Newsletter for the<br>Wiltshire, Swindon,<br>Beckington, Bath Astronomical Societies

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## Happy New Year and another lock in. Stay Safe

The lock downs are certainly affecting astronomy now. A lot of providers of outreach astronomy are now looking at more time with zero income and this is hitting hard.

I was just lining some schools for Zoom sessions for January and then the schools are closed for an unknown period. Crazy times.
And now is not the time to try and buy and astronomical equipment, especially from Europe with the government in its infinite wisdom and interpretation of taxation and duty meaning anything over £135 incurring duty charges, and then VAT to be paid on the goods price AND the incurred duty, an effective double taxation. Some suppliers are now refusing to export into the UK until something is sorted out.
However the government IS starting a new ministry for dark skies, with a minister and the RAS coordination because astronomy and dark skies sites were being seen as potential stay at home big business. The ministry will not promise clear skies, but they hope to link the environmental departments and planning departments at some level. Where that will be is unknown. Talking to Wiltshire planning department officers they have heard NOTHING about this new ministry.
I hope you all stay well and have clear skies

Andy

Andy Burns is inviting you to a scheduled Zoom meeting.
$5^{\text {th }}$ January 2021 Wiltshire Astronomical Society Meeting
Topic: Andy Burns Sir John Herschel Time: Jan 5, 2021 07:45 PM London
Join Zoom Meeting
https://us02web.zoom.us/j/87548756423?
pwd=ZUt0azNuSjRERUUxZExFYjhRSEJ2d z09

Meeting ID: 87548756423
Passcode: 115227
Passcode: 580823

## 21/12/2020 2020 Sum-

 mer Solstice to 2020 Winter Solstice SolargraphsSix month exposure beer can pin hole camera using liford Multigrade Photographic Paper and post processed in Affinity Photo.
John Dartnell


## 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. During COVID19 ZOOM meetingd

HALL VENUE the Pavilion, Rusty Lane, Seend

## Meet 7.30 for 8.00 pm start

## SEASON 2020/21

2021
5 Jan Slough.
2 Feb
Andy Burns: Sir John Herschel, 1st Baronet of
Prof David Southwood/Moon and Mars the next Giant
2 Mar Pete Williamson/The moon \& Moons of the Solar System. 6 Apr Prof Mike Edmunds/The Clockwork universe.
4 May
1 Jun TBC Robert Harvey/Understanding the Universe.

Thank you Peter and those that have helped get a list together in the circumstances.

Membership Meeting nights $£ 1.00$ for members $£ 3$ for visitors

## Wiltshire AS Contacts

Andy Burns Chair, anglesburns@hotmail.com
Andy Burns Outreach and newsletter editor.
Bob Johnston (Treasurer) Debbie Croker (vice Treasurer)
Philip Proven (Hall coordinator) Dave Buckle (Teas)
Peter Chappell (Speaker secretary)
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

Father brought him into astronomy after a show down where John wanted to take the cloth

Became botanist (to entertain wife), geological specimen hunter
Introduced a plan to establish a new free for all education system in the colony. This included natives and ex slaves. There would be 25 schools and help for a further 25 run by missionaries. The Dutch felt beleaguered. For example, when in 1839 Herschel planned to build an observatory the Dutch complained that the English would not even leave their stars alone.

Returned to do chemistry, meteorology standard work (and where we see a nasty academic slant to John)
Helped Fox Talbot fix his images (photography is JH word plus others)

The Magaret Cameron picture is a staged 'mad scientist' joke
Discovered blue print
Became governor of the Mint
Influenced Darwin on evolution after study of geology. Trips with William.
Trips with William.

Philanthropist. Science should be above profit (Faraday and ice making)
Given a Baronacy at the coronation of queen Victoria

And this is just his life OUTSIDE astronomy.


## Swindon's own astronomy group

Due to the current crisis our meetings, like many other physical meetings have been suspended and replaced with Zoom meetings.
Next Zoom Meeting: David Bryant


David Bryant BSc, Cert Ed has been a full-time meteorite dealer for around 20 years. He has written numerous books and articles and lectured about meteorites to audiences of all ages and backgrounds.

On the 15th January, 2021 his subject will be 'Meteorites and their planet of origin'.

## Ad-hoc viewing sessions postponed

All ad-hoc meetings are currently cancelled until further notice.

Regular stargazing evenings are being organised near Swindon. To join these events please visit our website for further information.
Lately we have been stargazing at Blakehill Farm Nature Reserve near Cricklade, a very good spot with no distractions from car headlights.
We often meet regularly at a lay-by just outside the village of Uffcott, near Wroughton. Directions are also shown on the website link below.
Information about our evenings and viewing spots can be found here:
http://www.swindonstargazers.com/noticeboard/ noticeboard06.htm
For insurance reasons you need to be a club member to take part. If you think you might be interested email the organiser Robin Wilkey (see below). With this you will then be emailed regarding the event, whether it is going ahead or whether it will be cancelled because of cloud etc.

We are a small keen group and I would ask you to note that you DO NOT have to own a telescope to take
part, just turn up and have a great evening looking through other people's scopes. We are out there to share an interest and the hobby. There's nothing better than practical astronomy in the great cold British winter! And hot drinks are often available, you can also bring your own.
Enjoy astronomy at it's best!

Meetings at Liddington Village Hall, Church Road, Liddington, SN4 OHB - 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 2020

Friday 11 December Zoom meeting
Programme: Prof. Martin Hendry FRSE: Einstein Goes to Hollywood
Meeting Dates for 2021
Friday 15 January Zoom meeting Programme: David Bryant: Meteorites and their planet of origin
Friday 19 February Zoom meeting Programme: Prof Rene Breton: Cosmic Fireworks
Friday 19 March Zoom meeting
Programme: AGM + speaker: Viv Williams 'Setting up and using telescope mounts'

## Website:

http://www.swindonstargazers.com

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## 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 7.30 pm

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

## STAR QUEST ASTRONOMY CLUB

Meet at Sutton Veey near Warminster.

## BATH ASTRONOMERS

Bath Astronomers are holding webinar sessions linking in with Stargazers web sight.

The third of our series of Zoom lectures is coming up at 7.30 pm on Friday 6th November. You may have already received an email about it. I am making a special effort to reach out to more people with this one, as it crosses the boundary between Art and Physics, so it would be great if you could make your colleagues in the Wiltshire Astro Soc and others aware that this is an especially good lecture.

## SPACE NEWS JANUARY 21

## What colour is the sun?

By Benjamin Plackett 13 hours ago
All the colours of the rainbow.


NASA's Solar Dynamics Observatory caught an image of a mid-level solar flare emitted by the sun on Oct. 1, 2015. (Image: © NASA/SDO)
If you cast your mind back to school and can remember when your teacher shone light through a prism to create an artificial rainbow, then you'll probably already know the answer to this question.
"The entire sun and all of its layers are glowing," said Christopher Baird, an assistant professor of physics at West Texas A\&M University in Canyon, Texas. "The 'colour of the sun' is the spectrum of colours present in sunlight, which arises from a complex interplay of all parts of the sun." So essentially, if we're trying to figure out what colour the sun is, we need to dissect the sun's rays here on Earth and quantify them. There are a few different ways to do this and they aren't especially high-tech - in fact, most kids have probably done some version of this experiment.
"The colour content of a beam of light can easily be identified by running the beam through a prism," Baird told Live Science. "These simple, cheap, handheld objects spread out the beam of light into its various pure colour components. Each pure colour has a distinct wave frequency." That's why scientists tend to use the words "colour" and "frequency" interchangeably, because a ray of light's colour is defined by its frequency - for visible light, red has the lowest frequency and violet has a highest. The range of colours or frequencies in a beam of light is called a spectrum.
The electromagnetic spectrum, from highest to lowest frequency waves. (Image credit: Shutterstock)
When we direct solar rays through a prism, we see all the colours of the rainbow come out the other end. That's to say we see all the colours that are visible to the human eye.
"Therefore the sun is white," because white is made up of all the colours, Baird said.
The slightly more sophisticated way of doing this is with a camera, which takes a quantitative measurement of the brightness of light hitting different pixels, and therefore gives us a way to plot the brightness of the different frequencies in the solar spectrum. If one particular frequency were consistently brighter than any of the others, we could conclude the sun is a shade of that colour, but that's not the case. "When we do this, we find quantitatively that all of the visible colours are present in sunlight in approximately equal amounts," Baird said.
Critically, though, these frequencies aren't present in precisely the same amount, it's just that the variances aren't significant enough to be meaningful. "The colour components of sunlight are so close enough to being present in equal amounts that it is much more correct to say that the sun is white than to say it is yellow, orange, or any other single, pure colour," Baird said.
So, white it is then.
Originally published on Live Science.

## How long is a galactic year?

By Grant Currin - Live Science Contributor August 30, 2020
The galaxy is a big place, after all.


In one galactic year, also known as a cosmic year, the sun orbits the Milky Way.
(Image: © Shutterstock)
Humans are used to keeping time by measuring Earth's movement relative to the sun. But while Earth's trips around its star are noteworthy to life on our pale blue dot, that journey is pretty insignificant when compared with the epic voyage that carries the sun - and our entire solar system - around the center of the Milky Way.
Orbiting the Milky Way galaxy just once takes the sun approximately 220 million to 230 million Earth years, according to Keith Hawkins, an assistant professor of astronomy at the University of Texas at Austin.
In other words, if we were to measure time by this galactic
"clock," Earth would be about 16 years old (in galactic, or cosmic years), the sun would have formed about 20 years ago, and the universe would be just about 60 years old.
The solar system's journey around the galaxy resembles Earth's orbit around the sun. But rather than orbiting a star, the sun circles the supermassive black hole that lies at the center of the Milky Way, Hawkins said. It exerts a tremendous amount of gravity on objects near the center of the galaxy, but it's the gravity exerted collectively by the material in the Milky Way itself that keeps the sun in its orbit.
"The sun is moving with enough speed - about 230 kilometers a second, about the equivalent of 500,000 miles per hour - that it continues to revolve around the center of the galaxy in sort of a circle" instead of getting pulled toward the black hole, he said.
Our place in the galaxy
Compared with an Earth year, a galactic year represents time on a grand scale - but it's not a consistent measurement across the galaxy. What we Earthlings call a galactic year is specific to Earth's place in the Milky Way's spiral.
"We would say that a galactic year is 220, 230 million years. Other stars in the galaxy, their galactic year is different," Hawkins said.
The galaxy is about 100,000 light-years across, and the Earth is about 28,000 light-years from its center. "If you imagine the galaxy as a city, the Earth is somewhere near the suburbs," Hawkins explained. For stars that orbit close to the black hole - the center of the "city" - a galactic year is relatively short. Out in the "suburbs," where our solar system lies, "the galactic years are a little longer," he said.
Similar rules control variability in the length of a year between planets. For instance, Mercury, the innermost planet in our solar system, makes a complete orbit around the sun in about 88 Earth days. Uranus, the seventh planet from the sun, orbits the sun every 84 years, by Earth standards. And the distant dwarf planet Pluto takes 248 Earth years to finish one orbital cycle.
While the physics of planetary orbits are similar to the mechanisms that shape the orbit of our solar system around the Milky Way, it's worth asking how astronomers have figured
out the span of a galactic year. Hawkins says that it's actually pretty basic science that became clear in the early days of modern astronomy.
"It's mostly about watching stars move around the galaxy," he said. "You can watch stars move around the galaxy and deduce from the speed and direction of other stars." Editor's Note: This story was updated on Aug. 31 to note that the sun stays in its orbit around the Milky Way not just because of the black hole at the center of the Milky Way but also due to the gravity exerted collectively by the material in the Milky Way.

## Astronomers Discover Hundreds of HighVelocity Stars, Many on Their Way Out of the Milky Way

Within our galaxy, there are thousands of stars that orbit the center of the Milky Way at high velocities. On occasion, some of them pick up so much speed that they break free of our galaxy and become intergalactic objects. Because of the extreme dynamical and astrophysical processes involved, astronomers are most interested in studying these stars - especially those that are able to achieve escape velocity and leave our galaxy. However, an international team of astronomers led from the National Astronomical Observatories of China (NAOC) recently announced the discovery of 591 high-velocity stars. Based on data provided by the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) and the ESA's Gaia Observatory, they indicated that 43 of these stars are fast enough to escape the Milky Way someday.
The study was published in The Astrophysical Journal Supplement Series on Dec. $17^{\text {th }}$. The study was led by Dr. LI Yinbi, an NAOC astronomer, and included researchers from the Chinese Academy of Sciences (CAS), the Max-Planck Institute for Astronomy (MPIA), the Institute for Advanced Study, the European Southern Observatory (ESO), the ExtantFuture Technology Co., the Institute of Statistical Mathematics in Tokyo, and multiple universities.


An artist's conception of a hypervelocity star that has escaped the Milky Way. Credit: NASA
In terms of astrophysical studies, high-velocity stars are a relatively recent discovery. The first was observed in 2005, and in the subsequent 15 years, over 550 have been discovered by multiple observatories. From these, astronomers have been able to deduce four subclasses of high-velocity stars, which include: hypervelocity stars, runaway stars, hyper-runaway stars, and fast halo stars.
This latest discovery is especially significant then because it effectively doubles the number of known high-velocity stars, which are quite rare in our galaxy. "The 591 high-velocity stars discovered this time doubled the total number previously discovered, bringing the current total number exceeding 1,000," said Dr. Li.
Hypervelocity stars (HVS), the fastest of the bunch, are especially interesting because they have achieved relativistic speeds (a fraction of the speed of light). In fact, astronomers have estimated that with the right kind of gravitational acceleration, hypervelocity stars can reach $1 / 10^{\text {th }}$ to $1 / 3^{\text {rd }}$ the speed of
light - roughly 30,000 to $100,000 \mathrm{~km} / \mathrm{s}(18,640$ to $62,130 \mathrm{mi} /$ s).

It is these stars that have the escape velocity needed to leave the Milky Way. Said Prof. LU Youjun from NAOC, a co -author of this paper:
"Though rare in the Milky Way, high-velocity stars, with unique kinematics, can provide deep insight into a wide range of Galactic science, from the central supermassive black hole to distant Galactic halo."


The positions and reconstructed orbits of 20 high-velocity stars, represented on top of an artistic view of the Milky Way. Credit: ESA/Marchetti et al. 2018/NASA/ESA/Hubble "Rare" is certainly an apt description. According to previous estimates made by astrophysicists, there are likely to be just 1000 HVS in our galaxy (that's $0.0000005 \%$ of the galactic population). But given their speed and the vast distances they travel, tracking these stars and creating a database of their movements could tell us a great deal about a number of cosmic mysteries.
For the sake of their study, the international team relied in part on data provided by LAMOST. In addition to being the largest optical telescope in China, LAMOST has the highest spectral acquisition rate of any telescope in the world and can observe about 4,000 celestial objects in a single exposure. Since it began conducting surveys in 2012, it has established the world's largest spectra database.
In addition, the team relied on astrometric measurements performed by the Gaia Observatory, which was launched by the European Space Agency (ESA) in 2013. Since then, it has gathered information on the location, proper motion, and velocity of over 1.3 billion celestial objects, making it the largest astrometric database in the world. Both observatories and their massive databases have been invaluable in the detection and study of HVS.
Based on the motion and composition of the objects they observed, the research team identified 591 HVS that originated in the Milky Way's inner halo. "Their low metallicities indicate that the bulk of the stellar halo formed as a consequence of the accretion and tidal disruption of dwarf galaxies," said co-author Prof. Zhao Gang of the CAS School of Astronomy and Space Science.
One of the greatest takeaways from this study the way it demonstrates how combining multiple large surveys can lead to the discovery of rare objects. In the future, astronomers will be able to draw from even larger databases containing survey data provided by next-generation instruments. This data will be especially useful in the study of Dark Matter, the mysterious mass that constitutes $27 \%$ of the massenergy density of the Universe.
By tracking the movement of HVS, astrophysicists will be able to better constrain the shape of the Milky Way's dark matter halo. In addition, they could tell us a great deal about the formation and evolution of the Milky Way itself, as HVS are believed to be the result of galactic mergers and other extreme gravitational forces (i.e. supermassive holes). Having more to study could therefore help astronomers create a history of past galactic mergers.
It has also been ventured that HVS could allow astrophysicists to accurately constrain the mass of our galaxy, something that remains unresolved. On top of all that, previous
research has indicated that HVS can carry their planetary systems with them, which could be one of the ways that life is spread throughout the cosmos (intergalactic panspermia).
Further Reading: Chinese Academy of Sciences, The Astrophysical Journal

## Astronomers Improve Their Distance Scale for the Universe. Unfortunately, it Doesn't Resolve the Crisis in Cosmology

Measuring the expansion of the universe is hard. For one thing, because the universe is expanding, the scale of your distance measurements affects the scale of the expansion. And since light from distant galaxies takes time to reach us, you can't measure what the universe is, but rather what it was. Then there is the challenge of the cosmic distance ladder.
The distance ladder stems from the fact that while we have lots of ways to measure cosmic distance, none of them work at all scales. For example, the greatest distances are determined by measuring the apparent brightness of supernovae in distant galaxies. That works great across billions of light-years, but there aren't enough supernovae in the Milky Way to nearby measure distances. Perhaps the most accurate distance measurement uses parallax, which measures the apparent shift in the position of a star as the Earth orbits the Sun. Parallax is a matter of simple geometry, but it's only accurate to a couple of thousand lightyears.

The Cosmic Distance Ladder:


Some of the methods used to measure cosmic distances. Credit: Tabitha Dillinger
Because of this, astronomers often measure scale by building one method upon the other. Use parallax for the closest stars, including a type of variable star known as Cepheid variables. Cepheids vary in brightness proportional to their average luminosity, so you can use them to measure distances up to 100 million light-years or so. Supernovae occur all the time within that range, so you can then use supernova measurements to determine distances over billions of light-years. These aren't the only methods used in the cosmic distance ladder, but each method has a limited range and a limited accuracy.
Since there is an uncertainty to any measurement you make, errors can build in the distance ladder. If your parallax measurements are a bit off, then your Cepheid measurements will be more off from the get-go, and your supernova measurements are even less accurate. Because of this, when we measure cosmic expansion using different methods we get results that disagree slightly. This is known as cosmic tension. In the past, this wasn't a huge problem. While different methods gave different results, the uncertainty of measurement was large enough that results overlapped. But as our measurements get more accurate, they aren't overlapping anymore. They downright disagree.


The new distance ladder measure disagrees with the Planck measure. Credit: Riess, et al
To resolve this problem, a team of astronomers recently focused on making the cosmic distance ladder more accurate. Their focus is on parallax measurements, which is the ground on which the distance ladder stands. In this case, they use data from the Gaia spacecraft. Gaia has measured the parallax and motion of more than a billion stars, including Cepheid variable stars. From this, the team reduced the uncertainty of the Cepheid distance method to just $1 \%$. Using this new result in the cosmic distance ladder, they get a measurement for the Hubble constant (the rate of cosmic expansion) to be between 71.6 and $74.4 \mathrm{~km} / \mathrm{sec} / \mathrm{Mpc}$. This is great, but it further conflicts with other methods, particularly data from the Planck satellite measurement of the cosmic microwave background, which gives a value of between 67.2 and $68.1 \mathrm{~km} / \mathrm{sec} / \mathrm{Mpc}$.
It seems the more accurate our measurements, the worse the tension problem becomes. There's something about cosmic expansion we clearly don't understand, and we can only hope that more and better data will lead us to a solution.
Reference: Riess, Adam G., et al. "Cosmic Distances Calibrated to 1\% Precision with Gaia EDR3 Parallaxes and Hubble Space Telescope Photometry of 75 Milky Way Cepheids Confirm Tension with LambdaCDM." arXiv preprint arXiv:2012.08534 (2020).

## Some of Hayabusa2's Samples are as Big as a Centimetre

A fireball hurtled across the sky on December $5^{\text {th }}$ - the sample return capsule from the Hayabusa2 asteroid mission by JAXA (Japan Aerospace Exploration Agency). The capsule landed in Woomera, a remote location in the Australian Outback. Earlier this month, the capsule's sample containers revealed fine grain topsoil from asteroid 162173 Ryugu. A second sample container has since been opened that contains chunks up to an entire centimetre in size.


Soil Samples returned by the Hyabusa2 Spacecraft -c JAXA Lighten the Load

These larger fragments are thought to be pieces of bedrock from Ryugu. They were collected during Hayabusa2's sec-
ond touchdown in July 2019 to collect subsurface soil. Topsoil was collected on the first touchdown in February of 2019. Hayabusa2 was able to make multiple touchdowns on the surface because Ryugu only experiences microgravity being a relatively small asteroid only 1 kilometer in diameter.
The low gravity allows Hayabusa2 to "hover" just above the asteroid's surface and use a sample "horn" to collect soil. On the first touchdown, the probe fired a small 5 g tantalum projectile into the surface at $300 \mathrm{~m} / \mathrm{s}$. In the microgravity, the ejected material could travel upward along the probe's horn funneled into the sample collector. A second scheduled topsoil collection was scrubbed. A suitable landing site was difficult to locate because of Ryugu's uneven, rocky terrain.


Rotation of Ryugu captured by the Huabysa2 Probe CC BY 4.0 JAXA
The subsurface soil collection in July 2019 was achieved by literally bombing the surface of Ryugu with the equivalent of an armour piercing anti-tank projectile. Hayabusa2 deployed a free-flying gun 500 m from Ryugu's surface while itself moving to a safe location to avoid being hit by debris. Hayabusa2 also deployed a detachable camera which remained to watch the impact while Hayabusa2 was out of harm's way. The gun then detonated a explosive, launching a 2.5 kg copper round at the surface.


Impact site on Ryugu created by the Hayabusa2 free floating gun - JAXA
The resulting impact created a 10 m wide crater exposing subsurface soil later collected by the probe. The large 1 cm chunks in the container could be fragments of bedrock shattered by the impact that then broke into smaller pieces as they entered the collection compartment. The material collected from Ryugu also includes gas samples, likely released from the soils, which marks the first time that extraterrestrial gas has ever been collected from space.
"The sample of the asteroid extraterrestrial material that we dreamed about is now in our hands"

## Yuichi Tsuda -Hyabusa2 Project Manager A Blast From the Past

Samples of soil and gases have yielded more material than the Hayabusa2 team had anticipated which is great for followup research. The team will analyze the soil to learn more about the asteroid itself and gain insights to the early history of our Solar System. Asteroids like Ryugu are floating time capsules orbiting our Sun with a record of the Solar System's past. Blasting Ryugu revealed soils that are shielded from solar radiation and the surrounding Solar System environment - essentially a preserved state from the asteroid's formation billions of years ago. Ryugu was chosen as a target because it is a "C-Type" or carbonaceous asteroid - primordial stone from the early Solar System.
These samples will be analyzed for organic material which can help us understand how organic material was spread through the young Solar System and if it shares any relationship to life on Earth. So while we're learning about the history of the Solar System, Ryugu may yield secrets of our own past as well.
We've also learned more about Ryugu the asteroid itself. In addition to soil sample collection, Hayabusa2 landed 4 different rovers on the surface. Rather than rolling around on wheels, these "hopped" using spinning masses to torque themselves off the surface in low gravity.


Ryugu's night surface imaged by the Hyabusa2 MASCOT rover using red green, and blue LEDs for illumination. MASCOT/JAXA
The rovers were able to capture stunning pictures and video from the asteroids surface. Ryugu was determined to be a "rubble pile" object in the Solar System. Rather than a solid mass, Ryugu is $50 \%$ empty space - a lumped collection of rocks loosely held together by gravity. This could indicate that at some time in the past, Ryugu was shattered by a cosmic impact and then coalesced under its own gravity as a pile of rocky fragments.
Video captured from the surface of Ryugu with Hyabusa2's rovers showing the asteroids "day" with a setting sun - JAXA Voyage Home

After retrieving the samples, Hayabusa2 completed a 13 month return journey to Earth. At a distance of 220,000km the probe released a capsule containing the gas and soil samples which entered Earth's atmosphere on Dec $5^{\text {th }}$ travelling at $12 \mathrm{~km} / \mathrm{s}$ creating a long-tailed fireball. Both the outbound journey to Ryugu and the return journey logged a total of 5.24 BILLION km. The solar system is really, really big. The containers were located by several retrieval teams in the Australian Outback.

Video captured of Hayabusa2's return sample capsule streaking through Earth's atmosphere - JAXAReturn sample Replica of Hayabusa's sample-return capsule (SRC) used for re-entry. Hayabusa2's capsule is of the same size, measuring 40 cm (16 in) in diameter and using a parachute for touchdown. CC BY-SA 3.0 Mj-bird

## Back into the Expanse

This isn't the end of Hayabusa2's mission. Having completed its primary mission, the probe is now headed to rendezvous with another asteroid, $1998 \mathrm{KY}_{26}$ Scheduled for July 2031. 1998KY ${ }_{26}$ is much smaller than Ryugu at only 30 m in diameter and is considered a rapidly rotating microasteroid making one rotation every 10.7 minutes. Hayabusa2's rendezvous will mark the first visit to one these rapidly rotating objects as well as the smallest object in the Solar System to be visited by a spacecraft. JAXA isn't finished sampling rocky worlds either. A mission is planned for the mid 2020's to sample the Martian moon Phobos. Universe Today Fraser Cain talks about JAXA mission to sample Phobos
This era of robotic exploration of the Solar System is astonishing. Think of all that we just accomplished with one 600 Kg space probe. It fits four rovers, a deployable space gun, detachable camera, and its host of senor equipment all in one probe. That and it can do multiple journeys to and from Earth as it explores space. We're gearing up for more human exploration of the Solar System but, in the meantime, robots are doing the heavy lifting (or microgravity lifting). I'm already counting down to Perseverance's' landing on Mars in just a month and a half!

## Layers Upon Layers of Rock in Candor Chasma on Mars

In many ways, Mars is the planet that is most similar to the Earth. The red world has polar ice caps, a nearly 24 -hour rotation period (about 24 hours and 37 minutes), mountains, plains, dust storms, volcanoes, a population of robots, many of which are old and no longer work, and even a Grand Canyon of sorts. The 'Grand Canyon' on Mars is actually far grander than any Arizonan gorge. Valles Marineris dwarfs the Grand Canyon of the southwestern US, spanning $4,000 \mathrm{~km}$ in length (the distance between LA and New York City), and dives 7 kilometers into the Martian crust (compared to a measly 2 km of depth seen in the Grand Canyon). Newly released photos from the HighResolution Imaging Science Experiment (HiRISE) aboard the Mars Reconnaissance Orbiter (MRO) reveal a stunning look at eroding cliff faces in Candor Chasma, a gigantic canyon that comprises a portion of the Valles Marineris system.


Three progressively closer looks at the HiRISE image site (represented by the white rectangle) within Candor Chasma. Credit: Google Mars
This spectacularly detailed look at the geographic features of Candor Chasma reveals a detailed look at layers of sedimentary rock, helping to deepen our understanding of the depositional processes that laid these strata over billions of years.
The resolution of the visible wavelength images shows details down to the scale of a single meter, allowing the visualization of rocks as small as an average golden retriever. HiRISE also observes in the near-infrared portion of the electromagnetic spectrum, and the resolution of these IR images acquires pixels a mere 30 centimeters wide, more like the size range of a toy poodle (it isn't necessary to convey resolution in terms of dogs, but it can be helpful when conveying the magnitude of such imagery to folks that are less familiar with space).


The High-Resolution Imaging Science Experiment or HiRISE camera system (shown before flying to Mars)


Credit: NASA/JPL/University of Arizona
Valles Marineris can be seen stretching for thousands of kilometers across the face of Mars. Credit: NASA
A close look at the HiRISE images shows jagged bedrock jutting out of windswept sand and dust, and also shows gully-like channels, possibly from seasonal runoff of liquid water down the sloping cliff-faces. As with most finely detailed image-capture systems, HiRISE sacrifices field of view for a crisp, highly detailed look at the subject planet. In order to choose good HiRISE targets, a wider view is necessary. MRO uses another instrument with a much wider field of view to gain context from which to make scientific observation decisions. This context-gathering camera is known as the Context Camera, or CTX. CTX gives huge views of the Mars, showing large-scale geological (geo is Greek for Earth, perhaps it should be ares-ological?) features, painting a big picture of the planet.


The Context Camera, or CTX, takes big-picture views of the terrain surrounding smaller rock and mineral targets for other instruments aboard the Mars Reconnaissance Orbiter. Credit: NASA/ JPL/University of Arizona
This kind of broad view instrument paired with a detailed, close-up camera, is reminiscent of more down-to-Earth setups that Universe Today readers may already be familiar with. CTX can, in some ways, be thought of as a kind of finder-scope like that seen on a telescope. An amateur astronomer would first use their finder scope to aim in a broad area of interest and locate a specific portion of the sky to then probe deeply with the much narrower view provided by the main telescope, or in this case, HiRISE.


Another HiRISE image of Candor Chasma shows bright mineral deposits streaked across the canyon. Credit:


A broad overview of a crater on Mars taken with CTX. Oddly, smaller features within the crater have led to the uncanny resemblance to a "happy face". Credit: NASA/JPL/Malin Space Science Systems
By collecting broad, big-picture views, and simultaneously taking astonishingly high-resolution close up looks, we are gaining a better sense of the structure of Candor Chasma, Valles Marineris, and the overall geological processes and deep history of Mars. Unlike the Arizonan canyon, Valles Mariners was not formed by surface river erosion. Which geological process could be behind the formation of the largest canyon known to humankind? Is it a dry process like the depression of a chunk of crust along parallel faults known as a graben? Another possibility that may be responsible for some of the formation of such features is the dissolution of various rocks by subsurface water in what geologists call karst.


Mars Perseverance launching from Cape Canaveral on July 30, 2020. Credit: NASA/Joel Kowsky
The watery past of Mars is a big part of what makes it such a fascinating planet to study. The Mars Perseverance Rover, already on the way and slated to land in mid-February 2021, will be landing on what is thought to be shore of an ancient

Martian ocean. Large bodies of liquid water are very rare outside of the Earth, and are thought to be a necessary ingredient for the rise of living things. It goes without saying that finding evidence of life on another planet, even if it has since gone extinct, would be as impactful a scientific discovery as is possible.
Lead Image: HiRISE image of Candor Chasma reveals layers upon layers of sedimentary rock on Mars. Credit: NASA/JPL/University of Arizona

## Planetary Scientists Have Created a Map of Mars' Entire Ancient River Systems

Navigating and mapping rivers has long been a central component in human exploration. Whether it was Powell exploring the Colorado's canyons or Pizarro using the Amazon to try to find El Dorado, rivers, and our exploration of them, have been extremely important. Now, scientists have mapped out an entirely new, unique river basin. This one happens to be on an entirely different planet, and dried up billions of years ago. Three to four billion years ago, Mars did in fact have running rivers of water. Evidence for these rivers has shown up in satellite imagery and rover samples for almost as long as we have been exploring the red planet. Since Mars has little tectonics or erosion, that evidence has remained somewhat intact until the present day.
Youtube video discussing Mars' rivers.
Credit: Anton Petrov
Recently, a team of scientists developed a tool to better examine those features. They managed to stitch together an 8 -trillion pixel image of the entire Martian surface. Each pixel in this incredibly detailed image represents about a 56 square meter area. Unfortunately, it also doesn't seem to available to the general public just year. Whether it is or not it is sure to prove useful for a variety of research projects regarding the environment of Mars. One of the first ones, which was recently published a paper
in Geology was a map of the red planet's river "ridges". The old dried up riverbeds on Mars are well mapped, and have been for quite some time, starting with Giovanni Schiaparelli's famous "canali". However, there are other features of rivers that geologists like to study. One of the most important is the ridges described in the paper.


Some highly detailed pictures of the Martian river systems as part of the 8 trillion pixel image of the surface.
Credit: J.L. Dickson et all.
River (or "fluvial") ridges are caused by the sediment that a river erodes away during its journey downhill. The sediment a river picks up is occasionally picked up and deposited in different spots, resulting in ridges that can grow to be significant in size. Deltas such as those of the Nile and the Mississippi are examples of this sedimentary deposition process.
Like the rivers on Earth, Mars had a similar process taking place back when it had liquid water running on its surface. In the past, scientists had tried to inventory the fluvial ridges using data from 1997-2006, but the data itself was not detailed enough to make out the sort of features needed for a full inventory.


Stunning picture of the Mississippi River Delta. Similar river deltas would have been present on Mars billions of years
ago.
Credit: NASA
That more detailed data has now been made available with the stitched together image of the entire Martian surface. Interestingly, only the southern hemisphere of the planet appears to have these ridges. The best explanation as to why is that the northern hemisphere has been more dramatically resurfaced in the intervening billions of years, primarily due to lava flows.
The southern hemisphere, on the other hand, is "some of the flattest surfaces in the solar system" according to Woodward Fischer, one of the paper's authors. These flat surfaces are ideal to detect the ridges that sedimentary deposition would create. It is easier to distinguish the extra material when the surrounding area doesn't have significantly differing heights as part of the natural geological features.


Schiaparelli's original map of Mars showing river basins and highlands.
Credit : Giovanni Schiaparelli
In addition to simply being a really cool use for this new detailed map, the study is a helpful guide to the geological and environmental processes on Mars. Understanding where these ridges exist can potentially help lead future rover missions to a deposit of some interest. Any additional information that can be gleaned from these sedimentary processes would be welcomed by the geological community. It can also contribute to our increasingly high resolution understanding of the Martian surface. With that scientific goal in mind, the surveyor of the next great unexplored river system might just be a robot.
Learn More:
The Geological Society of America: Fluvial Mapping of Mars
Geology: The global distribution of depositional rivers on early Mars
American Geophysical Union: Global Map of Martian Fluvial Systems: Age and Total Eroded Volume Estimations UT: Was This Huge River Delta on Mars the Place Where its Oceans Finally Disappeared?
Lead Image: Example of fluvial ridges on Mars.

## Credit: J.L. Dickson

## Astronomers Capture a Direct Image of a Brown Dwarf

The field of exoplanet photography is just getting underway, with astronomers around the world striving to capture clear images of the more than 4000 exoplanets discovered to date. Some of these exoplanets are more interesting to image and research than others. That is certainly the case for a type of exoplanet called a brown dwarf. And now scientists have captured the first ever image of exactly that type of exoplanet.
Brown dwarfs are "substellar objects" - they do not have enough mass to spark nuclear fusion in their core, and therefore were not able to become an actual star, but are much more massive than any traditional planet. The one imaged by a team of astronomers at the Subaru Telescope and the W. M. Keck observatory in Manuakea has a mass 46 times that of Jupiter.
This particular brown dwarf is interesting for reasons other than its size though. Of primary interest is its orbital path
and the stellar system it resides in. The planetary system it resides in is known as HD 33632. The star in HD 33632 is a main sequence star, in many ways similar to our sun. The brown dwarf, now named very creatively as HD 33632 Ab , orbits around the star at a distance of about 20 AUs (approximately the distance from Mercury to Pluto). That solar distance combined with the similarities between HD 33632's star and our sun make the existence of a brown dwarf in that system highly informative to models predicting how those systems might be formed. The image the scientists captured also provides valuable data points for the analysis of other directly imaged exoplanets. There is a chance the atmosphere of the HD 33632Ab may contain carbon monoxide and water, making it a useful barometer for comparing other exoplanets atmospheres.
Our ability to see any exoplanet's atmosphere, even one as big as HD 33632Ab, are thanks to advances in adaptive optics and near-infrared imaging systems. Those systems on the Subaru and Keck observatories joined together to snap this unique image. Subaru leveraged it's exoplanet hunting system SCExAO/ CHARIS while Keck contributed images from a nearinfrared camera called NIRC-2. These combined instruments resulted in a much more clearly defined picture than would have been possible with only one of the observatories.


Graphic depicting the sizes of brown dwarfs compared to planets and stars.
Credit: NASA
This finding certainly won't be the last application of that combination of powerful exoplanet imaging technologies. Nor will it be the last exoplanet, or brown dwarf, that we as a species will directly image. But as these images start to trickle in, what we will begin to find will hopefully become more and more fascinating as we begin to take a peek at these newly discovered worlds.
Learn More:
W. M. Keck Observatory: Direct image of newly discovered brown dwarf captured
UT: Astronomers find 100 brown dwarfs in ours neighborhood
TechExplorist: This is the direct image of a newly discovered brown dwarf
Sci-News.com: Astronomers Directly Image Brown Dwarf Around Nearby Sun-like Star
Lead Image: Direct image of the stellar system HD 33632, including the brown dwarf on the right of the screen.
Credit: W. M. Keck Observatory

## ESA is Working on its own Reusable Booster Stage

It's an exciting time for space exploration! All around the world, national space agencies are sending missions to deep-space and preparing to send astronauts to orbit and the Moon. At the same time, the commercial aerospace industry (NewSpace) is expanding to include more launch providers and service new markets. These developments
are adding up and making space more cost-effective and accessible.


One such development of the emergence of reusable rockets, which are reducing the cost of individuals launches down considerably. Earlier this month (Dec. $15^{\text {th }}$ ), the European Space Agency (ESA) contracted with aerospace giant ArianeGroup to develop a reusable rocket. As part of the Themis Program, the ESA will use this rocket to evaluate the technologies involved for potential use on future European launch vehicles.

## Brines Could be Present on the Surface of Mars for up to 12 Hours, Never for a Full day

We are extremely interested in the possibility of water on Mars, because where there's water, there's the potential for life. But a new study throws a bit of a wet blanket (pun intended) on that tantalizing possibility. Unfortunately, it looks like even the saltiest of brines can only exist on the Martian surface for up to a few hours at a time.
Water is a very tricky thing to keep in a liquid state. Despite the fact that it's the most common molecule in the universe, it's almost always frozen as ice or evaporated into a gas.
Usually, liquid water needs something to hold it in and keep it in the right pressure and temperature regime. On Earth, we have a thick atmosphere, and some moons of the outer solar system have thick icy shells.
But Mars has neither, and so while it had abundant water on its surface billions of years ago, there's likely nothing left. Still, astronomers have been searching for any hints of moisture on the surface, especially in the form of brines: super-salty solutions that have enough added chemicals to keep the water in a liquid state, despite the extremely low pressures and frigid temperatures
While those searches have come up inconclusive, Earthbound scientists have turned to ways to test the possibility: building Mars simulation chambers, like the one at the University of Arkansas.
Combining data from those simulations and maps of total sunlight across the face of Mars, researchers have delivered some grim news: brines don't like it on the red planet, either.
After taking into account all the possible phase changes of water, including freezing, melting, and evaporating, the researchers found that previous studies uniformly overestimated the stability of brines. At most, even in the midlatitudes where the chances are highest, brines can survive on the surface for only up to 12 hours
That's not even a full day. If there is life on Mars, it's not exactly having a good time.

## To Help Trudge Through the Snow, the Chang'e-5 Recovery Team Wore Powered Exoskeletons

Other worlds aren't the only difficult terrain personnel will have to traverse in humanity's exploration of the solar system. There are some parts of our own planet that are inhospitable and hard to travel over. Inner Mongolia, a northern province of China, would certainly classify as one of those areas, especially in winter. But that's exactly the
terrain team members from the China Aerospace Science and Technology Corporation (CASTC) had to traverse on December 16th to retrieve lunar samples from the Chang'e-
5 mission. What was even more unique is that they did it with the help of exoskeletons.
Strangely enough, the workers wearing the exoskeletons weren't there to help with a difficult mountain ascent, or even pick up the payload of the lunar lander itself (which only weighed 2 kg ). It was to set up a communications tent to connect the field team back to the main CASTC headquarters in Beijing.
The exoskeletons were designed to help people carry approximately twice as much as they would be able to. Local state media described a single person carrying 50 kg over 100 m of the rough terrain without becoming tired. Setting up communications equipment isn't all the exoskeletons are good for though. They were most recently used by Chinese military logistics and medical staff in the Himalayas, where the country has been facing down the Indian military over a disputed line of control.
One advantage those workers had is that they didn't have to charge their suits. The exoskeletons used for the Chang'e-5 mission were unpowered. This was a conscious design decision, given the harsh environments the suits will operate in. Bad weather can knock out electrical systems, and a powered exoskeleton without any battery simply becomes more weight to carry rather than a helpful tool. However, they will be less useful in eliminating fatigue without the extra push of electric motors.
Powered or not, this is certainly not the last time such suits will be used on space exploration missions. Similar technology could help future space explorers navigate the terrain of even less hospitable environments off world. The suits would just need to hitch a ride on a rocket first.

## One of the Largest, Most Complete Einstein Rings Ever Seen. Astronomers Call it the "Molten Ring"

A very rare astronomical phenomenon has been in the headlines a lot recently, and for good reason. It will be hundreds of years until we can see Jupiter and Saturn this close to one another again. However, there are some even more "truly strange and very rare phenomena" that can currently be observed in our night sky. The only problem is that in order to observe this phenomena, you'll need access to Hubble.
As always, Hubble provides an absolutely breathtaking pictures This particular one depicts a gravitational lensing effect that gives an almost perfect example of an "Einstein Ring". The image of this ring, called GAL-CLUS-022058s, or, in an enlightened bit of astronomical branding, the "Molten Ring", was released late last week.
That branding idea came partially from the physical appearance of the object, which indeed looks like a molten metal ring. But it also came from the location of the object itself. Located in the southern constellation Fornax (the Furnace), the image depicts an extremely far away galaxy whose light is bent by a much closer galaxy cluster.


Another Einstein Ring. This one is named LRG 3-757. This one was discovered by the Sloan Digital Sky Survey, but this image
was captured by Hubble's Wide Field Camera 3.
Credit: NASA/Hubble/ESA
One of the advantages of this lensing effect is that it actually allows scientists to better study the farther away galaxy, which might have been completely invisible otherwise. While this is not the only known example of the phenomena happening, it is one of the most striking. But there's still lots more to potentially find, which Hubble will continue to do, no matter how our solar system's planets align.

## Astronomy 2021: Top Events for the Coming Year

Eclipses, meteor showers, occultations and more in store for the next year of astronomy 2021.
Ready for another exciting year of skywatching? 2020 produced several memorable astronomical events, including a surprise naked eye comet C/2020 F3 NEOWISE, the sure-fire Geminid meteors, and a fine, once in a lifetime close pairing of Jupiter and Saturn rounding out the year.
The Sun also awoke from its slumber, as Solar Cycle \#25 (finally) got underway in earnest, with the last half of 2020 producing some of the most massive sunspots of recent years. Expect more of the same in 2021, along with increased aurora activity, as we head towards the peak of the 11-year solar maximum in mid-2025.


A sunrise sunspot in late 2020... more of the same in store for 2021? Credit: Dave Dickinson

## Top 10 Astronomical Events for 2021

First, here is a distilled list featuring the very the 'best of the best' events for the coming year, in chronological order: Starting in January: mutual eclipse season for Jupiter's moons.
April $17^{\text {th }}$ : An occultation of Mars by the Moon.
May $\mathbf{2 6}^{\text {th. }}$ : A total lunar eclipse.
June $10^{\text {th }}$. An annular solar eclipse.
June $23^{\text {rd }}$ : Mars crosses the Beehive cluster (M44).
August $12^{\text {th }}$ : The Perseid meteors peak.
August $18^{\text {th }}$ : A close conjunction of Mars and Mercury.
October $10^{\text {th }}$ : Taurid fireball season peaks.
November 19 ${ }^{\text {th }}$ : A partial lunar eclipse.
December $4^{\text {th }}$ : A total solar eclipse.
So what can you look forward to in 2021? Here's our annual look at top skywatching events, coming to a sky near you:

## Eclipse Action in 2021

2021 contains the minimum number of eclipses that can occur in a calendar year with four: two solar and two lunar.


Lunar eclipse stages. Credit: Dave Dickinson.
Lunar eclipses include: A total lunar eclipse on May 26th,
with a maximum duration 15 minutes centered on the Pacific Rim region, and a deep ( $97 \%$ umbral) partial lunar eclipse on November $19^{\text {th }}$, favoring the Americas, Northern Europe, Eastern Asia, Australia and the Pacific.


The only total solar eclipse for 2021. Credit: NASA/GSFC/A.T. Sinclair.
Solar eclipses in 2021 include: an annular solar eclipse on June $10^{\text {th }}$, with a maximum duration of 3 minutes and 51 seconds crossing the Arctic, and a total solar eclipse on December 4th, with a maximum duration for totality of 1 minute and 54 seconds crossing the Antarctic.
The Sun and Moon in 2021
Either equinox marks the peak of aurora season, as well as the span of geostationary satellite eclipse and flare season, as distant satellites reach full illumination shortly before and after passing into and out of the Earth's shadow. Equinox season is also a great time to spy the elusive zodiacal light at dawn or dusk. In contrast, the solstices mark a period near which the International Space Station enters a span of full illumination, with June favoring the northern hemisphere for multiple sightings in one night, and December favoring the southern.
Here are those seasonal start dates for 2021:
January $2^{\text {nd }}$ : Earth is at perihelion
March $20^{\text {th }}$ : :
June $21^{\text {st }}:$ northward solstice
July $5^{\text {th }}$ : Earth is at aphelion
September 22 ${ }^{\text {nd }}$ : southward equinox
December $21^{\text {st. }}$ : southward solstice
2021 also continues to be an 'ecliptic-like' year in terms of the Moon's path versus the ecliptic plane, as we head towards the 'hilly years' mid-decade around 2025. In 2021, the 'Supermoon' or the Full Moon nearest perigee (plus a total lunar eclipse) occurs on May $\mathbf{2 6}^{\text {th }}$, and the 'Minimoon' with Full Moon nearest apogee occurs on December $19^{\text {th }}$. A Blue Moon also occurs on August 22 ${ }^{\text {nd }}$, in the old timey archaic sense of the $3^{\text {rd }}$ in a season with 4
Occultations in 2021
It's always fun to watch the Moon cover up a bright star or planet while it weaves its monthly flight 'round the ecliptic plane. The Moon occults three planets seven times in 2021: Mercury twice, Venus twice, and Mars three times:
April 17th: Mars versus a $26 \%$ illuminated, waxing crescent Moon for southeast Asia.


The Moon occults Mars for SE Asia. Credit: Occult 4.2. May 12th: Venus versus a 1\% illuminated, thin waxing crescent Moon for the South Pacific.
November 3rd: Mercury versus a $2 \%$ illuminated waning crescent Moon for northeastern North America.
November 8th: Venus versus a $20 \%$ illuminated waxing crescent Moon for the northwestern Pacific region.
December 3rd: Mars versus a 1\% illuminated waning crescent Moon, for northeast Asia.
December 4th: Mercury versus a 1\% illuminated waxing crescent Moon for South Africa.
December 31st: Mars versus a 6\% illuminated waning crescent Moon for SE Asia.
The Moon does not manage to occult a +1 st magnitude star in 2021, but does visit +3.1 magnitude Mebsuta (Epsilon Geminorum), +2.6 magnitude Acrab (Beta Scorpii), +2.8 magnitude Lambda Sagittarii, and +2.1 magnitude Sigma Sagittarii in 2021.
Highlighted events for occultations of these stars in 2021 include:
January $\mathbf{2 6}^{\text {th }}$ : Epsilon Geminorum for Southeast Asia (96\% illuminated, waxing gibbous Moon).
February $5^{\text {th }}$ : Beta Scorpii for India (38\% illuminated, waning crescent Moon).
April $3^{\text {rd }}$ : Lambda Sagittarii for Australia and Southeast
Asia (60\% illuminated, waning gibbous Moon).
April $\mathbf{2 8}^{\text {th }}$ : Beta Scorpii for South Africa (97\% illuminated, waning gibbous Moon).
May $28^{\text {th }}$ : Sigma Sagittarii for North Africa and the Middle East (94\% illuminated, waning gibbous Moon).
June $24^{\text {th }}$ : Lambda Sagittarii for South Africa (99\% illuminated Moon near Full).
June $\mathbf{2 5}^{\text {th }}$ : Sigma Sagittarii for North America (99\% illuminated Moon near Full).
July 22 ${ }^{\text {nd. }}$ : Sigma Sagittarii for North Africa and southwest Asia (91\% illuminated, waxing gibbous Moon).
August 19 ${ }^{\text {th }}$ : Sigma Sagittarii southern North America ( $89 \%$ illuminated, waxing gibbous Moon).
September $2^{\text {nd }}$ : Epsilon Geminorum for Europe (21\% illuminated, waning crescent Moon).
Occultations: Asteroids versus Stars
Tiny asteroids can, on occasion, pass in front of distant stars, briefly revealing their shape as their 'shadow' flits across the surface of the Earth, and over any diligent observer that happens to be watching along their path. On any given year, hundreds of asteroid occultations are predicted.
In 2021, the brightest star occulted by an asteroid occurs on September $20^{\text {th }}$, as 762 Pulcova occults $a+7.1$ magnitude star for Mexico and the southeastern United States.

## The Planets in 2021

The dance of the planets across the sky continues in 2021. The worlds Mercury and Venus are interior to the orbit of the Earth, and always appear in the dawn or dusk sky, racing back and forth around the Sun. The very best time to catch either world is when they're near greatest elongation, or at their farthest angle versus the Sun as seen from Earth.
Greatest elongations for Mercury and Venus in 2021 are: January 23rd: Mercury is 19 degrees east of the Sun at dusk.

March 6th: Mercury is 27 degrees west of the Sun at dawn.
May 17th: Mercury is 22 degrees east of the Sun at dusk. July 4th: Mercury is 22 degrees west of the Sun at dawn. September 14th: Mercury 27 degrees east of the Sun at dusk.
October 25th: Mercury is 18 degrees west of the Sun at dawn.
October 29th: Venus is 47 degrees east of the Sun at dusk. Also, check out Venus on June $4^{\text {th }}$, when it passes in front of the open cluster Messier 35 at dusk 18 degrees east of the Sun, and chases Mars across the Beehive Cluster (Messier 44) on July $3^{\text {rd }}$, 26 degrees east of the Sun at dusk. Mars crosses M44 on June $23^{\text {rd }}$ into June $24^{\text {th }}$.


Mars crosses the Beehive Cluster. Credit: Stellarium. Outer planets orbiting the Sun exterior to the Earth can reach opposition, rising opposite to the setting Sun. This is the best time to observe a given planet, as it stays above the horizon the entire night. On most years, each of the outer planets can reach opposition. Only speedy Mars can skip on alternating years... and 2021 is just such a year.
March $4^{\text {th }}: 4$ Vesta reaches opposition, at $+6^{\text {th }}$ magnitude in the constellation Leo.
July $17^{\text {th }}$ : Pluto reaches opposition, at $+14^{\text {th }}$ magnitude in the constellation Sagittarius.
August $2^{\text {nd. }}$ : Saturn reaches opposition at magnitude +0.2 in the constellation Capricornus.
Aug 20 ${ }^{\text {th }}$ : Jupiter reaches opposition, at magnitude -2.9 on the Capricornus-Aquarius border.
September $14^{\text {th }}$ : Neptune reaches opposition, at +7.8 magnitude in the constellation Aquarius.
November $4^{\text {th }}$ : Uranus reaches opposition at magnitude +5.7 in the constellation Aries
November $27^{\text {th }}$ : 1 Ceres reaches opposition at +7 magnitude in the constellation Taurus.
Mutual eclipse season for Jupiter's major moons begins in early 2021, as the four major Galilean moons pass in front of one another, casting shadows and occulting each other in their complex orbital dance. Innermost lo is actually joined by a 'faux moon' on April $2^{\text {nd }}$, as the +5.9 magnitude star 44 Capricorni passes just 0.5" from the moon around ~6:20 EDT/10:20 UT.


Varieties of transits and eclipses of Jupiter's moons. Credit: Dave Dickinson
Saturn's rings are tipped around 18 degrees open relative to our view in 2021 with the planet's north pole currently tipped
sunward, and this tilt is narrowing towards edge-on in 2025.

## The Best Conjunctions in 2021

The 'Grand Conjunction' of Jupiter and Saturn on December $21^{\text {st }}, 2020$ was one for the ages. And hey, lots of planetary conjunctions happen every year, providing dramatic celestial pairings as the clockwork solar system turns. We say 'conjunction' when it's a twosome pairing, and 'grouping' when it's three or more.
Some of the very best celestial meet-ups to watch for in 2021 are:
March $5^{\text {th }}$ : Mercury-Jupiter 21' apart at dawn, 27 degrees from the Sun.
March $10^{\text {th }}$ : Mercury, Jupiter, Saturn and the waning crescent Moon form a 14 degree circle at dawn, 14 degrees from the Sun.


Looking eastward at dawn on the morning of March 10th. Credit: Stellarium.
April $25^{\text {th }}$ : Mercury-Venus are one degree apart at dusk, just seven degrees from the Sun.
May 12 ${ }^{\text {th: }}$ : Venus and the slim waxing crescent Moon are just one degree apart at dusk, 12 degrees from the Sun. July 11th: Venus, Mars, and the waxing crescent Moon fit in a 3 degree circle, 29 degrees from the Sun in the dusk sky.


Looking westward on the evening of July 11th. Credit: Stellarium.
July 30th: Mars-Regulus are 36' apart, 23 degrees east of the Sun in the dusk sky.
August $18^{\text {th }}$ : Mercury and Mars are 4' apart, 17 degrees east of the Sun in the dusk sky. This is the best conjunction for 2021.
Comets at Perihelion
Every year, comets come and go. While most of the nota-
ble periodic comets follow well-known orbits, new comets on orbital paths measured in the thousands or millions of year may appear without warning. Will 2021 host a 'Great Comet?' No one knows for sure... but for now, here's the list of surefire apparitions of known comets to watch for the coming year:
May 26 ${ }^{\text {th }}$ : Comet 7/P Pons-Winnecke reaches perihelion, shining at $+8^{\text {th }}$ magnitude in the constellation Aquarius.
July $13^{\text {th }}$ : Comet 15P/Finlay reaches perihelion, shining at +9 th magnitude in the constellation Taurus.
August 21 ${ }^{\text {st }}$ : Comet 8P/Tuttle reaches perihelion, shining at +9 th magnitude in the constellation Cancer.
September $17^{\text {th }}$ : Comet 6P/d'Arrest reaches perihelion, shining at +9 th magnitude in Sagittarius.
November $3^{\text {rd }}$ : Comet 67/P Churyumov-Gerasimenko reaches perihelion, shining at +9 th magnitude in the constellation Gemini.

## Meteor Showers in 2021

2021 is an 'off year' for many major showers, including the Geminids, Leonids and the Quadrantids, owing to the interfering phase of the Moon. Your best bet in 2021 are the faithful August Perseids, with the waxing crescent Moon safely out of view:
May 6th: The Eta Aquariids peak with a Zenithal Hourly Rate (ZHR) of 50, during a $23 \%$ illuminated, waning crescent Moon.
June 7th: The daytime Arietids peak with a ZHR of 30, during a $7 \%$ illuminated, waning crescent Moon.
August 12th: The Perseids peak with a ZHR of 100, during a $18 \%$ illuminated, waxing crescent Moon.
October 10th: The Taurids peak with a ZHR of 10, during a $22 \%$ illuminated, waxing crescent Moon (Note: the source comet 2P/Encke just reached perihelion in 2020).
December 3rd: The Andromedids peak with a ZHR of 20, during a slim $1 \%$ illuminated, waning crescent Moon. That's what we can look forward to in the fine year of astronomy coming up in 2021. Watch this space: we'll be writing about these events and more in the year to come.

# E Mails Viewings Logs and Images from Members. 

Hi Andy,

## Viewing log and pictures for the magazine.

## Viewing Log for $\mathbf{2 4}{ }^{\text {th }}$ of December

Finally after we had come out of the latest 'Lockdown' and with a free evening and a clear sky I would be off to do something called Astronomy? Last time I was out with my telescope was the $9^{\text {th }}$ of October, around 10 weeks ago!
I knew it would not be a good night for viewing deep sky objects as the Moon was around $75 \%$ lit or about 10 days old? Anyway I arrived at my usual viewing spot near Uffcott at 18:32 and noticed a telescope was already set up and viewing, so I had some company for the evening. Turns out it was Arron with his sons (Mackenzie and Oliver), members of the Swindon Stargazers club. Unfortunately I did not remember them as they had not been to a club meeting in a couple of years? After having a chat with them I went off and set up my Meade LX90 eight inch (203 mm for younger people) GOTO telescope with a 14 mm XW Pentax eye piece. I had a reasonably strong wind to contend with and with it being around $3{ }^{\circ} \mathrm{C}$ knew it could be a cold one, hopefully the wind would die down as evening took hold?
First target for the evening was Mars, not far from the Moon but I could make out some markings, which I could not determine what they were? I was getting some glare from the Moon down thru the telescope while viewing Mars! Uranus was also close to the Moon so no details there apart from seeing the usual green dot! Neptune was much further away from the Moon but was only a point of light to me? With a nice shadow of me on the road (done by the Moon) I thought I would stay with Messier (M) for the evening, so first object was M 29 in Cygnus which was starting to set in the western sky. This open cluster (O C) is mainly made up of six stars which look like a crushed rectangle, always good to look at, nearby is M 39 another O C but much more looser than M 29? To the south of Cygnus is Vulpecula and its main attraction and $M$ 27, the Dumbbell nebula, this Planetary nebula (P N) looked like the remains of an apple core? Off to M 56 and the first globular cluster (G C) of the evening, this looked like a large fuzzy blob (F B), think the Moon was washing out any detail I might have seen? Off to another good P N and M 57, could make out the circle as a blob but nothing else? M 31, the Great Andromeda galaxy is normally good to look at and it was this time, probably far enough from the Moon? Nearby is M 32, could not make out any detail what so ever, so I called this a faint fuzzy blob (F F B). Both M 81 and M 82 in Ursa Major were good to look at, these are probably two of the best spiral galaxies to look at? Normally I find spiral galaxies just blobs in the sky with no detail? Just below the pan of the plough is M 97 (the Owl nebula), my old nemesis, but this time I could just make it out with adverted vision? Off to probably the most boring object in Messier's list and M 40, a double star, normally I give this one a miss and I know why? Next five objects would be O C's, starting with M 34 in Perseus, this object is small and tight to look at? M 35 in Gemini is wide and loose, next three are all in Auriga and starting with M 36 and this is a compact O C? M 37 is probably the best of these five to look at, quite dense to view and finally M 38, another loose O C. Tried for another G C but M 79 was in a hedge, would need a later viewing time or later in the winter to see this odd ball? By now Orion was starting to get well up and finally Sirius (brightest star in the night sky) had cleared the horizon, for a small time you can see both the Summer (Deneb, Altair and Vega) triangle and the Winter (Sirius, Procyon and Betelgeuse) triangle up in the sky at the same time, of course you will need a good western and eastern horizon to see this, lucky Uffcott has this but the hedges can cause some problems while viewing objects need the horizon! As usual, M 42 the Great nebula in Orion was good to look at, yet next door is M 43, this was nearly washed out? The other Messier object in Orion is M 78, this emission nebula was washed out apart from the two main stars of this object. Overhead was

Taurus, M 1 was just a large F B to look at? That was enough of Messier objects, time to turn to NGC objects and 457, the Owl cluster, this looked beautiful to view. By now I was starting to get quite cold, the wind had not died down as I had hoped but was getting a bit stronger, so time to put the Moon filter on the eye piece and view the the terminator, there was some nice objects along this line could make out some central peaks of some craters, Mare Imbrium (Sea of Rains) had nearly cleared the terminator.
By now it was 20:28 and my hands were not happy, temperature had dropped to $1^{\circ} \mathrm{C}$ so it was time to pack up everything and go home, Arron and his family had long gone by now and with it being Christmas Eve only three cars went past me in the time I was there, had I gone out the following night it would probably be no cars go past me but I did not find that out as it was cloudy then!
Clear skies.
Peter Chappell


Conjunction of Jupiter and Saturn on $20^{\text {th }}$ of December details:
Coming out of the clouds: ISO 500, f6.3 and 1/15 of a second shutter speed.


Close up of the Moons: ISO 1600, f6.3 and one second shutter speed. Io was too close to Jupiter to be seen in this picture?


Hi Andy,
Happy New Year!
Here are my submissions for the WAS January 2021 Newsletter.

## 01/12/2020 Moon Halo



Handheld and leaning outside a bedroom window!
Canon 7D, Tokina F2.8 11-16mm
11 mm (effective focal length 18 mm ), F2.8, 0.6 sec , ISO 1600

27/12/2020 Sunspots AR2794 and AR2795


Canon SX50HS 1200mm, ISO 100, F8, 1/1250 sec
Sun in white light using Baader filter
100 raw images converted to tiff in Canon DPP, cropped and centred in Pipp, stacked in Autostakkert, wavelet in Registax 6 and post processed for colour in Affinity Photo and Photoshop.

## 31/12/2020 97\% Lit Waning Gibbous Moon

Canon SX50HS 1200mm, ISO 80, F8, 1/125 sec
80 raw images converted to tiff in Canon DPP, cropped and centred in Pipp, stacked in Autostakkert, wavelet in Registax 6 and post processed in Affinity Photo.


Clear Skies,
John Dartnell

Happy New Year to one and all.
A new All Party Parliamentary Group has recently been set up to combat light pollution. For more information and the latest news see the website below:
https://appgdarkskies.co.uk/


#### Abstract

APPG for Dark Skies We are the UK Parliament's only all-party group dedicated to reducing light pollution. The All-Party Parliamentary Group for Dark Skies is a new APPG, never represented before in the UK Parliament. appgdarkskies.co.uk


Register your interest and subscribe to their latest news updates:
We are the UK Parliament's only all-party group dedicated to reducing light pollution.
The All-Party Parliamentary Group for Dark Skies is a new APPG, never represented before in the UK Parliament. Our membership includes parliamentarians of all parties from both the House of Commons and House of Lords.

We work with major organisations, experts and communities to identify political priorities on dark sky issues, discuss lighting and planning policies and advocate for them in the UK Parliament.

## Our objectives are to:

- Highlight the importance of preserving the ability for citizens to see a dark sky at night;
- Promote the adoption of dark sky friendly lighting and planning policies;
- Protect existing UK Dark Sky reserves and support potential new reserves; and

Collaborate with international groups and countries hosting Dark Sky Reserves - currently Canada, France, Germany Ireland, Namibia and New Zealand.
https://appgdarkskies.co.uk/our-work
Our Work - APPG for Dark Skies
The UK Parliament's All-Party Parliamen-
tary Group for Dark Skies exists to fight
light pollution to protect our dark skies for
future generations.
appgdarkskies.co.uk

The UK Parliament's All-Party Parliamentary Group for Dark Skies exists to fight light pollution to protect our dark skies for future generations. We provide a forum for parliamentarians and organisations across the public, private and third sectors to work together to discuss issues regarding the visibility of the night sky and promote the adoption of dark sky friendly lighting and planning policies. We principally focus on efforts to preserve the night sky within the UK but also include international issues within our remit.

The group was founded in January 2020 by our Co-Chairs Andrew Griffith, MP for Arundel \& South Downs, and Lord Martin Rees of Ludlow, the Astronomer Royal and former President of the Royal Astronomical Society.
Lobby your MP.
Dave.Buckle

## From Tony Vale

## Primary Minimum of EO Aurigae on $25^{\text {th }}$ December 2020 at 01:51 UT

EO Aurigae is an eclipsing variable of type EA/DM. EA indicates that it is of the Algol type and DM that the components are detached main sequence stars. Algol type eclipsing binaries have components which are sufficiently well separated that they remain broadly spherical in shape and are not distorted to ellipsoids by the proximity of their companion star. This means that the brightness does not vary significantly between eclipses. The system is about 1,540 light years away and both components are spectral class B3V ( B3 indicates that the stars are hot white stars and V that they are main sequence). The period of 4.06 days is comparatively long and the full primary eclipse lasts 12 hours which can make it difficult to observe a full eclipse in one night. The eclipse of $25^{\text {th }}$ December took place at about 2am in the morning and so there were several hours of darkness before and after and this presented a good opportunity, weather permitting. The observations were made with a 4 " refractor and DSLR at ISO 100 with exposures of 25 s . 36 of these were stacked for each data point which therefore represents 15 mins of integration time and the total observation extended over about 7.5 hours. The resulting light curve shows a clear minimum and this was estimated using Fourier and Kwee van Worden curve fitting to have occurred at $24,512,345.678$ Heliocentric Julian Date or 01:43.5 UT. (Adjusting to Heliocentric Julian Date eliminates the effect of the change in light path from the star (and therefore the timing of the eclipse) resulting from the earth's orbital motion, by adjusting the timings as if the observations had been made from the centre of the sun.
Below the light curve is the O-C diagram. The Time of Minimum is shown as a red dot (the rightmost dot, if not in col-
our). Although this star is on the BAAVSS priority list, minima have only been observed infrequently - only 18 published observations since 1916 (incidentally, the 1916 observation was made by Sergei Gaposchkin who later married Celia Payne-Gaposchkin). With so few observations there is no clear pattern which might reveal period or mass changes or the presence of a third body in the system.

Light Curve showing Primary eclipse of EO Aurigae,

$25^{\text {th }}$ to $25^{\text {th }}$ December 2020
O-C Diagram


Credit: Czech astronomical society


January 2, 3-Quadrantids Meteor Shower. The Quadrantids is an above average shower, with up to 40 meteors per hour at its peak. It is thought to be produced by dust grains left behind by an extinct comet known as 2003 EH1, which was discovered in 2003. The shower runs annually from January $1-5$. It peaks this year on the night of the $2 n d$ and morning of the 3rd. The waning gibbous moon will block out most of the faintest meteors this year. But if you are patient, you should still be able to catch a few good ones. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Bootes, but can appear anywhere in the sky.
January 13 - 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 05:02 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.
January 24 - Mercury at Greatest Eastern Elongation. The planet Mercury reaches greatest eastern elongation of 18.6 degrees from the Sun. This is the best time to view Mercury since it will be at its highest point above the horizon in the evening sky. Look for the planet low in the western sky just after sunset.
January 28 - 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 19:18 UTC. This full
moon was known by early Native American tribes as the Wolf Moon because this was the time of year when hungry wolf packs howled outside their camps. This moon has also been know as the Old Moon and the Moon After Yule.

Clear skies, Andy

## Observing Notes - January 2021

This month we take a ride alongside Auriga, the Charioteer.

Happy New Year and welcome to the first Wiltshire Astronomical Society's Observing notes of 2021. As we are still in a lockdown scenario the observing team will continue to provide these extended observing suggestions each month.

This month's area of interest is one of 2nd century Greek-Egyptian astronomer Ptolemy's 48 original constellations and representing the importance of the chariot in that era.

Auriga is a pentagon-shaped collection of stars that is situated just north of the celestial equator and is most prominent during winter evenings from the UK. To be honest, I still mix up Auriga with Cepheus in the night sky, I don't know why this is but hopefully typing these notes will help me to remember.

At the time of the year Auriga is in the North

East and lies to the west of Ursa Major (The Plough) and to the East of Taurus with Perseus above and Gemini to the below.

Auriga is close to the plane of the northern Milky Way and as a result, it is littered with open clusters and nebula.

The name Auriga is derived from Latin and means "the charioteer" and is associated with many characters from Greek mythology. The most common of which Erichthonius who was generally credited as being the inventor of the four-horse chariot and used in battles that made him king of Athens. Because of this and his heroic deeds, Zeus raised him into the heavens, riding his chariot.

Another common story is that Auriga is Myrtilus the son of Hermes and the charioteer of Oenamaus the son of Ares. This is supported by depictions of the constellation which rarely show a chariot, as Myrtilus's chariot was destroyed in a


Looking East to Gemini
race intended to win the heart of Oenomaus's daughter Hippodamia. After being killed by a competing suitor, Myrtilus father Hermes placed him in the sky.

Yet another mythological association is Theseus's son Hippolytus, who was ejected from Athens after he refused the romantic advances of his stepmother Phaedra. He was killed when his chariot crashed.

## The Constellation

The main stars of Auriga form a pentagon or oval shape in the sky so starting at the brightest (Capella) and working our way around in a clockwise direction we have:

Alpha (a) Aurigae or Capella which at 43 light years distant, it also the sixth brightest star in the sky. If you could visit Capella you would see that it consists of two binary pairs of giant stars in close orbit with a pair of small red dwarf stars, located about $10,000 \mathrm{AU}$ away. This system belongs to the

Hyades moving group, a large group of stars that share a similar trajectory with the Hyades cluster, an open star cluster in the constellation Taurus that we looked at back in the November observing notes.

Capella marks the Charioteer's left shoulder but often represented by the goat he is carrying. This is often the subject of much debate and arguably is believed to be the goat that suckled Zeus and is often referred to by its Sumerian name mul.ÅŠ,KAR and means "the goat star".

Almaaz or Epsilon ( $\varepsilon$ ) Aurigae, is another eclipsing binary star 135 times larger than that of our own Sun and 2000 light years distant. Its unusual dark companion is believed to be a large disk orbiting a binary star and recent studies suggest that the companion is a single B-class star inside the disk. The apparent magnitude of the system drops from 2.92 to 3.93 for about 66 days every 27 years. The name Almaaz means "(billy) goat" in Arabic.


- Detail of Auriga

Observing Notes - January 2021 : Riding with the Charioteer!
Zeta ( $\zeta$ ) Aurigae or Haedus but also commonly called Sadatoni which comes from the Arabic phrase for "the second arm (of the Charioteer)." But is also call the 'Kid' (lots of goat themes in this constellation) start representing one of the kids of the goat the charioteer is holding.

Sadatoni is an eclipsing binary star 790 light years distant. It consists of a red supergiant and a B8 type ( 3 times our sun) companion. The system's magnitude varies between 3.6 and approximately 4.0 with a period of 972 days.

Representing the second of the 'kids' of the goat held by the Charioteer lying close to Sadatoni is Eta ( $\eta$ ) Aurigae, a blue-white B-type main sequence dwarf star located about 219 light years away. It has an apparent magnitude of 3.18 .

Its traditional name is Haedus II (or Hoedus II) and it comes from the Latin word haedus, which means 'kid.' It is occasionally called Mahasim ("wrist"), a name it shares with Theta Aurigae.

Iota (1) Aurigae is known by several traditional names. Kabdhilinan (or Al Kab for short) comes from the Arabic phrase for "the ankle of the rein holder." The star is also commonly referred to as Hassaleh. Hassaleh is an orange K-type bright giant star approximately 512 light years distant and has a magnitude of 2.7 .

Gamma ( $\gamma$ ) Aurigae is actually part of the Taurus constellation (Beta Tauri). The star's traditional name is El Nath or Elnath (see November Observing notes)

Mahasim otherwise known as Theta ( $\theta$ ) Aurigae comes from the Arabic word for "wrist." It is also sometimes called Bogardus. It is in fact a double star about 173 light years from Earth with a magnitude of 2.7 . The brighter component in the system is a white A-type main sequence dwarf and the companion star is a yellow G-type main sequence dwarf of magnitude 7,2 .

Beta ( $\beta$ ) Aurigae or Menkalinan whose name comes from the Arabic phrase mankib dhu altinan, meaning "shoulder of the charioteer" is a triple star system, 85 light years distant. The brightest two components are sub-giants and the third star is a red dwarf. The system member of the moving group of stars that includes most of

Page 3
the bright stars in the constellation of Ursa Major (the great Bear) or better known as the Plough asterism.

Delta ( $\delta$ ) Aurigae or Prijipati is a binary star about 140 light years from Earth. It consists of an orange giant and a companion star 115 arc seconds away. The primary star has an apparent magnitude of 3.7 and the companion, 9.7. In Indian astronomy, the star's name means "the Lord of Creation".

AE Aurigae sits within the Auriga pentagon shape and is a runaway star moving through space at an extremely high velocity when compared to the neighbouring stars. It is suspected to have been ejected when two binary stars collided in the Trapezium Cluster, located in the Orion Nebula (Messier 42), about two million years ago. luminosity varies between 5.8 and 6.1 and lights the Flaming Star Nebula (IC 405, Caldwell 31, SH 2-229).


4 Location of AE Aurigae

## DEEP SKY OBJECTS

## Pinwheel Cluster

Messier 36 (M36 or NGC 1960), also known as the Pinwheel Cluster, is about 4100 light years distant and one of the fainter open clusters in Messier's catalogue, but it can easily be seen in binoculars and small telescopes.

Binoculars will show a faint, fuzzy patch of


- Finder chart for M36
light and small telescopes at low or medium
 powers will reveal just over a dozen brightest stars in the cluster, arranged in an X-type shape.

A 6 -inch telescope will resolve about 25 stars, while 12 - in ch instruments will reveal stars across the cluster.

The Pinwheel Cluster can be found on a line drawn from El Nath in Taurus to Menkalinan but appears about halfway between El Nath and Mahasim.

## Messier 37 Open Cluster



Hodierna. The cluster is between 3,600 and 4,700 light years from Earth and contains some 500 stars, about 150 of which are brighter than
magnitude 12.5. of which about a dozen are red giants.

The cluster can be found lying east of the midpoint of the line drawn from Mahasim to El Nath in Taurus, which lies to the southwest. Being the easternmost of the three Messier clusters


- Finder chart for M37
in Auriga, M37 is the only one found outside Auriga's pentagon asterism.

In $10 \times 50$ binoculars, M37 appears as a hazy patch of light, but $20 \times 80$ and larger binoculars reveal a very compact star cluster, resolving the brightest stars. Small telescopes will show a dozen brightest stars, while 8 -inch and larger instruments reveal several hundred stars in the cluster.

## Starfish Cluster

Messier 38 (M38 or NGC 1912), also known as the Starfish Cluster, is an open star cluster about distance of 4,200 light years from Earth. The brightest stars in the cluster form an oblique cross, or the letter Pi.

With an apparent magnitude of 7.4 , it is invisible to the naked eye but is relatively easy to find. M38 can be found roughly two thirds of the distance from Capella to the bright El Nath

Messier 38 appears quite large in $10 \times 50$ binoculars and binoculars with larger magnification resolve some of the cluster's stars.


- Finder Chart for M38

4-inch telescopes show many of the cluster's stars, mainly concentrated toward the central region and forming an irregular pattern that has been

compared to the Greek letter Pi , an irregular arrow and an oblique cross.

## The Flaming Star Nebula

The Flaming Star Nebula, (IC 405, SH 2-229, and Caldwell 31), can be seen near the open cluster M38, the star Iota Aurigae, or the emission nebula IC 410 .

The Flaming Star Nebula is an emission/ reflection nebula that surrounds the star AE Aurigae. It lies 1,500 light years from Earth and has an apparent magnitude of 6.0 and can be seen
is small telescopes under the right condition so is

this month's challenge. Its certainly a target for astro-photographers with a DSLR.
IC 410
IC 410 is an emission nebula, one that slightly resembles the Rosette Nebula in the constellation Monoceros. The nebula surrounds the very small

open cluster NGC 1893 and can be found just below the Flaming Star nebula. However, it is a challenge for all but larger scopes.

## WITHINTHE SOLAR SYSTEM

## Meteor Showers

The Quadrantids is an above average shower, with up to 40 meteors per hour at its peak. The shower runs annually from 1st - 5th January. It peaks this year on the night of the 2nd and
morning of the 3rd. Unfortunately, the waning gibbous moon will block out most of the faintest meteors this year but you should still be able to catch a few good ones. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Bootes, although they can appear anywhere in the sky.

## The Moon \& Planets

The Moon starts the beginning of the month as a waning gibbous and so its not good for deep sky observing or for the Quadrantids mentioned earlier. New moon is around the middle of the month and observing is best carried out a week either side of this.

Mercury is too close to the sun at the beginning of the month but as it moves away you may just be able to get a glimpse of it on the 14th to the right of the thin crescent moon. The planet continues to be visible just after sunset for the remainder of the month.

Venus is rising only an hour before the sun at the start of the month as it slowly moves closer and more difficult to see in the Morning skies.

At the start of the month Mars is well placed, reaching its highest position due south around 19:00. The magnitude. -0.2 planet shows a 10.4 arcsecond disc on 1 January, still large enough to show detail through an amateur telescope and showing a slight phase ( $90 \%$ ) over the month. Mars will close to the Moon on 20th and 21st. On the evening of 21 st January Mars will be $1.7^{\circ}$ north of the magnitude +5.8 planet Uranus. Mars moves east over the month and reducing in brightness and apparent size as it goes. By the end of the month Mars shines at mag. +0.4 and is only $2 / 3$ of it size by month end.

Although still visible low down both Jupiter and Saturn at the very beginning of the month both planets but in particularly Saturn, are soon lost to the sun and will not be visible again until the morning skies of March 2021.

Uranus is easy to see throughout the month initially to the East of Mars at the beginning of the Month with Mars taking a close pass to the planet
on the 21st.
Neptune is still well place at the beginning of the month to the South West but is rapidly losing height as the month moves on. By the end of January Neptune is setting around an hour or two after the sun sets.

Chris Brooks
Jonathan Gale WAS Observing Team

CONSTELLATIONS OF THE MONTH: ORION


Orion is the master of the winter skies. He lords over the heavens from late fall to early spring, with his hunting dog Sirius trailing at his feet.

The mythic tales of Orion go as far back as the Hittites, who flourished from the Second Millenium BC to around 1200 BC.
One story from this culture gives an interesting account of Orion's death. Here he is called Aqhat, and was a handsome and famous hunter. The Battle-Goddess Anat fell in love with Aqhat, but when he refused to lend her his bow, she sent another man to steal it. This chap bungled the job, and wound up killing Aqhat and dropping the bow into the sea. This is said to explain the astronomical fact that Orion and the Bow (an older version of the constellation) drops below the horizon for two months every spring.
Like all myths borrowed from several sources over a great length of time, the Greek stories offer many variations. Generally speaking, Orion was known as the "dweller of the mountain", and was famous for his prowess both as a hunter and as a lover. But when he boasted that he would eventually rid the earth of all the wild animals, his doom may have been sealed.
It might have been the Earth Goddess herself who sent the deadly scorpion to Orion. Or possibly Apollo, concerned that Orion had designs on his sister, Artemis. Thus Apollo may have told the Earth Goddess of Orion's boast. In any case, it seems clear that it was the Earth Goddess who sent the scorpion on its mission.
Some stories have the scorpion killing Orion with its sting. However the general consensus is that he engaged the scorpion in battle but quickly realised its armour was impervious to any mortal's attack. Orion then jumped into the sea and swam toward Delos. But Apollo had witnessed Orion's struggle with the scorpion and would not let him escape so easily. He challenged his sister Artemis, who was an excellent shot, if she could hit that small black object far away in the sea, the head -- he told
her -- of an infamous and treacherous villan. Artemis struck the object with her first shot. She then swam out to retrieve her victim's corpse, and discovered she had killed Orion. Artemis implored the gods to restore his life, but Zeus objected. So she put Orion's image in the heavens.
In his eternal hunting, Orion is careful to keep well ahead of the scorpion. In fact Orion has disappeared over the horizon by the time Scorpio rises in the east, as it becomes his turn to rule the evening sky.
Finding Orion should be no problem. Its stars are some of the most familiar in all the heavens. Question: can you name the three stars that make up Orion's Belt. (Answer below.)

Above the belt, slightly to the left, is Betelgeuse, alpha Orionis.
Betelgeuse, the right arm of Orion (or "armpit" as the name suggests), glows with a dull red. Although labelled alpha Orionis, it is less bright than beta Orionis (Rigel), in the opposite corner of the constellation, to the southwest. Yet if slightly less bright, it is much larger, estimated at around 250 Suns. If one were to replace our Sun with Betelgeuse, its size would completely engulf the Earth and extend as far as Mars.
As the brightest star in Orion, Rigel ranks as the seventh brightest star in all the heavens, just behind Capella. It is a visual binary; its companion is much fainter, but quite visible if you are persistent enough (PA 202 $\left.{ }^{\circ}, 9.4^{\prime \prime}\right)$.
The other corners of the constellation are formed by Bellatrix (gamma Orionis) and Saiph (kappa Orionis). It was once thought that all women born under the sign of Bellatrix would be fortunate and have the gift of speech. The star's name is often translated as Female Warrior or Amazon, and another name sometimes seen is "Amazon Star".
The constellation's main feature is of course the three stars which form the "belt" across the middle of Orion: from west to
east Mintaka, Alnilam, and Alnitak. Even the Bible makes reference to this famous group. God, while pointing out how all-powerful he was, is purported to have asked Job if he (Job) was able to "loose the bands of Orion" (Job 38.31).

The last of these stars is also known as zeta Orionis, and is a well known triple star system. The primary is a bluewhite star, and its companion ( $165^{\circ}, 2.3^{\prime \prime}$ ) is a dull red. Close by, just to the south, is the renowned Horsehead Nebula, a so-called dark nebula that is not visible in scopes but quite spectacular in long-exposure photographs.

## Binary stars in Orion:

There are many double stars in this constellation visible in small telescopes. Below are several selected from a wide list.
Beta Orionis (Rigel) has a 10.4 visual magnitude companion at $202^{\circ}$ and a wide $9.5^{\prime \prime}$ separation. This is a fixed system.

Lambda Orionis (between Betelgeuse and Bellatrix) is another fixed binary, with a 5.5 companion at PA $43^{\circ}$ and $4.4^{\prime \prime}$ away.
Theta ${ }^{1}$ is a complex system of fixed stars. The four brightest form The Trapezium, an outstanding multiple system for small telescopes. AB is at a position angle of $32^{\circ}$ and separation $8.8^{\prime \prime}$, AC: PA $132^{\circ}, 12.7^{\prime \prime}$, and AD: PA $96^{\circ}, 21.5^{\prime \prime}$.

Theta $^{2}$ is also a fine binary, a triple system to the southeast of The Trapezium. Component B is a binocular object: 6.4 magnitude at a position angle of $92^{\circ}$ and separation $52.5^{\prime \prime}$. Component C (8.5) is even wider: PA $98^{\circ}$ and separation 128.72".
Sigma Orionis is one of the few orbiting binaries found in Orion. Component $B$ has an orbit of 158 years and is one of the few components that traces a not-quite-perfect circle. That's to say, we see it nearly face on, as a wheel spinning around its hub.

The separation never changes much from its current distance of only $0.2^{\prime \prime}$. Its 2000.0 position angle is $132^{\circ}$.

Much easier to resolve is component E , with a visual magni-

tude of 6.7, this is a binocular object at a position angle of $61^{\circ}$ and separtion of $42^{\prime \prime}$.

Zeta Orionis $(1.9,4.0)$ has a very slow orbit of 1509 years, and is currently at $165^{\circ}$ and $2.3^{\prime \prime}$ separation.

## Variable stars in Orion:

A dozen stars in this constellation are visible in small scopes, but most of them are of the EA type of eclipsing binaries, which change very little. These include two stars of the Trapezium (theta 1A and 1B).
EA variables are old stars, nearing the end of their evolutionary process. The companion has grown to the size of a subgiant, perhaps equal in size to its primary. But their luminosities are quite different; thus, as the dimmer com-

This is a celestial nursery; soon (that's to say, in several hundred million years) young stars will appear from this wealth of cosmic matter.
Inside the nebula is the fascinating four-star system known as The Trapezium: theta 1A, 1B, 1C, and 1D - four stars held together by common gravity (actually at least two other stars are part of this complex system.) They are visible in medium sized telescopes and, with the nebula, form one of the most beautiful binary systems in the heavens.
M43 (NGC 1982) is a detached part of the Orion Nebula, with a ninth magnitude central star. A dark lane of gas separates M43 from M42, although the two are actually part of the same vast cloud.
M78 (NGC 2068) is a faint reflection nebula NE of Alnitak (zeta Ori), that looks best in long-exposure photographs.

panion revolves around its primary, variations in the total brightness occur.
The maximum brightness occurs of course when the two are not eclipsed, with each one adding its luminosity to the total output. Two minima also occur: the principal minimum is when the companion blocks out the primary; while a secondary minimum occurs when the companion is eclipsed by the primary.
The only interesting Mira-type regular variable is $U$ Orionis, which usually has a brightness of 4.8 but every 368.3 days it drops down to 13. In 2000 the minimum is scheduled to occur on 5 December.

## Deep Sky Objects in Orion:

M42, The Orion Nebula is perhaps the most photographed deep sky object in the heavens, a vast nebula of gas and dust exquisitely lit by surrounding stars.

The Horsehead Nebula is an intriguing and devilishly difficult dark nebula found just between zeta Orionis and sigma Orionis, visible in medium to large telescopes given the right sky conditions. An H-Beta filter is also helpful.

ISS PASSES For January/Feb 2021 from Heavens Above website maintained by Chris Peat

| Date | Brightness | Start | Highest <br> point | End |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :--- | :--- | :--- | :--- | :--- |
|  | (mag) | Time | Alt. | Az. | Time | Alt. | Az. | Time | Alt. | Az. |


| 05 Jan | -0.6 | 04:52:13 | $14^{\circ}$ | ESE | 04:52:13 | $14^{\circ}$ | ESE | 04:52:46 | $10^{\circ}$ | ESE |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 05 Jan | -2.4 | 06:25:10 | $24^{\circ}$ | SW | 06:25:54 | $26^{\circ}$ | SSW | 06:28:46 | $10^{\circ}$ | SSE |
| 06 Jan | -2.1 | 05:39:29 | $27^{\circ}$ | SSE | 05:39:29 | $27^{\circ}$ | SSE | 05:41:27 | $10^{\circ}$ | SE |
| 07 Jan | -0.5 | 04:53:51 | $11^{\circ}$ | SE | 04:53:51 | $11^{\circ}$ | SE | 04:53:58 | $10^{\circ}$ | SE |
| 07 Jan | -1.5 | 06:26:49 | $13^{\circ}$ | SW | 06:26:54 | $13^{\circ}$ | SW | 06:28:34 | $10^{\circ}$ | SSW |
| 08 Jan | -1.1 | 05:41:14 | $13^{\circ}$ | S | 05:41:14 | $13^{\circ}$ | S | 05:41:51 | $10^{\circ}$ | S |
| 19 Jan | -1.4 | 18:28:22 | $10^{\circ}$ | S | 18:29:36 | $13^{\circ}$ | SSE | 18:29:36 | $13^{\circ}$ | SSE |
| 20 Jan | -1.6 | 19:15:30 | $10^{\circ}$ | SW | 19:16:54 | $21^{\circ}$ | SSW | 19:16:54 | $21^{\circ}$ | SSW |
| 21 Jan | -2.5 | 18:27:59 | $10^{\circ}$ | SSW | 18:30:55 | $28^{\circ}$ | SSE | 18:31:10 | $27^{\circ}$ | SE |
| 21 Jan | -0.3 | 20:04:03 | $10^{\circ}$ | WSW | 20:04:07 | $10^{\circ}$ | WSW | 20:04:07 | $10^{\circ}$ | WSW |
| 22 Jan | -1.9 | 17:40:40 | $10^{\circ}$ | SSW | 17:43:12 | $20^{\circ}$ | SE | 17:45:22 | $12^{\circ}$ | E |
| 22 Jan | -2.2 | 19:16:13 | $10^{\circ}$ | WSW | 19:18:19 | $34^{\circ}$ | SW | 19:18:19 | $34^{\circ}$ | SW |
| 23 Jan | -3.4 | 18:28:27 | $10^{\circ}$ | SW | 18:31:44 | $50^{\circ}$ | SSE | 18:32:28 | $41^{\circ}$ | ESE |
| 23 Jan | -0.4 | 20:05:04 | $10^{\circ}$ | W | 20:05:24 | $12^{\circ}$ | W | 20:05:24 | $12^{\circ}$ | W |
| 24 Jan | -2.8 | 17:40:46 | $10^{\circ}$ | SW | 17:43:55 | $37^{\circ}$ | SSE | 17:46:34 | $13^{\circ}$ | E |
| 24 Jan | -2.5 | 19:17:09 | $10^{\circ}$ | W | 19:19:30 | $42^{\circ}$ | W | 19:19:30 | $42^{\circ}$ | W |
| 25 Jan | -3.8 | 18:29:15 | $10^{\circ}$ | WSW | 18:32:37 | $79^{\circ}$ | SSE | 18:33:34 | $44^{\circ}$ | E |
| 25 Jan | -0.4 | 20:06:03 | $10^{\circ}$ | W | 20:06:30 | $13^{\circ}$ | W | 20:06:30 | $13^{\circ}$ | W |
| 26 Jan | -3.5 | 17:41:23 | $10^{\circ}$ | WSW | 17:44:43 | $64^{\circ}$ | SSE | 17:47:37 | $13^{\circ}$ | E |
| 26 Jan | -2.7 | 19:18:07 | $10^{\circ}$ | W | 19:20:33 | $44^{\circ}$ | W | 19:20:33 | $44^{\circ}$ | W |
| 27 Jan | -3.8 | 18:30:11 | $10^{\circ}$ | w | 18:33:33 | $85^{\circ}$ | N | 18:34:35 | $42^{\circ}$ | E |
| 27 Jan | -0.5 | 20:06:59 | $10^{\circ}$ | W | 20:07:31 | $14^{\circ}$ | W | 20:07:31 | $14^{\circ}$ | W |
| 28 Jan | -3.8 | 17:42:14 | $10^{\circ}$ | W | 17:45:36 | $89^{\circ}$ | S | 17:48:38 | $12^{\circ}$ | E |
| 28 Jan | -2.8 | 19:19:02 | $10^{\circ}$ | W | 19:21:34 | $47^{\circ}$ | W | 19:21:34 | $47^{\circ}$ | W |
| 29 Jan | -3.8 | 18:31:04 | $10^{\circ}$ | W | 18:34:28 | $89^{\circ}$ | NE | 18:35:37 | $38^{\circ}$ | E |
| 29 Jan | -0.5 | 20:07:55 | $10^{\circ}$ | W | 20:08:34 | $14^{\circ}$ | W | 20:08:34 | $14^{\circ}$ | W |
| 30 Jan | -3.8 | 17:43:06 | $10^{\circ}$ | W | 17:46:29 | $85^{\circ}$ | N | 17:49:43 | $11^{\circ}$ | E |
| 30 Jan | -2.8 | 19:19:55 | $10^{\circ}$ | W | 19:22:39 | $46^{\circ}$ | WSW | 19:22:39 | $46^{\circ}$ | WSW |
| 31 Jan | -3.6 | 18:31:55 | $10^{\circ}$ | W | 18:35:17 | $68^{\circ}$ | SSW | 18:36:48 | $29^{\circ}$ | ESE |
| 31 Jan | -0.6 | 20:09:04 | $10^{\circ}$ | W | 20:09:44 | $14^{\circ}$ | WSW | 20:09:44 | $14^{\circ}$ | WSW |
| 01 Feb | -3.7 | 17:43:57 | $10^{\circ}$ | w | 17:47:19 | $82^{\circ}$ | s | 17:50:41 | $10^{\circ}$ | ESE |
| 01 Feb | -2.2 | 19:20:52 | $10^{\circ}$ | W | 19:23:51 | $29^{\circ}$ | SSW | 19:23:58 | $29^{\circ}$ | SSW |
| 02 Feb | -2.6 | 18:32:46 | $10^{\circ}$ | W | 18:35:58 | $40^{\circ}$ | SSW | 18:38:17 | $16^{\circ}$ | SE |
| 03 Feb | -3.0 | 17:44:44 | $10^{\circ}$ | W | 17:48:02 | $54^{\circ}$ | SSW | 17:51:20 | $10^{\circ}$ | ESE |
| 03 Feb | -1.1 | 19:22:16 | $10^{\circ}$ | WSW | 19:24:16 | $15^{\circ}$ | SW | 19:25:42 | $12^{\circ}$ | SSW |
| 04 Feb | -1.4 | 18:33:49 | $10^{\circ}$ | W | 18:36:27 | $21^{\circ}$ | SW | 18:39:05 | $10^{\circ}$ | SSE |
| 05 Feb | -1.8 | 17:45:36 | $10^{\circ}$ | W | 17:48:35 | $30^{\circ}$ | SSW | 17:51:33 | $10^{\circ}$ | SSE |
| 06 Feb | -0.4 | 18:36:12 | $10^{\circ}$ | SW | 18:36:44 | $10^{\circ}$ | SW | 18:37:15 | $10^{\circ}$ | SW |
| 07 Feb | -0.7 | 17:46:52 | $10^{\circ}$ | WSW | 17:48:56 | $15^{\circ}$ | SW | 17:50:59 | $10^{\circ}$ | S |

## END IMAGES, OBSERVING AND OUTREACH



Orion rising. Through the bamboo in my garden. 35mm for 30 seconds on Nikon D850, tracked. ISO 640.
Cloud scudding through.
Andy Burns

## January Observing Suggestion

Wiltshire Astronomical Society Observing Suggestions for January 2021 @ 20:00
We have updated the observation targets this month for those with binoculars or smaller wide field telescopes to have something to search for.

The WAS Observing Team will provide recommended observing sessions for you to do while maintaining social distancing away from the home or as part of your social bubble at the homes of close friends or relatives. Please always follow the latest government guidelines if observing away from the home.

These observing recommendations will continue until we can start our group observing again.
Most target objects can be found around due South East at about 20:00.

## Where To Look This Month:

This month we concentrate on and around the constellation of Auriga.
Just select 'What's Up' link below to get the PDF file.
What's Up Link:
WAS_January_2021.pdf
Also Wiltshire Astronomical Society will produce the monthly newsletter containing further information, which can be downloaded here: https://wasnet.org.uk/

## OUTREACH

I have a Zoom school session at Stonar on 14th January (tbc)
The Westbury Leigh school have been in touch and want a Zoom session but recent events have put everything on hold until this lockdown is over.

