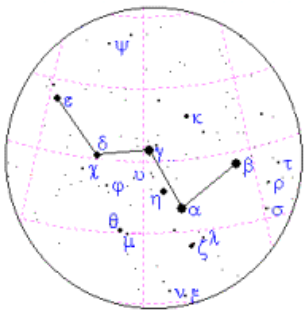


Wadhurst Astronomical Society Newsletter APRIL 2016

MEETINGS

COMMITTEE MEETING

Members of the Committee are respectfully reminded that there is a meeting of the Committee on Tuesday the 26th of April at Phil's house, starting at 1930.

THE MARCH MEETING

Phil Berry led the March meeting and welcomed both members and visitors. After outlining the evening's programme he introduced Dr. David Mannion for a very welcome return visit.

David has three degrees in astronomy and lectures at CATS College in Canterbury. But another of his burning interests is weightlifting where he has gained a number of high awards. But tonight he talks about something we are only just beginning to be aware of.

The Search for Dark Matter and Dark Energy
Dr David Mannion FRAS

A hundred years ago astronomers already knew the distances to the planets and many stars and research was beginning to show what stars were made of and their temperature. David said they began to wonder if the Milky Way was not the entire Universe.

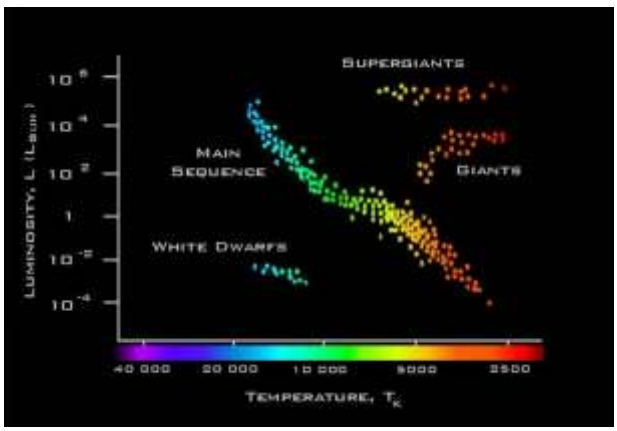
In his unique way of involving his audience he spent some time describing how measurements were made using techniques available then such as ever more accurate angle measurements and the use of interferometery.

We went on to look at how science was developing through the years allowing us to work out how stars are born, develop and how they die.

The Milky Way was mapped by Herschel although David said the centre of our galaxy was not discernible in visible light but more modern methods enable us to see further using infrared and radio astronomy.

Puffy clouds had been seen in the night sky from the southern hemisphere and it was suggested in the Shapley-Curtis "Great Debate" that these could be extra-galactic, which was later proved to be the case by Hubble and now known as the Great and Small Magellanic Clouds.

The Magellanic Clouds seen from the southern hemisphere



The Hertzsprung – Russell diagram

In 1912, Hertzsprung and Russell worked on and produced a diagram that at last showed the relationship between a star's absolute magnitude and its temperature or spectral classification and represents a major step towards understanding stellar evolution.

We were told about Olber's Paradox which suggested that if the Universe was infinite, there would be a star at every point in the night sky and it would be very bright, but what we do see is a black sky with stars in it. According to Edwin Hubble using spectral red-shift the Universe is still expanding. And now with data from the Hubble Space Telescope it has been possible to determine that the Universe resulted from the Big Bang over 13 billion years ago.

In one minute, David ran through the development of knowledge from the discovery of Cosmic Rays in 1912 through discoveries made with the Hubble Space Telescope to the incredible accuracy of measurements today using WMAP (Wilkinson Microwave Anisotropy Probe) to determine the age of the Universe, density of atoms in it, the Inflation that took place immediately after the Big Bang and the epoch when the first stars appeared.

We were told how, by measuring the orbital period of planets it is possible to calculate the mass of the Sun. Using the same method Franz Zwicky calculated the mass of galaxies but other scientists looked at the stars going around the centre of the Andromeda galaxy and calculated the mass but found it was ten times what had been expected and suggested it was due to Dark Matter.

David now looked at the Standard Model, describing the various quarks, - subatomic particles and describing the strong and weak forces, then talked about the spaces between particles, demonstrating Baryonic Matter by showing that things we a familiar with feel solid.

He showed a picture of the Hot Big Bang Model which begins at 10^{-43} of a second after the Big Bang. We can't get any earlier because of the Planck constant limit. After initial inflation the first stars didn't appear until after the first 500 million years.

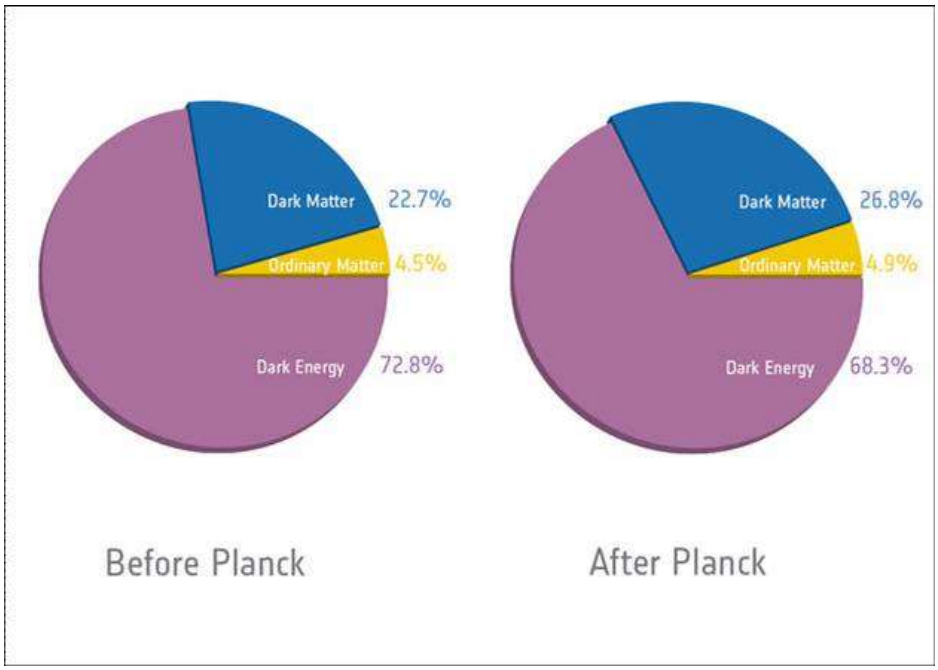
Moving to Dark Matter we were told that it can only be detected through the effects of gravity. It doesn't react with electro-magnetic radiation, it doesn't emit or absorb or reflect light and doesn't have an electric charge but it makes up about 27% of our Universe and holds the galaxies together. One way the effect can be seen is through gravitational lensing of light from very distant sources.

A candidate for Dark Matter is the WIMP (Weak Interacting Massive Particle) which can only be detected through its interaction with other particles when it bumps into them, which is expected to be an extremely rare event. Several very deep locations about two miles beneath the Earth's surface are being used as observatories because the Earth itself cuts out the confusing Cosmic Radiation and provides a better chance of seeing these events. Using special detecting methods such as liquid argon it is hoped to detect these very rare trails resulting from the interactions.

David now turned to Dark Energy. Until recently, the Universe was thought to be expanding and some writers had worked out that taking the mass in the Universe, this expansion would slow and then the Universe would collapse into what Isaac Asimov called the Big Crunch.

In 1998 two groups of scientists announced that when looking at very distant Super Novae they discovered that they appeared dimmer than they should have done and explained that this meant that the Universe was not just expanding but its expansion is accelerating only being explained by what they call Dark Energy.

David ended his talk by saying that from data gathered by the Planck Mission 2009 – 2013, the amount of Dark Matter has been determined and from this, the amount of Dark Energy. He concluded by saying that 68.3% of the Universe is Dark Energy, 26.8% is dark Matter and only 4.9% is ordinary matter!



The proportions of matter in the Universe

Snippets from the World of Science
John Wayte

Navigation

So if you want to get from Wadhurst to say The Cavern in 10 Matthew Street Manchester. How do you do it?

Obvious I hear you say. You simply put L2 6RE into your sat nav and start the car.

But if you want to go to "Alpha Centauri", a mere 25,690,000,000,000 miles or 4.37 light years away then you might have a bit of a problem in finding it. OK so you could point your spaceship to the Earth's nearest star (excluding our sun) ask Scottie to fire up the "Gravimetric Field Displacement Manifold" on the Enterprise and get Jim to go to warp factor 6.3. But the chances are that you would completely miss your intended destination and do a flyby of the Andromeda Galaxy.

So what do you do?

The moon's not too bad because apparently our satellite navigation systems can just about reach our space friend.

NASA has been using Deep Space Network (DSN). This is a system that uses giant radio antennae in California, Spain and Australia to send out radio signals to a probe and then measure how long it takes for them to bounce back. Providing you get 2 signals back you can calculate its angular position to Earth.

But this system is only so accurate over large distances. Pluto for example was photographed by NASA's "New Horizons probe" and could only examine Pluto for a very short time because the spacecraft couldn't be accurately guided so that it could go into orbit around the planet. While we do have some exceptionally good images just imagine what we could have obtained if we could orbit the planet for several weeks. Using the current guidance methods the absolute accuracy was 200 Km – still an unbelievable accuracy over 7.5 billion Km from earth.

So how do we increase the accuracy for true inter-galactic travel?

What we need are some signposts!

What we need is GPS – not Global Positioning Systems -but a Galactic Positioning System.

Well we have them!

The answer is Pulsars. These are scattered all around the universe and we know the location of over 2,000 of them.

Now just to remind you what a Pulsar is, it's the remains of a large star that has run out of fuel and has gone Supernovae and collapsed into a ball that weighs as much as 1.4 times our sun compacted into a sphere that is only 20 Km across. Most spin very fast and a particular class known as Millisecond-pulsars can spin up to 700 revs. per second. These emit an intense beam of electromagnetic radiation across several wavelengths including radio and X-ray bands from their poles like a lighthouse with exquisite regularity.

Using this method it is estimated that the accuracy of space travel could be increased to less than 5 Km over almost any distance and some scientists claim an accuracy of less than 1 Km.

The system is going to be tested aboard the International Space Station this autumn with a bundle of 56 newly developed X-ray telescopes each the size of a poster tube.

With this system we won't get lost going to the Andromeda Galaxy.

WHEN PATRICK MOORE TAUGHT IN LANGTON GREEN

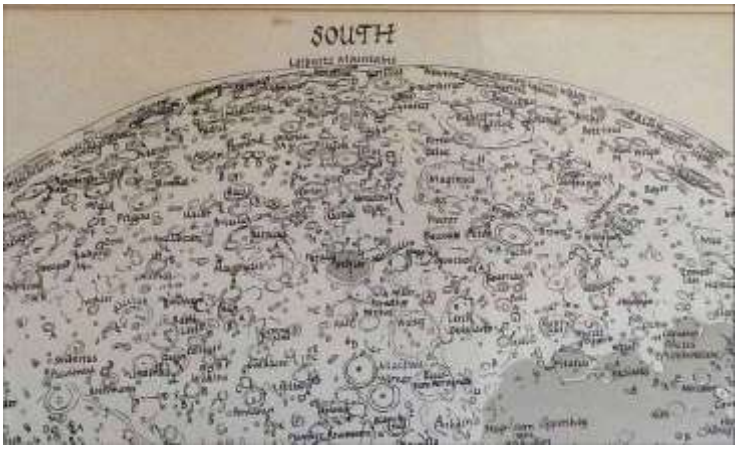
Phil Berry gave a short talk about a rather interesting visit he had recently.

The Society was offered the donation of a motorised 6-inch Newtonian telescope and Phil went to collect it but in doing so came across a fascinating story.

The gentleman who has donated the telescope is Richard Smith and he said that one of his relations by marriage had co-founded Holmewood House School in Langton Green where Patrick Moore was a teacher. One of our old members of the Society also taught there and in fact Patrick Moore was Best Man at Alexander (Sandy) Helm's wedding. Sandy is a real gentleman of the "old school" but sadly had to leave the Society because of serious eye-sight problems.

Patrick Moore is well known to have been seriously interested in the Moon and did an enormous amount of work as an amateur astronomer and wrote "A Guide to the Moon" which was partly illustrated by Sandy Helm's wife whose name then was Patricia Cullen. Patricia also designed the planetarium backdrop for the very first Sky at Night programme.

Richard Smith still has a highly detailed hand-drawn map of the moon drawn by Patricia and Phil took a photo of it.



Part of the map of the Moon drawn for Patrick Moore

Phil's photograph of the map's dedication

Subsequently, another of our members, Bob Seaney is in touch with Sandy and says Sandy's wife used to sell the moon maps from home in the 70s. The plates went to Patrick Moore and later were produced and sold with his signature on them. The original drawings seem to have come from Percy Wilkins and Sandy's wife did the annotations. Copies of the map like the one illustrated are for sale on eBay.

APRIL MEETING

20th April – Rob Cray gives another of his talks on America's Space Programmes; this time he calls it "Skylab – America's First Space Station"

This meeting will take place in the Drama Studio at Uplands Community College. The address is: The Drama Studio, Uplands Community College, Lower High Street, Wadhurst TN5 6AZ and is through the gates and on the left. It is just possible that the meeting could be held in one of the classrooms by the tennis courts instead. Signs would redirect you if that is the case.

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.

2016 SUBSCRIPTIONS

Subscriptions to the Wadhurst Astronomical Society become due from the 1st of January 2016. They remain at £16 per adult member and £23 for two members at the same address.

Subscriptions can be paid either by cheque made payable to Wadhurst Astronomical Society or as cash at the meetings or by post to:
John Wayte
Members Secretary
Wadhurst Astronomical Society
27 Pellings Farm Close
Crowborough
East Sussex
TN6 2BF

The Subscriptions can also be paid via electronic banking to:
Wadhurst Astronomical Society
Account Number **35104139**
Sort Code **60-22-15**
Putting your name as the **Reference** so we know who is paying.

FUTURE MEETINGS

18th May – Our own John Lutkin brings us up to date with "The Blackboys Triple Telescope Array"

15th June – To Be Announced

ANY BUDDING AUTHORS?

The Society has received the following note from Graham G Bryant of SAGAS, the Southern Area Group of Astronomical Societies.

On Tuesday, 1 March 2016, 10:03, John Watson <john.watson@clara.co.uk> wrote:

I hope you don't mind me contacting you 'out of the blue' like this.
I work for Springer New York as their Consultant Publisher for astronomy in the UK – I live in Hampshire – and I'm mailing you in the hope that Hampshire Astronomical Group can help me find some new book projects.
Basically, I'm looking for people who are interested in writing books for amateur astronomers.
Not everyone is aware of just how involved Springer is in amateur astronomy publishing, so in case you haven't seen our list of about 200 amateur astronomy titles currently in print, look on www.springer.com/sky .
We are constantly seeking new authors and new talent, and I'd be most grateful if you could pass this on to your members.
If anyone has something to say, and a willingness to write a book to share it with other amateur astronomers, I would like them to get in touch with me. It doesn't usually matter if there seems to be a similar book in print, either in Springer's list or in those of other publishers, as there is almost always room for a different take on most subjects.
I'm looking for books that will make 200 pages or more of the usual 156 x 234 mm (9 x 6 inches) format. Any amount of colour illustration is no problem, by the way. All our books are published as paperbacks, and also as eBooks. Kindle versions are available from Amazon for most of them, too. We pay royalties on all sales, or give the option of a single cash payment (on publication) instead.
If a book's concept looks like something we would want to publish, I can send a detailed 'proposal form' which, in addition to giving a lot of useful advice about how to present a book to a publisher, also sets out formally all the information I need to put the book forward for contract approval.
Needless to say, everything will be kept in strict confidence and will be shared only with the relevant Springer editorial staff.
Thanks in advance for your help.
Clear skies!

John Watson FRAS
Consultant Publisher, Astronomy
Springer New York

SKY NOTES FOR APRIL 2016

Planets

Mercury moves east of the Sun following superior conjunction on 23rd March until it reaches greatest eastern elongation on 18th April to provide us with our best evening views of 2016 as seen from the UK. Fig 1 shows the western sky on that date with the Sun 6° below the horizon, which marks the end of civil twilight and the beginning of nautical twilight. Mercury is 12° high at magnitude +0.0 with nothing close by to aid identification other than the bright star Capella that lies almost directly above it at an altitude of 50°. It would be wise to look for Mercury from the 7th onwards as although it will be lower in the sky, it will also be brighter at magnitude -1.1.

The planet's elongation will be 20° which is sadly nowhere near the maximum possible of 28°. The minimum is just 18°, which demonstrates how eccentric the orbit of Mercury is. In simple terms we would expect that the best views of Mercury could be had when the angle of elongation is largest or, to put it another way, when the planet is furthest, in angular terms, from the Sun. This is not necessarily the case because both a planet's position with regard to the celestial equator and the angle of the ecliptic at the time has an impact on the degree of visibility.

Please remember that if you do look for Mercury you should wait until the Sun has set. **You risk serious and permanent damage to your eyes if, even accidentally, you look at the Sun with any optical aid.**

Following elongation the Sun moves back into the twilight in readiness for an inferior conjunction that brings with it an all to rare chance to see Mercury in transit across the solar disk.

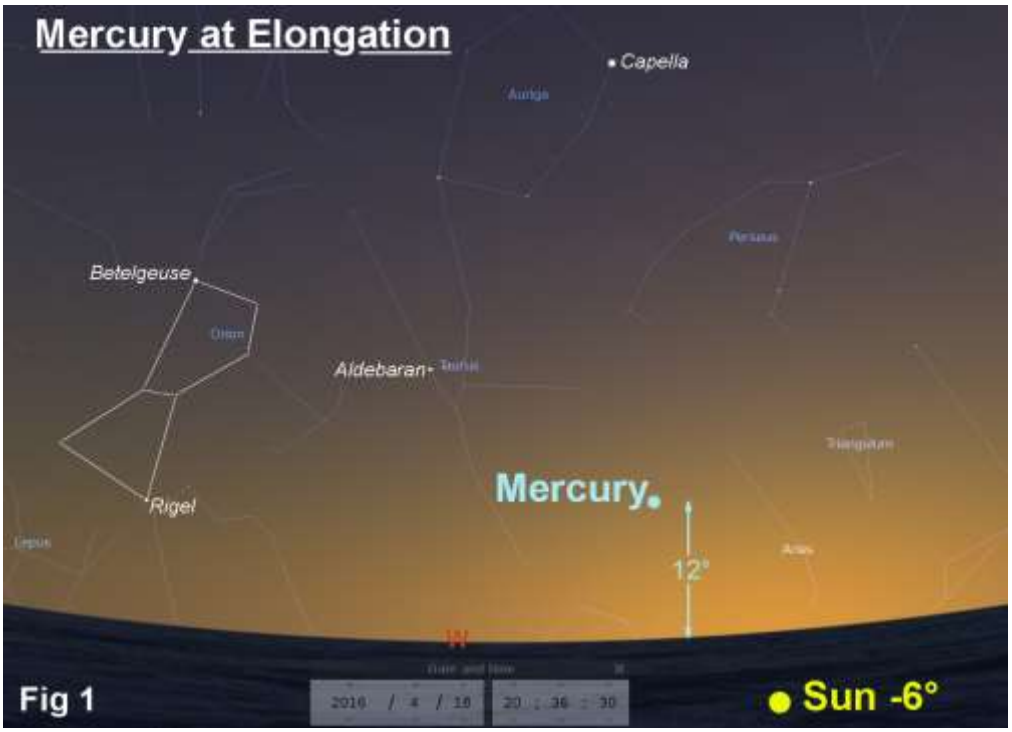


Fig 1

Venus is now sadly impossible to observe (in dark skies) from the latitudes of the UK due to its proximity to the Sun. The planet is still technically a morning object but rises just 15 minutes ahead of our parent star as it approaches superior conjunction on 6th June. Following that it will be seen as an evening object towards the end of August.

However, on the morning of 6th April there will be a lunar occultation of Venus, when the body of the Moon will briefly pass in front of the planet. The Sun will have risen and will be only 15° to the east so great care should be taken if you do not have an accurately aligned go-to telescope. Do not sweep too widely if you are trying to find the Moon/planet manually. The details of the event are given below, and from them you can see that Venus will disappear behind the bright limb of the Moon at 08.30 BST and emerge half an hour later at the dark lunar limb. Saying that it disappears at the bright limb is something of a technicality as the Moon is only 2% illuminated, with the bright portion forming the thinnest of slivers. This is illustrated in fig 2.

Date	Time (BST)	Mag	Phase	% Illum	Alt. °	Sun Alt °
6/4/2016	08.30	-3.8	DB	2	20	+19
6/4/2016	09.01	-3.8	RD	2	25	+23

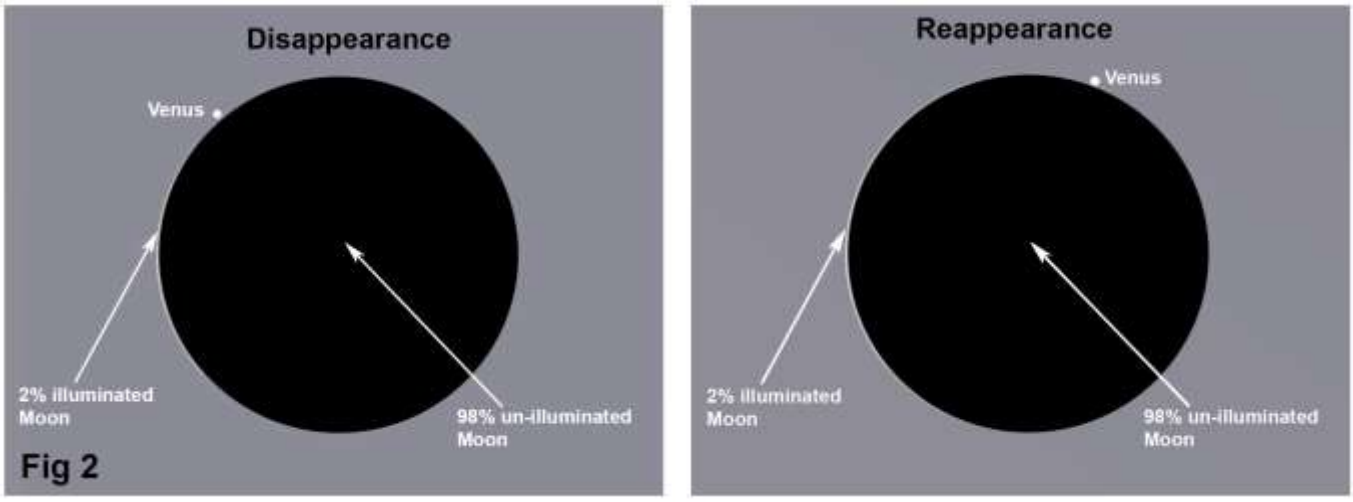


Fig 2

Mars is still a morning object but only just as it rises half an hour after midnight, although by the end of the month this will have become 22.45. It begins April in Scorpio and, travelling eastwards, crosses into Ophiuchus within the first few days. It then reaches its first stationary point on the 17th after which it travels retrograde (westwards) back across the boundary into Scorpio.

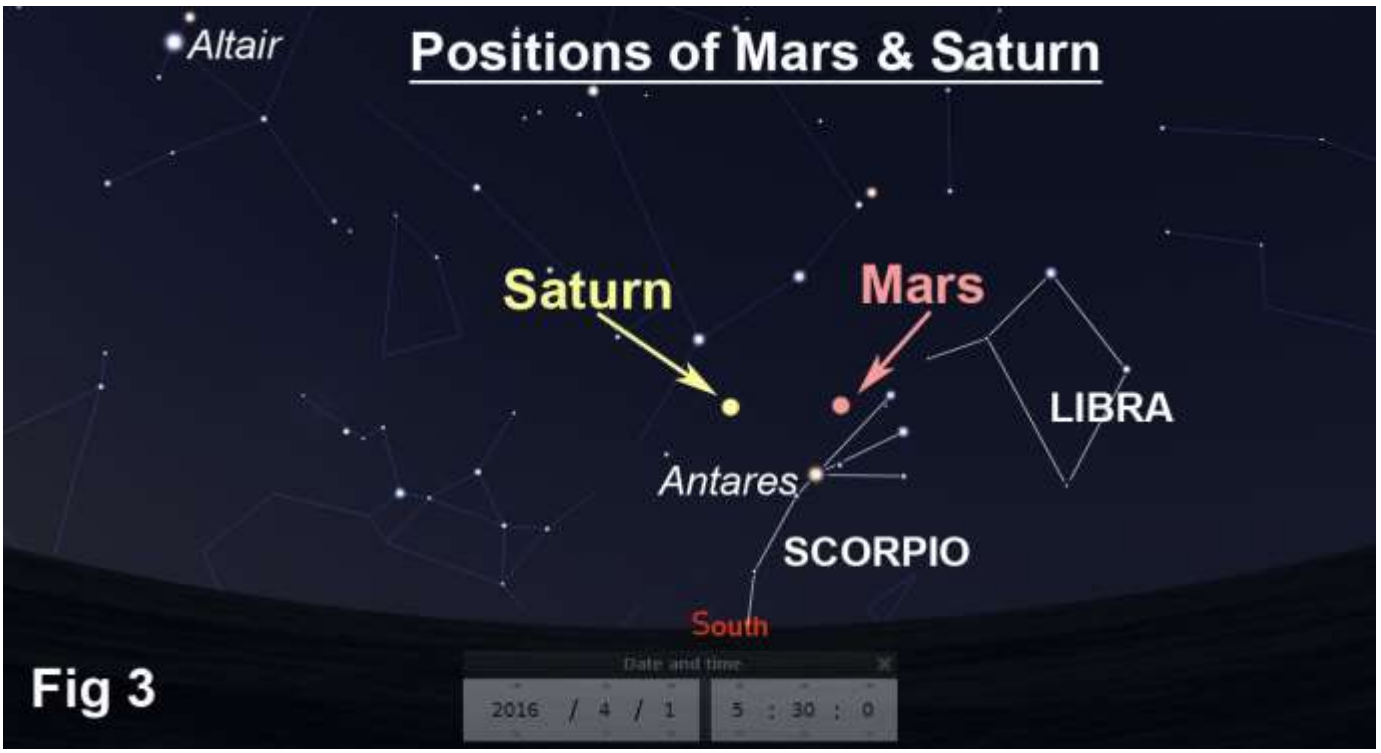


Fig 3

The red planet will reach opposition on 22nd May will it will be at the closest to us that it has been for 2 years. At it approaches that date it will grow both in brightness (up to magnitude -1.4) and apparent size (up to 16 arc seconds). Fig 3 shows its position at 05.30 at the beginning of the month as this is accurate enough for all of April with the planet moving only a little as described above.

Jupiter reached opposition in early March so is still visible for most of the hours of darkness, setting at 04.00 by the end of April. Around the middle of the month the giant planet culminates (crosses the meridian) at 22.30 with an altitude of 45°. Jupiter, at magnitude -2.4 is currently moving retrograde in Leo, just below the belly of the lion as shown in fig 4.

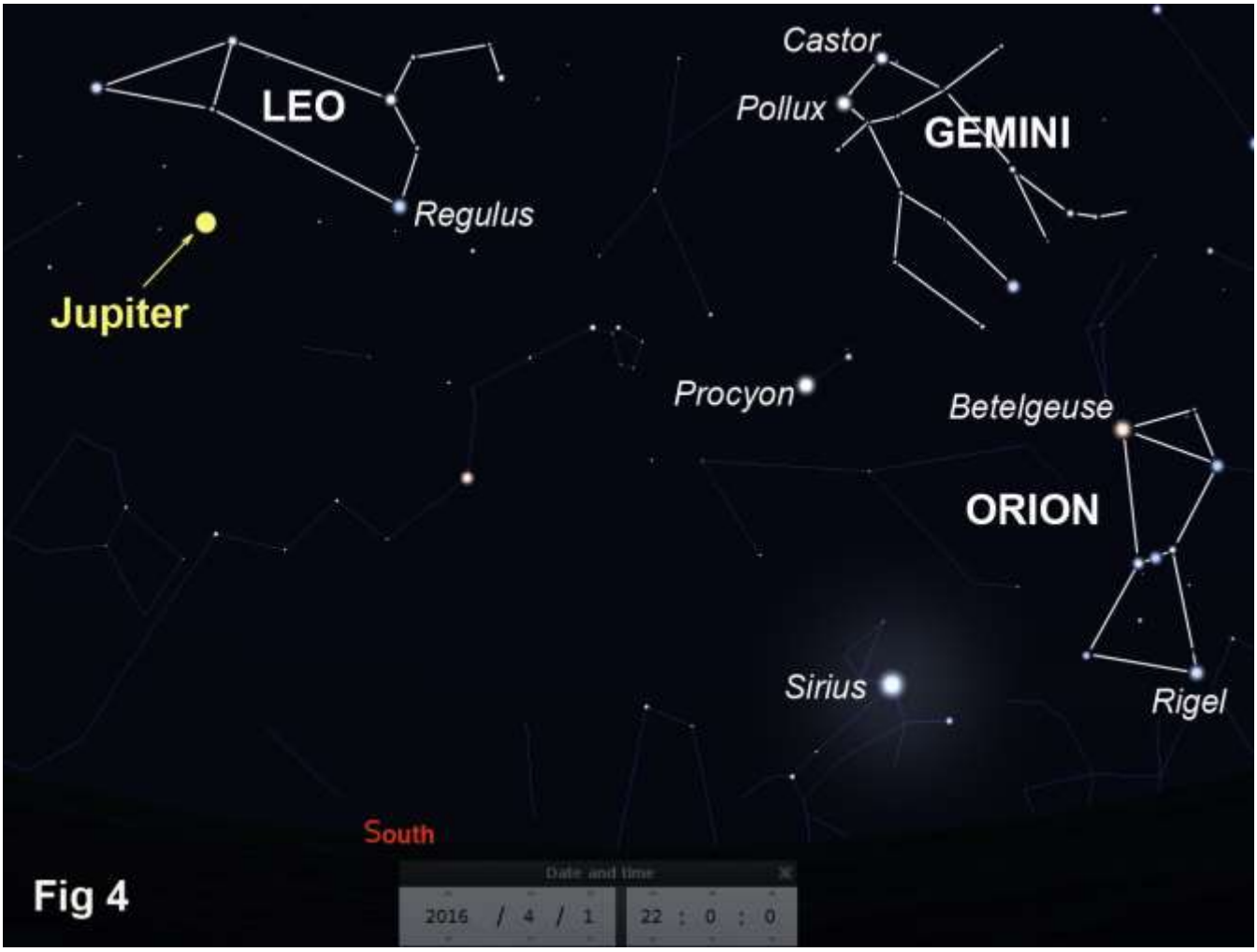


Fig 4

Saturn is a morning object rising at 01.30 at the beginning of the month, although it will rise before midnight by month's end. It is moving towards a June opposition so is gradually increasing in both brightness and apparent size. The planet is moving retrograde in Ophiuchus, a little to the east of Mars which is considerably brighter (+0.3 compared to -0.6). The ring system continues to be well displayed thanks to Saturn's north pole being tilted towards Earth at approximately 26°. Saturn's position is shown in fig 3.

Lunar Occultations

In the table below I've listed events for stars down to magnitude 7.0 that 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 RD = **r**eappearance at the **d**ark limb. The column headed "mm" (millimetres) shows the minimum aperture telescope required for each event. There are a number of events on 10th April because the Moon is again passing in front of the Hyades cluster in Taurus. **Times are in BST.**

Apr.	Time	Star	Mag	Ph	Alt °	% illum.	mm
10th	21.03	ZC 669	3.8	DD	23	16	40
10th	21.07	ZC 671	3.4	DD	22	16	40
10th	21.20	ZC 672	6.7	DD	20	16	40
10th	22.00	ZC 677	4.8	DD	14	16	40
10th	22.02	ZC 680	6.5	DD	14	16	40
10th	22.31	ZC 682	6.0	DD	10	16	40
11th	20.56	ZC 820	5.8	DD	34	25	40
17th	20.30	ZC 1567	6.4	DD	41	84	70
18th	21.14	ZC 1676	6.5	DD	38	90	70

Phases of the Moon for April

New	First ¼	Full	Last ¼
7th	14th	22nd	30th

ISS

Below are details for passes of the International Space Station (ISS) that occur before midnight and are magnitude -2.0 or brighter. The details of all passes, including those visible after midnight, 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 BST.**

Apr.	Time	Mag.	Alt°	Az.		Apr.	Time	Mag.	Alt°	Az.
1st	21.16	-2.9	39	SSE		7th	22.25	-2.0	36	W
2nd	20.23	-2.2	26	SSE		8th	21.34	-3.4	89	N
2nd	21.58	-2.4	44	WSW		9th	20.42	-3.3	80	N
3rd	21.07	-3.4	63	SSE		9th	22.17	-2.2	37	WSW
4th	20.15	-2.9	45	SSE		10th	21.25	-3.3	68	SSW
4th	21.51	-3.4	81	N		11th	20.33	-3.3	86	SSW
5th	20.59	-3.4	88	SSE		12th	21.17	-2.6	43	SSW
6th	21.43	-3.3	79	N		13th	20.24	-3.0	61	SSW
7th	20.50	-3.3	79	N						

Iridium Flares

The flares that I've listed are magnitude -2.0 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 . Remember that 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 at those times. **Times are in BST.**

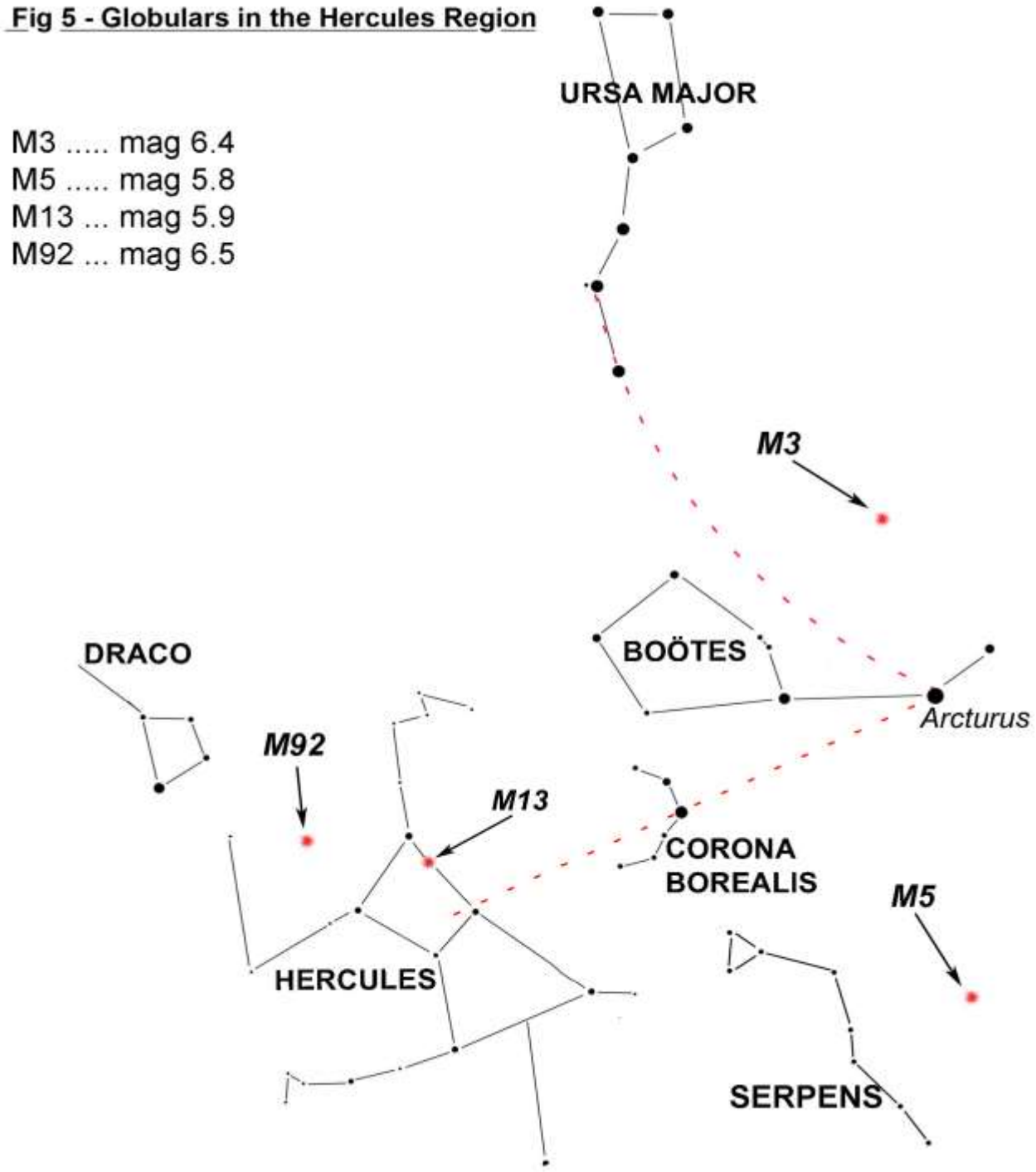
Apr.	Time	Mag.	Alt°	Az.°		Apr.	Time	Mag.	Alt°	Az.°
2nd	20.05	-3.2	43	354 (N)		23rd	23.24	-6.4	19	259 (W)
4th	19.53	-3.6	46	354 (N)		24th	23.18	-4.0	20	261 (W)
11th	21.44	-5.7	13	355 (N)		25th	23.21	-2.7	18	264 (W)
17th	23.42	-6.7	22	245 (WSW)		26th	23.16	-6.4	18	266 (W)
19th	20.44	-2.1	31	351 (N)		27th	23.09	-2.1	18	268 (W)
19th	23.39	-2.3	20	251 (WSW)		28th	23.09	-3.3	16	271 (W)
20th	23.33	-6.7	21	252 (WSW)		28th	23.12	-6.1	16	271 (W)
21st	23.27	-2.7	22	254 (WSW)		29th	23.06	-2.9	16	273 (W)
23rd	23.18	-6.7	20	258 (WSW)		30th	23.10	-6.0	14	277 (W)

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

In the north the Plough lies close to the overhead point whilst the actual zenith is within the boundaries of Ursa Major. The great bear points generally toward Gemini and Auriga, but between them lies the faint and rather poorly defined shape of Lynx. It essentially appears as a rather irregular line of stars the brightest of which is magnitude +3.1. It does however contain the globular cluster NGC 2419 known as the "Intergalactic Wanderer" that appears to be on a highly elliptical path around the galaxy. Cassiopeia, with its smattering of open clusters, lies close to the meridian twenty five degrees above the horizon as seen from southern England. Also in Cassiopeia are the Heart and Soul Nebulae, IC 1805 and IC 1848 respectively both of which have a visual magnitude of 6.5.

Turning our attention to the east we find that two of the members of the Summer Triangle, Vega and Deneb, are becoming more prominent whilst the third member still lies below the horizon. Other summer groups also in evidence are Boötes, Corona Borealis and Hercules. The latter is best found using the other two by drawing a line from Arcturus, through the bright Alphekka (α CrB) which brings you to the so called "Keystone" which forms one of the quadrilaterals that make up the strong man's body. The position of these groups means that there is now a selection of globular clusters available for observers whose interests lie in that direction. M3, M5, M13 and M92 are probably the best known of their genre. Use fig 5 to help you locate the above constellations starting from the handle of the Plough, before you see if you can find the four globular clusters shown. All are easy binocular objects, but remember you will see much more if the instrument is mounted on a tripod to hold it steady.

Fig 5 - Globulars in the Hercules Region

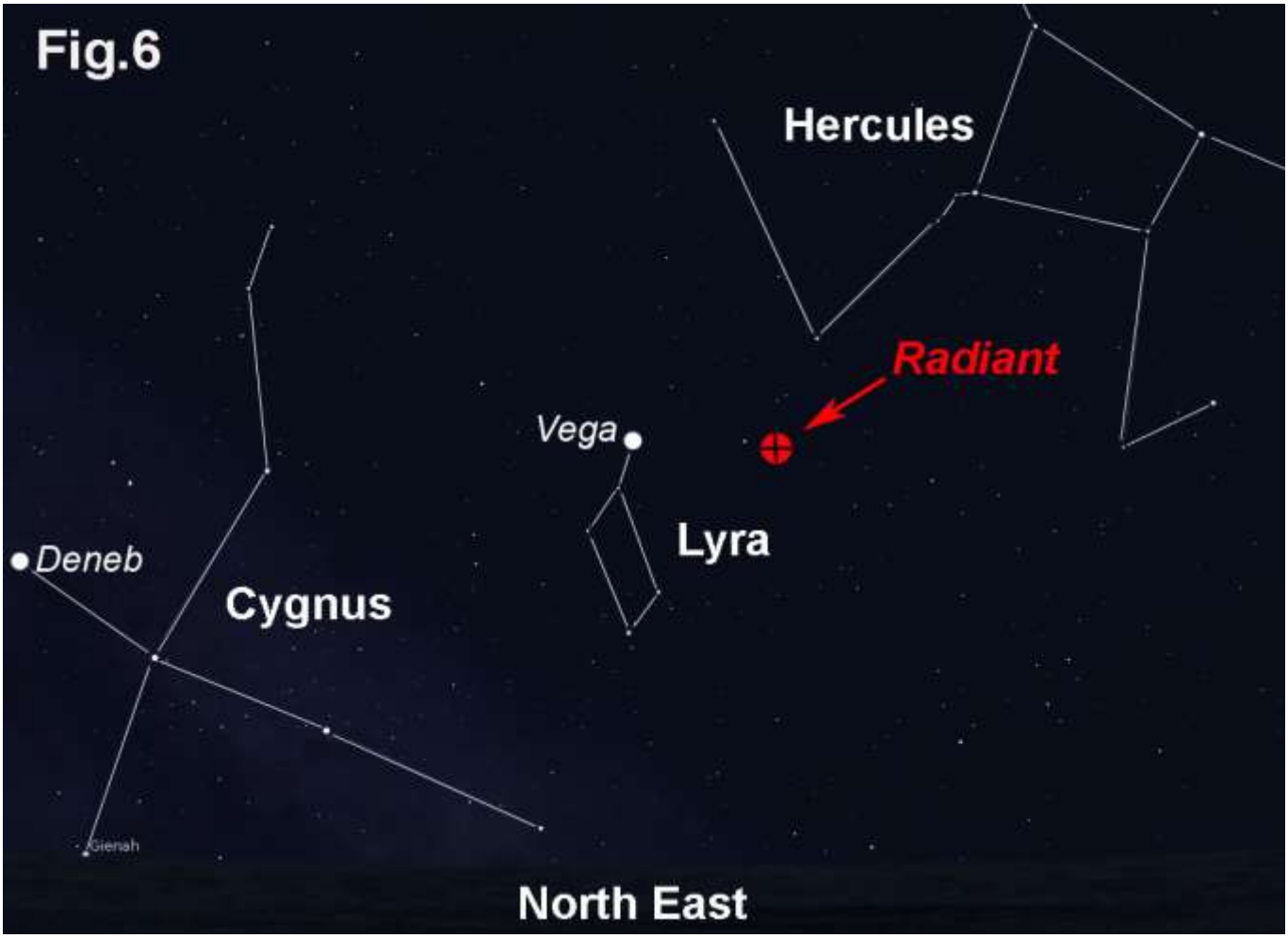


Towards the south, Virgo is approaching the meridian whilst above her lie Coma Berenices, which contains the globular M53, and Canes Venatici. Below Virgo is the tail of Hydra, and riding on the back of the water snake are Crater, the cup and Corvus, the crow. Hydra, Crater and Corvus all belonged to the second century astronomer Ptolemy's original list of 48 constellations.

In the west, Orion has almost disappeared although some of his retinue are more easily visible. The celestial twins are 50° in altitude whilst Capella is just a little lower. M44, the open cluster in Cancer is still at a healthy altitude (50°) and is a pleasing sight seen against a pollution free sky. It is thought to share a common origin with the Hyades cluster in Taurus.

Meteors

The Lyrids - This year the April Lyrids are one of the showers that suffer at the hands of moonlight. The shower's normal limits are from 18th April to the 25th with maximum expected at 23.00 BST on the 21st. A ZHR of 10 is predicted though this will be severely curtailed by a full Moon in Virgo. The location of the radiant is shown in fig 6.



Advanced Warning
9th May – Transit of Mercury
22nd May – Mars at opposition.

Wadhurst Astronomical Society Outreach
During the last few months Phil and Brian have continued with the Societies outreach activities by attending a number of groups in the area. The first was a visit to the 12th Royal Tunbridge Wells Scout Group though the weather was awful so no observing was possible with the telescopes. Next were the 1st Speldhurst Brownies who were much luckier with the weather. An outdoor introduction to the sky was followed by a talk and then some observing through the two telescopes that had been taken. The last visit of this period was to the 1st Hildenborough Girl Guides. Again the weather was poor so they had a talk and video presentation.

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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Gravitational Wave Astronomy Will Be The Next Great Scientific Frontier
By Ethan Siegel

Imagine a world very different from our own: permanently shrouded in clouds, where the sky was never seen. Never had anyone see the Sun, the Moon, the stars or planets, until one night, a single bright object shone through. Imagine that you saw not only a bright point of light against a dark backdrop of sky, but that you could see a banded structure, a ringed system around it and perhaps even a bright satellite: a moon. That's the magnitude of what LIGO (the Laser Interferometer Gravitational-wave Observatory) saw, when it directly detected gravitational waves for the first time.

An unavoidable prediction of Einstein's General Relativity, gravitational waves emerge whenever a mass gets accelerated. For most systems -- like Earth orbiting the Sun -- the waves are so weak that it would take many times the age of the Universe to notice. But when very massive objects orbit at very short distances, the orbits decay noticeably and rapidly, producing potentially observable gravitational waves. Systems such as the binary pulsar PSR B1913+16 [the subtlety here is that binary pulsars may contain a single neutron star, so it's best to be specific], where two neutron stars orbit one another at very short distances, had previously shown this phenomenon of orbital decay, but gravitational waves had never been directly detected until now.

When a gravitational wave passes through an objects, it simultaneously stretches and compresses space along mutually perpendicular directions: first horizontally, then vertically, in an oscillating fashion. The LIGO detectors work by splitting a laser beam into perpendicular "arms," letting the beams reflect back and forth in each arm hundreds of times (for an effective path lengths of hundreds of km), and then recombining them at a photo-detector. The interference pattern seen there will shift, predictably, if gravitational waves pass through and change the effective path lengths of the arms. Over a span of 20 milliseconds on September 14, 2015, both LIGO detectors (in Louisiana and Washington) saw identical stretching-and-compressing patterns. From that tiny amount of data, scientists were able to conclude that two black holes, of 36 and 29 solar masses apiece, merged together, emitting 5% of their total mass into gravitational wave energy, via Einstein's $E = mc^2$.

During that event, more energy was emitted in gravitational waves than by all the stars in the observable Universe combined. The entire Earth was compressed by less than the width of a proton during this event, yet thanks to LIGO's incredible precision, we were able to detect it. At least a handful of these events are expected every year. In the future, different observatories, such as NANOGrav (which uses radio telescopes to the delay caused by gravitational waves on pulsar radiation) and the space mission LISA will detect gravitational waves from supermassive black holes and many other sources. We've just seen our first event using a new type of astronomy, and can now test black holes and gravity like never before.

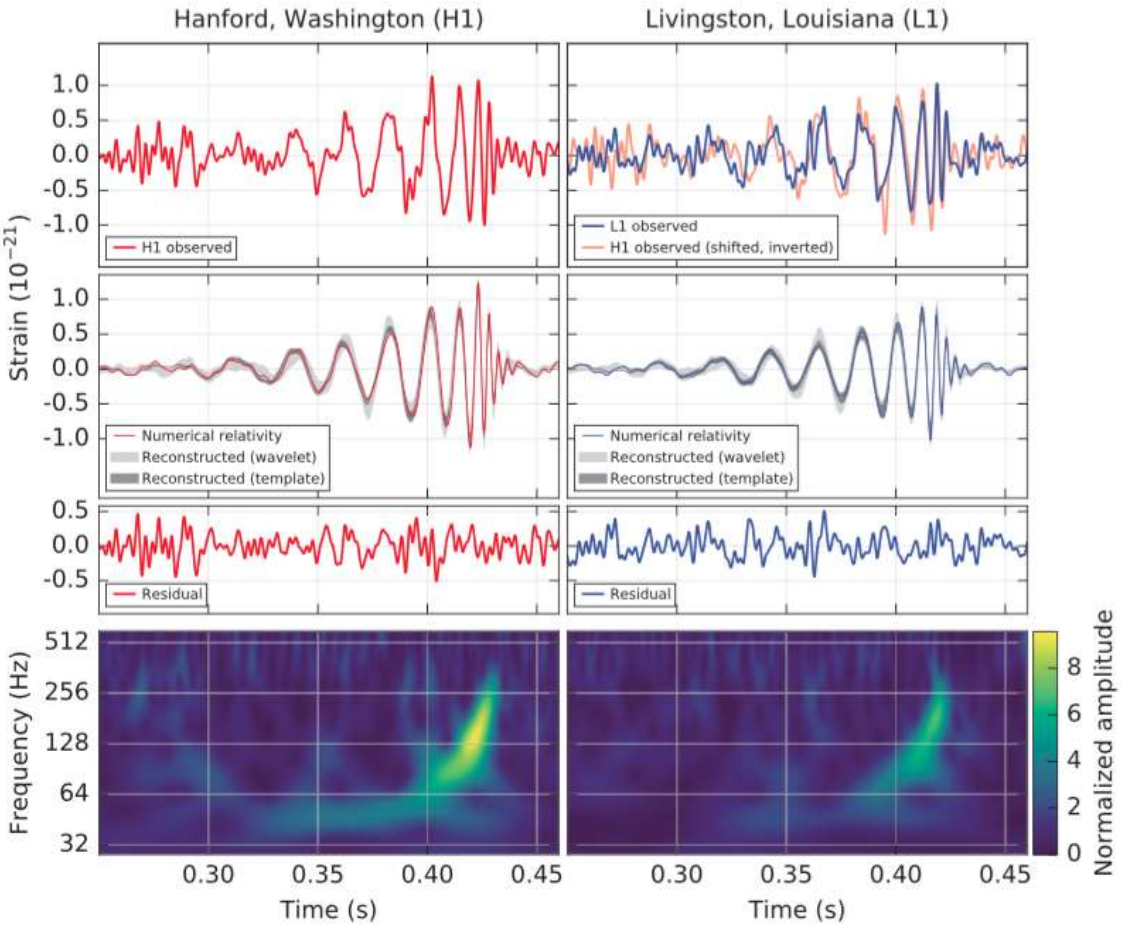

Image credit: Observation of Gravitational Waves from a Binary Black Hole Merger B. P. Abbott et al., (LIGO Scientific Collaboration and Virgo Collaboration), Physical Review Letters 116, 061102 (2016). This figure shows the data (top panels) at the Washington and Louisiana LIGO stations, the predicted signal from Einstein's theory (middle panels), and the inferred signals (bottom panels). The signals matched perfectly in both detectors.

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