ORWELL ASTRONOMICAL SOCIETY (IPSWICH)

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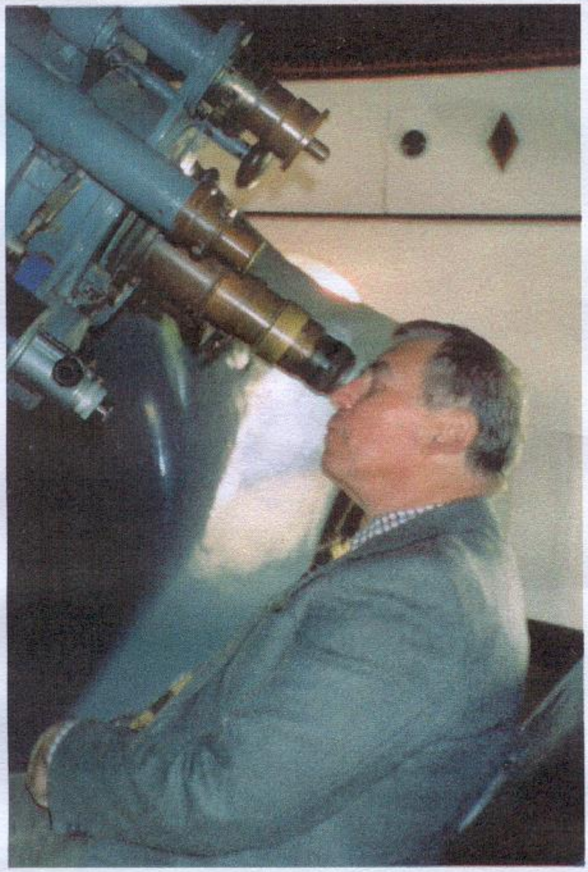
NEWSLETTER – 2005 FEBRUARY



115 years on and a 'Plummer' returns to Orwell Park. John Isaac Plummer's Gt Grandson, Richard Bellamy-Brown, proudly poses on his ancestor's observing couch, 2004 20th December.

More inside…

SOCIETY NEWS FROM THE SECRETARY

Roy Gooding

Society News

1 Subscription Renewal for 2005

If you not already paid for the 2005 session, please return the renewal form enclosed with January's Newsletter to, Martin Cook, together with monies.

2 Events for 2005

Meeting	Venue	Date
Astronomy Workshops	James Appleton Constellation Close-up: Auriga	Wednesday 2nd February
AstroFest	Kensington Town Hall Hornton Street London	Friday 4th and Saturday 5th February
Star Party at Ashcroft Observatory	Ashcroft Observatory [redacted] Ipswich from 19:30 **See note below**	First option: Saturday 12th February. Second option: Saturday 19th February
Lecture Meeting	Members short talks **See note below for new meeting venue.**	Friday 25th February 20:00 start. Doors open 19:15
Astronomy Workshops	Bill Barton Positioning Ourselves - A Look At Trigonometry And Spherical Triangles	Wednesday 2nd March
Visit from Loughton Astronomical Society	Meet at the Shepherd & Dog Pub for a meal **See note below**	Saturday 12th March 17:30
Open Weekend	Orwell Park Observatory **See note below**	Saturday 19th & Sunday 20th March
Astronomy Workshops	Dave McCracken Planetary Atmospheres	Wednesday 6th April
Lecture Meeting	Dr. Alan Chapman This meeting will take place at Orwell park School. More details when they are available	Friday 22nd April
Society Excursion	A return visit to the National Space Centre in Leicester will be arranged if sufficient members are interested. **See note below**	Saturday 7th May
Astronomy Workshops	Wednesday 04 May 2005 Paul Whiting Debris of The Solar System	Wednesday 4th May
BAA Exhibition Meeting	The Cavendish Laboratory Madingley Road Cambridge	Saturday 25th June

FAS Convention	Institute of Astronomy Cambridge	Saturday 1st October Date?
Christmas Meal	Venue to be fixed	Wednesday 14th December

3 Find Your Way Round the Night Sky Meetings (The Night Sky Section)

I plan to continue these meetings throughout the winter period if there is sufficient demand from 20:30, on Wednesday evenings when the Astronomy Workshops are not meeting. There will not be any formal dates when these meetings will take place, as it is so dependent on the weather, and my availability.

If on a clear Wednesday members would like to have a meeting, it can be convened straight away. The proposed observing site is on Nacton shores. This is about a 7 or 8 minute walk from the observatory. **It is important that members bring along a good torch**. The track to Nacton shores can be muddy, so suitable footwear would be advisable. Other items that may be useful are binoculars and simple star maps such Planispheres.

4 New Lecture Meeting Venue

As a trial we will be holding this lecture meeting on Friday 25th February at a hall in the Methodist Church in Museum Street, **but use the entrance in Black Horse Lane.**

The church has a car park, bigger enough to take about 30 cars in Black Horse Lane Alternatively there is a Park & Display car park at the top of Black Horse Lane, next too the Town Council block. This is about 100 yards form the church.

Black Horse Lane has only one entrance, which is from Elm Street. This is just past the Police Station, if you are arriving from Civic Drive. The church car park is on the right, just past the Black Horse pub.

Meeting starts at 20:00, doors open at 19:15

5 Visit by Loughton Astronomical Society on Saturday 12th March

This will follow the usual external Society visiting arrangement. Any interested member is invited to come along to the Shepherd & Dog Restaurant at 17:30 for a meal and a chat with this group, before proceeding on to the observatory.

6 Open Weekend 2005 Saturday 19th and Sunday 20th March From 19:00 to 22:00

As usual as much help as possible from members is required for this annual fund raising event, please come along and give a hand.
A poster is included with this Newsletter. Please find it a good home.

Dates	**Saturday 19th March**
Moon Phase	1st quarter 17th March
Mercury	Sets 19:50
Jupiter	Rises 19:30
Saturn	Visible all night

7 Ashcroft Observatory Star Party

Option 1: Saturday 12th February.
Option 2: Saturday 19th February
From 19:30

I will be opening my observatory and garden for another Star Party in February. Its setting is not perfect, but considering it is a town observatory it is probably in one of the better positions available in northern Ipswich. I am able to see over 75% of the sky, and being in a hollow, much of the surrounding streetlights are screened from sight.

If it is cloudy on the Saturday 12th, the meeting will be rearranged to the alternative date of Saturday 19th February. Watch this space if it's cloudy on both evenings

If you are interested in attending please contact me, (Roy Gooding: Home ', Work). I should be able to accommodate at least a dozen members quite easily, so please confirm your interest early, it will be first come first served. These numbers may be flexible if demand is greater then expected. If the weather is good to us I may even consider running a Star Party on both evenings.

Unlike Orwell Park Observatory, my observatory can only accommodate 3 people easily at a time, so people will have to queue. However, on the plus side I do have a reasonable size garden, with an additional over flow into my neighbour's garden. This gives plenty of space in which telescopes can be set up. While you are waiting, there will be a selection of smaller telescopes to use. In fact it will be similar to the arrangements will have at Nacton, with the advantage of being able to see much more of the night sky. I have several smaller telescopes, ranging in size form 70 to 140mm and binoculars up to 11x 80s. At the AGM it was suggested that the MMT might be brought along if it has been completed.

Ashcroft Road is normally full with parked cars in the evening, so you may have to park some distance away. Please come round to the back garden when you arive.

8 Summer Excursion Saturday 7th May

I will arrange a visit to the National Space Centre in Leicester if sufficient members are interested. Before I book a coach and obtain tickets, I need a minimum number to make this trip financially viable. This minimum number is 35.

The last excursion was run at a loss, costing the society over £200, so I need as many members as possible to make this trip a success.

If you are interested, please contact me Roy Gooding straight away

9 Society Equipment Inventory

I would like to compile an inventory of society member's astronomical equipment. If you would like to participate please supply me with a list of what observational equipment you have. This inventory list with the relevant names will remain with in the society. Though the total numbers of each class of instrument maybe added to the Society Web site.

10 Welcome to New Members

William James and Dawn Bostock have joined since the last Newsletter was published

Night Sky (February)

All times GMT

Sun

The sun will be rising approximately between 07:30 to 06:50
The sun will be setting approximately between 16:50 to 17:30

Moon

3rd Quarter	New Moon	1st Quarter	Full Moon
2nd	8th	16th	24th

Mercury Mercury is at superior conjunction on the 14th. It will move back into the evening sky in March.

Venus Venus has moved to close to the sun this month and will not be observable

Mars Mars is visible in the morning sky this month .It will be rising before 05:00 this month. Magnitude 1.2

Jupiter Jupiter is presently in Virgo, it will be rising at about 21:00 by the end of the month. Magnitude –2.3

Saturn Saturn is Gemini this month, it will setting at about 05:00 by the end if the month. Magnitude –0.2

Uranus Uranus is in conjunction on the 25th.

Neptune Neptune is conjunction on the 3rd

Meteor Showers

There are no prominent meteor showers visible this month

OCCULTATIONS DURING FEBRUARY

The table lists stellar occultations which occur during the month under favourable circumstances. The data relates to Orwell Park Observatory, but will be similar at nearby locations.

D R	Date & Time (UT)		Lunar Phase	Sun Alt (°)	Star Alt (°)	Star	Mag
D	13 Feb	18:46	0.28+	-16	38	ZC 264	7.1
R	15 Feb	17:48	0.47+	-7	59	63 Ari (double)	5.1
D	19 Feb	20:15	0.83+	-28	64	ZC 1067	7.2
D	20 Feb	02:01	0.85+	-43	31	47 Gem	5.8
D	20 Feb	02:55	0.85+	-37	22	Hip 34830	7.4
D	20 Feb	04:36	0.86+	-23	9	ZC 1105 (double)	6.4
D	20 Feb	04:50	0.86+	-21	7	Hip 35273	7.3
D	21 Feb	00:33	0.91+	-48	50	2 Cnc	5.9

James Appleton

ORWELL ASTRONOMICAL SOCIETY (IPSWICH)
http://www.oasi.org.uk/

PUBLIC OPEN WEEKEND

Visit One of the Few Remaining Operational Victorian Observatories
Located at Nacton off the A1156 between Ipswich and Felixstowe

THE ORWELL PARK OBSERVATORY WILL BE OPEN TO THE PUBLIC ON

SATURDAY 19th March From 7:00pm to 10:00pm
SUNDAY 20th March From 7:00pm to 10:00pm

The weekends programme includes:

OBSERVATIONS OF THE MOON, JUPITER, SATURN and the NIGHT SKY

Observatory Tower using the 10" Tomline Refractor and other small telescopes and in the field using naked eye and small telescopes

If you have a pair of binoculars we recommend that you bring them with you and please come with warm clothing

An alternative programme of talks and slide shows will be arranged if weather conditions are not suitable for observations

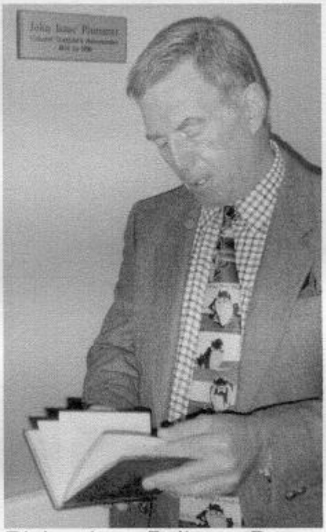
Entrance by Donation	
Child & Senior Citizen	**£1**
Adult	**£2**

Honorary Secretary
Roy Gooding
168 Ashcroft Road
Ipswich
IP1 6AE

A REUNION AFTER 115 YEARS

On Monday 20th December, Orwell Park was delighted to welcome a very special visitor – Richard Bellamy-Brown – the Gt Grandson of Colonel Tomline's paid astronomer, John Isaac Plummer FRAS. Richard has recently retired to Italy after a long and successful career in the British Army, where he rose to the rank of General. He is now using his newfound spare time to trace his ancestors and found out about his Gt Grandfather by trawling the Internet and happening upon the OASI web site.

OASI members Garry Coleman, Paul Whiting and Ken Goward took great delight in showing Richard around the Observatory and explaining at length his family ties to Orwell Park. Richard also kindly posed for photographs at the eyepieces of the Tomline Refractor and the Transit Instrument, thereby recreating scenes of more than a century ago. Luckily, the December Suffolk sky was clear and Richard was greatly impressed with an ad hoc spot of Solar Projection from the Tomline. Luckier still, as a large sunspot obligingly graced the projected image and Richard was fascinated by Paul's explanation of the phenomena. The school Headmaster, Andrew Auster, found time to meet Richard and kindly presented him with a souvenir decorated Orwell Park School mug. Richard's visit was rounded off by a congenial lunch at the nearby Shepherd & Dog Carvery, after he'd taken a few moments to stop and photograph Orwell Dene, previously known as the Astronomer's House built specially for his Gt Grandfather by Col Tomline.



Richard Bellamy-Brown examines the OASI copy of J I Plummer's 1872 edition 'Introduction to Astronomy' in our new Library. The library was dedicated in JIP's memory last spring.

Above photograph and front cover by K Goward

At the OASI AGM on 15th January, Richard Bellamy-Brown was proposed and elected as a Hon member of OASI, in the same manner as our good friends, the Airy family. Welcome to OASI Richard, we look forward to a long and happy association with the Plummer family.

Kenneth J Goward FRAS
Chairman

ESTIMATES OF THE ASTRONOMICAL UNIT BASED ON OASI OBSERVATIONS OF THE TRANSIT OF VENUS, 08 JUNE 2004

James Appleton

The Transit of Venus (TOV) on 08 June 2004 was long awaited and much anticipated! Many members of OASI observed the TOV, and I compiled their observing reports into a four-part article in the October 2004 – January 2005 Newsletters. At the end of that article, I promised a more detailed analysis of the timings recorded by OASI observers – this article fulfils that promise!

The OASI Web site contains an article summarising all the observing reports and analysis completed to date. It can be accessed at:

www.OASI.org.uk → Observations → Transit of Venus, 08 June 2004

1 HISTORICAL PERSPECTIVE

The mean distance from the Earth to the Sun is known as the Astronomical Unit or AU: the currently accepted values are as follows:

- 149,597,870 km (IAU 1976 system of constants)
- 149,597,870.66 km (best modern estimate)

The Earth's orbit has relatively low eccentricity, and the minimum and maximum values of the Earth – Sun distance are as follows: 0.983 AU and 1.017 AU. To a first approximation therefore, the Earth – Sun distance at any time may be taken equal to the AU, even though strictly this is true only in an average sense.

Historically, astronomers used observations of the TOV to estimate the Earth – Sun distance. Knowledge of this distance was very important to early astronomers to support the formulation of accurate theories of Solar System dynamics necessary for the prediction of astronomical phenomena for navigation.

The three most noteworthy astronomers involved in using the TOV to estimate the Earth – Sun distance were Jeremiah Horrocks (~1619 – 1641), an English astronomical genius, Edmond Halley (1656 – 1742), famous for the comet that bears his name, and Simon Newcomb (1835 – 1909), a Canadian-born American mathematical genius and astronomer.

Horrocks

On 24 November 1639 OS, Jeremiah Horrocks and his friend William Crabtree became the first people ever to observe a TOV. (Note that OS refers to Old Style, i.e. Julian Calendar, used in England prior to 14 September 1752.) Horrocks' method to estimate the Earth-Sun distance was inherently incapable of producing accurate results; nevertheless it is of interest because of its historical significance. In essence, his method was as follows:

1. Use the relative orbital periods of the Earth and Venus to relate the angles subtended by the radius of Venus to heliocentric and topocentric observers during a TOV.
2. Assume that the Earth subtends the same angle to a heliocentric observer as does Venus. Clearly this is a false assumption, but in Horrocks' time there was no reason to doubt it, and it does hold very approximately for the terrestrial planets Mercury, Venus, Earth and Mars.
3. Estimate the angular diameter of Venus during the TOV by comparing it with angular diameter of the Sun, considered known or estimated by other means.
4. Calculate the Earth – Sun distance directly by definition of the half-angle subtended by the Earth to a heliocentric observer.

Horrocks' estimate of the Earth – Sun distance was 95,700,000 km, approximately 64% of the currently accepted value. At the time, no astronomical constant was known accurately, so Horrocks could take nothing for granted – undoubtedly his need to estimate the apparent diameter of the Sun contributed to the error of his estimate of the Earth – Sun distance.

Halley

In 1716, some 77 years after Horrocks' observation, Edmund Halley presented a proposal, known as an *Admonition*, to the Royal Society for observing the next TOV in 1761. (Halley was almost 60 at the time, so did not live to see the TOV.) Halley's admonition included predictions of the circumstances of the TOV, recommended observing locations worldwide and outlined a technique to use the observations of the TOV to estimate the Earth – Sun distance.

Halley's approach relied on measurements of contact times of the TOV. The contact times are defined as follows:

1st contact: the limb of Venus first appears to touch the solar limb.

2nd contact: the disk of Venus first appears totally inside the solar disk.

3rd contact: the last instant at which the disk of Venus appears totally inside the solar disk.

4th contact: the last instant at which the limb of Venus touches the solar limb.

Fundamentally, Halley's approach relies on the well known parallax effect, whereby observers at different locations on the Earth see bodies in the Solar System at slightly different apparent locations and therefore witness the same event occur at slightly different times. By applying geometrical techniques equivalent to the triangulation employed by terrestrial cartographers, it is possible to combine observations from different locations on the Earth to estimate the distance of celestial objects. Halley proposed to combine results from observers spread widely over the globe, and thereby obtain an accurate estimate of the Earth – Sun distance.

Halley's approach required observations of 2nd and 3rd contact at each of two well-separated observing stations. A variant of Halley's approach, known as De Lisle's method (named after its originator) requires only an observation of either 2nd contact at two well-separated observing stations or of 3rd contact at two well-separated observing stations.

Newcomb

Although observational difficulties and in particular the well-known teardrop effect limited the accuracy of timings of the TOV, using timings from astronomers worldwide for the 1761, 1769, 1874 and 1882 TOVs, Newcomb, working at the US Navy Observatory (USNO), calculated a value for the AU of 149,590,000 km, only 0.005% different from the currently accepted value.

Newcomb's calculations represented the culmination of efforts in the Victorian era to utilise the TOV to estimate the Earth – Sun distance. Subsequent to the TOV of 1882, astronomers adopted other methods to measure the scale of the Solar System, including in the modern era the use of direct radar ranging and spacecraft tracking.

2 TIMINGS BY MEMBERS OF OASI

On 08 June 2004, many members of OASI observed the TOV, and some of the observers recorded contact times. Table 1 lists all observers who reported contact times to me.

Observer	Location	Instrument & Measurement
M Cook, J Appleton, G Coleman	Orwell Park	Tomline Refractor used to project an image of the Sun (approximately 50cm in diameter.) Contact times estimated visually using audio tape and Rugby clock as timing reference, also estimated by later analysis of a video recording synchronised to the Rugby clock.
G Pilling, P O'Sullivan	Orwell Park	250mm Dobsonian reflector (stopped down to 180mm and fitted with a mylar solar filter). Rugby clock used as timing reference.
W Barton	Orwell Park	50mm refractor fitted with Hydrogen-alpha filter. Rugby clock used as timing reference.
D & A McCracken	Skelling-thorpe, Lincs	Meade ETX70 refractor fitted with full aperture solar filter. 70 mm aperture, 350mm focal length. Celestron WA80 refractor used to project the solar image onto white card. 80mm aperture, 400mm focal length. Oregon radio controlled watch used as timing reference with digital stopwatch used to estimate contact timings.
A Smith	Grundis-burgh	75mm equatorially mounted refractor using a WW I (Great War) gunsight as eyepiece. The telescope projected an image approximately 150mm in diameter onto a translucent screen behind the eyepiece. Contact times estimated from the onboard camera clock synchronised to a Rugby radio clock.

Table 1. OASI observers of the TOV.

Table 2 contains the observers' estimates of contact times. Note that some observers did not observe or record all event times.

Observer	Method	Estimated Timings (UT)			
		1st C	2nd C	3rd C	4th C
J Appleton	Visual	05:20:15	N/A	11:04:00	11:23:12
W Barton	Visual	05:20:14	05:39:20	N/A	11:22:53
M Cook	Visual	05:20:15	05:38:40	11:03:45	11:23:12
D & A McCracken	Visual	05:21:56	05:39:08	11:03:31	11:22:31
G Pilling & P O'Sullivan	Visual	05:20:30	05:39:20	11:03:58	11:22:52
A Smith	Visual	N/A	05:40:10	11:03:44	11:22:55
G Coleman	Video	05:20:12	05:38:11	11:03:57	11:23:19
M Cook	Video	05:20:14	05:38:53	11:04:11	11:23:13
A Smith (see note below)	Video	05:18:25	05:38:48	11:03:20	11:23:10

Table 2. OASI estimates of contact times for the TOV.

Note: Alan Smith suffered from a particularly fraught observation of 1st contact! He suffered disruption caused by a local power cut less than five minutes before 1st contact, and this was compounded by confusion over the quadrant of the solar limb on which Venus would first appear. As a result, Alan did not observe or record the phenomenon of 1st contact itself, and he was forced to use backwards extrapolation from later frames of his video recording to estimate the time of 1st contact listed above. The inaccuracy inherent in this approach is evident in the analysis below.

3 ANALYSIS OF TIMINGS BY HORROCKS' METHOD

At Orwell Park Observatory, Patrick Cook was one of the observers watching the projection of the TOV by the Tomline Refractor. Patrick sketched the position of Venus against the solar disk approximately every 30 minutes throughout the TOV.

During his sketching, Patrick measured the diameters of the projected disks of Venus and the Sun as 15 mm and 511 mm respectively. (In fact, use of a rather poor quality eyepiece resulted in noticeable radial distortion towards the edge of the image. The measurement of Venus' diameter quoted here is taken in a circumferential direction not affected by the radial distortion of the eyepiece). Using Patrick's measurements and treating the following as known quantities:

Siderial period of Venus:	224.701 days,
Siderial period of Earth:	365.256 days,
Equatorial diameter of Earth:	12,757 km,
Apparent solar diameter on 08 June 2004:	1890.8 arcsec,

Horrocks' method gives an estimate for the Earth – Sun distance of 124,000,000 km (*c.f.* the currently accepted value 149,597,870.66 km and Horrocks' estimate in November 1639 of 95,700,000 km). The effect of neglecting the radial distortion of the eyepiece is to make the estimate of the Earth – Sun distance larger than it would otherwise be; it is not possible to compensate for this inaccuracy as the radial distortion profile of the eyepiece is unknown.

4 ANALYSIS OF TIMINGS BY BBC/OU CALCULATOR

The BBC and OU (Open University) ran a website at the following url supporting observations of the TOV:

http://www.open2.net/prog_pages/transit_of_venus.html

The OU/BBC website provides a calculator for estimating the Earth – Sun distance based on the observer's timing of 3rd contact. The calculation is based on De Lisle's method and utilises an additional, unspecified timing of the TOV made far south of the UK in South Africa.

Table 3 lists estimates of the Earth – Sun distance calculated by the BBC/OU website from timings of 3rd contact by OASI observers. It lists estimates in km and as a percentage of the currently accepted value.

Observer	Method	Estimate of E-S Distance (km)	% of Accepted Value
J Appleton	Visual	149,700,000	100.1%
M Cook	Visual	145,800,000	97.5%
D & A McCracken	Visual	143,600,000	96.0%
G Pilling & P O'Sullivan	Visual	149,200,000	99.7%
A Smith	Visual	145,500,000	97.3%
G Coleman	Video	148,900,000	99.5%
M Cook	Video	152,600,000	102.0%
A Smith	Video	139,700,000	93.4%

Table 3. Estimates of the Earth – Sun distance by the BBC/OU calculator.

Unfortunately, a question mark hangs over the accuracy of the calculator on the BBC/OU website. To see why, consider the following:

1. The USNO (former workplace of Simon Newcomb) provides definitive predictions of astronomical phenomena, using the latest and most accurate ephemeris data. The USNO makes its predictions available on its web site:

   http://aa.usno.navy.mil/data/docs/Transit.html

The USNO gives a predicted timing of 3rd contact at Orwell Park of 11:04:03 UT.

2. At the time of 3rd contact predicted by the USNO, the distance between the Earth and the Sun, computed by the NASA JPL reference ephemeris DE-405, was 151,851,436 km (1.0150642 AU).

3. The BBC/OU web site gives an Earth-Sun distance of 150,460,000 km (0.99084 AU) for the USNO's predicted time of 3rd contact. This is clearly different from both the currently accepted length of the AU and the instantaneous Earth-Sun distance (from DE-405) at the time.

The above discrepancy prompted me to re-examine techniques for estimation of the AU from observers' estimates of contact times.

5 ANALYSIS OF TIMINGS BY DIRECT METHOD

Using the power of modern computers, it is possible to apply a more direct approach to estimating the Earth – Sun distance than Halley or De Lisle and to calculate an estimate of the AU directly from every single recorded contact time. A modern PC can utilise a high-precision reference ephemeris (e.g. DE-405) to compute in a matter of seconds an accurate prediction of the four contact times for the observer's location. By repeating the calculation for different hypothetical values of the AU, it is possible to compile a table of the predicted contact times as a function of the assumed length of the AU. To estimate the AU, the observer need only look down the table to see which assumed value of the AU provides a predicted contact time equal to the measured contact time.

Note that the above approach estimates the length of the AU directly, not the instantaneous value of the Earth – Sun distance like Horrocks' method. Further, it is based upon accurate values for all other astronomical quantities involved in the calculations, with the only unknown being the length of the AU. It therefore offers the promise of a more accurate estimate than other approaches which rely on estimation of intermediate quantities together with the AU itself.

I applied the above approach (*direct method*) to the OASI estimates of contact times of the TOV, using the algorithms given in *Astronomy On The Personal Computer* (by O Montenbruck and T Pfleger, Springer-Verlag, 1999) and the ephemeris DE-405 to compute predictions of the contact times for each observer's location.

I performed two checks on the basic accuracy of the direct method using predictions from the USNO as reference data. Both checks showed good agreement with the reference data.

1. Comparison of predicted contact times from USNO with those of the direct method (based on the currently accepted value of the AU) for

Orwell Park Observatory. Table 4 shows the results, with a worst-case discrepancy of two seconds:

	Predicted Times (UT)	
Contact	**USNO**	**Direct Method**
1st	05:19:57	05:19:56
2nd	05:39:40	05:39:40
3rd	11:04:03	11:04:02
4th	11:23:25	11:23:23

Table 4. Comparison of predicted contact times.

2. Application of the direct method to the time of 3rd contact predicted by the USNO for the location of Orwell Park Observatory (11:04:03 UT). The direct method gives a value for the AU of 149,590,400 km, equal to 99.995% of the currently accepted value, clearly very close to the nominal value of 100%.

Table 5 gives the results, listing for each observer the corresponding estimate of the AU expressed as a percentage of the currently accepted value.

		Estimated Length Of AU (%)			
Observer	**Method**	**1st C**	**2nd C**	**3rd C**	**4th C**
J Appleton	Visual	100.1%	N/A	100.0%	100.1%
W Barton	Visual	100.1%	99.9%	N/A	100.2%
M Cook	Visual	100.1%	99.7%	100.1%	100.1%
D & A McCracken	Visual	100.7%	99.9%	100.1%	100.3%
G Pilling & P O'Sullivan	Visual	100.2%	99.9%	100.0%	100.2%
A Smith	Visual	N/A	100.2%	100.1%	100.1%
G Coleman	Video	100.1%	99.5%	100.0%	100.0%
M Cook	Video	100.1%	99.8%	100.0%	100.1%
A Smith	Video	99.5%	99.7%	100.0%	100.1%

Table 5. Direct estimates of the length of the AU from the TOV.

Figure 1 illustrates the results.

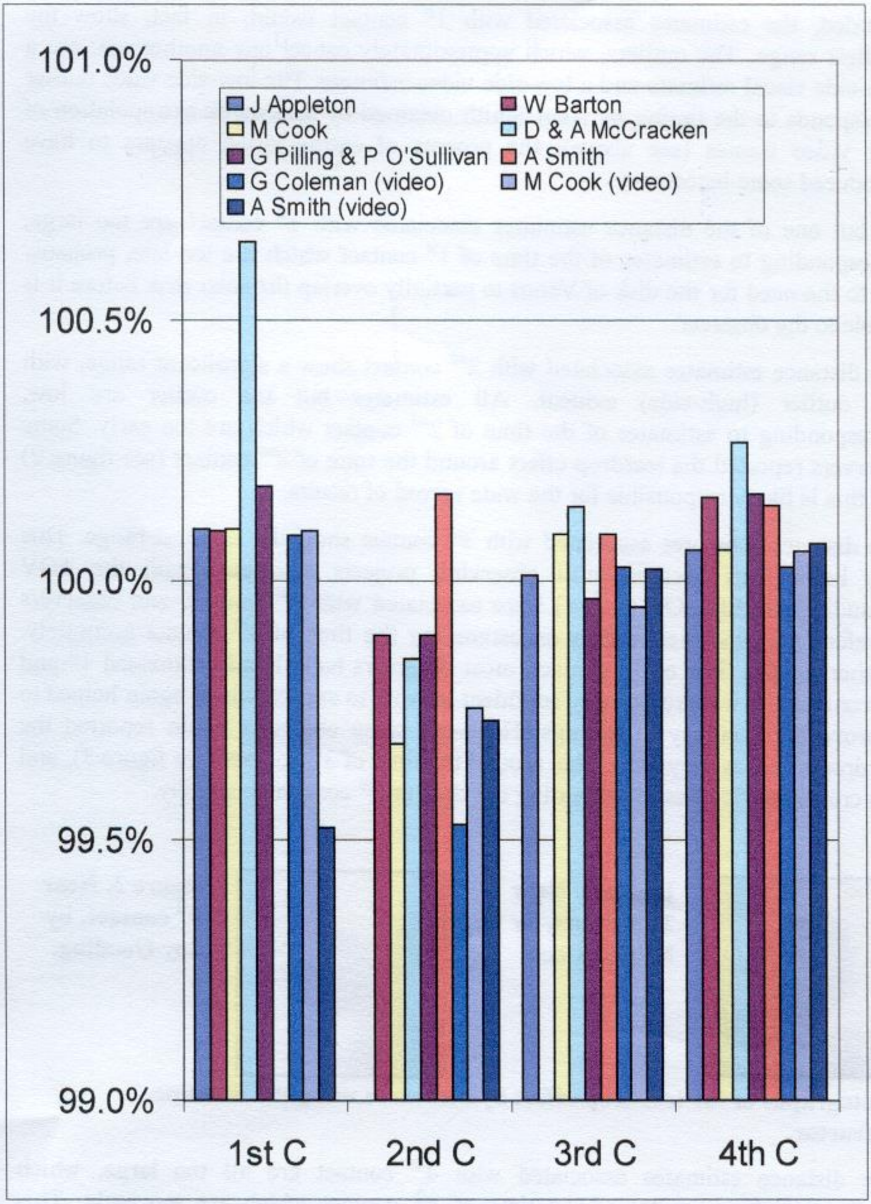


Figure 1. Direct estimates of the length of the AU.

The distance estimates associated with 1st contact show the greatest range. However, this is largely due to the presence of two outliers; if the outliers were excluded, the estimates associated with 1st contact would, in fact, show the smallest range. The outliers, which approximately cancel one another out, are a high-side visual estimate and a low-side video estimate. The low-side video outlier corresponds to the timing by Alan Smith obtained by backwards extrapolation of later video frames (see above): the process of extrapolation appears to have introduced some inaccuracy.

All but one of the distance estimates associated with 1st contact are too large, corresponding to estimates of the time of 1st contact which are too late, probably due to the need for the disk of Venus to partially overlap the solar disk before it is visible to the observer.

The distance estimates associated with 2nd contact show a significant range, with one outlier (high-side) evident. All estimates but the outlier are low, corresponding to estimates of the time of 2nd contact which are too early. Some observers reported the teardrop effect around the time of 2nd contact (see figure 2) and this is likely responsible for the wide spread of results.

The distance estimates associated with 3rd contact show the smallest range. This may be in part because most observing projects associated with the TOV (including the BBC/OU project) were associated with 3rd contact, and observers therefore focussed their efforts on estimating the time of 3rd contact accurately. Further, by the time of 3rd contact, most observers had already witnessed 1st and 2nd contact and were reasonably confident in what to expect, which again helped to improve the accuracy of timings. However, some observers again reported the teardrop effect as very noticeable around the time of 3rd contact (see figure 3), and this created difficulties in estimating the time of 3rd contact accurately.

Figure 2. Near 2nd contact, by Martin Cook.

Figure 3. Near 3rd contact, by Roy Gooding.

Photographs of the teardrop effect by observers using the Tomline Refractor.

The distance estimates associated with 4th contact are all too large, which corresponds to estimates of the time of 4th contact which are too early. This suggests that the observers were too hasty in judging the instant at which the last segment of Venus left the solar disk.

In general terms, estimates based on analysis of a video recording of the event did not prove to be significantly more accurate than those based on the best visual timings. This result is somewhat unexpected, as prior to the TOV there had been much interest in using video recordings with subsequent frame-by-frame analysis to obtain highly accurate estimates of contact times.

Averaging all the OASI estimates in table 5 gives the following estimate of the AU: 149,622,000 km or 100.02% of the currently accepted value.

6 TRANSIT OF MERCURY 07 MAY 2003

It is possible to apply techniques for analysis of the TOV to a transit of Mercury (TOM). On 07 May 2003, members of OASI observed the last TOM from Orwell Park Observatory and from other locations within the UK. Details are in the July 2003 Newsletter and on the OASI Web site at:

www.OASI.org.uk → Observations → Transit of Mercury, 07 May 2003

Results of applying the above analysis methods to OASI timings of the TOM are as follows.

Horrocks' Method

OASI observers did not measure the apparent sizes of Mercury and the Sun. However, I was able to estimate the relative apparent sizes of Mercury and the Sun as 1:128 from photographs taken of the event at Orwell Park Observatory (image projection using the Tomline Refractor).

Treating the following as known quantities (*c.f.* section 3):

Siderial period of Mercury:	87.969 days,
Siderial period of Earth:	365.256 days,
Equatorial diameter of Earth:	12,757 km,
Apparent solar diameter on 07 May 2003:	1902.1 arcsec,

Horrocks' method gives an estimate for the AU of 112,000,000 km, significantly worse than the estimate based on observations of the TOV. The added inaccuracy is due partly to the inherent inaccuracy of the method and partly to the small apparent size of Mercury and the attendant difficulty in accurately measuring it.

Direct Method

Thick cloud prevented observation of the ingress phase of the TOM, so OASI observers reported timings only for the egress phase, as detailed in table 6. All timings were made by direct visual methods using a Rugby clock as timing reference (not post-event analysis of video recordings). Note that the observers reported the timings as potentially inaccurate as the images were not crisp at the solar limb.

	Estimated Timings (UT)	
Observer	**3rd Contact**	**4th Contact**
Various observers at Orwell Park Observatory	10:28:23	10:32:23
Dave McCracken, Skellingthorpe, Lincs (timings adjusted for observer's personal equation)	10:28:20	10:31:28

Table 6. OASI estimates of contact times for the TOM.

Table 7 (c.f. table 5) shows the estimates of the length of the AU obtained from analysis of the timings in table 6.

		Estimated Length Of AU (%)			
Observer	**Method**	**1st C**	**2nd C**	**3rd C**	**4th C**
Orwell Park Observers	Visual	N/A	N/A	100.1%	100.1%
D McCracken	Visual	N/A	N/A	100.0%	100.4%

Table 7. Direct estimates of the length of the AU from the TOM.

Averaging the four estimates in table 7 gives an estimate of the length of the AU of 149,826,000 km or 100.15% of the currently accepted value.

7 CONCLUDING REMARKS

Members of OASI enjoyed successful observations of the TOM on 07 May 2003 and the TOV on 08 June 2004. Modern computers give a direct means of estimating the length of the AU from observations of transits. Applying the direct approach to OASI timings yields the following estimates for the AU -

- Transit of Mercury: 149,826,000 km (100.15% of currently accepted value).
- Transit of Venus: 149,622,000 km (100.02% of currently accepted value).

Clearly, both estimates represent very creditable work for a group of amateur astronomers!

A Pulsar Investigation

Paul Whiting *FRAS*

Introduction & Background

The aim of this experiment was to use the 42ft radio telescope at Jodrell Bank Observatory to measure an effect known as *pulse dispersion* of a pulsar and use timing analysis to investigate the electron density along the line-of-sight to this pulsar and its distance.

On its way to the Earth the pulsed radiation passes through ionised plasma in the interstellar medium. The speed of light varies according to the refractive index of the medium through which it is passing, and since the refractive index is a function of frequency, the radiation experiences a frequency-dependent delay, ie. the interstellar medium is dispersive. Higher frequency radiation travels faster/arrives earlier than lower frequency RF.

From the difference in arrival time of pulses at varying frequencies, a calculation can be made of the *dispersion measure*, which is defined as being the integrated electron number density along the line-of-sight distance to the pulsar.

$$DM = \int_{\text{pulsar}}^{\text{Earth}} n_e \, dl$$

where n_e is the electron density

If the asumption is made that the electron density is constant over the distance L to the pulsar, then this integral reduces to

$$DM = n_e L \qquad \text{... equation 1}$$

The usual units for this dispersion measure are $cm^{-3}pc$, ie. number of electrons per cubic centimetre over a distance in parsecs. Given one parsec is 3.1×10^{18} cm, the time delay due to dispersion is given by

$$t = DM / (2.410 \times 10^{-4} . \upsilon^2_{MHz}) \text{ seconds} \qquad \ldots \textit{equation 2}$$

where υ_{MHz} is the frequency in MHz

Hence if the time of arrival of pulses is measured when observed at different frequencies, the Dispersion Measure can be calculated.

The dispersive effect of the interstellar medium causes initially sharp pulses to become smeared in addition to the time delay introduced, when observed with a finite bandwidth receiver. This pulse-smearing effect must be removed by special-purpose electronics, called *de-dispersers*, in order to restore the original signal-to-noise ratio.

Procedure

The first decision was to decide which of a number of candidate pulsars was to be observed. The criteria for this decision were as follows:

- Proximity of the pulsar to the Sun or other strong local noise sources
- Height of the pulsar above the horizon, for the duration of the observation

These considerations would maximise the signal to noise ratio.

A simple tool giving time of day and azimuth/altitude position was used to help make this decision.

Before using the telescope, the assumption was made that it was set-up for reception within the band around 608 MHz and that it was available for use!

To make the first observation the following procedures were undertaken.

- Set the telescope observing parameters.
  - Integration time of 300 seconds, ie. the accumulation of signal from the pulsar. A longer acquisition time would produce smoother results but a trade off had to be made with time available for the observation.
  - Number of bins to 500, ie. the number of integration registers to be used to sample the signal.

- Set the source parameters.
  - The name of the pulsar to be observed - the detail of which was retrieved from an on-line database of objects.

The observation was then started at 608 MHz.

Following execution of the observation a plot of the pulse profile (combining both left and right hand polarizations) was produced and printed.

Next, the observing parameters were changed to localise the plot to measure the pulse in more detail, and the observation was repeated, again at 608 MHz.

The resulting plot was printed to obtain a hardopy for analysis.

A series of plots using these localised plot parameters were repeated for frequencies between 606 MHz and 611Mhz, in 1MHz steps.

Results

It was decided that Pulsar 1933+16[1] would be the best choice to observe given the time of the experiment.

At the conclusion of the experiment six plots were obtained, a sample of which is given below.

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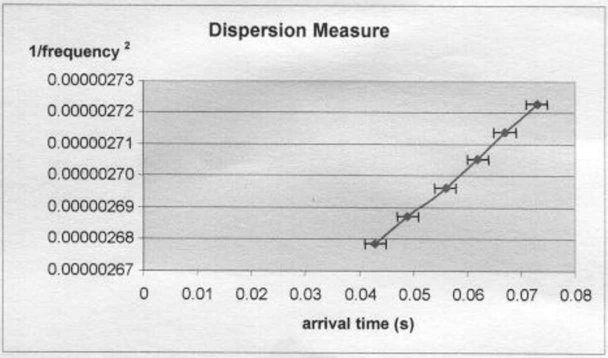
[1] So named after its Right Ascension and Declination, viz. 19 hrs 33 mins RA +16 degrees Dec.

A graph of arrival time versus frequency $^{-2}$ was plotted.

Frequency (MHz)	Frequency $^{-2}$ (MHz $^{-2}$)	Arrival time (s)
606	2.7230×10^{-6}	0.073
607	2.7141×10^{-6}	0.067
608	2.7052×10^{-6}	0.062
609	2.6963×10^{-6}	0.056
610	2.6875×10^{-6}	0.049
611	2.6787×10^{-6}	0.043

The error estimate for the arrival time was ± 0.002 seconds.

The graph of arrival time versus frequency $^{-2}$ was plotted.



From *equation 2* above, it can be seen that the gradient of this graph will give a value to the Dispersion Measure (DM), as the equation is equivalent to that of a straight line.

To derive this measure, the best fit line was derived. This will give an estimate of the Dispersion Measure.

Best Gradient Fit:

$\delta y = 0.0444 \times 10^{-6}$
$\delta x = 0.0315$

$\delta y/\delta x = 1.409 \times 10^{-6}$

$\therefore$ DM $= 2.41 \times 10^{-4} / 1.409 \times 10^{-6} = 171.04$ cm^{-3} parsecs

The best fit value is therefore

171 ± 30 cm^{-3} parsecs

From *equation 1* above, using an estimate for n_e, the average electron density along the line of sight, of 0.02 electrons per cm ^{3} , an estimate can be made of the distance of the pulsar.

$L = DM / n_e$

Using greatest and least values for DM derived above, a value for L is obtained of

8550 ± 1000 parsecs

Conclusion

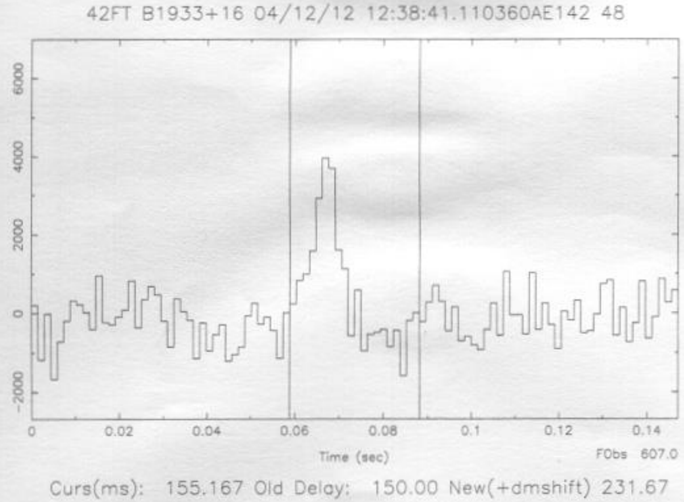
The calculated value for the Dispersion Measure for the line of sight to pulsar 1933+16 was found to be 171 ± 30 cm^{-3} pc.

The derived value for the distance of the pulsar, assuming an average value for the electron density of the line of sight path of 0.02 cm^{-3}, was found to be 8550 ± 1000 parsecs.

The actual value quoted for the dispersion measure is 158 cm^{-3} pc, which agrees well with the observed value. A more accurate value may have been obtained by one or both of the following:

- employing a more accurate way of measuring the pulse arrival times, or better,
- using a longer data acquisition time, which would produce a better defined and sharper pulse.

The quoted value for the distance of the pulsar is 7900 parsecs, which again agrees well with the calculated value of 8550 ± 1000 parsecs.



Plot at Observing frequency: 607 MHz

I would like to thank Dr Tim O'Brien at Jodrell Bank Observatory for his help with this experiment.

OASI COMMITTEE CONTACTS & RESPONSIBILITIES

Kenneth J Goward FRAS	**Chairman**	☎	Press Publicity with the Secretary. Open Weekend.
Roy Gooding	**Secretary**	☎	**Main point of Society Contact.** Press Publicity with the Chairman. Observatory Decoration. Visits by potential new members.
Garry Coleman	**Treasurer**	☎	Finance. Supervision of Grant Applications.
James Appleton	Committee	☎	Committee Meeting Minutes. Web site.
Martin Cook	Committee	☎	Membership. Tomline Refractor Maintenance.
Neil Morley	Committee	☎	Equipment Curator.
Ted Sampson	Committee	☎	Workshops. Tomline Refractor tutoring.
Eric Sims	Committee	☎	Newsletter
Mike Whybray	Committee	☎	Librarian.
Paul Whiting FRAS	Committee	☎	Visits by outside groups.
Bill Barton FRAS	Committee		Safety & Security
Peter Richards	Working under Committee direction but not Co-opted		Lecture Meetings.

DIARY FOR FEBRUARY

MONDAY	**SMALL TELESCOPES OBSERVING NIGHTS** 7th 8pm - Orion 21st 8pm – Gemini, Canis Major & Minor ☎ Paddy O'Sullivan
WEDNESDAY	**OBSERVATORY CLUB NIGHTS** 2nd, 9th, 16th, 23rd ☎ Martin Cook
WEDNESDAY 2nd **Science Classroom**	**ASTRONOMY WORKSHOP** From 7.45pm *CONSTELLATION CLOSEUP - AURIGA* Presented by James Appleton ☎ Ted Sampson
THURSDAY	**OBSERVATORY VISITS BY OUTSIDE GROUPS** 3rd 8pm – Wattisham ATC 24th 8pm – Institute of Quality Assurance ☎ Paul Whiting FRAS
FRIDAY **25th at 8pm** **Museum Street Methodist Hall, Black Horse Lane, Ipswich.** ****NEW VENUE****	**LECTURE MEETING** SHORT TALKS BY OASI MEMBERS • *'HARK THE AURORA'* Paul Whiting FRAS • *'AN UNUSUAL PLANETARIUM IN THE NETHERLANDS'* Garry Coleman • *'MILLENNIUM TELESCOPE UPDATE'* Neil Morley **Further speakers and subjects to be confirmed** ☎ Peter Richards (evenings)

SOCIETY PRIMARY CONTACTS

CHAIRMAN Kenneth J Goward FRAS ☎ (daytime & evenings)
SECRETARY Roy Gooding ☎ (daytime) (evenings)
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Contact details for the full Committee may be found on the inside back page

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