Astronomy
La Société Guernesiaise

Sagittarius

The Newsletter of the Astronomy Section of La Société Guernesiaise

2021

Dedicated to David Le Conte FRAS

Forthcoming Events

Courses will be advertised by email, on our website and Facebook page with tickets available on Eventbrite. We hope to run a variety of courses during 2021, but dates have not yet been set.

Public Open Days

We will be running public open evenings during 2021, although the exact format and timing of these is still to be decided. We will also be running more daytime solar open days, which due to the nature of the event will be advertised only a few days before they take place. It is likely there will also be a Halloween themed event in October as there has been in previous years. Our events will be announced via the media, on the Astronomy Section website, www.astronomy.org.gg, and on the Section's Facebook pages.

Contents

Section meetings

The Section meets at the Observatory every Tuesday evening at 8.00 pm, sometimes with a discussion topic. Also the last Saturday evening of each month, if clear, except summer, for observing and photography.

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Material for, and enquiries about Sagittarius should be sent to the Editor: tharvey303@gmail.com

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Astronomy Section Officers, 2021

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Editor	Tom Harvey
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Open Days	Anthony Nel
Equipment mtce.	Allan Phillips
Public relations	Elaine Mahy
Research	Jason Hill
Library	Clive Stubbings
Imaging	Jean Dean
IT/Website	Owain Catton

Introduction from the Editor

Welcome to the 2021 Edition of Sagittarius. 2020 has been a very different year for us all, and I hope this newsletter finds you safe and well. The Astronomy Section has been fortunate that due to Guernsey's control of Covid-19, we have been able to continue our weekly meetings and other public outreach since June.

This is the 2nd edition of the newsletter that I have published, and I sadly must report that the previous editor, David Le Conte, passed away in August of last year. He will be sorely missed, and this edition of the newsletter is dedicated to him. There is a lovely article written by his wife, Dorothy, and daughter Sarah in the coming pages.

In these pages you will also find a variety of articles written by members of the section. In this edition we look at near-earth asteroids and how we might stop an impact, an analysis of Sir Fred Hoyle's, "The Black Cloud", and a tour through some of the largest stars in the Universe. You can also test your astronomical knowledge with a short quiz based on 1st year university astronomy questions. If anyone would like to get involved and contribute an article or picture for the next edition of Sagittarius, please contact me.

Thomas Harvey

Astronomy Section Report 2021

Maintenance

Last year's summer and autumn maintenance has focused mostly on the telescope building. Despite being well maintained over the years it is showing its age. The hinges on the drop-down sides had either completely rusted away or were broken and there was very little holding them on. Over a few weekends the inner plywood sheets were removed completely and the top panels bolted to the lower panels and the south-east and south-west corners were strengthened with extra timber and bolted together. Taking the internal panels off also allowed examination of the extent of the rot on the south gable. It was decided that this gable was too rotten to be repaired and needs to be completely replaced. This will require the roof to be rolled off and left off until the gable can be rebuilt, so this work will take place in the late spring when the weather improves, and evenings are lighter. Until then the building cannot be used for observing as it is not safe to roll the roof off as the north-west corner is in danger of collapsing. Ravenscroft Construction have kindly donated 13 sheets of plywood for the repairs. I would like to thank Owain, Allan, Tom, and Anthony for helping with the repairs to date, and Clive, Jill and Jen for clearing out the store to make room for the contents of the telescope building which was a job that was long overdue. We also extend our thanks to Richard Sweet, who kindly replaced the lights in the car park.

New internal lights have also been fitted to the inside of the telescope building which give much better illumination for maintenance and for use as an extra display space when there is bad weather during public or educational outreach events. Two new external electrical boxes are in the process of being fitted, one on the slab in front of the meeting room and one on the south-west corner of the telescope building.

Equipment

A member of the public very generously donated money for a new focuser on the Meade 16" SCT. We have bought a Baader Diamond Steeltrack focuser with a Click-Lock adapter. This will replace the JMI

Heart Nebula by Jean Dean.

motorised focuser that was no longer working. It will make focussing easier and adjustment of the diagonal position much simpler on open events.

La Société Council has given the Astronomy Section a grant for the purchase of a mobile solar set-up that can be taken into the schools for solar outreach. We will have two Skywatcher SolarQuest mounts which automatically locate and track the sun, one will have a Lunt 60mm diameter solar scope on it to look at the chromosphere and the other a Skywatcher Skymax 102mm Maksutov-Cassegrain optical tube fitted with a Baader solar filter to view the photosphere. There will also be a Celestron 8-24mm zoom eyepiece for each telescope. La Société full and part-time educational officers Becky Ogier and Sarah Allez will be helping with the solar outreach as part of their remit to promote conservation nature education in the schools. This new equipment will also be very useful for on-site solar open days.

We have also been donated two, almost brand new manual equatorially mounted Skywatcher telescopes, a refractor and a newtonian. These will be lent out to members as required, they will be particularly good for novices to learn the basics. In addition, we have been donated two new flat screen monitors by Digimap Limited, which have proved extremely useful on open evenings.

The Section has purchased two pairs of 8x42 Hawk Nature Trek binoculars which are of the porros prism type, so they are lightweight and suitable for smaller hands. Binoculars have been very useful on the Introduction to Astronomy course and the intention is to purchase one or two more pairs over next year. Finally, our equipment has now been security marked thanks to Allan.

Public Outreach and Courses

In September of last year Elaine Mahy handed over the responsibility of organising educational outreach for the observatory to Anthony Nel, who was supported by Jill Barnicoat. Thanks to Elaine for all the outreach work she has done this year. Anthony and Jill continued communications with the groups that had previously reached out to the section, and arranged visits for the 7th St Stephens guide unit, and the 12th Guernsey Beavers.

On the 23rd November around 20 of the 12th Beavers came up to the observatory. Unfortunately, due to cloudy skies there was no opportunity to look through the club's telescopes. As an alternative, they were given a longer presentation on the solar system and were also able to view one of the observatory's telescopes indoors and hopefully, left with greater knowledge than before their visit. Jean Dean and Owain Catton also hosted the 9th Scout Group for a visit in November.

Looking into the future, we've contacted the island's primary schools and some of the secondary schools and have arranged multiple visits running from January to February of this year. We hope to build further on this and continue with our educational outreach throughout 2021.

During August and September, we held six public open evenings with a selection of telescopes allowing views of Jupiter, Saturn, and Mars, as well as several deep space clusters, nebulae and distant galaxies. There was also a short focal length refractor with a CCD camera fitted with luminance and hydrogen-alpha filters so members could look at galaxies, globular clusters, planetary nebulae, supernovae remnants and star forming emission nebulae.
Talks were given in the meeting room, in a change from previous years we advertised the titles in advance which led to a greater interest with all seats occupied and, on many evenings, people were also standing outside on the pad listening. Thank you to Jason for presenting the talks each week and to Tom for his talk on Comet Neowise, which was very topical and to Pieter for a short talk on the Fermi Paradox. Thanks to

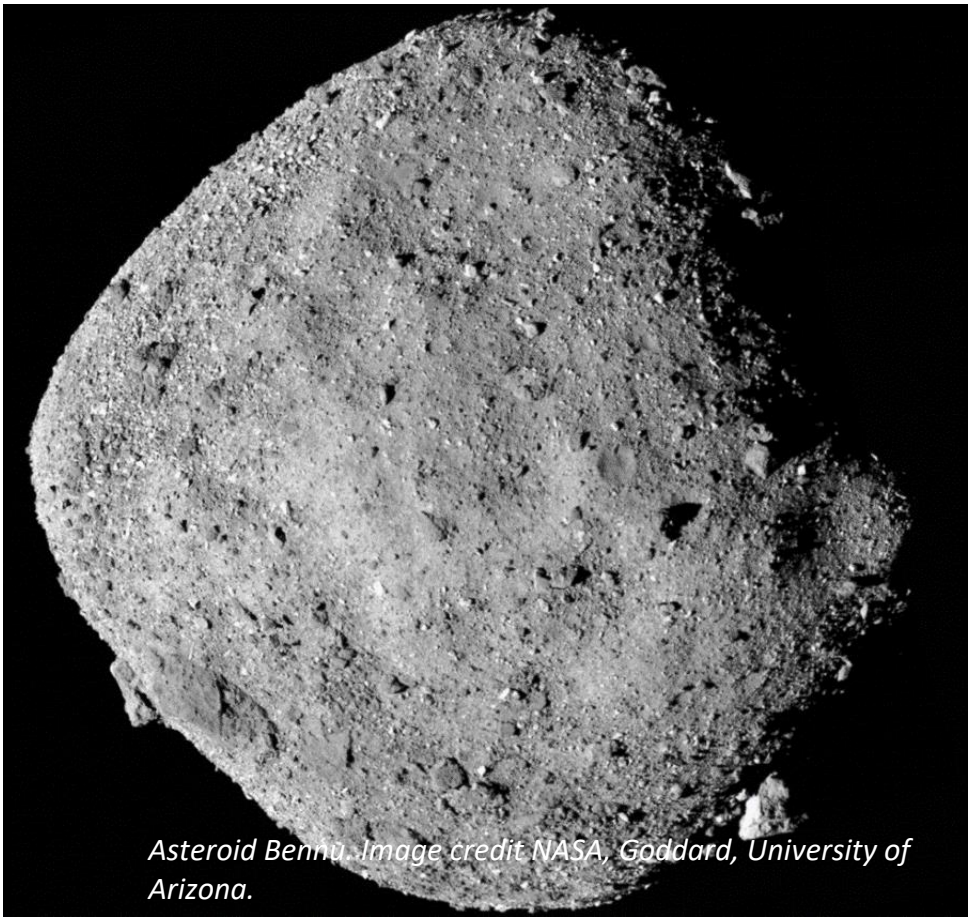
Introduction to Astronomy Course. Image credit Nick Despres.

Owain, Allan, Anthony, Tom, Stephanie, Peter, Jill, Clive and Jen for setting up, manning the telescopes and greeting visitors.

In October and November, we ran two, 2-week Introduction to Astronomy courses. Both filled up very quickly. Participants learnt about constellations, star hopping, the solar system and basic deep sky objects such as star colours, stellar evolution, nebulae and star clusters. In addition, they had an introduction to binoculars, mounts and telescopes. From the two courses we have attracted new membership. The intention is to run the Introduction to Astronomy course on a semi-regular basis during 2021 and follow it up with a second short course on the solar system and exoplanets, and a third course looking at cosmology. These courses replace the annual WEA Stargazing Course. Splitting the previous 6-week Stargazing course allows us to reach more people and hopefully will result in more members. Thanks to Owain for helping with the lectures and practicals, Jill for arranging the catering with the help of Ella, Becky and Sarah.

We also took part in two Nature Guernsey events, one an open event on 30th August at Pleinmont and the other a Halloween event at the observatory in October. Thanks to Matt and Elaine for organising these events and to Tom, Owain and Anthony for helping with the Pleinmont event and Jason, Peter, Matt and Nick on Halloween. The Halloween event was also attended by the Bat and Entomology Sections.

In November we hosted a group of autistic adults and looked at the solar system and the recent OsirisRex mission to the near earth carbonaceous asteroid Bennu. In October the mission successfully collected a sample from the early solar system planetoid and will return it to earth in September 2023. There was great interest and lively discussion. Thanks to Jill for organising the event and Jill and Allan for helping out on the night.



Asteroid Bennu. Image credit NASA, Goddard, University of Arizona.

Jean Dean and Thomas Harvey took part in an interview for BBC Radio Guernsey on the Astronomy Section, as part of a series on La Société Guernesiaise. They fielded a variety of interesting questions from Jenny-Kendal Tobias, including on whether they thought politicians were secretly controlled by aliens. They also highlighted the outreach the Section undertakes, and explained how members of the public can get involved.

In the same month we also hosted the L'Islet Women's Institute who managed a brief look at a few objects before it clouded over and retired inside to listen to a lecture by Elaine. Thanks to Elaine for organising the visit and to Clive and Jen for helping.

Imaging

We are currently running an informal deep space astrophotography course for members who wish to learn, refresh, or refine their skills. It is on Tuesday nights between 7-8pm. All members are welcome.

NGC7635, the Bubble Nebula, imaged from Guernsey by member Allan Phillips. The Bubble Nebula is an emission nebula of ionised hydrogen around 8000 light years from Earth. The image consists of 29x300s lights, darks, flats and bias frames.

NGC6668, the Crescent Nebula, is an emission nebula in Cygnus, 5000ly from Earth. It was imaged by member Allan Phillips from his back garden in Guernsey, using an 8 inch Ritchey-Chrétien telescope.

Talks

In September Tom Harvey gave an informative talk on “How to Photograph a Black Hole”, the meeting room was full with people sitting in the kitchen area. Afterwards members surprised Tom by turning up to help him celebrate his 21st birthday!

La Société Guernesiaise and the WEA ran a series of talks over October and November in the Frossard Lecture Theatre to promote the activities of the society. Each Section was invited to give a presentation of their history and current activities. Frank Dowding presented an interesting and informative talk for the Astronomy Section which was well attended.

The year was rounded off with a talk by Jason Hill on “Guernsey Astronomers” to a full lecture theatre. David Le Conte had originally written the talk, which was to be presented during the summer open evenings as part of Heritage 75. Because of David’s passing it was decided to present it instead at the Frossard Lecture Theatre in honour of David. The talk included various people associated with astronomy and Guernsey, including Warren de la Rue and of course David who had a very distinguished career.

Regular Meetings

Regular Tuesday evening meetings continue as normal, it is very encouraging to see an increase in the number of members attending, typically it is between ten and fifteen. When the sky is clear members can be found outside using the GOTO telescopes and binoculars.

Frank Dowding and Geoff Falla being presented with their awards, pictured alongside other section members. Photo credit Donna Francis.

Awards

Honorary Membership of La Société Guernesiaise was awarded to Frank Dowding and Geoff Falla at Blanchlande Nursing Home. They were also presented with a framed image of the Milky Way taken from Petit Bot as recognition as founding members and for a lifetime of service to the Astronomy Section. Tom Harvey was awarded a Fellowship of the Royal Astronomical Society in October having been nominated by David Le Conte.

Geminids meteor shower on 14/12/20 by Elaine Mahy.

Library

The Section has a substantial library which has grown over the years. It includes hundreds of books ranging from biographies to technical reports and books for young children. Clive has started the task of cataloguing what we have with a view to making the library more accessible in the future. To date there are some 300 books recorded and many more still to do.

Jean Dean

Astronomical Events in 2021

It will be a good year for eclipses if you are a penguin, with Antarctica receiving a total solar eclipse on December 4th, but a poor year for those of us in Guernsey. This section summarises the key astronomical events happening in 2021.

Planets

For up-to-date information on the planets and the night sky, please see our website: www.astronomy.org.gg/do-and-see/months-sky There is a wealth of information about the month's events, the astronomy forecast, the sunrise/set times and the moon phases.

Mercury will be visible in the periods around its greatest elongations:

Date	Elongation	Direction	Time
24 January	18.6º Eastern	Low in West	After sunset
06 March	27.3º Western	Low in East	Before sunrise
17 May	22º Eastern	Low in West	After sunset
04 July	21.6º Western	Low in East	Before sunrise
14 September	26.8º Eastern	Low in West	After sunset
25 October	18.4º Western	Low in East	Before sunrise

Jupiter passes through its superior conjunction in January, before becoming visible in the dawn in mid February. Jupiter will ascend the ecliptic throughout this time, improving visibility in the UK. Jupiter reaches opposition on Aug 19th, with an apparent diameter of 50". It will be visible earlier as we move through the year, becoming an evening object by September and remaining one for the rest of the year.

Photo of the conjunction of Jupiter and Saturn, taken by member Elaine Mahy on 19th December 2020. Taken using a Nikon D5100 camera at 600mm.

Mars will be visible in the West in the evening until June, although it will be getting fainter as it is now receding from us. In January it will have an apparent diameter, of 10", which is less than half of its diameter at its closest approach in October 2020. It reaches its furthest point from the Sun on July 13th. It will be lost into the solar glare around September, before reemerging in late October.

From Early May, Venus will be visible around dusk, as the "Evening Star" in the Western Sky.

When Jupiter is visible we will have good views of the four Galilean moons, atmospheric bands on the planet's disc, and the Great Red Spot. Transit, shadow and occultation events involving Jupiter's moons can be found online. They can also be found in the 2021 BAA Handbook. They can be simulated on software such as StarryNight and some of the many astronomy apps, some of which also gives the transit times of the Great Red Spot. The Spot's transit times are also available at

http://www.skyandtelescope.com/observing/celestial-objects-to-watch/transit-times-of-jupiters-great-red-spot/ using the US date format).

Saturn closely follows Jupiter across the sky throughout the year, and they should make a lovely pair, although never rising higher than about 22 degrees. It reaches opposition on 2 August. The rings are still at a good angle for observation, and its brightest moons, especially Titan, should also be visible. Saturn reaches its solar conjunction on the 24th January. Saturn will be visible low in the South-East, moving towards the South, after dusk from around August. It will be visible in the early morning from around May, rising earlier as the year progresses.

Uranus will be at opposition in Aries on November 5th, at magnitude 5.52. Neptune will be at opposition in Aquarius on 14 September, at magnitude 7.84.

Phases of the Moon

New Moon	First Quarter	Full Moon	Last Quarter
Jan. 13	Jan. 20	Jan. 28	Feb. 4
Feb. 11	Feb. 19	Feb. 27	Mar. 6
Mar. 13	Mar. 21	Mar. 28	Apr. 4
Apr. 12	Apr. 20	Apr. 27	May 3
May 11	May 19	May 26	June 2
June 10	June 18	June 24	July 1
July 10	July 17	July 24	July 31
Aug. 8	Aug. 15	Aug. 22	Aug. 30
Sept. 7	Sept. 1	Sept. 21	Sept. 29
Oct. 6	Oct. 13	Oct. 20	Oct. 28
Nov. 4	Nov. 11	Nov. 19	Nov. 27
Dec. 4	Dec. 11	Dec. 19	Dec. 27

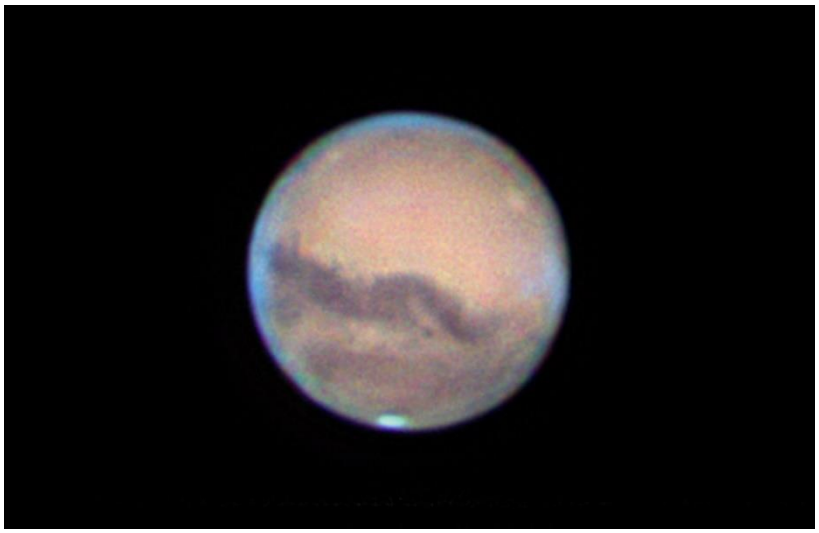
Supermoons

So-called 'supermoons' occur when the Full Moon happens to coincide with the Moon's closest approach to Earth ('perigee'), and therefore appear larger than usual. In 2021 there will be three such moons: on 27 April, 26 May and 04 December.

Dwarf planets and asteroids

Pluto will reach opposition on the 18th of July, at magnitude 14.9, around midnight in the South. It will appear star-like and requires a telescope to observe. The other three dwarf planets (Eris, Makemake and Haumea) are too faint to be seen in most amateur telescopes, although Makemake does reach opposition on the 27th March.

Ceres, the largest asteroid in the Asteroid Belt, will reach opposition on November 27th, at magnitude 7.2, visible in the South around midnight.



Mars Opposition on 11/10/20. Photo by Elaine Mahy.

Vesta, one of the largest asteroids in the Asteroid Belt, will reach opposition on the 4th March, around midnight, in the East, at an altitude of 40 degrees. It should be visible as a reddish dot in a small telescope.

Eclipses

This is a very poor year for eclipses, with one partial annular solar eclipse, and one partial lunar eclipse, being visible from Guernsey. The partial solar eclipse is on the 10th June, peaking at 11:05am with a maximum coverage of 18.15% from Guernsey. The partial lunar eclipse will be visible on the 19th November, peaking at 07:23am UTC.

There will also be a total lunar eclipse on the 26th May, not visible from Guernsey. It can be seen from Australia, New Zealand, East Asia and the Northwestern United States.

A total solar eclipse on 4 December will not be visible from Guernsey, being seen only from South Africa, South Australia, Chile, Argentina, the South Pacific, South Atlantic and Antarctica.

Occultations

There are 2 lunar occultations of Mars, and one of Venus, in 2021, but none are visible from Guernsey.

Lunar conjunctions

The best conjunctions of the Moon and the bright planets, with their positions and separations are:

19 March	Mars	Low in west in evening	2.25°
17 April	Mars	West in evening	0°07'
16 May	Mars	West in evening	1°28
13 June	Mars	Very low in south in evening	2°
17 September	Saturn	Low in South in evening	4°
07 Dec	Venus	Around midnight, in the South	2°

Planetary conjunctions

There aren't many good conjunctions this year, but the best, with their positions and separations, are:

21 Jan	Mars and Uranus	High in south, early evening, near moon	1°43'
13 July	Venus and Mars	Not visible at daytime conjunction-close at dusk in West	0°29'

Meteors

The Quadrantids will peak on the night of 03/04 January, with about 10 per hour, but the Moon at ¾ will be a problem. The Perseids will peak on the night of 12/13 August, with some 80 per hour, and with the Moon at Last Quarter will again be quite favourable. The richest annual shower, the Geminids**,** will peak on the night of 13/14 December, but the almost full Moon will limit the number of comets seen.

There are, of course, minor meteor showers during the year, and sporadics may be seen at any time. For shower details see the 2021 BAA Handbook.

Comets

Comet 7P/ Pons-Winnecke will be well placed for observation, reaching perihelion on May 27th 2021 at a peak magnitude of +8.

Later in the year, Comet 67P/ Churyumov-Gerasimenko, the destination of the European Rosetta mission, will be visible from around November, reaching perihelion on January 22 2022.

Detailed comet predictions for 2021 are available on the website of the British Astronomical Association's Comet Section: http://www.ast.cam.ac.uk/~jds/preds21.pdf. Also check the Heavens-Above website (heavens-above.com) for star charts showing comet positions, and use programs such as StarryNight for detailed location charts.

The Sun

The current solar cycle 25 began in December 2019. Activity was slow at first but started to increase mid-October 2020 (Figure 1). We are moving towards a solar maximum in 2025, where solar activity, including sunspots, should be most active. By November there were some large sunspot regions (Figure 2), in the southern hemisphere: 12781 which contained one sunspot 80MH* in size and 12782 with 6 sunspots averaging 30MH each. As expected for southern hemisphere sunspot regions on the ascending phase of cycle 25 the regions lead with a negative polarity (Figure 3 and b).

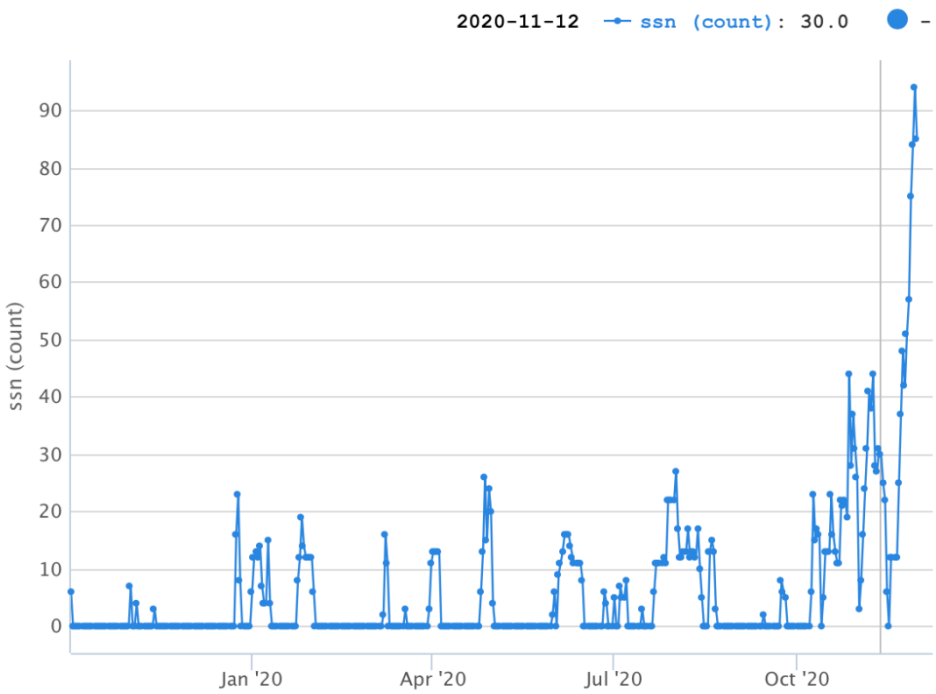


Figure 1 – International sunspot number November 2019 to December 2020. Vertical black line indicates 12 November 2020. Graph from Lasp Interactive Solar Irradiance Centre (LISIRD).

There can be outbursts of activity, not only of sunspots but also of coronal holes and coronal mass ejections, which can result in displays of the aurora borealis (and australis) at high latitudes. Details of sunspot numbers are at www.ips.gov.au/Solar/1/6, and real-time views of the Sun are at umbra.nascom.nasa.gov/newsite/images.html. Auroral alerts, with lots of other information, are at www.spaceweather.com.

*MH millionths of a solar hemisphere, 10MH = 30 million square kilometres.

Jean Dean

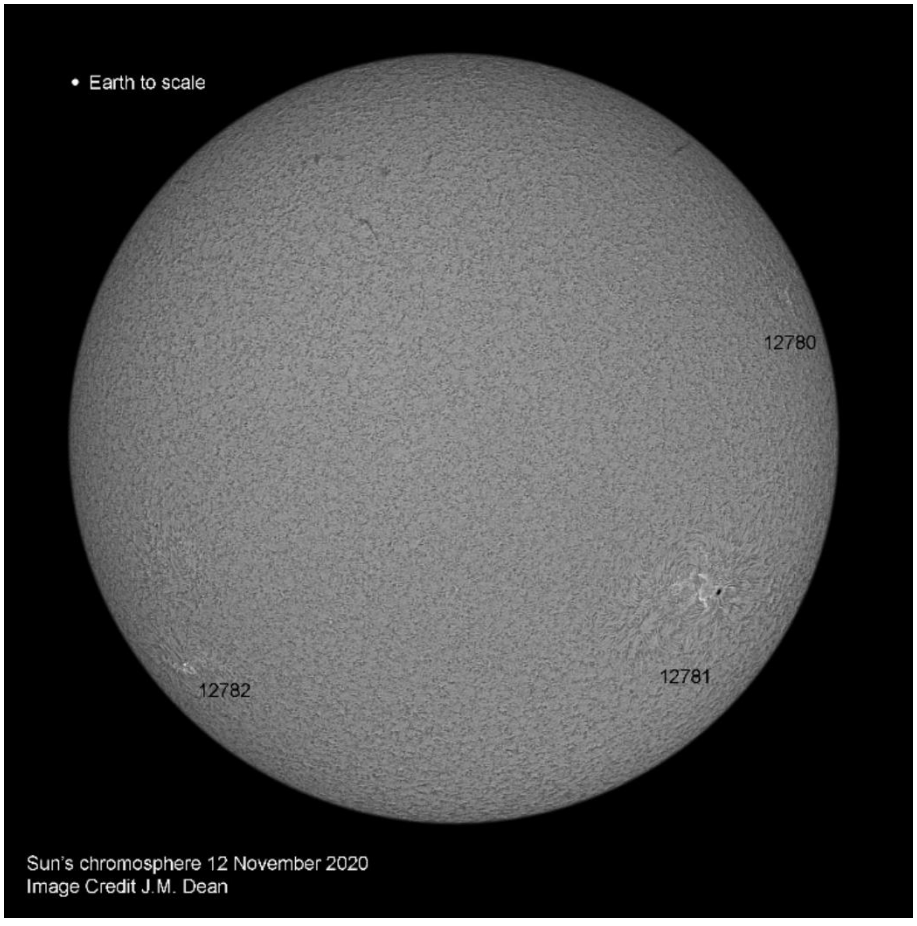


Figure 2 (left) – Sun's chromosphere 12 November 2020.

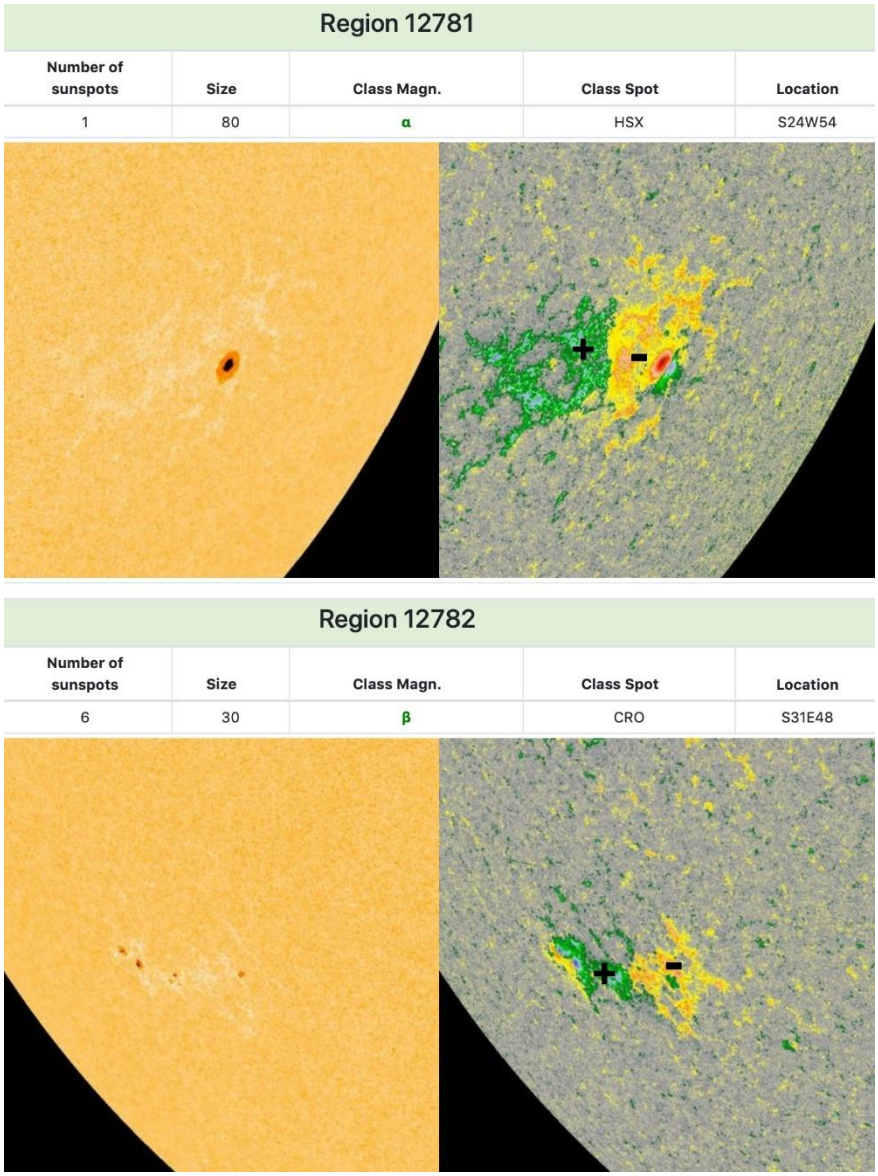


Figure 3 (right)– Solar Dynamics Observatory HMI Intensitygram (left) and Colourised Magnetogram (right) of Regions 12781 and 12782 on 12 November 2020. The darker sunspot areas are regions of reduced surface temperature where magnetic fields are particularly strong and thus inhibit convection of heat from within the sun. Data from NASA and compiled by spaceweatherlive.com.

Equinoxes and solstices

The following are the dates and times of the equinoxes and solstices in 2021:

Vernal Equinox	20 March	09.37 UTC
Summer Solstice	21 June	04.32 BST
Autumnal Equinox	22 September	20:21 BST
Winter Solstice	21 December	15:59 UTC

Satellites

The International Space Station (ISS) is regularly visible from Guernsey, looking like a very bright star crossing our skies from west to east. With the decommissioning of Iridium satellites flashes from them are now quite rare. Many other, fainter, satellites appear every night. Details of the times and directions of visibility (together with sky charts and much more) can be obtained from www.heavens-above.com, linked from our webpage www.astronomy.org.gg/more/iss.

References

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http://astropixels.com/ephemeris/astrocal/astrocal2021gmt.html
http://www.timeanddate.com/

https://www.calendar-12.com/moon_phases/2021
https://www.nakedeyeplanets.com/
https://in-the-sky.org/
Equinoxes, etc: https://www.weather.gov/media/ind/seasons.pdf
Royal Astronomical Society diary, 2020
The Handbook of the British Astronomical Association, 2020

Thomas Harvey

Calendar of Astronomical Events 2021

Month	Date	Time	Event
January	03/04		Quadrantid meteor shower (favourable)
January	02	13:50 UTC	Earth at perihelion (147,091,144 km)
January	21	18:47 UTC	Conjunction of Mars and Uranus (1°36')
January	24	Early morning	Mercury at Greatest eastern elongation
February	02	All night	Asteroid 18 Melpomene at opposition
February	27	All night	Full moon
March	05	All night	Vesta at opposition
March	20	Evening	Venus at greatest eastern elongation (46^{o})
March	20	03.51 UTC	Vernal Equinox
March	28	All night	Full moon
March	28	01.00 UT	BST starts
April	27	All night	Supermoon
May	17	08:04 UTC	Mercury at greatest eastern elongation
May	26	All night	Supermoon, lunar eclipse (not visible in Guernsey).
June	10	Evening	Annular solar eclipse (not visible in Guernsey).
June	21	04.21 BST	Summer Solstice.
July	05	23:27 BST	Earth at aphelion (152,095,296 km)
July	18	07:20 BST	Pluto at opposition.
July	24	02:37 BST	Full moon.
August	2	All night	Saturn at Opposition.
August	12/13	All night	Peak of Perseids meteor shower.
August	19	All night	Jupiter at Opposition.
August	22	01:02 BST	Full moon, blue moon.
September	14	All night	Neptune at Opposition.
September	14	Evening	Mercury at Greatest Eastern Elongation (26.8 degrees)
September	22	19:11 UTC	Autumnal Equinox.
October	20	14:57 UTC	Full moon
October	21/22	Morning	Orionids Meteor Shower
October	29	Evening	Venus at greatest Eastern Elongation(47 degrees)
November	5	All night	Uranus at Opposition.
November	17/18	Morning	Peak of Leonids Meteor Shower.
November	19	09:02 UTC	Partial Lunar eclipse – not visible from UK
November	27	23:56 UTC	Ceres at opposition.
December	4	07:33 UTC	Total solar eclipse – not visible from UK
December	13/14	All night	Peak of Geminids meteor shower
December	19	04:37 UTC	Full moon.
December	21	15:50 UTC	Winter solstice.

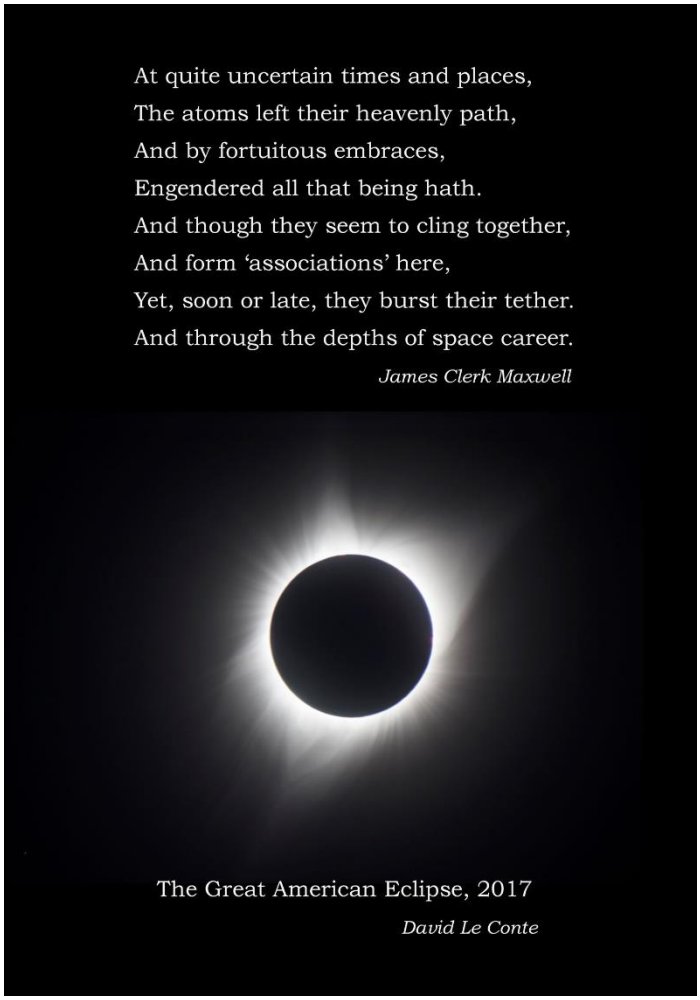
In Memorium: David Le Conte FRAS

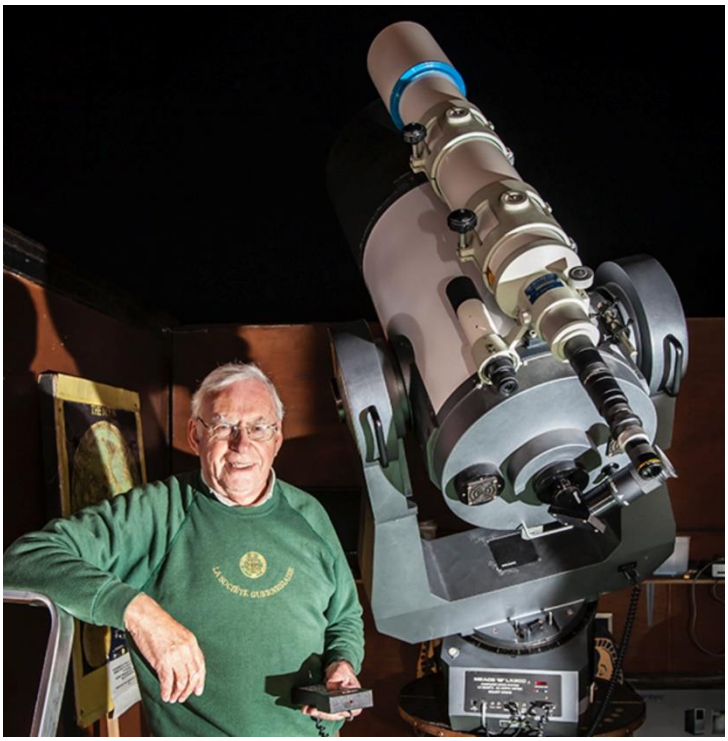
The Astronomy Section was greatly saddened by the passing of long-term member and former Secretary David Le Conte in August of last year, and we would like to highlight the immense contributions he made to the section over the last 40 years.

After returning from the USA in 1978, David joined the nascent Astronomy Section, becoming Secretary in 1985. He held many roles over the years, including Secretary, Sagittarius Editor and Public Relations Officer. David was heavily involved in the Section's outreach over the years and was always keen to explain the wonders of the night sky to anyone who would listen. He is pictured below as many will remember him, in control of our large 16-inch telescope as he guided visitors around the night sky. On the not so clear nights, David had a variety of entertaining and meticulously researched talks ready to present. As a testament to his skill as an educator, David also ran the ever-popular WEA Stargazing course for 18 years.

He was also the editor of this newsletter on and off for a significant number of those 40 years, producing many informative and entertaining articles. The archive of previous newsletters is available on our website.

David was instrumental in securing the current observatory site, in 1991, and in the construction and equipping of the separate telescope building in 1993. He also arranged for his friend Sir Patrick Moore to open the observatory building. Sir Patrick Moore was also responsible for David's election as a Fellow of the Royal Astronomical Society, for his dedicated public outreach.





David Le Conte. Image credit David Le Conte.

If you would like to learn more about David's fascinating life outside the Astronomy Section, please see the next article, entitled "Life in an Astronomer's Family", along with the obituaries published in the Guernsey Press, and the La Société Guernesiaise newsletter. He is greatly missed by all the members who knew him.

David was an inspiration to many members of the Section and his dedication to astronomy and public outreach gives us a legacy to carry into the future.

Thomas Harvey

Life in an Astronomer's Family

Born on the vernal equinox, the 20th March 1940 (the equinox actually occurred at 6.23 pm, coinciding exactly with sunset!), the planets Jupiter, Saturn, Venus and Mars were all in a line in the evening sky, and must have been spectacular. This was prescient to David Le Conte's lifelong passion for studying the sky and his search for knowledge.
My father's mantra was *Just Look Up*. As a family, our life, holidays and sleeping patterns were largely determined by the skies and David would often wake us up and drag us out of bed to witness an extraordinary astronomical event. He always longed for other people to share the magic of the night or day skies that he knew so intimately. He would have been delighted that so many people have told us since his death, that he inspired them to learn about the sky around them.

My father's passion for astronomy and how it defined his life was demonstrated when he and my mother, Dorothy were first courting. My father flew from Florida on Christmas Eve, 1965 to visit my mother in Leicestershire. That very same day, the largest meteor to fall in the UK (the size of a turkey prior to impact) was hurtling through the atmosphere, to land in a field in the village of Barwell, near to where my mother lived. Despite my mother's Christmas preparations, my father (eager to collect a sample to take back to the Smithsonian for research) dragged her out into the freezing cold, pitch black darkness to crawl around muddy fields trying to find a fragment of meteorite; using one shared torch! Sadly, they were unsuccessful - despite reaching the site prior to the main meteorite hunters who arrived the following morning on Christmas Day, including one (Sir) Patrick Moore. Characteristically, however, David later managed to secure a piece for the Smithsonian Institute taking it back with them after their wedding in April 1966.

Living in the most magnificent locations due to my father's work, our family were surrounded by both incredible views and opportunities. For myself, before moving to Guernsey, living firstly close to the Smithsonian in Washington DC and then in the foothills above Tucson, Arizona, I clearly recall the stunning sky, the magnificent mountains, and the vastness of the desert landscape.

David and Dorothy Le Conte. Image credit Dorothy Le Conte.

In his position as Executive Director of the Smithsonian Research Foundation in Washington DC, David travelled extensively including to: India, Sri Lanka, Morocco, Tunisia, Egypt, Israel, Yugoslavia and Poland. During this 5 year position, he administered some 40 research projects in 10 countries at any one time, as well as a similar number of in-house projects, and other programmes, such as overseeing the prestigious Woodrow Wilson International Centre. Reflecting on these years, as we reviewed photos and memories in his last few weeks, David felt very fortunate to be paid to travel and to meet so many fascinating people. During his initial scientific trips, he stayed in some very unusual accommodation including scientific research centres, a kibbutz, a fold down wooden top bunk on a long train journey across India and a field jungle hut in Sri Lanka. Returning to many of these countries with my mother Dorothy later in life, he stayed in more comfortable hotels but still loved the adventure and thrill of exploring.
Following on from Washington DC, my father worked at the Kitt Peak National Observatory (KPNO) in Arizona, based at 5,000ft. KPNO was the largest observatory in the world at the time and was run by the Association of Universities for Research in Astronomy Inc. (AURA), a consortium of 13 US universities with some 13 telescopes. My father would drive us up the twisting 17-mile-long road carved out of the mountain, avoiding the odd rattle snake, coyote, coatimundi, mountain lion or skunk - to walk around the different telescopes, learn about his work and meet his colleagues.

It is these amazing exceptional experiences that David loved to recount, however he is more well known for his work as Manager of the Hawaii tracking station. His first triumph was on the 22nd October 1968 when he and his team successfully photographed the re-entry of the Apollo7 spacecraft, which had been in Earth's orbit. An even greater success was his photography of the Apollo 8 trans-lunar injection (TLI) rocket burn on 21 December 1968, which for the first time sent men beyond Earth and out towards the Moon producing

David and Dorothy Le Conte. Image credit Dorothy Le Conte.

photos that were published internationally. Whilst in Hawaii, David, Dorothy and their very young son, Christopher were also fortunate to observe the incredible Kilauea Volcano eruption. Staying in a nearby hotel close to the edge of the crater, they enjoyed not only the fantastic view of the violent eruption but also the novelty of the steam room fuelled by the volcanic steam.

Despite these exceptional experiences, my father longed to return to his homeland, Guernsey and we did so in 1978. His insatiable search for knowledge continued; researching even up until the days before his death. When my mother introduced him to sundials many years ago as one of her own interests, my father delved deeply into them, their joint research culminating in my parents' booklet on Guernsey Sundials, as well as his very precise calculations used in the creation of the Guernsey Monument designed by artist Eric Snell. In addition to astronomy, sundials, photography, flags, megaliths and Channel Island history, my father was involved for many years with writing the Lihou tide tables. We often had a family day out to Lihou island to verify the tide times. On one such visit, as my father scribbled his calculations in one of his tiny notebooks, my mother alerted us to the rising tide. Whilst my father continued making detailed notes, so engrossed in his work that he was oblivious to the fact that we were quickly being surrounded by surging water. We then needed to roll up our trousers and wade across the now waist high water, hanging onto each other to fight against the racing currents.

Other times that our family were in deep water was in a completely different context when helping to restore the shipwrecked Asterix in wet and dry docks and, on drier land, taking part in numerous digs around the Bailiwick. Holidaying in Bayeux, we analysed the tapestry as part of historical research into the Guernsey flag and when aged about 14 years, I was fortunate to accompany my father, who represented La Société Guernesiaise in travelling to the United States to secure the return of the 16th century Falcon, referred to as *the Guernsey Falcon*, attending the numerous impressive ceremonies and meetings. When the cannon was finally returned to Guernsey by naval frigate, despite its historical value, it arrived in a very large but plain wooden box, scrawled on top, *David Le Conte, Guernsey*.

Throughout our childhood and into adulthood as we had our own families, our parents were always surrounded by richness in terms of interesting environments and people - each experience a deep involvement into finding out more about the world around us. My father loved showing us our tiny place in the universe and his own small part played in its discovery, a part of which as family members, we are very proud to have been involved in. What a life!

Dorothy Le Conte and Sarah Neild-Le Conte

A Good Friend

David leaving us was the end of a chapter for me. I had known David Le Conte for 42 years, since he became a member of the Astronomy Section in 1978. It has been well established that his career in astronomy brought a boost to the section.
Previously Dr David Falla, along with his brother Geoff had started the Section back in 1972 and had brought it to a point where numbers were increasing and regular activities were being enjoyed, by a membership looking for more and more knowledge of a science becoming increasingly popular.
David Falla and David Le Conte became very good friends and because David Falla was a lecturer in Physics at Aberystwyth and could only be in Guernsey during University holidays, he handed the work as Secretary to David Le Conte in 1982.

To say I was impressed by David Le Conte is an understatement. The Eighties were a time of increasing interest in space and here was a man that had not only worked in United States observatories, which was rather cool in my eyes, but he had been involved with the moon landings and had even been contracted to NASA. Not only that, he was answering all my questions.

One of the first things David did was to find us a home for our equipment and establish the Tuesday evening meetings, something which continues till this day. David was Secretary for quite a short time but then became our PR which really suited him. All through the years I have kept close to David. I know that my increasing knowledge of astronomy over the years was totally in my favour rather than his, but I am comforted by his occasional idea that he would ask for my opinion.

David helped me with my science degree and when he proposed me as Secretary it was a very proud moment. But I always knew that if I had a problem it was easily solved. Thank you David for your company over the years. It is a privilege to have known you. And thank you Dorothy Le Conte for the recent interesting talks that we have had.

Frank Dowding

Save the Earth - Asteroids

One of the most important future space missions has recently taken an important step forward.

The DART (Double Asteroid Redirection Test) and Hera mission is a planetary defence, dual spacecraft, joint exercise between NASA and ESA with NASA launching DART and ESA launching Hera. The NASA component is scheduled for a 2021 launch but the ESA component has sometimes seemed to struggle to get the priority it deserves, but now is finally underway. In September 2020 ESA awarded a €129.4 million contract covering the detailed design, manufacturing, and testing of Hera. This will be ESA's first mission for planetary defence.

One of the biggest threats to the planet and humanity does not come from man’s own behaviour on Earth, but actually from outside. There are millions of asteroids spinning around in the solar system. Some have crashed into the Earth, more will in the future. Assuming we can spot them in time, what could we do to avert the impact.

That's what DART and Hera plan to investigate. Could we deflect an asteroid? This combined mission is intended to help us learn and test theories of impact-based deflection of an asteroid. According to NASA the current number of known asteroids is over one million. Of those, as of December 2020 there were 2,155 known asteroids considered to be potentially hazardous and of those 157 are estimated to be larger than one kilometre in diameter.

When new objects are discovered and future trajectories are calculated, they are classed as potentially hazardous if they are larger than 140 metres across and are expected to come within a few lunar distances of Earth. That's not to say smaller pieces are not capable of doing some significant damage, but the focus is on serious regional impact. As an example, the 2013 Chelyabinsk meteor was estimated to be only 20 metres in diameter but caused an air-burst of around 500 kilotons, an explosion 30 times the size of the one over Hiroshima. It managed to cause damage out to 120km from its path and shatter more than 3600 apartment windows.

Potentially hazardous asteroids.
Image credit NASA/JPL-Caltech.

At the other end of the size scale, it is now believed that an asteroid impact that caused the Chicxulub crater was the likely cause of the extinction of the dinosaurs and many other species. It is estimated it was over 10km in size and was responsible for the event, referred to as the Cretaceous-Tertiary extinction, approximately 66 million years ago that devastated the global environment and saw a sudden mass extinction of three-quarters of the plant and animal species on Earth. It certainly puts the current planetary worries into perspective.

One of the better-known future visitors is Apophis, a near-Earth asteroid more than 340 meters across which is predicted to pass within just 31,900 kilometres of the surface of the earth on Friday April 13, 2029. It weighs in at around 61 billion kg and will be travelling at around 30km/sec. Fortunately we are confident it will miss, but it will pass inside the orbit of the moon and inside the orbit of some satellites. It's a lot smaller than the one that caused the dinosaur extinction but were it to collide with the Earth it would make quite a big mess and a crater nearly as big as Guernsey.

Searching for these potential visitors is clearly a very important activity, but there is no point spotting them if we don't know how to defend against them. There are many possible defence strategies and that's where DART and Hera hope to contribute to a future defence; how to make an asteroid on a collision course with Earth miss us, assuming we see it in time, without Bruce Willis to help.

The NASA DART mission aims to crash a small spacecraft at high speed into an asteroid. Firstly, to prove we can hit a fast moving object with sufficient accuracy a long way away. Secondly to see how much effect such a collision actually has on the asteroid. One of the key unknowns is how much material will be thrown up and how this will impact the change of momentum that the asteroid receives. The launch window for DART begins in late July 2021 and will launch aboard a SpaceX Falcon 9 rocket from Vandenberg Air Force Base, California.
The ESA Hera mission (named after the Greek goddess of marriage) will then go and perform an in-depth analysis of the asteroid and the crash site. The asteroid target is the Didymos binary system. Didymos is the 780m diameter main body and Dimorphos (sometimes known as Didymoon for obvious reasons) is the 160m diameter orbiting secondary body. There are several reasons why Didymos was selected as a target. Firstly there is no chance it will hit Earth before or after the experiment, but it is near enough to observe. Its size, at 160 meters, is typical of the size of asteroids that could pose the most likely significant threat to Earth.

Perhaps Didymos's most important feature is that it is a binary system, a main asteroid with a small orbiting moon. Didymos spins rapidly, rotating about once every 2.26 hours. Dimorphos revolves around Didymos about once every 11.9 hours at a distance of around 1.2km. A binary system has huge advantages for making accurate measurements. If you change the momentum of a lone asteroid by a tiny amount it is very difficult to measure that accurately, especially when it is a long way away. But in this case a small change in momentum of Dimorphos will change its orbital velocity of about 17 cm/s by around half a millimetre per second. That will change its rotation period around Didymos by about 200 seconds, enough to be easily measured with Earth-based telescopes. In addition Didymos and Dimorphos are a binary eclipsing pair when viewed from earth, so by monitoring the brightness we can get an easy measure of the orbital period. The impact speed is approximately 6.6 km/s, and DART will be the first-ever space mission to demonstrate asteroid deflection by kinetic impact.
The timing of the DART impact is September 2022, chosen to minimise the distance between Earth and Didymos. At that time the Didymos system is within 11 million kilometres of Earth. That will enable the highest quality telescopic observations post impact but the Didymos binary is already being intensely observed using telescopes on Earth to get the best possible measurements of its properties before DART arrives. Soon after the impact we will see the initial effects from our earth-based observations. When Hera arrives at Didymos it will hugely extend our knowledge of both asteroids and make many more accurate measurements.

Hera is planned to launch in October 2024 and arrive in December 2026. Hera carries a number of instruments for making detailed observations including a camera to provide information about the composition of physical properties of the surface of Dimorphos. It also carries a compact lidar (laser radar) to measure surface altimetry for mapping and close-range asteroid operations, a thermal infrared system that will image the asteroid in the mid-infrared spectral region to map the temperature on Dimorphos's

surface to learn more about the physical properties of its surface and capabilities to measure the mass and the mass distribution (including internal density variations) of Didymos, and the mass of Dimorphos.

Hera also has 2 CubeSats named APEX & Juventas. These will carry additional scientific instruments, including a radar to investigate the interior of Dimorphos and an imaging spectrometer and a mass spectrometer to determine the mineralogical and elemental composition of Didymos and Dimorphos. They will perform detailed spectral measurements of both asteroids surfaces and magnetic readings that will give insight into their interior structure and a low-frequency radar survey of the asteroid interior. Both CubeSats will also attempt landings and perform additional surface investigation. Hence Hera's detailed survey of the asteroids will fill in many blanks about the exact nature of what DART hit, especially what the impact crater looks like and how the impact affected Dimorphos.

Two very interesting space flights and a mission that is important to us all.

Clive Stubbings

The Mathematics of "Looming" Contained in "*The Black Cloud*" by Sir Fred Hoyle

There is, I am told, a proverb in the world of publishing to the effect that for every equation contained in a "popular" science book you halve your audience. On that basis, one might expect *The Black Cloud* (1957) – a science fiction novel - by the well-known astronomer and astrophysicist Sir Fred Hoyle FRS (1915 - 2001) to have lost over 99% of its readers by page 20. The early part of the book contains a brief explanation of the method of "looming" to calculate how long a moving object will take to reach an observer without, significantly, knowing how fast the object is moving. In an interesting footnote stretching from page 19 to page 20 a formal mathematical derivation is given; I hope that my brief comments on this technique will be of interest.

First, a synopsis of the plot. The fly leaf contains the following summary:

> "*A cloud of gas, of which there are countless numbers in the Universe, approaches the solar system on a course that in a little more than a year is reckoned to bring it between the Sun and the Earth, causing incalculable changes on our planet. Together with top-ranking experts in other fields and from other countries, Chris Kingsley, Professor in Astronomy at Cambridge, is sent to a highly secret establishment set up to advise the British Government. During the months that follow the nature of the cloud becomes more and more awe-inspiring, while the advisers, under Kingsley's influence, become less and less content to remain purely advisory.*
>
> *Politicians and scientists, and their peculiarities, provide a human, often a humorous element in this gripping and alarming story. 'How much of this steps outside the bounds of possibility?' the author asks in his preface, and answers: 'I believe very little.'* "

Early in the book astronomers discover a dark cloud apparently moving across the sky and becoming larger. Naturally enough they ask "Is it coming towards us?" and having answered that in the affirmative they ask "How long will it take to reach us?" The first question is answered by noting, first, that if an object is coming directly towards an observer it will appear to increase in size, but its centre will not move relative to more distant objects. If, on the other hand, an object has an additional element of transverse, or sideways, velocity relative to the observer it will not only appear to increase in size, but its centre will also appear to move against a distant background; the greater that sideways velocity, the greater the apparent shift in position. The scientists in *The Black Cloud* are able to find reference photographs from 20 years ago of the area where the cloud was first identified – its centre has barely moved more than an angle of a quarter of a degree. They

conclude that the cloud is heading toward the solar system "like a bullet at a target" and is going to score a bull's eye.

How long do we have before collision? The obvious answer is to start by calculating the cloud's speed by measuring the Doppler shift of spectral absorption lines formed by the cloud obscuring background stars on its fringe. This Doppler shift can then be converted directly into a speed of approach. They estimate that it might take about a week to complete the necessary measurements. Even then, of course, we still need a measurement of distance before we can calculate the time until collision.

One of the scientists then interjects that he doesn't see why they need the speed of the cloud; he says the time to collision can be calculated directly. For those readers anxious to find out what happens next in the story the process of calculation is dealt with by a grand sweep of narrative and descriptions of "lengthy calculations" on the blackboard. The answer, calculated in what appears to be the course of a discussion between the characters, is about 20 months.

So how is it done? This piece of magic that doesn't require knowledge of the speed of the cloud or its distance? This is where the footnote comes in and the phenomenon of "looming". The chatty footnote for the interested reader explains as follows:

> Let:
> α be the present angular diameter of the cloud, measured in radians.
> d be the linear diameter of the cloud.
> D be the distance of the cloud away from us.
> V be the velocity of approach.
> T be the time required for the cloud to reach the solar system.
>
> Evidently we have $\alpha = d/D$ [Note: this assumes that α is "small", which it certainly will be if it needs an 18-inch Schmidt telescope to see the cloud as described in the story.]
>
> Now, differentiate this equation with respect to time to obtain $\frac{d\alpha}{dt} = \frac{-d}{D^2}\frac{dD}{dt}$
> But, $V = -\frac{dD}{dt}$, so that we can write $\frac{d\alpha}{dt} = \frac{d}{D^2}V$.
> Also, we have $\frac{D}{V} = T$. Hence we can eliminate V, giving us $\frac{d\alpha}{dt} = \frac{d}{DT}$.
> But since $\alpha = d/D$, we can also write $\frac{d\alpha}{dt} = \frac{\alpha}{T}$.
> Thus $T = \alpha\frac{dt}{d\alpha}$.
> The last step is to approximate $\frac{dt}{d\alpha}$ by finite intervals, $\frac{\Delta t}{\Delta\alpha}$.
> [From the story so far we know that one of the characters, Dr. Jensen, took two photographs of the cloud 1 month apart and another character, Dr. Marlowe, estimated that the change in the cloud's apparent angular size between those two photographs was about 5% Consequently, we have Δt = 1 month and $\frac{\alpha}{\Delta\alpha} = 20$]
> If we then use the approximation $T \approx \alpha\frac{\Delta t}{\Delta\alpha}$ we immediately see that $T \approx 20\Delta t = 20$ months.

What is particularly interesting about this method is that it only requires knowledge of the initial angular size on the sky and an approximation of the rate of change of apparent angular size (in this case calculated from two photographs taken one month apart). It is this change in apparent angular size that gives the technique its name, "looming".

How many readers have I lost in the course of this article? Not many I hope, given that the audience probably has an interest in this sort of thing to start with.

One other interesting aspect of the book is that it begins with a retrospective "Prologue" that contains a letter from one of the characters supposedly written on 19 August 2020. It is because of that timely coincidence that I judged it appropriate to bring this entertaining book and useful little technique to the attention of a wider audience.

Jason Hill

The Largest Star in the Universe: Stephenson 2-18 (4KUHD)

It is impossible to know how many stars are in the cosmos, but it is estimated that the Universe contains at least one quadrillion stars, which is 1 followed by 24 zeros. They come in a variety of shapes and sizes, some are extremely small and heavy such as the exotic neutron star, while others are low mass and much cooler and are common throughout the galaxies such as red dwarfs. Our sun is technically classed as a yellow dwarf; compared to earth it is enormous, but on a stellar scale it is fairly average.

The universe has produced some enormous stars, such as the mighty UY Scuti, this gigantic ball of glowing plasma is classed as a red supergiant and once was considered the biggest star ever discovered, located in the constellation Scutum. UY Scuti was thought to be 1700 times larger than the Sun.
For years it was believed to be the largest star in the known universe. These days, however, UY Scuti doesn't even make into the top ten because it is a lot closer to earth than originally estimated. More recent and accurate measurements have found that UY Scuti is more likely to be 775 times larger than the Sun, it is still an enormous star, but nowhere near as big as many others that have been discovered.

The title of largest known star in the Universe, currently belongs to Stephenson 2-18. Stephenson 2-18 is truly enormous, with an estimated radius of 2150 times the size of the Sun. In fact if we could replace the Sun with this enormous star it would easily engulf the orbit of Earth, Mars, Jupiter, and Saturn which on average is 886 million miles away.

This enormous star is part of small cluster called Stephenson 2 which is located 20,000 light years away. The cluster contains 26 other red supergiants, far more than any other cluster in the Universe, but none of them seem to be as large as Stephenson 2-18.

This is a new discovered star and is very young, between 14 and 20 million years old. Stephenson 2-18 may continue to grow even larger and possibly one day turn into a yellow hypergiant.
In just a few million years this gigantic ball of plasma will also enter its later stages of life as it quickly burns through its fuel and explodes into a massive supernova, leaving behind a black hole.

Allan Phillips

University Challenge: 1st Year University Astronomy Questions

Here are a selection of questions taken from a real 1st year undergraduate introductory astronomy course. Test yourself and see if you could pass the module!

1. The Moon's angular size in the sky is about half a degree, and its radius is about 1700km. Based on this information, what is the approximate earth-moon distance?
    a. About 200,000 km
    b. About 70,000 km
    c. About 7,000 km
    d. About 400, 000 km

2. The maximum angular distance of Venus from the Sun (as viewed from Earth) is 46.1 degrees. What is the orbital distance of Venus to the Sun in astronomical units?
    a. About 0.69 AU
    b. About 0.72 AU
    c. About 0.92 AU
    d. About 0.39 AU

3. Which planets are occasionally observed to exhibit retrograde motion and why?
    a. Retrograde motion is only observed when the Earth overtakes a planet, so only superior planets exhibit retrograde motion.
    b. Retrograde motion is only observed when the Earth is being overtaken by a planet, so only inferior planets exhibit retrograde motion.
    c. Retrograde motion is observed whenever the Earth overtakes a planet or is being overtaken by one, so all planets (except the Earth) sometimes exhibit retrograde motion.
    d. Retrograde motion is observed whenever a superior planet is being overtaken by one of the inferior planets, so only superior planets exhibit retrograde motion.

4. Which of the following objects cannot transit (pass in front of) the Sun, when viewed from Earth?
    a. Jupiter
    b. Mercury
    c. Venus
    d. The Moon

    Answers at the end of the newsletter.

Could there be life closer than we think?

The first discovery of an exoplanet around a star-like sun was in 1995. Since then, over 4000 exoplanets have been confirmed, alongside a plethora of other unconfirmed exoplanets needing further research. The closest collection of stars to our solar system is a triple star neighbourhood that is just 4.4 lightyears away (Howell, 2018). It consists of three stars, two of which are Alpha Centauri A and B and the third, Proxima Centauri. Alpha Centauri A is the largest star of the trio, with Alpha Centauri B being the smaller, dimmer companion. These two stars both have a similar mass to our Sun and orbit each other at roughly 23.4AU.
The third star, Proxima Centauri, is roughly 0.12 times the mass of our Sun (Lewin, 2016); it is debated if the star is part of this system or if it is simply travelling through the system but in either case, Proxima Centauri is the closest star to our solar system, at roughly 4.2 lightyears away. This star could possibly maintain the conditions needed for life (Udry et al., 2020). A recent discovery of an exoplanet orbiting Proxima Centauri has been a cause for interest and curiosity. The super-Earth, discovered in 2016, is 1.27 times the size of Earth and is 0.0485AU from the star, meaning it lays within the stars habitable zone. This planet is exposed to bursts of ultraviolet radiation (UV rays), which are much more intense than the exposure Earth receives from the Sun (Proxima b 3D Model, 2020).

On Earth, a high level of exposure to UV rays can cause a plethora of issues and health problems, alongside several helpful uses. For example, it assists with the production of Vitamin D and can be used as a disinfectant. However, this fact is not optimal if we are looking at the existence of life. It demonstrates that UV rays are capable of killing microbes and small living organisms, prohibiting the very early developments of life. UV rays also majorly affect DNA; strands of DNA are readily open to absorb these UV rays, which changes their shape. From this, distorted proteins can be made, causing mutations, cancers, and other genetic issues.

DNA, however, has become more capable of self-repair through evolution (Ultraviolet Radiation: How It Affects Life on Earth, 2001). This means that DNA is somewhat resistant to the effects of UV rays. Hypothetically, this could allow the idea that other organisms in other conditions would be capable of adaption and evolution to live in conditions with higher levels of ultraviolet radiation.
One key point is that UV radiation can be blocked by water; on Earth, a maximum of 1000 metres is needed to block sunlight altogether but there is rarely any significant light after 200 meters (How far does light travel in the ocean? ,NOAA, 2020). This is something that should be acknowledged, due to the fact that Proxima b is in the habitable zone and could possibly contain water. As Proxima b is a Super-Earth, its mass is considerably larger than our planet, meaning it could contain much deeper oceans and seas. This allows speculation surrounding extremophiles, or larger organisms, could be present in the depths of water.

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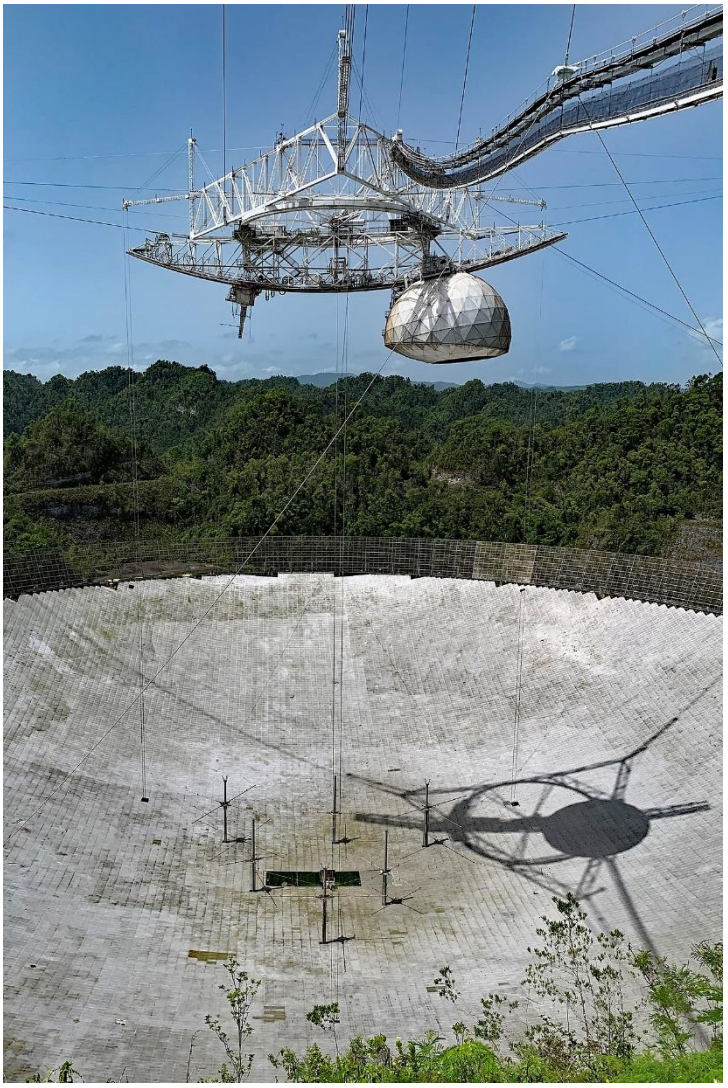
Ella Jura

The Arecibo Telescope: The End of an Era

A few hours before I sat down to write this article, we got the news that the final cables holding the Arecibo receiver/transmitter snapped, sending the 900-ton structure crashing into the dish below. This brought to an end the unfortunate saga astronomers from around the world have been watching since August, when the first cable snapped unexpectedly. The National Science Foundation had already ruled out repair, as it was too dangerous for people to go near the structure. Although the collapse was expected for the last couple of weeks, this is a tragic end for one of the world's most famous and largest telescopes. I thought I would commemorate its almost 60 years of operation by looking back at some of its most famous discoveries.



Arecibo Observatory CC BY-SA(Mario Roberto Durán Ortiz)

For those of you who haven't heard of it, the Arecibo telescope was a single, 300metre dish built into a natural sinkhole in the mountains of Puerto Rico. A massive, moveable 900ton transmitter suspended by cables above the dish, allowed scientists to "aim" the telescope at distant targets. You may remember Arecibo Observatory as a backdrop for the 1995 James Bond movie GoldenEye, It also played a key role in the 1997 movie Contact, starring Jodie Foster, which was based on a book by Carl Sagan. The Arecibo Telescope also received popular attention for the Arecibo Message, which was a short message beamed towards the M13 Globular Cluster in 1974. It contained basic mathematical and scientific information, such as the numbers one through ten, the atomic numbers of the elements that make up DNA, a drawing of a human, a drawing of the Solar System showing Earth, and a drawing of the Arecibo Telescope itself. It was meant more as a demonstration of technical progress than an actual attempt to contact aliens as when it arrives at M13 in 25,000 years' time, the signal strength will be so low it will be almost impossible for any aliens to even detect the message.

Moving back to more conventional science, the Arecibo Telescope has been an incredibly useful tool for astronomers for nearly 60 years. It was used to detect the first binary pulsar. Pulsars are type of tiny and energetic stars which have strong magnetic fields and rotate very quickly. The strong magnetic fields cause the pulsars to emit massive amounts of electromagnetic radiation in a beam, which sweeps across the sky as the star rotates. You can image the star as a single gigantic lighthouse! This leads to the name pulsar, as the light from these stars is received in very regular pulses. In 1974 the Arecibo telescope detected a pulsar where the time between pulses changed, and scientists worked out this was because the pulsar was actually orbiting another star at high speed, and the variation in pulse length was actually due to the Doppler effect. This is the same effect that makes an ambulance siren change in pitch as it drives past you. The scientist who made this discovery won the 1993 Nobel Prize for his work. In the 1992 a similar technique was used to detect the first exoplanet, which is a planet orbiting another star, again with the Arecibo Telescope. They discovered 3 planets, named Draugr, Poltergeist and Phobetor respectively, around the pulsar PSR

B1257+12, also known as Lich. Lich is a millisecond pulsar, which means the entire star spins on its axis 161 times a second!

The Arecibo Telescope has also had a big impact on planetary science, using a technique which is known as radar astronomy. This consists of transmitting a powerful signal at a target in the solar system, usually another planet or moon, and then measuring the signal that bounces off the surface of the target and returns. Not only does this allow precise distances to other planets to be measured, careful analysis of the returned signal allows scientists to learn about the composition of the target itself. This technique was used to produce the first radar maps of Venus's surface, as the radio waves can penetrate the dense clouds that obscure the ground. It was also used to determine the length of Mercury's day much more precisely, with the previous measurement being wrong by 30 Earth days! Finally, this technique was also used as evidence for liquid oceans on the surface of Saturn's moon Titan, 20 years before it was confirmed by the Cassini mission.

Overall, the Arecibo Telescope has had a big impact on both popular culture and astronomy, and unfortunately at the moment there is no replacement. One of the reasons the telescope collapsed was due to a lack of funding for repair, and for radio astronomy, so it is unlikely it will be replaced in the short term. A similar but larger facility in China, with a 500m dish, came online in 2016 but in many ways this facility is more limited than Arecibo. For example, the Chinese facility, called FAST, has no capability to transmit, meaning it can't be used for radar astronomy or messages to aliens. Hopefully in a few years' time attitudes will have changed, and the US or Europe will announce a worthy successor to Arecibo, using modern electronics and techniques.

Thomas Harvey

Answers to University Questions

1. d – Simple trigonometry gives us 1700/tan(0.25 degrees)
2. b – Trig again – sin(46.1) = x/1 AU
3. c – For an explanation of retrograde motion see - https://mars.nasa.gov/all-about-mars/night-sky/retrograde/
4. a – Jupiter orbits further from the Sun than the Earth, so it can never appear to cross the face of the Sun.