WAS NEWS

Monthly Newsletter of the **W**orthing **A**stronomical **S**ociety

Official website: www.was.org.uk
Affiliated websites: www.observatory99.freeserve.co.uk

Number 168 **October 2003**

ALMANAC

All times U.T. add one hour for B.S.T.

October. / November.

LUNAR

October	Date	Time	rise	set
First Quarter	2nd	19.09	14.29	21.18
Full Moon	10th	07.27	17.37	06.07
Last Quarter	18th	12.31	21.58	14.39
New moon	25th	12.50	06.19	16.53
November				
First Quarter	1st	04.25	14.34	22.54
Full Moon	9th	01.13	16.27	07.29
Last Quarter	17th	04.15	23.32	13.58
New moon	23rd	22.59	06.46	15.36
First Quarter	30th	17.16	13.18	23.18

EARTH

October	Sunrise	Sunset
2nd	06.02	17.37
10th	06.15	17.19
18th	21.58	14.39
25th	06.19	16.53
November		
1st	06.53	16.34
9th	07.07	16.21
17th	07.21	16.09
23rd	07.31	16.02
30th	07.42	15.56

PLANETS(as at October 25th.)

	Constellation	Rises	Sets	Mag.
Mercury	Virgo	06.40	16.53	-1.4
Unfavourable				
Venus	Libra	08.23	17.29	-3.9
Unfavourable				
Mars	Aquarius	15.17	01.22	-1.4
Visible low in the south west				
Jupiter	Leo	02.02	15.26	-1.9
Morning object in the East				
Saturn	Gemini	20.40	12.49	0.0
Morning object				
Uranus	Aquarius	14.53	00.56	+5.8
Difficult				
Neptune	Capricornus	14.07	23.10	+7.9
Difficult				
Pluto	Ophiuchus	10.08	19.50	+13.9
Unfavourable				

PHENOMENA

Day	Hour	October
17th	14	Saturn 5° S. of moon
22nd	02	Jupiter 4° S. of moon
23rd	02	Neptune at stationary point
25th	10	Mercury in superior conjunction
25th	13	Mercury 1° S. of moon
26th	00	Saturn at stationary point
26th	20	Venus 0°.09 N. of moon
		November
3rd	11	Mars 3° N. of moon
8th	13	Uranus at stationary point
9th	01	Total eclipse of moon
13th	20	Saturn 5° S. of moon
18th	19	Jupiter 4° S. of moon

Minima of Algol

October 9th 03.06 12th 00.01 14th 20.48 29th 04.48
November 1st 01.36 3rd 22.30 6th 19.18 21st 03.18

Lunar Occultations

Times as at W.A.S. Observatory

Date	U.T.	S.A.O.No	Mag	Phase
October	**h. m. s.**			
10th	20.32.17	109926	5.1	reapp
15th	01.03.11	76737	6.1	reapp
16th	00.01.34	77281	7.8	reapp
16th	00.36.55	77310	6.3	reapp
16th	02.40.54	77360	5.0	reapp
16th	03.43.38	77407	8.5	reapp
16th	04.50.14	77456	8.3	reapp
17th	01.03.56	78455	8.0	reapp
17th	02.31.47	78490	8.6	reapp
17th	05.20.07	78576	8.0	reapp
18th	01.30.49	79382	8.5	reapp
18th	02.04.46	79405	7.3	reapp
18th	02.11.43	79404	8.9	reapp
18th	04.20.51	79469	8.5	reapp
18th	04.47.12	79482	8.8	reapp
18th	05.15.53	79495	7.8	reapp
19th	00.41.53	80089	7.0	reapp
19th	01.19.55	80113	5.8	reapp
19th	02.02.00	80129	8.5	reapp
19th	03.35.46	80165	7.2	reapp
19th	04.42.50	80192	8.5	reapp
20th	02.18.22	80735	8.4	reapp
20th	03.20.53	80753	8.6	reapp
20th	03.58.49	80764	8.0	reapp
20th	04.23.04	80772	8.6	reapp
21st	04.13.06	99007	9.0	reapp
21st	04.42.51	99020	9.1	reapp
21st	04.54.26	99019	7.3	reapp
22nd	04.44.46	99437	8.7	reapp
22nd	05.21.05	99455	7.2	reapp
November				
5th	22.05.15	128868	6.9	diss
10th	22.35.20	76608	4.4	reapp
10th	23.14.32	76613	5.4	reapp
14th	23.27.52	79855	8.0	reapp
15th	00.03.44	79869	6.2	reapp
15th	00.18.00	79874	8.5	reapp

This is only about 16% of the predictions for the W.A.S. observatory

Dave Wells

Editors Note

Evening all! If you haven't seem Mars yet, I recommend that you rush outside and take a peak, For those of you unable to do that feast your eyes on the remarkable image captured at the WAS Observatory last month. For information on that and much more – read on.

Rob

Dates for your Diary

Total Lunar Eclipse

Alex Vincent

On the night of November 8/9 2003 there will be a total eclipse of the moon. Details are as follows.

Moon enters penumbra at 22.15.
Moon enters umbra at 23.32.
Totality begins at 01.06.
Mid eclipse is at 01.18.
Totality ends at 01.30.
Moon leaves umbra at 03.04.
Moon leaves penumbra at 04.21.
Magnitude of the eclipse is 1.017.

The moon only just enters wholly into the umbra and that is why totality is short and so one will see a bit of brightening at the Moon's southern limb. This is the last total eclipse of Saros 126 and will be a large partial in 2021. Also this eclipse has a relatively large total penumbral magnitude where it is 1.097 just before entering and just after leaving the umbra and so a good amount of shading should be seen during the penumbral phase. The largest total penumbral magnitude possible is 1.107 and this can only occur when the moon is at extreme Apogee.

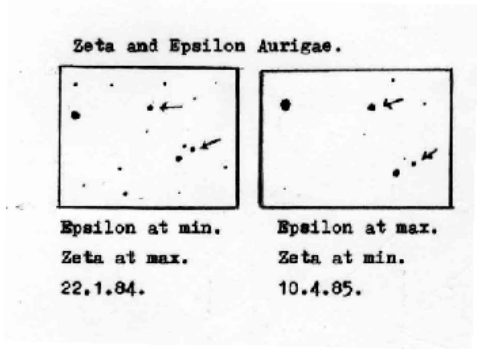
Eclipsing Binary Minima.

Alex Vincent.

Below are two long period eclipsing binary stars which will be at minimum during October and November 2003.

RZ OPHIUCHI.
This eclipsing binary will be at minimum on October 30. Eclipse begins on October 21 and ends on November 8. It has a period of 261.92 days and a duration of 19 days. It is magnitude 9.65 at maximum and drops down to 10.4 at minimum. Its RA is 18h 45m 46s and declination is +07 degrees 13' 14" Epoch 2000.0. Dates of future minima are July 18 2004 and April 6 2005.

ZETA AURIGAE.
This eclipsing binary star will be at minimum on November 25. Eclipse begins on November 5 and ends on December 14. It has a period of 972.16 days and a duration of 40 days of which 38 are total. It has a magnitude of 3.7 at maximum and 4.2 at minimum. Its RA 05h 02m 28s and declination is +41 degrees 04' 34" Epoch 2000.0. Dates of future minima are July 24 2006 and March 23 2009.



Reports

Mars

This image was taken at the Observatory on the evening of Friday 19th September 2003 by David Chilard & Colin Thomson using a Schmidt/Cassegrain f 10 Celestron 20cms aperture at prime focus fitted with a Philips ToCam Pro PCVC740K Web Cam.

Images were captured over a 15 second period. The best images were saved & stacked automatically to make this final image. The seeing conditions were excellent

The laptop computer used was supplied by Alex Vincent & the main computer by Graham Boots.

The Planets in October 2003

Glen Thomas - Planetary Section Director

Mercury completes a favourable morning apparition by the middle of October. Look for it around the start of civil twilight low in the east (see table).

Date	Time	Alt	Az
Oct 08	6:39	6.2	95
Oct 11	6:44	4.2	96
Oct 13	6:47	2.8	97

Venus is still recovering from its **Aug 17th** superior conjunction (far side of the Sun).

Mars is past its best following is close August opposition, but is now visible at a much more sociable hour. The Red Planet is now only slightly smaller in the eyepiece than at its best showing during the 2001 opposition (20' apparent diameter), so it is still well worth seeing. Use as high a magnification as conditions allow and observe close to transit (time it passes due south) to cut the effects of the atmosphere to a minimum. See if you can spot the southern polar ice caps, visible in fairly small instruments.

Jupiter can be seen now climbing clear above the SE horizon before dawn, as it rises around **03:00** (04:00 at the end of the month). On the morning of the **18th** Jupiter reaches 33° altitude at **06:00**, before the sky is too bright.

Saturn is a glorious morning object, appearing very high at 61° altitude before the dawn twilight swamps it. By the end of October Saturn reaches 30° altitude at **midnight**, allowing steady views early in the night as well as before dawn.

Uranus is still favourable for one more month. It will be 27° above the southern horizon at **21:00** now, 19:30 by the end of October. The sky only darkens around an hour earlier, so observation becomes difficult by November.

Neptune is close to Uranus and Mars in the neighbouring constellation of Capricornus, but catch it early in the month. Look for Neptune 22° above the horizon, due south around **17:45**.

Pluto disappears into the low altitude haze before the sky is dark and will not now be observable until next Spring.

Observatory Annual Report No 33 September 2002 – 2003

Graham Boots - Curator of the Observatory

This session has enjoyed two exciting planetary events, the transit of Mercury on the 7th May 2003 and the very close opposition of Mars in August of the same year. During the transit the sky remained clear throughout and was observed by 21 members and friends. Four telescopes were in use plus the black and white video camera and many photographs were taken. Mars brought about large numbers of members, friends and visitors on specially arranged evenings throughout September and again photographs were taken. On these occasions members are encouraged to bring along their own telescopes and in this regard I thank Brian Halls and Trevor White. On one occasion Mars attracted 24 members and visitors to the Observatory, which was the highest single attendance we have received this session.

Other photographic activities have involved Leighton Clay using the 125 mm f 15 Maksutov/Cassegrain for solar photography; very sharp images are obtained with this equipment. Alex Vincent used the 29.2 cms Newtonian piggyback position to record eclipsing binary stars at minimum and maximum as well as obtaining astrometric images of two comets. The two faint comets were C/2002 V1 (NEAT) and C//2002 Y1 (Juels-Holvorcem)

Members and a visitor timed four lunar occultations and 18 Geminids (meteors) were recorded by Alex. My Stellar & Deep Sky section has had no real success due to the weather and bright moonlight so I intend to return to the chosen constellations of Leo and Aquarius at the next appropriate times of the year.

Other group observing has taken place at other sites when members have got together while I have been away. The other sites used have been Hill Barn Golf Course and Ferring Beach and the home of David Chilard also in Ferring.

Over the last 12 months the weather has been both kind and cruel to activity at the Observatory. Throughout most of October and all of November and well into December we were clouded out, not just on Friday observers nights, but most other evenings as well. Whereas, during the summer of 2003 we had 9 clear, consecutive observers nights.

In summary we had 27 clear observer's nights with and average attendance of 9, 17 were cloudy with and average attendance of 5 and 7 were cancelled due to my absence although on some of these occasions alterative events were held at other observing sites.

As in previous years we have received a large number of visitors, not just at times of special events but throughout the entire year. This session we have received well over 50 visitors. Pam Spence who operates an astronomy class at a university in Brighton encourages her pupils to come to the Observatory and this has led to many more visitors than usual. Families with their children are always especially rewarding visitors, as they are so appreciative of our efforts to educate and entertain them. On leaving visitors are given coloured brochures that cover many aspects of astronomy and space research as well as the Society's threefold leaflet that gives information and history about the Worthing Astronomical Society. The coloured brochures are obtained free of charge from the Particle Physics and Astronomy Research Council from their Swindon office. Information and programme of shows on behalf of the South Downs Planetarium at Chichester are also given. We did not take part in National Science Week in March as our entry in their magazine was omitted. We have been given assurances that this will not happen next year.

This session the curator purchased a Philips ToCam Pro PCVC740K Web Cam which has proved a remarkable piece of colour electronic imaging equipment. It can be attached to any telescope with the 1¼" diameter fitting. It is used in conjunction with a laptop computer either in the Observatory or on a chair in the garden placed next to a telescope. A series of images of a celestial object are saved and loaded into a 64-mega byte USB (Universal Serial Bus) Flash Disk that is then detached and taken to the main computer where image enhancement software programmes are used. Please see the image of Mars in this edition of WAS News. David Chilard and Colin Thomson carry out this work. I thank Alex Vincent for the use of his laptop computer that is used in conjunction with the Web Cam.

The black and white video camera/computer imaging system is now successfully concluded and much use is now being made of this system. I thank all those who were involved with this project, which proved quite a challenge. The faintest magnitude reached on this system now stands at 11.7. On cloudy observer's night we spend our time in general discussion and these evenings have lead to many improvements and new systems coming into use at the Observatory. I thank Colin Thomson for his extensive electrical work and the rebalancing of the 29.2cms Newtonian reflecting telescope which has greatly reduced the back lash on the polar axis and allowed the right ascension drive to work reliably.

This session the Society purchased 7 x 50 binoculars which have been mounted on a tripod and are kept at the observatory. Michael Marshall and the curator carried out the annual audit of Society's telescopes, electrical equipment and other instruments, which now numbers 47 items, all was found in order. A purchase planned for the future is the incredibly accurate Zeon Tech radio controlled clock at £12.95 to go into the observatory.

Glen Thomas and the curator carried out the annual Observatory Health and Safety Tour in July. No work was found necessary this year but several recommendations were made and a report has been written and recorded. A Sky Dairy is kept which gives details of observing activity and attendance figures.

Recently the Observatory web site has been updated and David Chilard has added a 'hits counter' that records the number of visitors to this site. This counter was obtained free of charge and was downloaded from www.digits.com/

Recently Leighton Clay and the curator washed and polished the Observatory and are currently carrying out a full service of the Newtonian telescope and some of the accessories.

This has been a particularly rewarding and active session. We now have several image processing programmes to learn how to use upon wealth of images captured and stored.

David Chilard has now moved to Queen Mary's University London to take a one-year course for a Master of Science degree in Astrophysics where we wish him every success.

I thank all those members who have helped and supported the Observatory this session.

Solar Section Report-September, 2003

Section Director, Brian Halls

September was very much a repeat of August in the ebb and flowing of sunspot activity.

Activity was very much as one would expect on this decline phase of the present sunspot cycle. During much of the second week, only two groups were recorded on several days.

Only during the third week did activity once more begin to increase – activity being very much evenly distributed between the northern and solar hemispheres.

One group - 10464 $N06^0$ L=353, area=560, reached naked eye visibility during the third week – Graham observing this group on the 24^{th} and 26^{th}.

This group was still on the Sun at the close of the month, though close to the western solar limb. As in August, sunspot activity increased somewhat at the close of the month as sunspot-bearing longitudes rotated earthwards.

Reports were received from Graham Boots, and the Director. The Sun was observed on 29 days during a September that proved itself remarkable weather wise.

From the Chairman

Have you been to the South Downs Planetarium?

If not, why not? Now is your chance. Members of Salisbury Astronomical Society shall be visiting the Planetarium on Saturday, 18th October and the 14.30hrs show is still not fully seated, so to make up numbers members of WAS are invited to make up numbers – ticket prices are not available as WASNews goes to press but contact the ticket hotline for further details – 07818 297292.

Was Giggle

Meteor Crater - A Close Call!

Brian Halls

As the airliner was flying over Arizona on a clear day, the co-pilot was providing his passengers with a running commentary about landmarks over the PA system.

"Coming up on the right, you can see the Meteor Crater, which is a major tourist attraction in northern Arizona. It was formed when a lump of nickel and iron, roughly 150 feet in diameter and weighing 300,000 tons, struck the earth at about 40,000 miles an hour, scattering white-hot debris for miles in every direction. The hole measures nearly a mile across and is 570 feet deep."

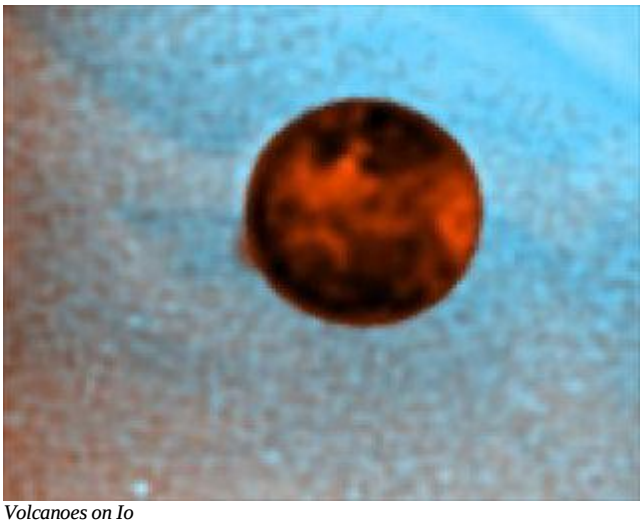
From the cabin, a passenger was heard to exclaim, "Wow! It just missed the highway!"

Ok, no excuses! I've got half a page to fill, so rather than some tired old plea for more contributions from members I thought I'd squeeze in some astronomical photographs which of course look passable in black & white, but really come to life in colour.

Colour version of WAS News are at present only available by joining the growing number of members who enjoy the news letter delivered direct to their PC via email.

Why not sign up ?Send a request to:wasnews@tiscali.co.uk

Hubble Vision



Volcanoes on Io

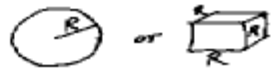
Saturn

The Cartwheel Galaxy

Konrad Marilyn-Smith's fascinating talk on White Dwarf Stars at the August Meeting has prompted the request for the reproduction of his 'Degenerate Considerations in White Dwarfs - Ed

Degenerate Considerations in White Dwarfs

1/ Let there be 'N' fermions in a star of radius 'R'



∴ fermions per unit volume = N/R^3

∴ volume per fermion = R^3/N (Pauli excludes another electron of the same energy in that unit volume)

∴ linear extent available to fermion = $\sqrt[3]{\frac{R^3}{N}} = \frac{R}{N^{\frac{1}{3}}} = x$

2/ (Momentum = mv = p)

Heisenberg's Uncertainty Principle gives lowest limit of 'px' :-

$$px \geq \frac{h}{2\pi} = \hbar \quad \therefore p \geq \frac{\hbar}{x} \quad \text{ie} \quad p \geq \frac{\hbar N^{\frac{1}{3}}}{R}$$

3/ Non-relativistic minimum Energy of a fermion, E_0 :-

$$E_0 \doteq \tfrac{1}{2}mv^2 = \frac{1}{2m}(m^2v^2) = \frac{1}{2m}p^2 = \frac{1}{2m}\frac{\hbar^2 N^{2/3}}{R^2}$$

(E_0 is the Quantum mechanical zero point energy, E_0 is never zero – even when T=0)

Fermi Energy, E_f, is generally > E_0

N.B $E_f \propto \frac{1}{R^2}$

4/ Gravitational Energy, E_G per fermion is :-

$$E_G \doteq -\frac{GMm_B}{R}$$

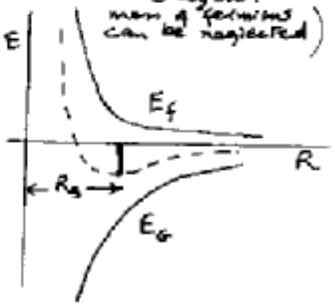
but $M = Nm_B$

$$\therefore E_G \doteq -\frac{GNm_B^2}{R}$$

(M = mass of star, m_B = mass of a Baryon. mass of fermions can be neglected)

5/ Total minimum energy of system per fermion:

$$E = E_f + E_G = \frac{\hbar^2 N^{2/3}}{2mR^2} - \frac{GNm_B^2}{R}$$



There exists a stable radius corresponding to minimum energy, R_s

The Chandrasekha Case (dwarf so dense that many electrons are relativistic)

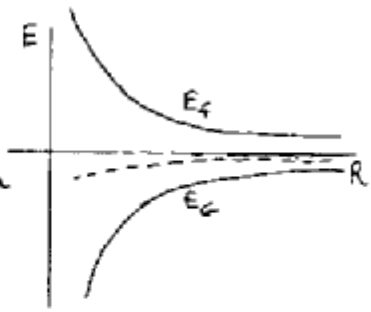
6/ If E_f is relativistic, then $E_f = mc^2 = (mc)c$

ie $E_f = pc \doteq \frac{\hbar N^{\frac{1}{3}} c}{R}$ per fermion N.B $E_f \propto \frac{1}{R}$

7/ Total minimum energy of system per fermion:-

$$E = E_f + E_G = \frac{\hbar N^{\frac{1}{3}} c}{R} - \frac{GNm_B^2}{R}$$

Note that both terms scale as $\frac{1}{R}$!



There is no stable radius corresponding to minimum energy! The star collapses.

ie. when N is large, not only is E negative, but it can be made more negative by reducing R to 'zero'

Parameters of Chandrasekha's Limit

(a) maximum baryon number can be calculated by setting E = 0

then $\frac{\hbar N^{\frac{1}{3}} c}{R} = \frac{GNm_B^2}{R}$ and $\therefore N^{2/3} = \frac{\hbar c}{Gm_B^2}$

$$\therefore N_{max} = \left(\frac{\hbar c}{Gm_B^2}\right)^{3/2} = 2 \times 10^{57}$$

$$\therefore M_{max} = N_{max} m_B = 1.44\, M_\odot$$

(b) Since $E_f = mc^2 = \frac{\hbar N^{\frac{1}{3}} c}{R}$

$$\therefore R = \frac{\hbar N_{max}^{\frac{1}{3}}}{mc} = \frac{\hbar}{mc}\left(\frac{\hbar c}{Gm_B^2}\right)^{\frac{1}{2}} = 5000\ \text{km}$$

(c) Density = $\frac{\text{Mass}}{\text{Volume}} = \frac{(1.44)(2\times10^{30})}{\frac{4}{3}\pi(5\times10^6)^3} = 5\times10^9\ \text{kgm}^{-3} = 5\times10^6\ \text{g cm}^{-3} = 82\ \text{tons in}^{-3}$

Articles

***September Lecture Reviewed** – Report by Vanessa Wegner*

Cosmology

Caroline Beevis

Caroline Beevis and her dog, Toby.

Caroline told the audience that an early childhood revelation for her was that the universe is so immense, we will only ever understand a fraction of what is out there, however advanced our knowledge and tools to explore the universe become.

A fundamental question Cosmologists ask is "why are we here?" Linked to this is a primal drive in human beings to find out if there is other life out there. Astronomy helps us find the answers to these questions. Every so often someone finds a little bit of the answer, e.g. Einstein ironically thought he had made his biggest blunder with the introduction of the "cosmological constant". Astronomers did not know that the universe is expanding until the 1920`s. This opened up a whole new science; quantum physics which compliments Einstein's "blunder".

During the recent TV series "Universe" a scientist being interviewed said, "Perhaps us humans are the conscience of the universe". This sounds very profound and takes us back to the first question, why are we here? Perhaps the universe needs a conscious identity or perhaps we are one of many signposts and one day the whole universe will be linked and it will all make sense.

One of the first images Caroline observed was the Plough. It is an awesome thought that 100,000 years ago the constellation looked very different, as it will in another 100,000 years. This gave Caroline much to think about regarding time and the depth of space. Her next learning curve was that the universe is made up of an impossible number of galaxies. This is very exciting and optimistic because such a huge number of galaxies mean the chances are that much higher for other life in the universe. It is an interesting thought that elsewhere there is probably life wondering if there is other life out there!

The Hubble space telescope has given us images of extraordinarily distant galaxies, some 10 billion light years away. The images we see are actually, as the galaxies looked 10 billion light years ago. It is quite an isolating thought that we never look at the universe in the present, Andromeda is 2 million light years away, the sun's light takes 8 minutes to reach us and the moon takes 1.5 seconds.

When Caroline was in her early twenties she discovered the possibilities of the future of the universe. One idea is the open universe theory, the universe just keeps expanding and expanding until there is nothing near us, this is a very bleak proposition the flat universe theory proposes that the universe has some energy but eventually it will run out of steam and stop expanding. The closed theory postulates that the universe will collapse back in on itself ultimately resulting in another big bang, the "big crunch". This was a popular theory but is now considered to be the least likely and the open universe theory is currently the accepted proposition.

It is a popular misconception that the big bang means an explosion but this is incorrect because an explosion requires matter exploding into space. This leads one to ask what was there before the big bang; we need to think in surreal terms. The COBE satellite launched in 1989 has given us pictures of the radiation present in the entire universe, radiation believed to be a remnant of the big bang. The WMAP (Wilkinson microwave Anisotropy probe) gave us an even clearer picture of the microwave light present just 379,000 years after the big bang, over 13 billion years old. Such images and discoveries will surely help us in our quest to find out how/why the big bang happened.

Caroline often wonders what we will do should the day occur when we can explain the universe in full. Perhaps we will only achieve this by connecting up with other civilisations, ultimately increasing the consciousness of the universe. Why are we here if we are the only life in the universe with this strong urge to reach out and contact other life?

Caroline's talk provoked many questions from the audience and was very well received and thought provoking, reminding us why we continually seek answers to the most fundamental questions of life.

WAS Ad

Telescope for Sale

Celestron 8 20cms aperture Sch/Cass f10 with 2 finders Drive & Guidance units Equatorial wedge Tripod & many accessories but eyepieces retained. Good condition £700 ono

Tel., Worthing 01903 233456 or Mobile 07790432181

What's on the Box

Saturday 11th October 2003

BBC TWO

13.00 - 13.25 ~ **The Sky at Night.**
The SMART Way to the Moon. The world of astronomy with Patrick Moore. In a new era of space age discoveries, Europe sends its first rocket to the Moon. With its revolutionary ion engine and pioneering instruments, scientists hope SMART-1 will answer fundamental questions about the Moon, such as where it came from.

WAS News News

Galelio Spacecraft Crashes into Jupiter

Peter Bond - Astronomy Now

One of the enduring and exciting episodes of the planetary exploration came to an abrupt end Sunday when the Galileo spacecraft plunged into the atmosphere of giant Jupiter.

With its fuel supply nearly gone, the craft was intentionally commanded to the collision course with Jupiter to eliminate any chance of a future impact with Europa that could contaminate the icy moon, which is likely to have a subsurface ocean and possibly life.
The battered ship Galileo was crushed, melted, and then assimilated into the planet's all-embracing atmosphere at the completion of its 35th and final circuit around the hostile Jovian system. Galileo's life ended as it impacted the gas giant in darkness just south of the equator at 1857 GMT (2:57 p.m. EDT) spacecraft-time at a speed of approximately 48.26 km per second (nearly 108,000 miles per hour).

From launch to its demise, the spacecraft travelled 4,631,778,000 km (2,878,053,500 miles) during its 14-year mission.
However, the first man-made satellite of Jupiter leaves behind a rich legacy. Apart from the few hours of data transmitted back to Earth before its dramatic high-speed descent into the planet, Galileo bequeaths a treasure trove of scientific data that has revolutionized our ideas about the king of the planets, its retinue of satellites, its dark, dusty rings and radiation-riddled environment.

"We learned mind-boggling things. This mission was worth its weight in gold," said Dr. Claudia Alexander, the seventh and final Galileo project manager.

"We haven't lost a spacecraft, we've gained a stepping-stone into the future of space exploration," added Dr. Torrance Johnson, Galileo project scientist.

Triumph over adversity. Eventually launched on October 18, 1989, the failure of the umbrella-shaped high-gain antenna to open, restricted Galileo's promised flood of images to a trickle. Then further disaster threatened when the onboard tape recorder stuck only eight weeks before its scheduled arrival. Fortunately, although the opportunity to image Io from close range was lost as a result of the malfunction, the mechanical blip proved to be temporary.

Galileo finally braked into orbit around the planet on December 7, 1995 and, despite the continual threat from technical glitches, it has since completed one of the most productive missions in the history of Solar System exploration.

A menagerie of moons
The two-year prime mission began with observations of the two outer Galilean moons, the gas giant and its hostile environment. Inserted into a highly elliptical 198-day orbit around Jupiter, Galileo eventually made its first satellite flyby on June 27, 1996 sweeping past Ganymede at a distance of 835 km (519 miles) - 70 times nearer than either of its Voyager predecessors.

To everyone's surprise, Galileo's instruments revealed that the largest moon in the Solar System possessed a magnetic field. Close-up images showed prominent ice mountains and ridges that looked as if a giant rake had been dragged across the surface, while large fractures snaked across the ancient plains.

Next to be explored was cratered Callisto, a world that seemed to have changed little over billions of years. However, Galileo showed that even this inactive moon undergoes subtle changes. A blanket of dark material seems to have smoothed out the wrinkles and smaller impact features, while the rims of larger craters have slumped to expose a bright, icy basement.

Subsequent attention switched to the icy moon Europa as the CCD camera provided the most detailed images ever obtained of the strange, curved bands and 'icebergs' that etched its surface.

"In some places, the ice is broken up into large pieces that have shifted away from one another, but obviously fit together like a jigsaw puzzle," said Galileo imaging scientist, Ron Greeley. "This shows the ice crust has been, or still is,

lubricated from below by warm ice or maybe even liquid water."

After Galileo's prime mission came to an end in December 1997, the spacecraft was granted a two-year extension - known as the Galileo Europa Mission, because its main purpose was to delve deeper into the secrets of the mysterious ice world.

Further flybys convinced most scientists that the smallest of the Galilean moons boasts a subsurface, saltwater ocean that might support alien forms of life. Just as surprising was the discovery that similar oceans may be hidden deep beneath the icy crusts of both Ganymede and Callisto.

World of fire

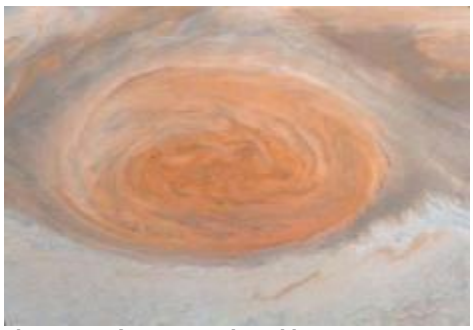
Galileo's first colour image of Io was taken on June 25, 1996 at a distance of 2.2 million km (1.4 million miles). Subsequent long-range views confirmed that major changes had taken place on the volcanic moon since the Voyager flybys 17 years earlier. Clearly visible were the volcanic plumes blasted outwards from violent eruptions and ever-varying patterns of colourful, sulphurous deposits around major centres of activity.

However, it was not until October 1999 that scientists were prepared to risk the spacecraft by exposing it to the intense radiation in the vicinity of Io. High-resolution images (5 to 500 m per pixel) provided spectacular views of lava in many forms - lakes, flows, fountains and curtains. The temperature of the molten rock reached a sizzling 1,700 deg C, making it the hottest lava observed anywhere in the Solar System.

Galileo also imaged huge mountains (some more than twice the height of Everest) plateaus and collapsed calderas, further evidence of Io's tectonically active crust.

Giant Jupiter

Although most attention was focused on the menagerie of moons, turbulent Jupiter also came under scrutiny. Images of the Great Red Spot showed considerable internal structure and a "top hat" shape in which the central region rose 3 - 7 km (2 - 4 miles) above the dense, surrounding clouds. Numerous thunderheads up to 50 km (30 miles) tall were identified just north of the Spot.



The Great Red Spot as seen by Galileo

Galileo's near-infrared spectrometer was also able to detect dry, hot spots where the deeper atmosphere was visible through localised thinning of the main cloud deck.

Other targets of interest were the auroras of Io and Jupiter, the Io torus (a doughnut-shaped cloud of charged particles surrounding its orbit), the dark, dusty rings, some of the smaller moons, and the huge magnetosphere.

Towards the end of its marathon mission, Galileo took part in a unique experiment to explore the Jovian environment. Taking advantage of the fleeting flyby of the Cassini spacecraft, en route to Saturn, scientists organised a joint observational campaign to study the magnetosphere and its interaction with the solar wind. The results provided new insights into the complex bubble of charged particles that surrounds the giant planet.

Grand finale

The final phase of Galileo's epic journey began on November 5, 2002 when the orbiter flew past Amalthea and through part of Jupiter's gossamer ring before beginning its 35th and last orbit around the planet.

During this farewell loop through the Jovian system, Galileo travelled to a point more than 26 million km (16 million miles) from Jupiter - the farthest it had been in almost eight years. It then started the return leg, accelerating towards its doom.

Despite a delayed start and several, potentially devastating, handicaps along the way, Galileo has proved to be one of the most successful planetary missions ever flown, not only in terms of its longevity, but also for the myriad scientific discoveries that have shed new light on the remarkably complex Jovian system.

Swooping through Jupiter's monumental magnetosphere and belts of trapped energetic particles, the orbiter has received more than four times the cumulative dose of radiation it was designed to withstand. Despite this unprecedented battering, Galileo has operated for almost eight years in Jupiter's proximity and completed 34 encounters with Jupiter's moons.

"It has been an astonishing mission, a tribute to the ability of the ground team to overcome the obstacles and achieve a great result," said former Galileo project manager, Eilene Theilig.

An artist's concept of Galileo burning up in Jupiter's atmosphere. : David A. Hardy

Diary

October 8 ***AGM & Members Contributions***

November 12 ***Space Weather*** **- Dr. Andrew Coates of Mullard Space Sciences Laboratory University College London**

December 10 ***The Relevance of Astronomy to Human Culture*** **- Dr Francisco Diego University College London**

January 14 2004 ***The First 3 Minutes of the Universe*** **- Bob Turner F.R.A.S.,**

February 11 2004 ***Solar Neutrinos*** **- Dr. Robert C. Smith University of Sussex**

All Meetings **(bold)** are held on the second Wednesday of every month unless otherwise stated, at Heene Church Rooms, Worthing at 7.30 p.m. Meetings include the latest astronomical work, reports and, photographs by members. For further information please call 01903 521205, on the Internet at *www.was.org.uk* or
Email: *worthing_astronomical_society@hotmail.com*

Executive Committee

Chairman: Brian Halls

7 Ryecroft Court, Penhill Road
Lancing
West Sussex,
BN15 8HJ
Tel: 01903 521205
Email: worthing_astronomical_society@hotmail.com

Vice-Chairman: Bob Turner

21 Beechwood Ave
Worthing
West Sussex
BN13 2HR
Tel: 01903 692522
Email: rfturner@compuserve.com

Secretary: *Post Vacant*

All Correspondence to: The Chairman, Brian Halls at:

7 Ryecroft Court, Penhill Road
Lancing
West Sussex,
BN15 8HJ
Tel: 01903 521205
Email: worthing_astronomical_society@hotmail.com

Assistant Secretary: David Chilard

40 Ferring Street
Ferring
Worthing,
West Sussex
BN12 5HJ
Tel: 01903 501819
Email: dave-ros@tinyworld.co.uk

Treasurer: Michael Marshall

84 Bramley Road,
Worthing,
West Sussex.
BN14 9DT
Tel: 01903 823576

Curator of the Observatory: Graham Boots

101 Ardingly Drive,
Worthing,
West Sussex
BN12 4TW.
Tel / Fax: 01903 505346
Email: grahamboots@observatory99.freeserve.co.uk
Web Site: www.observatory99.freeserve.co.uk

Note to Contributors

Contributions & Correspondence for the **November** issue of WAS NEWS should be with the Editor by **November 1st**. All material for inclusion should be sent to the Editor.

Rob Davis
61 Stirling Court Road,
Burgess Hill
West Sussex
RH15 0PS
Tel: (01444) 239205
Email: wasnews@tiscali.co.uk

a b c d e f g h i j k l m 0 n o p q r s t u v w x y z