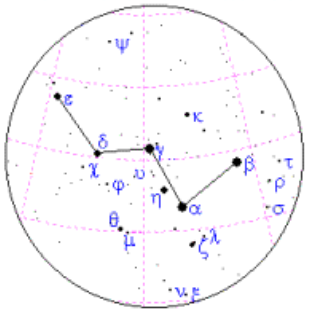


Wadhurst Astronomical Society Newsletter January 2018

A very Happy New Year to all Members of the Wadhurst Astronomical Society and a warm welcome to our 21st Year

Chairman's Letter

Once again the AGM looms although, if you are a regular attendee, you will know this a mostly brief and painless affair where officers give short reports, you get to ask any questions that you want answered and we move briskly on the evening's main speaker. This time we are fortunate that our very own Ian King will be speaking about his ability to remotely image from the observatory site he has set up in Spain. Ian has been a WAS member for many years and has been at the forefront of developments in digital imaging since its earliest inception. There are very few people with more experience or deeper knowledge of the subject than Ian.

You are probably aware that there will be a small increase in membership fees this year although I hope you will understand that these are necessary to keep the Society's modest finances on an even keel. Phil Berry has booked some first class external speakers again this year though, of course in many cases, this comes at a cost but he has also been able to make use of some of our own "home grown" talent. The task of continually finding speakers (11 each year) is an onerous one and I would like to offer our collective thanks to him for his efforts which have provided us with a great variety of speakers and topics. Incidentally, Phil is also our Librarian and he is doing his utmost to promote the library and its range of books that are available for members to borrow.

I would also like to thank Geoff for the continued high standard of the Newsletter, which he has edited for many years, and for the NASA contacts that he maintains. John Lutkin continues as our very able Treasurer and John Wayte as our Membership Secretary, not forgetting the most important person at every meeting, our Catering Manager Jim Cooper. Eric Gibson is still our man at SAGAS and represents the Society at their meetings. I thank all of them for their efforts on our behalf. Lastly I would like to thank all our members and visitors for supporting the Society in the last year.

As always, please feel free to ask any questions that you have of our committee members. If for instance you have a pet subject that you would like to hear a talk about or are in a position to give a talk yourself about a specific subject of interest, then please let Phil know.

I hope that in the New Year we may be able to organise another visit to Ashdown Forest (or somewhere equally dark) where we can enjoy some constellation identification to help you learn your way around the sky, or possibly carry out some imaging.

Wherever your interest in astronomy lies, I hope that we can help to nurture that and increase your enjoyment of such a broad and diverse science.

I hope you all had an enjoyable Christmas and wish you a peaceful and prosperous New Year with numerous clear skies.

Brian Mills FRAS
Chairman
Wadhurst Astronomical Society

MEETINGS

COMMITTEE MEETING

Members of the Committee are respectfully reminded that there is a meeting of the Committee at Jim's house at 1930 on Tuesday the 9th of January.

DECEMBER MEETING

Our December meeting was opened by our Secretary, Phil Berry who began by saying that there is an update on the operation of the College's security gates. It has been announced that the gates will open after daytime classes at 1530 and then close again at 2230 for the night. It means that members must have their cars outside the gates by 2230. Those visiting the pub after the meetings will need to remove their cars before going.

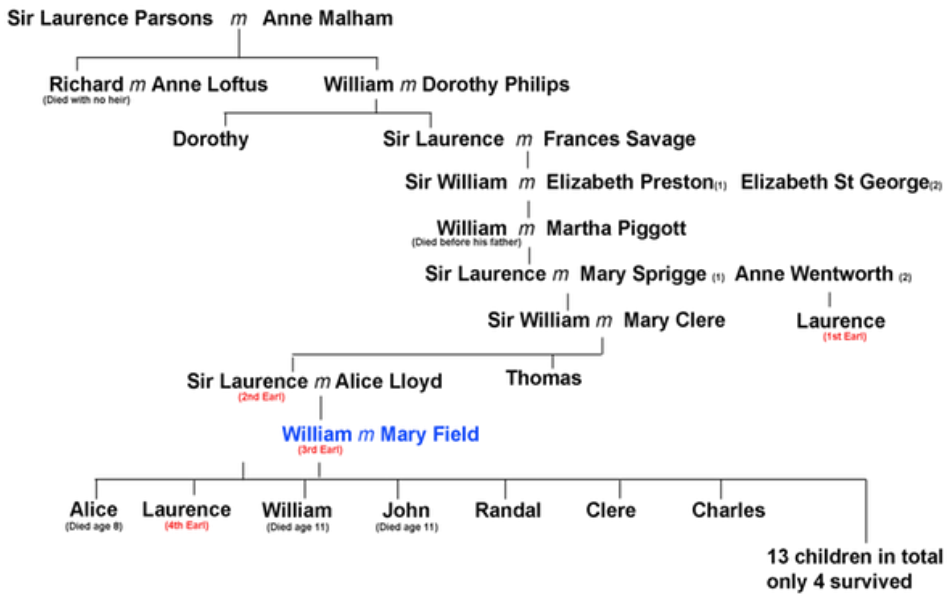
Membership subscription fees become due from the first 1st January. From March 2018 Membership fees will be increasing to £20 per member and £27 combined membership for those living at the same address. The good news is that those renewing their membership during January and February will only pay the old rate of £18 and £25 respectively. Students and members under 17 remain free.

Phil said that our January meeting will be held in the Drama Studio, to the left just inside the gates. There will be signs to direct you.

Then Phil introduced our talk, this evening given by our own Chairman and Director of Observations, Brian Mills.

Birr Castle, The Earls of Rosse and the Giant Telescope
Brian Mills FRAS

Birr Castle is situated on a low damp plain midway between Dublin and Limerick in Eire and belongs to the Parson family. Brian said the earliest that is known about the Parson's is that they came originally from Leicestershire and that James Parson married the sister of the Secretary of State for Ireland, Sir Geoffrey Fenton. James's eldest son, William became Surveyor General and it was his descendants that became the Earls of Rosse of the first creation.



The Parsons Family Tree & The Earls of Rosse

It was noted that the names of the eldest sons alternated between William and Laurence in each following generation, sometimes making it difficult to identify them because on occasion the eldest son died before their father.

Brian described the history of the castle in some detail saying that at times it had been in a very neglected state.

It was the third earl (of the second creation), William who married Mary Field, Countess of Rosse. Her father was a wealthy estate owner and having no sons when he died, Mary inherited a considerable amount from his private estate.

Interestingly, one of their sons, Charles, invented the steam turbine and also bought the optical business of Thomas Grubb to become Grubb-Parsons who went on to build both the William Herschel and Isaac Newton telescopes, now both on Las Palma.

Brian returned to William Parsons who was born in 1800 and married Mary Field in 1836. It was Mary who took charge of the rebuilding of Birr Castle after it had suffered a serious fire some time before, using her considerable wealth.

On the death of William's father in 1841, William took the title of third Earl.

William was working with telescopes before his marriage, making smaller reflecting telescopes and devising his own grinding machine.

This was about the time that William Herschel became famous for his telescopes making.

We were told that William began to grind larger and larger metal speculums, which were made by casting a mixture of copper and tin. The more tin that was added the whiter the mirrors became but this also made the blanks more brittle which led to a number of disasters. He experimented with making an 18-inch and then a 24-inch mirror.

He joined the Astronomical Association in London, which later became the Royal Astronomical Society and later still he gained recognition when he was elected to membership of the Royal Society in 1831.

In 1839, he built the 36-inch reflecting telescope, which stood near where the 72-inch was to be constructed in the grounds at Birr.

Brian told us that William's main interest was to try and resolve the fuzzy objects seen in the night sky. Good quality glass blanks were hard to make and lenses suffered from aberrations, so he chose to cast speculum mirrors.

One mirror was made so that the centre could be adjusted, thus reforming the mirror's surface but this proved to be unsuccessful.

The first 72-inch mirror was cast but it accidentally broke after 4 weeks of grinding. The second weighed 4 tons and wasn't that good. The third mirror had a crack through the middle of it and the fourth shattered during the 16-week cooling period.

The fifth mirror was good but William was concerned that it only weighed 3½ tons. We were told that he finally made another mirror to replace that in the telescope when regrinding and polishing became necessary since speculum mirrors tarnish after a short period of time.

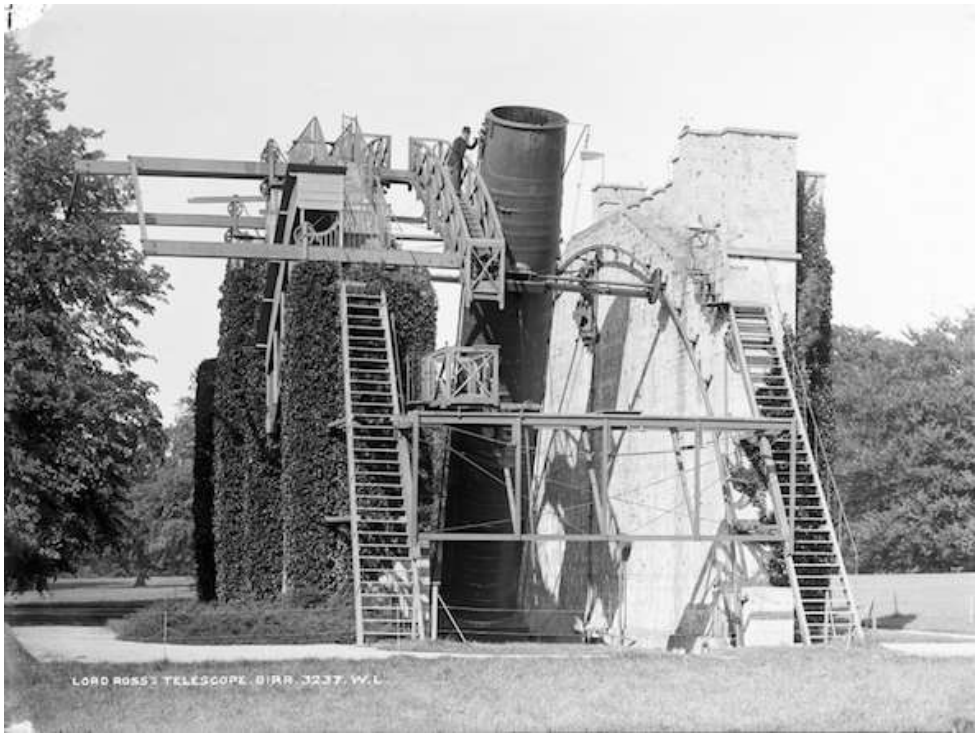
Brian described in detail the specially constructed foundry built in the grounds of the castle and said that the crucibles had to be heated to a temperature of 1,100^{o} C, which melted both copper and tin. They were heated using local turf. This was also used in the annealing oven, a process that allowed the mirror to cool very slowly over many weeks to prevent stresses in the blank.

The surviving mirror now in the Science Museum in London. The other was lost

The final mirror was fitted in a mirror-box and supported at 18 points. This box was then placed at the end of the telescope tube on an enormous universal joint that was mounted on a stone foundation.

The mirror box at the end of the telescope tube

The telescope mounted on a universal joint in the 'observatory'



The 4th Earl at the eyepiece in the early days of the telescope

The walls of the observatory were 24 feet apart, each 70 feet long and 56 feet high. Brian said that an object could be followed for about an hour since the mount was rather like a transit telescope with the ability to move horizontally a few degrees facilitated by the universal joint.

The telescope, with a focal length of 52 feet, had galleries, which allowed eyepiece-access at different elevations. The lowest elevation was 13^{o} and the tube was capable of passing the zenith by 12^{o}.

We were told that the first test took place on the night of 11th September 1844 when M2 and M13 were observed but official first-light was on the 11th February 1845.

One important fact was that the Earl shared his information about the construction and difficulties encountered when building the telescopes with anyone who was interested

Despite the fact that his wife was familiar with early photography, Lord Ross drew observed objects.

A remarkable drawing by Lord Ross of M51, the Whirlpool Galaxy compared with a modern photograph

Following the potato famine between 1846 to 1848, the Earl employed a number of astronomers to use the 72-inch telescope although he himself also continued to observe.

After the 3rd Earl died in 1867, the fourth Earl continued nebula observations with both the 36-inch and the 72-inch. In 1880, he appointed Otto Boeddicker, a German as resident astronomer who stayed until 1916 when he had to leave because of the Great War.

The telescope remained the biggest in the world for 70 years when the Mount Wilson 100-inch Hooker telescope was completed and came into service in 1917.

The 7th Earl, William Brendon Parsons is the current owner and the telescope has now been restored although the present mirror is now glass. Brian concluded by saying that Patrick Moore had suggested the speculum mirror in the Science Museum be re-installed.

The restored telescope at Birr Castle today

The Castle Estate now houses a Science Centre, which is open to everyone as are the grounds although the Castle itself remains closed to the public. Dublin University have installed a solar spectrometer whose data on the Sun is being shared worldwide.

Following the talk, the coffee break included wonderful Stollen and Christmas fare provided by Jan Drozd and his wife, and Gill Rathbone's mince pies.

The break was followed by a bit of enjoyable Christmas challenge with an astronomical bent.

THE CHRISTMAS QUIZ

John Wayte devised a quiz for our December meeting. Here are just 10 selected from his questions.

1. Which is the heaviest of all the planets?
2. Which is largest moon in our solar system?
3. How long does it take for a Neutrino to reach Earth from the Sun?
4. Neutrinos are made at the core of the Sun; so how long does it take to reach the surface?
5. A Galactic year is the length of time that it takes our Sun to orbit the galaxy. In Earth years, how long is a Galactic Year?
    a) 100 million years
    b) 230 million years
    c) 620 million years
    d) 940 million years
6. The Universe as a whole is made up of at least:
    a) Billion galaxies
    b) Million galaxies
    c) Billion stars
    d) Million stars
    e) Million constellations
7. The rapid expansion and then explosion of a Red Giant is called:
    a) A Neutron Star

b) A White Dwarf
c) A Pulsar
d) A Black Hole
e) A Supernova

8. When a star like our Sun runs out of fuel it may then:
   a) Contract to become a White Dwarf
   b) Contract to become a Black Hole
   c) Expand to become a White Dwarf
   d) Expand to become a Red Dwarf
   e) Expand to become a Red Giant
9. A Supernova:
   a) Is a small galaxy
   b) Throws dust and gas into space
   c) Is a small star
   d) Is an exploded planet
10. During a star's lifetime nuclei of lighter elements (mainly hydrogen and helium) gradually:
   a) Join to produce nuclei of heavier element – called fusion
   b) Join to produce nuclei of heavier element – called fission
   c) Split to produce nuclei of heavier element – call fusion
   d) Split to produce nuclei of heavier element – called fission

Answers at the end of the newsletter.

DECEMBER MEETING

17 January 2018 – A brief AGM will be followed by a talk by Ian King, entitled "Remote Astronomy in Spain" This meeting will be held in the Drama Studio

This meeting will take place at Uplands College, Lower High Street, Wadhurst and are held in the Drama Studio, which is just inside the gates to the left through the security gates. Signs will direct you. The postcode is TN5 6AZ.

Parking is on the right just before the security gates. These gates close at 1930 but there is still access through the pedestrian gate by pressing the call button and Reception will open them.

Meetings begin at 1930 prompt although members are invited to arrive anytime after 1900, as this is a good time to exchange ideas and discuss problems and also help set things up before the meeting starts.

Anyone is welcome but non-members are asked if they wouldn't mind contributing £3 towards costs.

FUTURE MEETINGS

21 February 2018 – Dr Graham Appleby tells us about "Monitoring Sea Levels from Space – The Role of Geodesy"

21 March 2018 – A welcome return from William Joyce whose subject his time is "Asteroids & Comets"

18 April 2018 – Barry Soden returns to enlighten us on "Daylight Skies"

16 May 2018 – Colin Stuart tells us " How to Weigh the Universe"

SKY NOTES FOR JANUARY 2018

Planets

Mercury is a morning object at greatest western elongation on January 1st, when in angular terms it will be 23° from the Sun. On that morning it rises at 06.15, which is 1¾ hours before sunrise, so that by the beginning of civil twilight (Sun 6° below the horizon) the planet is at an altitude of 8° in the south east. Its magnitude at elongation will be -0.2 but, of course, it will not be seen against a dark sky. Following elongation Mercury moves closer to the Sun, making it an increasingly difficult object, reaching superior conjunction in mid February. Fig 1 shows its position on the first of the month.

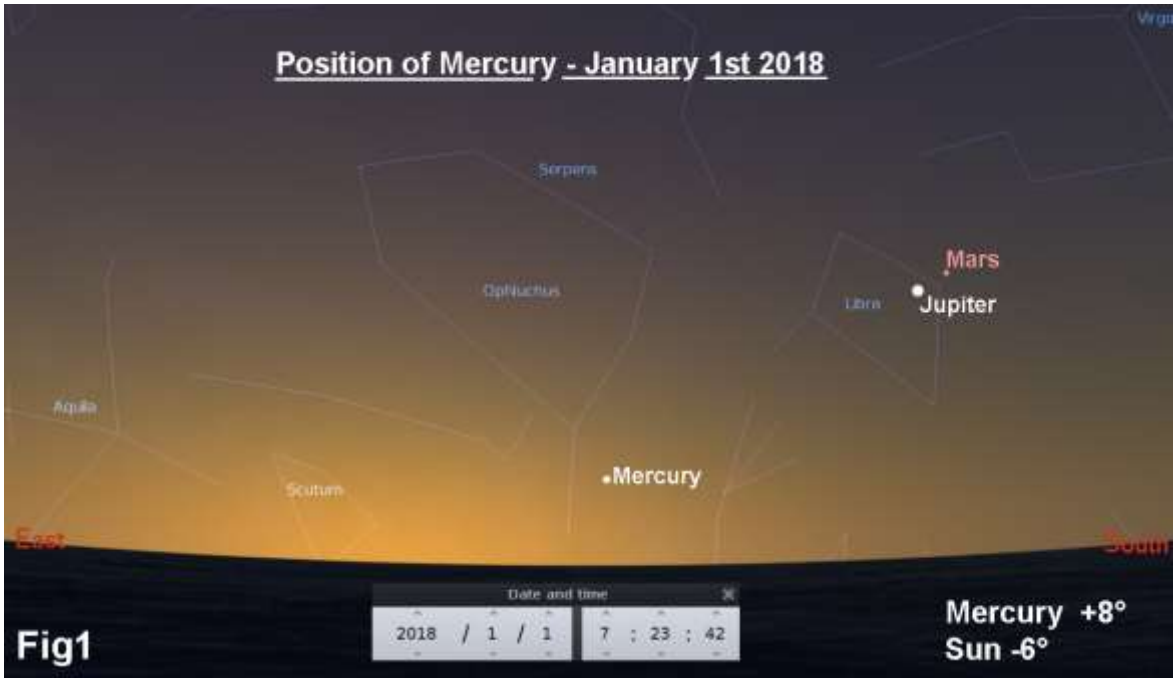


Fig1

Venus will not be visible for the first part of the year because it reaches superior conjunction on January 9th when it will be on the far side of the Sun. It is likely to be late February before the planet becomes visible in the evening skies.

Earth reaches perihelion (when it's closest to the Sun) on January 3rd at 05.35 GMT.

Mars rises in the morning skies at around 03.15 at the beginning of the month. The red planet moves swiftly eastwards through Libra until it crosses the boundary into neighbouring Scorpio on the last day of January. On the 7th Mars passes within 0.2° of the much brighter Jupiter, and then on the 11th the pair, which have by now moved apart, are joined by a waning crescent Moon to offer an interesting photo opportunity. The brightness of Mars and its angular size are both rising as the Earth draws closer in readiness for an opposition in late July. By the middle of the month it appears as a disk 5" (five arc seconds) across with a magnitude of +1.4. See fig 1 for the location of Mars on January 1st.

Jupiter is also a morning object in Libra, although at magnitude -1.9 it is considerably brighter than Mars. The gas giant rises 4½ hours before the Sun at the start of January meaning that it can be seen against a truly dark sky although it will be only 15° high at around 06.00. See fig 1 for its location. By the end of the month Jupiter rises at 02.00 and crosses the meridian due south at 06.30 with an altitude of 22°. As was the case with Mars, Jupiter is growing in apparent size and brightness in anticipation of its opposition in early May. By mid-month its apparent size is 34" (34 arc seconds) which is roughly seven times that of Mars.
Saturn was in conjunction with the Sun towards the end of December and is now just emerging into the morning sky though its altitude remains limited. On the last day of January, Saturn is 9° high in the south east at 07.00 when its magnitude will be +0.6. See fig 2 for its position. Sadly, even at opposition on June 27th, the planet will only be 16° in altitude which will make it a challenging object for both visual observers and imagers.

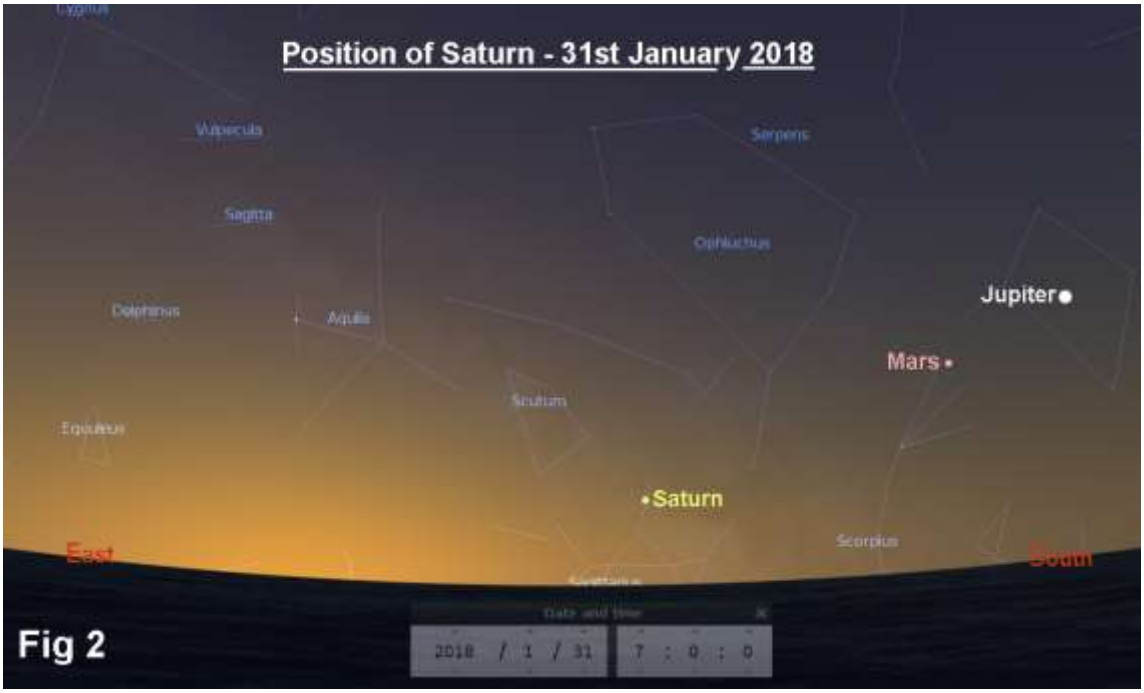


Fig 2

Lunar Occultations

In the table below I've listed events for stars down to magnitude 7.0 that mostly occur before midnight although there are many others that are either of fainter stars or occur at more unsociable hours. DD = **d**isappearance at the **d**ark limb. RD = **r**eappearance at the **d**ark limb. The column headed "mm" (millimetres) shows the minimum aperture telescope required for each event. **Times are in GMT.**

Jan.	Time	Star	Mag	Phase	Altitude °	% illumination	mm
4th	20.07	ZC 1434	5.4	RD	11	89	60
5th	08.24	Regulus	1.4	DB	16 Sun +2	86	80
5th	09.16	Regulus	1.4	RD	8 Sun +8	85	70
25th	17.35	ZC 444	5.9	DD	48	59	40
25th	23.25	ZC 462	6.0	DD	22	61	50
26th	23.29	ZC 608	6.0	DD	32	72	50

Phases of the Moon for January

Full	Last ¼	New	First ¼
2nd	8th	17th	24th
31st			

ISS

Below are details for passes of the International Space Station (ISS) this month where its brightness is in excess of -3.0. I have also included a few bright morning passes for those who may be up early. The details of other passes, including those visible between midnight and dawn, can be found at www.heavens-above.com. Please remember that the times and directions shown below are for when the ISS is at it's ***maximum*** elevation, so you should go out and look at least five minutes beforehand. **Times are in GMT.**

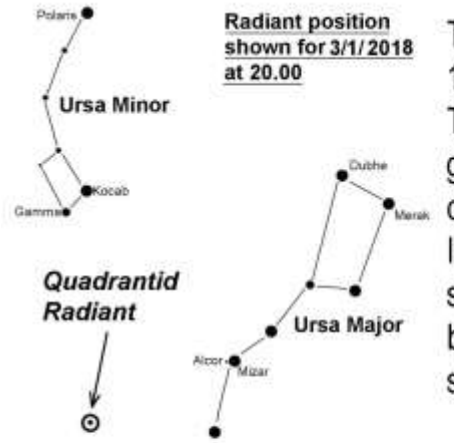
Jan.	Time	Mag.	Alt°	Az.		Jan.	Time	Mag.	Alt°	Az.
1st	06:56	-3.8	85°	SSE		8th	07:15	-3.1	45°	SSW
2nd	06:04	-3.6	67°	SSE		9th	06:22	-3.7	64°	SSW
3rd	06:48	-3.9	80°	N		29th	18:22	-3.1	39°	SSE
5th	06:39	-3.9	79°	N		30th	19:05	-3.2	56°	WSW
6th	07:23	-3.6	70°	SSW		31st	18:12	-3.7	63°	SSE
7th	06:31	-3.9	88°	SSW						

Iridium Flares

The flares that I've listed are magnitude -3.0 or brighter although there are a lot more that are fainter or occur after midnight. If you wish to see a complete list, or obtain timings for somewhere other than Wadhurst, go to www.heavens-above.com . When one of these events is due, it is sometimes possible to see the satellite before and after the "flare" although, of course, it will be much fainter then. **Times are in GMT.**

Jan.	Time	Mag	Alt°	Az.°		Jan.	Time	Mag	Alt°	Az.°
3rd	17:00	-5.7	16°	212° (SSW)		21st	18.26	-3.4	41°	166° (SSE)
5th	17.47	-5.7	14°	294° (WNW)		22nd	17.07	-6.1	24°	207° (SSW)
7th	17.17	-5.7	19°	287° (WNW)		26th	18.13	-7.9	40°	172° (S)
11th	16.35	-6.5	28°	279° (W)		27th	16.57	-5.4	18°	218° (SW)
12th	17.40	-7.0	31°	186° (S)		27th	18.12	-5.2	39°	173° (S)
13th	17.37	-6.8	30°	188° (S)		28th	17.36	-4.7	16°	284° (WNW)
15th	17.29	-6.9	29°	192° (SSW)		30th	17.59	-3.1	38°	178° (S)
19th	17.16	-6.5	26°	201° (SSW)						

Meteors
The Quadrantids



The Quadrantids usher in the new observing year and run from January 1st to 6th with peak activity occurring in the late evening of January 3rd. The ZHR at maximum is predicted to be in the region of 80 though a gibbous Moon in Cancer will rise at 18.00. The name relates to a now defunct constellation, Quadrans Muralis, which disappeared during the International Astronomical Union (IAU) reorganisation in 1930. The shower name remains as before but the radiant now lies within the boundaries of Bootes, the herdsman. The position of the radiant is shown in fig 3.

Fig 3

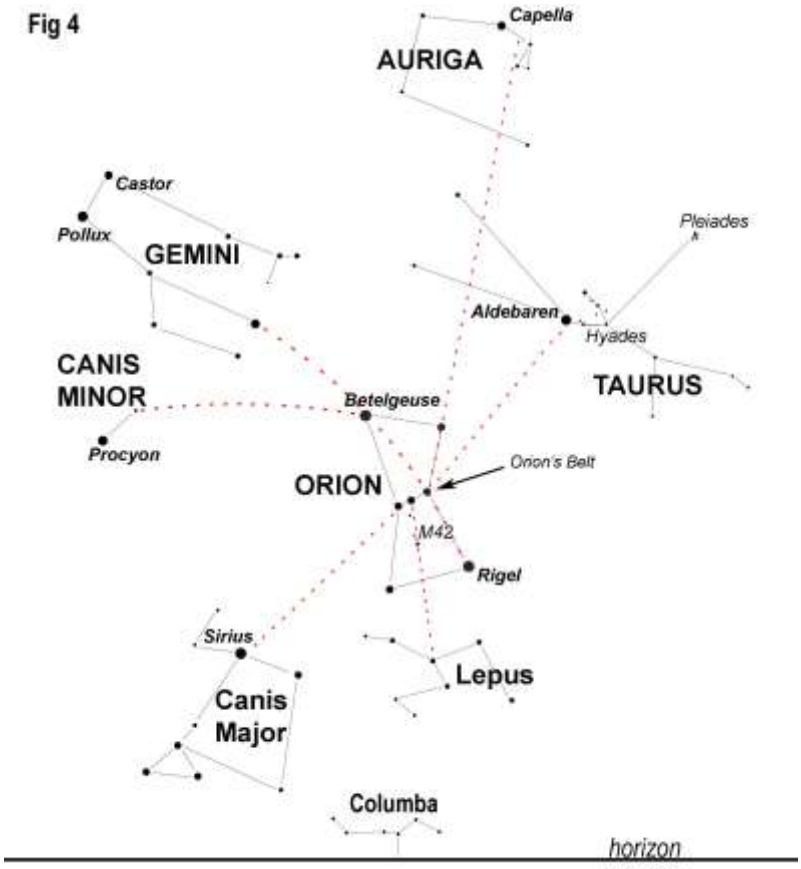
The Night Sky in January (Written for 22.00hrs GMT mid month)

In the east Leo is clear of the horizon and behind him the small groups of Coma Berenices and Canes Venatici have also risen. The former contains both the north galactic pole and the “Coma Cluster” which is one of the richest galaxy clusters known. West of Leo is the faint constellation of Cancer which contains the open cluster M44, otherwise known as the “Beehive”.

The brightest star in Cancer is β (beta) with a magnitude of +3.5 which tells you why the crab is so inconspicuous and the dimmest of all the zodiacal constellations. The only other star brighter than fourth magnitude is γ (gamma) at +3.9. This is the star that holds the record for the longest proper name, "Arkushanangarushashutu", which originates from ancient Babylonian.

Looking south Orion straddles the meridian with his retinue scattered around him. South of the hunter is Lepus (the hare) whilst further south still is Columba (the dove) which would be an ideal target for someone on the south coast with a sea horizon. Fig 4 shows the brighter groups that surround Orion as well as faint Columba partly obscured by the horizon.

Fig 4



The bright star Capella, in Auriga, is just 6° from the zenith whilst around it there are a host of open clusters of which M35 at magnitude 5.1 is the brightest.

Towards the west Pisces and Pegasus are beginning to set although the Andromeda Galaxy (M31) is still at a respectable altitude of 40°. It is the most distant object visible with the naked eye being some 2.5 million light years away, meaning that the light that enters your eye from it left on its journey towards us 2.5 million years ago. The latest estimate carried out using the Spitzer Space Telescope suggests that it contains in the order of one trillion stars. Almost directly north of M31 at this time is the double cluster in the "Sword Handle" of Perseus which is a lovely sight in binoculars or a rich field telescope and is also a good target for a digital camera.

Turning to the north we see the head of Draco on the meridian with two of the stars of the Summer Triangle just west of it. One of them, Vega, will just graze the horizon from these latitudes whilst the other, Deneb, will be 7° high when it crosses the meridian. Ursa Major is east of the celestial pole and standing on its tail with its smaller relative apparently hanging by its tail from Polaris and pointing eastwards. Now is a good time to try and identify the faint constellation of Lynx which currently lies above the Great Bear forming a line of stars between it and the "Twins" in Gemini.

Graze Occultation on January 27th – Call for Observers.

A graze occultation of a magnitude +5.5 star will take place on Saturday January 27th 2018 at 18.19 GMT. The graze track makes landfall at Swanage in Dorset and travels roughly north eastwards passing closest to us in the Sevenoaks area. The track continues north of West Kingsdown and across the Isle of Grain reaching the Thames estuary not far from Allhallows.

The prediction software suggests that an aperture of only 50mm is required to see this event. This is the type of group observation that we have taken part in before, and have provided useful information that helps astronomers to determine the precise shape of the Moon.

If you are interested in taking part, please contact Brian using the details at the end of this Newsletter.

Advance warning for 2018

May 9th – Jupiter at opposition
June 28th – Saturn at opposition
July 27th – Mars at perihelic opposition
July 27th – Total lunar eclipse
August 13th - Very favourable Perseid maximum

Brian Mills

SPACEPLACE - NASA

This article is provided by NASA Space Place.
With articles, activities, crafts, games, and lesson plans, NASA Space Place encourages everyone to get excited about science and technology.
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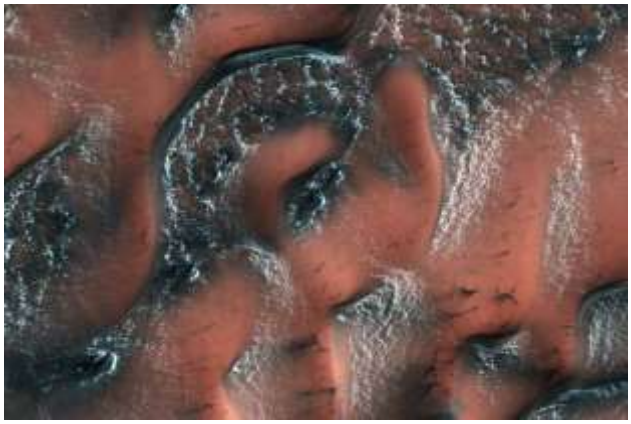
Snowy Worlds Beyond Earth
By Linda Hermans-Killiam

There are many places on Earth where it snows, but did you know it snows on other worlds, too? Here are just a few of the places where you might find snow beyond Earth:

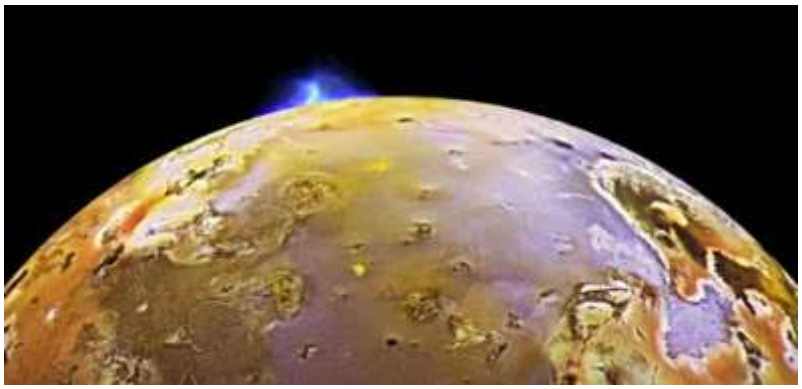
Mars
The north pole and south pole of Mars have ice caps that grow and shrink with the seasons. These ice caps are made mainly of water ice—the same kind of ice you'd find on Earth. However, the snow that falls there is made of carbon dioxide—the same ingredient used to make dry ice here on Earth. Carbon dioxide is in the Martian atmosphere and it freezes and falls to the surface of the planet as snow. In 2017, NASA's Mars Reconnaissance Orbiter took photos of the sand dunes around Mars' north pole. The slopes of these dunes were covered with carbon dioxide snow and ice.



NASA's Mars Reconnaissance Orbiter captured this image of carbon dioxide snow covering dunes on Mars. Credit: NASA/JPL/University of Arizona

A Moon of Jupiter: Io

There are dozens of moons that orbit Jupiter and one of them, called Io, has snowflakes made out of sulphur. In 2001, NASA's Galileo spacecraft detected these sulphur snowflakes just above Io's south pole. The sulphur shoots into space from a volcano on Io's surface. In space, the sulphur quickly freezes to form snowflakes that fall back down to the surface.



A volcano shooting molten sulphur out from the surface of Io. Credit: NASA/JPL-Caltech

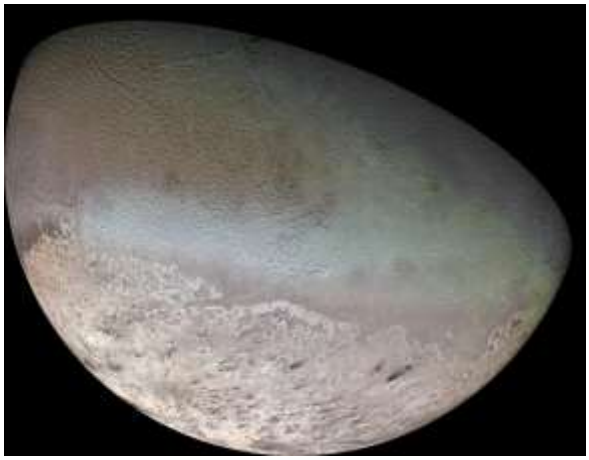
A Moon of Saturn: Enceladus

Saturn's moon, Enceladus, has geysers that shoot water vapour out into space. There it freezes and falls back to the surface as snow. Some of the ice also escapes Enceladus to become part of Saturn's rings. The water vapour comes from a heated ocean which lies beneath the moon's icy surface. (Jupiter's moon Europa is also an icy world with a liquid ocean below the frozen surface.) All of this ice and snow make Enceladus one of the brightest objects in our solar system.

Enceladus as viewed from NASA's Cassini spacecraft. Credit: NASA

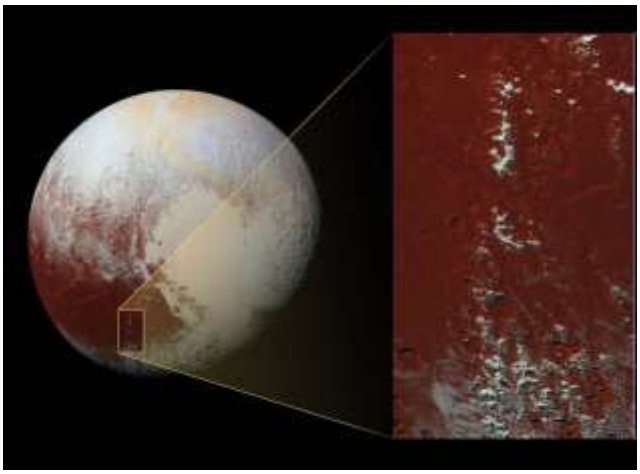
A Moon of Neptune: Triton

Neptune's largest moon is Triton. It has the coldest surface known in our solar system. Triton's atmosphere is made up mainly of nitrogen. This nitrogen freezes onto its surface covering Triton with ice made of frozen nitrogen. Triton also has geysers like Enceladus, though they are smaller and made of nitrogen rather than water.



The Voyager 2 mission captured this image of Triton. The black streaks are created by nitrogen geysers. Credit: NASA/JPL/USGS

Pluto
Farther out in our solar system lies the dwarf planet Pluto. In 2016, scientists on the New Horizons mission discovered a mountain chain on Pluto where the mountains were capped with methane snow and ice.



The snowy Cthulhu (pronounced kuh-THU-lu) mountain range on Pluto.
Credits: NASA/JHUAPL/SwRI

Beyond Our Solar System
There might even be snow far outside our solar system! Kepler-13Ab is a hot, giant planet 1,730 light years from Earth. It's nine times more massive than Jupiter and it orbits very close to its star. The Hubble Space Telescope detected evidence of titanium oxide—the mineral used in sunscreen—in this planet's upper atmosphere. On the cooler side of Kepler-13Ab that faces away from its host star, the planet's strong gravity might cause the titanium oxide to fall down as "snow."

This is an artist's illustration of what Kepler-13Ab might look like. Credit: NASA/ESA/G. Bacon (STScI)

Want to learn more about weather on other planets? Check out NASA Space Place: https://spaceplace.nasa.gov/planet-weather

THE ANSWERS TO JOHN'S QUIZ

1. **Jupiter** is the heaviest planet in the solar system, with a mass of 1.9 x 10^{27}, that is twice as heavy as all the planets in the solar system combined.
2. Jupiter's **Ganymede**, with a diameter of 3,270 miles and is larger than Mercury.
3. They travel at the speed of light, so **8 minutes and 20 seconds**
4. **About 100,000 years**. However since this is a slightly dubious fact, I will accept as correct any substantially long period – say in excess of 1,000 years.
5. **b) 230 million years** in Earth years. A Galactic year is the length of time that it takes our Sun to orbit the galaxy.
6. The Universe as a whole is made up of at least: **a) a billion galaxies**
7. **e) A Supernova**
8. **d) Expand to become a Red Dwarf**
9. **b) Throws dust and gas into space**
10. **a) Join to produce nuclei of heavier element – called fusion**

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