



OASI News

The newsletter of Orwell Astronomical Society (Ipswich)



The Ningaloo Eclipse

Trustees: Mr Roy Adams Mr Neil Morley Mr David Payne
Honorary President: Dr Allan Chapman D.Phil MA FRAS

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Society Notices

Dear Members,

We haven't been experiencing many clear nights over the last few months, but when the skies have eventually cleared, I hope you have been outside observing. At the end of February, the aurora was even visible from Suffolk on a couple of evenings!

As the nights grow shorter, we will soon be moving in to our Solar Outreach season. We have a number of events planned over the next few months and are always looking for members to come along and help at these events. Please check our website for details.

It is great to see so many old and new members attending our meetings at Newbourne, we always aim to provide a mix of observing, talks and telescope fettling.

On the subject of Newbourne, I regret to announce that our Newbourne Coordinator and Newsletter Editor, Martin Richmond-Hardy has recently been taken ill and is in Hospital. I'm sure that everybody will wish to join me in sending Martin best wishes for a speedy recovery.

Finally, in Martin's absence, Paul Whiting has stepped forward to edit this month's Newsletter. Big thanks to Paul for this.

Andy Gibbs, Chairman

Society Contact details

Email queries: info@oasi.org.uk

Facebook: Orwell Astronomical

Twitter: @OASlpswich

YouTube:
<https://www.youtube.com/channel/UCHgxe3QAeRVWf7vkjKkCI2Q>

Members-only message board

<https://groups.io/g/OASI>

Observatory (meeting nights only)
07960 083714

**Please send material for the OASI
web site and newsletter
e.g. observations, notices of events,
general interest articles, to
news@oasi.org.uk**

The CLOSING date is the 15th day of the month

Access into the School Grounds and Observatory Tower

Orwell Park School have changed our access route to the observatory.

The new route will be as follows:-

- Enter through gate 2 (gate 1 being the main gate) and park inside as per the attached map.
- Enter the school through the double black doors as indicated on the map. A key fob will be required to open the door.
- Continue straight through the next two sets of double doors.
- Turn left at the end of the short corridor then immediately right.
- Pass through the single door and on your left you will find the staircase leading to the observatory.
- On no account must you deviate from this route.

When leaving the observatory use the same route but in reverse. Please keep noise to a minimum as there are staff quarters nearby.



Areas out of Bounds

- The staircase on the left through the first door is **out of bounds**.
- The staircase on the left through the second door is **out of bounds**.
- The double doors on the right just through the second doors is also **out of bounds**.

Any problems on the evening please phone the observatory number (07960 083714) on the back of your membership card.

Remember this is a school and straying into the main part of the school where the pupils reside would cause the society big problems and could see us losing the use of the observatory. Any member found to be anywhere other than the approved access route or the observatory area will face serious sanctions up to and including expulsion from OASI.

Please note that access time for all observatory member nights is after 20:15.

Articles for OASI News

News, pictures and articles for this newsletter are always welcome. Details above. Please submit your articles in any of the following formats:–

Text:	txt, rtf, rtf, doc, docx, odt, pdf
Spreadsheets:	xls, xlsx, OpenOffice/LibreOffice
Images:	tiff, png, jpg

Please send tables as separate files in one of the above formats.

If you don't feel up to writing a major article, perhaps you might write a short note for OASI News along the lines of "This month I have mostly been observing/constructing/mending/reading/etc."

The Newsletter archive is at www.oasi.org.uk/NL/NL_form.shtml

Authors, please note that your articles will be publicly available worldwide!

Reproducing articles from OASI News

If you plan to reproduce an article exactly as per OASI News then please contact the Editor – otherwise, as a matter of courtesy, please seek permission from and credit the original source/author. You may not reproduce articles for profit or other commercial purpose.

Committee 2023

Chairman	AndyGibbs	Set overall agenda for OASI, Chair committee meetings, Press and publicity
Secretary	RoyGooding	Outreach meetings (jointly with Chairman), observatory decoration
Treasurer	PaulWhiting	Finance, Supervision of applications for grants. Visits by outside groups, Observatory tours, Public appreciation of astronomy, Outreach activities
Committee	James Appleton	Committee meeting minutes, Web site
	MartinCook	Membership, Tomline refractor maintenance & user testing
	Matt Leeks	Safety & security
	PeterRichards	Lecture meetings, Email distribution lists
	John Wainwright	Equipment curator
	Mike Whybray	Astronomy Workshops, Child protection officer, Orwell Park School Astronomy Club
	Andy Willshere	Librarian
Martin Richmond-Hardy	Newsletter, OASI @ Newbourne	

For newsletter and Newbourne please contact Paul Whiting, while Martin is indisposed.

Committee Meeting

The next Committee Meeting will be on Friday 26 May at 8:00pm via Zoom. All members welcome.

Welcome to new members

James Vince
Andrew Rodgers
Benjamin Cook

OASI and BAA Events

For the latest event details, please see www.oasi.org.uk/Events/Events.php

There's a Google Calendar on the OASI web site with the latest dates (and corrections!).

If you want to easily add OASI Events to your own computer/phone/tablet calendar application click this button on the website Events page (bottom right of the calendar)



or use this address to access this calendar from other calendar applications:–

<https://calendar.google.com/calendar/ical/1jhs9db7lncki4sojo7092vfvc%40group.calendar.google.com/public/basic.ics>

For other astronomy news and astro pictures try our

Twitter feed <https://twitter.com/OASlpswich>

Facebook page <https://www.facebook.com/pages/Orwell-Astronomical/158256464287623>

Date, Time & Location	Contact	Event
Weekly, every Wednesday, from 20:15	Martin Cook, Roy Gooding	Observatory open
Thu 18 May 2023 20:00 Zoom	Paul Whiting, FRAS treasurer@oasi.org.uk	3rd Thursday Zoom meeting
Monday 22 May Newbourne Village Hall	Paul Whiting, FRAS treasurer@oasi.org.uk	OASI at Newbourne. Beginners welcome!
Fri 26 May 2023 20:00 Zoom	Andy Gibbs chairman@oasi.org.uk	Committee meeting via Zoom. All members are invited to attend.
Sat 03 Jun 2023 11:00-16:00 Christchurch Park	Roy Gooding secretary@oasi.org.uk	Public access event. Observing the sun safely. Booking not necessary. Details to be advised here when known.

Meetings via Zoom

To join, please first contact Paul Whiting, treasurer@oasi.org.uk – OASI members only. Be sure to install/update to the latest version of Zoom – there's no need to set up an account. Go to <https://zoom.us/join> and enter the meeting ID or personal link name. You will have received a link from the meeting organiser.

As well as for some lectures & talks, we meet via Zoom on the 3rd Thursday of every month at 8pm.

OASI @ Newbourne

Martin Richmond-Hardy
newbourne@oasi.org.uk

We meet at Newbourne Village Hall,
Mill Lane, IP12 4NP on the 2nd and 4th Mondays
from 19:30.

**Visitors are welcome but we do ask you
to join the Society after two visits.**

<http://www.oasi.org.uk/OASI/Membership.php>

Newbourne dates for 2023

May	1	22 note
June	12	26
July	10	24
August	14	28
September	11	25
October	9	23
November	13	27
December	11	

Note: The Parish Council requires the hall on 8 May
(our usual date).

We open up for all meetings at 7:30pm. Astro
News/Star Guide (A) at 7:45pm followed by any
Talks (T), Workshops (W) and occasional Quiz (Q).

STOP PRESS!

Newbourne Village Hall now has wifi.

Stargazer's Guide

On the last meeting each month, at 19:45, Bill Barton FRAS will give a short presentation of what can be viewed in the following 4 weeks plus a reminder of OASI events. These will be available on our website.

Paul Whiting FRAS will give occasional Astro News briefings.

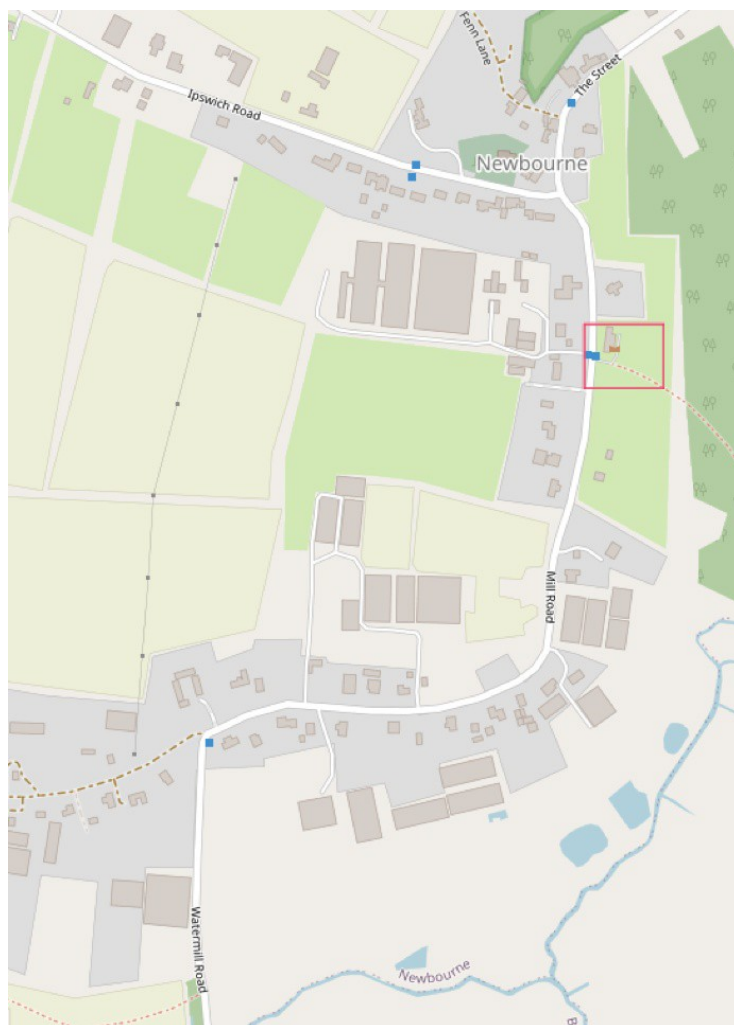
Astronomy Workshops/Informal talks

Contact Mike Whybray

Monday meetings start at 7:30pm. Workshops / Talks start at 8pm

If you are a new OASI member, or haven't been to one of these informal workshops before, they are a mixture of events of different characters including beginners talks, interactive workshops, films, etc., suitable for all.

Do you have a subject you could workshop/talk? You could do a short one, or share the effort with a partner. Drop Mike Whybray a line! workshops@oasi.org.uk



Lectures – via Zoom

Contact: Peter Richards lectures@oasi.org.uk

These may resume over the Summer period - - watch this space. The start time for all talks will be 8pm and, as usual, the talks will usually be held on a Friday evening. Contact Paul Whiting if you can't find the Zoom details.

Athaneum Astro Society

www.3a.org.uk/index.htm

Meetings (<http://www.3a.org.uk/programme.htm>) at Whepstead Community Centre, Bury Road, Whepstead, Bury St Edmunds, IP29 4TA <http://www.3a.org.uk/contact.htm>.

LYRA Lowestoft & Yarmouth Regional Astronomers

For events please see <http://www.lyra-astro.co.uk/events/>

DASH Astro

Darsham And Surrounding Hamlets <http://dash-astro.co.uk>

Meetings are normally held at New Darsham Village Hall and all DASH Astro observing sessions will take place at Westleton Common. ASOG observing sessions and locations may be arranged at the time of observation. Unless stated, all group meetings will take place from 7:30 pm. on Sundays.

Meetings <https://www.dash-astro.co.uk/Events>

BAA news & webinars

For full details of all meetings or cancellations, please go to <https://britastro.org/events/future-events>

13 May 2023	BAASpringMeeting–Cosmology:GalaxiesandStars , Cardiff
20 May 2023	HistoricalSectionMeeting2023 , Birmingham and Midland Institute, Margaret St, Birmingham
7 June 2023	BAA Meeting and George Alcock Lecture, Institute of Physics, London
8 July 2023	Comet Section Meeting, National Maritime Museum, Greenwich.

The BAA Radio Astronomy Section

The BAA Radio Astronomy Section have been enjoying talks, seminars and tutorials via Zoom and these are available on the BAA YouTube channel

<https://www.youtube.com/user/britishastronomical/playlists>.

The Night Sky in May 2023

Martin RH (with some help from his friends)

All event times are for the location of Orwell Park Observatory 52.0096°N, 1.2305°E.
Times are **BST** unless otherwise stated.

Sun, Moon and planets

Sources: <http://heavens-above.com/PlanetSummary.asp> <http://heavens-above.com/moon.aspx>

May 2023

Object	Date	Rise	Set	Mag.	Notes
Sun	1	05:26	20:19		
	31	04:42	21:04		
Moon	1	15:21	04:22		Full Moon 05 May 17:34 Last Quarter 12 May 14:28 Perigee 11 May 05:06 New Moon 19 May 15:53
	31	16:45	03:00		First Quarter 27 May 15:22 Apogee 26 May 01:40
Mercury	1	05:53	17:50	6.0	
	31	04:19	16:19	0.5	
Venus	1	08:53	20:53	-4.0	
	31	09:14	21:14	-4.2	
Mars	1	10:45	22:44	1.3	
	31	10:00	21:59	1.6	
Jupiter	1	05:00	16:58	-1.9	
	31	03:31	15:29	-1.9	
Saturn	1	01:51	13:49	1.0	
	31	23:59	17:01	1.0	
Uranus	1	06:24	18:22	5.9	
	31	04:36	16:34	5.8	
Neptune	1	03:10	15:08	7.9	
	31	01:18	13:16	7.9	

Occultations during April 2023

https://iota-es.de/moon/grazing_descr101.html and <http://www.lunar-occultations.com/iota/bstar/bstar.htm>

Observers are encouraged to download and install the **Occult** software program [Windows only] to generate predictions for their own particular site coordinates.

Meteor showers during May 2023

Source: BAA Handbooks 2022 & 2023 p26-27 and <https://in-the-sky.org/newsindex.php?feed=meteors>
<https://earthsky.org/astronomy-essentials/earthskys-meteor-shower-guide/>

Shower	Normal limits	Maximum	ZHR at Max	Notes
η -Aquarids	Apr 19 – May 28	May 5–7	40	Fine southern shower but poorly seen from the UK.
η -Lyrids	May 5 – May 12	May 10	3	Medium speed, nice if you catch one
T-Herculids	May 19 – Jun 19	Jun 1	var	An unknown quantity adding to the background

See also <https://www.rmg.co.uk/stories/topics/meteor-shower-guide>

For radio observation, use reflections from Graves radar on 143.050MHz or the Brams transmitter in Belgium on 49.97MHz and UK GB3MBA on 50.408MHz <https://www.ukmeteorbeacon.org/Home>

See also https://www.popastro.com/main_spal/meteor/radio-meteor-observing-2020/.

Comets

Source : <https://heavens-above.com/Comets.aspx> on 2 May.

Comet	Brightness	Date of last reported observation	Angular separation from Sun	Constellation
C/2020V2 ZTF	9.7	2023-Mar-05	11°	Aries

Visible ISS passes $\geq 10^\circ$ max altitude for May 2023

Source: <http://heavens-above.com/PassSummary.aspx?satid=25544>

Times are **BST**.

Predictions are approximate (2 May) due to craft adjustments. Check the day before.

Date	Bright-ness (mag)	Start			Highest point			End		
		Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
10 May	-3.7	19:03:11	10°	SW	19:06:31	76°	NW	19:09:49	10°	NNE
10 May	-3.7	19:03:11	10°	SW	19:06:31	76°	NW	19:09:49	10°	NNE

Not a good month for the ISS from Suffolk!

Starlink passes

<https://heavens-above.com/AllPassesFromLaunch.aspx>

For a dynamic 3-D display, see <https://heavens-above.com/StarLink.aspx>

Bill Barton's Radio Broadcast

ICRFM (Ipswich Community Radio) 105.7 MHz at about 08:25 in the morning of the first Wednesday of each month. I aim to cover what there is to see in the sky and then a little bit on something topical. ICRFM is also available to listen to over the Internet and there is a listen again option on their website. <http://www.icrfm.com>

Forthcoming Outreach Programmes

All members are welcome to come along and help out at these events – you don't need to be an expert in the subject. Just respond to the email call for help prior to the event.

Please note that not all events are open to the public.

Saturday 3rd June

Solar event in Christchurch Park, outside the Mansion. We will be using several filtered and solar telescopes to view the Sun safely. *Public Event.*
More details to follow.

Sunday 18th June

Solar event at ESWR Radio Rally, Kirton. 9 for 10am start, Kirton Sports Field. *Public Event.*

Sunday 23rd July

Solar event at Needham Lakes. This meeting is still pending, More details to follow, if the go ahead is given. *Public Event.*

Sunday 27th August

Solar event at Bawdsey Radar Museum. *Public Event.*
9.30 for 11am start. Follow AA signs from A12.

Friday 22nd September

Star Party at Thomas Mills School, Framlingham
A night time observing event, with lecture option if wet. More details to follow nearer to the date.
Private Event



Total Solar Eclipse (The Ningaloo Eclipse), Exmouth, Western Australia

Paul Whiting

For our little sojourn around Australia prior to the eclipse, we decided to make use of the direct Qantas flight from Heathrow to Perth. Just under 17 hours in the air. Travel to Heathrow was strangely uneventful, the Elizabeth Line was actually working all the way from Liverpool Street to Heathrow, cutting out the need to venture into the Underground.

The Hotel Hoppa bus services were running a more regular service than previous journeys post Covid, more regular and less full than last time I experienced them.

The flight was good, but an over helpful Qantas agent in LHR, and a less than helpful agent in PER did not do much for the experience! It appears that if you don't have a smartphone you're screwed! Paperless flights are now the norm.

Because of the airport security staff strike / go slow, we were advised to arrive at the airport 4 hours before departure, allowing an extra hour for delays. Of course, we got straight through and had to wait! The Qantas Business lounge has stopped serving champagne, only sparkling wine. I can understand this, given the number of corks popped while we were there!

Despite all the usually food and beverages (real champagne!) on board, I didn't sleep a wink though for some reason. Consequently, I arrived in Perth completely drained, luckily our overnight airport hotel had a free airport shuttle service – it just cost £4 in phone calls to tell them we had arrived. We were told to look out for a "silver van", so of course arguments entailed – "Is that silver? ..."

The airport apartments had no food or drink outlets. We were advised to try the pub up the road or Hungry Jacks next to it. So we did both. The pub – The Redcliffe Tavern – was a quaint Aussie pub, hangar like with corrugated iron walls, obviously a former warehouse. I was not quite sure why one of the barmaids was dressed as a bunny girl. Then I remembered it was Easter Saturday. Alas this was not the only reason. Western Australia has set the cause of anti-sexism back a few decades by introducing "Skimpies", of which this establishment was one. It means that there are topless or scantily clad waitresses working during quiet times to try to drum up trade.

The onward flight to Darwin the next day was straightforward and, although we had no transfer booked, we found a very useful group taxi-shuttle who collected a group of passengers together and then gave a guided tour of the city whilst delivering them – and all for \$15 each.

At the hotel we joined up with the Astro Trails group and were very surprised to see old friend John Mason there to welcome us.

The Double Tree Hotel was one of two side by side on the Esplanade in Darwin. Our side was being decorated, so we had to use the other for bar and restaurant purposes. It was the end of monsoon season so it was still very wet, but very high temps dried us out quickly!

Early start tomorrow, 6am – the first of many. I'm getting too old for this malarkey!

Off to Kakadu NP. Passed Humpty Doo, an Aussie military radio station, with acres of antennas of various sorts.

Our driver / guide (nick-named "Meatloaf" as he had more than a passing resemblance) was very garrulous – he narrated continuously throughout the 2 days we were with him. He does know his stuff though, but just did not know when to stop!

An early start (again!) saw us on a dawn cruise to see the sunrise. Didn't see the sunrise (too cloudy), but we did see a couple of large crocodiles and some magnificent birds of prey. There was also a last-minute opportunity for a flight over the Jim-Jim Falls. Jim Jim means lots of Jim, whatever that is (water pandanus plants)! There was plenty of wildlife about our chalets – hundreds of little frogs and our pet lizard, Harry.

Back to Darwin and fewer monsoons – we are now in Banggereng, one of the 6 aboriginal seasons, meaning “knock ‘em down” – referring to the sudden, swift storms preceded by very strong winds blowing down the elephant grass.

This time we went to the other Double Tree hotel, saving us getting wet going for dinner. I ended up with a two-floor suite, with stairs up to bedroom.

I always like to find a pleasant beer that I can call the “Beer of the Eclipse” – this distinction must go to a rather nice fruit beer – Mango (figure 1).



Figure 1: Mango Beer



Figure 2: The Ghan

Early start again on to the Ghan train (figure 2), named after the Afghan camel herders that were used to build the road infrastructure in the Northern Territories. This took us from Darwin all the way down the middle of Australia to Adelaide.

Each day on the Ghan is filled with various tours off the train, whether you want to go or not! I let myself be “persuaded” at Katherine (an afternoon boat trip along the Gorge) and at Alice Springs (a visit to the Royal Flying Doctor Service and the School on the Air HQ. Tonight, we have planned a dinner under the stars! Or rather thanks to cyclone Isla, under the cloud. The odd recognisable star did appear briefly, including Canopus, the Southern Cross, and a spectacularly bright Venus. I gave the camel rides a miss this time.

Cyclone Isla turned out to be nastier than first thought. It caused floods in the Adelaide region, which delayed the train for nearly a day. Still an extra few hours of free food and drink – I was even asked to run a quiz!

Safely arrived in Adelaide about 9 hours later than planned. Not enough to upset any onward travel plans. It was the night of a big football clash, and the locals had just won. The streets were heaving with drunkard fans as we tried to find an open restaurant, everywhere seems to close at 9pm. Eventually, after waiting for the police to arrest a guy for violent robbery, a Japanese restaurant took pity on us and opened up. It is amazing how different the streets appeared the next day – a Sunday morning!

And so, to Perth and on to Fremantle, where we met more familiar faces from eclipses past, including our new tour leader Nick James. John Mason gave everyone “the talk” on the Monday prior to the eclipse, before we all split up into various observing groups. I took a train ride in to Perth to try to find a Post Office selling eclipse stamp first day covers. Not a chance. Everywhere from Alice Springs, Adelaide, Fremantle and Perth had long since sold out. Maybe in the small insignificant village we are viewing the eclipse from ...

To get to the viewing site involved several private charter flights from Perth Airport. Not THE Perth Airport, but the private bit where all the executive jets are parked. Despite dire warnings about luggage weight and size (they actually didn't mind too much) we all successfully managed the 90-minute flight up the west coast of Australia, including flying over Rottnest Island, to Learmonth, a RAAF base near Exmouth, our home for the next 3 nights. The coach driver made a priceless comment, "Strewth, you're only here four days!" whilst hefting all our 3-week luggage. We knew this place was isolated, but they were not kidding! Despite the remoteness, tens of thousands of visitors were expected on the day. The Exmouth Escape holiday retreat where we stayed was good. They catered well for several large groups including ourselves. Our Astro Trails group was the leisurely observe from your own backyard over 4 days group, led by Nick James. John Mason had left us at Perth to fly in and out on the day with his large group, leaving at 2am.

The first night in Exmouth gave us the opportunity to visit a dark sky site at a local turtle beach sanctuary. There were magnificent views of the Coal Sack Nebula (figure 3) and Large Magellanic Cloud (figure 4).



Figure 3: Dust nebulae around Southern Cross

The day dawned. Not a cloud in the sky and a very nice but very short total eclipse was seen by all. Thank goodness I obeyed the first rule of eclipses – "When all else fails around you, watch the eclipse."

The most striking aspect of the eclipse was that the solar disc seemed so much smaller than in previous eclipses. Obviously, this was an optical illusion given it was a lunchtime event, consequentially being high in the sky. The fact that this was a hybrid eclipse meant the Sun was a tad further away from the Earth than usual, but this would not have been noticeable.

The fact it was a hybrid also meant that the chromosphere would be more visible, and indeed it was – a wonderfully reddish-pink surrounded by the solar corona, with at least one massive flare visible to the naked eye. A large sunspot was just visible with solar viewers.



Figure 4: Coal Sack and LMC

The tight corona was as expected with the Sun approaching its peak activity cycle.

Amongst other things noted were the rapid and more intense darkening than was expected, given the height of the Sun, with the light quality sharpening slowly over a long time period. Vague shadow bands were observed by some. The approaching shadow was also noted by some observers, but I was too busy panicking about equipment not working to notice. Jupiter and Venus were prominent, but Mercury proved too elusive.

I had four experiments planned for this year; with hindsight this was over stretching. The shade temperature recording, which is totally automatic, gave up half an hour before second contact (C2). Despite the data failure, adding a trendline to the data that was captured shows an interesting extrapolation, this appears to show the expected up-curve in temperature at the time of C3. While this is most probably an artefact of the data, it could suggest that a high order polynomial represents the eclipse shade-temperature reduction (figure 7).

The videoing of potential shadow bands also did not happen. So, I was left with imaging the eclipse itself and, new this year, recording the light level drop. The latter worked well. If only I had not fiddled with the pre-focussing I had done earlier, I may have captured some good images. I had captured the whole eclipse from diamond ring to the fantastic corona, alas none were in focus.

The evening followed with a celebration meal and drinks party. Everyone was given 4 free drinks, but some generous non-drinkers soon found good homes for their unused tokens.

All too soon it was back to Perth for a final couple of days wind-down before the journey home.

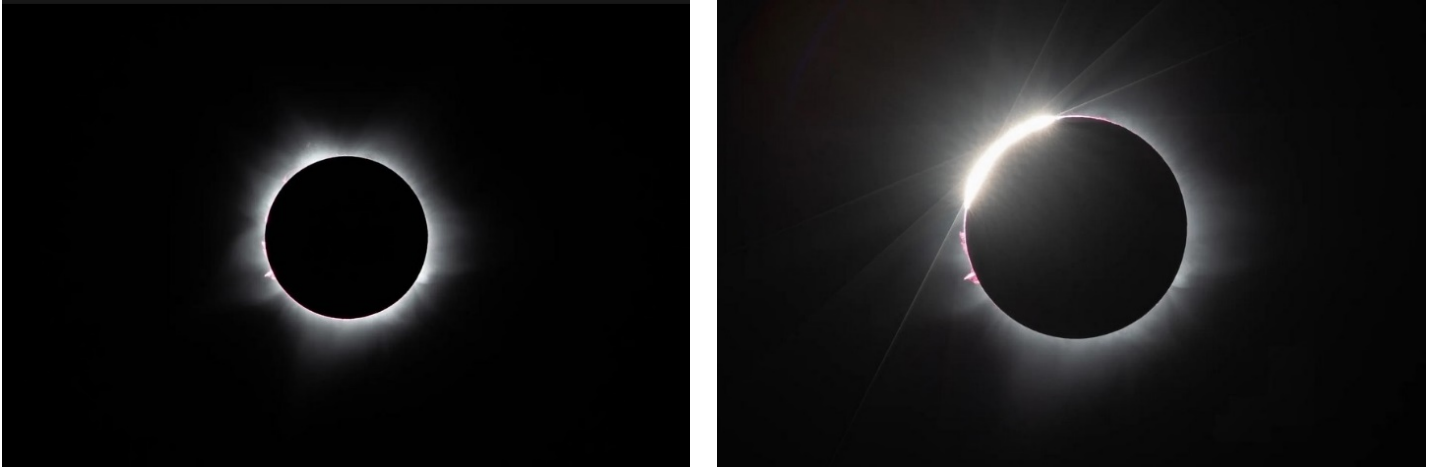
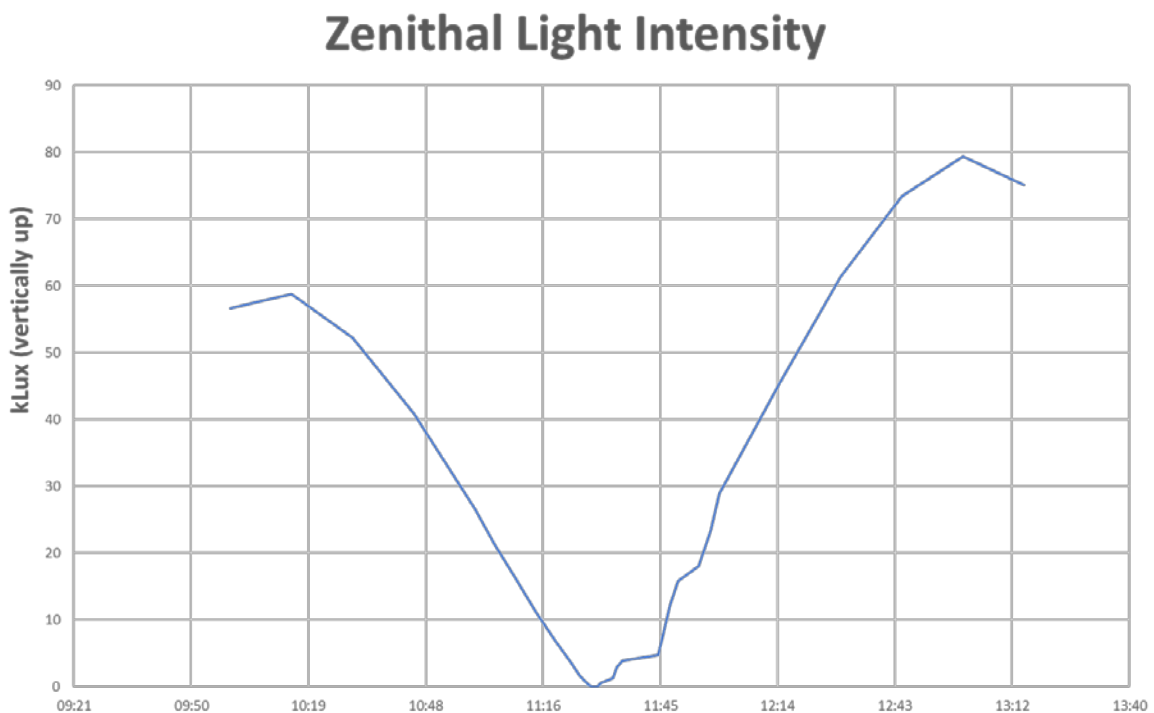


Figure 5: Images of the eclipse

The eclipse luminosity experiment was successful. A simple manually operated light meter, pointing vertically upwards (zenith measurement) was used to take luminance readings periodically throughout the eclipse from C1 to C4. The graph of the results is presented below. As the luminance readings are logarithmic by nature, it looks as if the light level reduced to zero during totality. To show that this was not so, the graph is also presented in logarithmic scale (figure 6).

The graph is quite smooth and “ideal”. This is because for the entirety of the eclipse, the sky was totally devoid of cloud, save for some minor strato-cumulus on the horizon. For the duration of the eclipse the light levels were only affected by the advancing Moon.



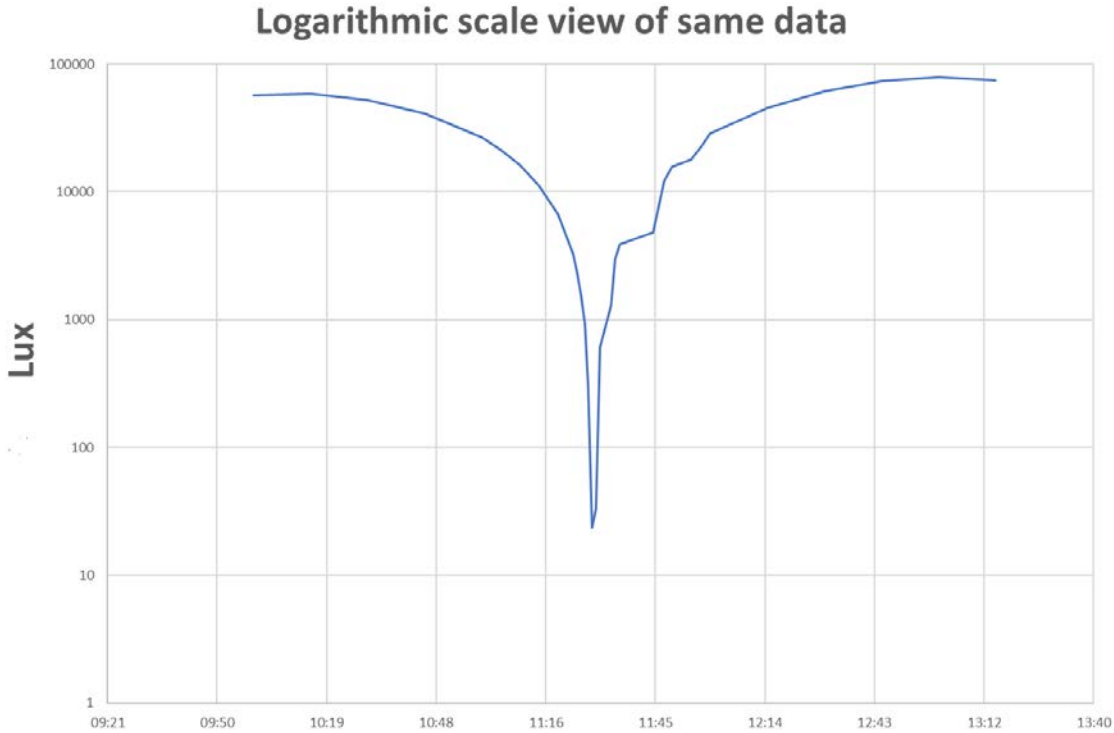


Figure 6: Zenithal Luminance during eclipse.

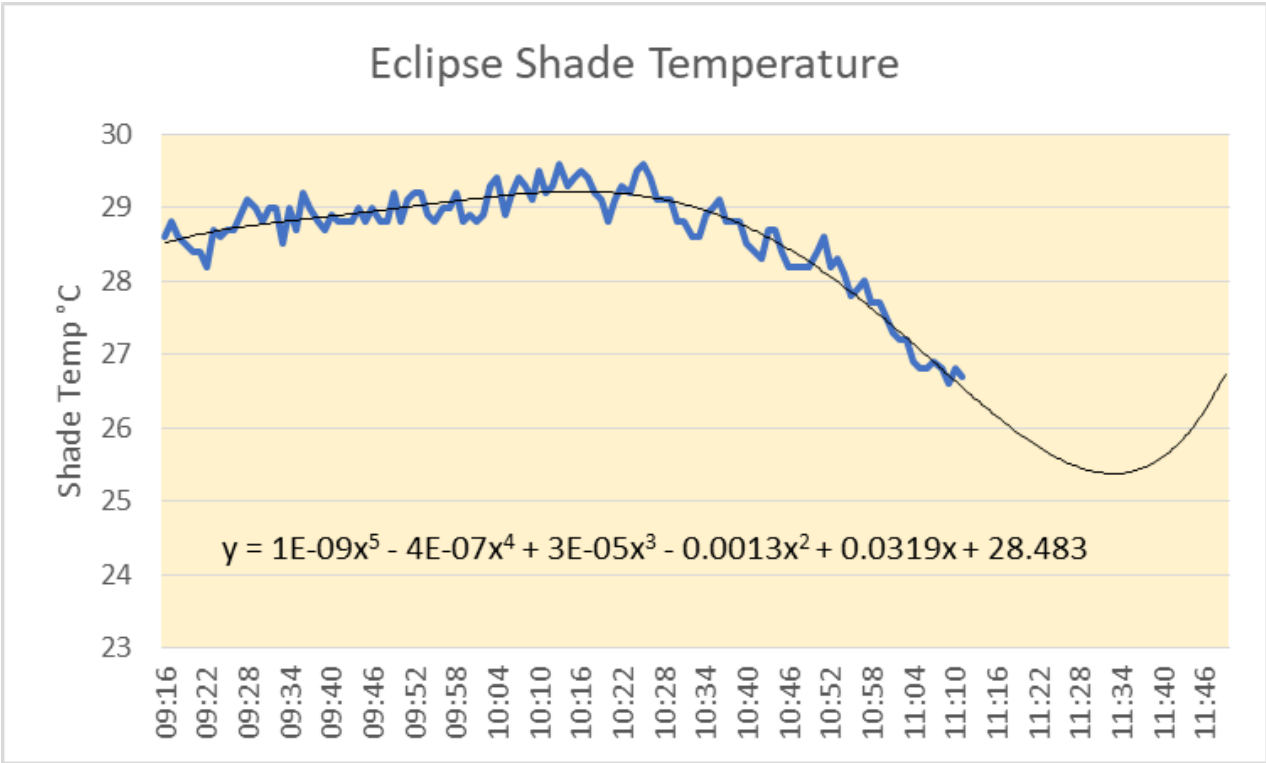


Figure7: Eclipse Shade Temperature with possible trend line

Jupiter's Icy Moon Explorer. (J.U.I.C.E)

A short article from the Library Andy Willshere

This article was first published in the OASI magazine for June 2022. Since then, JUICE has successfully been launched at 12:14 GMT on the 18th April 2023. The article has been re-vamped and more detail included.

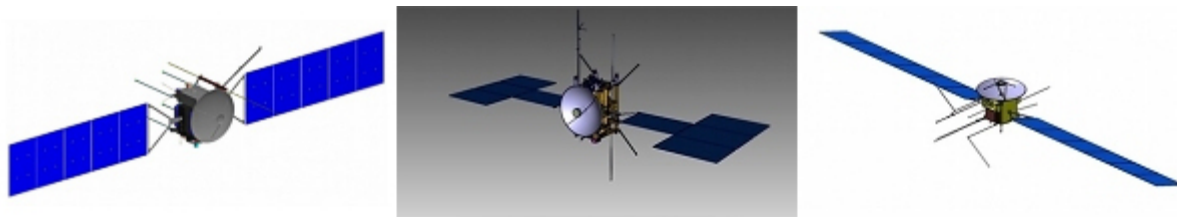
When we look through our telescopes at the planet Jupiter, we can see very easily the four Galilean moons. These were discovered independently by Galileo and Simon Marius around 1610, and are some of the largest in the solar system. There are about 80 moons of Jupiter known collectively as the Jovian system. Since 1892, many smaller moons have been detected, all being named after daughters and/or lovers of the Roman god Jupiter.

Since Galileo spotted these moons, scientific knowledge of the gas giants within our Solar System has grown steadily, with both ground and space-based observations adding to the knowledge. Flybys by Pioneer and Voyager as well as information obtained from Galileo and Cassini spacecraft being of major importance. The Galileo discoveries provided verification that there were oceans situated under the icy surface layers of three of the four large moons, Europa, Ganymede and Callisto.

It is because of these results that the European Space Agency (ESA) decided to send a space -craft to investigate, and to call the project J.U.I.C.E. (Jupiter Icy moon Explorer). This has taken the place of the Europa Jupiter System Mission (JAXA), which was to be an un-crewed Joint NASA/ESA space mission. JUICE will primarily centre on Ganymede as a primary scientific task, but will also investigate the Jupiter system, including Europa, to check out its surface and sub-surface composition. JUICE has been designated as an essential step for future research into our Solar System.

The key science goals are therefore to investigate Ganymede, Europa and Callisto, to consider their possibilities of providing habitats and having investigated the Jupiter system, use all methodology acquired to provide a mainstay for all future gas giant research. Habitability is considered to be the possibility of a location to underpin any type of life. JUICE was launched on 18 April 2023, using an Ariane +5 ECA (Evolution Cryotechnique type A) rocket, with Jupiter orbital insertion in July 2031. It will have taken 7.5 years of travelling to reach this point. NASA hope to launch Europa Clipper in 2024, an orbiter designated for several flybys around Europa. If all goes well, the two scientific projects will overlap.

The Ariane5 space rocket is capable of lifting into space 10 metric tons into geostationary transfer orbit, or 20 metric tons into low earth orbit. It is 50.5 m tall, 5.4 m in width and has a mass of 780t. The launch system consists of the main cryogenic stage, two solid boosters and an upper cryogenic stage. By the end of 2023, the Ariane 6 rocket will come into operation. All preparations culminating in the final launch took place at Guiana Space Centre (GSG), by the European Space Agency (ESA).



Picture credit: ESA

The basic JUICE mission scenario will be continuous scanning of the atmosphere and magnetosphere of Jupiter. Two flybys of Europa and one flyby of Callisto, and then on to Jupiter at approximately latitude 30°, at which point another orbital phase will take place. If all goes well, JUICE's final act is to head into Ganymede in a final act of self-destruction. The propulsion systems for these tasks will be bi-propellant. Getting to Jupiter will be by using standard chemical propulsion and several gravity assists, Earth-Moon August 2024, Venus- August 2025, Earth- September 2026 and finally Earth again January 2029. This will take about 7.5 years, with power being obtained from its solar arrays. On arrival its trajectory will be on the exterior side of Jupiter's inner radiation belt. The spacecraft will carry approximately 3000kg of chemical propellant in order for it to orbit Jupiter and Ganymede and fulfil its mission combining approximately 35 flybys. The signal time from Earth to Jupiter and back can be as long as 1hr 46 m, so all instructions must be succinct.

Comprehensive Mission Profile

- 18th April 2023 - Launch by Ariane-5 (ECA.)
- 07/2031 Arrive at Jupiter for orbit insertion. High orbit to study Jupiter's magnetosphere.
- 11 months to fly to Callisto.
- Europa stage (July 2032): 2 Europa and 3 Callisto flybys taking 36 days.
- Jupiter High latitude phase including 9 Callisto flybys taking 260 days.
- Onward flight to Ganymede taking 11 months.
- 12/2034 Ganymede stage.
- Elliptical #1. Global geological mapping. 30days.
- Elliptical and high altitude circular section taking 120 days and medium altitude orbit (500km) 102 days.
- Low altitude circular orbit (200km) 30 days.

Housed on-board the JUICE spacecraft are eleven instruments that were considered as essential by the ESA science study team.

- I) JANUS – a camera system to provide wide ranging observations of the moons, at better than 400 m/pixel resolution.
- II) MAJIS – (Moons and Jupiter Imaging Spectrometer). This is able to operate from 400nm to 5.70µm with a spectral resolution of 3-7 nm.
- III) UVS – (UV Imaging Spectrograph). Operates in the wavelength range of 55-210 nm, with spectral resolution of < 0.6 nm.
- IV) SWI – (Sub-millimeter Wave Instrument). Spectrometer that operates using 30 cm antenna at 1080-1275 GHz and 530-601 GHz.

- V) GALA – (Ganymede Laser Altimeter). Laser altimeter which has a 20m spot size and 10 cm vertical resolution at 200 km.
- VI) RIME – (Radar for Icy Moons Exploration). Investigates the subsurface structure of the Jovian moons down to 9 km deep.
- VII) J-MAG – (JUICE Magnetometer). To assess Jovian magnetic field.
- VIII) PEP – (Particle Environment Package). Six sensors will investigate Jupiter’s magnetosphere and its relationship with the Jovian moons.
- IX) RPWI – (Radio and Plasma Wave Investigation). Investigate the plasma conditions and radio emissions around the spacecraft.
- X) 3GM – (Gravity and Geophysics of Jupiter and Galilean Moons).
- XI) PRIDE – (Planetary Radio Interferometer and Doppler Experiment). Used to gain exact measurements of the gravity fields of Jupiter and its icy moons.

Some of the main science objectives.

Investigate whether Ganymede can be considered a planetary object and that it has a feasible habitat	Investigate the range of the ocean and its depth. Investigate its ice shell. Investigate allocation of surface materials. Look for past and present movement. Investigate the Jovian magnetosphere
Investigate Europa especially some of the latest more active zones.	Explore the composition of non-ice material. Seek liquid water. Investigate recent activity processes.
Investigate Callisto	Investigate the atmosphere dynamics and how it circulates. Investigate non ice material Investigate past commotion
Survey the Jupiter System	Investigate the atmospheric potential Investigate the chemical composition Investigate the magnetosphere Study the moons sources of magnetospheric plasma. Study Io. Explore the activity of this moon

Initial data : ESA

JUICE will investigate the icy worlds of the moons of Ganymede, Europa and Callisto, with Ganymede as its primary target. This moon has a diameter of approximately 5260km and is larger than Mercury. It orbits Jupiter at about a distance of 1×10^6 km. There is belief that there is some form of tidal heating on the moon, but much less than on Io and Europa. This heat could be a marker to provide conditions for life to materialise and produce mild tectonic activity. Obtaining as much data as possible will be essential to verify if there are any conditions conducive for any form of life.

During the Galileo mission, it was noted that Ganymede has its own magnetic field, which is a fact that is not held by any other moon in the Solar system. It generates a magnetic dipole field. This magnetic field is tiny when compared to Jupiter’s, but together the two perform complex programmes. JUICE will investigate how Ganymede’s magnetic interactions will affect the auroras on Jupiter, as well as how it generates and maintains this effect. More recently, observations point to a probability of there being an ocean under the ice. Its depth and dimensions will be one of the JUICE objectives, as well as calculating its rotation rate, gravity field, effects on the surface from Jupiter’s tidal influences and elucidate how the various layers of the moon are composed.

Callisto is the outermost and second in size of the moons, but is the least dense. Similar to the other two moons, it is thought that a large ocean rests below its surface, but up to now, this theory is not as convincing as for the other moons. Because of where Callisto exists, orbiting past Jupiter's main radiation belt, it has lower radiation levels and less interaction with the Jovian magnetosphere than its compatriots. It exists 1.88 *10⁶ km distance from Jupiter and is geologically more stable due to minimal tidal heating than the inner moons. The JUICE project will investigate the cratered surface, with its lack of resurfacing to try to understand its past history. This surface will also be studied both chemically and compositionally. Instrumentation, which includes ice –penetrating radar, will also be able to explore the internal structure.

Europa is the smallest of the Galilean moons and is tidally locked. It takes about 3.5 days to rotate around its parent body. Europa's orbit is elliptical, and therefore experiences different gravitational stresses especially on its surface, as well as providing some degree of heating. Of the three moons, Europa is considered to be the most likely to provide data that could support habitability. There is specific data to suggest that a sub-surface lake of water exists beneath its crust; some think twice as much water volume as on Earth. Hubble when recently scanning this area spotted water-vapour plumes exiting from the icy crust and rising to 160km. JUICE when performing a flyby may be able to acquire a sample, which would give information about the ocean, without having to drill into the ice layer. Cracks have been noted on the crustal region, which may be due to some form of tectonics, or even subduction faults. In these areas, JUICE will be able to provide chemical analysis, searching for evidence of life. The spacecraft will flyby twice around the areas of Europa's hemispheres.

At the end of its mission JUICE is expected to crash into Ganymede, however if by any chance a hint of life is found on this moon, then the rules of planetary protection must be observed, and therefore another scenario may have to be devised.

The scientific world will be hoping that JUICE will provide many answers to all of these relevant questions about this specific astronomical area.

References:

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[ESA Science & Technology - JUICE's primary target: Ganymede](#)

[Jupiter Icy Moons Explorer - Wikipedia](#)

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