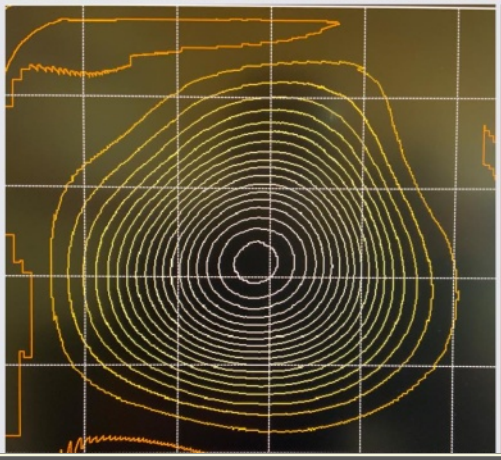
Summer 2022 Number 36

Kielder Observatory Newsletter



NEWS
Winter/Spring tickets released

NIGHT SKY
Highlights Aug/Sept/ Oct

SCIENCE
JWST/Neutrinos

S.T.E.A.M
Helen McGhie's exhibition

EDITORIAL

Well, the James Webb Space Telescope is sending back its first, spectacular images and we take a brief look in this edition. Back on terra-firma, Helen McGhie describes her new exhibition - which forms part of a walking trail up to the observatory, and Robert Williams takes a look at that elusive particle, the neutrino.

The nights are now getting darker and deep sky astrophotographers will be dusting off their equipment after the summer break. If you are thinking of visiting the observatory in the next few months then book as soon as you can. Places sell fast!

Nigel Metcalfe

Editors: Nigel Metcalfe & Robert Williams

Kielder Observatory Astronomical Society

Registered Charity No: 1153570.

Kielder Observatory Astronomical Society is a Charitable Incorporated Organisation. Its aims are to

* Promote interest in the science of astronomy to the general public
* Facilitate education of members of the public in the science of astronomy
* Maintain an astronomical observatory in Kielder Forest to support the above aims

https://kielderobservatory.org

E-mail: chairman@kielderobservatory.org
secretary@kielderobservatory.org
admin@kielderobservatory.org

KIELDER OBSERVATORY
Infinite Inspiration

Front cover: Many (safe) ways of observing the sun.
Rear cover: Looks like a good night in prospect!

Small Visitor Attraction of the Year

North East England Tourism Awards 2022

Gold Award Winner

KOAS NEWS

As mentioned in the last newsletter, our annual report and accounts for 2020/21 have now been submitted to the Charity Comission. Any member of the public can view the details. In fact, the accounts for the last five years are available on the Charity Commission site. No sooner has that been done and the trustees have to set the budget for next year (i.e. 2022/23)!

The trustees met online in May and again in July - we are still waiting for our first full in-person meeting since the pandemic (July's attempt was scuppered by the record temperatures that day!). With any luck this will happen in August ...

There are some changes in the offing. Trustees are appointed initially for three years, with the possibility of reappointment for up to three such periods, after which, following Charity Commision recommendations, our constitution requires that they step down. Given KOAS was registered as a CIO (Charitable Incorporated Organisation) in 2013, you won't be surprised to learn that some of our longest serving trustees are approaching the end of their third term (including yours truly - but don't worry, the newsletter will continue!).
We currently have nine trustees. With our constitution allowing a maximum of 12 trustees, there is plenty of scope for new faces, and we are actively seeking new people to join us on our journey.

Nigel Metcalfe
Secretary

KIELDER OBSERVATORY
Infinite Inspiration

OBSERVATORY NEWS

Dressing appropriately for the weather at Kielder means different things at different times of the year. In summer, it means prepare for the midge! Here our astronomer Ellie Macdonald is using a Smidge midge-proof headnet to keep them off.

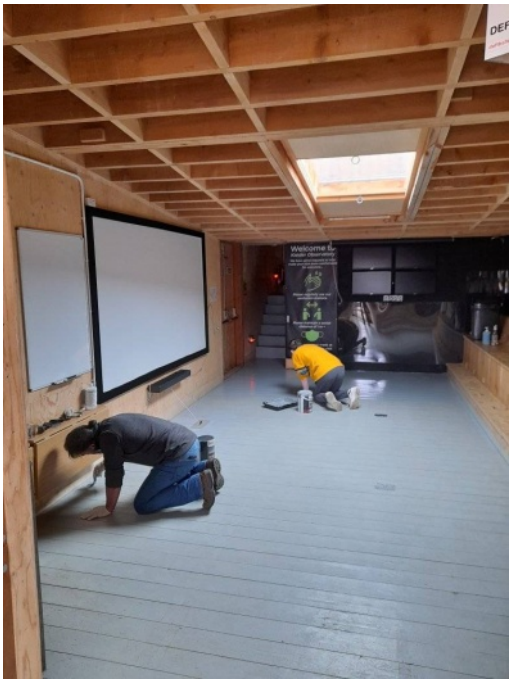
Summer tends to be the quieter time at the observatory, but, as I write this at the end of July, August is pretty much sold out! We do still have a few seats left for our Space Kids events, which are running at 17:30 throughout the school holidays. Choose between our long-running 'Rockets & More' theme or the new 'Solar Quest' - these events are guaranteed to inspire young minds and offer fun activities such as rocket building and UV light workshops. Meanwhile, our winter/spring 2023 events calendar is now mostly listed on the website for booking.

Weekend tickets are already starting to sell, so if you have a date in mind do keep an eye on availability! There are a few dates and certain event types still to be listed so please bear with us as we get these loaded.

At the beginning of June we held an event to watch the lighting of the Kielder Beacon to celebrate the Queen's Platinum Jubilee. It was possible to see Steve Cram CBE lighting the beacon though our telescopes!

Later in June, we closed the observatory

for a few days few of maintenance, and our astronomers swapped the telescopes for paintbrushes and rollers!



A bit of DIY!

On the personnel front, our astronomer Naz Jahansahi, who has been with us for 3 years, is leaving to join the team over at Jodrell Bank where we are sure she will continue inspiring hundreds of people to get involved in science and astronomy. Join us all in wishing her the best of luck in her new adventures!

We have a very special event taking place

Naz is heading for Jodrell Bank

this September as we welcome poet Caroline Burrows on her cycling tour 'Turning Pedals into Poems'. There will be a special talk from our team of astronomers alongside Caroline's one-woman hour-long show, including fantastic poems about astronomy! She's creating a sustainable tour by cycling from venue to venue, so we're very excited to be welcoming her to Kielder Observatory! There have been a few new episodes of our ever popular Kielder Observatory

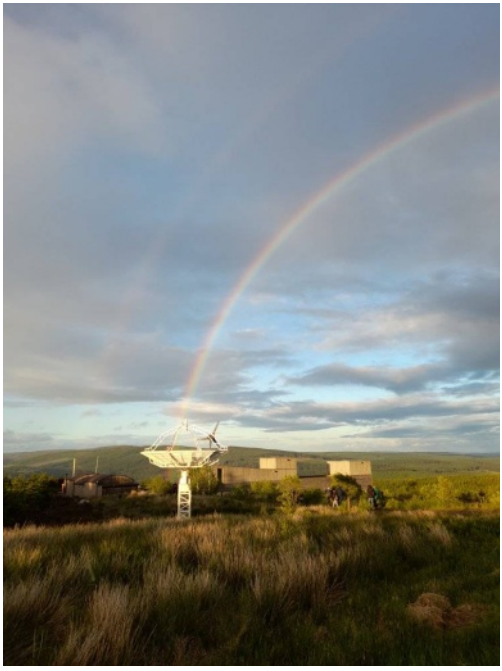
OBSERVATORY NEWS

Podcasts since the last newsletter. In May's edition Dan Pye explains Noctilucent Clouds and is joined by Helen McGhie to discuss her new art installation (more on this later!) and then in June Dan Pye and Ian Brannan discuss the Secret Life Of Stars and compare our own sun with the very largest star in the known Universe. And hot off the press for July is

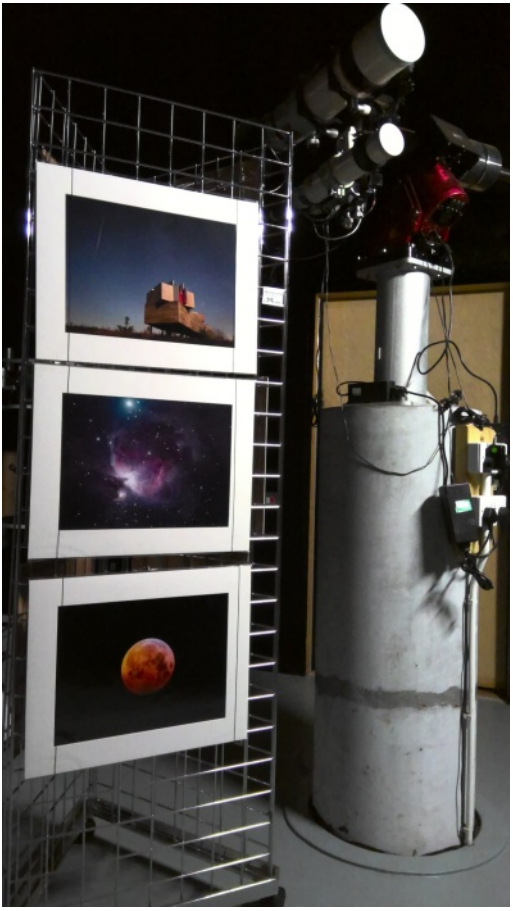
a podcast about the new images released by the James Webb Space telescope - including a contribution from our trustee Jürgen Schmoll, Senior Optical Engineer at the Centre for Advanced Instrumentation at Durham University, who has actually worked on the instruments for the James Webb.

In print, Dan Pye, our Director of Astronomy and Science Communication wrote an article about the Observatory for this quarter's Royal Astronomical Society's magazine, A&G. We also feature in Rough Guide's new pocket guide to Newcastle and Northumberland - as their pick of one of the region's top 15 places to visit!

We're pleased to say we've made it on Tripadvisor's Travellers' Choice Award list again, for 2022! Our positive reviews and ratings put us in the top 10% of attractions worldwide. Thank you everyone for your support.



OBSERVATORY NEWS



Our ever-popular prints have had an update in our online shop to include some wonderful new images taken by our team of astronomers. You can see our full range of prints in our online gift shop and up at the Observatory when you visit.

Finally, we have just launched, in partnership with Utilita Arena Newcastle, an exciting competition to win tickets to see Professor Brian Cox in his show 'Horizons: a 21st Century Space Odyssey' on Saturday17th September. The prize will also include a family ticket to the Observatory and a goodie bag of our merchandise. The competition will be on our Facebook and Instagram pages.

KIELDER OBSERVATORY
Infinite Inspiration

Late Night Explorer - 1st July

"Fantastic night. The team were extremely knowledgeable, excellent delivery of all the information, well organised, friendly and approachable team. Despite the rain and low cloud it was an excellent plan B. I came away with my head buzzing! Blown away by the rocks and meteors."

Susan, Northampton

STEAM SLOT

'Another Dimension' outdoor exhibition: a creative encounter with dark skies

. Open on the track to Kielder Observatory, visit until 30 September 2022.

'Another Dimension' is my new outdoor exhibition, giving visitors the chance to explore the darkness of a winter Kielder night throughout the summer months. It is a series of 11 large photographic banners suspended between trees on the Skyspace walking trail, about 10 minutes' walk from the Skyspace (lower) car park at Kielder Observatory. The exhibition includes portraits of dark sky observers, astronomy equipment and glimpses of a winter Kielder night. This is the major

outcome of my artist-residency (and University of Sunderland PhD research project) with the Observatory, which I embarked on in 2017. It follows a series of photographic displays, from 'Observe, Experiment, Archive', a photographic exhibition at Sunderland Museum and Winter Gardens back in 2019-20, to the virtual exhibition 'Another Dimension' which was launched earlier this year.

You might ask, why? What is this exhibition all about?
The answer is in my main research question: can art photography create new encounters with dark skies in Northern England? Rooted in art rather than science, this project aims to find new creative ways to communicate the experience of being in an international dark sky park (engaging new and existing audiences), and how photographs can challenge existing representations of dark skies. After spending so much time reflecting on and under dark skies (see my article 'Creative observations and snoozing under the stars' in the Spring 2020 newsletter), I now wish to share the sensations and encounters I've had (and the experiences shared to me by others) when observing the sky at night, be they physical or mental. The Observatory (and 'obsy' community) is full of inspiration and stories. I have explored a range of creative experiments at the Observatory (which has become my


© H. Goodfellow

wonderful research laboratory), from asking questions to staff, volunteers and visitors, to photographing and even mapping the space with augmented reality software.

After producing work on site and in my artist studio, I have shared my art in different contexts: in and outdoors, online, sonic and invisible. If you visited in February this year, you may have heard a surprise glitchy hum on the path from the upper car park to the Observatory buildings. This was in fact a series of 'sonified' photographs that sounded like a sci-fi soundtrack-crossed with the swoon of an electric car, listen here. Back then, I wondered how/if it is possible to experience a photograph under dark skies, where one should not really look at artificial light. Transforming the photographic data into audio removed a need for illumination and located the experience inside the mind. One lovely visitor shared how the sound made them feel like an “explorer” as they attempted to work out what the sound was when wandering towards the Observatory. Under a semi-cloudy sky, this comment was music to my ears, for it demonstrated the magic of a night at Kielder, without the need for a clear sky.

‘Another Dimension’ is an exhibition that aims to bring a sense of the winter dark sky experience to the summer. Activated by daylight, there are images of stargazers (which include staff member Jesse and previous team members Naz and Natasha) who gaze up at the sky, surrounded by inky darkness, the encounter of an opaque night seen whilst eyes adjust to night vision. I’m interested in such moments, which can feel a bit


© H. Goodfellow

unsettling at first. I remember the first time I visited Kielder—I got out of my car, stretched out my arm and couldn’t see my hand! Other images show Kielder artefacts, one shows a cosmic-esq shot of

gravel, another a meteorite-shaped rock. Both locate the landscape as an exciting elsewhere, sharing the Kielder experience as 'out of this world'. In a world increasingly illuminated by screens and the glow of artificial light, the art of darkness becomes another domain to discover.

Like scientific research, artistic research means to test and trial ideas to generate data and the potential for new findings. My process has involved sharing my photographs in a range of contexts. The current outdoor exhibition transforms the space of the forest into a place of accidental encounter (McKay and Ritson, 2017), where unsuspecting visitors may unintentionally discover the work, suddenly finding themselves in an art gallery that had no clear entrance. Art, dark skies and the forest collide, with banners offering images as portals to a different time of the year and an alternative perspective of Kielder Forest (and Observatory), hopefully encouraging new audiences to return to witness the winter dark skies later on.

The merging of art and science is nothing new. Methods of creative practice are used to inspire audiences with science in new ways—think hands-on art workshop activities or impressive installations, such as Luke Jerram's work Gaia, a giant

Luke Jerram. (2022) Gaia, Oxford Festival of the Arts. Image: Roy Riley

illuminated Earth. During one 'sci-art' panel I participated in at a huge online science conference, the chair invited scientists and artists to meet and work with one another. The invitation was for the artist to communicate complex scientific research to 'share knowledge' with new audiences, in exchange for creative inspiration. Whilst I see the many benefits in such work (particularly for a scientist who may gain innovations in how to communicate complex research), my project does not seek to illustrate scientific ideas through

art. Instead, it questions the cultural operation of images in a dark sky park and how they function as part of a science organisation. I am not an astrophotographer, but I am interested in the role of images. How photographs relate to our relationship with the cosmos, and how traditional starry-sky images can,

perhaps, dislocate what a visceral encounter with a dark outdoors feels like. On a clear winter night, it may be really (really) cold, and the thick nocturnal environment landscapes may be frightening to navigate for new visitors to a truly dark place. There is so much more to the cosmos--to sense, imagine and to feel when one visits a dark place than is often represented in photography, clear skies or not. I hope that my work offers this provocation.

Helen McGhie

References:

Luke Jerram (2022) Gaia. Available at: https://my-earth.org/ (Accessed: 29 July 2022)

McKay, C. & Ritson, A. (2017) 'Photography in the City', in Callaghan, P. (ed.) Culture in the City. My World.

Ticketed parking is available at Skyspace car park at all times, please note there is no vehicular access to the track except for those with a ticket for an observatory event in the evening (please follow traffic flow rules). The work is on show until the 30 September and there will be a very special tour of Another Dimension, James Turrell's Cat Cairn: Kielder Skyspace and Kielder Observatory with Peter Sharpe (Kielder Art and Architecture curator) and Helen in September. Further details will be shared soon.

Helen is Senior Lecturer in Photography at the University of Sunderland. The work is supported by the Arts and Humanities Research Council's National Productivity Investment Fund. She is keen to hear what people think of the exhibition and welcomes comments through social media: @kielderobservatory, @visitkielder #kielderdarkskies or contact Helen at: helen.mcghie@sunderland.ac.uk You can also view a virtual part of Another Dimension hosted on our website.

SCIENCE SLOT

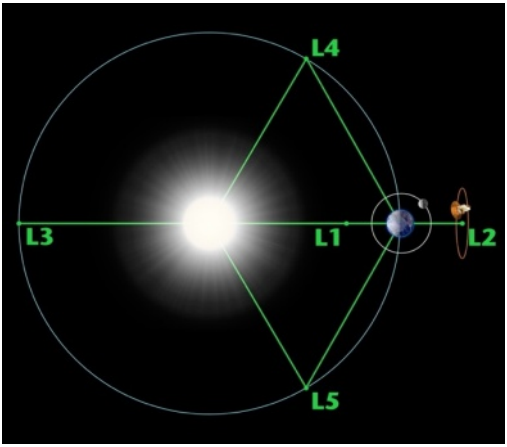
James Webb Space Telescope: First Images

In our Summer 2021 newsletter we took a look forward to what we might expect from the James Webb Space Telescope (JWST). Well, as you probably have noticed, the first science images have now been returned from space, so we felt it time to revisit the topic …

JWST is designed to mainly carry out infrared astronomy. Infrared astronomy is an important branch of astronomical observations because infrared radiation is not blocked by dust clouds in the way that visible light is. Also, due to the expansion of the Universe, the light from distant galaxies gets shifted to redder and redder wavelengths, and they become invisible except in the infrared. The JWST is therefore able to observe the formation of the first stars and early galaxies, as well as the atmospheric composition of exoplanets, including those that might support life.

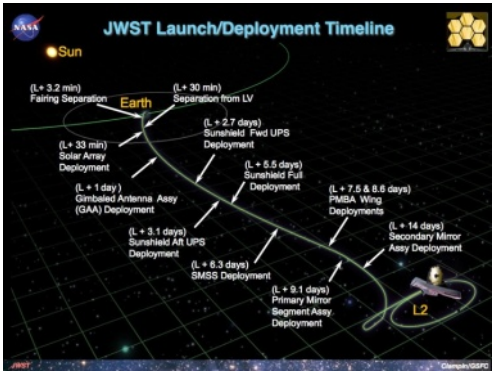
The telescope is named after James E. Webb, who was the NASA Administrator from 1961 to 1968 during the Mercury, Gemini, and Apollo programs. The telescope is the successor to the Hubble Space Telescope.

Eventually, after many delays (it was something of a standing joke in astronomy that launch was always going to be 'next year' - ed.), JWST was successfully launched on 25th December 2021. On 24th January 2022, JWST arrived at its final orbit around the second Sun-Earth Lagrange point, L2, nearly 1 million miles away from the Earth. Commissioning activities were finalised on 11 July 2022, and the first full-colour images and spectroscopic data were publicly released on 12th July.



***The Sun-Earth Lagrange points*.**

Credit: NASA



The various stages of deployment on the way to L2

Credit: NASA

The L2 Lagrange point is one of five L points. Lagrange points are positions in space where objects sent there tend to stay put. At Lagrange points, the gravitational pull of two large masses precisely equals the centripetal force required for a small object to move with them. These points in space can be used by spacecraft to reduce the fuel consumption needed to remain in position.

JWST operates in a halo orbit around the L2 point, 1,500,000 km beyond Earth's orbit around the Sun, its actual position varying between about 250,000 and 832,000 km from L2 as it orbits. This keeps it out of the Moon's and Earth's shadows, and at the same time, the telescope can orbit the Sun at a more or less constant distance, and it can simultaneously block incoming heat and light from the Earth, the Moon and the Sun, and avoid the smallest temperature changes. This arrangement keeps the telescope's temperature constant and below the 50K (−223°C) necessary for faint infrared observations.

JWST has a 6.5-meter-diameter (21 ft) mirror, composed of 18 hexagonal segments This gives JWST a light-collecting area of about 25 square meters, some six times that of Hubble. Unlike Hubble, which observes in the near ultraviolet, visible, and near infrared (0.75–1.4 μm) spectra, JWST only observes in a lower frequency range, from long-wavelength visible light (red) through to mid-infrared (0.6–28.3 μm). Being a much larger telescope, it can detect objects up to 100 times fainter than Hubble can, and, with its mid-infrared capabilites, objects much earlier in the history of the universe. It can go back to redshift z≈20 (about 180 million years cosmic time after the Big Bang). The earliest stars are believed to have formed between z≈30 and z≈20 (100–180 million years cosmic time), and the first galaxies may have formed around z≈15 (about 270 million years cosmic time).

SCIENCE SLOT

Components

The Integrated Science Instrument Module (ISIM) provides support services for the JWST, such as electrical power, computing resources and cooling capability. There are four main instruments:

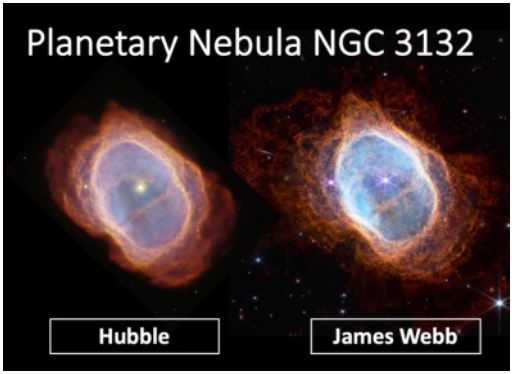
* NIRCam (Near InfraRed Camera) is an infrared imager covering the edge of the visible (0.6 μm) through to the near infrared (5 μm); there are 10 four-megapixel sensors.
* NIRSpec (Near InfraRed Spectrograph), built by ESA, will carry out spectroscopy over the same infrared range.
* MIRI (Mid-InfraRed Instrument) observes the mid-to-long-infrared wavelength range from 5 to 27 μm, with a mid-infrared camera and an imaging spectrometer.
* FGS/NIRISS (Fine Guidance Sensor and Near Infrared Imager and Slitless Spectrograph), led by the Canadian Space Agency, are used to stabilize the line-of-sight of the observatory during science observations.

Measurements by the FGS are used both to control the overall orientation of the spacecraft and to drive the fine steering mirror for image stabilization. The Canadian Space Agency is also providing a Near Infrared Imager and Slitless Spectrograph (NIRISS) module for astronomical imaging and spectroscopy in the 0.8 to 5 μm wavelength range.

NIRCam and MIRI feature starlight-blocking coronagraphs for observation of faint targets such as extrasolar planets and circumstellar disks very close to bright stars.

First Results

The first public release of JWST images showed a degree of detail much improved compared to equivalent Hubble images.



Comparison of images taken by Hubble and JWST

Credit: NASA, ESA, CSA, and STScI

The images of NGC 3132 above illustrate the higher resolution power compared with that of Hubble.

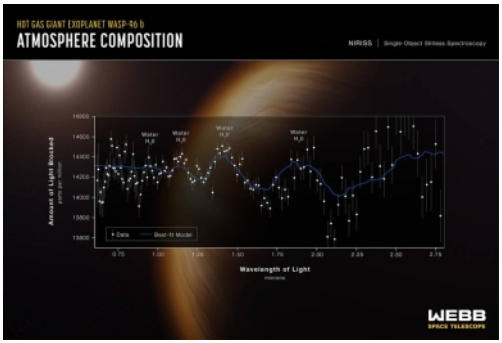
The deep field image of galaxy cluster SMACS J0723.3-7327, which totals 12.5 hours of exposure in several filters, shows many beautiful gravitational arcs caused by light from galaxies behind the cluster

being 'bent' by the gravitational pull of its huge mass. However, more excitingly, the first scientific results from this field are believed to show the most distant galaxy ever seen, at a redshift of ≈16 (although by the time you read this, this record might well have been broken!).

The SMACS J0723 deep field NIRCam colour image.

Credits: NASA, ESA, CSA, and STScI

Our final image shows the atmospheric composition of the exoplanet WASP-96 b. JWST has captured the signature of water, along with evidence for clouds, in the atmosphere surrounding a hot, gas giant planet orbiting a distant Sun-like star. While the Hubble Space Telescope has analysed many exoplanet atmospheres over the past two decades, JWST's detailed observation marks a huge



NIRISS spectrum of the atmosphere of WASP-96 b.

Credits: NASA, ESA, CSA, and STScI

improvement in the search for life on other worlds.

This is just the beginning; JWST is sure to produce many such stunning images in the coming years. NASA's goal is a 10-year operation, and there is enough fuel onboard to maintain the halo L2 orbit to support this.

More information about these images can be found at:
https://www.nasa.gov/webbfirstimages

Other information about JWST can be found at:
https://webb.nasa.gov/

You can also listen to our podcast!

Trevor Robinson

NIGHT SKY

AUGUST 2022 (times in BST)

Lunar phases

First quarter	05/08/2022	12:06
Full moon	12/08/2022	02:35
Last quarter	19/08/2022	05:36
New moon	27/08/2022	09:17

PLANET SUMMARY

Mercury is too close to the Sun to be seen this month. Venus will be a difficult object, lost as it rises in the morning twilight. Mars will be visible from around 0030 until 0330. Jupiter is close to opposition and will be visible from about 2300 until 0330. Saturn is at opposition [rises as the Sun sets] this month and will be visible from around 2230 until 0330. Uranus will be visible from midnight until 0400.

THE STARS AT 10PM

North – Lyra will be overhead with the two Bears nicely placed along with Cepheus. Auriga will be close to the horizon.

East – Andromeda and Pegasus will be nicely placed. Perseus and Cassiopeia are rising. Cygnus is high up.

South – Aquilla, Serpens Cauda and Ophiuchus are nicely placed.

West – Hercules is nicely placed with Bootes.

METEOR SHOWERS

August is well known for the Perseid Meteor Shower which is visible for most of the whole month. Maximum of the shower in 2022 falls on a Full Moon so it will be a challenge to view this shower in 2022. Expect around 50 to 100 shooting stars per hour.

COMETS

Comet 107P/Wilson-Harrington is expected to reach peak brightness [magnitude 7 – binoculars] in early August, when it passes close to Messier 45 in Taurus – best seen before dawn. In-The-Sky.org has printable finder charts for 107P/Wilson-Harrington.

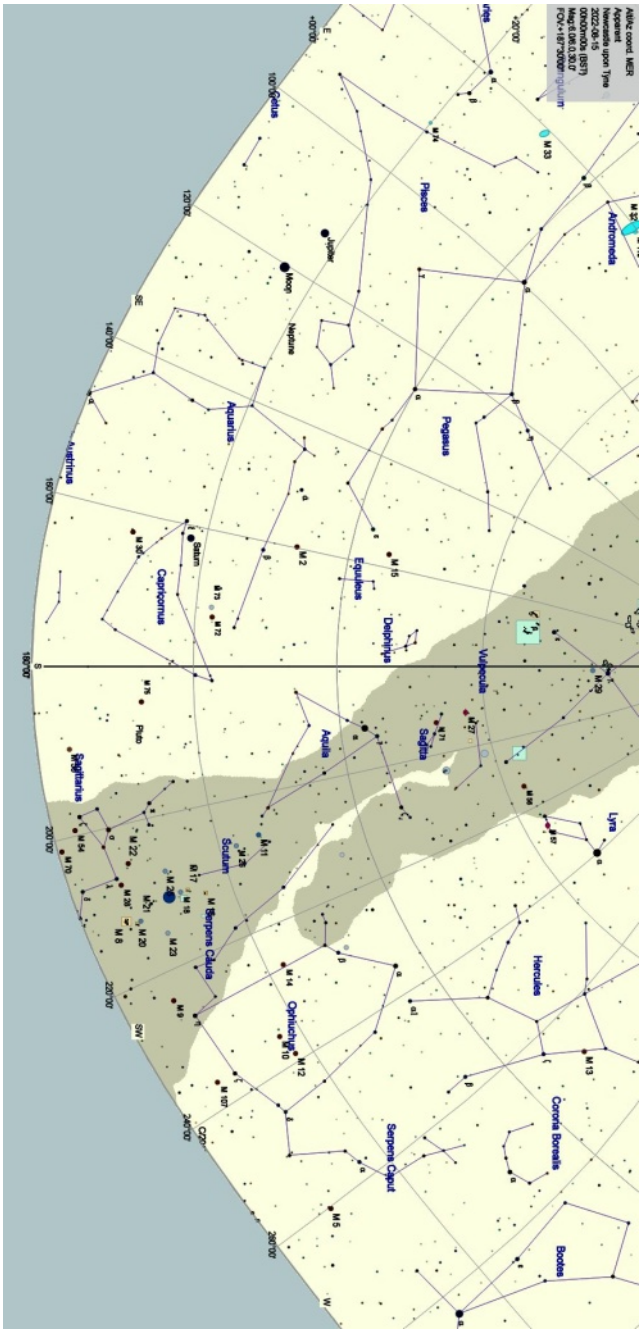
Comet C/2017 K2 PANSTARRS will also reach 7th magnitude at the similar time. It is visible in the constellation of Scorpius – one for the holidays to southern Europe perhaps, this year.

There are no other comets brighter than magnitude 9 on view during August.

The Planets 15/08/2022

	Sun	Moon	Mercury	Venus	Mars	Jupiter	Saturn	Uranus
Rise	05:37	21:58	08:09	03:49	23:16	21:49	20:39	22:48
Set	20:40	09:59	21:14	20:05	15:06	10:17	05:41	14:24

The sky chart for Newcastle looking S at midnight on 15/08/2022.



NIGHT SKY

SEPTEMBER 2022 (times in BST)

Lunar phases

First quarter	03/09/2022	19:07
Full moon	10/09/2022	10:59
Last quarter	17/09/2022	22:52
New moon	25/09/2022	22:55

PLANET SUMMARY

Mercury is too close to the Sun this month. Venus is lost in the morning twilight. Mars will be visible from around 2330 until 0430. Jupiter is close to opposition this month and will be visible from 2130 until 0500. Saturn will be visible from 2100 until 0130. Uranus will be visible from 2230 until 0500.

THE STARS AT 9PM

North – Lyra and Cygnus will be overhead with the two Bears nicely placed along with Cepheus. Auriga will be close to the horizon.

East – Andromeda and Pegasus will be nicely placed. Perseus and Cassiopeia are rising. Cygnus is high up.

South – Aquilla, Serpens Cauda and Ophiuchus are nicely placed.

West – Hercules is nicely placed with Bootes.

METEOR SHOWERS

There are no major meteor showers in September.

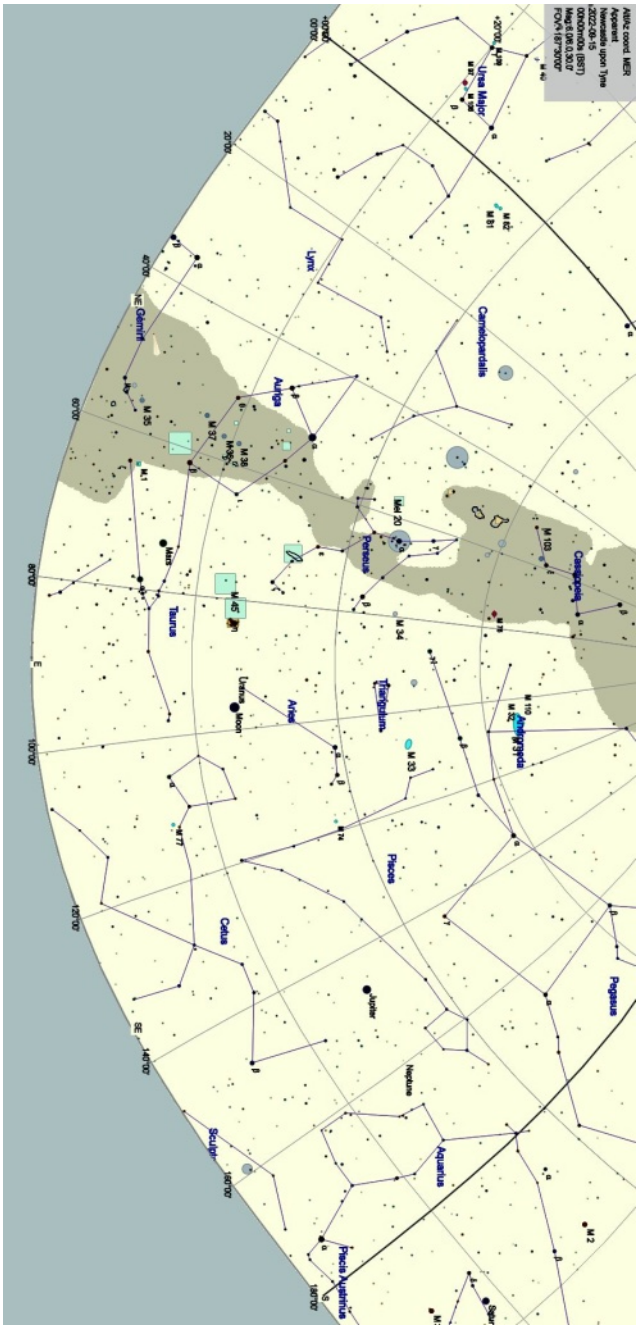
COMETS

There are no other comets brighter than magnitude 10 expected in the sky this month. Weekly comet updates can be found at http://aerith.net/comet/weekly/current.html or https://in-the-sky.org/data/comets.php

The Planets 15/09/2022

	Sun	Moon	Mercury	Venus	Mars	Jupiter	Saturn	Uranus
Rise	06:35	20:44	08:22	05:39	21:59	19:44	18:29	20:46
Set	19:24	13:05	19:14	19:17	14:39	07:57	03:22	12:22

The sky map looking E from Newcastle at midnight on 15/09/2022.



NIGHT SKY

OCTOBER 2022 (times in BST)

Lunar phases

First quarter	03/10/2022	01:14
Full moon	09/10/2022	21:54
Last quarter	17/10/2022	18:15
New moon	25/10/2022	11:49

PLANET SUMMARY

Mercury will be visible in the morning twilight. Venus is in conjunction with the Sun. Mars will be visible from 2200 until 0530. Jupiter is still close to opposition, and will be visible from 2000 until 0430. Saturn will be visible from 2000 until 2330. Uranus will be visible from 2030 until 0530.

THE STARS AT 10PM

North – Cepheus will be overhead with the two Bears nicely placed along with Cepheus. Auriga will be close to the horizon.

East – Andromeda and Pegasus will be nicely placed. Perseus and Cassiopeia are rising. Cygnus is high up. Capricornus will be low down.

South – Aquilla, Serpens Cauda and Ophiuchus are nicely placed.

West – Cygnus, Lyra and Hercules are nicely placed with Bootes low down.

METEOR SHOWERS

The major meteor showers of October are:

a) Around 8th October – the Draconids – a minor show but can still put on a show – visible all night in the North. Near Full Moon in 2022 so a challenge to view this shower.

b) Around 20th October – the Orionids – a major shower of the year. Near to Last Quarter Moon which will be rising as Orion rises so difficult conditions to see this shower in 2022.

COMETS

No bright comets are expected in October.

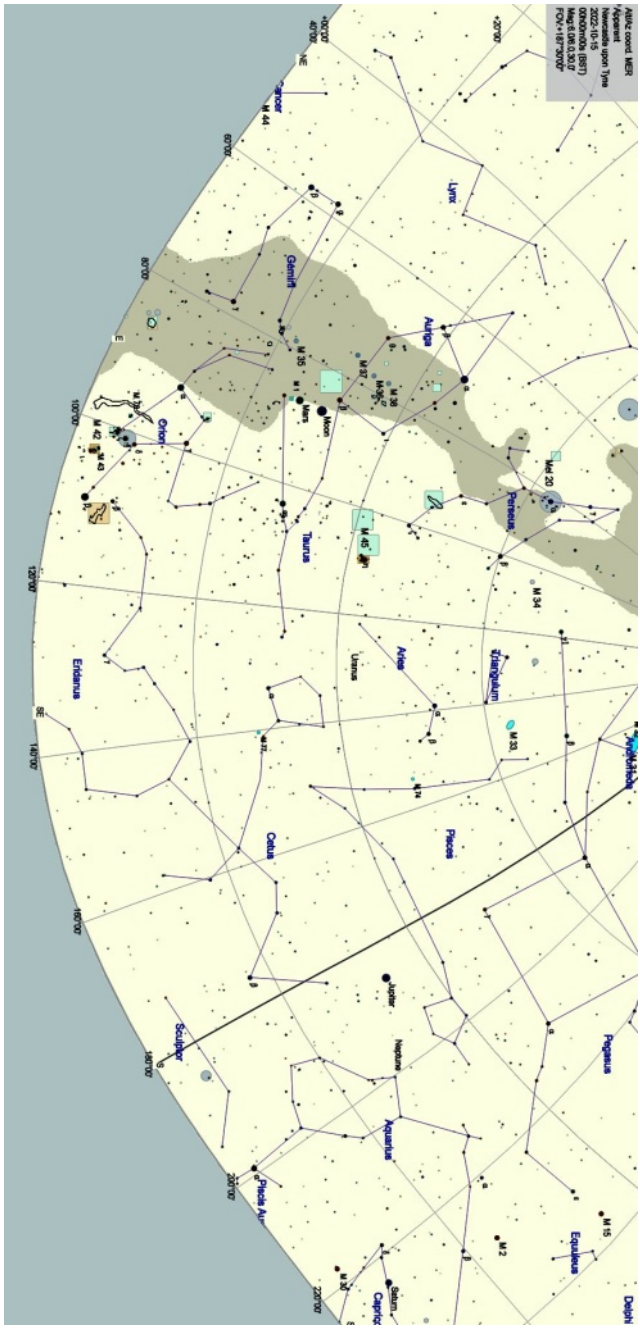
The Planets 15/10/2022

	Sun	Moon	Mercury	Venus	Mars	Jupiter	Saturn	Uranus
Rise	07:32	19:46	05:54	07:19	20:28	17:37	16:29	18:46
Set	18:08	14:30	17:56	18:11	13:40	05:52	01:17	10:19

The sky map looking SE from Newcastle at midnight on 15/10/2022.

Night Sky credits:

Data sourced from Cartes du Ciel, https://www.timeanddate.com/moon/phases/ and https://in-the-sky.org/



SCIENCE SLOT

Neutrinos

The neutrino is an ethereal particle. It has – almost – no mass, travels at – almost – the speed of light and interacts with – almost – nothing. Yet it seems to be one of the most important particles in the Universe.

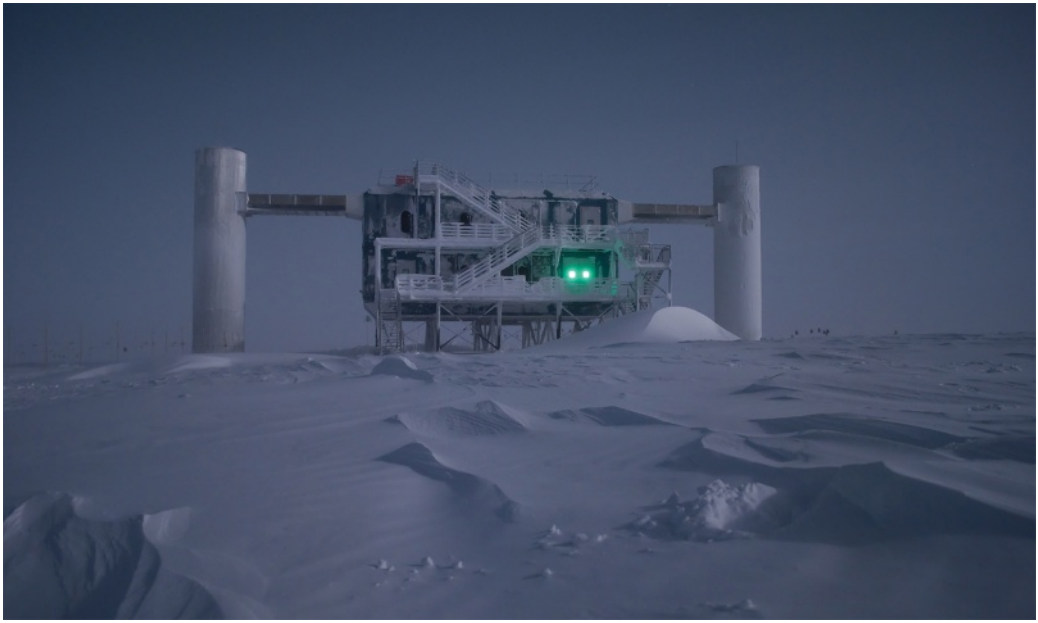
Our Sun pumps out trillions of neutrinos every second but these mysterious particles seem to have the ability to change their nature at will.

The neutrino is a lepton, a particle that has a spin=1/2 and has a mass of less than 0.12eV [about 40 times smaller than a photon of light and 1-millionth that of the electron]. There are currently 3 flavours of neutrino known, the electron neutrino (v_e), muon neutrino (v_μ) and the tau (v_τ) neutrino, each of which has an alter-ego anti-neutrino with opposite spin. They are created in supernovae and by the spin down of neutron stars. They are principally found on Earth due to the interaction of cosmic rays with the atoms of Earth's atmosphere. The Sun generates $6.5x10^{11}$ neutrinos every second per square centimetre of the Sun-facing side of the Earth but mostly they travel right though Earth unimpeded. In other words about $6.5x10^{15}$ neutrinos are passing through your body every second!

Neutrinos were first postulated by Wolfgang Pauli in 1930, to match the observed properties of beta decay [i.e. electrons] of radioactive nuclei. In 1932, James Chadwick discovered another neutral particle – the neutron – whose mass was many orders of magnitude greater than the neutrino. The neutrino was a by-product of how the neutron was created, from a proton.

The Solvay Conference - of 1934 - discussed the nature of the neutrino and found that Pauli was correct and in 1942 an experiment was proposed to make the measurement of this 'new' particle. Confirmation came in 1956. Anti-neutrinos from a nuclear reactor were collided with protons which created neutron-positron pairs. The positron reacted with an electron to create two gamma rays with a specific energy. In 1965, in an experiment 3 km underground in a South African gold mine, natural (i.e. not man-made) neutrinos were directly detected for the first time.

By that time, it had been established that there were indeed 3 flavours of neutrino. However a new mystery showed up, in that the Sun appeared to be producing fewer electron neutrinos than expected. The solar neutrino problem took over 30 years to resolve, simply because it



The IceCube Neutrino Observatory in Antarctica under moonlight.

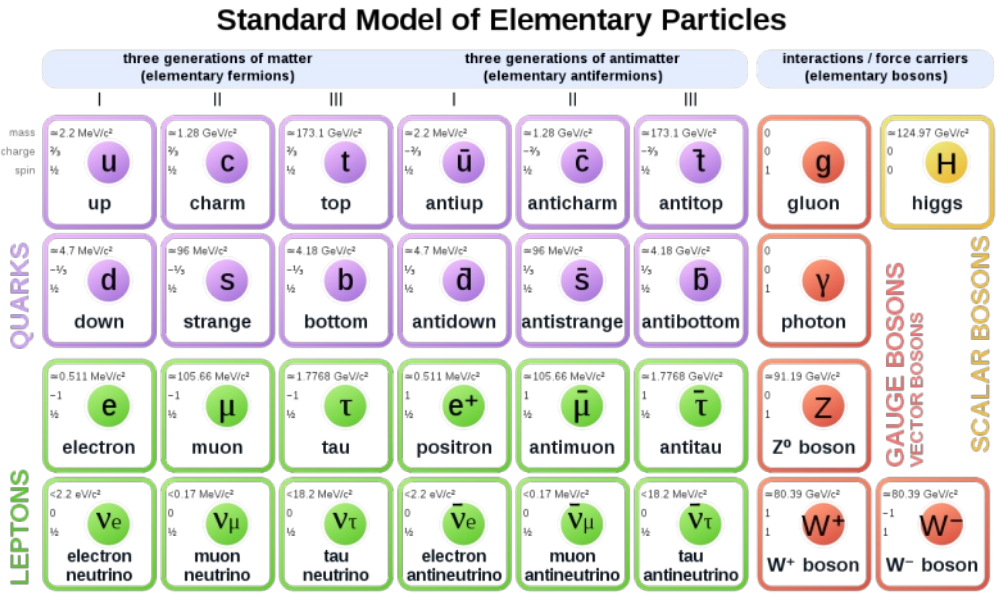
Credit: Emanuel Jacobi, IceCube/NSF

turned out that neutrinos were rather more exotic than expected. Results announced in 2001 based on two experiments [Super Kamiokande and the Sudbury Neutrino Observatory] showed that the neutrino can switch between flavours - so the 'missing' neutrinos turned out to be muon and tau neutrinos. In 2002 two researchers were awarded the Nobel Prize in Physics for their work detecting solar neutrinos, alongside the direct observation of neutrinos from the explosion of SN1987A in the Large Magellanic Cloud. In 2015 two theorists were awarded the Nobel Prize in Physics for the discovery of neutrino oscillations.

Neutrinos were created in the Big Bang, when about 1 second after 'kick-off' they decoupled from the evolving Universe to form the so-called Cosmic Neutrino Background. Despite their elusive nature these neutrinos have a measureable effect on the evolution of the Universe, affecting the Big Bang nucleosynthesis of the elements and the growth of structure in the Cosmic Microwave Background. Even though neutrinos have very little mass,

they could also contribute to the problem of Dark Matter in the Universe. So astrophysically neutrinos are very interesting to study. Unfortunately it is rather difficult to detect neutrinos directly from outside the Solar System. The IceCube Neutrino Observatory in Antactica was completed in 2010 and consists of a detector made of one cublic kilometre of ice. Even, so the number of cosmic neutrinos they have detected is only in the low hundreds (they detect billions of indirect neutrinos from cosmic rays hitting the Earth's atmosphere).

As fermions, Neutrinos interact by the Weak Force. Currently, it has not been possible to measure the mass of the individual types. The simplest reason is that – according to the Heisenberg Uncertainty Principle - when attempting to measure the mass of the neutrino, the mass/position of the particle is changed and that is not allowed. They also undergo the Mikheyev–Smirnov–Wolfenstein effect, which basically says that a tiny fraction of their mass is transferred to the medium through which they travel.



More recently neutrinos have been thought to be their own anti-particle. There are a number of experiments currently running to check if this is indeed correct. They have also been thought to be the 'trigger' to induce the decay of heavy nuclei and may explain the wide selection of isotopes of every element found in the cosmos.

And now onto the latest news of neutrinos. There are been various anomalous results from experiments over the last 20 years or so which hint that there may yet be a fourth flavour of neutrino, the 'sterile' neutrino. Running since 2002, in 2018 the MiniBooNE experiment at Fermilab reported they had found a possible signal indicating the existence of the sterile neutrino. The MicroBoone experiment was built to test this result – Microboone is essentially a tank containing 170 tons of liquid Argon at the detector end of a beam of neutrinos. In October 2021 it published its first results, and failed to confirm the presence of a sterlile neutrino. However, it was not able to offer any alternative explanation for the MiniBooNE result. And very recently, in June 2022, the Baksan Experiment on Sterile Transitions (BEST) experiment reported evidence in favour of the sterile neutrino. So the mystery continues ...

Robert Williams

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GALLERY

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Noctilucent clouds, 27th May 2022, seen from Seaton Carew, Co Durham.
Credit: Kevin Hubbard

The Sun with sunspots using a 25mm Pocket Borg refractor, Baader Solar film, 25mm Kellner eyepiece and a Google Pixel 3a. About 15x zoom.

Credit: Kevin Hubbard

GALLERY

Editor Robert Williams has been on his almost annual pilgrimage to sample the astronomical delights of the Southern Hemisphere, and sends us some sample images from his stay at the TIVOLI Southern Sky Guest Farm in Namibia.

Above: Milky Way shot from the Tivoli Guest Farm, Namibia. Taken with a Canon 6d plus14 mm lens, 30sec exposure at ISO 2000.

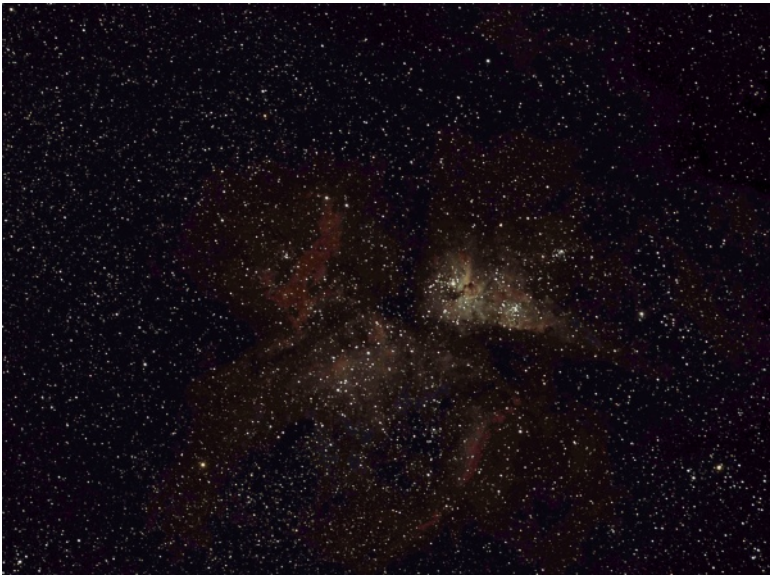
Next page: some of the equipment provided - a Takahashi FSQ 106ED refractor.

Introduction to Astronomy - 8th July

"Thank you guys it was enjoyable and informative. I walked away understanding about how to navigate the sky which is great. Also I enjoyed seeing the telescope. Overall this has fuelled my interest in Astronomy."

Manni, London

GALLERY



Above: NGC6188/93 - the 'Fighting Dragons of Ara'. About 80 mins of exposure stacked in AstroArt.

Left: NGC3372 (the Eta Carinae Nebula)

Credit: Robert Williams

Another Milky Way shot from the Tivoli Guest Farm, Namibia. Taken with a Canon 6d plus14 mm lens, 30sec exposure at ISO 2000.

Credit: Robert Williams

Secret Lives of Stars - 19th June

"Enthusiastic, engaging and highly informative team. Great experience, blew our minds and we found the whole visit amazing from start to finish. Time flew by and early morning finish well worth it! Already downloaded Stellarium and waiting for it to go dark. Thank you."

Mark, Birmingham

Young Explorers - 16th July

"Each person that spoke was clearly knowledgeable and really captivating with their talks. My son has ADHD so sitting and concentrating aren't his strong points but he was interested and engaged throughout! Thank you also for the two of you who took the time to talk to him at the end and offer suggestions of how to extend his interest further. You're all amazing and we can't wait to come back again soon."

Alison, Northumberland

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