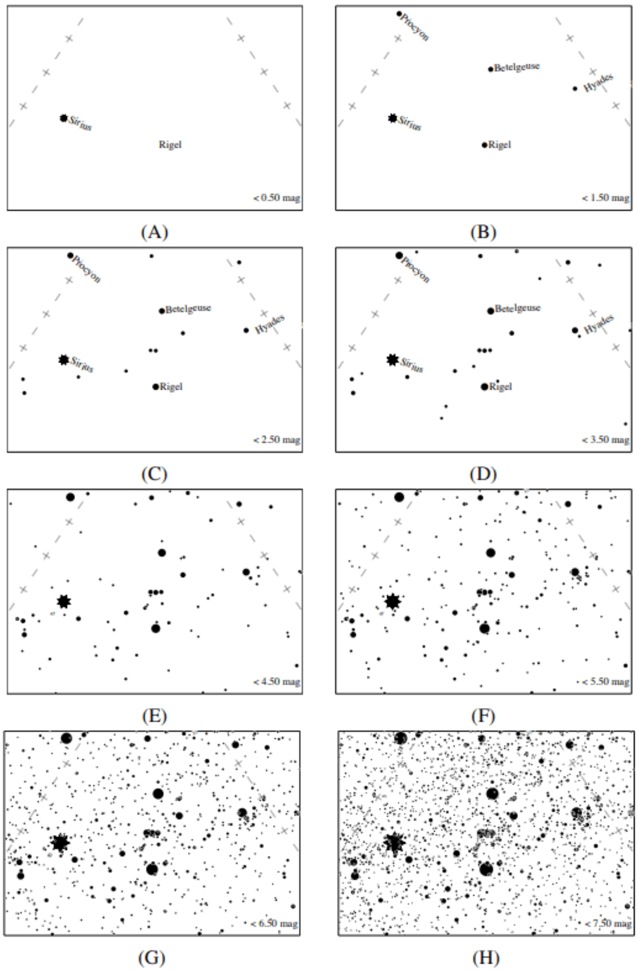
"The introduction of artificial light probably represents the most drastic change human beings have made to their environment."

Christopher Kyba, German Research Centre for Geosciences.

We should be able to see several thousand stars on a clear night. We should be able to see the grand arc of the Milky Way, too. But that's becoming increasingly difficult for more and more people. Our growing artificial lighting is responsible, but it's difficult to measure with satellites. A lot of our artificial light spreads horizontally, which satellites can't measure effectively.

Standing beside the Milky Way. Drowning out the night sky with artificial light blocks us off from nature, and that's not good for humans. Credit: P. Horálek/ESO

The authors of this paper got their data from citizen scientists taking part in Globe at Night. Participants rated their view of the night sky by comparing it to a standard set of images. The images were calibrated to show the night sky as seen by each participant in their location on Earth. The images are on a gradient so that each one shows progressively fewer stars to mimic increasing light pollution. Participants then selected the image that best matched their real view. The data gives an estimate of what's called the naked eye limiting magnitude. It tells how bright a sky object must be to be seen.



These are example star charts used in the Globe at Night citizen science project. These are the ones from 30 ° north showing the Orion constellation. Participants matched their naked eye view with these charts. The upper left is representative of the view from a city centre, and the bottom right is representative of the view from a remote location. Image Credit: Kyba *et al.* 2023.

The study shows that our growing light pollution is having a profound effect. About 30% of people around the globe and approximately 80% of people in the United States can no longer see the Milky Way. This is changing faster than scientists thought. But they've based their conclusions on satellite data, which struggles to measure the glow from surface light. The Globe at Night collects data from the ground, and this study is a wake-up call.

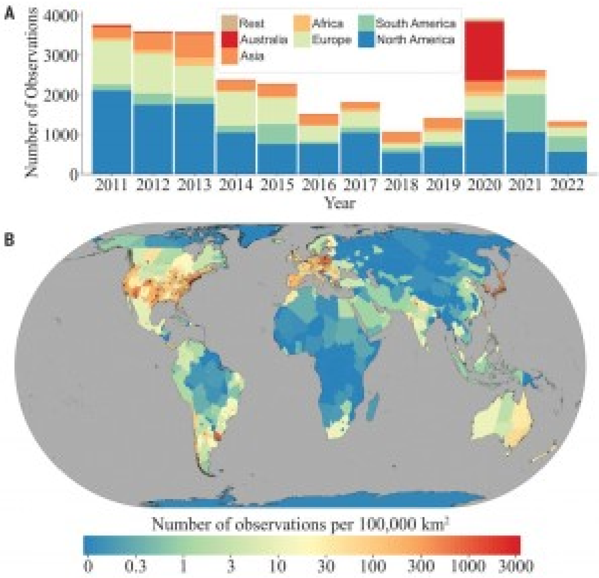
This is what sky-glow looks like in Mexico City. By Fernando Tomás from Zaragoza, Spain – Flickr, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=348732

At a time when war rages in Europe and humanity is confronting climate change, changes in the night sky might not seem very impactful. But there's something poignant and sad about it. The night sky is part of humanity's natural and cultural heritage. And it's fading before our eyes.

Yet this is about more than humanity's contemplative relationship with the night sky, something that reaches well back into pre-history. The increasing artificial lighting clashes with our natural day/night cycles and can be detrimental to human sleep cycles. It's also disruptive to wildlife since their natural cycles have evolved alongside the natural day/night cycle, too. Not only can our artificial lighting disrupt habitat the same way a bulldozer can, but it disrupts predator/prey relationships since predators use light to hunt and prey uses dark to hide. It's also driving nocturnal animals away from our lighted areas.

In an interview at Darksky.org, study lead author Christopher Kyba said, "The introduction of artificial light probably represents the most drastic change human beings have made to their environment. Predators use light to hunt, and prey species use darkness as cover," Kyba explained. "Near cities, cloudy skies are now hundreds or even thousands of times brighter than they were 200 years ago. We are only beginning to learn what a drastic effect this has had on nocturnal ecology."

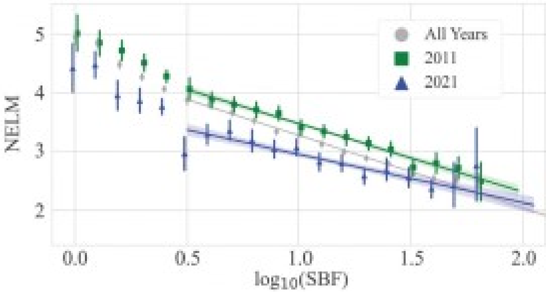
We intuitively know that we're lighting up the night sky as more and more of us live in larger and larger cities. But data has been difficult to gather. That's where Globe at Night comes in. Since 2006, they've been gathering data on stellar visibility. In their paper, the authors analyzed more than 50,000 observations submitted to *Globe at Night* between 2011 and 2022.



This figure from the study shows where citizen scientists' observations were distributed globally. ***A*** shows the number of observations by year and continent, and ***B*** shows the spatial distribution of all years combined. Image Credit: Kyba *et al.* 2023.

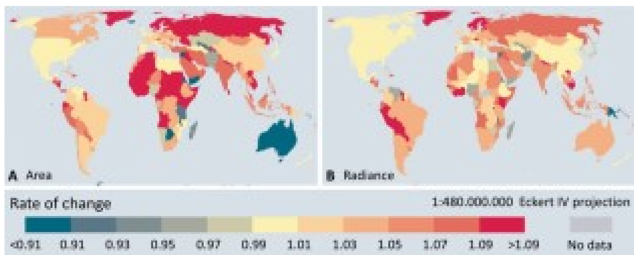
The data plots the growing price we pay for our light pollution. It shows that for the average Globe at Night participant, the sky is becoming 9.6% brighter each year. During an average person's childhood, which spans 18 years, the night sky brightness increases by a factor of four. This isn't true in every location on Earth, so it wouldn't be so bad for people in rural or remote locations. But for people in cities or in suburbs close to cities, it's likely even more pronounced.

"At this rate of change, a child born in a location where 250 stars were visible would be able to see only around 100 by the time they turned 18," said lead author Kyba.



This figure from the study plots the Sky Brightness Factor (SBF) with the Naked Eye Limiting Magnitude (NELM) to illustrate how we're losing visibility of the night sky. An SBF of 1 indicates starlight, and SBF 10 indicates that the sky is 10 times brighter than starlight. (Since it's a logarithmic scale, these are plotted as $\log_{10}$SBF = 0 and 1, respectively.) Smaller NELM values on the *y-axis* show that fewer stars are visible. The graph plots 2011 data, 2021 data, and all-years data. Image Credit: Kyba *et al.* 2023.

Kyba was also the lead author of a 2017 research article that looked at artificial lighting. It's titled "Artificially lit surface of Earth at night increasing in radiance and extent," and it was published in the journal Science Advances.



This figure from the 2017 study shows the rate of change globally for both Area and Radiance. Changes are shown as an annual rate for both lit area (A) and the radiance of stably lit areas (B). Annual rates are calculated based on changes over a four-year period from 2012 to 2016. Since this is based on satellite data, some of what it shows is related to warfare (Syria) and forest fires (Australia.) Image Credit: Kyba *et al.* 2017.

Some of our lighting problem is related to technology. The development of LED streetlights created a more energy-efficient type of lighting that's lowered the cost of lighting outdoor areas. Lower energy lighting technology hasn't reduced light, though, because it's cheaper to use. People can use more of it without paying more. "Regardless of historical or geographical context, humans tend to use as much artificial light as they can buy for ~0.7% of GDP," the authors of the 2017 study point out.

A glittering night-time map of Europe. Most of the lights in this image are streetlights, which make up the majority of light pollution. The atmosphere scatters the light, creating sky-glow. NASA Earth Observatory images by Joshua Stevens, using Suomi NPP VIIRS data from Miguel Román, NASA's Goddard Space Flight Center

Humanity grew up under the night sky, and the evidence from ancient cultures makes that clear. Numerous ancient structures still standing today were oriented toward celestial objects in the night sky and the changing of the seasons. These are called archaeoastronomical structures and archaeoastronomical observatories. From Machu Picchu in Peru to Gaocheng in China, these structures show how strong the relationship between people and the sky was. (There's even some evidence that the Incans used the observatory at Machu Picchu to observe the Pleiades and time the planting of corn.)

For most of humanity, our connection to nature via the night sky is being severed. But all is not lost. Some of it comes down to how much we value the night sky and what policies we're willing to put into place. The Globe at Night project is important because it illustrates what's at stake.

From the paper: "We draw two conclusions from these results. First, the visibility of stars is deteriorating rapidly, despite (or perhaps because of) the introduction of LEDs in outdoor lighting applications. Existing lighting policies are not preventing increases in skyglow, at least on continental and global scales. Second, the use of naked-eye observations by citizen scientists provides complementary information to the satellite datasets."

"The increase in skyglow over the past decade underscores the importance of redoubling our efforts and developing new strategies to protect dark skies," said study co-author Constance Walker from the National Optical Astronomy Observatory. "The Globe at Night dataset is indispensable in our ongoing evaluation of changes in skyglow, and we encourage everyone who can to get involved to help protect the starry night sky."

CPRE STARCOUNT 2023

Hi Andy

Thank you for signing up to Star Count which is taking place 17-24 February! There's not long to go now.

A velvety night sky scattered with shining stars is a sight we should all have the opportunity to see.

But light pollution is increasingly obscuring our view of the stars, negatively impacting our health, and causing problems for wildlife – particularly nocturnal species such as bats and moths.

Our analysis of last year's Star Count showed that just 3% of people in the UK experience 'truly dark skies', but most of us – 1 in 2 or 49% - live in areas with severe light pollution.

That's why we need your help to map the nation's view of the stars, so we can work towards rewilding the night sky for the benefit of people and wildlife.

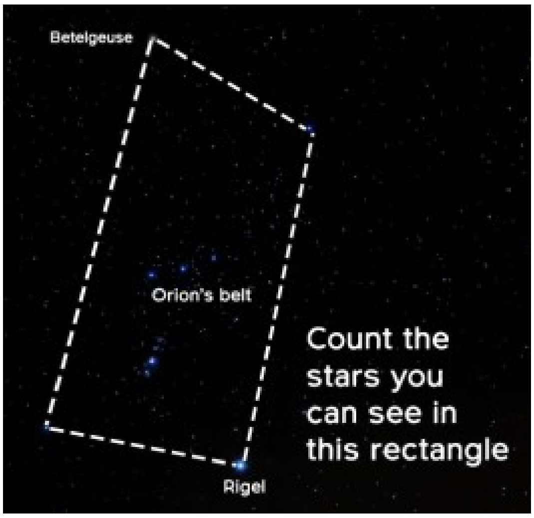
By counting the number of stars you can see in the constellation of Orion, you'll be helping us to track light levels across the country and take action on the issue of light pollution.

Not sure how to take part? Follow our five simple steps below!

1) Find a good spot to do your Star Count which is south-facing – this could be your garden if you have one, a local green space or even balcony.

2) If you're doing your Star Count from home, turn off all the lights in your home so it's as dark as possible and go outside.

3) Look south in the night sky (the way satellite dishes face) and find the constellation of Orion. Look out for Orion's belt (see image below).



4) Let your eyes adjust to the dark – the longer you wait, the better (we recommend at least 20 minutes) Count the number of stars you can see within the rectangle formed by the four corner stars. You count the 'belt', but not the corner stars.

5) Head to our website to submit your count and help us map the nation's view of the night sky.

Happy stargazing!

Emma

Emma Marrington
Dark skies campaigner
PS: Click here for everything you need to know about taking part.

E Mails Viewings Logs and Images from Members.

Hi all
I just had a request from Bob's daughter Helen, that Bob's wife has offered Bob's 10 inch reflector telescope (no further details) to the society or to one of its members. Apparently, she wants it "she doesn't want any money, and wants it out of the way and would not know how to get rid of it".
In general, how should we deal with offers to donate kit to society, as this has come up from time to time via the web-site contact email?
Speaking personally, I don't currently have a telescope and would really like to get one at some point, so would gladly take it off their hands. Although, I don't want to jump the queue if another member would like the chance.
To do this fairly, perhaps at the next meeting, we can ask members present to "register an interest for use" (i.e. and not just sell on ebay). If there's more than one interested party, then we can draw names out of a hat?
What do you think?
Cheers
Sam

Viewing Log for 16th of January

As I was on holiday from my Asda delivery job (work afternoons and evenings) and the sky was clear, I thought I would go out and do a viewing session.

I arrived at my usual viewing place near Uffcott and had my Meade LX90 GOTO telescope set up and ready by 19:17, I would be using the 10 mm XW Pentax eye piece instead of the usual 14 mm one. With a temperature of – 1 °C and no wind the conditions should be okay but a bit on the cold side?

Saturn has now been lost to the western twilight sky, so my first target was Jupiter, could see the two main weather belts clearly and the moon Io out to the east of the planet and Calisto, Europa and Ganymede out to the west. The Great Red Spot was on display but I could not see it? While viewing Jupiter, Hilary Wilkey from Swindon Stargazers came and joined me, so I would have company for the session. Hilary said the sky looked very good, while she was setting up her equipment the first of three cars went past us. With the car gone the next planet was Uranus, as usual this planet was in the finderscope, so I had to do a manual slew to centre the planet. Could not make out any detail on the planet, the same story for Neptune, in finderscope and no detail of the surface. Mars was shining very bright nearly overhead of us, again could not make out any detail of the surface. With the planets out of the way I went for the 'Trapezium' of stars within Messier (M) 42, the Great Orion nebula, these stars were bright and the dust lanes looked good. The second car now went past us, I told Hilary to try and find M 79 in Lepus, this is an odd ball globular cluster (GC) as there are no other GC's nearby. Being only 12 ° above the horizon it was a faint blob to look at, not often I get a chance to view this object. At 20:38, Hilary decided to leave me and I also changed over to the 14 mm XW Pentax, this would give me a larger field of view to look at. First of the open clusters (OC) was M 46, a large and dim OC in Puppis, not far away is M 47, another OC which was large and sparse for stars, some of which were bright. M 50 in Monoceros is compact, again with some bright stars. Back to Orion and M 78 just above the belt stars, this emission and reflection nebula has two bright stars and showed some nebula which often I do not manage to see due to sky conditions? The last car now went past me. Looking at my sky atlas, I noticed NGC 2244 near Orion which is an OC within the Rosette nebula, this cluster is very loose with some bright stars, and this is AKA Caldwell 50. My last object to look at was M 36 in Auriga, a compact and dim OC to look at. I noticed Leo had cleared the eastern horizon, so the spring constellations were not far off from rising.

I gave up at 21:18 as most of the sky was now covered in cloud, a lot of them was long and thin. The temperature had now dropped to – 3 °C and a nice covering of ice was on the telescope (see picture attached).

Clear skies.

Peter Chappell

PS During the evening after the telescope had stopped slewing to an object I noticed the object would bounce around in the eye piece for a few seconds before being stationary, I checked the RA and Dec clutches but they seem okay, could not figure out what was wrong until I started to pack the equipment up, the tripod to telescope locking knob was NOT fully tight, this gave the bouncing feeling, doh!

Viewing Log for 17th of January

Another clear night, two on the trot nearly a record for me to go out and do another viewing session! I went to my usual viewing place near Uffcott but this time Hilary would not be joining me as she would be watching football on the TV. I would again be using my Meade LX90 telescope but this time using a 6 mm Televue Delos eye piece which I would change over to the 10 mm Delos after looking at the planets, I had everything set up by 19:53 with no wind and a temperature of – 1° C the conditions were similar to yesterday when I was out?

First target was Jupiter starting to set in the western sky, this time Ganymede was out to the east of the planet with Io, Europa and Calisto out to the west, no Great Red Spot on view this evening. While viewing Jupiter two cars went past me fairly close together. On to Neptune, now getting very low in the western sky, only 13 ° up when I looked at it so its viewing window would be closing soon? As usual it was in the finderscope and the first star I slewed too, no real colour to be made out for this planet. Could not find Uranus, tried several stars in the finderscope but each time I went to an object it was a star and not a planet! Final object was Mars shining brightly in Taurus, no details of the surface could be seen by me. For a change I thought I would do the first 20 objects on the Messier (M) marathon list, this marathon is normally done around mid-March time when the Moon is out of the way? First object is M 74 in Pisces, this spiral galaxy (SG) was a faint fuzzy blob (FFB) to look at, easy to miss being so small? On to M 77 in Cetus, another SG but this time only a faint blob (FB), small but had a bright core. M 33, the Pinwheel Galaxy in Triangulum is another SG, a large FFB with low surface brightness, again easy to miss. One SG which you cannot really miss is M 31, the Andromeda Galaxy, this SG has a large bright core. Not far away is M 32, a satellite galaxy of M 31, this elliptical galaxy (EG) is a FB with small bright core. Another satellite galaxy of M 31 is M 110, this EG is an FFB and easy to miss, I had to use adverted vision to see the object. M 110 is the last object on Messier's list. On to the first open cluster (OC) on the list and M 52 in Cassiopeia, this OC was dim and loose to look at with no bright stars within the cluster. Also in Cass is M 103 another OC which was also dim and had fewer stars than M 52? The first planetary nebula to look at is M 76, the Little Dumbbell nebula in Perseus, this was a small grey blob to look at with no detail. Back to OC's and M 34 in Perseus, this is a large and sparse OC with some bright stars. Another car went pass me but did not affect my night vision as next target can be seen with one's eyes, M 45, the Pleiades. No good using the telescope as I am looking thru the cluster using the finderscope it looks great to view. First globular cluster on the list is M 79 in Lepus just below Orion. This is a FB to look at and was better than yesterday's session, sky conditions are better tonight? In to Orion and the Great Orion nebula and M 42 with M 43 nearby, can be seen with the same field of view. Trapezium stars looked good with dust lanes filling the eye piece. M 43 had one star with some nebulously around it, this diffused nebula (DN) is easy to miss with M 42 next door! M 78 is another DN just above the belt stars, as usual I could make out the two bright stars but this time had some nebulously around them? The only Supernova Remnant on his list is M 1, the Crab nebula in Taurus, this was a large grey blob to look at. Final four objects are all OC's starting with M 35 in Gemini, this OC is very large and fills the eye piece, lot of bright stars within the cluster. Last of the cars went past me while I was looking at M 37 in Auriga, again this fills the eye piece and has a mass of dim stars in the cluster. M 36 was next, a very large and loose cluster. Final object was M 38, similar to M 36 but has more stars in the cluster. Being at 73 ° high, these objects would be hard to track with an EQ mount as I would be on the floor trying to look up. Of course using GOTO equipment does might the challenge much easier, to do the real marathon you should NOT be using GOTO equipment but star hop instead. A lot of the object I have seen tonight I would not find, SG's are nearly impossible for me to find?

At 21:49, I called it a night, temperature was - 3°C with no dew and little frost on the telescope, much better than last night's conditions when I packed up all of the equipment used.

Clear skies.

Peter Chappell

Viewing Log for 24th of January

Recently there has been a good run of clear weather during the evening and with the Moon out of the way until early morning the viewing sessions have been good! This was my third outing within a week, this time I was a bit earlier than recently and had my Meade LX90 GOTO set up and ready by 19:07 using the Pentax XW 14 mm eyepiece and with a temperature of – 1 °C and no wind, conditions should be okay for me.

The Moon was setting in the west, so this was my first target, normally this is the last object I look at as my night vision would probably be affected by the brightness of the Moon. I could see three large craters on the terminator line, namely Cleomedes (76 miles in diameter), Endymion (76 miles in diameter) and Geminus (52 miles in diameter). Mare Crisium (Sea of Rains) was about 75 % in daylight and Mare Fecunditatis (Sea of Fruitfulness) was about half in daylight.

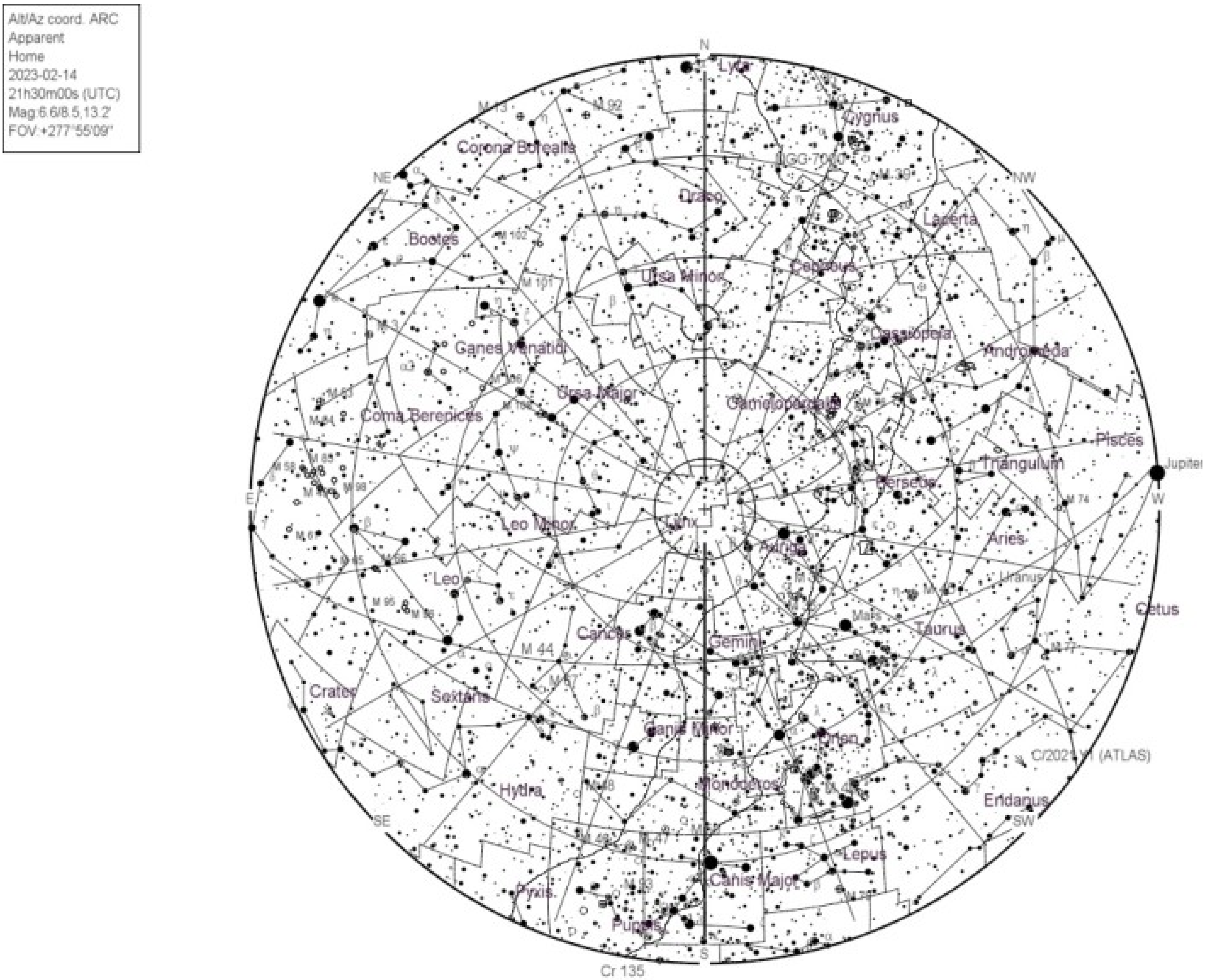
With the Moon out of the way, it was time to hit the planets starting with Jupiter, 40.76 light minutes from Earth. Calisto, Europa and Io were to the east of Jupiter and Ganymede out to the west, there was another point of light which might be confused as one the moons, this turned out to be a magnitude 7.1 star? As usual, I could not find Neptune or Uranus, I tried several points of light but no luck. While trying to find one of these planets the first of many cars for the evening went pass me. At least I would not have any trouble finding Mars shining brightly in Taurus, think I could actually make out some markings on the surface of the planet?

Now to try and find the 'green comet' C/2022 E3 (ZTF), some of my recent sessions I tried to locate the comet but it was still too low in the sky. I started off using 15x70mm binoculars to the north west of the Plough's handle, it did not take me too long to find the comet J, this is the first comet I have seen since Neowise a few years ago. I then tried to locate it with the telescope starting with the finderscope and doing manual slewing, again it did not take long to find it, and using the eye piece it was a faint blob (FB) with a small bright core. I know Messier (M) 101 and 102 are in the area, so I slewed to these objects to make sure I had found the comet, both of these objects the telescope had to move too, so I had found the comet.

With the comet out of the way I thought I would carry on with my Messier marathon list starting with number 21 (numbers 1 to 20 I had done on the last viewing session). First object was M 41, a large and very loose open cluster (OC) with few stars in the cluster. Another car just went pass me as I had a look at M 50, another OC but smaller than M 41, again few stars in the cluster. Yet another car went pass me while I found M 47, very loose with not many stars in this OC. With finding few stars in the clusters I wanted to check to see if my GOTO was accurate, so I slewed to Sirius and that was well placed in the eye piece. Not far away from M 47 is M 46, a very large, dense and dim OC. Another car went pass me while I was trying to locate M 93 but that was still in a hedge, so I would have to come back to this OC later when it is higher in the sky. Before I went to M 48, another two cars went pass me, it was starting to be busier than the M4! M 48 filled the eye piece with stars but not many of them and they were dim. Just for a change and a first for me since I have been coming to Uffcott, four cyclist went pass me! Next target was M 44, the Beehive cluster in Cancer, this is best seen with the finderscope as I am looking thru the cluster with the eye piece. Back to another car going pass me while I went off to M 67, an OC which can be over looked with M 44 nearby, this OC is compact, dense and dim. On to my first spiral galaxy (SG) for the evening and M 81 (Bode's galaxy), this is a FB with a bright core. Not far away is M 82, the Cigar galaxy, this is a long and thin irregular galaxy and a FB. The first faint fuzzy blob (FFB) is M 108 below the sauce pan of the Plough, this SG is easy to miss. The Owl nebula (M97) used to be my nemesis and this time was hard to find this planetary nebula. Now a helicopter went over me at least I had no trouble with white lights just flashing nav lights! I was not sure if I bagged M 109, this SG had the glow of Swindon to deal with? Another car went pass me as I hunted M 106, another SG which is easy to miss, and a real FFB. The same car went pass me another three times in quick time, must have been ferrying items up the road and back? On to the most uninteresting object in his list and M 40, the only double star, just two dim stars to look at. By now M 93 had cleared the hedge, so I had a look at this OC, a small, compact and dim cluster. That was it for the Messier list as I was getting fed up with all the cars that went past me during the evening, final look was M 42 and M 43 in Orion, good to look at as usual.By now it was 21:02 and time to pack up, the temperature had dropped to – 3°C and a nice covering of frost on the telescope which would need drying once I got home.

Clear skies.

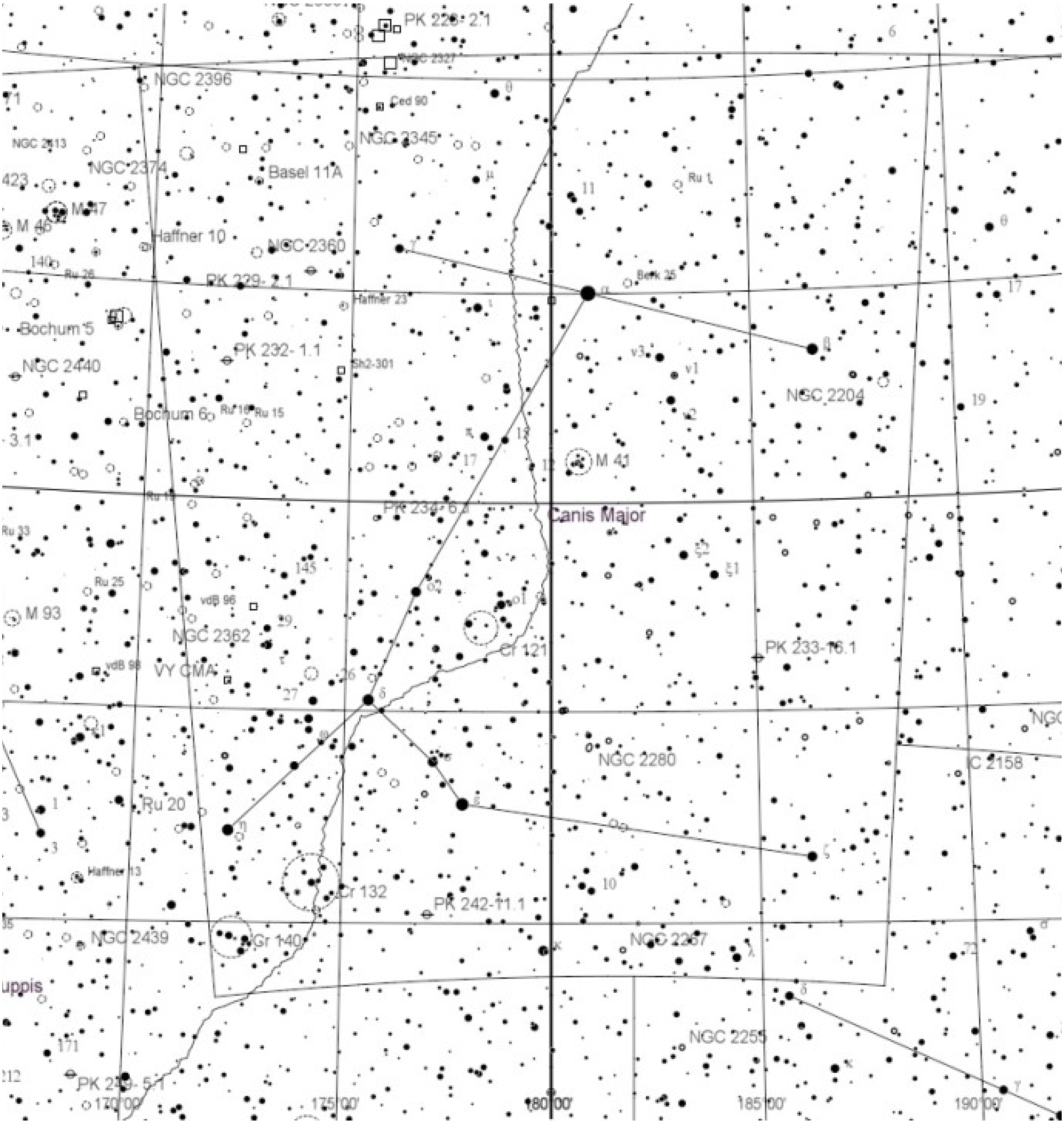
Peter Chappell



February 5 - **Full Moon.** The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This phase occurs at 18:30 UTC. This full moon was known by early Native American tribes as the Snow Moon because the heaviest snows usually fell during this time of the year. Since hunting is difficult, this moon has also been known by some tribes as the Hunger Moon.

February 20 - **New Moon.** The Moon will located on the same side of the Earth as the Sun and will not be visible in the night sky. This phase occurs at 07:08 UTC. This is the best time of the month to observe faint objects such as galaxies and star clusters because there is no moonlight to interfere

CONSTELLATIONS OF THE MONTH: CANIS MAJOR



In the 2nd century CE, Greek-Egyptian astronomer Claudius Ptolemaeus (aka. Ptolemy) compiled a list of all the then-known 48 constellations. This treatise, known as the *Almagest*, would be used by medieval European and Islamic scholars for over a thousand years to come, effectively becoming astrological and astronomical canon until the early Modern Age.

One of these constellations included in Ptolemy's collection was Canis Major, an asterism located in the southern celestial hemisphere. As one of two constellations representing "the dogs" (which are associated with "the hunter" Orion) this constellation contains many notable stars and Deep Sky Objects. Today, it is one of the 88 constellations recognized by the IAU, and is bordered by Monoceros, Lepus, Columba and Puppis.

Name and Meaning:

The constellation of Canis Major literally translates to "large dog" in Latin. The first recorded mentions of any of the stars associated with this asterism are traced back to Ancient Mesopotamia, where the Babylonians recorded its existence in their *Three Star Each* tablets (ca. 1100 BCE). In this account, Sirus (KAK.SI.DI) was seen as the arrow aimed towards Orion, while Canis Major and part of Puppis were seen as a bow.

Artist's impression of a white dwarf star in orbit around Sirius (a white supergiant). Credit: NASA, ESA and G. Bacon (STScI)

To the ancient Greeks, Canis Major represented a dog following the great hunter Orion. Named Laelaps, or the hound of Prociris in some accounts, this dog was so swift that Zeus elevated it to the heavens. Its Alpha star, Sirius, is the brightest object in the sky (besides the Sun, the Moon and nearest planets). The star's name means "glowing" or "scorching" in Greek, since the summer heat occurred just after Sirius' helical rising.

The Ancient Greeks referred to such times in the summer as "dog days", as only dogs would be mad enough to go out in the heat. This association is what led to Sirius coming to be known as the "Dog Star". Depending on the faintness of stars considered, Canis Major resembles a dog facing either above or below the ecliptic. When facing below, since Sirius was considered a dog in its own right, early Greek mythology sometimes considered it to be two headed.

Together with the area of the sky that is deserted (now considered as the new and extremely faint constellations Camelopardalis and Lynx), and the other features of the area in the Zodiac sign of Gemini (i.e. the Milky Way, and the constellations Gemini, Orion, Auriga, and Canis Minor), this may be the origin of the myth of the cattle of Geryon, which forms one of The Twelve Lab ours of Heracles.

Sirius has been an object of wonder and veneration to all ancient peoples throughout human history. In fact, the Arabic word *Al Shi'ra* resembles the Greek, Roman, and Egyptian names suggesting a common origin in Sanskrit, in which the name Surya (the Sun God) simply means the "shining one." In the ancient Vedas this star was known as the Chieftain's star; and in other Hindu writings, it is referred to as Sukra – the Rain God, or Rain Star.

Sirius was revered as the Nile Star, or Star of Isis, by the ancient Egyptians. Its annual appearance just before dawn at the Summer Solstice heralded the flooding of the Nile, upon which Egyptian agriculture depended. This helical rising is referred to in many temple inscriptions, where the star is known as the Divine Sepat, identified as the soul of Isis.

To the Chinese, the stars of Canis Major were associated with several different asterisms – including the Military Market, the Wild Cockerel, and the Bow and Arrow. All of these lay in the Vermilion Bird region of the zodiac, on of four symbols of the Chinese constellations, which is associated with the South and Summer. In this tradition, Sirius was known *Tianlang* (which means "Celestial Wolf") and denoted invasion and plunder.

This constellation and its most prominent stars were also featured in the astrological traditions of the Maori people of New Zealand, the Aborigines of Australia, and the Polynesians of the South Pacific.

History of Observation:

This constellation was one of the original 48 that Ptolemy included in his 2nd century BCE work the *Amalgest*. It would remain a part of the astrological traditions of Europe and the Near East for millennia. The Romans would later add Canis Minor, appearing as Orion's second dog, using stars to the north-west of Canis Major.

In medieval Arab astronomy, the constellation became *Al Kalb al Akbar*, ("the Greater Dog"), which was transcribed as *Alcheleb Alachbar* by European astronomers by the 17th century. In 1862, Alvan Graham Clark, Jr. made an interesting discovery while testing an 18″ refractor telescope at the Dearborn Observatory at Northwestern University in Illinois.

In the course of observing Sirius, he discovered that the bright star had a faint companion – a white dwarf later named Sirius B (sometimes called "the Pup"). These observations confirmed what Friedrich Bessel proposed in 1844, based on measurements of Sirius A's wobble. In 1922, the International Astronomical Union would include Canis Major as one of the 88 recognized constellations.

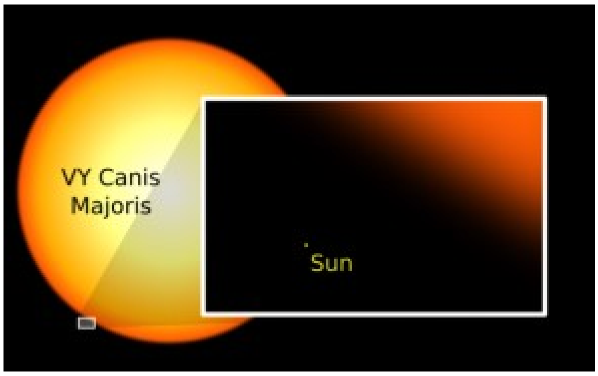
Notable Features:

Canis Major has several notable stars, the brightest being Sirius A. It's luminosity in the night sky is due to its proximity (8.6 light years from Earth), and the fact that it is a magnitude -1.6 star. Because of this, it produces so much light that it often appears to be flashing in vibrant colors, an effect caused by the interaction of its light with our atmosphere.

Then there's Beta Canis Majoris, a variable magnitude blue-white giant star whose traditional name (*Murzim*) means the "The Heralder". It is a Beta Cephei variable star and is currently in the final stages of using its hydrogen gas for fuel. It will eventually exhaust this supply and begin using helium for fuel instead. Beta Canis Majoris is located near the far end of the Local Bubble – a cavity in the local Interstellar medium though which the Sun is traveling.

Next up is Eta Canis Majoris, known by its traditional name as *Aludra* (in Arabic, "*al-aora"*, meaning "the virgin"). This star shines brightly in the skies in spite of its distance from Earth (approx. 2,000 light years from Earth) due to it being many times brighter (absolute magnitude) than the Sun. A blue supergiant, Aludra has only been around a fraction of the time of our Sun, yet is already in the last stages of its life.

Another "major" star in this constellation is VY Canis Majoris (VY CMa), a red hypergiant star located in the constellation Canis Major. In addition to being one of the largest known stars, it is also one of the most luminous ever observed. It is located about 3,900 light years (~1.2 kiloparsecs) away from Earth and is estimated to have 1,420 solar radii.



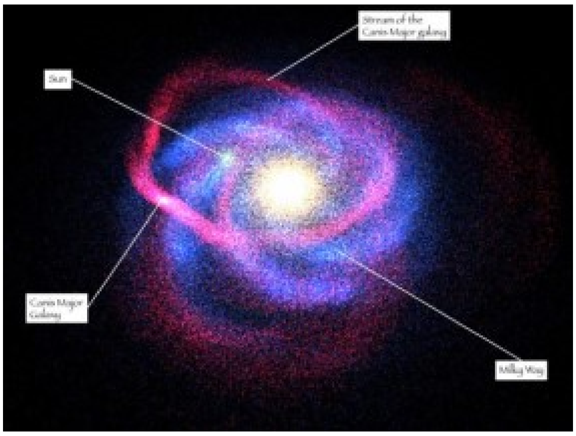
Size comparison between the Sun and VY Canis Majoris, which once held the title of the largest known star in the Universe. Credit: Wikipedia Commons/Oona Räisänen

Canis Major is also home to several Deep Sky Objects, the most notable being Messier 41 (NGC 2287). Containing about 100 stars, this impressive star cluster contains several red giant stars. The brightest of these is spectral type K3, and located near M41's center. The cluster is estimated to be between 190 and 240 million years old, and its is believed to be 25 to 26 light years in diameter.

Then there's the galactic star cluster NGC 2362. First seen by Giovanni Hodierna in 1654 and rediscovered William Herschel in 1783, this magnificent star cluster may be less than 5 million years old and show shows signs of nebulosity – the remains of the gas cloud from which it formed. What makes it even more special is the presence of Tau Canis Major.

Easily distinguished as the brightest star in the cluster, Tau is a luminous supergiant of spectral type O8. With a visual magnitude of 4.39, it is 280,000 times more luminous than Sol. Tau CMa is also brighter component of a spectroscopic binary and studies of NGC 2362 suggest that it will survive longer than the Pleiades cluster (which will break up before Tau does), but not as long as the Hyades cluster.

Then there's NGC 2354, a magnitude 6.5 star cluster. While it will likely appear as a small, hazy patch to binoculars, NGC 2354 is actually a rich galactic cluster containing around 60 metal-poor members. As aperture and magnification increase, the cluster shows two delightful circle-like structures of stars.



The Canis Major Dwarf Galaxy – currently recognized as being the closet neighbor to the Milky Way. Credit: APOD

For large telescopes and GoTo telescopes, there are several objects worth studying, like the Canis Major Dwarf Galaxy (RA 7 12 30 Dec -27 40 00). An irregular galaxy that is now thought to be the closest neighboring galaxy to our part of the Milky Way, it is located about 25,000 light-years away from our Solar System and 42,000 light-years from the Galactic Center.

It has a roughly elliptical shape and is thought to contain as many stars as the Sagittarius Dwarf Elliptical Galaxy, which was discovered in 2003 and thought to be the closest galaxy at the time. Although closer to the Earth than the center of the galaxy itself, it was difficult to detect because it is located behind the plane of the Milky Way, where concentrations of stars, gas and dust are densest.

Globular clusters thought to be associated with the Canis Major Dwarf galaxy include NGC 1851, NGC 1904, NGC 2298 and NGC 2808, all of which are likely to be a remnant of the galaxy's globular cluster system before its accretion (or swallowing) into the Milky Way. NGC 1261 is another nearby cluster, but its velocity is different enough from that of the others to make its relation to the system unclear.

Finding Canis Major:

Finding Canis Major is quite easy, thanks to the presence of Sirius – the brightest star to grace the night sky. All you need to do is find Orion's belt, discern the lower left edge of constellation (the star Kappa Orionis, or Saiph), and look south-west a few degrees. There, shining in all it glory, will be the "Dog Star", with all the other stars stemming outwards from it.

Unfortunately, Sirius A's luminosity means that the means that poor "Pup" hardly stands a chance of being seen. At magnitude 8.5 it could easily be caught in binoculars if it were on its own. To find it, you'll need a mid-to-large telescope with a high power eyepiece and good viewing conditions – a stable evening (not night) when Sirius is as high in the sky as possible. It will still be quite faint, so spotting it will take time and patience.

Between Sirius at the northern tip, and Adhara at the south, you can also spot M41 residing almost about halfway. Using binoculars or telescopes, all one need do is aim about 4 degrees south of Sirius – about one standard field of view for binoculars, about one field of view for the average telescope finderscope, and about 6 fields of view for the average wide field, low power eyepiece.

Thousands of years later, Canis Major remains an important part of our astronomical heritage. Thanks largely to Sirius, for burning so brightly, it has always been seen as a significant cosmological marker. But as our understanding of the cosmos has improved (not to mention our instruments) we have come to find just how many impressive stars and stellar objects are located in this region of space.

M41 image Andy Burns

The Next Sky Blemish for Profit: Bluewalker 3 communication sail will be making itself seen.

06 Feb	1.9	19:09:00	10°	WNW	19:12:54	83°	SSW	19:13:32	61°	ESE
06 Feb	5.2	20:47:55	10°	W	20:48:20	12°	W	20:48:20	12°	W
07 Feb	1.9	18:50:01	10°	WNW	18:53:54	81°	SSW	18:55:31	34°	ESE
07 Feb	4.6	20:28:58	10°	W	20:30:19	17°	W	20:30:19	17°	W
08 Feb	2.0	18:31:01	10°	WNW	18:34:55	79°	SSW	18:37:34	20°	ESE
08 Feb	4.1	20:10:00	10°	W	20:12:22	22°	WSW	20:12:22	22°	WSW
09 Feb	2.1	18:12:01	10°	WNW	18:15:54	77°	SSW	18:19:42	11°	ESE
09 Feb	3.9	19:51:02	10°	W	19:54:08	23°	SW	19:54:31	22°	SSW
10 Feb	2.1	17:53:00	10°	WNW	17:56:54	75°	SSW	18:00:47	10°	ESE
10 Feb	4.1	19:32:03	10°	W	19:35:05	22°	SW	19:36:47	17°	S
11 Feb	4.2	19:13:05	10°	W	19:16:03	21°	SW	19:19:01	10°	S
12 Feb	4.4	18:54:06	10°	W	18:57:00	20°	SW	18:59:54	10°	S
13 Feb	4.6	18:35:08	10°	W	18:37:57	19°	SW	18:40:46	10°	S
14 Feb	4.7	18:16:08	10°	W	18:18:52	18°	SW	18:21:37	10°	S
15 Feb	4.8	17:57:09	10°	W	17:59:48	18°	SW	18:02:27	10°	S
26 Feb	5.2	06:16:43	10°	SSE	06:17:52	11°	SE	06:19:00	10°	ESE
27 Feb	5.0	05:57:19	10°	SSE	05:58:42	12°	SE	06:00:05	10°	ESE
28 Feb	4.9	05:37:56	10°	SSE	05:39:31	12°	SE	05:41:07	10°	ESE
01 Mar	4.8	05:18:34	10°	SSE	05:20:20	13°	SE	05:22:06	10°	ESE
02 Mar	4.7	04:59:14	10°	SSE	05:01:09	13°	SE	05:03:04	10°	ESE
03 Mar	4.6	04:39:54	10°	SSE	04:41:57	14°	SE	04:44:00	10°	ESE
03 Mar	2.6	06:16:08	10°	SW	06:19:54	54°	SSE	06:23:41	10°	ENE
04 Mar	4.4	04:21:29	13°	SSE	04:22:45	15°	SE	04:24:56	10°	E
04 Mar	2.5	05:56:57	10°	SW	06:00:44	56°	SSE	06:04:31	10°	ENE
05 Mar	4.3	04:03:19	15°	SE	04:03:32	15°	SE	04:05:50	10°	E
05 Mar	2.4	05:38:06	12°	SW	05:41:33	58°	SSE	05:45:20	10°	ENE
06 Mar	4.5	03:45:02	15°	ESE	03:45:02	15°	ESE	03:46:43	10°	E
06 Mar	2.3	05:19:48	20°	SW	05:22:20	60°	SSE	05:26:09	10°	ENE
07 Mar	4.7	03:26:40	13°	ESE	03:26:40	13°	ESE	03:27:36	10°	E
07 Mar	2.2	05:01:26	30°	SW	05:03:08	62°	SSE	05:06:58	10°	ENE

ISS PASSES For FEBRUARY 2023

from Heavens Above website maintained by Chris Peat.

Date	Brightn	Start	Highest point	End						
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
17 Feb	-0.7	06:16:59	10°	SSE	06:18:36	13°	SE	06:20:12	10°	ESE
19 Feb	-1.7	06:15:32	10°	SSW	06:18:21	25°	SSE	06:21:11	10°	E
20 Feb	-1.3	05:27:50	10°	S	05:30:11	18°	SE	05:32:33	10°	E
21 Feb	-1.0	04:41:29	12°	SSE	04:42:02	12°	SE	04:43:29	10°	ESE
21 Feb	-2.9	06:14:57	10°	SW	06:18:10	47°	SSE	06:21:25	10°	E
22 Feb	-2.4	05:28:11	20°	SSW	05:29:52	34°	SSE	05:32:57	10°	E
23 Feb	-1.9	04:41:51	24°	SE	04:41:51	24°	SE	04:44:23	10°	E
23 Feb	-3.6	06:14:45	10°	WSW	06:18:02	75°	SSE	06:21:22	10°	E
24 Feb	-0.5	03:55:25	11°	ESE	03:55:25	11°	ESE	03:55:37	10°	E
24 Feb	-3.5	05:28:19	32°	SW	05:29:37	59°	SSE	05:32:56	10°	E
25 Feb	-2.6	04:41:47	40°	SE	04:41:47	40°	SE	04:44:26	10°	E
25 Feb	-3.8	06:14:41	11°	W	06:17:52	87°	N	06:21:13	10°	E
26 Feb	-0.7	03:55:12	14°	E	03:55:12	14°	E	03:55:53	10°	E
26 Feb	-3.8	05:28:06	35°	WSW	05:29:23	85°	S	05:32:44	10°	E
27 Feb	-3.2	04:41:27	56°	ESE	04:41:27	56°	ESE	04:44:14	10°	E
27 Feb	-3.8	06:14:21	10°	W	06:17:39	87°	N	06:21:01	10°	E
28 Feb	-0.9	03:54:47	17°	E	03:54:47	17°	E	03:55:42	10°	E
28 Feb	-3.8	05:27:40	32°	W	05:29:06	85°	N	05:32:28	10°	E
01 Mar	-3.5	04:40:57	66°	E	04:40:57	66°	E	04:43:53	10°	E
01 Mar	-3.7	06:13:57	10°	W	06:17:18	74°	SSW	06:20:38	10°	ESE
02 Mar	-1.0	03:54:14	19°	E	03:54:14	19°	E	03:55:19	10°	E
02 Mar	-3.9	05:27:07	28°	W	05:28:43	86°	SSW	05:32:05	10°	E
03 Mar	-3.7	04:40:23	74°	E	04:40:23	74°	E	04:43:29	10°	E
03 Mar	-3.2	06:13:33	10°	W	06:16:46	46°	SSW	06:19:59	10°	SE
04 Mar	-1.2	03:53:40	20°	E	03:53:40	20°	E	03:54:51	10°	E
04 Mar	-3.7	05:26:33	26°	W	05:28:13	61°	SSW	05:31:31	10°	ESE
05 Mar	-3.7	04:39:51	70°	SSE	04:39:51	70°	SSE	04:42:56	10°	ESE
06 Mar	-1.2	03:53:11	19°	E	03:53:11	19°	E	03:54:17	10°	E
06 Mar	-3.0	05:26:05	24°	WSW	05:27:30	35°	SSW	05:30:34	10°	SE
07 Mar	-3.1	04:39:29	42°	SSE	04:39:29	42°	SSE	04:42:07	10°	SE

END IMAGES, AND OBSERVING

.While setting up to find the comet 2022 E3 ZTF is it skipped by Polaris I used Dubhe in Ursa Major as my 2nd alignment star (just around neighbours house) then worked up to M81 and M82 galaxies in Ursa Major, on the way to the comet (then 30 million miles from Earth, but M81 and M82 are galaxies 12 Million light years away, to the bottom right is smallerngc 3077 just over 13 million light years away. 60 second exposures. Nikon D810a on 5" refractor.

Observing Sessions

Proposed Observation Sessions for 2022-2023

Planned observing evenings will be on a Friday night in the Lacock playing fields behind the Red Lion pub at 19:00 or an Hour after sunset depending on the time of year.
With the New Moon being around the beginning of the month and the full moon generally around the middle, the following dates for observing are proposed:

a ad-hoc session for other reasons and at other locations, such as astro-photography, solar observing etc, with other like-minded members then they can do so through the Society Members Facebook Page or through the WAS contact page on the website.

Opportunity	Day	Date	Month	Set-up	Observe
First	Friday	10th	February	18:30	19:00
Second	Friday	17th	February	19:00	19:30
Third	Friday	24th	February	19:00	19:30
First	Friday	17th	March	19:00	19:30
Second	Friday	24th	March	19:30	20:00
First	Friday	14th	April	20:00	20:30
Second	Friday	21st	April	20:30	21:00
First	Friday	12th	May	20:30	21:00
Second	Friday	19th	May	20:30	21:00

OUTREACH:

No Outreach commitments booked