The Newsletter of the Orwell Astronomical Society (Ipswich)

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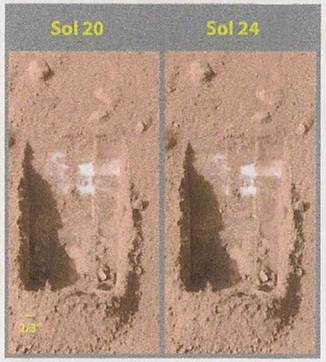
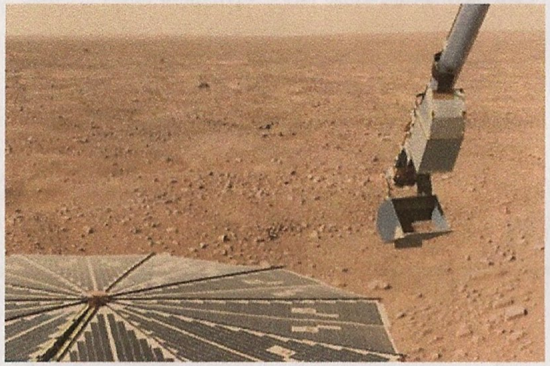
Prospecting on Mars





Left 2008 June 15th and 19th Sublimination of Ice from trenches dug by NASA's Phoenix Lander. Over the next few days the Ice was seen to disappear/melt.

Right 2008 June 21st Scooped soil awaiting insertion into Phoenix's instrument packages.

Images courtesy www.nasa.gov/phoenix

Society News (Roy Gooding)

1 Committing Meeting Provisional Date Saturday 13th September

The provisional date for the next committee meeting is Saturday 13h September from 20:00 at the Methodist Church Hall. This is meeting is open to any member who would like to attend.

2 Events for 2008

This event list will be updated through out the year

Meeting	Venue	Date
Summer Barbecue If you would like to host this years event please contact any committee member	No venue fixed yet	No date set yet
Perseid Meteor watch Note new date	**The "Dip" Felixstowe**	**Wednesday 13th August 20:30**
Herstmonceux Astronomy Festival	Observatory Science Centre Herstmonceux, Hailsham, East Sussex,	5th to 7th September
Lecture meeting The Biggest Telescope in the World. by Peter Hingley	Methodist church hall	Friday 12th September From 20:00
FAS Cambridge Convention	Institute of Astronomy, Cambridge	Saturday 20th September
Autumn Equinox Sky Camp Organised by Loughton Astronomical Society with the support of the SPA http://www.starparty.org.uk/	Kelling Heath, Weybourne Norfolk.	Monday 22nd September to Thursday 2nd October Main day Saturday 27th
Lecture meeting To Infinity & Beyond by Andy Green	Methodist church hall	Friday 24th October From 20:00
Lecture meeting William Herschel by Tony Dagnall	Methodist church hall	Friday 14th November From 20:00
Geminid Meteor watch	The "Dip" Felixstowe	Saturday 13th December
Christmas Meal		Wednesday 10th December?

3 Access into the School Grounds and Observatory Tower

Please use the third gate into the school grounds, this is the gate behind the Gym. If the Black door entrance at the base of the observatory tower is locked, you will have to phone someone in the observatory to let you in. My mobile number is [redacted]. (Roy Gooding) alternatively the Observatory mobile is [redacted] during meeting hours.

4 Welcome to New Members

Richard Walne and Alan Murdie

5 Lecture Meeting Venue

Our town lecture venue is now at the Methodist Church Halls, in Blackhorse Lane. The Church has a car park, which can take about 30 cars.
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.

Meetings start at 20:00 doors open at 19:30

Persid Meteor Watch Wednesday 13th August 20:30

The venue is behind the Refreshment Hut at the "Dip" end of Felixstowe

There will be no meeting at the observatory unless the weather is unfavourable

This location is on the top of the cliff, which gives unrestricted views from the north east to the south.

Directions for those who do not know this part of Old Felixstowe

- From the Hamilton Road roundabout, take the turning into High Road East
- Travel to the open area of grass where Brackenbury Fort was once located.
- There is a parking area, on the right just past the open area of grass, in front of the Refreshment Hut.
- The meeting time 20:30
- The Moon will be at first quarter on the 8th
- If the weather is bad there will be a normal meeting at the observatory

OCCULTATIONS DURING JULY

There are no good lunar occultations during July.

James Appleton

Night Sky (July)

All times BST

Moon

New Moon	1st Quarter	Full Moon	3rd Quarter
3rd	10th	18th	25th

Object	Date	Times		Mag.	Notes
		Rise	Set		
Sun	1	04:40	21:19		
	31	05:16	20:47		
Mercury	1	03:33	19:21	-0.2	Mercury is at greatest western elongation On the 1st. It never moves from the morning twilight.
	31	05:18	21:03		
Venus	1	05:06	21:46	-3.8	Venus is reappearing from behind the Sun, into the evening sky. It is still to close to the sun to be easily seen this month
	31	06:34	21:26		
Mars	1	09:15	23:35	1.7	Mars has now move into Leo. It appears close to the Saturn at the beginning of the month
	31	09:03	22:06		
Jupiter	1	21:37	05:35	-2.7	Jupiter will be at opposition on the 9th
	31	19:27	03:17		
Saturn	1	09:40	23:46	0.8	Saturn is in Leo. It is now rapidly disappearing in the evening twilight
	31	08:01	21:54		
Uranus	1	00:07	11:35	5.8	Uranus is in Aquarius
	31	22:05	09:35		
Neptune	1	23:09	08:52	7.8	Neptune is in Capricornus
	31	21:10	06:50		

Meteor Showers

Shower	Limits	Maximum	ZHR
α Cygnids	July to August	July 21st & August 21st	5
Capricornids	July to August	July 8th July 15th July 26th	5
δ Aquarids	July 15th to August 20th	July 29th & August 6th	20 10

Meteor source is the BAA Handbook

From Nacton to Florence

by Stephen Bentley

On my recent travels to Europe and the UK, I was very fortunate to be the guest speaker on March 5th at the OASI monthly workshop in Nacton. I presented a talk of my experiences observing the Messier 100 objects in my home state of Victoria, Australia. Tina Hammond gave a very good account of my efforts in the OASI April Newsletter, so I do not wish to repeat the details here. However, I would like to say that I enjoyed myself very much at the meeting and I was made to feel very welcome by all those present.

Thank you once again to the OASI for your generosity, and thanks to Tina for asking me to be the guest speaker, and Mike Whybray for co-ordinating the room and equipment and arranging for an announcement to go into the Newsletter. I was also most impressed when I was later shown the Tomline Refractor Telescope at Orwell Park Observatory by Paul Whiting. I will be submitting a brief article about this instrument and the OASI to the ASV's newsletter, Crux, for the benefit of our Aussie astronomers.

After I left the UK I embarked on a guided tour to several European countries for 27 days, and thoroughly enjoyed myself. I had one astronomical experience during that journey. In Florence I

visited the Museo di Storia della Scienza, which had an exhibition of the telescopes of Galileo.

I was deeply moved to see the actual instrument that Galileo used to make his most historic observations. The exhibition also provided a very comprehensive explanation on the development of optics and on a technical assessment of Galileo's instrument. I was not able to take photographs in the museum unfortunately, but I have included a scanned image of the museum entrance ticket, which has a picture of the 37mm main objective lens from Galileo's telescope. The now damaged lens, dating back to 1610, is beautifully presented within a very ornate display feature. Anyone going to Italy is highly recommended to visit Florence and see this exhibition while it is still open.

Tidbinbilla

by Tina Hammond

The first NASA Deep Space Station (DSS) 41 in Australia, at Woomera, was built in 1947 and closed in 1972. In 1960 the US wanted to build another facility there, but the Australian government were keen to bring employment to their new capital city, and felt that Woomera was too remote for the mass employment opportunities created by such a huge foreign investment, and this chance of populating Canberra was too good to miss.

Therefore, NASA's second Australian DSS was within the Canberra Deep Space Communications Complex (CDSCC) at a 29 acre site in the Tidbinbilla valley, 35-40 km south west of Canberra, and was the first NASA Deep Space Network (DSN) in Australia.

Reasons for choosing this site include:
1 It sits on a level floor of bedrock for stability.
2 It was within 240 km of a (military/government use) international airport.
3 A guaranteed local workforce of 35 – 50 were already living in Canberra.
4 The surrounding hills gave natural protection from interference from other tracking sites in the area; and also from the nearby, but remote enough, city.

All in all, it promised excellent working conditions.

It was established in October 1962, with rapid (by today's standards) construction starting in June 1963, and operations commencing on 9 December 1964, in time for Mariner 4 which was tracked on its Mars encounter by Tidbinbilla's (DSS 42) 26m telescope antenna. It was not officially opened until 19 March 1965 by then Prime Minister Robert Menzies. Later that year the Pioneer 6 photos of the Sun were relayed via Tidbinbilla.

<u>Other additions, modifications and achievements over the years include:</u>

In 1969, a 64 m antenna, DSS 43, was commissioned and operational before early 1973 when it was officially opened by - later to be dismissed - Prime Minister Gough Whitlam. This was six times more sensitive than DSS 42, and extended to 70 m in 1987, making it the largest steerable parabolic antenna in the southern hemisphere, a title it still retains.

In 1980 the original 26 m antenna, DSS 42, was extended to 34 m in time to assist with the Voyager missions to the four gas giants, Jupiter, Saturn, Uranus and Neptune.

The 34 m high efficiency DSS 45 was up and running by 1985/1986 and assisted DSS 43 with Voyager 2's fly by and survey of Uranus, as it was able to detect a higher frequency than DSS 43.

After the closure of Honeysuckle Creek, the 26 m antenna there was removed to Tidbinbilla in 1983 and renamed DSS 46.

As part of the Compton Gamma Ray Observatory, a 10 m and a 4.5 m antennae were added in 1993. The 4.5 m was not long lived and was dismantled and removed to the USA in 1995. Both were, however, instrumental in supporting the Space Shuttle and Hubble missions.

In June 1996, an 11 m Very Long Baseline Interferometery (VLBI) antenna, DSS 33, was added but decommissioned in February 2002.

In 1996/1997 a 34 m Beam Wave Guide antenna, DSS 34 (similar to DSS 45) was added. Most of it is underground for reasons of stability and to minimise structural strain.

In 1997 a massive Yagi Array was installed to support the Interplanetary Monitoring Platform (IMP) 8 spacecraft. As Pioneer 6, 30 years earlier, it also concentrated on the solar winds, magnetic fields and cosmic rays of the Sun.

The original DSS 42 remained in use until drive problems, performance, metal fatigue and dated technology meant it would cost more to properly maintain than to replace, so it was decommissioned in 1998 and removed in December 2000.

Tidbinbilla also boasts a fully automatic Global Positioning System (GPS), which is operational 24 hours a day, every day of the year, and can track eight satellites simultaneously. It also helps to track the 24 strategically placed GPS satellites, helps monitor signals reflected from various celestial sources, and calculates the relative distance, size, mass, etc. of such bodies.

It is now the only operational NASA installation currently in Australia, and in January 2008 was the prime source for Messenger's fly by photographs of Mercury.

The 70 m antenna, DSS 34, is the only one Australians have a chance to use for their own research, and time spent on it is strictly limited for a specified fraction of the total operational time.

As it was tied in so closely with the installation at Honeysuckle Creek, both Tidbinbilla and HSK share the same 'sister' stations, i.e. Madrid in Spain and Goldstone in California. Thus the only three flags to fly at Tidbinbilla are those of Australia, Spain and the USA.

In the early 1980's it was renamed the Canberra Space Centre and enlarged and modernised to create a cutting edge focal point of space exploration for visitors. A theatre was added, as well as the banally named Moon Rock Cafe, barbecue facilities, kids area and an ubiquitous gift shop.

Other attractions include topical exhibitions with audio/ visual presentations; models of spacecraft, planets, etc; real 'flown' space hardware (e.g. space craft, space suits); plaques; examples of Shuttle meals; and a 3.8 billion year old piece of moon rock.

Open 7 days a week, 365 days a year except Christmas Day, and free of charge, it is a viable reason to visit Canberra.

OASI Committee Contacts & Responsibities

Kenneth J. Goward FRAS	**Chairman**	☎	
Roy Gooding	**Secretary**	☎	**MAIN POINT OF SOCIETY CONTACT** Press Publicity with Chairman. Observatory Decoration. Visits by potential new members.
Paul Whiting FRAS	**Treasurer**	☎	**Finance.** Supervision of Grant Applications. Visits by outside groups. **IYA 2009 Coordinator**
James Appleton	Committee	☎	Committee Meeting Minutes. Web Site.
Martin Cook	Committee	☎	Membership. Tomline Refractor Maintenance.
Neil Morley	Committee	☎	Equipment Curator.
Peter Richards	Committee	☎	Lecture Meetings. School Lighting liaison. Email Distribution Lists.
Eric Sims	Committee	☎	Newsletter.
Mike Whybray	Committee	☎	Librarian & Workshops.
Bill Barton FRAS	Committee	☎	Safety & Security.
John Wainwright	Co-opted	☎	Forward planning & Strategy

IYA 2009 – ADVANCE DATES NOTICE

- Monday March 30th - Sunday April 5th - **Saturn Week**
- Monday July 20th - Sunday July 26th - **Moon Week**
- Monday October 26th - Sunday November 1st - **Jupiter Week**

Diary for June

Wednesdays **FROM 8PM**	**MAIN OBSERVATORY CLUB NIGHTS** **Primary Observational targets: Nebulae and faint objects.** ☎ Martin Cook (mobile) ☎ Roy Gooding (mobile)

Society Primary Contacts

Chairman: Kenneth J. Goward FRAS ☎ (daytime & evenings)
Secretary: Roy Gooding ☎ (daytime) (evenings)
E-Mail queries: Ipswich@ast.cam.ac.uk

Society Trustees

Mr Roy Adams Mr David Brown Mr David Payne

Society Honorary President

Professor Allan Chapman D.Phil MA FRAS

Observatory Telephone Number

Meeting nights only

We offer our hearty Congratulations and Very Best Wishes to OASI members Nicky Gillard and Peter Richards on the eve of their forthcoming wedding. Our esteemed First Magnitude friends will celebrate their conjunction on Saturday 5th July at Claverham Church near Bristol.


Way to go Nicky & Pete...

John Isaac Plummer, Colonel Tomline's Astronomer Part 4

A1 Transits Of Mercury

Ten transits of Mercury occurred during Plummer's lifetime. The years in which the 10 transits occurred are as follows, where a "v" denotes that the transit was visible in whole or in part from Plummer's place of residence (the UK until 1890, then Hong Kong until 1911 and finally the UK again until his death in 1925): 1845(v), 1848(v), 1861(v), 1868(v), 1878(v), 1881, 1891(v), 1894(v), 1907 and 1914(v). Plummer reported observations of the transits of Mercury on 05 November 1868 and 06 May 1878.

The 1868 transit began before the Sun rose over the UK, and only the last hour and a half of the event was visible from the UK (the precise duration visible depended on the location of the observer and his local horizon). In 1868 Plummer was based at Durham University and Professor Temple Chevallier communicated his observing report [1868a] to MNRAS. Plummer observed the transit under exceptionally favourable conditions, with not a cloud seen during the entire transit, using the 16.5cm (6.5") Fraunhofer equatorial at Durham Observatory. The instrument was fitted with a wire micrometer, power 112, for making positional measurements. Due to atmospheric turbulence, the solar limb was tremulous and Mercury was ill defined when the Sun rose but the situation improved towards the end of the transit although the Sun was at an altitude of only 11° at the time of 4^{th} contact.

Plummer estimated several quantities during the course of the transit, and compared his estimates with theoretical calculations based on elements in the *Nautical Almanac*. Table 4 compares Plummer's empirical estimates, his calculations and modern calculations based on a value $\Delta T = 2.35$ seconds.

Plummer's estimate of the time of 3^{rd} contact is in good agreement with modern theory. His estimate of 4^{th} contact is almost 17 seconds earlier than modern theory predicts, but as he remarked, his measurement was inexact due to undulations on the solar limb.

Modern calculations give a difference in RA of the centres (Mercury – Sun) systematically greater than that given by the *Nautical Almanac* by almost ¼ s throughout the period in question. Plummer's empirical estimate of the difference in RA in the main lies between the two theoretical estimates, and is not consistently closer to one than to the other.

Plummer's estimates (both empirical and theoretical) of the difference in declination between the north limb of Mercury and the south limb of the Sun and between the south limb of Mercury and the south limb of the Sun were both negative. However, at the time in question, the disk of Mercury appeared wholly in front of the solar disk, therefore both estimates should have been positive! It appears therefore that Plummer actually estimated the difference in North Polar Distance (NPD) rather than in declination. In neither case do his numerical estimates, interpreted as differences in NPD, agree well with modern calculations.

Phenomenon	**Plummer's Estimate**	**Plummer's Calculation**	**Modern Calculation**
3^{rd} contact	09:00:12.0 GMT	-	09:00:09 UT
4^{th} contact	09:02:29.2 GMT (1)	-	09:02:46 UT
Difference in RA of centres, Mercury – Sun, at 08:08:42.0 UT	-42^s.338	-42^s.432	-42^s.187
Difference in RA of centres, Mercury – Sun, at 08:16:41.2 UT	-45^s.188	-45^s.354	-45^s.112
Difference in RA of centres, Mercury –Sun, at 08:22:19.0 UT	-47^s.442	-47^s.414	-47^s.175
Difference in RA of centres, Mercury – Sun, at 08:40:55.5 UT	-54^s.044	-54^s.222	-53^s.988
Difference in RA of centres, Mercury – Sun, at 08:44:24.7 UT	-55^s.267	-55^s.498	-55^s.270
Difference in dec, NL (2) Mercury – SL Sun, at 08:32:36.7 UT	-7' 41".11	-7' 37".46	8' 31".56
Difference in dec, SL (2) Mercury – SL Sun, at 08:34:21.8 UT	-7' 35".73	-7' 32".94	8' 26".11
Apparent diameter of Mercury	9".001 (3)	-	9".956 (4)

Table 1. Comparison of Plummer's results with modern calculations.

Notes on table:

1. Plummer reported that the time was not exact due to undulations on the solar limb.

2. NL is North Limb; SL is South Limb.
3. Plummer noted that he had to make the measurements rapidly and that the image of Mercury was unsatisfactory, so he did not consider his measurement *of any great value*.
4. Plummer did not specify the time at which he estimated the apparent diameter of Mercury, so the calculation here is made for the time of mid-transit, 07:14:45 UT.

Plummer made his estimate of the diameter of Mercury with a double image micrometer of Airy's original construction. His estimate was 9".001, which he stated *is a somewhat small result*. Plummer blamed his low estimate on poor image quality and haste in undertaking the measurements. He compared this estimate with an estimate[1] of 8".693 which he made on an unspecified date in March 1868, which he stated agreed closely with the value determined some years earlier by the Rev R Thomson. Modern calculations indicate an apparent diameter of Mercury at mid-transit of 9".956.

In 1878, Plummer was employed at Orwell Park Observatory. Only the ingress phase of the 1878 transit was visible from the UK as the Sun set before the transit finished. Plummer reported [1878e] observing the transit under unfavourable circumstances. From midday, cirrus cloud spread over the sky, gradually becoming denser, until around sunset it started raining. However, around the times of initial contact (some three hours before sunset), the clouds thinned, and although limb definition was poor, Plummer was able to observe the Sun through the equatorial refractor using *a slightly tinted glass* and to estimate the times of 1st and 2nd contact. His description of the quality of his timings betrayed thinking that was muddled, or perhaps wishful. He stated that around the times of contact the Sun was *well seen* but that limb definition was *very bad and unsuited for scrutinising the phenomena of contact*. He considered that his timing of 1st contact was *very good*, but that it could be three or four seconds late *as the undulations of the limb were so considerable that a little hesitation could hardly be avoided*. Regarding the time of 2nd contact he stated: *owing to the violent motion* [of the limb] *it is possible that this timing is one or two seconds too soon…* Yet in fact, limb definition was so poor that he did not attempt to make any micrometer measurements.

Table 5 compares Plummer's empirical estimates of contact times with modern calculated values, based on a value $\Delta T = -4.82$ seconds.

[1] In fact, Plummer's text is not entirely clear at this point. The value printed in the paper is 18".693, presumed to be a misprint with a spurious leading "1". The apparent diameter of Mercury during March 1868 varied from a minimum of 8".2 to a maximum of 10".9.

Phenomenon	Plummer's Empirical Timing (GMT)	Modern Calculation (UT)
1st contact	15:11:34.2	15:11:25
2nd contact	15:14:19.7	15:14:33

Table 2. Comparisons of Plummer's empirical estimates with modern calculations for the transit of Mercury 1874.

Plummer's estimate of 1st contact is later than the modern theoretical result, and his estimate of 2nd contact is earlier: this is not unexpected for an astronomer making visual observations.

Plummer noted that at 2nd contact, the limb of Mercury appeared to disengage from the solar limb more suddenly than anticipated (the opposite of the "black drop" effect). He wrote: *there was the reverse of clinging… the planet disengaged itself from the limb more suddenly and rather earlier than the progress of the phenomenon led the observer to anticipate*. He stated that he remembered the same effect during the 1868 transit, but this is a clear case of wishful thinking, as the ingress phase of the 1868 transit was not visible from the UK: from Durham, Plummer's location at the time of the 1868 transit, 2nd contact occurred at 05:29 UT but Mercury did not rise until 07:26 UT!

He noted that so far as atmospheric conditions permitted, he could discern no black drop, ligament, bright spot, aureola or other effects around the time of 2nd contact.

Plummer's final paragraph in his report of the 1878 transit (quoted in full below) is intriguing. He reported that the silhouette of Mercury was visible against the solar corona before 1st contact.

A search during March – April 2007 in the archives of the NASA ADS for papers on the transits of Mercury in 1868 and 1878 uncovered a total of 58 papers recommending techniques to observe the transits or reporting observations of the phenomena. Table 6 shows how the papers treated observations of Mercury silhouetted against the solar corona.

The literature shows that in 1868 astronomers had no expectation of observing the silhouette of Mercury against the solar corona. Only one observer, Huggins [1868o] referred to the subject, and in fact his mention of it was almost incidental: his main interest during the event had been the study of two features which he observed during the transit, namely a bright aureola around the silhouette of the planet and a luminous point of light close to the centre of the planetary disk[2]. Huggins observed both phenomena consistently

[2] Other observers reported observing these phenomena during the transit of 1868. Still other observers reported looking for the luminous spot but failing to find it.

until the silhouette of Mercury left the solar disk, after which the planet was no longer visible.

Things had changed by the time of the 1878 transit! In early 1878 the editor of *The Observatory* [1878k] encouraged observers of the forthcoming transit to *examine carefully whether the planet could be seen outside the Sun*. Three observers reported searching for the planet silhouetted against the solar corona unsuccessfully and three reported searching successfully (Plummer was one of the latter three).

Visibility of Mercury Silhouetted Against Solar Corona	**Transit 05 Nov 1868**	**Transit 06 May 1878**
No mention of the subject	26 references: [1868a, 1868b, 1868c, 1868d, 1868e, 1868f, 1868g, 1868h, 1868i, 1868j, 1868k, 1868l, 1868m, 1868n, 1868p, 1868q, 1868r, 1869i, 1869j, 1869k, 1869l, 1869m, 1869n, 1869o, 1869p, 1869q]	23 references: [1878g, 1878h, 1878i, 1878l, 1878m, 1878n, 1878o, 1878q, 1878r, 1878s, 1878t, 1878u, 1878v, 1878w, 1878x, 1878y, 1878z, 1878aa, 1878ad, 1878ae, 1878ag, 1878ah, 1879e]
Written in advance of the transit, recommending that observers search for the silhouette	No references	[1878k]
Reported unsuccessful search for the silhouette	[1868o]	[1878j, 1878p, 1878ab[3], 1878ac]
Reported successful search for the silhouette	No references	[1878e, 1878f, 1878ab[3], 1878af]

Table 3. References referring to visibility of Mercury against the solar corona.

[3] Reference [1878ab] contains the observing reports from six observers at Lord Lindsay's observatory at Dunecht, near Aberdeen. It contains reports of both successful and unsuccessful attempts to find Mercury silhouetted against the solar corona.

Table 7 summarises the reports of attempts to observe the phenomenon of Mercury silhouetted against the solar corona in 1868 and 1878. The table puts in context Plummer's claim to have observed the phenomenon. Only two other observers, Lord Lindsay observing at his observatory at Dunecht near Aberdeen and Professor Langley observing at Allegheny Observatory in Pennsylvania, USA, made similar claims. Lord Lindsay, using a specialised imaging spectroscope, reported seeing the silhouette of Mercury approximately 14 seconds before 1st contact. Langley enjoyed exceptional skies, and reported seeing the silhouette of Mercury approximately 30 seconds before 1st contact. Several skilled observers, using equipment comparable to or better than Plummer's, searched for but failed to observe the phenomenon. Plummer's wife, using the Orwell Park equatorial refractor with a slightly tinted glass claimed to see the silhouette of Mercury approximately 134 seconds before 1st contact, while Plummer, using the same equipment, reported detecting the silhouette 74 seconds before 1st contact.

Plummer may have realised that his claim to have observed Mercury in silhouette off the solar disk was exceptional. Perhaps because of this he responded [1879c] to Langley in the pages of *The Observatory*. He noted that in Langley's case, the excellent transparency of the atmosphere meant that the difference in light intensity between Mercury and the solar corona was not masked by light scatter. Definition was at best moderate, but the quantity of light transmitted was at maximum, a situation that is preferred by astronomers for glimpsing faint objects such as nebulae. Conversely, at Orwell Park, Plummer saw Mercury *most sharply cut against the corona*. The sky was hazy, but Plummer stated that a certain amount of haze was beneficial in terms of definition and was most favourable for judging slight differences of light intensity – and it is to this, together with *the fine optical qualities of the telescope*, that he attributed his success in observing the silhouette of Mercury. Plummer [1879b] returned briefly to this theme in his annual report to the RAS for 1878, writing: *the transit of Mercury on May 6 was very fairly observed, and afforded gratifying proof of the excellence of definition of the object glass.* Plummer appears to have been rather disingenuous in defence of his claim to have observed the silhouette of Mercury: although he admitted that the sky was hazy, he made no mention of the *very bad* limb definition and the *violent motion* of the limb.

The author of the present document is of the opinion that Plummer's claim to have observed the silhouette of Mercury against the solar corona is fanciful, and that Plummer was victim for a second time of wishful thinking in regard of his observations of the planet. There are three aspects to this belief.

- Plummer observed under *unfavourable conditions*, suffering from a haze of cirrus cloud, *very bad* limb definition and a limb suffering from *violent motion*. It is simply not credible that he observed the silhouette in these circumstances!
- Plummer's wife, Marion, who first supposedly discerned Mercury against the solar corona, was not known to be an astronomer. To observe Mercury in the way reported would require her to have possessed exceptional eyesight and to be skilled in observing. Yet Plummer does not mention her in any other of his publications.

- In modern times, members of OASI observed the transit of Mercury on 07 May 2003 [2003a] and the transit of Venus on 08 June 2004 [2005b], using the equatorial refractor employed by Plummer in 1878. The refractor may provide slightly better definition nowadays than in Plummer's era by virtue of the object glass having been refigured by Horace Dall in 1973 and through the use of modern eyepieces. The observers employed projection and direct viewing using a mylar solar filter and a hydrogen alpha filter. In no case could the 21st century observers discern the silhouette either of Mercury or Venus off the solar disk. For the 2003 transit of Mercury, conditions were initially cloudy, perhaps approximating those experienced by Plummer in 1878.

Reference [2007b] and the references therein detail modern sightings of Mercury silhouetted against the inner corona or chromosphere near to the solar limb.

Location	Sky / Seeing	Observer	Equipment	Results
Huggins' observatory, Tulse Hill, South London, UK	*The Sun's edge was a little tremulous from atmospheric agitation, but the solar surface was so well defined that the bright granules of which it is composed could be distinctly seen.*	W Huggins [1868o]	200mm (8") refractor with prismatic solar eyepiece. Magnification 120x and 220x. Sliding wedge of neutral tint glass.	After Mercury passed off the solar disk, Huggins noted that *...the form of the planet was no longer visible to serve as a guide to the eye.*
Dunecht Observatory, Aberdeen, UK	*The sky was until first contact covered with thin clouds, which were at times sufficiently thick greatly to diminish the Sun's light.* Before 2nd contact, the sky had cleared and definition was good.	H J Carpenter [1878ab]	330mm (12.9") Newtonian with unsilvered mirror. Magnification 171x. 380mm (15.1") refractor stopped down to 250mm (10"). Magnification 380x. Merz polarising eyepiece.	Using 330mm Newtonian on ingress: *The images were very bad… I could not see Mercury outlined against the sky…* Using 330mm Newtonian and 380mm refractor on egress: *I could not see Mercury outlined against the sky…*
		A C Ranyard [1878ab, 1878ac]	95mm (3.7") refractor with spectroscope. 380mm (15.1") refractor stopped down	Before 1st contact: used the spectroscope to search for Mercury in red light for 10 minutes. Swept the view in the spectroscope in RA outwards from the Sun looking for any change in

Location	Sky / Seeing	Observer	Equipment	Results
			to 250mm (10"). Magnification 244x. Merz polarising eyepiece.	intensity of the field marking the position of the planet. Detected no indications of the presence of the planet off the Sun's disk. Between 1st and 2nd contact: could detect no portion of the planet off the Sun's disk using either the spectroscope or the 380mm refractor.
		Lord Lindsay [1878ab]	150mm (6") refractor with a direct vision prism and spectroscope giving an image of the Sun's limb and chromosphere.	Glimpsed the planet silhouetted against the corona 14 seconds before first contact.
Allegheny Observatory, PA, USA	*An unusually blue and transparent* sky at ingress.	S P Langley [1878f, 1878af]	330mm (13") refractor, stopped down to 230mm (9"), with a polarising solar eyepiece.	Observed the entire disk of Mercury outside the solar disk about half a minute before 1st contact. Speculated that it would have been possible to see the planet even earlier had he not wasted time searching for it.

Location	Sky / Seeing	Observer	Equipment	Results
Sydney, NSW, Australia	Definition poor *owing to low altitude of the Sun, and unsteadiness of the air...* *…not very favourable for successful observing, a good deal of haze and clouds impairing telescopic vision.*	W J Macdonnell [1878j]	110mm (4.25") refractor. Magnification 100x – 180x.	*…the planet completely disappeared as it glided off the Sun's face…*
Morrison Observatory, Glasgow, MI, USA	Edge of Sun's disk *clearly defined and remarkably steady.*	C W Pritchett [1878p]	310mm (12.25") refractor stopped down to 180mm (7"). Magnification 275x. Blue glass filter.	Pre ingress: *With my utmost scrutiny I could detect no trace of the outline of the planet projected on the solar corona…* Post egress: *The search for the planet outside the Sun's disk was again unsuccessful…*

Location	Sky / Seeing	Observer	Equipment	Results
Orwell Park Observatory	Haze. Cirrus cloud. Around the times of contact the Sun was *well seen*. However limb definition was *very bad and unsuited for scrutinising the phenomena of contact*. The limb suffered from undulations which were *considerable* and from *violent motion*.	J I Plummer [1878e]	258mm (10.2") refractor, full aperture employed. Magnification 303. Slightly tinted glass.	Plummer's wife (Marion) saw Mercury approximately 2m 14s before first contact and Plummer saw the planet one minute later: *My wife, who assisted me at the observation, first detected the planet against the solar corona, though I had previously looked for it in vain. On taking my station at the telescope a minute later I also detected it, dimly visible, but sufficiently so to direct my attention to the exact point where contact was to take place, and to lead me to suppose that, but for the clouds through which the observation was made, it would have been fairly conspicuous.*

Table 4. Reports of attempts to observe Mercury against the solar corona.

A2 Minor Planets

During the years 1868 – 1871, while Plummer was at Durham University, he observed 34 minor planets. After he left Durham, he did not publish any further observations of minor planets, indicating perhaps that his observations of the bodies formed part of a programme of observations being carried out at the Observatory and that he had no great personal love of them as a subject of observation! The Director of Durham Observatory while Plummer was employed there was Professor Temple Chevallier. It is possible that Chevallier used observation of minor planets as a means of training observers in the reduction of observations of moving bodies such as comets – however, this is speculation at present.

Table 8 summarises Plummer's schedule of observation of minor planets.

Minor Planet	Dates Observed	Reference
80 Sappho	09 - 10 Sep 1868 11 May – 07 Jun 1871	[1869a, 1872a]
48 Doris	10 Sep 1868	[1869a]
49 Pales	07 - 16 Oct 1868	[1869a]
42 Isis	08 - 17 Oct 1868	[1869a]
101 Helena	09 - 22 Oct 1868	[1869a]
92 Undina	07 - 20 Nov 1868	[1869a]
64 Angelina	03 - 11 Dec 1868	[1869a]
60 Echo	11 Dec 1868 - 07 Jan 1869	[1869a]
43 Ariadne	18 - 22 Dec 1868 05 - 22 Apr 1870 17 – 18 Nov 1871	[1869a, 1871b, 1872a]
19 Fortuna	08 - 25 Jan 1869	[1869b]
52 Europa	18 Feb - 18 Mar 1869	[1869a]
71 Niobe	19 Feb - 18 Mar 1869 19 Aug – 03 Sep 1870	[1869a, 1871b]
51 Nemausa	30 Mar - 04 Apr 1869 26 – 30 Aug 1870	[1869a, 1871b]
20 Massilia	01 Apr 1869 06 – 23 Jul 1870	[1869a, 1871b]
85 Io	10 - 20 Aug 1869	[1869a]
67 Asia	25 Aug - 13 Sep 1869	[1869a]

Minor Planet	Dates Observed	Reference
69 Hesperia	27 Sep - 13 Oct 1869	[1870a]
59 Elpis	09 - 23 Oct 1869	[1870a]
72 Feronia	26 Oct - 06 Nov 1869	[1870a]
109 Felicitas	06 - 10 Nov 1869	[1870a]
82 Alkmene	24 - 28 Jan 1870	[1870a]
29 Amphitrite	25 Feb - 24 Mar 1870	[1870a]
37 Fides	25 Feb - 01 Apr 1870	[1870a]
11 Parthenope	13 – 28 Sep 1870	[1871b]
28 Bellona	21 Sep 1870	[1871b]
44 Nysa	11 – 23 Nov 1870	[1871b]
63 Ausonia	16 – 23 Nov 1870	[1871b]
113 Amalthea	22 Mar – 10 May 1871	[1872a]
23 Thalia	22 – 23 May 1871	[1872a]
12 Victoria	23 May – 08 Jun 1871	[1872a]
41 Daphne	24 Aug – 15 Sep 1871	[1872a]
88 Thisbe	09 Sep – 10 Oct 1871	[1872a]
31 Euphrosyne	11 Oct – 10 Nov 1871	[1872a]
79 Eurynome	09 Dec 1871	[1872a]

Table 5. Plummer's observations of minor planets.

Plummer reported using the following micrometers to estimate the positions of minor planets: a ring micrometer, a parallel wire micrometer with illuminated wires and occasionally a dark-bar micrometer. Appendix 18 describes the various types of micrometer which Plummer used.

Plummer did not describe his technique for estimating the positions of minor planets, but it is likely to be similar to his technique for estimating cometary positions (see Appendix 4). His reduced his observations to yield estimates of the RA, declination and parallax of each minor planet. He compared his observations, where possible, with ephemerides in the *Berliner Jahrbuch*, as a means of checking for any major errors in his analysis.

A3 Comets

Plummer reported observations and attempted observations of 53 comets during the course of his astronomical career. He developed the necessary skills at Durham Observatory, where he observed four comets, and went on to apply them at Orwell Park Observatory, where he observed and attempted to observe a further 49 comets.

In 1875, in his first annual report to the RAS from Orwell Park Observatory, he noted [1875e] that Colonel Tomline had established the Observatory primarily for the observation of comets: *it has been determined to employ this fine instrument chiefly for the observation of comets, both periodical and occasional…* We do not known why Tomline selected the observation of comets as the chief business of his Observatory. By the time Plummer started work at Orwell Park, he had already gained experience in cometary observing and he believed that comets played an important part in the formation of the Solar System (and other planetary systems) and in the long-term production of energy by the Sun (see Appendix 13). Although it is speculation at present, it is possible that Plummer's interest and experience in observing comets influenced Tomline's selection of the chief business of his Observatory.

Towards the end of his time at Orwell Park, Plummer [1888a] noted in his annual report to the RAS for 1887 that observers in England undertook observations of comets only occasionally, and he sought to address this deficiency: *As this department of astronomical study* [cometary positions] *is only intermittently taken up elsewhere in England, it will be the aim of this Observatory in future to make the observations as full as possible and to include all comets visible in the northern hemisphere*.

Table 9 lists the comets which Plummer observed.

Designation In Plummer's Era	Modern Designation	Informal Name	Date Observed	Where Observed	Ref
1868 II	C/1868 L1	Winnecke	24 – 28 Jun 1868	Durham	[1869a]
1869a = 1869 I	7P1869 G1	Pons-Winnecke	01 May – 14 Sep 1869	Durham	[1869b, 1869e]
1870b = 1870 II	C/1870 Q1	Coggia	20 Sep – 31 Oct 1870	Durham	[1871a]
1873d = 1873 V	C/1873 Q2	Henry	29 Aug – 11 Sep 1873	Durham	[1874c]
1874c = 1874 III	C/1874 H1	Coggia	? until Nov 1874?	Orwell Park	[1874d, 1875e]
1874e = 1874 IV	C/1874 Q1	Coggia	24 Aug – 15 Nov 1874	Orwell Park	[1875a, 1875e]

Designation In Plummer's Era	Modern Designation	Informal Name	Date Observed	Where Observed	Ref
1875a = 1875 II	2P	Encke	31 Jan 1875 – ?	Orwell Park	[1876d]
1877a = 1877 I	C/1877 C1	Borrelly	27 Feb – 17 Mar 1877	Orwell Park	[1879a]
1877b = 1877 II	C/1877 G1	Winnecke	13 Apr – 20 Jun 1877	Orwell Park	[1879a]
1877c = 1877 III	C/1877 G2	Swift	03 – 18 May 1877	Orwell Park	[1879a]
1877e = 1877 VI	C/1877 R1	Coggia	04 – 07 Oct 1877	Orwell Park	[1879a]
1877f = 1877 V	C/1877 T1	Tempel	04 – 14 Oct 1877	Orwell Park	[1879a]
1879a = 1879 I	5D	Brorsen	29 Mar – 19 May 1879	Orwell Park	[1879d, 1880a, 1880b, 1880c, 1881c]
1879b = 1879 III	9P	Tempel	Unsatisfactory observation	Orwell Park	[1879b, 1880b]
1879c = 1879 II	C/1879 M1	Swift	27 Jun – 25 Jul 1879	Orwell Park	[1880b, 1882a, 1884a]
1879d = 1879 V	C/1879 Q1	Palisa	10 Sep – 15 Oct 1879	Orwell Park	[1880b, 1880c, 1882a, 1884a]
1879e = 1879 IV	C/1879 Q2	Hartwig	08 – 15 Sep 1879	Orwell Park	[1880b, 1882a, 1884a]
1880b = 1880 II	C/1880 G1	Schäberle	30 Apr – 10 Sep 1880	Orwell Park	[1881c, 1882a, 1884a]
1880d = 1880 III	C/1880 S1	Hartwig	18 Oct – 25 Nov 1880	Orwell Park	[1881c, 1882a, 1884a]

Designation In Plummer's Era	Modern Designation	Informal Name	Date Observed	Where Observed	Ref
1880f = 1880 V	C/1880 Y1	Pechüle	21 Dec 1880 – 31 Jan 1881	Orwell Park	[1881c, 1882a, 1884a]
1881b = 1881 III	C/1881 K1	Great Comet	24 Jun – 17 Nov 1881	Orwell Park	[1881a, 1881b, 1882d, 1884a]
1881c = 1881 IV	C/1881 N1	Schäberle	28 Jul – 28 Aug 1881	Orwell Park	[1882c, 1884a]
1882 a = 1882 I	C/1882 F1	Wells	24 Mar – 03 Jun 1882	Orwell Park	[1884a, 1884b]
1882c = 1882 III	C/1882 R2	Barnard[4]	22 Sep 1882	Orwell Park	[1884a, 1884c, 1885a]
1883a = 1883 I	C/1883 D1	Brooks-Swift	03 Mar – 09 Apr 1883	Orwell Park	[1884a, 1884c, 1885a]
1883b = 1884 I	12P/1883 R1	Pons-Brooks	08 Sep 1883 – 28 Jan 1884	Orwell Park	[1884a, 1885a, 1885b]
1884b = 1884 II	D/1884 O1	Barnard	?	Orwell Park	[1885a]
1884c = 1884 III	14P/1884 S1	Wolf	25 Sep 1884 – 07 Mar 1885	Orwell Park	[1885a, 1886a, 1887a]
1884d = 1885 I	2P	Encke	18 Feb – 01 Mar 1885	Orwell Park	[1885a, 1886b, 1887a]
1885a = 1885 II	C/1885 N1	Barnard	17 Jul 1885	Orwell Park	[1886b, 1887a]
1885d = 1886 I	C/1885 X1	Fabry	30 Jan – 11 Mar 1886	Orwell Park	1886b, 1887a]

[4] It is thought that Plummer also saw Comet C/1882 R2 while travelling by steamer to the West Indies to observe the transit of Venus in 1882.

Designation In Plummer's Era	Modern Designation	Informal Name	Date Observed	Where Observed	Ref
1885e = 1886 II	C/1885 X2	Barnard	08 Mar – 27 Apr 1886	Orwell Park	[1886b, 1887a]
1886a = 1886 V	C/1886 H1	Brooks	06 – 20 May 1886	Orwell Park	[1886b, 1887a]
1886e = 1886 VII	15P/1886 S1	Finlay	18 Nov 1886 – 25 Feb 1887	Orwell Park	[1887a, 1887b, 1888a, 1888b]
1886f = 1886 IX	C/1886 T1	Barnard-Hartwig	23 Oct 1886 – 10 Jan 1887	Orwell Park	[1887a, 1887b, 1888a]
1887b = 1887 II	C/1887 B2	Brooks	12 Feb – 23 Apr 1887	Orwell Park	[1887b, 1888a]
1887c = 1886 VIII	C/1887 B3	Barnard	13 Feb – 20 May 1887	Orwell Park	[1887b, 1888a]
1887d = 1887 III	C/1887 D1	Barnard	28 Feb – 10 Apr 1887	Orwell Park	[1887b, 1888a]
1887e = 1887 IV	C/1887 J1	Barnard	09 Jun – 29 Jul 1997	Orwell Park	[1887b, 1888a]
1887f = 1887 V	13P/1887 Q1	Olbers	13 Sep 1887 – 11 Feb 1888	Orwell Park	[1888a, 1888b, 1888d, 1889a]
1888a = 1888 I	C/1888 D1	Sawerthal	04 Apr – 10 Aug 1888	Orwell Park	[1888d, 1889a]
1888c = 1888 III	C/1888 P1	Brooks	29 Aug – 08 Oct 1888	Orwell Park	[1889a, 1889b]
1888e = 1889 I	C/1888 R1	Barnard	11 Sep 1888 – 22 Jul 1889	Orwell Park	[1889a, 1889b, 1890a, 1890b]
1888f = 1888 V	C/1888 U1	Barnard	13 Nov 1888 – 25 Mar 1889	Orwell Park	[1889a, 1889b, 1889c, 1890a]

Designation In Plummer's Era	Modern Designation	Informal Name	Date Observed	Where Observed	Ref
1889b = 1889 II	C/1889 G1	Barnard	06 Sep – 31 Oct 1889	Orwell Park	[1890a, 1890b]
1889d = 1889 V	16P/1889 N1	Brooks	29 Aug 1889 – 12 Feb 1990	Orwell Park	[1889d, 1890a, 1890b]
1889e = 1889 IV	C/1889 O1	Davidson	29 Aug – 13 Nov 1889	Orwell Park	[1890a, 1890b]
1889f = 1889 VI	64P/1889 W1	Swift-Gehrels	11 Dec – 24 Dec 1889	Orwell Park	[1890a, 1890b]
1889g = 1890 I	C/1889 X1	Borrelly	25 Dec 1889	Orwell Park	[1890a, 1890b]
1890a = 1890 II	C/1890 F1	Brooks	17 Apr – 24 May 1890	Orwell Park	[1890b]

Table 6. Comets observed by Plummer.

In table 9, the column *Modern Designation* is the identifier for the comet according to the IAU rules for comet nomenclature [2006b].

Plummer also searched for, but was unable to find, three comets as follows:

- Swift's Comet (1878 I, C/1878 N1): the problem was an *unfortunate misinterpretation of the telegram announcing its discovery* [1879b].
- Tempel's Comet (1878 III, 10P/1878 O1): Plummer was unable to locate it due to persistent cloud and haze near the horizon [1879b].
- Faye's Comet (1888 IV, 4P): although the weather in 1888 was generally poor, Plummer looked for Faye's Comet on three occasions when the atmosphere was clear, but did not find it – he concluded that it was too faint [1889a].

Most of Plummer's cometary observing reports provided primarily positional data, usually accompanied by a sparse set of notes detailing any problems with his data reduction (e.g. comparison stars with doubtful positions). Occasionally Plummer provided descriptive details of the comet itself, but this was very much the exception. The positional data comprised estimates of RA, declination and parallax.

Plummer did not describe his technique for observing comets until almost at the end of his time at Orwell Park. In [1890a] he stated that his technique was to observe each comet on every occasion when it was possible to do so and to make one observation each night, generally consisting of eight separate comparisons of the comet with a single neighbouring comparison star. Subsequent calculations enabled him to estimate the apparent position of the comet. Plummer did not give details of the mathematical techniques that he employed to reduce his raw data. However, there is evidence that on occasion he took some shortcuts. For example he was sometimes selective in his application of proper motion corrections, such as in [1879a] where he reported applying a correction for proper motion for only one comparison star, despite harbouring suspicions that there was evidence of discernible proper motion for a further four stars. Whatever Plummer's technique, it is clear that data reduction was very time-consuming, and this undoubtedly encouraged the use of shortcuts: in many of his annual reports to the RAS, he refers to a backlog of cometary observations awaiting reduction.

Plummer's observing reports mention the use of the following types of micrometer to estimate the positions of comets:

- At Durham: ring, parallel wire with illuminated wires, dark bar, parallel bar, double image and type unspecified.
- At Orwell Park: ring, parallel wire, dark bar and type unspecified.

Appendix 18 describes the types of micrometer which Plummer used.

Plummer reported the following equipment difficulties during his cometary observations:

- In his observing report of Comet Pons-Brooks (1884 I) Plummer [1885b] stated that from 08 September - 05 October 1883 he used a dark bar micrometer. However, its action was *not satisfactory*, so from 06 October to 26 November he used instead a ring micrometer. On 28 November, he returned to using the bar micrometer and continued to use it for the remainder of his observations, which concluded on 28 January 1884. Plummer provided no further details to explain this particular course of action.
- In several papers Plummer noted difficulty hearing the observatory chronometer due to high wind. In [1887b] he reported difficulty when using a dark bar micrometer; in [1882d, 1888d, 1889b] he reported difficulty with an unspecified type of micrometer. Astronomers of the era customarily adjusted the observatory chronometer to beat sidereal seconds then counted the beats as a means of estimating the time of an observation in the darkness of the observatory. A skilled observer could achieve quarter-second accuracy with this technique ([1995a]).

The majority of Plummer's cometary observations were unremarkable. His more noteworthy observations were as follows:

Winnecke's Comet (1869 I). Plummer [1869e] observed the comet on 13 May 1869, using a 165mm (6.5") refractor at Durham University, through *an aurora of surpassing magnificence*. This demonstrated that the aurora was extremely tenuous.

Coggia's Comet (1874 III). Plummer [1874d] reported sending a set of drawings of the comet to the RAS. The RAS did not appear to publish the drawings, so it remains a topic for the future to attempt to locate them in the RAS library[5].

Coggia's Comet (1874 V). Plummer [1875a] remarked that during August 1874 the comet presented a sensible condensation, and subsequently became a hazy patch of light.

Tempel's Comet (1879 III). Plummer [1880b] reported that his observations of the comet were *meagre and unsatisfactory, owing to its low altitude and the presence of a haze near the horizon at that season of the year.*

Hartwig's Comet (1879 IV) and Palisa's Comet (1879 V). Plummer [1880b] noted that his observation of the comets would have been more extensive *if intelligence of their discovery had reached the Observatory at an earlier date*. As Whiting [2006a] remarks, it is not clear whether this heartfelt remark was a general expression of despair or was directed at any person or organisation in particular! Plummer mentioned Palisa's comet in three other publications. In [1880c] he reported a peculiarity in the appearance of the comet. During the period 25 September – 10 October 1879, a few days on either side of perihelion, he observed that the nucleus of the comet was fainter and more diffuse than predicted by theory. By 15 October the nucleus had returned to its expected brightness and definition. Plummer was confident in his observations and noted: [the peculiarity] *is not to be accounted for by atmospheric conditions, as upon Oct. 5, 10 and 15 the most satisfactory state of the sky prevailed, particularly on the first-mentioned dates*. Plummer stated that during the period in question, the distance of Palisa's Comet from the Sun did not significantly change, so he dismissed this as a possible explanation for the phenomenon. The only other comet which Plummer knew to behave in this way was Encke's Comet. Plummer requested reports from other astronomers, and in particular spectroscopic observations, to confirm his observations. Unfortunately, no astronomers appear to have responded to his request: of the eight references listed in the NASA ADS archives[6] dealing with Palisa's comet [1879f, 1879g, 1879h, 1879i, 1879j, 1879k, 1880f, 1880g], none makes reference to Plummer's request. However, Lord Lindsay, reporting observations from Dunecht Observatory, provided observations that partially supported Plummer: he reported in MNRAS [1879i] that on 23 September 1879 the comet appeared to have no nucleus even at high power (307x) whereas by 19 October 1879 the comet was *much brighter in the middle*, even though he could not discern a specific nucleus. Although in [1880c] Plummer had expressed confidence in his observations, he contradicted this in his final observing report of Palisa's Comet [1882a], where his notes included the following:

> *Sept. 26-27: Very faint from moonlight and haze.*
>
> *Oct. 5-15: Comet faint and low down. The later comparisons are less reliable.*

[5] This will need to await the reopening of the RAS library, which, at the time of writing is closed for refurbishment.

[6] As of 21 August 2007.

This casts serious doubt on the veracity of Plummer's claim of a brightness peculiarity.

Plummer's final mention [1884a] of Palisa's Comet was in his annual report to the RAS covering 1882 and 1883, in which he mentioned simply that he had caught up with arrears of data reduction and had published several results, including his observations of the comet.

Brorsen's Comet (1879 I). J F Julius Schmidt [1879d], observing at Athens, reported observations of the comet 24 March – 20 May 1879. He noted that the comet was difficult to observe with a 2m (6 ft) refractor. He reported the magnitude of the coma in the range 7-8 on various evenings and estimated the length of the tail variously as 3', 7', 10' and 30', and described it as *indistinguished* and *weak*. Plummer [1880c] described the tail as *inconspicuous*, and noted that Schmidt was the only other observer to mention the tail at all. Plummer recalled that on the comet's previous apparition, in 1868, its tail had been *fairly observable*. Plummer noted that periodic comets tend to become fainter on each apparition, and suggested that it would be interesting to note the stages by which this occurs.

The Great Comet (1881b) and Schäberle's Comet (1881c). W F Denning [1881a], observing at Ashleydown, Bristol, reported that on 13 July 1881, the nucleus of the comet made a close approach to the 4th magnitude star P Camelopardi. Denning observed with a 250mm (10") reflector and magnification 100x at 23:25 GMT[7], at which time the two objects were within 3' and approaching. Unfortunately, at 23:30 GMT clouds rolled in and prevented further observations. On the following evening the comet appeared approximately 40' distant from the star. The star was considerably brighter than the comet's nucleus, and on both evenings Denning observed *some very minute stars* shining through the coma and tail of the comet. As a postscript to Denning's report, the editor of *The Observer* noted that Greenwich Observatory recorded the comet within 1' of the star on 14 July at 01:52 GMT.

Plummer [1881b] responded briefly to Denning, reporting an even closer approach of the comet to a star. On 29 June 1881 he had observed the comet pass within only 17".3 of the star Radcliffe 1661. Plummer noted that at the time of closest approach, the comet was moving very rapidly in declination, at almost 6" per minute. Plummer also noted that on 13 July 1881 (the day of Denning's observations), the comet approached the star Radcliffe 2324 at a distance of 31".9.

Finally, in something of a digression, Plummer reported that on 04 August 1881, he judged by naked eye that Comets 1881b and 1881c were of equal magnitude. On the following night, Comet c appeared to be the brighter of the two. Plummer compared the intrinsic luminosities of the two comets and predicted that Comet c at maximum brilliance would equal the brightness of Comet b on 13 July. He noted that such a comparison between the magnitudes of comets was only rarely possible.

[7] Denning's reported times are assumed to be local times, here converted to GMT.

Pechüle's Comet (1880 V). Plummer [1882a] reported that on 31 January 1881 the comet appeared *faint owing to light of aurora*.

Wells' Comet (1882 I). Plummer [1884b] estimated the position angle of the comet's tail throughout most of the period of his observations. He noted that from 21 May the tail appeared slightly curved. Surprisingly, this is the only occasion on which Plummer provides any significant description of the tail of a comet.

Barnard's Comet (1884 II). Plummer [1885a] made repeated attempts to find the comet, but only succeeded on one occasion. He eventually concluded that the comet was faint and better positioned for observation by more southerly observatories.

Barnard's Comet (1887 IV). Plummer [1887b] reported on 28 July 1887: *The comet has become faint and difficult to observe, especially in declination, owing to its peculiar form. It is much elongated from N to S, and narrow from W to E. This peculiarity has been noticed on several occasions recently.*

Sawerthal's Comet (1888 I). Plummer [1888d] noted on 08 August 1888: *Comet very faint and the coma has almost disappeared. Nucleus small and starlike. On Aug 2 the nucleus was indeed thought to be a small star within the coma, and no observation was then taken, as it was considered that such observation would be that of a star and would not accurately represent the place of a comet*.

Olbers' Comet (1887 V). Plummer [1889a] reported poor weather during 1888, which meant that he was able to obtain only three observations of Olbers' comet.

Brooks' Comet (1889 V). E E Barnard [1889c] reported observations of Comet Brooks during 01 - 05 August 1889 using the 300mm (12") and 915mm (36") telescopes at Lick Observatory. He found that the comet had split into nine components, the main body plus eight companions. The four faintest companions appeared simply as nebulous objects, while the brightest four showed structure like "mini-comets". In a short paper in 1889, Plummer [1889d] gave an initial summary of his observations of Brooks' Comet in September and October of the year. He was able to observe the main body and just one fragment of the comet. During September, he observed the fragment and main body grow further apart, but at a slower rate than had been reported in August. In late October, he made further observations and found that the fragment had diminished in brightness relative to the main body, and that the two objects appeared closer together. Plummer appealed to other observers to verify his observations. Of course Plummer observed under English skies with all the associated vagaries of the weather and poor atmospheric conditions. His full observing report [1890b] makes it clear that the cometary fragment was on the limit of his visibility:

13 Nov: *The companion comet was glimpsed, but the sky was not sufficiently transparent to admit of its observation.*

15 Nov: *Failed to see companion comet. Some fog.*

25 Nov: *Again failed to see companion comet with certainty, though perhaps it was glimpsed at times. Windy.*

The contrast with the report by Barnard [1889c], observing with the 915mm refractor at Lick Observatory on 03, 04 and 05 August is stark:

> *Both* [companions] *B and C were beautifully seen in the great telescope…*

Sekanina and Yeomans [1985a] give a modern perspective on Brooks' Comet. They fit ten models to observations of the comet during the period 1889 – 1980 and conclude that the comet made a very close approach to Jupiter on 21 July 1886, when it passed at a distance of only two Jovian radii (142,800km) from the planet. It is likely that the intense gravity of Jupiter triggered a series of fractures of the original cometary body, eventually creating the bodies that Barnard, Plummer and others observed in 1889. Sekanina and Yeomans speculate that the original cometary body may have been sizeable, and observers may have missed several fragments.

Final cometary observations from Orwell Park. Plummer's [1890a] last annual report to the RAS from Orwell Park detailed his activities during 1889. In the report, he listed six comets which he had observed but for which he had not completed reducing data or published an observing report. The comets were: Barnard (1889 I), Barnard (1888 V), Barnard (1889 II), Brooks (1889 V), Davidson (1889 IV), Swift (1889 VI) and Borrelly (1890 I). Colonel Tomline died on 25 August 1889, and following his death, Plummer had only a *very limited time* within which to complete the reduction and publication of all outstanding observations. He promised to make *every effort* to complete the reduction and publication of his outstanding data. In this he was successful, publishing his results [1890b] at length in 1890 after he had left Orwell Park and was resident in Ipswich.

--- To be continued ---