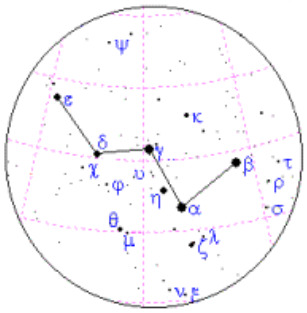


Wadhurst Astronomical Society Newsletter January 2017

A Very Happy New Year to all Members of the Wadhurst Astronomical Society and a warm welcome to our 20th year

MEETINGS

THE DATES OF MEETINGS IN 2017

Meetings will be held at Uplands Community College and all but one will be held in Classrooms IL5/6 in the block at the top of the drive by the tennis courts. On May 17th, the meeting will be held in the Drama Studio on the left just through the entrance gates.

January 18th
February 15th
March 15th
April 19th
May 17th (in the Drama Studio)
June 21st
July 19th
No August meeting
September 20th
October 18th
November 15th
December 13th (this is the second Wednesday of the month)

DECEMBER MEETING

The well attended December meeting was introduced by Phil Berry, the Society Secretary who said he had recently had a meeting with Bob Mizon of the Commission for Dark Skies to talk about Wadhurst being recognised as a Dark Skies Community.

A couple of years ago WAS joined forces with the AONB, Areas of Outstanding Beauty here at Uplands to help make the public aware of the need for dark skies and to avoid light pollution. That meeting was a great success with the Society providing a number of telescopes and the AONB using a mobile planetarium to make people aware of the need.

Phil said that at his meeting it had been suggested that a similar event is held again in the near future.

Next Phil introduced tonight's speaker, our Chairman and Director of Observations, Brian Mills.

Local Astronomers
Brian Mills FRAS

This is another of Brian's well researched talks with a few surprising connections.

Most of us are familiar with Norton's Star Atlas but the author's later years were spent in Tonbridge.

Arthur Philip Norton was born in Cardiff in 1876 and we were told that his father was a church minister, which meant that he spent much of his early life moving from parish to parish but during his childhood, his grandfather gave him a small telescope and this was to give him a lifelong interest in astronomy.

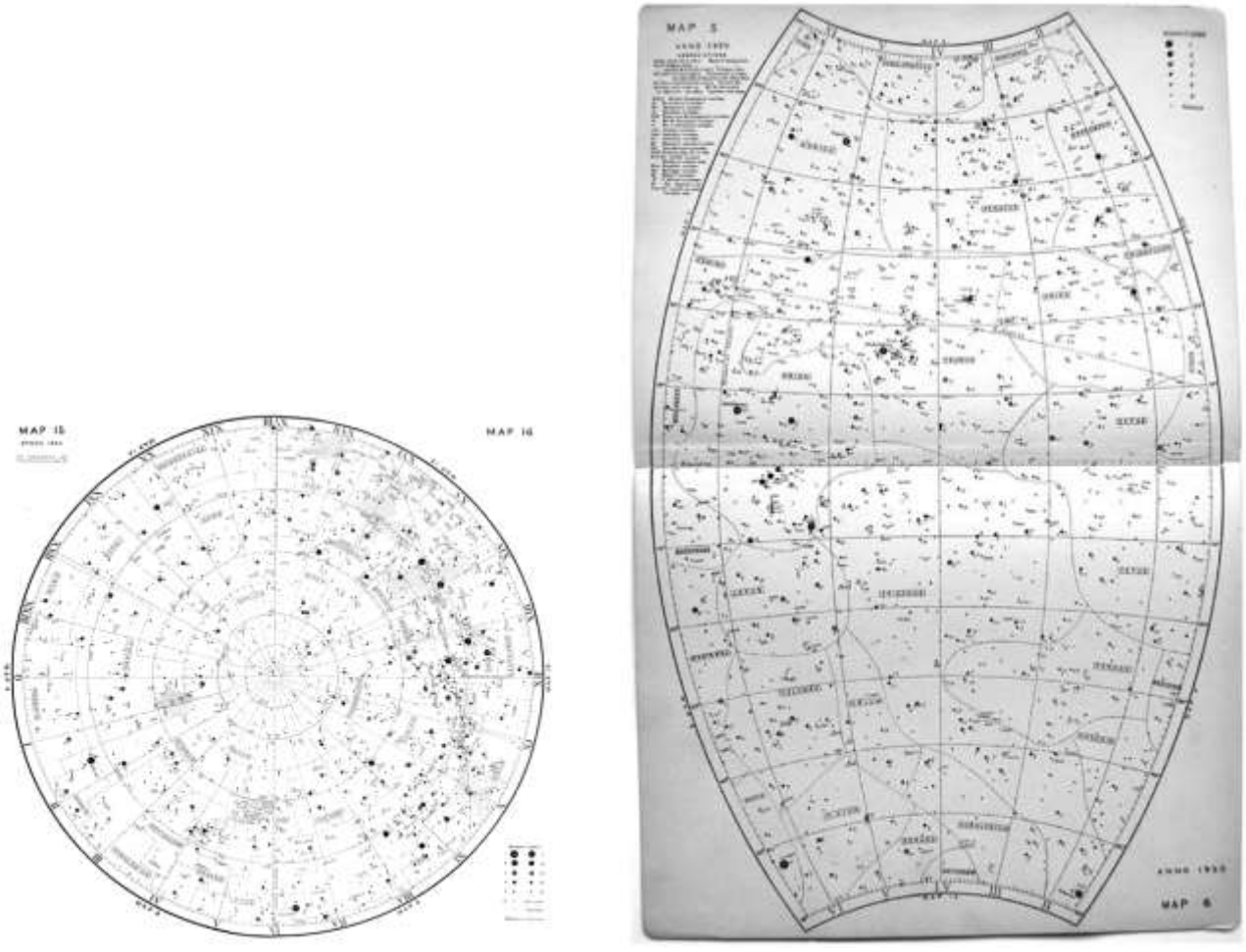
Norton trained as a teacher but at weekends he returned home to his parent's parish which was now in Norfolk. He built himself a workshop in the stables where he ground his own 6½-inch mirror. He also built a number of other telescopes having bought in the optics. One was a 10¼-inch reflector and another was a telescope using a 4½-inch Cooke lens. These instruments he kept for the rest of his life.

Norton taught English, Maths and Latin but at the same time he designed and drew a star projection chart for minimum distortion. This was published in 1910 and called the "Star Atlas and Reference Handbook", intended to be used with "Webb's Celestial Objects for Common Telescopes" and Smyth's "A Cycle of Celestial Objects".

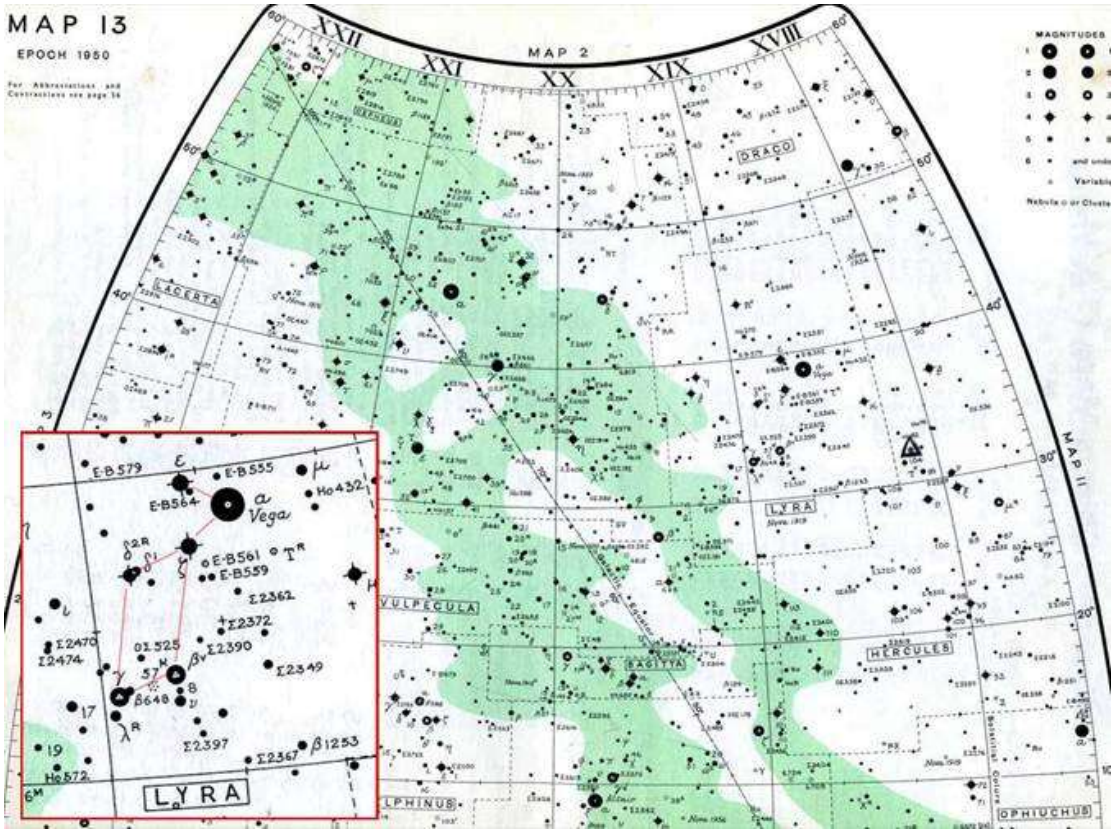
Brian told us that in 1914 Norton moved to Tonbridge to teach at Judd School. Interestingly, the school had no idea that Norton had published his atlas until a member of the British Astronomical Association announced that he had used the atlas to plot the position of a nova in 1918. This brought the atlas to the public's notice.

In 1919 his father retired and Norton had to move his workshop to Tonbridge where he designed and built amongst other things, a regulator clock which kept pretty good time.

In 1920 his eyesight began to fail and he gave up much of his observing but still produced editions of his atlas. He had included constellation boundaries drawn as curved lines but in 1930 the International Astronomical Union redefined the constellation boundaries to run along declination and right-ascension as straight lines and Norton redrew his atlas to include them. At the same time, he included star magnitudes down to 6.2 including half magnitudes. Later in the 9th edition he began to include the Milky Way in green.



Examples of Norton's first projections



An example of Norton's Atlas from the 9th edition showing the straight line-boundaries of the constellations with the Milky Way in green

Norton retired from Judd in 1936 and bought a house at 2 Quarry Rise, Tonbridge, where he spent the rest of his life. He died there in 1955 aged 79 and was buried in Tonbridge Cemetery. He had the distinction of having an asteroid named after him in his honour.

We were told that his Atlas continued to have further editions published and for some time had included many notes often written by other members of the British Astronomical Association of which he was also a member.

Next Brian introduced what he called the Crowborough connection, a fascinating link between two local astronomers.

Charles Leeson Prince was born in Uckfield in 1821 and trained as a surgeon following the family line. He spent much of his time observing and recording the climate of Uckfield although he did have an astronomical observatory built which housed a Tully 7-inch refractor, yet there are no records of his astronomical observations.

He moved to Crowborough around 1872, where, on a piece of high common land he had built a house he called "Observatory House". He continued with his weather observations although Brian said it wasn't certain whether the word "observatory" referred to his weather observations or to his astronomy.

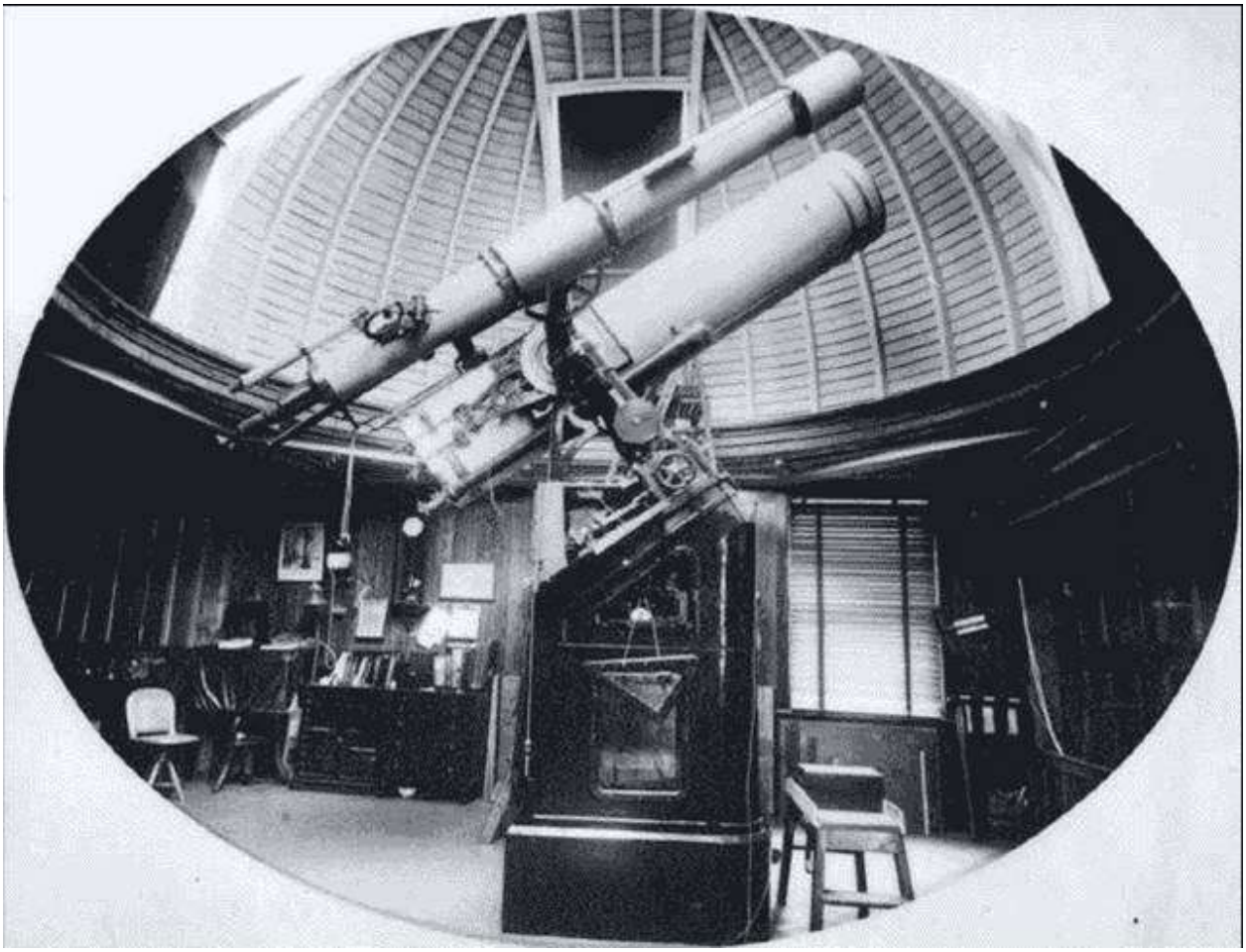
Later this house became re-named "The Grange" and he built a new house called just "The Observatory" on another part of his land.

In 1890, Prince sold 4 acres of this land which contained another building called "Starfield" to Isaac Roberts.

Isaac Roberts was born 1829 in Denbighshire into a farming family. Looking for a better life, he moved to Liverpool in 1836 where he eventually set up his own very successful building business.

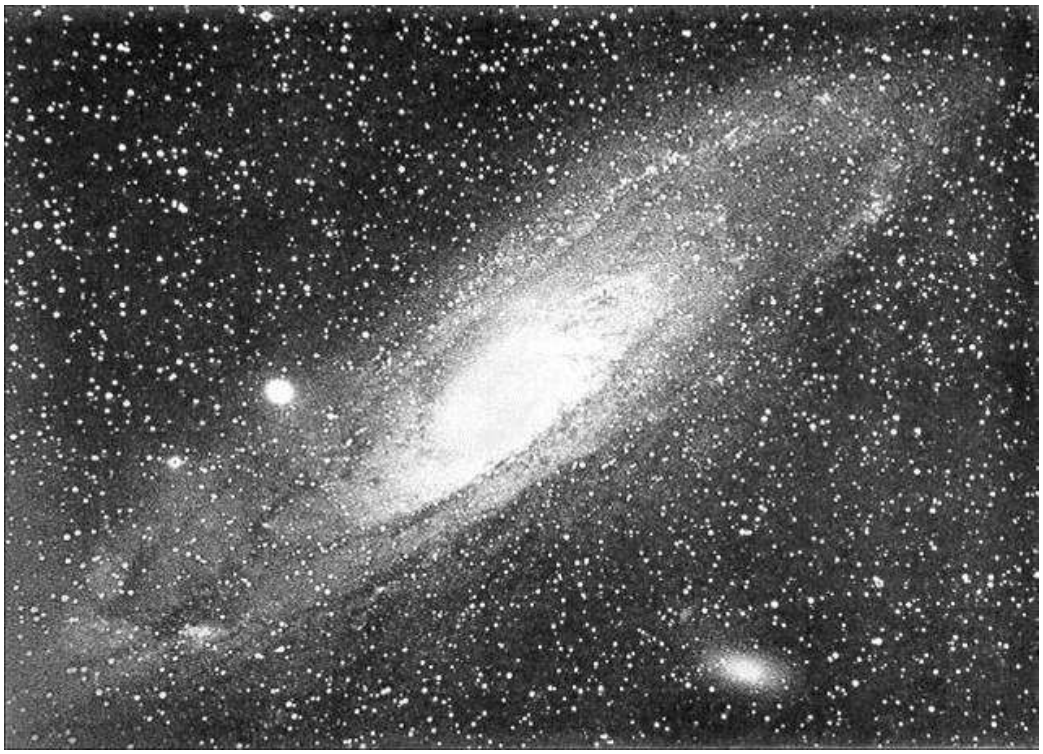
We were told that Roberts became a practical astronomer around 1878 and bought himself a Cooke 7-inch refractor and then his interest turned to photographing stars. He experimented with various lenses to achieve the best results.

One of the earliest astro-photographers was a man called Andrew Common who showed that there were more than just stars in the night sky. Common's images influenced Roberts so much that he bought an 18-inch reflector. After a short time, he replaced this with a 20-inch reflector with a stipulated focal length of 100 inches from Grubb but Brian said there must have been something wrong with the mirror because Roberts later had a new 20-inch mirror ground by Calver in 1888. The telescope had no secondary lens and was intended purely for photographing onto glass plates.



This shows Roberts setup. William Huggins had devised the attachment that allowed both his 20-inch and 7-inch scopes to be counterbalanced on the declination shaft.

By now, the Royal Astronomical Society was made aware that Roberts had taken over 200 images. His favourite was of M31 the Great Andromeda Galaxy taken in 1888 and we were told that it took something like 4 hours of exposure.



This remarkable picture of M31 was Robert's favourite and was actually taken in 1888

By 1888 Roberts retired and devoted more of his time to astronomy but he was now looking for a better site and in 1890, moved to Starfield on Crowborough Hill and built his observatory, saying it was the ideal location having brought tons of instruments and equipment from just north of Liverpool.

In 1901, Brian told us that Roberts married Dorothea Klumpke, a well know female astronomer which was unusual for the time and who had been the Director of the Bureau of Measurement at the Paris Observatory. Because of her work she was already familiar with Roberts' photographs.

Dorothea was a great help to Roberts, photographing nebulosity in particular.

Another person that helped was William Sadler Franks who acted as Roberts practical photographer, and they worked together.

Franks had always been interested in astronomy and had a particular interest in the colour of stars well before spectroscopy, and became the first Director of the BAA's Colour Star Section.

He came to live in East Grinstead in 1910 and one task he undertook was to show visitors interesting objects through the telescope of a local private observatory at Brockhurst.

One young man he took around was a fourteen-year-old Patrick Moore who lived close by, yet another local astronomer. Following Franks' death, the owner of the observatory asked Patrick to be the observer.

Sadly, Roberts died in 1904 and Brian told us that Dorothea and Franks, before his death, continued and completed photographing the 52 areas Roberts had set himself to photograph. Following the completion, Dorothea left Starfield and went to live in France still working on the images which were eventually published in a book in 1929.

Brian finished his well-researched talk by telling us that Roberts' instruments were eventually passed to the Science Museum in London where they are mounted in the observatory in the roof of the museum although sadly there is now no public access.

In 1995 the observatory was demolished to make way for 14 houses but the road still retains the name, Starfield.

Piers Sellers

Sadly, it was announced a few days ago that Piers Sellers, a veteran of three Shuttle Missions died on the 23rd of December from cancer at the age of 61. It is particularly sad since he was born in Crowborough and following Brian's talk it seems appropriate to reflect on his life and work.

Piers gained an honours degree in ecological science at Edinburgh University, receiving his doctorate in biometeorology in 1981 from Leeds University.

He was selected as an astronaut candidate in 1996 and worked for a time in Moscow as technical liaison on international space station computer software.

In 2002 Piers had his first space flight on Space Shuttle Atlantis where he performed EVAs installing truss segments with the space station's Expedition 5 crew.

His final flight was also aboard Atlantis where he served as robotics officer.

He subsequently oversaw scientists researching climate and weather at Goddard Space Centre.

Following Brian's talk there was a break for tea and coffee. There was also Stollen provided by Jan Drozd and his wife Gabby and mince pies made by Gill Rathbone, Geoff's wife.

2016 CHRISTMAS QUIZ

For our December meeting, John Wayte devised an entertaining quiz to challenge our knowledge of astronomy and not to be taken too seriously. He said that there are four suggested answers but one answer would be correct, although in a few cases there might be two correct answers.

The answers are at the end of the newsletter

1. What is the central object of the Milky Way?

A) A Black Hole
B) A Neutron Star
C) Vacuum
D) A Large Magellanic Cloud

2. The Magellanic Clouds are visible from ……?

A) Northern hemisphere
B) Southern hemisphere
C) Both Northern and southern hemisphere
D) Neither Northern nor Southern hemisphere

3. The “Planetoids” are located between which of the following?

A) Mar and Jupiter
B) Saturn and Jupiter
C) Mercury and Venus
D) Earth and Mars

4. From the following, which of these planets shows phases?

A) Earth
B) Venus
C) Jupiter
D) Saturn

5. Which among the following is the Brightest Star?

A) Sirius
B) Alpha Centauri
C) Proxima Centauri
D) Polaris

6. Which among the following two gases contribute to begin the formation of stars?

A) Hydrogen and Nitrogen
B) Nitrogen and Helium
C) Helium and Hydrogen
D) Hydrogen and Oxygen

7. Apart from Saturn, which of the following planets possess ring systems of their own?

A) Jupiter only
B) Jupiter, Uranus and Neptune
C) Jupiter and Uranus
D) Jupiter and Neptune

8. Aurorae are produced by the collision of charged particles from Earth’s magnetosphere which arise due to….?

A) Solar winds
B) Ozone layer
C) Radio waves
D) Ionosphere

9. What name is given to the places around and between two gravitationally bound bodies where a third object could stay stationary relative to the other two?

A) Languid position
B) Ephemeris location
C) Lagrangian point
D) Apside

10. A cataclysmic nuclear explosion caused by the accretion of hydrogen onto the surface of a white dwarf star, would be termed as ….?

A) Nova
B) Nebula
C) Neutron star
D) Pulsar

11. The positions of the star Polaris, which lies approximately at the north pole axis of the earth changes slowly due to which among the following movements of Earth?

A) Rotation
B) Axial precession
C) Orbital revolution
D) Plate tectonics

12. Which among the following is the major cause of nutation in Earth's axis?

A) Earth's oblate spheroid shape
B) The difference between land and sea hemispheres
C) Oceanic currents
D) Tidal forces

13. In a black hole ……? Which is the correct statement?

A) All wavelengths of light are absorbed
B) All wavelengths of light are absorbed except green and blue
C) All wavelengths of light are absorbed except blue and red
D) All wavelengths of light are absorbed except red and green

14. Which among the following is NOT a true statement regarding White Dwarfs

A) They are the final evolutionary stage of stars with very high density
B) They reflect light and are not very dense
C) The light emitted by White Dwarfs is due to their heat and they are very dense
D) All are correct statements

15. What is the approximate diameter of the Milky Way

A) 1,000 light years
B) 10,000 light years
C) 100,000 light years
D) 1,000,000 Light years

This was followed by Brian's Sky Notes, presented by Phil Berry and which follow later in the Newsletter.

JANUARY MEETING

18th January 2017 – A short AGM will be followed by three short talks on astronomical subjects.

Meetings will take place in classrooms IL5 and 6 which are in the blue walled classroom block at the far end of the drive from the main gate of Uplands College and up by the tennis courts. Signs will direct you. There is car parking near the block. The postcode is TN5 6AZ.

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

15th February – Dr David Mannion gives another of his entertaining talks, this time he calls it "ET, Are You Out There?"

15th March – Professor Louise Harra brings us the latest news of "Solar Activity".

19th April - TBC

SKY NOTES FOR January 2017

Planets

Mercury is a morning object reaching greatest western elongation on January 19th when, in angular terms, it will appear to be 24° from the Sun. On that morning, at 07.15, it will be visible in the south east just 6° above the horizon whilst the Sun is 6° below it. This is the end of nautical twilight and the beginning of civil twilight. The situation is shown in Fig 1. The planet then moves back into the solar glare as it heads towards a superior conjunction in early March.

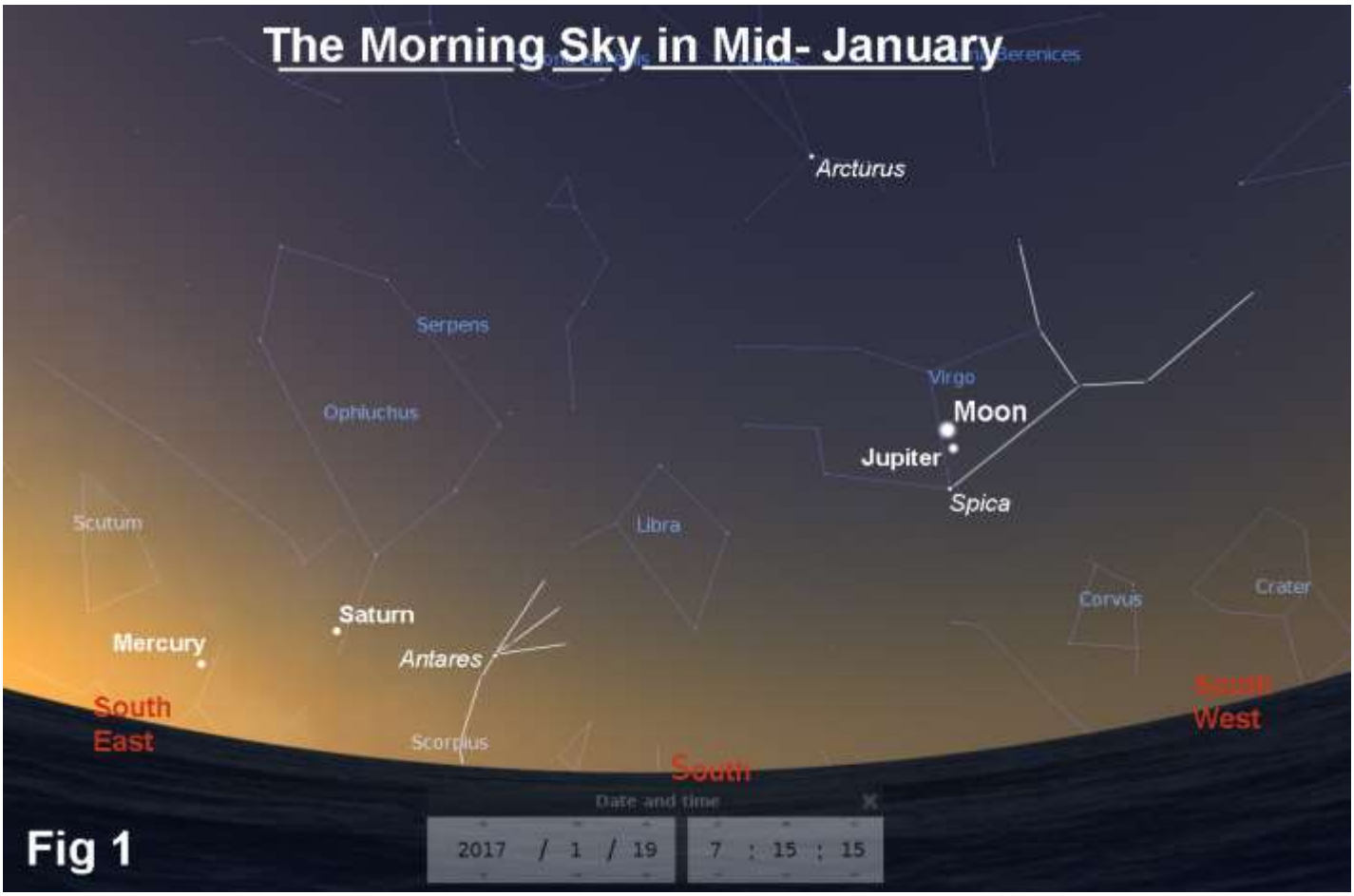


Fig 1

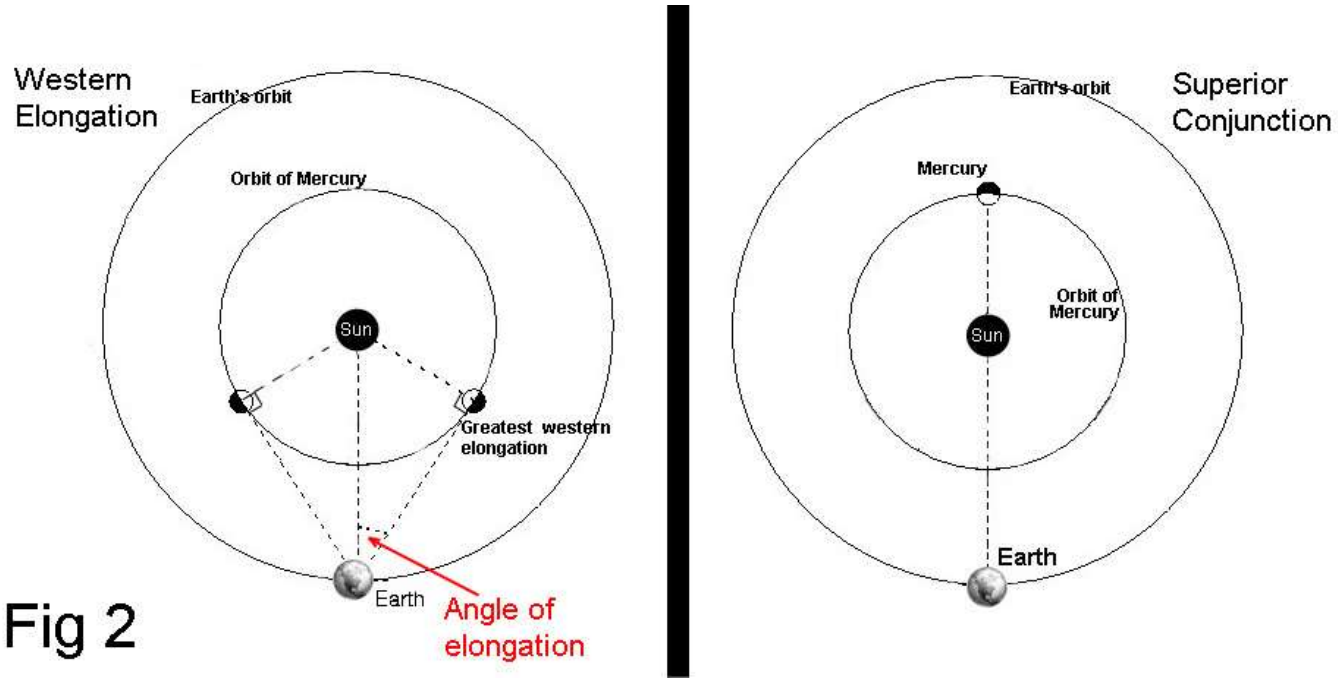


Fig 2

Fig 2 shows Mercury at both greatest western elongation and at superior conjunction. At greatest elongation it has reached a point west of the Sun where it *appears* to be as far away as it can possibly get. You can see that a line from the Earth to Mercury strikes its orbit at a tangent forming a right angle with its radius. At no other point can Mercury's angle of elongation be greater. However, the angle does vary with successive elongations because the orbit of Mercury is the most eccentric of any of the planets. As a result of this the angle at greatest elongation can vary between 18° and 28°.

Venus is a brilliant evening object in the south west at magnitude -4.5 and visible for more than four hours after sunset at the beginning of the month. It reaches greatest eastern elongation on January 12th (see fig 3) when it will be 47° from the Sun. This degree of elongation will normally allow it to be seen in a properly dark sky, Moon permitting. On the night of elongation Venus passes less than 30 arc minutes from the much fainter Neptune that will be magnitude +7.8. It should be easy to see in binoculars although Venus will tend to swamp the much fainter "ice giant".

Earth reaches perihelion (closest point to the Sun) on January 4th when its distance will be a little over 147 million km.

Mars remains an evening object although its brightness and apparent size both continue to dwindle. It begins the month in Aquarius where it is in conjunction with Neptune on the first at 07.00 hours. By the time darkness falls the two are still close, at 20 arc seconds, but are moving apart. The red planet continues its eastward motion and crosses the border into Pisces on the 19th. Fig 3 shows the position of Mars around the middle of January.

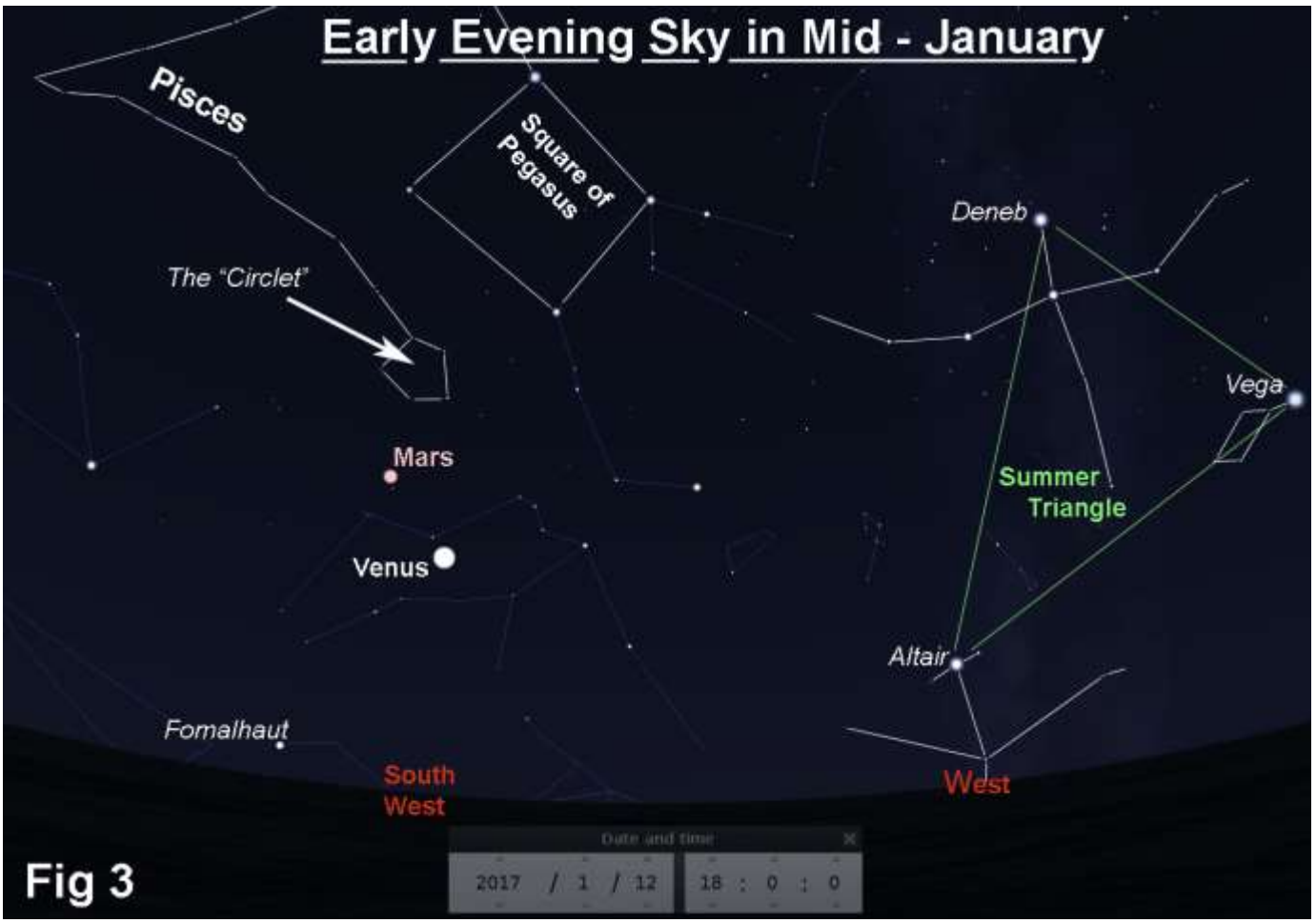
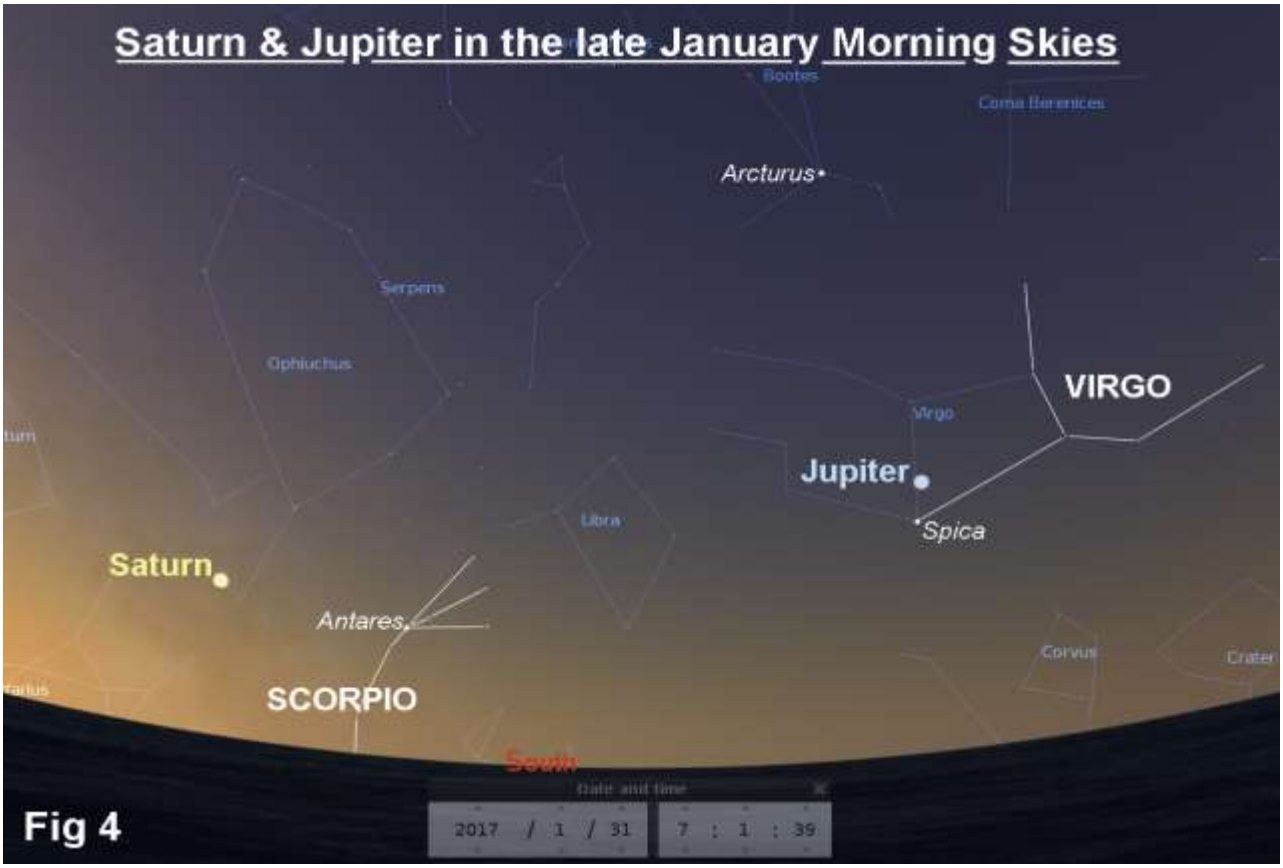


Fig 3

Jupiter is a brilliant morning object (magnitude -2.0) rising just after 01.00 at the start of the year although by the end of January it is technically an evening object as it rises a little before 23.30. Its position close to the bright star Spica is shown in fig 1. The gas giant's brightness is increasing gradually as it approaches opposition in early April, and its apparent size follows suit rising from 35 to 39 arc seconds this month.

Saturn was in conjunction with the Sun in early December, so it is just starting to emerge into the morning skies. In the first two weeks it is too close to the solar glare but as the days pass it becomes easier to find in the twilight. On the last day of the month it rises 2½ hours ahead of the Sun and will be 13° high in the south-south-east when the Sun is 6° below the horizon. Sadly, the ringed planet will not be well placed this year, even at opposition in June. It suffers from negative declination all year round and lies around 21 to 22 degrees below the celestial equator. At opposition it will only be 17° above the horizon making it an unsteady object for visual observers and imagers alike. Saturn's magnitude remains steady at +0.5 throughout January although its apparent diameter is increasing very slowly. It currently lies in the southern part of Ophiuchus close to Sagittarius, whose border it will cross in late February. Fig 4 gives its position for the 31st of January. The north pole of the planet is tilted towards us at a little over 28° which means we continue to be treated to excellent views of the upper surface of the rings.



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 whilst RB = **r**eappearance at the **b**right limb. The column headed "mm" (millimetres) shows the minimum aperture telescope required for each event. **Times are in GMT.**

Jan	Time	Star	Mag	Ph	Alt °	% illum.	mm
1st	17.04	ZC 3149	6.9	DD	18	11	50
1st	17.13	ZC 3152	6.6	DD	17	11	40
4th	18.38	ZC 12	6.4	DD	33	38	40
4th	18.55	ZC 13	6.2	DD	32	38	40
5th	17.02	ZC 128	7.0	DD	39	49	60
9th	22.53	ZC 741	5.5	DD	53	91	50
10th	17.00	ZC 878	5.5	DD	19	96	60

Phases of the Moon for January

First ¼	Full	Last ¼	New
5th	12th	19th	28th

ISS

Below are details for passes of the International Space Station (ISS) including several in the morning for those who rise early. The details of all 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.
3rd	07.22	-3.3	84	SSE		30th	18.11	-1.4	16	SE
5th	07.14	-3.4	81	N		31st	18.54	-2.4	38	S
7th	07.06	-3.4	79	N						

Iridium Flares

The flares that I've listed are magnitude -1.5 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	16.53	-1.7	69	64 (ENE)		20th	17.23	-3.5	65	50 (NE)
10th	18.15	-8.0	49	35 (NE)		24th	19.01	-3.0	38	25 (NNE)
11th	18.09	-8.0	51	37 (NE)		26th	18.51	-2.4	40	27 (NNE)
18th	17.35	-1.5	64	43 (NE)		27th	18.45	-3.6	43	27 (NNE)
19th	17.29	-6.7	63	47 (NE)		28th	16.43	-6.3	76	75 (ENE)

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

In the north the brilliant Vega, the brightest member of the Summer Triangle, is skimming the horizon whilst the faintest partner in that group, Deneb, is still 15° high. The tail of the Great Bear points downwards as the constellation climbs on the eastern side of the meridian. Directly opposite it lies the much less conspicuous shape of Cepheus, and between the two, the Little Bear hangs by its tail from the Pole Star. Immediately above the celestial pole is the faint constellation of Camelopardus which, despite being the eighteenth largest by area in the sky, contains no stars brighter than fourth magnitude.

As we look east we find that Leo and the head of Hydra have risen. Immediately above the water snake's head lie the faint and indistinct stars of Cancer. Of course Cancer contains one of the best known open clusters, the Beehive or Praesepe designated M44 by Messier when he compiled his catalogue of fuzzy objects to avoid when searching for comets. When Galileo observed the cluster he noted forty stars with his new telescope, though today we know of at least one thousand group members. The cluster is 95 arc seconds across meaning it is three times the size of the full Moon, although it is quite diffuse. The other open cluster in the Crab is M67, considerably fainter than the Beehive being only magnitude 6.9, which places it a little below naked eye visibility. If you have good eyesight, why not look for the constellation of Lynx that at this time of year presents itself as a nearly vertical line of faint stars above Leo and between Ursa Major and Gemini.

The south is dominated by the brilliant display of winter constellations that are in such contrast to the previous incumbents of the meridian, namely Eridanus and Cetus. Orion is straddling the meridian whilst above him Aldebaren, the eye of the bull in mythology, has passed it. One of the most photogenic of objects is M42, the Great Orion Nebula, within which we find the four stars that make up the well know "Trapezium". Above them both lies Auriga with the brilliant Capella just seven degrees from the zenith.

Turning to the west we see that the western extensions of Pegasus are on the horizon although Andromeda points towards the zenith and M31 is still some 40° in altitude. At magnitude 3.4 it is a naked eye object but photography really brings out the best in it. It is an excellent target for the DSLR user who takes numerous exposures and then stacks them. You will also be able to record two of M31's satellite galaxies - M32 and M110. Also in Andromeda at magnitude 5.7 is a large open cluster NGC 752 which has around sixty members.

Not too far from the Andromeda spiral lies M33, known as the Triangulum or Pinwheel galaxy, which is a spiral that is face on to Earth but much more difficult to detect due to its low surface brightness.

Meteors

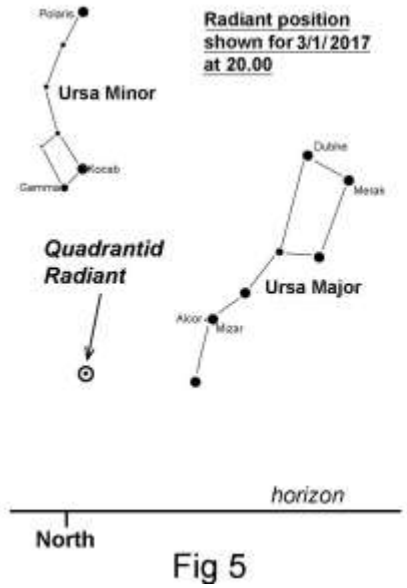


Fig 5

The Quadrantid meteor shower is active from January 1st to the 6th with maximum (which can last just a few hours) occurring on the 3rd at 15.00 hrs. The radiant, the point that meteors appear from, is now located in the constellation of Boötes, although before the constellation boundaries were rationalised by the IAU in 1922 the radiant was in the now defunct Quadrans Muralis. Hence the name of the shower. The zenithal hourly rate (ZHR) is predicted to be in excess of 80 meteors per hour although this assumes perfect conditions with the radiant at the zenith. The good news is that a 28% waxing Moon will set at 22.00, so will be out of the way for the rest of the night. Fig 5 shows the radiant's position.

Advance warning for 2017

February 11th – Penumbral eclipse of the Moon.
April 1st – Mercury at greatest eastern elongation (evening).
April 28th – Daylight occultation of Aldebaran.
June 3rd – Venus at greatest western elongation (morning).
July 25th – Daylight occultation of Mercury by the Moon.
August 7th – Partial lunar eclipse (Moon rises during eclipse).

August 16th – Daylight occultation of Aldebaran.
August 21st – Total solar eclipse, "The Great American Eclipse". There are certain to be numerous live feeds available on the internet.
September 12th – Mercury at greatest western elongation (morning).
November 6th – Early morning occultation of Aldebaran.
December 14th – Geminid meteor maximum.
December 31st – Early morning occultation of Aldebaran.

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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Big Science in Small Packages
By Marcus Woo

About 250 miles overhead, a satellite the size of a loaf of bread flies in orbit. It's one of hundreds of so-called CubeSats—spacecraft that come in relatively inexpensive and compact packages—that have launched over the years. So far, most CubeSats have been commercial satellites, student projects, or technology demonstrations. But this one, dubbed MinXSS ("minks") is NASA's first CubeSat with a bona fide science mission.

Launched in December 2015, MinXSS has been observing the sun in X-rays with unprecedented detail. Its goal is to better understand the physics behind phenomena like solar flares – eruptions on the sun that produce dramatic bursts of energy and radiation.

Much of the newly-released radiation from solar flares is concentrated in X-rays, and, in particular, the lower energy range called soft X-rays. But other spacecraft don't have the capability to measure this part of the sun's spectrum at high resolution—which is where MinXSS, short for Miniature Solar X-ray Spectrometer, comes in.

Using MinXSS to monitor how the soft X-ray spectrum changes over time, scientists can track changes in the composition in the sun's corona, the hot outermost layer of the sun. While the sun's visible surface, the photosphere, is about 6000 Kelvin (10,000 degrees Fahrenheit), areas of the corona reach tens of millions of degrees during a solar flare. But even without a flare, the corona smolders at a million degrees—and no one knows why.

One possibility is that many small nanoflares constantly heat the corona. Or, the heat may come from certain kinds of waves that propagate through the solar plasma. By looking at how the corona's composition changes, researchers can determine which mechanism is more important, says Tom Woods, a solar scientist at the University of Colorado at Boulder and principal investigator of MinXSS: "It's helping address this very long-term problem that's been around for 50 years: how is the corona heated to be so hot."

The $1 million original mission has been gathering observations since June.

The satellite will likely burn up in Earth's atmosphere in March. But the researchers have built a second one slated for launch in 2017. MinXSS-2 will watch long-term solar activity—related to the sun's 11-year sunspot cycle—and how variability in the soft X-ray spectrum affects space weather, which can be a hazard for satellites. So the little-mission-that-could will continue—this time, flying at a higher, polar orbit for about five years.

If you'd like to teach kids about where the sun's energy comes from, please visit the NASA Space Place: http://spaceplace.nasa.gov/sun-heat/

Astronaut Tim Peake on board the International Space Station captured this image of a CubeSat deployment on May 16, 2016. The bottom-most CubeSat is the NASA-funded MinXSS CubeSat, which observes soft X-rays from the sun—such X-rays can disturb the ionosphere and thereby hamper radio and GPS signals. (The second CubeSat is CADRE — short for CubeSat investigating Atmospheric Density Response to Extreme driving - built by the University of Michigan and funded by the National Science Foundation.) Credit: ESA/NASA

Answers to the Christmas quiz

1. A) A Black Hole
2. C) Both the northern and southern hemispheres
3. A) Mars and Jupiter
4. B) Venus
5. A) Sirius
6. C) Hydrogen and Helium
7. B) Jupiter, Uranus and Neptune
8. A) Solar winds
9. C) Lagrangian points
10. A) Nova
11. B) Axial precession
12. D) Tidal forces
13. A) All wavelengths of light are absorbed
14. B) They reflect light and are not very dense
    and
    D) All are correct statements
15. C) 100,000 lights years

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