



# NEWSLETTER

September - November 2015    Issue 172



*M31: 'The Andromeda Galaxy' taken by Grahame Carter*

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## **Contents**

	<b><u>Page</u></b>
Editorial	2
Message from the Secretary	3
Behind the scenes	4 - 7
The Night Sky - Sept. - Nov.	7 - 11
Spaceflight roundup	12-14
A Bombs: Why should astronomers care?	15-17

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## **Contents**

	<b><u>Page</u></b>
From New Hope to New Horizons	18-24
The Joan Thomas Library	24
Correction	24
Upcoming Events	25
Almanac	26-29
Junior Pages	30-32

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# Editorial

John Richards

The first newsletter of a new session, and what an exciting year it will be. The Committee have been very busy during the Summer. First thing to say is that we have a new web site. The address hasn't changed (see below), but the content and the layout have been completely revamped for our 40<sup>th</sup> year. Many thanks to Alan Stephens and other members of the Committee for their sterling efforts during the 'Summer' months. Most of the 'old favourites' are still there and hopefully over the next few months, a number of 'new favourites' will begin. Why not take a look, I think you'll be pleasantly surprised. Also, if you have a suggestion for the new site, why not contact a member of the Committee.

In this edition of the newsletter we have an article by our new Vice Chairman, Phil Wallace, on the similarities between nuclear weapons, and the processes that go on within our nearest star. We also have an article covering some highlights of spaceflight since the dawn of the Society. Added to this are the prelude of the night sky over the next quarter, a junior article by Phil Wallace (he's been busy over the Summer too!), and all the usual almanac data, now that the evenings are starting to lengthen.

Wishing you dark skies - John

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## Contact Details

Have you changed your email address or other contact details recently? If so, you could be missing out on receiving important society information. Please keep us up to date with any changes. Send your revised details to either our Membership Secretary ([membership.secretary@cardiff-astronomical-society.co.uk](mailto:membership.secretary@cardiff-astronomical-society.co.uk)) or Secretary ([secretary@cardiff-astronomical-society.co.uk](mailto:secretary@cardiff-astronomical-society.co.uk)).

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## Publication Dates

The CAS newsletter is published at the first society meeting of September, December, March & June. The deadline for submissions is 4 weeks before the publication date, and is 7<sup>th</sup> November for issue 173.

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## Visit CAS on the web @

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# **A message from the Secretary**

Well here we are, its official. 40 years old, it seems incredible now but way back in 1975 hardly anyone gave us a chance of lasting a year.

We were fortunate to meet at the Penylan Observatory but soon realised our future lay elsewhere.

The observatory was by then in a really poor state of repair, broken windows, and vandalised rooms were the norm. Speakers entertained us without taking off their thick overcoats, but this never looked out of place because the audience also dressed accordingly.

We quickly learnt the type of society we wanted, and just as important, what we did not want. This caused a myriad problems with the old guard but we got there in the end. Along the way, there have been many highs and lows, but this is normal in any society and I guess this is how we will continue.

One way we kept our heads above water in the early years was to hold Jumble Sales. Three times a year we would make use of a church hall in Splott and spend a morning selling whatever members had donated. It was fun, on average we made £60/£80 for three hours work. Whatever we had left we dropped off at the nearest charity shop.

How long can we continue? Well that's up to you. 40 years is a milestone, but 100 years would really be something. Can it be done? Without doubt, I will not see it, but I still retain the energy and enthusiasm from 1975 and I am not alone. As a group we will keep going forward and doing what we always set out to do, help anyone/everyone who has an interest in astronomy to get more out of the subject. There will always be a place in the society for beginners and whatever level of knowledge they have.

The Committee will always do their best to keep subscriptions down and you can help by renewing yours on time. The majority are due in September and October.

I do hope you enjoy the new programme for 2015/16.

**Dave Powell**

## Behind the scenes

## Dave Powell

The **May star party** went well. The sky was cloudless but the atmosphere very turbulent. This meant we could only view the planets, but this was ok as most of the people who turned up had never viewed Mercury through a telescope. We had lots of hand clapping before turning to Venus. As you know it's always difficult to see any discernable detail, but at least we had a good try. Then onto the evening's star attraction: Jupiter and its four bright moons. More detail here than you could shake a stick at. I leave others to explain how good it was: "Wow", "Crikey" and "Blimey" were just some of the remarks, and from one young lady "That was so cool". From my point of view it was nice that people were not interested so much in the size or power of the telescope but what it actually showed them. I went home tired, freezing cold but a happy bunny. Flushed with success, Bob and I had a chat and decided, that in the middle of what may well turn out to be the wettest, coldest May on record, to hold another party one week later.

So on Tuesday 19<sup>th</sup> we met at Dyffryn, and once again the sky was clear. Venus and Jupiter were again the "star" attractions, and we helped out beginners about to purchase telescopes of their own and allowed others to practise using the observatory telescope. One member, managed to attach his camera and take some pictures.

Work continues on our meeting room and I hope we will be back in, very soon. We had to move out our library and for the time being it is in store. We now have a new Librarian, Peter Crabbe(see page 24), and he is working on ways to continue to offer the service if we are not allowed to bring back the library case.

The **June star party** was successful. Yes the sky was very light, but the planet Saturn was everyone's favourite, well until we looked at planet Jupiter and noticed the "great red spot" was clearly visible.

The **British Astronomical Association** exhibition was held in St David's Hall on Saturday 27<sup>th</sup> June. Theresa and I got display boards out the day before and labelled everything ready for Saturday. On the morning the "A" team arrived early at 7am. Needless to say I am not a member of the "A" team. When I arrived

the four tables were already groaning under the weight of our merchandise, laptops, computers and things that glowed when you touched them, so Theresa and I set about putting up the boards. 20 seconds into this operation we decided we needed better, modern, easier to put up boards, but after what seemed like several hours we managed to get them up. The BAA had taken over two levels and their stands were on one level with the Welsh societies taking up the other. I then managed to get out of further manual labour by meeting and greeting all our friends from the other societies, as well as being on my best behaviour to meet all the bigwigs from the BAA.

During the day each Section Director went on stage and gave a 15 minute talk on what they did. One chap in particular, Steve Harvey, head of the computer section reminded me he was born in Cardiff, and was once a junior member of our Society until his parents moved to Sussex. So another claim to fame for CAS is that we've produced top Section Directors for a premier national astronomical organisation!. Then the final talk was given by Professor Haley Gomez of Cardiff University, on "Dark Matter".

During the day the BAA produced cakes and tea/coffee to keep everyone going. They liked the venue, and were pleased with the number of visitors through the door. Apparently it exceeded Manchester, the previous venue .

Then we had to take everything down, well except for the boards that fell down by themselves. We had a big team out and everyone was kept busy. Special thanks to Bob Love for transporting everything in his van (Tardis), Theresa for oiling the wheels and organising the team and of course, the team themselves. You know who you are and you have our grateful thanks. I rather think the BAA were pleased with us.

**Brecon Solar Viewing day Saturday July 25th**, went rather well. Theresa was away and so it was left to us lesser mortals to make sure we continued with the high class service people have come to expect from CAS. Once we arrived a quick overview showed a glowering, dark sky overhead and temperatures at least 10 degrees below average for this time of year. But were we downhearted? Well I was, and suggested we all went home and not tell Theresa.

The team on the other hand are made of sterner stuff (and perhaps a little scared of Theresa) so we stayed. They gave me the unenviable job of setting up the boards but I had an ally in Spencer who kicked, jabbed, pushed, and pulled everything into place while I held the bits together, and very smart they looked too. Now all that was left to do was tip-toe away before the whole thing fell down.

By the time we opened, the sky was still sullen, rather like me when told we can't go home, but I decided we should all do some training and I played the part of an '*interested member of the public*' and approached our trade stand of goodies. However, Jim advised me to "shove off and stop messing about". At 12 O'clock the Sun came out and for the next four hours we were all kept busy showing off telescopes, talking about the society, and selling stuff to an enthusiastic public with a real international flavour. I alone spoke to families from all over the U.K. ,Germany, Czechoslovakia, Australia and India.

There were other highlights. First we watched a tractor driver who appeared to be lost in a small field and was unable to find the gate. I had endless pleasure watching this, as well as the 20 or so people hiking up the mountain, only to find on reaching the summit there was no bus to take them back down. The real day's highlight though was the flight of a Red Kite over our field, "majestic, stunning, awe inspiring, graceful, beautiful," were just some words I heard to describe the Red Kite, though they may have been talking about me! Then it was time to pack everything away, pick up the boards that had long since fallen down, slap each other on the back, say fond farewells, and agree we should all do it again sometime, and change nothing, except perhaps for the boards.

The **August star party** went well. I must confess the sky did not look that good for watching Perseid meteors. We had quite a lot of people attending and I was hoping the clouds would melt away. Things though did improve gradually, First was a sighting of the International Space Station going almost overhead. After waving at those on board, various people began to notice the brighter stars shining through the ever thinning clouds. I was now able to do sky talks with the aid of my trusty laser pointer and keep everyone interested. Then someone shouted "meteor" and by the time the

clouds returned, everyone had seen at least a few. We also trained the observatory scope on Saturn, and considering how low the planet was had quite good views.

We loaned telescopes, showed a lovely couple how to use their recently purchased scope, and the following morning I received a nice email thanking the team for making them so welcome.

We gained a new member, and then once again greeted the Space Station as it went over our heads. This time to make the astronauts feel at home we all held up a cabbage.

**Dave Powell**

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## **The Sky September to November 2015**

**Robert Lang**

### **The planets**

In September, **Mercury** will be an evening object, (Magnitude 0.1 on the 1st), but will be quite difficult to see for northern observers. Inferior conjunction occurs on the 30<sup>th</sup>. The second week of October (7<sup>th</sup>) finds Mercury well placed in morning sky (magnitude +0.3 with an apparent diameter 10.2"), the planet reaching greatest elongation, (West 18 degrees) around the middle of the month (16<sup>th</sup>). From there on Mercury will be moving closer to the Sun as seen from Earth, becoming ever more difficult to find, and only putting a brief appearance for the first few days of November at visual magnitude -1.0 with an apparent size of 5.1". Mercury then reaches superior conjunction on the 17<sup>th</sup> of November with Aphelion occurring on the 25<sup>th</sup> and will reappear in December's dark evening sky.

By September 21st **Venus** will again be shining bright at mag -4.8 in the dawn sky. It's the brightest the planet will get this year and continues shining brightly in the dawn sky at visual magnitude -4.7 with an apparent globe size of 33" throughout October. The planet reaching greatest western elongation (W 46 degrees) on the 26<sup>th</sup> of the month. Also on the same day, Venus will be no more than two moon diameters away from Jupiter (about 1 degree separation)

The planet continues to shine brightly in the dawn sky during November and on the 3<sup>rd</sup> of this month will again be in conjunction with the planet Mars (Third time this year!) Venus then reaches perihelion on the 29<sup>th</sup> of the month.

In early September **Mars** moves eastward through Cancer and into Leo and will be in conjunction with the star Regulus on the 24<sup>th</sup> September (Mars mag +1.8). At the start of October, Mars is poorly placed been found low in the eastern dawn sky at visual magnitude +1.8 with an apparent globe diameter of 3.9" , but is slowly climbing into a darker sky as the month progresses. Mars will be only 0.4 degrees north of Jupiter on the 17<sup>th</sup> of October. By November Mars will be rising at around 03:00 the planet been at aphelion on the 20th of that month.

By the middle of September, **Jupiter** (At magnitude -1.7, apparent diameter 30.9 seconds of arc) re-appears low in the early morning twilight sky, amongst the constellation of Leo, and will continue to move through this constellation into darker skies as the month progresses. The planet will then be in conjunction with Mars on the 17<sup>th</sup> of October and then again with Venus on the 26<sup>th</sup> October. These three planets will be loosely grouped for several weeks. By November Jupiter will have slightly increased in brightness and size (Visual magnitude -1.8 apparent size 33".) but still rising well after midnight.

By September **Saturn** will be setting low in the south west around mid-evening. (Magnitude 0.6, apparent disk diameter 16.5 seconds of arc.) Saturn at visual magnitude +0.6 and an apparent globe diameter of 16.2" is now well past it's best for this year, slowly sinking into the murky south western sky, making observation difficult to say the least. By mid November it will have vanished into the twilight glare to be in conjunction with the Sun on the 30<sup>th</sup>.

**Uranus** is fairly well placed in the evening sky during mid September, and is now retrograding in the constellation of Pisces to reach opposition (19 AU from Earth around 2.6 light hours distant.) on the 12<sup>th</sup> October. The planet remains at visual magnitude +5.7, only slightly decreasing by 0.1 magnitudes by year's end, the



planets globe angular diameter remains at 3.7", and as such is as favourable as it gets to observe for the rest this year and onwards into the new year of 2016.

**Neptune** (Visual magnitude +7.8, apparent size 2.3") passes opposition at the start of September and can be found retrograding amongst the stars of Aquarius, not difficult to locate with binoculars. On the 18<sup>th</sup> of November the planet resumes its normal eastward motion amongst the stars.

## Constellations

October finds **Ursa Major** (Great Bear) low down in the North-North West. The constellation is rotating downwards on the sky to its lowest, and most northerly position during November. Looking upwards, slightly to the right of the pointer stars you should see Polaris, the Pole Star, one of the stars of **Ursa Minor** (The Little Bear.) Polaris is located close to the axis of the sky at declination +89:19:08 so appears to remain static in its celestial location as the other constellations rotate around it throughout the entire year. Over the centuries Polaris will leave this coveted place in the sky to be replaced by Gamma Cephei, sometime around year 3000, so don't hold your breath!

Between Major and Minor resides the constellation of **Draco** the Dragon of which during the month of October you we can observe its fiery head high in the sky toward the West-North West. The constellation has a number of faint galaxies contained within its borders including the fabled M102 and the Cat's Eye Nebula discovered by William Herschel in 1786. We then arrive at Cepheus, which is also part of the asterism known as "*The House*" It contains mainly faint stars not easily seen in the urban skies, but as mentioned one of its stars will become the pole star in the distant future. Moving along we come to the distinctive W shape of **Cassiopeia** which is easily picked out in the sky and one of the better known constellations to the general public, along with Orion. The constellation contains two messier open clusters M52 and M103, plus a number of NGC listed clusters within its boundaries. In the North East you should easily observe the conspicuous star Cappella, a yellow (G8) giant star in the constellation of **Auriga** 43

light years distant, this constellation will become quite conspicuous in the night sky over the coming winter and spring months, and contains three nice messier open clusters M36,37, and M38. Due West, the constellation of **Bootes** with the bright star Arcturus is setting, as also is **Serpens Ophiuchus** and **Scutum**. Above Bootes is the constellation of **Hercules** with the well-known globular cluster Messier 13. Above and fairly close to Hercules resides Vega in the constellation of the **Lyra** due west and high above the horizon. Another well-known messier object, M51 the Ring Nebulae, a now dead star that has puffed off its outer layers is located between the two lower stars of this constellation. The unmistakable cross shape of the constellation **Cygnus** (The Swan.) is roughly at the same elevation as Vega, the cross shape is now is upright with Cygnus's alpha star and is practically overhead. Cygnus is home to the North American Nebulae (NGC 7000/Caldwell 20.) that's located very close to Deneb; it covers an area of around 2 degrees, that's roughly four full moons, but it's very faint and needs very dark skies and good eyesight to pick out. In the South West, the bright star Altair, in the constellation of **Aquila**, is halfway between the Horizon and overhead. The asterism of the summer triangle comprises of the stars Vega, Deneb and Altair; Altair located at the sharp end of the triangle, now pointing toward the south west horizon. Between the bright stars of Vega in Lyra and Arcturus in Bootes is placed the constellation of Hercules previously mentioned, now at mid-western elevation.

In the murky southern sky are the water constellations of **Capricornus**, the sea goat, now due south it's a faint constellation composed of only one star above Magnitude 3.6 though there are several galaxies and star clusters contained within its boundaries. Messier 30 is a globular cluster of magnitude 7.5 and at some 30,000 light-years distant is well worth hunting out. Moving to the east side the constellation partly wrapping around above Capricornus is **Aquarius** the water carrier. One of the oldest recognised constellations along the zodiac, with 3 Messier objects are contained within its boundaries M2, M72 and M73 as well as two nice globular clusters. Moving eastward again we come across **Cetus** the Whale, now rising in the South east. Cetus lies far from

the galactic plane so we can find many distant galaxies within its borders, un-obscured by dust from the milky way The brightest, Messier 77, a 9th magnitude galaxy with a condensed nucleus, and Caldwell 56 'The Cetus ring' an 8.0 magnitude planetary nebulae. And don't forget Mira, the first discovered variable star. Above Cetus and Aquarius resides the constellation of **Pegasus** and to the East of Pegasus we arrive at the asterism of 'Great Square' and the constellation of **Andromeda**. M5, another nice globular, and three galaxies M31, 32 and 110 are contained within its boundaries. Sandwiched below the Great Square of Pegasus and the constellation of Cetus (mentioned earlier) is located **Pisces** the fish. The vernal equinox is located within Pisces boundary and is slowly drifting in the direction of Aquarius. Pisces has one messier object of note; M74, a loosely wound spiral galaxy some 30 million light years away. Above the tail of Cetus we come across **Aries** the Ram and also **Triangulum**, where M31, a distant member of the local group can be seen by the naked eye in dark skies. Due east **Taurus** the bull is rising and the fuzzy patch of the seven sisters The Pleiades should be well above the eastern horizon. Slightly closer to the Eastern horizon the star Aldebaran, known as the '*Eye of the Bull*' should be obvious, due to its distinctive red colour. The star is located close to The Hyades though only in optical alignment It's is not actually associated with this cluster of stars. Above Taurus, we find the famous Crab Nebula, a supernovae remnant, a pulsar and the first of the Messier objects catalogued. Now in the North east sky, we arrive at Auriga which is mentioned earlier in this section. Toward the westward side of Auriga is located Perseus, and moving again westward and slightly above Perseus, we arrive back at the distinctive W shape of the constellation of Cassiopeia.

Over the next three months another six sidereal hours will pass All the summer constellation will have disappeared, Aquarius and Aquila will be sinking below the western horizon and we welcome back the constellations Orion, Eridanus, Gemini, Canis Minor, Canis Major, Gemini, Cancer and Lynx. Part of the next installment of the night sky series.

# Spaceflight Roundup

## John Richards

When NASA launched the New Horizons probe to Pluto in 2006, their aim was to complete their 'Grand Tour' of the outer Solar System and visit the 9<sup>th</sup> planet. On July 14<sup>th</sup> when the probe past Pluto, travelling at more than 1 million miles a day, it wasn't even the 1<sup>st</sup> probe to photograph a Minor Planet. That though is where the disappointments end, as the imagery and wealth of already gleaned from a one hour flyby is staggering.

There was drama just prior to closest approach when New Horizons decided to enter 'Safe Mode'. It was initially feared a fleck of 'Oort Cloud' material had impacted the craft, and all non critical science activities were immediately abandoned until the cause was found. After investigation it was discovered that New Horizons computer entered this mode after receiving too many simultaneous commands to process, overloading the computer. Panic over, and after New Horizons entered normal operating mode, the flyby proceeded as planned, and WHAT a flyby.



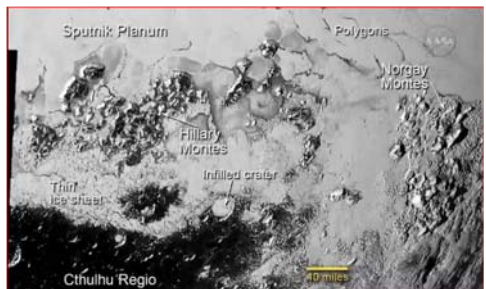
*'Heart of Pluto' image*



*11,000ft ice mountains*

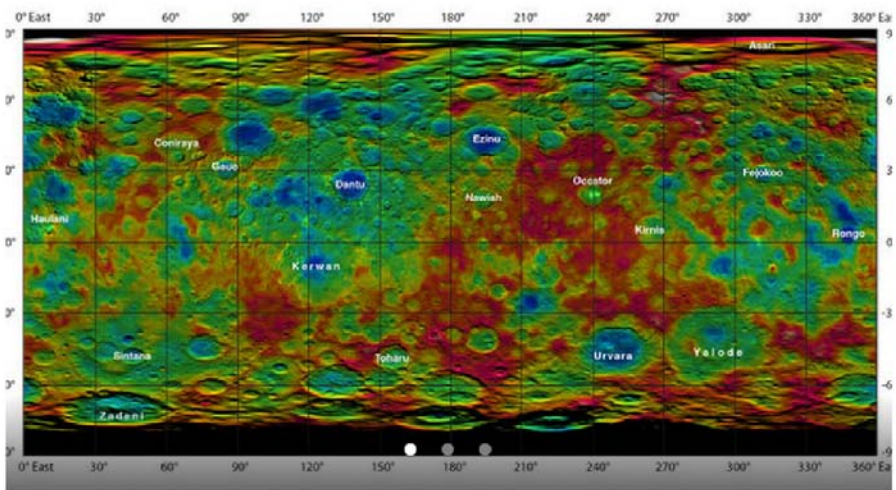
terms. In a series of weekly press conferences, scientists revealed more and more information from this system, including water ice mountains 11,000 feet high, frozen methane and nitrogen ice on the surface, nitrogen sublimating

24 hours prior to closest approach, NASA released the 'Heart of Pluto' image (see above) showing the (minor) planet in remarkable detail, interestingly free of surface cratering. This suggests a very young surface, in astronomical



from the surface, huge plains and a planet that has a surprising amount of surface activity, considering its distance from the Sun. Where is the energy that powers the system? With active systems like Io, there is an obvious parent body causing the effect, but with Pluto none such body exists. Like all good science, the answer to one question is the starting point for the next.

Meanwhile nearer to home, the NASA Dawn probe continues to orbit the Minor Planet/largest asteroid Ceres . NASA released this topological image showing Ceres has height variations from crater bottom to mountain top of around 9 miles. Scientists are still unclear what the bright spots are on the surface mentioned in the last issue. Closer inspection of the spots has revealed around 8 smaller spots. Scientists are intrigued, though the current favourite theory is that a 'recent' impact has exposed underlying ice under the surface. In



other observations it has spotted a 'pyramid' mountain in a relatively flat expanse of the surface. On August 13<sup>th</sup>, Dawn entered its 3<sup>rd</sup> mapping orbit (HAMO) where it will orbit at an average altitude of 915 miles above the surface, completing an orbit every 19 hours. It's planned to be in this orbit for around 2 months.

Even close to home, problems continue to plaque launch providers sending resupply missions to the ISS. This time it was the turn of Space X to suffer a launch failure, when on June 28th, after a flight

of around 2 1/2 minutes a SpaceX rocket exploded. An investigation concluded that a two-foot steel strut in the second stage holding down a helium pressure vessel snapped due to acceleration force. Once 'free' the vessel, travelled upwards and crashed into the upper stage liquid oxygen tank, causing the explosion. This was the 3<sup>rd</sup> cargo resupply mission failure in 8 months. While there was no immediate danger to the crew, when a Russian Progress cargo ship successfully docked at the PIRS compartment of the International Space Station on 5<sup>th</sup> July, carrying around 2 tonnes of supplies, controllers on the ground in Houston and Moscow were, I suspect, mightily relieved. To alleviate the issue yet further, the 5<sup>th</sup> Japanese HTV vehicle launched to the Space Station on August 19<sup>th</sup>, carrying another 6 tonnes of supplies, scientific experiments and spare parts. It should dock (by being grabbed by a robot arm, rather than automatically) on or about August 25<sup>th</sup>. Once docked it will occupy the nadir node of the Harmony module. In other ISS news, on 29<sup>th</sup>



*Gennady Padalka who holds the record for the longest time spent in space*

June, Russian cosmonaut Gennady Padalka broke the world record for the longest time in space, breaking the previous record of 803 days set by Sergei Krikalev. By the time Gennady returns to Earth on 11<sup>th</sup> September he will have spent 878 days in space.

To end on a British note, a 3 spacecraft DMC3 constellation, manufactured by Surrey Satellite Technology Ltd, was successfully launched on July 10<sup>th</sup>, by a PSLV (Polar Satellite Launch Vehicle)

rocket from the Satish Dhawan Space Centre in India. DMC3 offers clients daily revisit capability crucial for rapid change detection, and a 1 metre resolution. What is special about these satellites is normally these capabilities are only available in much larger satellites, but these 440kg smallsat design could revolutionise the provision of satellites for many years to come. British innovation wins again!!

# A-Bombs: Why Should Astronomers Care?

**Phillip Wallace**

At first glance, atom bombs have nothing at all to do with astronomy. So why are we mentioning them at all? In this article I'll try and deliver a simple(ish) answer to this.

In reality astronomy, in a pure sense, has nothing to do with bombs (except possibly irate astronomers complaining about light pollution from the rising fireballs). However, bombs have an intimate connection with astrophysics, that is; the study of stars, how they are born and how they live and die. Before we go any further, another distinction has to be made. A-bombs (that is, fission weapons) have nothing to do with stars. It's "hydrogen" bombs that are related to stars, in that they generate their energy by fusion.

So then, what are nuclear bombs? They're weapons, but unlike any other weapon in history. They are physically small but contain immense power, enough to divert the course of history, topple governments and bring about the Apocalypse if ever actually used.

In physical terms, they are fairly simple. For the most basic type of nuke, you need two masses of Uranium-235 in a large tube with explosives at either end. Each of the U-235 pieces is "subcritical", they're too small to sustain a nuclear chain reaction. But when the explosives detonate and fire the two pieces together, the U-235 reaches critical mass and fission starts.

Neutrons released from other elements slip into a U-235 nucleus, making it unstable and causing it to break in half, releasing a pair of smaller nuclei and two or three more neutrons. Each of those goes on to fission more atoms, and so on in an exponential sequence. First, one fission, then three, then nine, then twenty-seven and on and on, in a matter of nanoseconds. The part that makes this a weapon rather than a scientific curiosity is that the mass of all the neutrons and smaller nuclei released from the Uranium atom have a total mass slightly less than the original atom. About 0.7% of the mass disappears from the reaction. However, energy has to be conserved, and Einstein showed that energy and mass are equivalent. So that tiny fraction of the original atom gets turned into

energy. And when  $E=Mc^2$ , that is a **LOT** of energy.

In physics terms, each Uranium fission releases (on average) 931 MeV. In layman's term, that's about enough energy to make a grain of sand jump into the air. And that's from just one atom. The energy released from the whole critical mass of Uranium is enough to level a large chunk of a major city in a second. The largest US bomb, Castle Bravo, had a blast energy greater than all the bombs used in World War Two combined, including the atom bombs dropped on Hiroshima and Nagasaki.

Now, I've described fission bombs, and as I said above, these have little to no relation to stars. Hydrogen bombs however, are identical in basic principle to stars. They derive their energy from fusion. In simple terms, you take two Hydrogen-2 or -3 atoms (a proton and a neutron, or two neutrons in the case of H-3), heat them up to several million degrees and apply intense pressure. They crash into each other and combine into one larger nucleus of Helium. As with a fission reaction, some mass is lost: the combined mass of the two Hydrogen atoms is slightly more than the mass of the resultant Helium atom. And as with fission, this is released as energy. In physics terms, one fusion event releases approximately 16 MeV of energy. That's a lot less than the Uranium reaction, but you can fit a lot more Hydrogen into the same volume.

Now, I said you need high temperatures and pressures to make fusion happen, and this is where fission bombs come in. On Earth, the easiest way to generate those energies are by detonating a fission bomb, and designing the bomb case to channel and redirect the energy to compress the fusion fuel to the right pressures (hundreds of times the density of Lead).

And this, finally, is the link between stars and bombs. A star generates its colossal energy in precisely the same way as a fusion bomb; the fusion of Hydrogen into Helium. The difference is the Sun doesn't need a fission bomb to generate the temperatures and pressures; it has its immense mass to do that naturally.

A star is a huge, dense ball of superheated Hydrogen plasma. At its core, the temperatures approach 15 million Kelvin, and pressures are inconceivably high. Here, Hydrogen fuses to Helium naturally,



releasing the energy outwards, further heating the core region (and sustaining the reaction) and pushing outwards at the same time. Counteracting this push outwards is the mass of the star, pulling everything in to the centre and holding the Hydrogen in place. So then, you can think of a star as a hydrogen bomb so massive its gravitational pull holds it together while it explodes.

That's the physical connection. The historical link is equally strong. At the start of the 20<sup>th</sup> century, the Sun was thought to mostly be made of Iron, due to some impressive mis-reading of the spectra. Cecilia Payne eventually showed the Sun was made mostly of Hydrogen, with about a quarter of it being Helium. Once this was accepted, astrophysicists reached a problem: if the Sun is made of Hydrogen, what powers it? It can't be simple combustion; the Sun would either burn itself out in only 50 or so years of life, or it would not be enough to balance the gravity and the star would collapse in on itself. Developments in nuclear research in Europe proceeded onwards, quite uninterested in the astronomer's woes. In 1932, Mark Oliphant successfully fused heavy Hydrogen (H-2 or H-3) in the lab, building upon the transmutation work pioneered by Ernest Rutherford at Cambridge. With the knowledge of the fusion process in hand, Hans Bethe set about working out the complete fusion processes in stars over the rest of the '30's.

In the 40's fusion theories took a darker turn, when many of the scientists involved were drafted into the Manhattan Project to build the first nuclear bomb. Even at those early stages, some, like Edward Teller, began to consider fusion bombs, dreaming of controlling the powers of the stars like Prometheus of legend.

So, we have seen the physical connection between stars and bombs, and the closely linked theoretical development of both. That answers part of the question, but the main points remains; why should we as practical astronomers care about bombs at all?

The answer is; we shouldn't. For purely practical astronomy, you can go an entire career without any knowledge of the bomb. But, for academics, and for those interested in the how and why rather than the what of the universe, learning about stars leads inexorably to learning about bombs. And that's just the way it is.

# From 'New Hope' to New Horizons

In the 40 years since the Cardiff Astronomical Society came into being, space probes have revolutionised our knowledge of the Solar System and the Universe. This period has seen us peer through the acid clouds of Venus, marvel at the valleys of Mars, see volcanoes on Io, Ice on Mercury, and more recently let us view the dawn of Creation, and see hearts on Pluto.

## 1975 - 1985

As Dr Bob Owens and Dave Powell were formulating a plan to start the Society, in space there was a meeting of old adversaries. For the past 18 years, America and Russia had been trying to outdo each other in the space above our heads. The Russians had launched the first satellite and the first man and woman into orbit, while America had conclusively won the "Race to the Moon". No love was lost between the two.

We were also in the middle of the 'Cold War'. Russia and the US collectively had around 50,000 nuclear weapons, and were fighting (or had been fighting) on many fronts around the world. The Cambodian conflict had only recently finished, and the ink was barely dry on the settlement of the Vietnam war. Along with the brutal repression of people behind the Iron curtain and the civil rights movement in America, the 1970's could be said to be a



*Apollo Soyuz Test Project crew*

'different world'. But, there was a feeling the status quo could not continue (unlike The 'Status Quo' who are still together today) Treaties to mothball certain types of nuclear weapons had been negotiated and further reductions were planned.

The 'Apollo Soyuz Test Project', that occurred in 1975 was a very visible manifestation of the gradual thawing of relations between the 2 superpowers. The mission consisted of Soyuz 19 carrying cosmonauts Alexey Leonov and

Valery Kubasov launching from Baikonur cosmodrome on July 15<sup>th</sup> 1975. This was followed by the launch of Apollo (18), carrying Thomas Stafford, Vance Brand and Donald Slayton from the Kennedy Space Centre a few hours later. Docking occurred 2 days later on July 17<sup>th</sup> 1975. The 2 craft remained docked for 2 days. It proved the 2 arch enemies could work together in space and the mission paved the way for the future co-operation on the development of the International Space Station in the late 1980's through to the present day.

Earlier, In May 1975, ESA was formed, merging the *ELDO* (European Launch Development Organisation with *ESRO* (European Space Research Organisation). Britain was one of the founding members along with Belgium, Germany, Denmark, France, Italy, the Netherlands, Sweden, Switzerland and Spain. with Ireland joining later that same year. So ESA and CAS share an anniversary!

If Dave, Bob and the fledgling members of the Cardiff Astronomical Society were waiting for a WOW space moment, as opposed to the “WOW” moment that happened 2 years later in August 1977, they didn't have long to wait.

Venera (meaning Venus) 9, landed on the surface of Venus on October 22<sup>nd</sup> 1975, offering us the first tantalising glimpse of our closest neighbour. Previous Venera probes had limited success in the past withstanding the Venusian conditions, so Venera 9 was



different in scope. It weighed in at almost 5 tonnes, and consisted of an orbiter and a lander. The orbiter was the first probe to orbit the second planet, and the lander was the first to land and take pictures of the Venusian surface. Due to the extreme temperatures and

pressures on the surface Venera 9 only lasted 53 minutes before losing contact with Earth. Venera 10 landed 3 days later and lasted 65 minutes on the surface.



While people in Britain remember the summer of **1976** for being an actual 'proper summer', with hosepipe bans, Sun, drought etc, over in the US, they were preparing for the landing of Viking 1 on the surface of Mars. Launched in August 1975, Viking 1 was the first of 2 probes to sample the Martian surface, landing safely on the Martian surface on July 20<sup>th</sup>



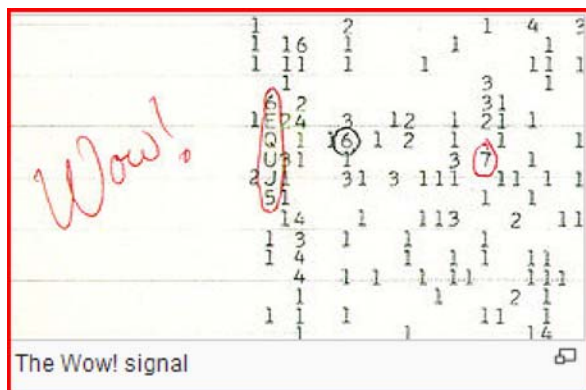
**1977** brought the roll out of the 1<sup>st</sup> Space Shuttle. NASA had previously agreed to call the new Shuttle *Constitution*, but due to

intense lobbying by fans of a certain well known TV sci-fi show, it was renamed Enterprise and handed to NASA on 14<sup>th</sup> January. The unpowered suborbital space plane was launched from the top of a modified 747 and the first unmanned flight occurred on February 18<sup>th</sup>. The first crewed flight occurred on June 19<sup>th</sup>. The first free flight (released from the 747) included Apollo 13 astronaut Fred Haise, and he landed Enterprise for the first time on 13<sup>th</sup> August.



Also during August and September, the two Voyager spacecraft were launched. Voyager 2, launched on August 20<sup>th</sup>, and travelled past Jupiter (1979), Saturn (1981), Uranus (1986) and Neptune (1989). Voyager 1, launched on 5 September, flew past Jupiter (1979) and Saturn (1980), and also included a close flyby of Titan.

Finally in 1977, we had our “WOW” moment. Using the Big Ear Radio telescope, Jerry R. Ehman, detected what he thought was a signal NOT from the Solar System. The plot, which became known as the “wow signal” is shown below. Each digit signifies a 12 second window, and each number indicates a signal strength above the

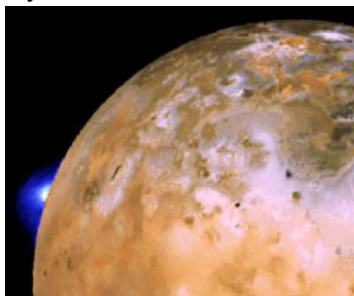


normal “hum” of space. 'A' indicates a signal 10 times higher than normal, B 11 times higher than normal etc. The “6EQUJ5” signal indicated an intense narrowband signal of around 70 seconds long, and matches closely to the Hydrogen

line. Was it a signal from 'ET', or an errant signal from a microwave telling Jerry his baked potato was ready? We may never know the full story, but suffice to say a similar signal has never been recorded since.

**1978** saw NASA's Pioneer Venus Multiprobe (consisting of 5 separate probes) venture to the Planet Venus. It was launched on August 8<sup>th</sup>, and reached Venus on December 9<sup>th</sup>. The probe consisted of a transporter (known as '*The Bus*'), a large atmospheric entry probe (called Sounder), and 3 small probes. The Sounder released from the Bus on Nov. 15<sup>th</sup> and the three smaller probes were released 4 days later. The probes sent data to Earth as they descended toward the surface, and the Sounder lasted 67 minutes, before like Venera 9 and 10, a few years earlier, it caved in to the enormous atmospheric temperatures and pressures.

**1979** more than made up for the mild hiatus that was 1978. In March, Voyager 1 arrived at Jupiter, followed in July by Voyager 2. They revolutionised our understanding of the largest planet in our



Solar System. They gave us some of the most iconic images ever seen from space, including images of the storms on Jupiter, Ganymede, and also Io, found to be one of the most volcanically active bodies in the Solar System. Also in 1979, a British hypersonic test rocket, Falstaff, was flown for the last time.

To further drive home the point in November **1980**, Voyager 1 also returned some iconic imagery of the planet Saturn, showing the ring system in never before detail.



April **1981** brought a 'new era' in space transportation, with the first flight of the US Space Shuttle Columbia. It was the first ever US space vehicle whose first test flight carried astronauts. John Young and Robert Crippen blasted off from Cape Canaveral on 12th April 1981 on a 54 hour test flight.

August saw Voyager 2 arrive at Saturn taking more spectacular pictures of the ringed planet, and following up on many of the discoveries hinted at when Voyager 1 passed the Planet 9 months previously. It also used Saturn's considerable gravity to help it reach Uranus, its next destination. November saw the launch of the Space Shuttle Columbia on its second mission; STS-2. After a mission of 2 days, carrying astronauts Joe H. Engle and Richard H. Truly, Columbia became the first craft in history to re-enter the Earth's atmosphere for a second time.

**1982** began the 'vogue' of long duration space missions. Russian cosmonauts Anatoli Berezovoy and Valentin Lebedev spent 211 days in orbit in the Salyut 7 space station (itself only launched less than a month before). Also the Russians, with dogged determination, landed Venera 13 on Venus, which was the first spacecraft to capture and scientifically analyse samples of soil on the Venusian surface, as well as the first vehicle to transmit colour photographs of the Planet. This time Venera 13 lasted 2 hours and 12 minutes before succumbing to the harsh conditions. It also saw of



the birth of HOTOL, the British space plane, offering a single stage to orbit via a revolutionary air-breathing engine and reusable winged design that was to use a runway to take off and land. It was co-developed by Alan Bond, and while the project has been “stop-start” in the intervening years, it has now transformed into the Skylon project, now being seriously studied by the ESA and funded, in part, by the British government. In November, the Space Shuttle Columbia conducts its first operational flight, launching 2 commercial satellites and conducting scientific experiments on its 5 day mission. Also in 1982, in fact on my birthday, the Space Shuttle Enterprise visited the UK, on top of a Boeing 747, landing in Stanstead airport.

In April **1983**, the maiden flight of the Space Shuttle Challenger took place, but it was becoming clear already the stated aim of a flight a week, and dramatically reducing the cost of spaceflight wasn't really in evidence. Multiple delays between flights and the need to be 100% confident the craft were flight worthy after a fiery re-entry made regular flights impossible and became a dilemma for NASA that ultimately lead to deadly consequences. In June Sally Ride became the first American woman in space on STS-7, and later in the year on STS-9, ESA launched Spacelab, a reusable laboratory flown inside the Shuttle's cargo bay. Other important satellites in 1983 included the IRAS satellite; the first to conduct an all sky survey at infrared wavelengths; EXOSAT and X-ray observatory. Venera 15 and 16 continued Russian investigation of Venus.

In **1984** Bruce McCandless conducted the first untethered space walk using a new device called the ‘Manned Manoeuvring Unit’ (MMU). Over 2



*Bruce McCandless flying the MMU*

days, McCandless and astronaut Robert Stewart spend over 12 hours performing tests with the MMU. The flight is also the first time a shuttle lands at the Kennedy Space Centre. In August, the maiden flight of the Space Shuttle Discovery took place. In October, cosmonauts Leonid Kizim, Vladimir Solovyov and Oleg Atkov return

to Earth having spent 230 days aboard Salyut 7 giving Russia a new long duration spaceflight record.

**1985** In January Japan launches its first interplanetary spacecraft; Sakigake to photograph Halley's comet, from around 4.3 million miles away. In July, ESA launches the Giotto space probe, with the same aim, but from a considerably closer distance. October sees the maiden flight of Space Shuttle Atlantis on a secret US Department of Defence mission. Finally, the British National Space Centre (BNSC) was formed to coordinate civil space activities in the UK.

In the next article the years 1985-95 will be covered. This decade, in particular exemplifies the huge highs and lows inherent in the exploration of space.

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## THE JOAN THOMAS LIBRARY

The Society has a new Librarian, Peter Crabb, who can be contacted at *Librarian@cardiff-astronomical-society.co.uk* by members wishing to borrow or return items held by the Library. The Library Catalogue is available on the Society's new website which also points out that the Library is, for the time being, no longer accessible to members at the Society's fortnightly talks.

Peter is aware that a number of books that have been out on loan to various CAS members for some months. Consequently, can all members who currently have a book in their possession that has been borrowed from the Library please get in touch with Peter so that it can be collected.

## CORRECTION

It has been brought to my attention that an error crept into the 2015-16 handbook. The error only appears in the paper copy you received. It relates to a name of the Deep Sky Co-ordinator. Her name is Claire O'Connell, **NOT** Claire Longville. I apologise for the mistake. Sorry Claire!!

With a corrections section, this is almost starting to look like a proper newspaper. All we need now is a letters page, and a sports section, and we'll be away..... **EXTRA EXTRA!!**



# Up-coming CAS Public Events

Date	Time	Event	Venue
17 <sup>th</sup> Oct.	7pm - 9pm	Stargazing Evening	Brecon Beacons Mountain Visitor Centre
31 <sup>st</sup> Oct.	10am - 4pm	Telescope Workshop	National Museum of Wales

## CAS Lectures September to November

Date	Title	Lecturer
3 <sup>rd</sup> Sept	Astronomy with two million eyes.	Dr. Chris Lintott, Oxford University.
17 <sup>th</sup> Sept	Astronomical Societies in Victorian Britain.	Dr Alan Chapman, Oxford University
1 <sup>st</sup> Oct.	Saturn: Lord of the Rings	Andy Lound, Planetary Society, Birmingham
15 <sup>th</sup> Oct	Journey to the Centre of the Earth	Dr David Whitehouse Farnborough, Hamshire.
29 <sup>th</sup> Oct	The Structure of the Cosmos - A Matter of some Gravity	Prof. John Brown, Astronomer Royal for Scotland.
12 <sup>th</sup> Nov	Supernovae & Serendipity: The Discovery of a 1A Supernova in M82, January 2014	Dr Steve Fossey, University College London.
26 <sup>th</sup> Nov	Confessions of an Astronomer	Prof. Ian Robson, Royal Observatory, Edinburgh

## Observing Sessions

Date	Day	Time	Venue
11 <sup>th</sup> or 12 <sup>th</sup> Sept..	Fri or Sat	20:30 - 24:00 BST	Dyffryn Gardens
25 <sup>th</sup> or 26 <sup>th</sup> Sept.	Fri or Sat	20:30 - 24:00 BST	Mountain View Ranch
9 <sup>th</sup> or 10 <sup>th</sup> Oct.	Fri or Sat	20:00 - 24:00 BST	Dyffryn Gardens
23 <sup>rd</sup> or 24 <sup>th</sup> Oct.	Fri or Sat	20:00 - 24:00 BST	Mountain View Ranch
6 <sup>th</sup> Nov or 7 <sup>th</sup> Nov.	Fri or Sat	20:00 - 24:00 GMT	Dyffryn Gardens
20 <sup>th</sup> or 21 <sup>st</sup> Nov.	Fri or Sat	20:00 - 24:00 GMT	Mountain View Ranch

**NOTE:-** Where two dates are given we will attempt to hold the session on the first date, weather permitting, otherwise we will try again on the subsequent date. All dates are subject to weather conditions. For confirmation of any session please check on the CAS Web site or the CAS Observing line. 07817 723 883 for more information.

Mountain View Ranch was formerly Castle Heights Golf Club.

# Almanac

Compiled by John Richards

## Sun Rise/Set & Twilight

Date	Astronomical Twilight Begins	Sun Rise	Sun Set	Astronomical Twilight Ends
01 <sup>st</sup> September	03:18	05:24	19:01	21:07
08 <sup>th</sup> September	03:34	05:35	18:45	20:46
15 <sup>th</sup> September	03:49	05:46	18:29	20:26
22 <sup>nd</sup> September	04:03	05:57	18:13	20:07
29 <sup>th</sup> September	04:16	06:08	17:57	19:49
1 <sup>st</sup> October	04:20	06:12	17:52	19:44
8 <sup>th</sup> October	04:32	06:24	17:37	19:28
15 <sup>th</sup> October	04:44	06:35	17:21	19:12
22 <sup>nd</sup> October	04:55	06:47	17:07	18:58
29 <sup>th</sup> October	05:07	06:59	16:53	18:45
1 <sup>st</sup> November	05:11	07:04	16:47	18:40
8 <sup>th</sup> November	05:22	07:17	16:35	18:30
15 <sup>th</sup> November	05:32	07:29	16:24	18:21
22 <sup>nd</sup> November	05:42	07:41	16:15	18:14
29 <sup>th</sup> November	05:51	07:52	16:09	18:10

## Meteor Showers

Date	Meteor Shower	RA	DEC	ZHR
09/09/15	Piscids	0h36m	7°	10
22/09/15	Piscids	0h24m	0°	5
14/10/15	Piscids	1h44m	14°	?
23/10/15	Orionids	6h24m	15°	25
04/11/15	Taurids	3h44m	14°	8
18/11/15	Leonids	10h08m	22°	10

## Observers Club Meetings & Dave's Star Parties

**NOTE:** The Observers club meetings have moved and are now held at Dyffryn Gardens. The event now takes place on the same evening as Dave's star parties.

Date	Day	Time	Venue
8 <sup>th</sup> September	Tuesday	20:30 to 23:30	Dyffryn Gardens/Observatory
13 <sup>th</sup> October	Tuesday	20:30 to 23:30	Dyffryn Gardens/Observatory
17 <sup>th</sup> November	Tuesday	20:30 to 23:30	Dyffryn Gardens/Observatory
1 <sup>st</sup> December	Tuesday	20:30 to 23:30	Dyffryn Gardens/Observatory

# Almanac September



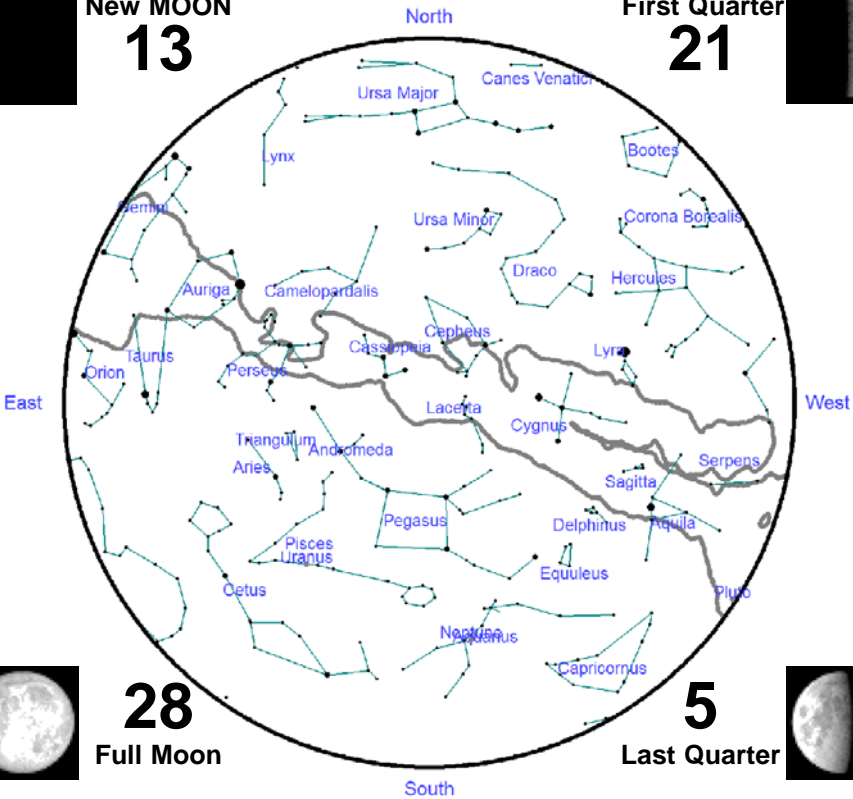
New MOON  
**13**

First Quarter  
**21**

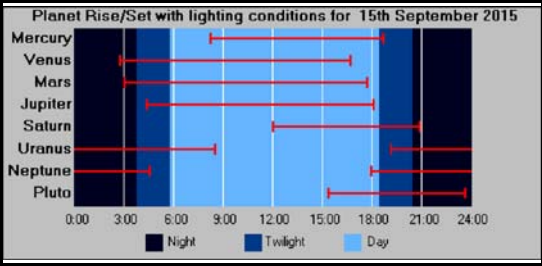


**28**  
Full Moon

**5**  
Last Quarter



	Constellation	R.A	Dec	Rises	Sets	Mag.
Mercury	Libra	15h13m19s	-17°53'42"	07:20	16:15	-1.2
Venus	Virgo	12h27m57s	-01°21'12"	03:07	14:59	-4.3
Mars	Virgo	12h06m53s	+00°48'18"	02:35	14:49	+1.6
Jupiter	Leo	11h21m00s	+05°19'58"	01:27	14:26	-1.9
Saturn	Scorpius	16h16m18s	-19°37'04"	08:34	17:08	+0.6
Uranus	Pisces	01h04m36s	+06°09'32"	15:04	04:15	+5.7
Neptune	Aquarius	22h47m11s	-08°34'09"	14:01	00:44	+8.0
Pluto (Dwarf)	Sagittarius	19h11m56s	-20°52'51"	11:37	19:55	+14.2



## Planet Events

1st Neptune at Opposition.  
30th Mercury at Inferior Conjunction.

The data presented here is for the 15<sup>th</sup> September. Positional data is at 00:00 GMT/UT

# Almanac October



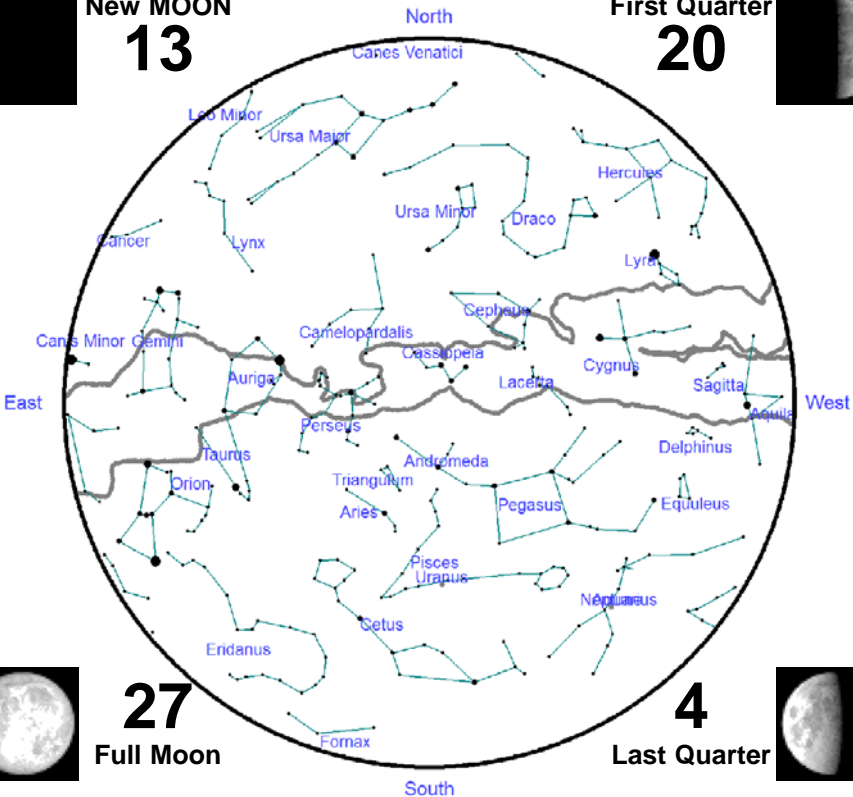
New MOON  
**13**

First Quarter  
**20**

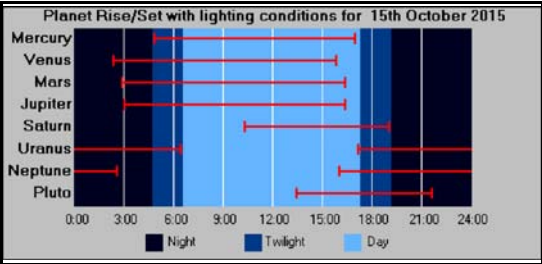


**27**  
Full Moon

**4**  
Last Quarter



	Constellation	R.A	Dec	Rises	Sets	Mag.
Mercury	Virgo	12h14m46s	+00°07'09"	04:48	16:55	-0.4
Venus	Leo	10h26m56s	+08°21'32"	02:19	15:49	-4.5
Mars	Leo	10h57m03s	+08°08'34"	02:50	16:18	+1.8
Jupiter	Leo	11h01m08s	+07°18'57"	02:58	16:18	-1.8
Saturn	Libra	16h02m16s	-18°56'00"	10:17	19:00	+0.6
Uranus	Pisces	01h08m53s	+06°35'18"	17:08	06:24	+5.7
Neptune	Aquarius	22h47m03s	-08°34'59"	16:03	02:45	+8.0
Pluto (Dwarf)	Sagittarius	19h11m51s	-20°52'56"	13:39	21:57	+14.2



## Planet Events

12th Mercury at Perihelion (0.31 A.U.).  
12th Uranus at Opposition.

The data presented here is for  
the 15<sup>th</sup> October positional data is  
at 00:00 GMT/UT

# Almanac November



New MOON

11

First Quarter

19

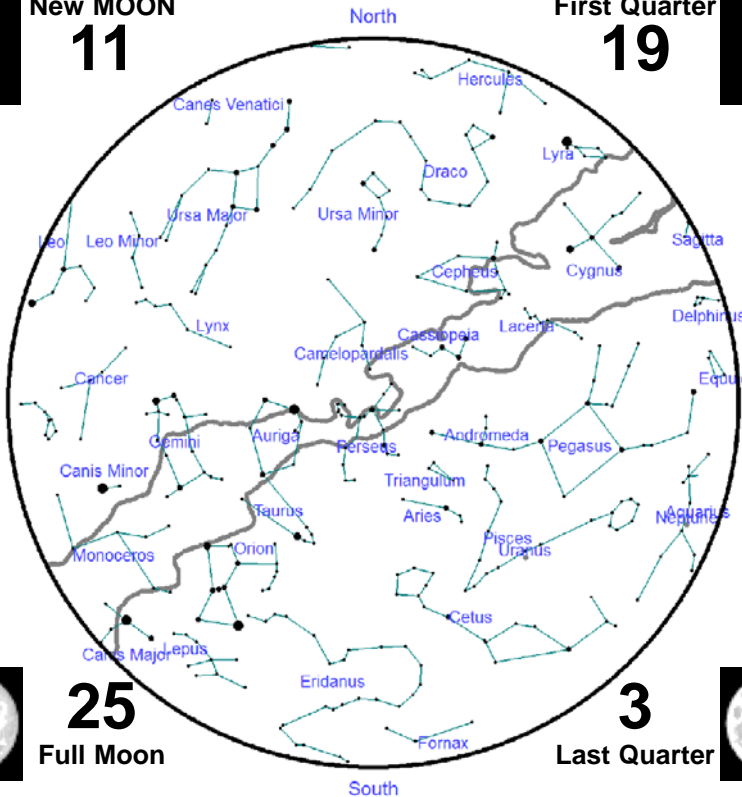


25

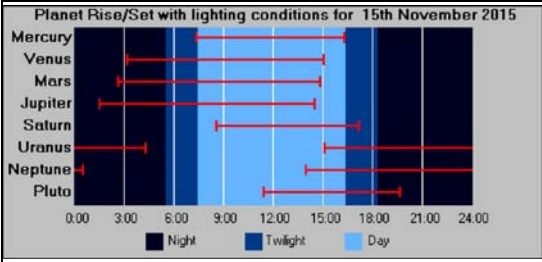
Full Moon

3

Last Quarter



	Constellation	R.A	Dec	Rises	Sets	Mag.
Mercury	Libra	15h13m19s	-17°53'42"	07:20	16:15	-1.2
Venus	Virgo	12h27m57s	-01°21'12"	03:07	14:59	-4.3
Mars	Virgo	12h06m53s	+00°48'18"	02:35	14:49	+1.6
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Saturn	Scorpius	16h16m18s	-19°37'04"	08:34	17:08	+0.6
Uranus	Pisces	01h04m36s	+06°09'32"	15:04	04:15	+5.7
Neptune	Aquarius	22h47m11s	-08°34'09"	14:01	00:44	+8.0
Pluto (Dwarf)	Sagittarius	19h11m56s	-20°52'51"	11:37	19:55	+14.2



## Planet Events

- 17th Mercury at Superior Conjunction.
- 20th Mars at Aphelion (1.6 A.U.).
- 25th Mercury at Aphelion (0.47 A.U.).
- 29th Venus at Perihelion (0.72 A.U.).
- 29th Saturn at Conjunction.

The data presented here is for the 15<sup>th</sup> November, positional data is at 00:00 GMT/UT



## The Physics of Star Trek by Phill Wallace

I'm a huge science fiction fan. I grew up with Doctor Who, Star Wars, the old Battlestar Galactica and of course Star Trek in all its glory (sometimes awesome, sometimes delightfully silly, sometimes just absurd). The Star Trek writers often like to brag about how scientifically accurate their TV program is. As a physicist, I can't let a challenge like that slip away, so let's have a look and see if this claim holds water.

Star Trek presents some very impressive technology by modern standards (though not quite as impressive as it was when first shown in the Sixties). They have faster than light engines, cool-looking energy weapons, big torpedoes, and of course transporters. Let's have a look at each of these:



**Warp Drive:** While it's certainly faster than light (and considerably so) it's still laughably slow by sci-fi standards, taking 70+ years to cross the galaxy. This piece of technology is one fans love to point to as something that's "possible." And it is, sort of. Physicists have a very strange relationship with the

saying "it's possible." What we actually mean is "it's not impossible" which is quite a difference. So, yes, a space-bending warp drive is physically possible, it was worked out mathematically by Miguel Alcubierre. Trouble is, it requires a lot of extremely rare materials to build. Specifically, it needs negative mass, which is another thing that is not impossible but may not actually exist. So no warp drives for us yet it seems.

**Phasers:** These are probably the most inconsistent and schizophrenic personal weapons in science fiction. They can hurt, stun, kill or vaporise a person, or large rocks, all in ways that are stunningly implausible from a physics standpoint. For instance, being able to stun or, on higher settings, kill people with an energy weapon is not unreasonable, we can more-or-less do that now with wireless tasers. But its when phasers vaporise someone that it gets weird.



The target simply dissolves into nothingness, while any onlookers are unaffected. If they'd actually been vaporised, the bystanders would get a face full of superheated plasma blown at them. Phasers also produce no recoil on the user, despite being able to throw men twenty feet or more through the air with a solid hit. Suffice to say, we definitely won't have phasers for a very long time.



**Photon torpedoes:** These are, oddly enough, the most plausible technology in Star Trek. While the engines that propel them are a bit weird, the explosive itself is perfectly reasonable. It contains a small amount of antimatter which is mixed with an equal amount of ordinary matter to detonate it.

Matter and antimatter have a rather unfriendly relationship when they mix: both masses are converted entirely into energy which is released explosively. It gives a similar effect to a large nuclear weapon but is considerably smaller. So, load up on antimatter and fire it at enemy ships for a quick kill. Perfectly reasonable.

**Transporters:** Ah, transporters, the technology that some Star Trek fans like to think makes their show superior to others. It's easy, you stand on a planet, say "beam me up Scotty" into your radio (which, incidentally, was never said in the original series), and they



disassemble you tiny small pieces, transmit them up to the ship, and reassemble you in the right order.

When I say it like that it sounds a really horrible process. It's also absurdly unrealistic. It would be necessary to have complete information on every single particle in your body, and since the number of particles in your body is about seven billion billion billion ( $7 \times 10^{27}$  if you're picky), that's a huge amount of data. What's worse is the Heisenberg Uncertainty Principle, a



rather irritating law of quantum mechanics that says you can never have complete information on **1** particle, never mind billions of them.

Then you'd have to somehow move those particles to the ship, and then reassemble them perfectly, or else you might get an artery hooked up wrong which would be messy. So, no transporters either.

So are we going to be flying around in star ships by the 24<sup>th</sup> century? Maybe, but we won't be doing it with Star Trek technology, that's for sure. Personally I just hope we can decorate the ships in something other than bland beige and tan colours.

Star Trekkin' across the universe,  
On the Starship Enterprise under Captain Kirk.  
Star Trekkin' across the universe,  
Only going forward, and things are getting worse!