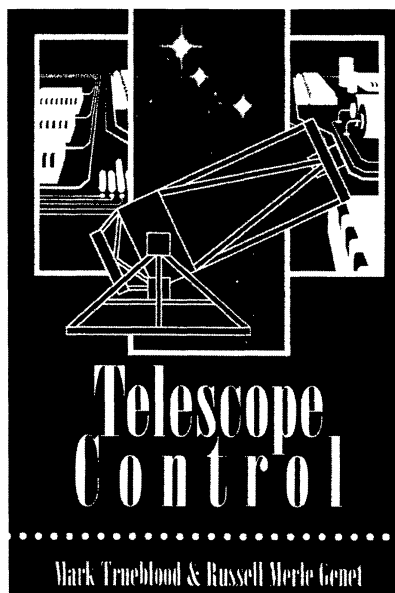


## Telescope Control

by Mark Trueblood & Russell Merle Genet



Willmann-Bell, Inc. 1997. ISBN 0-943396-53-0. Pp xviii + 561, \$29.95 (hbk).

Twenty years ago, commercial computerised telescopes were not commonplace like they are today. The two authors of *Telescope Control* and some of the contributors were true pioneers in this field where such systems were rare even in the realm of the professional. The introduction on page 1 gives the reasons why the second edition of *Micro-computer Control of Telescopes* is now entitled *Telescope Control*. Electronics have moved on and made some of the previous material obsolete; for example, it contained circuit diagrams for custom electronics that are now available off-the-shelf.

The new edition is much expanded, arranged more logically and divided into 5 parts: I) 'Why & how to computerise a telescope'; II) 'Telescope control design considerations'; III) 'Telescope control system components'; IV) 'Examples of telescope control systems'; V) 'Robotic telescope control'.

Rather than instructing the reader how a telescope should be computerised, the book gives many examples of different systems and the reader must decide which route would be the most suitable. For success, the constructor must have a good knowledge of electronics and be capable of writing software. Before committing soldering iron to any component, a great deal of thought must go into deciding how much of the task can be achieved in electronic hardware and what can be eliminated by software.

It is my personal opinion that when planning a complete system, an accurate drive system and a rigidly constructed and accurately aligned mounting is mandatory if software is not to reach epic proportions. Software should not have to correct for poor mechanics. Completely robotic systems can have huge cumulative errors. Chapter 6 has many line diagrams explaining the source of mechanical errors.

There are nine appendices; F & G are especially useful for those capable of writing their own software. Appendix E contains a list of the names and addresses of manufacturers of items related to telescope control, but they are mostly American. I found chapter 14 to be most interesting, containing descriptions of some of the relatively new hardware and software systems that are becoming available to computerise an existing amateur telescope. A British alternative will be available soon from AWR Technology. If this had been available at the time I would not have had to purchase a Schmidt-Cassegrain.

It is disappointing that there is virtually no discussion on commercial telescopes such as the LX200 from Meade. These systems allow a computer to communicate with the telescope via a serial link and enable the observer to control the telescope from commercial software such as *Megastar*. 'Home-brewed' software will allow greater flexibility for projects such as a customised automated supernova search.

*Telescope Control* contains a wealth of information for the reader with some knowledge of electronics and software who wants to build a computerised telescope, and I can thoroughly recommend it.

Ron Arbour

*Ron Arbour is a keen supernova hunter who first attempted automating his 40cm Newtonian in 1982. He conducted a photographic search for supernovae from 1978 to 1990 after which he has employed CCD imaging techniques. Since June 1997 he has used a 30cm SCT. Just six months after completing software to automate the system he discovered SN 1998an in UGC 3683, and is now awaiting no.2.*

## Pluto and Charon

by S. A. Stern and D. J. Tholen (Eds.)

Arizona University Press, 1997. ISBN 0-8165-1840-8. Pp xxi + 728, \$90.00 (hbk).

The format for the Arizona Space Science series of books is now well established. First a Symposium is held where leading researchers review the up-to-date state of knowledge of the subject in question. Then they write detailed review papers which after refereeing form the core of a book. This becomes the definitive book for researchers needing background information and inspiration for new projects. The latest book in the series (quite concise by Series standards at only just over 700 pages long!) covers the planet Pluto, its satellite Charon and the recently identified Trans-Neptunian bodies.

Though Pluto has yet to be visited by a spacecraft the discovery of the satellite and its recent series of occultations and eclipses have produced a great leap in our knowledge of the Pluto/Charon system. The improvements in observational capacity, such as those introduced by the modified Space Telescope, have led to additional discoveries being made. As such this book is sure to remain the standard reference text until *Pluto Express* or a similar mission reaches Pluto/Charon.

All our current knowledge and assumptions of conditions at the edge of the Solar System are contained in this book. The

topics cover the discovery, orbital evolution, atmospheric and morphology for Pluto and Charon and there is a review of the Trans-Neptunian disc of bodies at the inner edge of the Oort Cloud. Obvious errors are relatively rare, however the article by Christie would seem to have been e-mailed and inserted unchecked. Unfortunately the word-wrap, when removed, did not insert a space at line ends so every few lines there are two words runtogether (irritating isn't it). Otherwise mistakes are few and far between (though I wonder who detected the 116 mag star mentioned on page 45!)

If you have a serious interest in the edge of the Solar System or wish to carry out academic research then this should be your starting point. In particular the full reference bibliography will prove an invaluable lead to the source material – anyone wishing to carry out serious research should review everything done before, not just the paper that triggered the idea.

Andrew J. Hollis

*Andy Hollis has carried out numerical integration of the stability of Pluto's orbit which is in agreement with results presented in this book. To illustrate the improvement in modern computers the integrations over a 4Myr period took 2 days on a P75 PC, which compares favourably with the timescales given in Table II on page 130.*

## The 1799 Leonids

From the Director of the Meteor Section

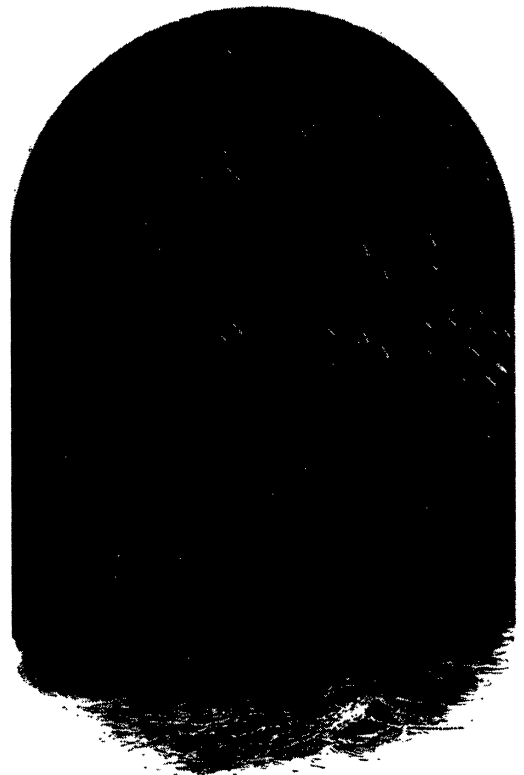
The interesting account of the Leonids of 1799 as seen from Cambridge, unearthed by Jeffrey Barham (*J. Brit. Astron. Assoc.*, **108**(3), 136 (1998)) is not in fact unique. The Leonid storm of 1799 was seen from several locations in the British Isles as dawn broke on the morning of November 11. Research by the noted Scottish historian of astronomy Dr David Gavine has turned up a number of other reports of the event, as seen from Banffshire in Scotland, Hartlepool, Enfield and the New Forest. These were published in learned journals of the day such as *The Gentlemen's Magazine*. Dr Gavine gave an account of his findings at a meeting of the Meteor Section in Edinburgh in 1991, which was later reported in the *Journal* (**101**(6), 366 (1991)).

It seems likely that further, similar reports exist in local newspapers of the day, and seeking these out may well be a profitable exercise for students of the history of astronomy.

The short duration of the Leonids at their most intense makes it a matter of fortune, to some extent, for observers at a given longitude to be under clear, dark skies at the time. We can only hope that the favourable circumstances for western Europe in 1999 are met with clear skies. A later-than-expected peak in 1998 might result in high activity being JUST visible from the British Isles as the radiant rises (around 23h local time) on November 17–18, though it is considered more likely that any storm peak will best be seen from more easterly longitudes. As with everything in meteor astronomy, the only way to verify the predictions is to go out and observe! Reports of the Leonids as seen in 1998 and 1999 will certainly be welcomed by the Meteor Section.

Neil Bone

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An artist's impression of the Leonid meteor storm of 1799 November 11–12, as seen off Cape Florida, USA, at about 0300 local time. *Reproduced in Mason J. W., J. Brit. Astron. Assoc.*, **105**(5), 219–235 (1995 October)

## Brown dwarfs in Praesepe and the Pleiades

From Ms Karen Holland

I would like to clarify a few points from the Deep Sky Section meeting summary that was published in the April BAA *Journal*.

With regard to the search for brown dwarfs in the Praesepe cluster, one of the main incentives for this study was the fact that work in which the Leicester group had been involved, *had* previously found some evidence that there might be a significant low mass population in this cluster (Hambly et al., *MNRAS* **273**, 505–512, 1995). Brown dwarfs in Praesepe would not be too faint to detect (Pinfield PhD thesis, Leicester University 1997, Chapter 4); it is simply reasonable to collect as much evidence as possible by fully analysing existing data, whilst at the same time, pursuing more expensive and time consuming searches.

Previous work done at Leicester on the Pleiades showed that large populations of brown dwarfs were unlikely to be discovered. However, brown dwarfs do exist in the Pleiades; researchers in the Leicester group recently found the lowest mass brown dwarf discovered to date in this cluster (Cossburn et al., *MNRAS* **288**, L23–27, 1997).

Karen Holland

*136 Northampton Lane North, Moulton, Northampton NN3 7QW [kho@star.le.ac.uk]*

## Finding Venus and Jupiter in daylight with binoculars

From Mr P. W. Parish

*Wednesday 22 April 1998*

After an overcast start the cloud cleared to leave a pale blue sky. Positioning myself so the Sun was hidden behind my house and using wooden steps as a tripod I located Venus in the 10×50s at 9.30 am GMT. The planet's phase was still just visible, looking like a very tiny white last quarter Moon although I knew it was actually well over fifty percent.

About half a degree to the left of Venus, Jupiter was easily visible well in the same field of view. Jupiter's little dull washed out round disk contrasted sharply with the much smaller but considerably brighter semi-circular one of Venus. It was interesting to compare the two planets simultaneously in identical daylight conditions. I tried but could not see Venus at any time with the naked eye although I observed both planets on and off in binoculars until just after midday GMT.

Two days later (24 April 1998) I picked Venus up again in the 10×50s at 6.45 am GMT. Jupiter was still clearly visible in the same field of view but this time between one and two degrees to the right of Venus. They were veiled by thin high cloud which quickly thickened until both planets were hidden. The sky remained cloud covered until 10.10 am when a clear blue mass made a welcome but brief appearance. The blue was richer than on April 22 and Venus was a naked eye object although it was far from conspicuous. Jupiter was invisible with unaided vision but both planets were very clear in the binoculars moving in and out of passing cloud wisps, until more permanent cloud intervened and I ceased observation.

P. W. Parish

*30 Wooldeys Road, Rainham, Gillingham, Kent ME8 7NU*

## Professional measurements of sunspot areas

From Mr Peter Norman

I was interested to read Bruce Hardie's Solar Section report for 1980–1989 recently published over two numbers of the *Journal* (1997 October and 1997 December). It was worth waiting for as it gave a comprehensive summary of the activity from shortly after the high maximum of 1979/80, through the minimum of 1986 and back to yet another high maximum in 1989.

Having been interested in the Sun since a schoolboy in the late sixties, I have over the years looked through the *Journals* and information provided by the Royal Greenwich Observatory on the largest and most active sunspots. Members will probably know that the definitive authority on sunspot areas was the RGO and their photographic record that extended from 1874 to the end of 1976 was unsurpassed; very few days in the 103-year record were missing, all of these in the early years when the number of cooperating observatories was fewer. It was indeed a sad loss when their programme ceased. However, the IAU resolved that this programme should be taken over by Debrecen Observatory in Hungary, so Greenwich's long continuous record could carry on. Debrecen are continuing using similar equipment and methods to RGO so the results are comparable.

These days, professional astronomers have more important areas of work than measuring and recording sunspot areas and positions, especially as it is now known that activity affecting the Earth environment can be measured and assessed more accurately using other techniques. The Debrecen programme can be seen more as a continuation of a long and historic record rather than a

primary scientific concern. Hence they have not been able to devote staff time in the same way that RGO could do and the results so far published are for the years 1977, 1978, 1986 and 1994 only. It is to be hoped that in due course the remaining years will become available. I understand that the volumes for 1978 and 1994 and all future years will only be published electronically; those interested can access them on the World Wide Web at <ftp://fenyi.sci.klte.hu>.

As Debrecen have taken over RGO's mantle, area measurements published by them are considered definitive. Bruce Hardie quotes some approximate area measurements of some of the larger and more interesting groups observed during the decade in question. I believe these were probably obtained from United States sources such as NOAA. It is worth noting that these US sources publish their results in 'real time' or 'near-real time', which means that they are not of 'research' quality and need to be used with caution. In addition, the US sources rely almost entirely on drawings and I do not think there is any quality control over these. Until the Debrecen results are published, amateur solar observers will have to look to other sources for more accurate area measurements.

Members might be interested to see some data that I consider to be more accurate than those from NOAA especially as the areas are measured from white light photographs, as were Greenwich's, rather than from drawings. These data come from two sources, originally given to me by NOAA, but subsequently by direct correspondence. The two observatories are Osservatorio Astronomico di Roma in Italy and Yunnan Observatory in China. They give information

**Table 2. Summary of large sunspot groups recorded since 1883**

Cycle maximum	No. of groups $\leq 2000\text{msh}$
<i>From Greenwich data:</i>	
1883.9	4
1894.1	7
1907.0	7
1917.6	4
1928.4	7
1937.4	17
1947.5	18
1957.9	17
1968.9	11
<i>Estimates from Rome &amp; Yunnan data:</i>	
1979.9	11
1989.6	15

on the largest sunspots observed during Solar Cycle 22 (1986–1996). As if to emphasise the difficulty in measuring sunspot areas, it can be seen that even from two professional observatories working on good quality photographs, there are discrepancies in the area values, which perhaps can be explained by such factors as photographs taken at different times, quality of the photograph and/or observing conditions, possible inclusion or exclusion of spots within the area covered by the group, etc. In all cases, the Yunnan areas are smaller than the Rome areas.

The tables include all the sunspot groups that were recorded as exceeding 2000 millionths of the visible hemisphere at OAR, with the corresponding data from Yunnan.

In order to compare the recently passed cycle to previous ones since 1874, the total number of groups whose area at maximum development reached or exceeded 2000msh is given in Table 2. It can be seen that Cycle 22 certainly had a good number of large groups as solar observers will recall. The giant group of March 1989 was the largest since May 1951 and spectacular in the activity it generated; however, both Rome and Yunnan made the long stream of September 1989 larger. If these area figures are reasonably accurate and are confirmed when the Debrecen results are published, the September group will rank as sixth largest in the 120-year record and the March group only a little way below.

For those with Internet access, the Rome Observatory Solar Phenomena Bulletins can be accessed via <http://oar.rm.astro.it>, although I have not been able to locate an Internet site for Yunnan.

**Peter C. Norman**

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**Table 1. Large sunspot groups recorded during Solar Cycle 22**

Rome No.	Yunnan No.	CMP	Latitude	Longitude	Max area (Rome)	Max area (Yunnan)	
9336	88161	<b>1988</b>	Jul 01.9	19°S	005°	3551	2834
9429	88304		Oct 24.1	21°N	295°	2054	1439
9511	89013	<b>1989</b>	Jan 13.2	32°S	307°	?	2144
9514	89019		Jan 15.9	21°N	271°	2029	1757
9536	89054		Feb 11.4	31°N	282°	2151	2059
9564	89105		Mar 12.8	33°N	255°	4125	3598
9654	89262		Jun 14.6	20°N	096°	3201	3054
9733	89381		Aug 17.7	16°N	327°	2464	2361
9747	89410		Sep 05.0	17°S	086°	4493	3842
10031	90243	<b>1990</b>	May 19.0	16°S	311°	2721	2111
10231	90589		Nov 20.0	19°N	026°	3581	3441
10302	91045	<b>1991</b>	Feb 01.2	13°S	142°	2521	2139
10360	91138		Mar 24.7	24°S	183°	3087	3038
10406	91224		May 05.5	09°S	352°	2604	1878
10446	91286		Jun 09.7	30°N	246°	2639	2593
10608	91548		Oct 28.5	11°S	184°	3007	2687
10672	91667		Dec 28.9	17°S	097°	2548	1814

### Obituary

## Herbert J. T. Carpenter (1931–1998)

H. J. T. (Bert) Carpenter died on 1998 January 21 at the age of 66 following many years of ill-health.

Bert studied mathematics and physics at London University, and after a brief flirtation as a professional photographer, turned to engineering and became a chartered engineer. He eventually joined a local engineering firm, and rose to the position of Chief Design Engineer, where for many

years he worked on the automatic postal system.

As a young man Bert had shown great athletic prowess and hurdled for Cambridge Harriers. He was also a skilled carpenter and, aside from carrying out many home improvements, made a number of toys for his children, which are still being enjoyed by his grandchildren. Typically, when his children developed an interest in playing music,

Bert supported their school band. He then helped in the formation of a new band, initially formed from the pupils leaving the school and eventually became their Vice President. Despite his health problems, Bert remained remarkably cheerful, even when he was forced to give up many of the activities which had given him so much pleasure throughout his life.

Following a long interest in astronomy, Bert attended evening classes in Catford in the 1970s and joined Crayford Manor House Astronomical Society in 1980 and the BAA the following year. He was also a member of the Society for Popular Astronomy. Bert's main astronomical interests were the Moon and occultations, particularly grazing occultations. This interest was further fostered when he took over the responsibility of Occultation Co-ordinator at Crayford, work for which he will be long remembered.

Grazing occultations had been popular at Crayford during the late 1960s and early 1970s under the guidance of Gordon Taylor, but when Gordon left interest dwindled for a while. However, Bert soon changed this, and organised expeditions all over the South East of England with meticulous detail. This involved producing a letter which was delivered to each household (very often a remote farmhouse) on which simple details of the event were described. It also advised that a party of amateur astronomers would be descending on their area (quite possibly at some very unsocial hour) to observe it. In addition, Bert always notified the local constabulary and advised the local residents of this fact as well. All this came about because on more than one occasion observers, who had thought themselves safe when setting up in a field, were visited by the local farmer who thought they were cattle rustlers!

Amongst his many other activities, Bert also became the International Occultation Timing Association (IOTA)'s UK Graze Coordinator and took on the task of computing and supplying grazing occultation predictions to UK observers about four years ago. He was working on this year's predictions when he died. In recent years he attended the annual European Symposia on Occultation Projects and last year he was the hard-working co-organiser of ESOP XVI.

It was Bert's wish, that if his body was of any use, it should be offered to medical science and this has been the case. Bert's main forte was in helping others and in this he will be sadly missed.

He is survived by his wife Sheila, his son Tom and daughter Therese.

**Roger Pickard & Andrew Elliott**

### Civic reception held to honour George Alcock



On 1998 March 24 a reception was held at the Mayor's Parlour in the Town Hall, Peterborough, for G. E. D. Alcock MBE 'in honour of his achievements and recognition of his services to Astronomy'. George Alcock has been a member of the BAA since 1935. He has discovered 5 novae and 5 comets, and also discovered the outburst of the recurrent nova RS Ophiuchi in 1985. Remarkably, all the discoveries were made with binoculars – in order to recognise his novae, George has memorised some 30,000 stars in the Milky Way. The photograph shows the presentation to George made by the Mayor, Cllr Mrs Yvonne Lowndes, at the reception, which was attended by Guy Hurst on behalf of the BAA and *The Astronomer*.

## The 32nd BAA Winchester Weekend, 1998 April 3-5

The 32nd BAA Winchester Weekend took place at the usual venue of King Alfred's College from Friday April 3 to Sunday April 5 1998. Nearly 120 people attended, many of whom were regulars at this very popular annual astronomy course. As in previous years, large groups from Crayford Manor House AS, Heart of England AS & Newbury AS were in attendance.

Friday evening saw the course organiser Richard Flux introduce the first speaker of the weekend – Owen Brazell, 'Observing the Local Group'. Owen presented a brief explanation of the physical aspects of our local group of galaxies, and went on to give hints on how to go about finding and observing them for ourselves. The weather was not so favourable for such optimism however, so after the talk had been well received, all would-be local group observers retreated to the students' bar to talk about what they may have seen in Winchester skies.

The first talk on Saturday morning introduced Bob Marriott, a Winchester first timer, who delivered a very entertaining presentation on 'Some Classical Instruments'. Bob, in his own unique way, spoke about the early instrument makers from Fraunhofer, through Alvin Clark, to our own David Sinden. Included in his many slides were several of historical instruments which he himself had restored.

Following a short interval, Maurice Gavin gave an extremely interesting talk on 'Everything you always wanted to know about CCDs but...' He touched on the devel-

opment of the CCD camera, and explained how they work, listing the advantages and disadvantages of the various CCD chips now available on the market. To demonstrate just how powerful a CCD can be in the hands of an amateur, Maurice showed slides of images taken by amateurs, including spectacular planetary images from Don Parker.

Following lunch, and the famous Winchester group photograph, Kevin West spoke about 'Variable Stars – from Eyeball to Photometer'. Kevin started by saying that he was not an expert on variable stars or photometry, then spent the next hour disproving this statement. He gave a brief description of a photometric light curve, and described the instrumentation needed to undertake this type of work. More light curves followed, this time from personal observations, and those done in collaboration with the Hungarian amateur Lazlo Kiss. Kevin then described how he had proved that BR CVn was variable, following remarks and prompts from visual observers. Following Kevin's talk, Bob Mizon had

his popular mobile planetarium inflated on stage.

The remainder of the afternoon was left for people to walk into Winchester or to remain on campus and take advantage of the trade stands which were now fully set up. These included Nigel Wakefield, Ian Poyser, Eclipse 99, *The Astronomer*, AWR



Bob Mizon (centre) with a group of members inside his inflatable planetarium (taken last year).

Tec, Webb Society, Earth & Sky and Venturescope. Also on display was Richard Fleet's remarkable fold-down 22cm reflector, and his enormous 50cm f5.6 reflector. In addition to trade stands, Crayford Manor AS & Newbury AS had put on displays of observations, photographs & images taken by members.

The Alfred Curtis Memorial Lecture on Saturday evening was introduced (as custom dictates) by the President Martin Mobberley, who welcomed this year's speaker, Dr Mark O'Dell, whose talk was entitled 'Why study Open Clusters'. Dr O'Dell began by giving a general description of open clusters and associations, and went on to describe why they make such interesting objects for professional research. He explained that OC's were excellent subjects for studying stellar evolution, and for distance determination using the moving cluster technique and ZAMS (Zero Age Main Sequence Fitting). A quick tour of typical open clusters followed. These included M45 (accompanied by a reading from Tennyson), the



The 1998 Winchester Group Photograph. Course organiser Richard Flux does the honours. (All photos by Peter Seiden)

Hyades, M44, the alpha Persei group and the little known OC Blanco 1. Finally, Dr O'Dell described the recent photometry undertaken by the AAT, JKT & JGT, and his eleven most recent/proposed studies. In conclusion, he suggested that the youngest clusters saw the most rapid rotation, the coolest stars displayed 'magnetic braking', and that from known ages of the alpha Per group, M45 & the Hyades, a distance of 120 million light years had been established for the high altitude galactic plane cluster Blanco 1.

The weather remained overcast and windy on Saturday night, so there was no chance of any observing. Quite a few people were looking forward to seeing Richard Fleet's telescopes in action, myself included. Still we could always discuss them in the bar!

Probably the most difficult talk for any speaker to take on at Winchester is the first spot on Sunday morning. However Jonathan Shanklin rose to the occasion superbly, and gave a most interesting and informative talk on 'Observing Comets'. Jonathan spoke about comets through history, from the Chinese who related the appearance of a comet to floods, harvests, war etc. through the Roman period, where some remarkable descriptions of comets were written down, and the recognisable



John Wall (left) and Alan Dowdell, also photographed by Peter Seiden at last year's Winchester weekend. Alan is taking delivery of the 22" mirror just ground for him by John.

radio astronomy, from the early years of James Clark Maxwell, Rudolf Hertz (who first proposed and demonstrated radio waves) and of course Karl Jansky. He discussed the evolution of the radio dish, and described the function and workings of MERLIN, the Commonwealth telescopes and Interferometers worldwide.

Following lunch, the final session of the weekend was dedicated to the members' session, often the most popular part of the whole weekend. We had slides of the

February 26th total eclipse from David LeCant, Mike Maunder and Alan Dowdell, and a very entertaining video of the eclipse from Martin Mobberley. John Wall informed the audience that he was about to embark on a most remarkable project – the building of a 75cm folded refractor! Mark Armstrong told of his latest supernova discovery SN 1998V, Bob Mizon showed slides taken with his scotch mount, and Laurie Linton concluded the session with slides of Comet Hale-Bopp.

The Winchester Weekend is about much more than attending lectures. It is a wonderful social occasion, and I am sure all those attending had a great time. I for one always look forward to this event, and I am sure next year will be no exception.

#### Gary Poyner

[Note: The 1999 Winchester Weekend will take place at Easter, from Thursday evening April 1 to Saturday April 3.]



Left to right: Martin Mobberley, Gary Poyner and Guy Hurst.

depiction of comet Halley on the Bayeux tapestry.

He then went on to describe the typical features of comets, their orbits, and how an observer can make useful observations. He concluded with the origin of comets, describing a typical model, and linked the association of comets with meteor showers.

The final talk of the weekend was given by Malcolm Jones of Norwich AS, whose topic was 'The History of Radio Astronomy'. Malcolm covered most aspects of

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<http://www.algarvenet.pt/coaa>

(New members continued from page 219)

**Asbury** Christopher Stuart, 31 Innox Hill, Frome, Somerset BA11 2LW

**Budd** Stephen, Flat 9, Cleveland House, 285 Hoe Street, Walthamstow, London, E17 9BG

**Cahill** Alan Edward, 51 Fieldfare, Abbeydale, Gloucester GL4 4WH

**Condra** Gerry, 245 St. Edmunds Road, Edmonton, London N9 7PL

**Cuppens** Wim, Verlorenstraat 12, B-3670 Gruitrode, Belgium

**Day** John Edward, Thanet House, 17 Montpelier Road, Ealing, London W5 2QP

**Dick** (James) Samuel, The Old Sweet Factory, Gardner Street, Herstmonceux, East Sussex BN27 4LB

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**Fitch** Anna C., 37 Ashfurlong Crescent, Sutton Coldfield, West Midlands B75 6EN

**Gaston** Mark, 8 Martingale Close, Upton, Poole, Dorset BH16 5ST

**Geldred** Richard Samuel Peter, 'Anneter', New Lancaster Road, Cabus, Nr Preston, Lancs. PR3 1AB

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**Lomas** Samuel Derek, 2 Chestnut Drive, Broadmeadows, South Normanton, Alfreton, Derbys. DE55 3AH

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**Mitchell** Malcolm George, Flat B, 11 Grafton Street, London W1X 3LA

**Moore** John David, 46 Yarbury Way, Weston-super-Mare, Somerset BS24 7DJ

**Morris** Gladys, Bathley House, Bathley, Newark, Notts. NG23 6DJ

**O'Dwyer** Heidi Hazel, 622 Roppongi 1st Plaza, 1-9-39 Roppongi, Minato-Ky, Tokyo 106, Japan

**O'Dwyer** Ian John, 622 Roppongi 1st Plaza, 1-9-39 Roppongi, Minato-Ky, Tokyo 106, Japan

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**Russell** Lee, 1 Drybeck Avenue, Ramsgate, Kent CT11 0NX

**Sandrock** John Dennis, 16 Gurney Close, Caversham, Reading RG4 7LE

**Scott** Stephen, Rosebank, High Brae, Torphichen, West Lothian EH48 4LX

**Simpson** Mark, 35 Rochford Crescent, Ernesettle, Plymouth, Devon PL5 2PY

**Smyth**, 68 Bankside Lane, Bacup, Lancs. OL13 8HJ

**Steer** Roger, Winpenny Cottage, Bagstone, Wotton-under-Edge, Gloucs. GL12 8BD

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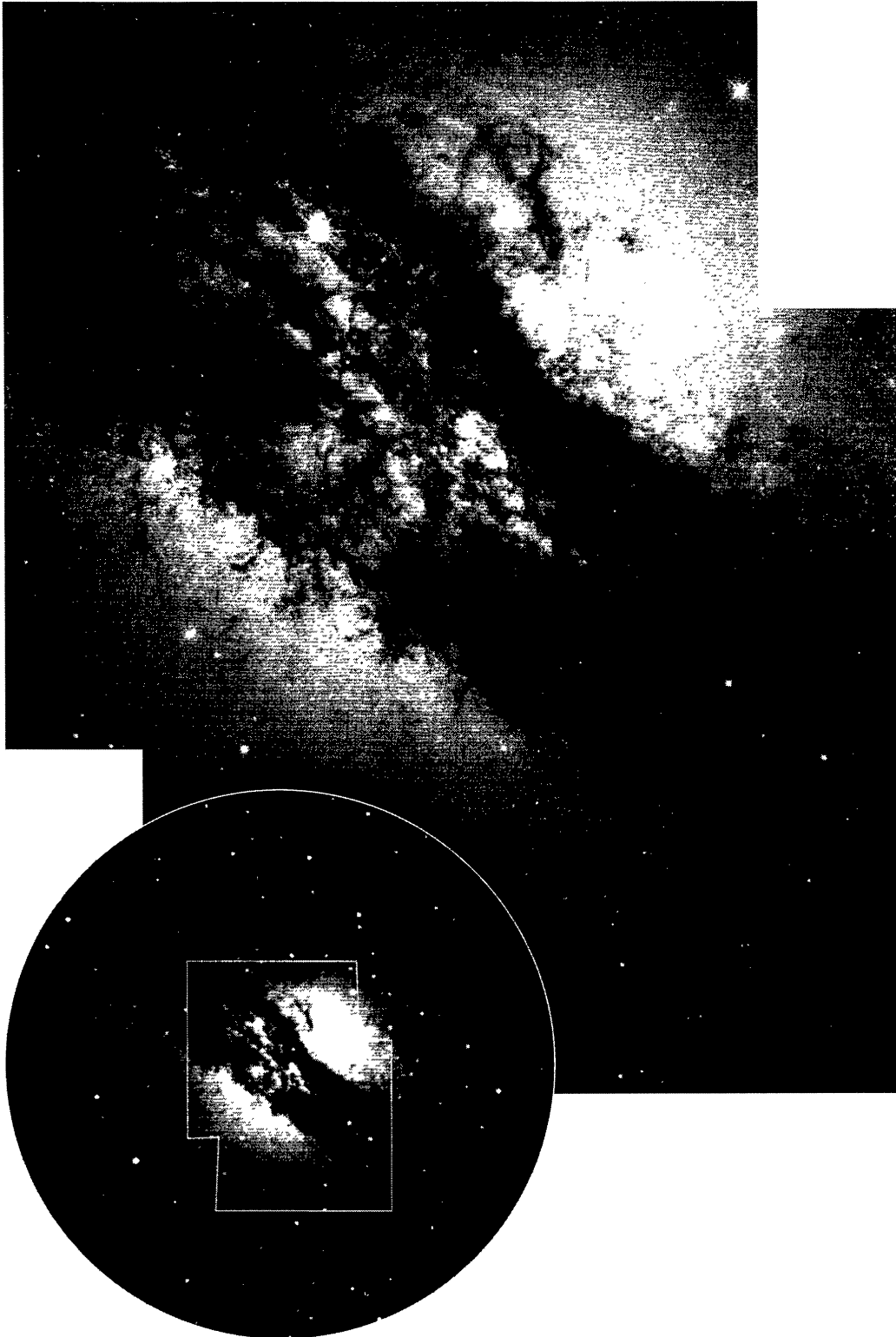
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# Journal of the British Astronomical Association

1998 October  
Vol. 108 No. 5



**HST reveals the dust disc around Centaurus A**

# Officers and Council

## Session 1997–98

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### Cover

The dust disc around the southern active galaxy Centaurus A (NGC 5128) imaged by the Wide Field & Planetary Camera 2 of the Hubble Space Telescope. Details as small as seven light-years across can be resolved. *Inset:* a ground-based image of the same galaxy, courtesy NAOA. (E. J. Schreier (STScI)/NASA)

# Journal of the British Astronomical Association

Editor and Advertising Manager

Mrs Hazel McGee

Papers Secretary: Nick James

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**Papers (three copies)** should be sent to the Papers Secretary at the address shown inside the front cover of this issue. They will be refereed, and, if approved by Council, published as soon as reasonably possible. Those wishing to speak at a meeting should contact the Meetings Secretary.

**All other contributions** should be sent to the Editor. As well as *Letters to the Editor*, she will be pleased to receive contributions to *Observers' Forum*, particularly interesting astronomical photographs providing they are not submitted or published elsewhere. Colour as well as black and white photographs are welcomed. Photographs will be returned only if a suitable stamped addressed envelope is enclosed.

## Advertisements

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**Display advertisements and loose inserts:** For a rate card and further information, contact the Editor.

## Deadline

Material for typesetting must be received by the following dates:

Issue	Date
February 1999	December 1
April 1999	February 1

Later dates apply to camera-ready advertising copy for which space has been reserved. Short letters and notes may be accepted up to the 10th of the month of the previous issue.

## Membership of the BAA

The annual subscription, for ordinary membership of the Association for the 1998–99 Session is £32.50. For details of concessionary rates, and other membership information, see page 246 of this issue. Subscriptions are due on 1st August each year and may be paid under a Deed of Covenant by members who pay income tax in order to benefit the Association, which is a registered charity. The annual subscription to *BAA Circulars* is £4.

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# Notes and News

## Meteor Section

### Good early-autumn prospects for meteor observers

Following a lean spell resulting from unfavourable moonlight conditions and poor weather, meteor observers have rather more to look forward to in the closing months of 1998. Prospects for the Orionids, active in the second fortnight of October, are excellent; a New Moon on Oct 20 means that skies will be dark for the shower's maximum which extends for a couple of days around Oct 21. The Orionids require late-night watches. The radiant, roughly midway between Betelgeuse and Gamma Geminorum, does not rise until about 22h local time, and is at its highest in the pre-dawn hours. Orionid meteors are very fast, and often leave persistent trains. Observed rates up to 15–20 per hour may be found on occasion. Watching the Orionids will be good practice for what many see as the main event of the autumn – the Leonids.

The parent of the Leonid meteor stream, Comet 55P/Tempel–Tuttle, returned to perihelion in February. Earth passes the descending node of the comet's orbit on November 17–18, some 258 days behind the comet, bringing the possibility of a meteor storm.

Leonid activity has been building since 1994. From quiet-time levels with sky- and radiant altitude-corrected Zenithal Hourly Rate (ZHR) around 10–15 at maximum through the 1980s and early 1990s up to and including 1993, the shower stepped up markedly in 1994 when, despite moonlight interference, observed rates were in the 20s.

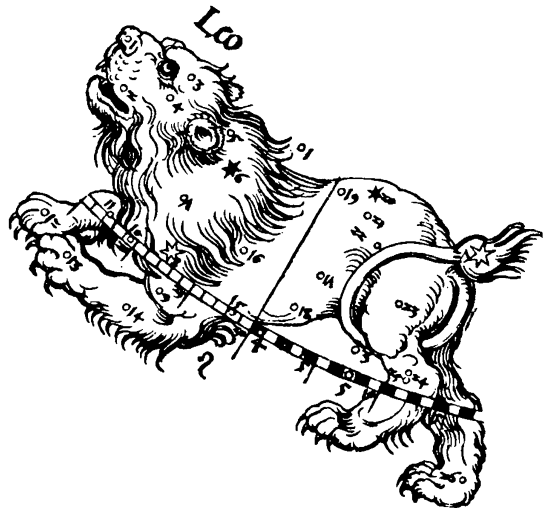
The 1995 return, in darker skies, brought substantial activity for observers in the British Isles on November 17–18, with peak ZHR about 40 for a couple of hours in early morning, and many bright Leonids. In 1996, the peak had broadened out – as happened previously in the early 1960s – to give a 12-hour span with ZHR above 40, and as much as 70, though no single obvious 'storm' peak was apparent. Leap year adjustments took the 1996 peak back to Nov 16–17, with best activity occurring up to about 13h UT.

Moonlight was again a hindrance in 1997, as was the weather for British observers. Data from the western US and Japan indicate that the Leonid peak on Nov 17 was again broad, and lacked a single very high-activity interval: the 1997 return offered no obvious

clues as to where any storm peak might lie. It would appear that no storm occurred in 1997 ahead of the comet's node-passage. This is not a bad sign; historical analyses by John Mason<sup>1</sup> and Joe Rao<sup>2</sup> show that Leonid storms most often occur when Earth follows 55P/Tempel–Tuttle to the node.

In the absence of a clear indication from the 1997 data, forecasts of when (and, from the point of view of being under dark skies with the radiant above the horizon, where) a storm peak might occur in 1998 are, at best, pure guesswork. The most likely outcome is that Earth will encounter the densest cloud of recently-ejected Leonid meteoroids close to the time of node passage, giving rise to an outburst which will be at its most intense for perhaps only 30–40 minutes. The node is currently encountered at Solar longitude = 235°.26, which is reached at 19h UT on 1998 November 17–18. At this time, the radiant will be far below the horizon for UK-based observers. Several groups are preparing to travel eastwards in longitude to improve their chances of seeing any outburst. Favoured locations may include India and the extreme east of Europe.

Past storms appear to have occurred an hour or two after the time of node passage. A delay of four hours or so in 1998 might just allow observers in the British Isles a glimpse of any extremely high activity as the radiant, in the 'Sickle' of Leo rises (around 22h30m local time). There is an outside possibility that the late evening of November 17–18 will be marked by unusually high numbers of long, near grazing-incidence Leonids streaking up from the eastern sky. Realistically, however, the chances must be



Leo: will he roar for us next year? (Woodcut by Albrecht Dürer, 1515)

considered better for observers at more easterly longitudes.

The intensity of the major peak is also uncertain. Probably the greatest of all Leonid storms was that seen in 1833 over the Americas, when – on the night of Nov 12 – Earth passed very close to the node of 55P/Tempel–Tuttle's orbit about 300 days behind the comet. The 1966 storm occurred with a greater miss-distance, but was still intense for 30–40 minutes, with reported rates of the order of 100,000 Leonids/hr in this interval.

In 1998, the distance between Earth and the node of the comet's orbit at closest approach is much greater, and it is possible that we could miss the densest parts of the meteoroid cloud. The display in this instance might be substantial, but not reach full-blown storm proportions (what some have described as a grand display).

Whatever the nature of any intense, sharp peak, it is fairly certain to be surrounded by a 12-hour (or longer) period of enhanced activity, the equal of that from the Perseids at peak in an average year. Some of this will undoubtedly be visible from the British Isles: we cannot depend on seeing any storm activity from our longitudes, but rates of perhaps a Leonid per minute are far from improbable in the hours after midnight on Nov 17–18. Storm or no storm, the Leonids will be well worth observing, whatever your location.

Reports of any Leonid observations should be sent to the Meteor Section as soon as possible after the event. Important details to record are the stellar limiting magnitude (an indication of sky transparency) and the start and end times of the watch. Ideally, watches are carried out for intervals of an hour, or several hours at a time. For each meteor, give time of appearance (UT), type (Leonid or sporadic) and magnitude relative to background stars. The presence and duration of any persistent trains left behind after meteors should be noted (Leonids sometimes produce spectacular, long-duration trains). Under conditions of very high activity, it will be more sensible simply to count Leonid numbers in intervals of five minutes or less, provided the times of these intervals are also recorded. Report forms and more detailed observing instructions can be obtained from the Meteor Section Director at the address on the inside front cover of the *Journal*.

Best current predictions suggest that the 1999 return could produce a grand display or a storm for observers in western Europe, in the early morning hours of November 18. The results from 1998 should help refine this forecast.

**Neil Bone**, *Director*

- 1 Mason J. W., 'The Leonid meteors and comet 55P/Tempel–Tuttle', *J. Brit. Astron. Assoc.*, **105**(5), 219–235 (1995)
- 2 Rao J., 'The Leonids: King of the Meteor Showers', *Sky & Telescope*, **90**(5), 24–31 (1995)

## From the President

At this month's AGM two of the BAA's most dedicated workers will be retiring after decades of service in various activities.

As Business Secretary for the past eleven years, Rossie Atwell has acted as minutes recorder at over 100 Council meetings. (Only Ernest Beet and J. G. Petrie have equalled Rossie's voluntary secretarial service during the history of the BAA). In addition, Rossie has advised six consecutive Presidents on Council procedures and processed literally hundreds of items of BAA mail during this period. As the last of those Presidents I am only too aware of how valuable Rossie's advice and timely reminders are.

Rossie also served the Association as a reliable employee, working as Assistant Secretary and deputy from 1970 to 1981. It was especially appropriate that someone following so closely in Lydia Brown's footsteps should be presented with the Lydia Brown Medal and gift for meritorious service in our centenary year. Rossie is also a former President of the SPA (formerly JAS) and a former Vice President of the BAA. She also edits the bi-monthly *Newsletter* in her characteristically friendly 'Rossie' style.

Rossie's contribution to British amateur astronomy is second to none and all on the Council wish her a long and happy retirement from her years of service as Business Secretary.

As BAA Treasurer for the past nine years, Henry Hatfield has been in the 'hot seat' with Lionel Mayling. While Lionel has been the backbone of the accounting team, processing thousands of cheques and carrying out all the tedious book-keeping chores, Henry has taken the flak when difficult policy decisions had to be made. Henry has supervised all of the Treasury and office activities, bringing computerised databases into the office at the start of his term, to make the BAA run as smoothly as possible.

In addition, Henry has fought battles on our behalf with computer manufacturers, software providers and photocopier leasing companies, enabling the office staff to concentrate on simply running the office. Over the years a number of critics have challenged Henry's policies; the test of time has shown that Henry has invariably been right and his critics have been wrong. Henry's policies have been simple enough however: straightforward common-sense decisions as opposed to hot air and waffle! In an era where we are increasingly bogged down with paperwork and spineless 'management-speak' I have always found Henry's approach a breath of fresh air.

In addition to Henry's tireless Treasury rôles he has been one of the BAA's leading and most charismatic observers since the late 1960s. His early photographic work on

the Moon and planets could only be bettered by the late Horace Dall and his entertaining talks on how he built his equipment inspired many younger members in the 1970s and '80s; I should know, I was one of those members.

Today, Henry's observatory at Sevenoaks is a major scientific facility, contributing hydrogen alpha and radio data to the Solar Section and to professional solar observatories. We wish Henry many years of fruitful solar observing in his retirement from BAA office, through the next solar maximum and well beyond.

Staying on the subject of the Treasury Department, we are indeed fortunate that Lionel Mayling has agreed to stay on for his 13th consecutive year as Treasurer/Assistant Treasurer. At the time of writing it seems likely that as President, I will be representing the Treasury Department during the next session, with Lionel continuing with his vital accountancy tasks. Attempts to find replacements for Henry and Lionel are continuing and we are currently investigating 'outsourcing' our accountancy activities to a commercial agency. It is disappointing that no one has stepped forward from the BAA's ranks to take on the Treasurer's post; it would appear that volunteers of the calibre of Henry and Lionel simply no longer exist... but I would be delighted if someone could prove me wrong.

Finally, I have decided to give my first Presidential Address, at this month's AGM, on the subject of 'Novae'. This is an area of astronomy that has interested me for many years but one that is, perhaps, being neglected, with the greater concentration these days on supernovae. We are well overdue for an easy naked-eye nova; I am hoping one will come along to coincide with the AGM!

**Martin Mobberley**

### *Iridium* satellite predictions

There were two errors in Nick James' article '*Iridium* satellites light up the sky' in the August *Journal*, page 187. The correct URL for the Website maintained by the German space agency DLR to provide predictions of satellite visibility (including *Iridium*) at any ground location is

<http://www.gsoc.dlr.de/satvis/>

and not as printed. The number of orbital planes and satellites per plane was also confused. The relevant sentence should read: '... the spacecraft are distributed between six equi-spaced orbital planes with each plane containing 11 equi-spaced satellites.'

Our apologies for these errors.



## Aurora Section

### British observations of noctilucent clouds in 1998 (provisional)

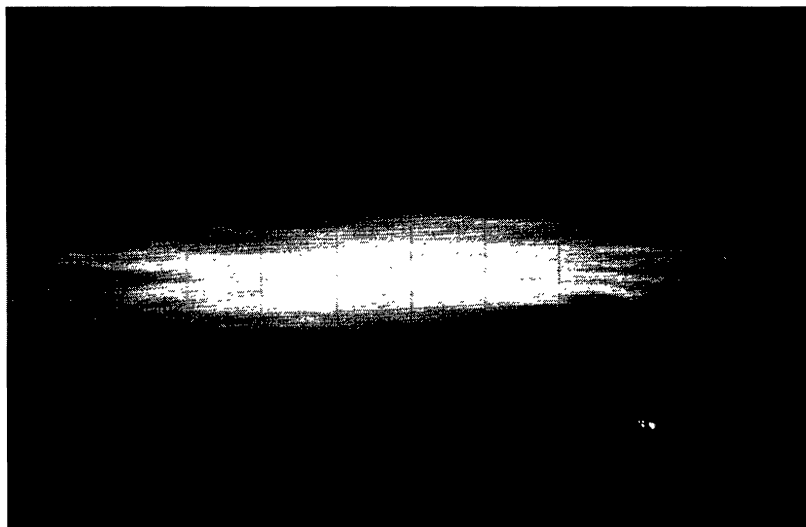
Date	No. of observers	*Types of NLC	Time range observed (UT)	Lowest latitude NLC observed	**Maximum brightness
<i>May</i>					
14/15	1	1	2203–2230	Morpeth	–
28/29	1	1,2	0000–0035	Edinburgh	1
<i>June</i>					
04/05	1	1,2,3,4	2225–0145	Edinburgh	3
06/07	1	2	2230	Edinburgh	1
11/12	4	1,2,3	2340–0040	Glangarnock	3
12/13	2	1,2,3,4	2250–0125	Morpeth	3
13/14	4	1,2,3,4	2025–0100	English Channel	4
14/15	2	1,2,3	0010–0100	Glangarnock	2
16/17	12	1,2,3,4	2155–0203	Sheffield	4
17/18	7	1,2,3	2245–0234	Morpeth	3
19/20	1	2	2245–0236	Trossachs	–
21/22	2	1,2,3,4	0100–0145	Upton on Severn	1
25/26	1	2,3	0100–0130	Morpeth	2
26/27	9	1,2,3,4,5	2150–0200	Slaley	3
27/28	1	2	0150	Stirling	2
<i>July</i>					
06/07	2	1,2	2300–0130	Morpeth	3
09/10	5	2,3,4	2225–0215	Morpeth	3
13/14	2	2	0055–0110	Glangarnock	1
14/15	2	1	2300–0040	Alness	1
16/17	1	2	0130	Birmam	3
17/18	1	2,3,4	0025–0200	Morpeth	2
18/19	1	2	2250–2345	St Andrews	1
21/22	2	1,2,3	0200–0300	Cambridge	4
23/24	3	2	0148–0245	Upton on Severn	2
26/27	1	2	2215	Stirling	2
<i>August</i>					
03/04	1	2	2222–2245	Pegswood	2

\*Types: 1 Veil 2 Bands 3 Billows 4 Whirls 5 Complex

\*\*Brihtnesses:

- |   |   |
|---|---|
| 1 Weak and barely visible                 | 4 Very bright, noted by casual observers                          |
| 2 Clearly detected but low brightness     | 5 Extremely bright and able to illuminate objects facing the NLC. |
| 3 Stands out sharply against twilight sky |   |

The above table summarises the work of 22 observers in the UK. Further observations have been received from 22 observers in Canada, Finland, Germany, Kazakhstan, the Netherlands and Norway.



Bright NLC photographed in 1996 by Jonathan Shanklin at the unusually southerly latitude of St Agnes, Cornwall. 1996 July 19, 22.10 UT. 8 secs. on 400 ISO Fuji slide film. *J. D. Shanklin.*

The summer of 1998 has been particularly cloudy in the troposphere, but nevertheless a number of observations has been made by Section members and others of noctilucent clouds in the mesosphere at an altitude of about 83km. In the accompanying table is given a provisional list of United Kingdom observations collected by Dr David Gavine, Assistant Director coordinating NLC observations and by Tom McEwan, Director of the Aurora Section in the Society for Popular Astronomy. In due course Dr Gavine will produce a final report covering all observations received from throughout northwest Europe.

While evidence of auroral activity during midsummer appears to be lacking in the UK there was an active mid-latitude aurora in North America on the night of June 25/26 with an associated American magnetic storm most active on June 26. This activity did not register significantly on our UK magnetometers. David Pettitt and the magnetometry team detected significant magnetic disturbance on July 16 that was driven by a high speed solar wind flux emanating from a coronal hole. Further stormy conditions were detected on July 22 to 24, again associated with coronal hole wind streams. Aurorae were reported to be active in North America at or around these dates. A lesser disturbance took place on July 31 with mid-latitude aurora building up in America on July 30/31.

**R. J. Livesey**, *Director*

### Brian Manning breaks Hind's asteroid record

The numbering of asteroid 1995 YF2 in a recent batch of Minor Planet Circulars means that eleven numbered asteroids have now been attributed to Brian Manning. This is one more than the record for an English observer held previously by J. R. Hind, which has remained for 141 years. For an asteroid to be numbered and its orbit regarded as fully defined, it must have its positions measured at four oppositions.

We offer our sincere congratulations to Brian and thanks to Gareth Williams for sending the relevant details via *The Astronomer* magazine.

**Hazel McGee**

## Solar Section

### 1998 May

From May 1 to 7 the disk was dominated by two very flare active groups. The largest was in the north at mean lat.+27° long. 105°–89°, classification Fkc from the 4th. The second which spawned a 3b flare on May 2 at 1300–1500 UT lay in the southern hemisphere at mean lat. –16° long. 136° Hkc. Other notable groups in May included one from the 7th to the 18th, Esi lat. –20° long. 353°–342°. From May 13 to 17 there was an interesting situation with two groups one in the north and the other in the south with similar longitudes. On the May 17 they both lay across the CM. The northern group with its forward spots inclined towards the equator was at mean lats.+19°/+22° long. 290°–276° with the following spot of the group the largest, class Eki. The southern group also had its leader inclined to the equator, mean lats. –24°/–30°, long. 290°–

### BAA sunspot data, 1998 May–June

Day	May		June	
	g	R	g	R
1	3	53	3	46
2	3	64	3	43
3	3	70	4	59
4	3	81	5	74
5	3	78	5	72
6	3	66	4	60
7	4	67	4	51
8	4	72	4	57
9	3	47	6	56
10	3	56	5	77
11	4	64	4	51
12	4	52	7	94
13	4	72	8	94
14	4	77	7	88
15	3	71	4	50
16	3	78	4	53
17	3	68	4	52
18	3	59	4	68
19	5	79	4	53
20	3	42	5	68
21	2	27	5	79
22	2	24	3	44
23	2	31	4	53
24	2	37	3	45
25	3	42	5	66
26	3	45	6	79
27	4	61	6	89
28	3	41	9	135
29	2	30	10	148
30	3	39	7	87
31	3	46		
MDF <sub>g</sub>	3.12		5.06	
Mean R		56.09		70.7

	MDF of active areas g	
	MDF <sub>Ng</sub>	MDF <sub>Sg</sub>
May	1.09	2.03
June	2.13	2.93

280°. This group consisted of a large number of penumbral spots with no large leader or follower, class Esi. However by May 19, it had lost all its vigour and ended up as Bxo class group. A small Axx spot seen on the 23rd developed rapidly into an Eko group at lat.+19° long. 213°, which by May 27 was flare active as it approached the NW limb. Also on that date a spot could just be made out tight on the SW limb at lat. –22° which produced a couple of Ib flares, one at 1019–1120 UT and the other at 1418 UT. The first was observed by the Director, the second by Ken Medway. The 3b flare mentioned earlier was recorded by members: Michael Hendrie, Ken Medway, Jack White and the Director.

Prominence MDF for May 7.64. There were some fine prominence displays during the month, a few of them in the active category. One at the SW limb on the 19th from 1320 to 1715 UT was well observed by Harold Hill. There were also some large filament structures on the disk. On May 4 a long filament extended from a few degrees east of the spot at –16° long 42° to bisecting the limb as a bright prominence. When fully on the disk this filament lay across the CM on May 9. By May 12 the full extent of the filament could be well seen. It was a long thin sinuous structure spanning some 40° of solar longitude in an E/W direction. By May 15 the western end bisected the SW limb showing a small prominence. Over the next few days the whole structure passed over the limb. From May 11 another large dark filament was recorded lying ahead of the northern Eki group. This filament extended in a N/S direction and it was just across the CM on May 6. Monty Leventhal recorded a large loop prominence in the area at the NW limb on May 20.

Naked-eye groups were visible from May 1–6 by members Michael Boschat, Mike Buck, Emilio Colombo, Alan Heath, Ken Medway, Nick Quinn and Jack White.

### 1998 June

A significant increase in activity this month. Some of this was probably due to a number of short lived spots and groups appearing spasmodically throughout the period. This was most noticeable in the northern hemisphere during the first part of the month. From June 1 to 4 there were two small bipolar groups at mean lat. +26° long. 93° and lat.+27° long. 350°. From the 12th to the 20th another small bi-polar group which became Cso on June 16 when at the CM, lat.+33° long. 251°. June 13–24 saw a large H type spot cross the disk at mean lat.+18° long. 213°. This spot had a few attendants lying close to it in a southerly direction; by June 20 the number of attendant spots had increased and surrounded the main H spot.

They had increased to 15 by June 21. On June 24–30 a Dsi group at mean lat.+17° long. 86° was flare active. The Director recorded a flare of importance Ib on June 24 at 1133–1151 UT when the group was in the NE region. John Trott observing at 18.6 KHz recorded an SID on the 24th at 1130–1138 UT duration 200 minutes. By June 29 three small additional groups appeared in the north, Axx at lat.+29° long. 131°, Bro lat.+17° long. 64° and a Cro lat.+23° long. 22°.

The southern hemisphere was only slightly more active. From June 3–12 two groups trailed each other across the disk, firstly a Dao at mean lat. –17°/–21° long. 45°–39°. The leading spot was well inclined towards the equator. It became flare active as it approached the SW limb. The second was an Hho group mean lat. –21° long. 354°. From June 12–14 small Bxo groups appeared briefly in the south at lat. –25° long. 318°, lat. –22° long. 289° and lat. –28° long. 261°. Also an Axx lat. –22° long. 246°, an Hxo lat. –20° long. 235°, and 16th to 19th an Hxx mean lat. –28° long. 54°. Activity in the south increased dramatically during the last days of June with six separate groups. On June 29 they stretched from near the CM to the SE limb, starting with an Hxx lat. –22° long. 72°, then Hxx lat. –26° long. 54°, Axx lat. –24° long. 44°, Hxx lat. –14° long. 44°, Cao lat. –21° long. 18° and a small Bxo grouping at mean lat. –22° long. 8°. On June 17 at 1448–1510 UT at lat. –24°/10°E Ken Medway recorded a 2b flare, probably associated with the Dao group mentioned above. This was supported by an SID at 1448–1452 UT duration 92 minutes recorded by John Trott.

Prominence MDF for June 8.43. There were a number of prominence displays both quiescent and active. Fine large sprays were seen on June 15 at 0722 UT at the SW limb and on June 21 at 0855–1622 UT by Harold Hill, this time at the NW limb. A number of filaments were also recorded on the disk, some associated with groups, others not. Eric Strach reports filaments as long as the solar radius were seen in the NE on June 1 and in the NW on June 5. On June 3 the Director observed a long filament in the SW partly as a prominence at the limb and its extension as a filament on the disk; it lay just east of the southern Dao group mentioned above. By June 7 the filament could no longer be seen. It must have been ejected from the disk.

Naked-eye groups were seen on June 4–11 and June 15–21 in the north. Observers: Michael Boschat 5th to the 8th and 10th only. Mike Buck, Ken Medway 6th, 7th and 21st only. Marie-Therese Pain, Nick Quinn 21st.

**Bruce Hardie**, Director

## Mars Section

## Mars 1996–97: a final Interim Report

The fifth in the series of Interim Reports appeared in the 1997 October *Journal*, and at that time the Director thought it would be the last of that series. However, as the full Section Report will not be ready for some time, and there have been some interesting events on the Red Planet, this note gives some further details about observations from the summer of 1997 onwards. So far, for the 1996–97 apparition as a whole, over 1800 observations have been received from 72 individuals.

BAA and other observations, 1997  
July to 1998 April

## General

From July 1 to December 31  $L_s$  ran from 156 to 246°, and  $D$  declined from 6.4 to 4.4 arcseconds. A number of good observations were contributed for July and August, after which the number dropped dramatically. No further modifications in the surface features were seen. The most interesting studies were done in association with two dust storms: these are mentioned below, but the routine observations of diurnal white clouds will be given in the final Section Report. The N polar hood was seen by the Director on July 6. HST data established that coverage of the cap was complete by July 9, as well as documenting the earlier buildup of polar clouds. Several observers recorded the S polar cap, but meaningful regression data were not obtainable. The last recorded ground-based observation of the apparition known to the Director comes from Don Parker's observatory in Florida, where despite low altitude the Syrtis Major and the SPC were spotted on the tiny 4.3 arcsec disk on 1998 January

21. The HST imaged Mars a record 311 times during the whole apparition, between 1996 September 18 and 1997 October 9. Though its images are of amazing resolution, we amateurs must congratulate ourselves in obtaining meaningful data both earlier and later than these limits!

*Mars Global Surveyor (MGS)* was imaging the planet well before *Pathfinder's* encounter, in preparation for its own orbital insertion on September 11. It imaged the planet frequently up until the start of its formal aerobraking activities (designed to lower and circularise its orbit) in 1997 November, though some of the early data were spoilt by martian diurnal cloud or simply 'lost in transit'. Technical problems due to a cracked solar panel have delayed the main two-year mapping mission, but in 1998 March it began mapping work from its interim 11.6-hour orbit. Solar conjunction occurred on May 12, since when contact has been reestablished and imaging resumed. At the time of writing (July) aerobraking was to resume in September, and to continue until 1999 March, when final orbit would be achieved.

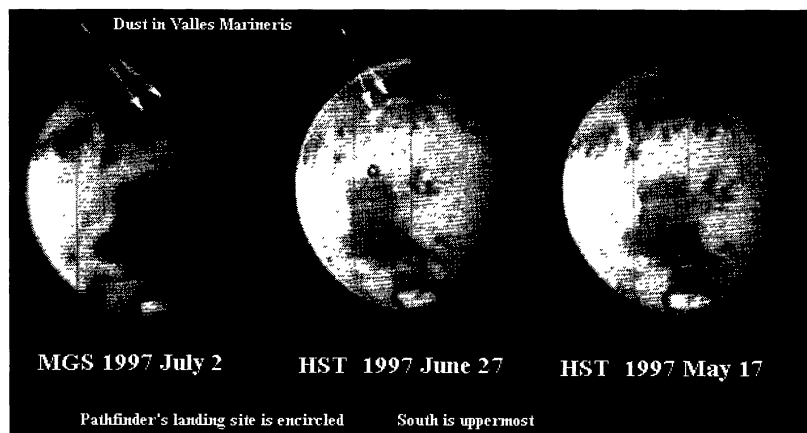
*Global Surveyor* has been returning impressive images of the surface of the planet with a much higher resolution (of order 10 metres) than anything achieved previously. The best is surely yet to come.

## Dust storm observed by the HST and Global Surveyor, 1997 June–July

It was mentioned in the last interim report that the HST had imaged a storm commencing over Valles Marineris in late June. The first image was actually acquired on June 27 (Figure 1), probably the first day of the event. Diffuse dust moved north over southern

Chryse and east over Mare Erythraeum and environs, as is typical with these events, but there was no effect upon *Pathfinder's* aerobraking (and subsequent landing at 19° 4N, 33° 1W). *MGS* imaged it on July 2, when most of the dust remained confined to the Mariner Valley. The event appeared to be over by early July, but the western extent of any dust over Thaumasia–Solis Lacus was less clearly established. Steve Lee and his team from the HST Institute reconstructed linear maps of the terrain about Solis Lacus, and Steve presented slides of the data at MTO-II (see below). These reveal obscuration in the region, but it was obliquely lit and the situation complicated by morning haze.

Section members did not possess the resolution to image the storm's initial phases from Earth, but diffuse dust, almost certainly having drifted NW from the Valles Marineris core, appeared bright in W25 red light to Martin Gaskell (200 mm refl., ×475, University of Nebraska) a few weeks later. These observations were reported to the writer and then published in *IAU Circular* No. 6693 (1997 July 5), where it is noted that Gaskell detected possible dust activity 'in the Ascræus–Ceraunius region near the Martian evening limb on June 26.09 UT.... Similar observations made on June 28.1, 29.1, 30.1 and July 1.1 suggested that the dust continued, roughly along the equator, to the Chryse region. R. McKim, British Astronomical Association, remarks that similar dust storms in the Ceraunius region were seen at the identical season in 1935 and 1978.' Gaskell's drawings are awaited. On August 4 Johan Warell (Tenerife, 384mm refl.) was able to see the initiation site on the CM: all had returned to normal, and there was morning equatorial white cloud.

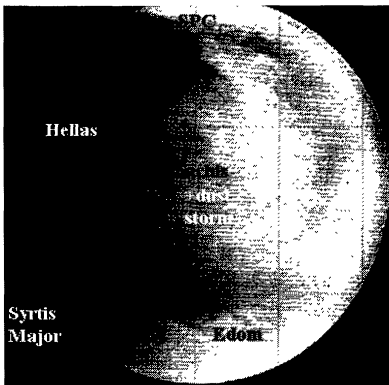


**Figure 1.** Comparison between HST and MGS images of the 1997 June–July dust storm over Valles Marineris. The original image has been relabelled and reorientated by the Director. On May 17 the Valley is clear of dust, but on June 27 the storm is in progress. Little change is visible in the (lower resolution) MGS image a few days later. (Original image copyright Malin Space Science Systems/NASA.)

A Global Surveyor dust storm, 1997  
November–December

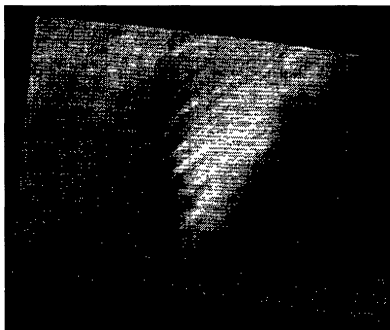
The first *MGS* images were taken on November 25, at  $L_s = 224^\circ$ , when there was an approximately 300km region (about 5° in martian longitude, and therefore only a small bright spot telescopically!) of dust seen in Noachis (and E and W). On November 26 the storm was positioned more precisely and had expanded to occupy 15 to 50° south, longitudes 325 to 5°. This is typical of events that commenced on the Iapigia–Noachis border, like the great storm of 1971.

On November 30, the contemporary report (published in the *International Mars-watch Electronic Newsletter*, Volume 3, issue 2, 1997 December) read as follows: '...the storm continues to intensify, spreading south onto the polar cap along a broad front from 30°W eastward to 290°W [Hellas to Argyre]. Considerable activity north of



**Figure 2.** Dust storm over Noachis Terra, etc., as imaged in red light by MGS on orbit 50 on 1997 November 26. South is uppermost, and key features such as Edom (Schiaparelli basin) have been labelled by the Director. (Original image copyright Malin Space Science Systems/NASA.)

Argyre, and from 10°S to 30°S at longitude 290°W.' (For comparison, see the writer's account of the 1988 June event over Hellas in *J. Brit. Astron. Assoc.*, **101**, 264–283 (1991).) At MTO-II, Todd Clancy reported contemporary microwave data which showed a warming of the martian upper atmosphere. According to the MGS Website, the storm was greatest in extent between November 26 and December 2, some 2500km in size. It then diffused out and faded, with dusty haze persisting for several weeks. In a brief account in *Science*, **279**, 1681–1685 (1998 March 13), M. C. Malin, M. H. Carr, G. E. Danielson *et al.* wrote that the storm's maximum extent was from 25 to 60° N and from longitudes 40°E (320°W) to 15°W. At the altitude of the spacecraft (124km) the dust storm caused orbit-to-orbit variations in atmospheric density by a factor



**Figure 3.** MGS image of the Viking 1 Lander site, 1998 April 12, on orbit 235. The spacecraft was 640km from the site, at which the Local Martian Solar Time was 9.20 am. The image is a map projection, 310km wide by 290km. (In the original colour image the green channel was synthesised from the red and blue channels.) Plumes from the well defined storm show that the wind is blowing from lower left to upper right. The storm covers most of the VL-1 site. (Image copyright Malin Space Science Systems/NASA.)

of 2 or more. Condensate clouds on the planet disappeared during the first four days of the event but reappeared within a month; in fact this has been observed with previous regional and encircling storms. Immediately before and following the event, there were small-scale storms reported within the 5° latitude band at the edge of the retreating SPC. Richard Schmude, (510mm refl., USA) sketched Mars on December 10, under CML= 272°. His drawing shows Mare Tyrrhenum clearly, but few other details.

The MGS image of the storm reproduced here for November 26 (Figure 2) was also published in the *Lunar & Planetary Information Bulletin*, No. 84, 1998 Spring. In the image the surface features appear slightly distorted due to the craft's low orbit, the features near the frame centre being exaggerated in proportion.

Since resuming systematic mapping from 1998 late March ( $L_s$  approx. 300°), MGS has taken crisp pictures of the surface, indicating a transparent martian atmosphere. We may therefore presume that the regional event of 1997 November–December was the largest storm this apparition.

#### Another MGS dust storm, 1998 April

A nice example of a small local dust storm was caught by *Global Surveyor's* cameras on 1998 April 12 ( $L_s=309^\circ$ ), in an image of the VL-1 landing site, at 22°N, 48°W, in Chryse Planitia (classical Xanthe). Full details appear on the MGS Website. The storm is pictured here (Figure 3), and the darkening of the ground at the edge of the cloud is surely due to the excavation of bright surface material by the storm. In his historical research the writer has found that Chryse/Xanthe produces telescopic storms during the  $L_s$  intervals 96–225° and 308–344°.

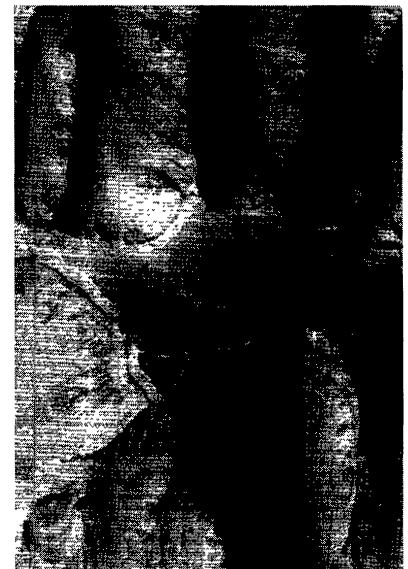
#### Other dust activity

At MTO-II, Steve Lee mentioned that HST images had revealed dust activity in the N polar region during 1997 July, when the polar hood was developing and polar clouds were changing daily. Descriptions of this activity were given in the *Proceedings of the 2nd International Mars Telescopic Observations Conference*. Other instances of activity may also be revealed by a close scrutiny of the HST data.

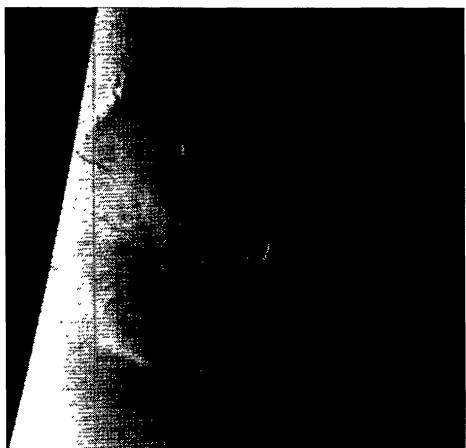
#### The martian surface viewed by *Global Surveyor*

If proof was required, MGS imaging on April 5 showed conclusively that the so-called 'Face on Mars' in Cydonia is nothing more than an irregular mesa, and the only resemblance to a human face comes from the combination of relatively low resolution and serendipitous lighting conditions experienced by *Viking*. (This feature is located at 40°.8N and 9°.6W; MGS resolution ex-

ceeded *Viking* by a factor of ten.) Most recently, *Sky and Telescope* for 1998 August gave a good selection of MGS images, and a couple of other interesting ones are given here. Images are being posted frequently on the NASA Website (the MGS main homepage can be found at <http://mars.jpl.nasa.gov/mgs/index.html>). The most exciting find was the complex stratification of the Mariner Valley (Valles Marineris), hinting that the geological history of the planet may be more complex than was previously believed. The *International Marswatch Electronic Newsletter* (Vol. 3, issue 4, 1998 February) further said that 'There is even a suggestion of the coming and passing of a sea across the terrain fairly high in the strata. Layering of the kind seen generally in the images could have formed from sedimentary deposits or episodes of volcanism... The resemblance to the Grand Canyon in Arizona is remarkable.' The *Lunar & Planetary Information Bulletin* records that 'high resolution images of dunes, sandsheets, and drifts are helping to reveal earlier chapters of martian history. Landforms shaped by erosion appear to be common, and dust spilling down the slopes of these ridges has invited comparisons to the snow-covered Rocky Mountains of Colorado. The martian crust also exhibits more layering at great depths... The steep walls of canyons, valleys, and craters show the martian crust to be stratified at scales of a few tens of yards [metres].'



**Figure 4.** MGS view of a tiny part of Valles Marineris, in the Coprates Chasma region, acquired at the start of orbit 80, 1998 January 1. The frame is only 9.8km wide, with a resolution of 6 metres! The small triangular mesa fills the frame, and the steep upper slopes of the spurs and gullies show the stratification referred to in the text, with layers of from a few to a few tens of metres thick. (Image copyright Malin Space Science Systems/NASA.)



**Figure 5.** *MGS* view of Olympus Mons, from 176km up, with afternoon water-ice cloud to the right, acquired on orbit 24, 1997 October 20. North is uppermost. The Local Martian Solar Time is 5.30 pm at the summit. The original image is in colour. (Image copyright Malin Space Science Systems/NASA.)

### Mars researchers meet in Tucson

As noted in the Council Report (see elsewhere), the writer attended the Second International Workshop on Mars Observations (MTO-II) in Tucson in 1997 October. The *Pathfinder* mission confirmed the presence of a weak, intrinsic planetary magnetic field, described at the conference as a 'frozen magma effect' involving the crustal layers of the planet. Analyses of the nearby rocks by *Sojourner* confirms that Ares Valles really must have been an ancient flood plain: they are geologically diverse, and some must have been transported from elsewhere. Daily weather reports came from *Pathfinder* until communications were lost. The reddish sky, sunsets, and 3D images all appeared on the screen. The latest HST images and maps were shown, and Steve Lee kindly gave the writer slides of unpublished Hubble images. Apart from the abstracts given in the conference proceedings, many of the papers were later to appear in a special issue of *Journal of Geophysical Research*, making a detailed review here superfluous. Meanwhile, there have been several papers in *Science*, most notably in volume 278, 1997 December 5.

A group photograph was taken by Ann Sprague (Figure 6). Meanwhile Mars fever has not abated, with no fewer than four international conferences scheduled for the summer of 1998.

### Observing Mars in 1999–2000

The next opposition of Mars will occur on 1999 April 24, with the planet at declination  $11^\circ$  south, with a disk diameter of 16.2 arcsec (distance from Earth = 0.583 AU). Thus Mars will be closer than in 1997, but

this will probably be more than offset for UK observers by the poorer seeing conditions to be expected from the lower altitude. Nevertheless, much useful work was done in the UK during the similar presentations of 1984 (R. J. McKim, *J. Brit. Astron. Assoc.*, **97**, 139–154 (1987)) and 1967.

At opposition,  $L_s$  will be  $129^\circ$  (compare  $L_s = 146^\circ$  in 1984). In 1984 the SPC began to become visible, and the NPC disappeared beneath polar clouds, at about  $L_s = 161^\circ$ , similar to the historical norm. Only the early 1998 observations will document the seasonal retreat of the N polar cap. Near opposition the cap will probably be surrounded by signs of the N polar hood, the cloud which will ultimately hide the cap. Also at about  $L_s = 161^\circ$  we may begin to see the foreshortened S polar cap, and very late observations may show its decline.

This will be another good apparition for observing the orographic clouds over the Tharsis volcanoes and over Olympus Mons and Elysium Montes. In 1984 there were numerous dust storms which began over Valles Marineris and environs, and their evolution mirrored that of the storm which began on 1997 June 27 as *Pathfinder* encountered the planet. Rapid communication between observers is essential if these events are to be followed, as no single terrestrial observer can follow the timecourse of any single event.

As to the surface markings, these have been remarkably stable for the last few apparitions, particularly since 1982. In brief, the Syrtis Major has been broad and blunt to the north, Moeris Lacus small and Nepenthes absent. Nodus Alcyonius has

been a dark round spot south of the southern tip of Casius–Utopia. The Deltoton Sinus area is faded, with the outline of Huygens crater perceptible within Iapigia. The east end of Sinus Sabaeus has frequently been weak, but a little variable, Pandora Fretum was moderately conspicuous. Following Mare Acidalium, Idaeus and Achilles Fons have formed two dark spots on the broad Nilokeras 'canal'. To the south, Solis Lacus has been large and dark since 1984, but the western part began a slow fade in 1995. The northwest part of Mare Sirenum has been weak since 1986. Throughout the late 1980s and early '90s Cerberus and Trivium Charontis have decreased in intensity and decreased in size. By 1997 they were scarcely visible even upon the HST images! At MTO-II, the Director provided historical information about the previous history of these features to Steve Lee and Jeff Moersch, who measured the thermal inertia of the region by ground based observations in 1997. Phlegra–Styx also faded concomitantly, but Propontis I remained dark, though variable in shape. A broad and diffuse darkening of the Aetheria desert at the NW corner of Elysium persisted through all these apparitions.

The disk diameter will exceed the usual lower observable limit of 6 arcsec by the end of this year, and I hope that observers will post, phone and email their data to me frequently. Report forms should be used, and will be sent on request. Remember that the Director will wish to prepare fortnightly or monthly summaries, and that a large batch of data sent at the close of the apparition will be much less useful to him. Finally, please note my change in address, telephone and email details since the last opposition.

**Richard McKim, Director**



**Figure 6.** MTO-II group photograph taken at the Starr Pass motel, Tucson, Arizona. Ann Sprague sits at lower left. Rik Hill is at the centre of the front row; standing behind and to the right of him is Don Hunten; right and left of the latter, respectively, are Dan Troiani and Dan Joyce (at the back). Standing, far left, is Todd Clancy. Fourth from the left is Gary Rosenbaum. Standing, from the right inwards: Jim Bell, Steve Lee, Don Parker, Kyosuke Iwasaki (at the front), Phil James (at the back), and the Director.

## The BAA Council, 1997–1998



Council members and officers photographed on the steps of Burlington House on 1998 May 27. *From left to right, back:* Ian Wood, Henry Hatfield, Lionel Mayling, John Mason, Jonathan Shanklin, Pat Barber, Owen Brazell, Tony Kinder, Mark Armstrong. *Centre and front:* Bob Marriott, Richard Miles, Laurence Anslow, Richard McKim, Martin Mobberley, Mike Maunder, Gordon Taylor, Nick James, Maurice Gavin, Rossie Atwell, Hazel McGee, Ron Johnson, Nick Hewitt. (Photo by Hazel McGee and Linda Newton)

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It would be greatly appreciated if overseas members and members from the Republic of Ireland would arrange payment in Sterling on a UK Bank.

New members joining between August and January will be sent the publications of the current session. New members (regardless of age) joining between February and June may pay the reduced rate of *either* £19.30 for the February, April and June *Journals* plus the current *Handbook* or £13.00 for the above *Journals* without the *Handbook*.

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Regular *UK Income Tax* payers may wish to consider signing a Deed of Covenant. The BAA is allowed to claim a refund from the Inland Revenue from the tax paid by the member. Apart from the deed, the only other form which requires the member's signature will be the tax claim form sent after the payment of the first year's covenanted subscription.

# A classification of auroral types

D. A. R. Simmons

All the currently recognised auroral types have been drawn together in a single classification based on their geophysical characteristics. A brief portrait of the most typical features of each type is presented with special reference to geomagnetic latitude, geomagnetic time sector and mechanism of aurora production. These and other characteristics make it possible to compare and contrast the similarities and differences between the different types of aurora on a geophysical basis.

## Introduction

The earliest auroral classifications were based solely on the morphology of the various visual forms observed in auroral displays. Perhaps the most important of these schemes was that published in 1927 under the auspices of the International Union of Geodesy and Geophysics<sup>1</sup> and later reproduced in 1930 as a *Photographic Atlas of Auroral Forms*.<sup>2</sup> Both these publications were based on the descriptions and definitions of auroral forms first proposed by Carl Størmer, one of Norway's most outstanding pioneers in auroral science. Later schemes extended the criteria for classification to include the colour of the various forms and structures. Perhaps the most useful of these later classifications was the *International Auroral Atlas*, also published by the International Union of Geodesy and Geophysics and later redrafted by Jacka and Paton<sup>4</sup> in 1963 under the auspices of the Comité International de Géophysique as an instruction manual for use during the International Years of the Quiet Sun (IQSY). A third atlas and auroral classification (the *Photographic Atlas of Auroral Forms Observed at Syowa Station*) was published in 1968 by Kaneda and his colleagues.<sup>5</sup> This atlas of the aurora australis retained the nomenclature of the *Photographic Atlas of Auroral Forms* (1930) for auroral morphology; the International Brightness Coefficients (IBC) of Hunten<sup>6</sup> for the measurement of brightness; and the nomenclature of the *International Atlas of Aurora* (1963) for colour classification. However, it also introduced new definitions and notation to describe the horizontal extent, the form of the lower border, the vertical profile and the activity of auroral structures.

In the present classification, the common types of auroral display are classified according to their geophysical characteristics with particular attention to their distribution in geomagnetic latitude and geomagnetic time. It will be apparent that this new classification does not supersede the older schemes cited above. Indeed, it complements them as it categorises the different types of auroral display on geophysical grounds whereas the older schemes categorised the morphology of the different visual forms whatever the type of the display. The proposed classification is followed by a brief description of the geophysical characteristics that define the different auroral types.

It should be noted that this report is only concerned with those naturally-occurring auroral events that result from collisional processes when atoms and molecules in the Earth's upper atmosphere are bombarded by electrons, protons and alpha-particles of solar origin. It will not include aurora-like phenomena such as night airglow which

results from irradiation of the upper atmosphere with solar ultraviolet light. Neither will it include the artificial (man-made) aurora-like events produced by ion releases from high-altitude rockets or by the ejection of electron showers from atmospheric nuclear test explosions.

## Classification of auroral types

### *Division I: Auroral oval population events*

- a) Nightside events
  1. Storm-type aurora including mid-latitude aurora
  2. Substorm aurora
  3. Diffuse-continuous aurora
- b) Dayside events
  4. Dayside cleft: Patchy prenoon aurora
  5. Dayside cleft: Noontime (cusp) aurora
  6. Dayside cleft: Discrete postnoon auroral arcs
  7. Dayside auroral transients

### *Division II: Polar cap population events*

- a) Discrete events
  8. Discrete polar cap aurora
  9. 1400h MLT (Magnetic Local Time) aurora
  10. Theta aurora
- b) Diffuse events
  11. Polar (auroral) rain
  12. Polar (auroral) showers
  13. Diffuse polar cap (polar glow) aurora

### *Division III: Lower latitude aurora*

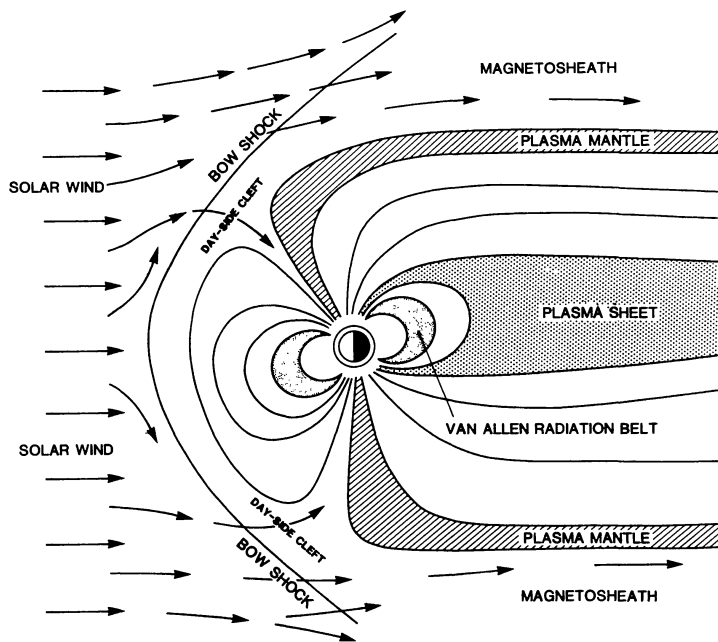
14. Stable auroral red arcs (SAR-arcs)

## General characteristics of auroral types and populations

### *Division I: Auroral oval population events*

The first major division in the above classification (I) includes those auroral types that are geophysically related to the auroral oval (see Figures 1 and 2). The structure and dynamics of the winter-time oval were first described in detail by Feldstein and Starkov,<sup>7</sup> who demonstrated that it lies in the upper atmosphere displaced eccentrically on the north geomagnetic pole in the direction of the midnight sector. When geomagnetic conditions are quiet the midday sector, some 2–3° in latitude, lies at geomagnetic latitude 75°N while the midnight sector, some 4–6° broad, lies at

## A classification of auroral types



**Figure 1.** Diagram of the Earth's magnetosphere showing the relationship of the different regions involved in aurora production. The general direction of flow of electrons from the solar wind is shown by arrows. The diagram is schematic and not to scale.

geomagnetic latitude  $67^{\circ}\text{N}$ . With increasing geomagnetic activity, there is all-round expansion and equatorward movement of the oval, usually restricted in the midday sector to a few degrees of latitude. In contrast, the midnight sector may broaden by  $10\text{--}13^{\circ}$ , sending its lower border down to geomagnetic latitude  $60^{\circ}$ , or even further south in severely disturbed magnetic conditions.

These simple observations explain some of the most characteristic features of oval population auroral events. First, as the auroral oval marks the position of the field-aligned (Birkeland) sheet currents formed by the auroral electrons flowing down into the ionosphere, it follows that the arcs and curtains of oval population aurorae tend to lie in east–west geomagnetic alignment along the curve of the oval. Second, the relatively fixed location of the dayside oval means that the dayside events are almost always found at high latitudes in the region of geomagnetic  $73\text{--}75^{\circ}\text{N}$ . In contrast, the structures in nightside aurora are usually found at lower latitudes depending to some extent on the type of aurora and the level of geomagnetic activity.

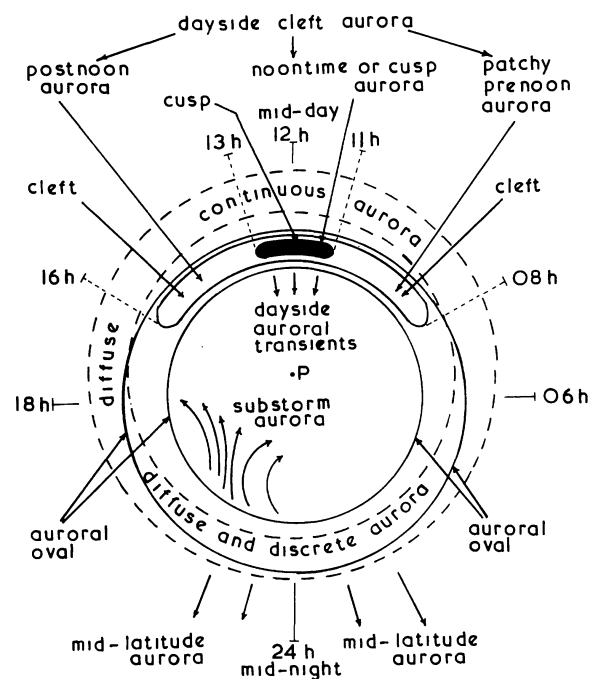
Third, while the predominant particle involved in oval population events is the electron, protons and other ions may make a significant contribution from time to time. However, there are marked differences in the energies of the dayside and nightside bombarding particles. Those on the dayside are mainly low-energy electrons of less than  $300\text{eV}$  that have gained access to the dayside oval through the dayside cleft or cusp with little or no acceleration along the route of entry. In the case of the cusp electrons, their energies are usually in the region of  $50\text{eV}$  or even lower. By contrast, the nightside electrons flow from the central plasma sheet in the Earth's magnetotail along the Earth's magnetic field lines to the nightside auroral zone where, after marked acceleration in the near-Earth environment, they are injected into the auroral ionosphere over a very

wide range of energies (mostly between  $3\text{--}20\text{keV}$ ). The higher flux rates of these high-energy electrons and the turbulence of the high-speed electron streams explain why the nightside aurora is so much brighter and more active than dayside population events.

#### Division II: Polar cap population events

For the purposes of auroral science, the polar cap is defined as the region enclosed by the auroral oval. The aurorae occurring within this region comprise the second main division (II) of the above classification and are usually referred to as polar cap aurorae (see Figure 3). The characteristic aurora of this region, discrete polar cap aurora, occurs when geomagnetic conditions are very quiet and the interplanetary magnetic field is lying in a northerly direction. At such times the equivalent current systems flowing in the polar cap form simple four-cell or complex multicell (vortex) patterns with the auroral arcs that are close to the oval lying almost east–west geomagnetic; with the auroral arcs that are lying close to the magnetic pole lying north–south geomagnetic; and the auroral arcs located between the

pole and the oval lying in transitional directions between north–south and east–west geomagnetic. The alignment of these arcs is clearly quite different from the east–west geomagnetic alignment of oval population events. Indeed, it is a striking feature of discrete polar cap aurora readily discernible when observing in polar regions.



**Figure 2.** Diagram showing the relationship of the different auroral types of the oval population to the auroral oval. The hour marks around the periphery of the diagram indicate local geomagnetic time. The point P represents the geomagnetic pole. The diagram is highly schematic and not to scale.

### A classification of auroral types

A second prominent feature of this type of aurora is the low activity and longevity of the arcs. This may be explained by the fact that the low-energy electrons (0.5–1.0 keV) associated with this type of aurora flow directly and steadily from their point of origin to the polar cap without intervening near-Earth acceleration. These electrons are believed to stem from the far magnetotail, or close to, the boundary plasma sheet.

A special type of polar cap aurora, diffuse polar cap (polar glow) aurora, is generated by highly energetic solar protons ejected by very large solar flares. It will be described in more detail below.

#### Division III: Stable auroral red arcs

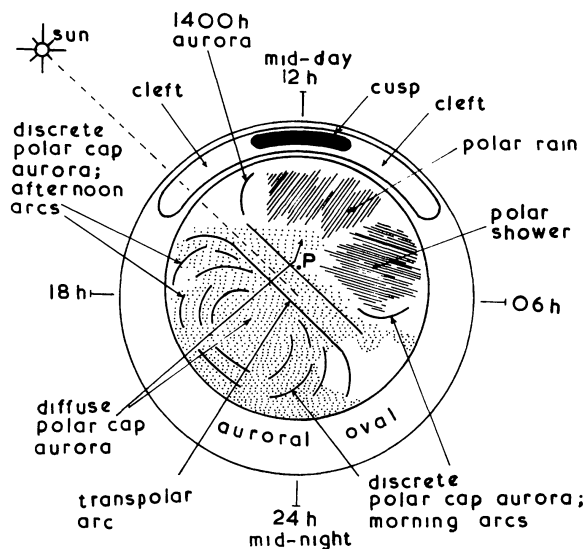
Stable auroral red arcs are the sole occupants of the third main division (III) of the classification. As their name implies, they are stable arcs that encircle the Earth about geomagnetic latitude  $45^\circ$  or a little higher. They are not related to the oval or polar cap populations of aurorae but appear at times of great geomagnetic activity. Their geophysical characteristics will be considered below.

## A summary of the geophysical characteristics of each auroral type

#### Division Ia: Auroral oval – Nightside events

**1. Storm-type and mid-latitude aurora** were once believed to be directly related to solar flares, eruptive prominences and disappearing filaments but there is now some evidence that the common factor in all these phenomena is a coronal mass ejection related to a coronal hole. This change of view was brought about by the discovery of a close, almost one-to-one relationship between auroral events and preceding white-light coronal mass ejections,<sup>8,9</sup> whereas the relationship between aurora and solar flares is very much poorer. Coronal mass ejections are probably related to cataclysmic changes in the lower corona in which stored magnetic energy is suddenly converted to heat, with the concomitant production of the hot plasma or ‘driver-gas’ that expels the overlying coronal mass into interplanetary space.

The launch of such a coronal mass ejection is sometimes, but not always, the trigger for solar flare production and its associated ‘crotchet’ in the Earth’s magnetic field. If the high-speed particle streams and shock waves associated with the coronal mass ejection encounter the Earth’s magnetosphere when the interplanetary magnetic field is strongly southward, reconnection or merging of the solar and terrestrial magnetic field lines is likely to follow. In that event, the high-speed plasma floods into the open dayside and nightside magnetosphere to reach the central plasma sheet in the Earth’s magnetotail and thence to the nightside auroral region where it is accelerated and injected into the auroral ionosphere to give brilliant aurora (see Figure 4). With the sudden increase in the flux of high-energy electrons into the nightside auroral oval, there is a marked increase in the field-aligned currents and magnetic fields that leads directly to the equatorward expansion that



**Figure 3.** Diagram showing the different auroral types of the polar cap population found within the auroral oval. It also shows the solar and north-south geomagnetic alignment of transpolar arcs of theta aurora. The hour marks around the periphery of the diagram indicate local geomagnetic time. The point P represents the geomagnetic pole. The diagram is highly schematic and not to scale.

drives the oval and its associated aurora down into mid-latitudes.

As the particles involved in these events are predominantly high-energy electrons in the range 1–100 keV, they penetrate the atmosphere deeply to a height of about 105km colliding with oxygen (OI) atoms to produce the characteristic predominant auroral green emission line at 557.7nm. Electrons with softer-than-average energies do not penetrate so deeply but give rise to collisional interactions with monatomic oxygen (OI) and molecular nitrogen ( $N_2^+$ ) producing intense red (630.0 and 636.4nm) and violet/blue (391.4 and 427.8nm) emissions respectively (see Figure 5). These emissions have ill-defined lower borders in the height range of 200–250km and may extend upwards for several hundred kilometres.

At the same time as these solar, interplanetary and magnetospheric events are taking place, there are concomitant changes in the Earth’s magnetic field. The first of these occurs eight minutes after the original solar outburst, when a blast of ultraviolet light and soft X-rays produces a short-lived magnetic ‘crotchet’ (Sudden Ionospheric Disturbance or SID) in the dayside magnetogram of the Earth’s magnetic field. Some thirty-six to seventy-two hours later, the sudden arrival of the pressure cap preceding the high-speed particle stream causes a sudden, wide-swinging disturbance (Sudden Storm Commencement or SSC) in the Earth’s magnetogram. This is usually, but not invariably, followed by a more-or-less prolonged magnetic storm, in which wild fluctuations in the Earth’s field are generated by the flow of electrons from the high-speed particle streams passing through the magnetosphere. The effects of the magnetic storm are observed world-wide as the charged particles flow through both the day and nightside hemispheres of the Earth.

In most instances, the initial solar disturbance is a ‘one-off’ event so the aurora and magnetic storm effects that

accompany it, are not repeated. However, from time to time, recurrent flares associated with an active region on the Sun produce a series of interfering shock waves and particle streams that generate several auroral displays and magnetic storms that last for days.

**2. Substorm aurora** which was first described and characterised by Akasofu<sup>10,11</sup> is generated by high-energy (1–10keV) nightside electrons. Unlike storm-type aurora which is associated with relatively rare cataclysmic solar events, substorms occur almost daily around geomagnetic midnight (see Figures 6 and 7). Indeed, there are an average of two to three substorms each day with as many as five or more on exceptionally active days. A typical substorm event usually lasts for two to three hours but some abort and are therefore of shorter duration. Quite commonly auroral substorms overlap or follow one another in quick succession to give longer periods of auroral and geomagnetic activity.

The electrons involved in this type of aurora stem from the solar wind. They pass through the cleft in the Earth's magnetosphere and thence through the entry and upper boundary layers to the Earth's magnetotail where they are stored during the 'loading' phase. The substorm is generated during the 'unloading' phase by the impulsive release of these stored electrons from the substorm onset region in the magnetotail by a triggering mechanism. These events are closely associated with magnetic substorms which show a small but characteristic positive wave or incursion followed by a negative magnetic bay in magnetograms of the H (horizontal) component of the Earth's magnetic field. Unlike magnetic storms which produce world-wide effects, the auroral and magnetic manifestations of the substorm are restricted to the vicinity of the auroral oval.

The nature of the triggering mechanism is currently the subject of much research but is not yet completely understood. However, the process seems to involve collapse of the mid-tail section of the Earth's magnetotail leading to a shut-down in the cross-tail current and its shunting through the auroral ionosphere as the wedge current and the westward travelling surge. The latter is now generally accepted as the driving force behind substorm aurora. A fuller account of the substorm process has been published by Simmons, Sigernes and Henriksen.<sup>12</sup>

In the foregoing account, it will be noted that storm and substorm aurora have been described separately. In this respect, it follows the early work of Akasofu who defined auroral events occurring in relation to a generalised world-wide geomagnetic storm as storm aurora<sup>11</sup> and those events occurring in relation to the more localised polar geomagnetic substorms, as substorm aurora.<sup>10</sup> Furthermore, from an observational point of view, these two types can be differentiated quite readily by the above criteria especially when magnetic records are available for the event in question. However, auroral science has moved on from its early observational and descriptive phase to consider two central problems, namely the transfer of solar energy from the solar wind to the Earth's ionosphere, and the nature of the mechanisms involved in the storage and release of particles and magnetic energy in the Earth's magnetotail. Until these mechanisms are fully elucidated, the precise relationship of

storm and substorm aurora will probably remain something of an enigma.

**3. Diffuse-continuous aurora** was first observed by Sandford<sup>13</sup> while comparing the variation of auroral intensity with changes in magnetic activity in the southern hemisphere. It was described as a broad band of diffuse emission, some 3–5° wide (in latitude), centred on the geomagnetic pole and extending in a circle round geomagnetic latitude 70°S. This band of emission therefore overlaps the midnight sector of the auroral oval but usually lies a good few degrees equatorward of it in the midday sector (see Figure 2). Although the precipitation was continuous and visually homogeneous, the flux density was greatest around the nightside and least in the afternoon sector. The energy of the electrons involved was about 1keV. Later studies by Lui and Anger<sup>14</sup> and by Winningham and his colleagues<sup>15</sup> confirmed the presence of this diffuse band of electron aurora using data from the INJUN and ISIS-1 and -2 satellites. They also noted that it contained a proton component which had virtually the same characteristics and spatial distribution as the broad 3–7° wide proton belt of Eather.<sup>16</sup> It lies along the southern edge of the diffuse electron aurora, or even equatorward of it, in the hours before geomagnetic midnight. Thereafter, the proton precipitation is more evenly distributed throughout the diffuse electron belt.

Winningham and his colleagues<sup>15</sup> were first to recognise that the electrons associated with the diffuse aurora came from the central plasma sheet (CPS) and are more-or-less independent of substorm activity. In contrast, the electrons associated with discrete auroral arcs in the oval come from the boundary plasma sheet (BPS) and are very sensitive to substorm activity. These observations account for the more-or-less constant position of the diffuse (CPS) aurora even when the discrete (BPS) aurora is migrating poleward during geomagnetic substorms.

#### *Division Ib: Auroral oval – Dayside events*

The daytime or dayside cleft aurorae are associated with two deep clefts in the magnetosphere, one in the northern and one in the southern hemisphere. These clefts are formed between the closed magnetic field lines on the Earth's dayside and the open magnetic field lines coming in from the magnetotail on the Earth's nightside (see Figure 1). They connect the magnetosheath through the outer and inner cusps to the underlying auroral ionosphere. The inner or low-altitude cusp lies immediately over the dayside auroral oval.

In the past, the terms cleft and cusp were used synonymously (and interchangeably) but they are now recognised as two distinct regions as a result of direct particle sampling by low-altitude satellites. The two terms have been redefined by Heikkilä<sup>17</sup> as follows: 'The cleft is the low-altitude region around (geomagnetic) noon of about 100eV electron precipitation associated with 630.0nm emission, but containing also structured features of higher energy. The cusp is a more localised region near noon within the cleft characterised by very low-energy precipitation only, having no discrete arcs, but often displaying irregular behaviour, presumably associated with the magnetic cusp'. Satellite

studies have also defined the dimensions of the cleft. It occupies some  $5^\circ$  of latitude at  $75^\circ\text{N}$  (corrected geomagnetic latitude) and 8.0 to 8.4 hours in longitude. The cusp which is  $2\text{--}3^\circ$  in latitude and 2.1 to 2.8 hours in longitude lies centrally within the cleft but is displaced towards its northern (poleward) border. These findings imply that the dayside aurorae are only visible from a very restricted zone on the Earth's surface. They also have a very short season of visibility for three weeks on either side of the winter solstice (that is, a total of six weeks) when the dayside sector of the auroral oval lies wholly within the darkness of polar night. It will also be apparent that the cusp divides the cleft into three regions, namely the prenoon, noontime and postnoon sectors. A more detailed account of the dayside cleft and cusp has been published previously by Simmons & Henriksen.<sup>18</sup>

**4. Patchy prenoon aurora** occurs at, or a little below, corrected geomagnetic latitude  $75^\circ\text{N}$  in the prenoon sector of the dayside oval between 0800 and 1100h MLT (Magnetic Local Time). For Spitsbergen, which is probably the most convenient land-based station for observing daytime aurora in the northern hemisphere, the corresponding times in UT are 0500 and 0800h UT. There are two populations of auroral electrons in this region. The first with energies about 170eV (range 100–300eV) passes through the turbulent regions of the entry layer which accounts for the patchiness of the green oxygen (OI) emission at 557.7nm (see Figure 8). These patches are usually weak, poorly active, sometimes rayed but often long-lived.

The second population of electrons is one that exists throughout the cleft. It consists of electrons with energies of about 50eV (range 10–100eV) that stem directly from the solar wind and which generate the red oxygen (OI) emissions at 630.0 and 636.4nm commonly associated with the dayside cleft region.

**5. Noontime (cusp) aurora** also occurs at, or a little below, corrected geomagnetic latitude  $75^\circ\text{N}$  but in the noontime sector of the dayside oval between 1100 and 1300h MLT. For Spitsbergen the corresponding times in UT are 0800 and 1000h. Here the aurora is generated by the 50eV population of electrons from the solar wind flowing directly through the outer and inner cusps with little or no acceleration in the near-Earth environment. The aurora presents as a broad, faint, diffuse band of red emission from the oxygen (OI) doublet at 630.0 and 636.4nm. This emission is sometimes so faint that it cannot be seen with the naked-eye but it can almost always be detected by spectrophotometry or interference filter photography. There are usually no discrete green auroral structures in this time sector so there is a gap of two or more hours (called the noontime gap) between the last of the green patchy prenoon aurora and the appearance of the green postnoon arcs.

The importance of Spitsbergen as a centre for dayside auroral research depends on the fact that it is the only readily accessible land site in the northern hemisphere that lies under the dayside aurora during the hours of darkness for approximately six weeks in the middle of the polar winter. Owing to the eccentricity of the southern auroral oval, the analogous site for the southern hemisphere happens to be

Scott–Amundsen base at the south geographic pole. The period of winter darkness there lasts for some 8–10 weeks.

**6. Discrete postnoon auroral arcs** also lie in the dayside auroral oval and therefore at, or a little below, corrected geomagnetic latitude  $75^\circ\text{N}$ . The arcs are found in the postnoon sector between 1300 and 1600h MLT (see Figure 9). For Spitsbergen the corresponding times in UT are 1000 to 1300h. The green and red aurorae seen in this sector are generated by the two populations of electrons noted in the prenoon sector, i.e. the green is generated by the 170eV electrons coming through the entry layer whereas the red aurora is generated by the 50eV electrons that come directly through the cleft from the solar wind. However, the green structures associated with the postnoon aurora take the form of arcs rather than the patches seen in prenoon aurora.

**7. Dayside auroral transients** are short-lived events that usually last for 5 to 10 minutes. Larger scale events may last for 8 to 15 minutes. Two different types have been described. In the first of these, Sandholt and his colleagues<sup>19</sup> noted that initial brightening in the 630.0nm emission on the equatorward side of the dayside oval was followed by enhancement of the 557.7nm green emission. As the auroral transient separates from the oval, it moves poleward into the polar cap where it gradually fades away. The same authors<sup>19</sup> were first to recognise these events as the 'ionospheric signature' of a plasma entry (flux transfer) event.

The second type of transient, observed by Fasel and his colleagues,<sup>20</sup> begins with enhancement of the 557.7nm emission in the dayside oval, moves poleward with multiple brightenings to reach its most northerly position where it brightens once more before finally fading away. This type of transient is believed to be caused by multiple reconnections and plasma transfer events in the same flux-tube. These flux transfer events are now attracting much attention as they are currently believed to be the most efficient way of transferring plasma between the solar wind, the magnetosphere and the ionosphere at times of electromagnetic coupling.

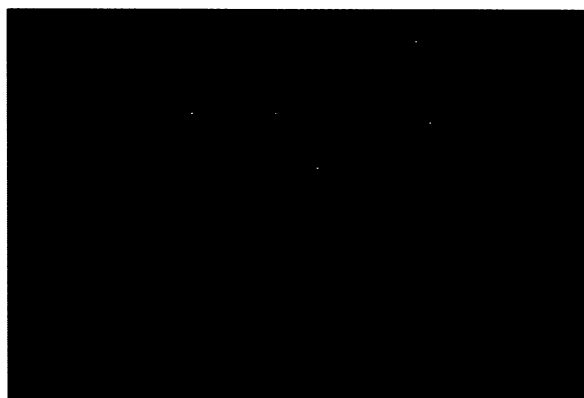
#### *Division IIa: Polar cap aurora – Discrete events*

**8. Discrete polar cap aurora**, first recognised as a separate auroral type in the south polar regions by Mawson,<sup>21</sup> was observed in northern latitudes during the International Geophysical Year by a number of auroral scientists including Lassen,<sup>22</sup> whose review gives a good account of the phenomenon. It is generated by electrons of intermediate energies (0.5–1.0keV) from the boundary layer of the plasma sheet in the magnetotail. These electrons flow directly to the polar cap without near-Earth acceleration. In the polar cap, the auroral electrons tend to precipitate along the equipotential lines of the equivalent current systems associated with the simple, multiple and complex cell systems described above. It follows that arcs close to the aurora oval lie almost in east-west geomagnetic alignment; that arcs near the geomagnetic pole lie in north-south geomagnetic alignment (and also in solar alignment); whereas those between the pole and the oval lie in transitional alignments. Thus the alignment of arcs in oval and polar cap aurora is quite different. Discrete arcs frequently

## A classification of auroral types



**Figure 4.** A typical bright, highly-active, storm-type auroral curtain photographed during a major geomagnetic storm. The sharp, well-defined, serpiginous edge of the lower border marks the height where the penetration of incoming auroral electrons has been brought to an abrupt halt by the exponential increase in atmospheric density. The brightest part of the arc, where the electron flux was greatest, is relatively overexposed and therefore appears white. The more distant part of the curtain, which has been more appropriately exposed, is 'auroral green' due to the forbidden monatomic oxygen (OI) emission at 557.7nm. The stars at the right-hand edge of the plate are  $\alpha$  and  $\beta$  Canis Minoris. The snow-clad mountain in the background is Bassen (height 1000m) and the building in the foreground is Nordlysstasjon (the Auroral Station). The photograph was taken with an exposure of 2 sec. on Kodak ASA 1600 professional slide film using a 50mm/f1.4 lens at 1803h UT on 1994 January 12.

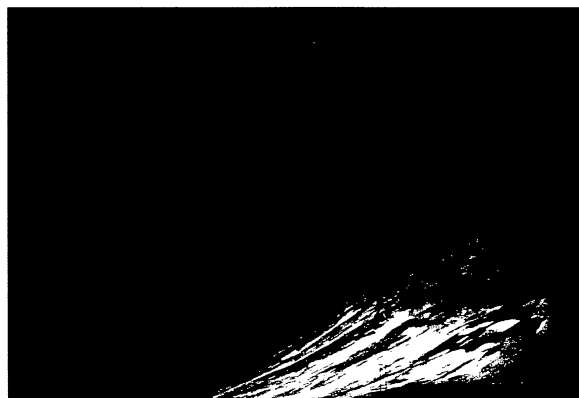


**Figure 5.** A typical 'type a' arc of mid-latitude aurora showing bundles of rays that were streaming slowly from east to west beyond the trees of Dougalston Estate, Milngavie, Scotland. The characteristic feature of such arcs is the green colour of the lower reaches of the rays due to 557.7nm emission, and the red colour of the upper reaches of the rays due to 630.0 and 636.4nm emission. Once again, the sharp lower border of the arc is to be noted. However, the most remarkable feature of this display was the intensity of the red emission along the top of the arc. The photograph was taken with an exposure of 30 sec. on Kodak ASA 200 slide film using a 50mm/f1.4 lens at 2128h UT on 1981 October 20.

**Figure 8 (right).** Patchy, prenoon aurora photographed from Nordlysstasjon in Adventdalen. This type of aurora comprises numerous weak and sometimes irregular patches that brighten and fade quite rapidly and unpredictably over large areas of the sky. Although they are usually quite homogeneous in nature, they frequently display a weakly rayed structure as shown here. The photography of such patches can be difficult as their contrast with the background sky is often reduced by the presence of weak but extensive diffuse aurora. This photograph was taken against the stars of the Plough with a 3 sec. exposure on Kodak ASA 1600 professional slide film using a 50mm/f1.4 lens at 0701h UT on 1994 January 12.



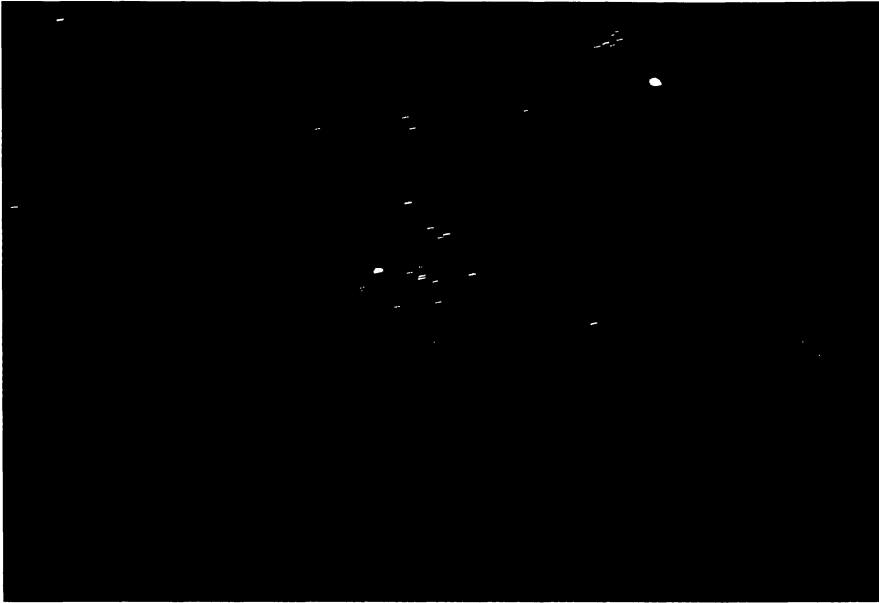
**Figure 6.** A substorm auroral arc moving northward from the southern horizon against the stars of Orion. The predominant emission is, as usual, from the green line at 557.7nm but weak blue light may be seen along the top of the arc from  $N_2^+$  emissions at 391.4 and 427.8nm. Such arcs are often multiple. In this photograph a weak, incomplete arc precedes the main one. When arcs are multiple, the southernmost is almost invariably the brightest. Weak diffuse-continuous aurora is just visible along the southern horizon. Note the red nebular emission from the HII region associated with the Orion nebula (M42) as it lies on the southern horizon. The photograph was taken from Adventdalen in Spitsbergen with an exposure of 5 sec. on Kodak ASA 1600 professional slide film using a 50mm/f1.4 lens at 2054h UT on 1995 December 24.



**Figure 7.** Another substorm event photographed from Teleriggen, Skjaeringa, Spitsbergen just after these oval-aligned arcs had started their poleward advance out of the auroral oval. The photo is typical of this type of aurora in that the southernmost arc is brightest with the more poleward arcs showing decreasing brightness. The auroral light on this occasion seems to consist entirely of green 557.7nm emission. The two brightest stars at top centre are  $\beta$  and  $\gamma$  Arietis and the brightest star at the centre of the photograph (behind the central arc) is  $\alpha$  Piscium. The photograph was taken with an exposure of 5 sec. on Kodak ASA 1600 professional slide film using a 50mm/f1.4 lens at 1835h UT on 1994 January 30.



*A classification of auroral types*



**Figure 9 (left).** Photograph of a post-noon arc taken from Nordllysstasjonen in Adventdalen showing a distinctly rayed auroral curtain against the stars of Taurus. The loose open cluster, the Hyades with the bright star Aldebaran, lies just above the mountain, Opera-fjellet, in the left-hand side of the picture. The bright and tighter open cluster, the Pleiades, lies at top centre with the planet Mars a little to the right and below. The slightly slotted appearance of the stars and planet is due to the longer (30 sec.) exposure used to secure this photograph. The predominant auroral emission probably comes from the auroral green line at 557.7nm but there are major blue (319.4 and 427.8nm) and red (630.0 and 636.4nm) components sometimes fused together to give a distinctly purple appearance. The photograph was taken on Kodak ASA 400 colour film with a 50mm/f1.4 lens at 1328h UT on 1991 January 05.

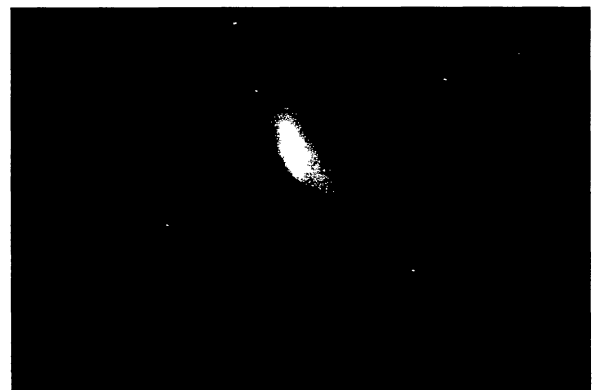


**Figure 10.** Discrete polar cap aurora photographed from Nordllysstasjonen showing the typical features of this type of event, namely the distinctly rayed structure of the arc, the great length of the rays and the intense blue emission from enhanced resonance excitation of the  $N_2^+$  emissions at 391.4 and 427.8nm due to irradiation with solar ultraviolet light. The great length of the rays is not so well demonstrated in this illustration as the exposure was a short one of only 1 sec. Taken on Kodak ASA 800 slide film using a 50mm/f1.4 lens at 1817h UT on 1986 February 09.



**Figure 11.** Photograph taken in Adventdalen showing the northern end of a transpolar arc (theta aurora) against the stars of Pegasus. The arc is running through the northern sky in roughly north-south geomagnetic alignment. This deduction can be made from the photograph itself which shows that the lower border of the arc is roughly parallel with the roof of the observatory which was built in north-south geomagnetic alignment for observational reasons. The photograph shows the faintly rayed and sometimes fragmented appearance that is typical of discrete polar cap arcs and their related aurorae. The crescentic light on top of the Station comes from a small observing dome illuminated by an unshielded 'courtesy light'. The photograph was taken with a 10 sec. exposure on Kodak ASA 800 slide film using a 50mm/f1.4 lens at 1915h UT on 1986 February 06.

**Figure 12 (right).** Diffuse polar cap (polar glow) aurora photographed through an interference filter with a peak transmission of 640.0nm. The central circular patch of auroral light of  $29^\circ$  diameter shown in this figure corresponds very closely with that predicted by calculation for auroral light of 630.0 and 636.4nm transmitted by a 640.0nm filter. The energetic solar protons that caused this event were probably generated by a solar flare that erupted around 0900h UT on 1986 February 14 in an active region of the Sun's northern hemisphere. The photograph was made with a 15min. exposure on Kodak ASA 400 slide film between 1730 and 1745h UT on 1986 February 15. The bright star trails can be identified as  $\epsilon$  Bootis at the right-hand edge,  $\alpha$  Coronae Borealis in the centre of the field and  $\beta$  Herculis immediately above Hiorthfjellet (the mountain at lower left). The pattern of light coming through the centre of the filter and the fact that this aurora was accompanied by polar cap (radio) absorption indicate that this event was almost certainly one of diffuse polar cap (polar glow) aurora.



bridge the polar cap connecting the morning and evening sectors of the auroral oval along the line of the transpolar (electron) current. Very high-latitude stations wholly within the oval during the Earth's diurnal rotation pass under the bridge twice a day giving morning and evening maxima at 0900 and 1900h MLT respectively. Stations at the latitude of Spitsbergen lie within the oval in the evening but under, or even south of the oval in the morning. From such stations the evening, but not the morning maximum is readily observed.

The observed features of discrete polar cap aurora are quite distinctive. With low flux rates and relatively low electron energies in the region of 0.5–1.0keV, the arcs are usually faint and poorly active compared with storm or substorm aurora. Individual structures within an arc are usually short-lived but, with the frequent emergence of new forms, the arc itself can persist for a few hours. Rays, which are frequently present, are usually exceptionally long reaching up into the sunlit atmosphere where they display a very obvious blue/violet colour from enhanced resonance excitation of the  $N_2^+$  emissions at 391.4 and 427.8nm, in consequence of irradiation with solar ultraviolet light (see Figure 10). However, the predominant colour of this type of aurora is green, from the auroral line at 557.7nm emitted by excited oxygen (OI) atoms. The arcs are often multiple and the typical 'braided stream' appearance is seen from time to time. As might be expected from the low energy of the bombarding electrons, the lower borders of discrete polar cap arcs lie at greater heights (about 150km) than those of substorm aurora (about 105 km).

These distinctive features determined by the low-energy profile of the electrons involved, make the differentiation of discrete polar cap aurora from other auroral types, a relatively easy matter. A fuller and more recent account of discrete polar cap aurora has been published by Simmons and Henriksen.<sup>23</sup>

**9. 1400h MLT (Magnetic Local Time) aurora** lies within the polar cap at latitudes above 75°N (geomagnetic) in the 1300–1500h MLT sector. The appearance of this type of aurora is indistinguishable from that of discrete polar cap aurora and the origin of the auroral electrons is also in the boundary layer of the plasma sheet along the Earth's magnetotail. The only differentiating feature seems to be the somewhat higher electron energies (0.5–3.0keV) in 1400h MLT aurora. However, the observation that 1400h MLT auroral arcs run into discrete polar cap arcs in the 1500–1900h MLT sector suggests that 1400h MLT aurora is a form of classical discrete polar cap aurora. A detailed account of 1400h MLT aurora has been published by Evans.<sup>24</sup>

**10. Theta aurora** is a special form of discrete polar cap aurora in which a complete arc bridges the polar cap connecting the morning and evening sides of the oval along the line of the transpolar (electron) current. The transpolar arc together with the oval, forms a structure resembling the greek letter theta, which explains the name of this type of event. Such transpolar arcs usually lie in north-south geomagnetic alignment in contrast to the east-west alignment of oval population events (see Figure 11). They also show a good degree of solar alignment at very high latitudes

because the oval is fixed in space with respect to the Sun (see Figure 3) and the electrons in the transpolar current flow through the cap in a sunward direction.

According to Frank and his colleagues,<sup>25</sup> bright discrete polar cap arcs are associated with the four-cell (vortex) system of Burke and colleagues.<sup>26</sup> In this system the plasma convection associated with the arc flows sunward in the transpolar current to the evening sector of the oval. In most other regions of the polar cap, the plasma convection is anti-sunward. When weak discrete arcs are observed in the polar cap, the simple four-cell pattern is replaced by a turbulent flow in which the plasma convection is usually sunward over most of the polar region. More recently, Neilson and his colleagues<sup>27</sup> have found that the plasma convection associated with an arc is usually sunward in the evening sector, static over the geomagnetic pole and anti-sunward in the morning sector of the arc. From optical, radar and electron-drift studies, it was concluded that the plasma flow pattern around the arc could be explained by the presence of 'lobe-cells'.

The proposed plasma flow pattern is of special interest because it offers an explanation for the observed facts that transpolar arcs are often deficient over the geomagnetic pole where the plasma flow is static and brightest just north of the oval where the transpolar plasma merges with the oval. A most detailed and comprehensive account of theta aurora has been published by Frank and his co-authors.<sup>25</sup>

#### *Division IIb: Polar cap aurora – Diffuse events*

**11. Polar (auroral) rain** is a weak, diffuse, homogeneous and unstructured type of aurora that frequently fills most of the polar cap region. Gussenhoven<sup>28</sup> has shown that it is generated by two populations of electrons around 10 and 60eV but it is still not known whether these electrons reach the polar cap via the cusp or directly through the open field lines in the magnetotail. According to Gussenhoven and her colleagues,<sup>29</sup> the flux density in this type of aurora is highest at latitudes just poleward of the dayside sector of the oval, but its intensity falls off (by about a factor of 20) across the cap to reach a minimum at high latitudes above the nightside oval. These same authors<sup>29</sup> found that polar rain is most common when the interplanetary magnetic field lies in a southerly direction and most intense when magnetic activity is high. This observation is consistent with the finding of Gussenhoven and Madden,<sup>30</sup> that polar rain is most frequent and most intense around solar maximum and weakest around solar minimum.

**12. Polar (auroral) showers** are generated within the polar cap by the same electron populations that generate polar rain but they occur when magnetic activity is quiet and the interplanetary magnetic field is in a northerly direction. Gussenhoven and colleagues<sup>29</sup> noted that these showers are produced by high-density bursts of electrons over wide areas of the polar cap. The auroral precipitation tends to invade the polar cap from the morning side of the oval but is patchier and more structured than polar rain. Hardy and his colleagues<sup>31</sup> have suggested that polar showers are a weakly accelerated form of polar rain. The most recent results from both Russian and American spacecraft indicate

that polar showers may be associated with the direct entry of solar wind plasma over large areas of the polar cap when the interplanetary magnetic field is in a northerly direction.

**13. Diffuse polar cap (polar glow) aurora** is a comparatively rare event generated by energetic solar protons from flares at times of great solar and geomagnetic activity. The particle stream has very few, if any, electrons but its alpha-particle content, usually about 1%, may rise to nearly 45% in large cataclysmic events. The energies of the particles normally lie in the range 1–100MeV and occasionally up to a few GeV. With such energies the maximum auroral precipitation usually lies at between 50 and 70km, which heights correspond to proton energies between 5–30MeV and alpha-particle energies between 20–100MeV. A few particles with higher energies may penetrate down to heights between 30 and 50km above sea-level.

As the protons pass through the atmosphere, they undergo successive electron capture and loss (by acquisition and collisional processes respectively). In the positive proton phase, the particles follow a helical pathway with the local magnetic field line as guiding centre. In the neutral hydrogen phase, the particles escape from the control of the magnetic field to follow a free, straight-line flight-path. As the radius of the helix is many hundreds of metres and the length of the straight-line flight-path some 200–300km, the incoming particles and their associated aurora usually fill the whole of the polar cap region according to Hakura.<sup>32</sup>

The spectrum of this type of aurora is most interesting. In contrast to what one might expect from a stream of protons and hydrogen atoms, the H $\alpha$  and H $\beta$  lines are poorly represented because the charge exchange reaction for such high-energy particles is very inefficient. The auroral line from monatomic oxygen (OI) at 557.7nm and the bands from the first negative, first positive and second positive states of molecular nitrogen are all enhanced. The red emissions associated with the polar glow aurora stem mostly from the red oxygen (OI) doublet at 630.0 and 636.4nm (see Figure 12). Most of this light is radiated from the D-layer of the ionosphere but, in the brightest of displays, some red emission also occurs at F-region heights generated by a second population of relatively low-energy (400keV) protons. Fuller accounts of diffuse polar cap (polar glow) aurora have been published by Sandford<sup>33,34,35</sup> and by Simmons and Henriksen.<sup>36</sup>

Polar glow aurora is also associated with concomitant polar cap radio blackouts due to the absorption of short-wave radio signals in the heavily ionised D-region of the ionosphere. The simultaneous occurrence of polar cap glow, high geomagnetic activity and polar cap radio blackout, is good evidence that these phenomena are causally related to energetic proton/alpha-particle emissions from large solar flares. Radio blackouts, like polar glow aurora, are long-lived events lasting two or more days so their disruption to radio communications can have serious social and business consequences.

#### *Division III: Lower latitude aurora*

**14. Stable auroral red arcs (SAR-arcs)** were first observed by Barbier<sup>37</sup> from southern France. Their properties

and characteristics have been reviewed in detail by Rees & Roble.<sup>38</sup> The arcs of this type of aurora are almost invariably subvisual necessitating the use of spectrophotometric equipment that can detect the characteristic emission lines at 630.0 and 636.4nm. The emitted light is almost pure red, there being no detectable emission at other auroral wavelengths. SAR-arcs normally lie about geomagnetic latitude 45° at heights of 300–700km with maximum emission around 400km. Their extent in latitude can be several hundred kilometres and, in longitude, they may encircle the globe in approximately east-west alignment. When the arcs are multiple, the most southerly is usually the brightest. Another characteristic feature of these structures is that they only occur at times of geomagnetic storms when the planetary magnetic index has a Kp value of 5 or more. SAR-arcs therefore have a much higher incidence around solar maximum (some estimates of up to 20% of nights) but a very much lower incidence around solar minimum.

A thermal conduction hypothesis proposed for the thermal excitation mechanism for this type of aurora by Cole<sup>39</sup> and by Cornwall and his colleagues<sup>40</sup> has been summarised by Jones.<sup>41</sup> This mechanism has now been accepted, because it explains the features and characteristics of SAR-arcs, their geographical position, the purity of their auroral spectrum, their geophysical relationship to the plasmasphere and their occurrence at times of great solar activity.

## Discussion and comments

The different types of aurora in the present study have been classified on the basis of their geophysical characteristics, some of which are summarised in Table 1. Such classifications can help to clarify the geophysical basis of the similarities and differences between the various types of aurora, provided the criteria for categorizing the different types have been clearly defined.

In the case of the bright nightside oval aurorae (Division Ia), all are generated by auroral electrons of higher-than-average energy (1–100keV; mostly within 3–20keV). The storm-type/mid-latitude aurorae are usually ‘one-off’ events associated with coronal mass ejections and high-speed solar electron streams that occur concomitantly with worldwide magnetic storms. In contrast, substorm aurora is triggered in the substorm onset region of the magnetotail and is associated with a characteristic negative bay in the H-component of the Earth’s magnetic field. Substorm auroral and magnetic events are often multiple and usually confined locally to the region of the auroral oval. The inclusion of the diffuse-continuous aurora in this group seems justified on the grounds that it lies in east-west geomagnetic alignment, is spatially related to the auroral oval and is generated by relatively high-energy electrons mainly, but by no means entirely, on the Earth’s nightside. Thus all members of this group of aurorae share a number of features in common determined by their relationship to the auroral oval and the fact that they are generated by nightside electrons of high energy. At the same time all three types can be recognised as different by their distinctive mechanisms of aurora production, namely: by coronal mass ejection in

**Table 1. Energies and routes of entry for particles involved in the production of different auroral types**

Table listing the energies and routes of entry for the various auroral particles involved in the production of the different types of aurora. The reference numbers indicate where the information was obtained and where further details can usually be found.

Type of aurora	Auroral particle	Average energy of particle	Reference	Entry route	Reference
Mid-latitude	electron	1–50keV	11	BPS	15
Substorm	electron	1–50keV	11	BPS	15
Diffuse-continuous	electron	1keV	13	CPS	15
Dayside cleft: prenoon	electron	170eV & 50eV	42, 43	LLBL/EL & SW	42, 44
Dayside cleft: cusp	electron	50 eV	43	SW	44
Dayside cleft: postnoon	electron	170eV & 50eV	42, 43	LLBL/EL & SW	42, 44
Dayside transient	electron	0.5–1.0keV	45	FTE	20
Discrete polar cap	electron	0.6–1.0keV	46	BPS & MS	25
1400h LMT	electron	0.3–3.0keV	24	BPS	24
Theta	electron	0.2–0.5keV	25	BPS (ES)	25
Polar rain	electron	10 & 60eV	28	OFL/MT or SW	28
Polar shower	electron	10 & 60eV	28	OFL/MT or SW	28
Diffuse polar cap (1)	proton	5–30MeV	47	PC	34
(2)	alpha-particle	20–100MeV	47	PC	34
SAR-arcs (1)	proton	10–50keV	38	Proton belt	38
(2)	electron	5–10eV	38	Plasmapause	38

*Entry route abbreviations:*

BPS = boundary plasma sheet (which defines the poleward boundary of the dayside cleft)

BPS(ES) = boundary plasma sheet (evening sector)

CPS = central plasma sheet

LLBL/EL = low latitude boundary layer/entry layer (which defines the equatorward boundary of the dayside cleft)

SW = direct entry of the solar wind

FTE = flux transfer event

MS = magnetosheath

OFL/MT = open field lines in the magnetotail

PC = direct entry through the polar cap or via open field lines in the magnetotail.

It should be noted that there are two populations of auroral electrons in the dayside cleft, namely the 170eV population from the low latitude boundary layer and the 50eV population which comes directly from the solar wind. Two populations of particles are also involved in SAR-arc production. These are the 10–50keV protons of the ring current which are not auroral particles in a collisional sense but which do energise the 10–50keV electron population from the plasmapause by thermal conduction.

aurora type 1; by triggering of the substorm onset region in aurora type 2; and by the production of a more-or-less steady flux of electrons from the plasma sheet in aurora type 3.

In the dayside oval aurorae (Division Ib), the three forms associated with the dayside cleft (patchy prenoon, noontime and discrete postnoon) are all generated by electron populations with low flux rates and energies mostly below 300eV, so they are fainter and less active than the nightside events. They have been described as three separate types on the basis of their distinctive visual appearance, their occurrence in different geomagnetic time sectors and their different mechanisms of aurora production. Thus although the dayside aurora hold some features in common, they also exhibit differences that can be related to different conditions in different regions of the cleft, namely: the patchiness of prenoon aurora to turbulent plasma passing through the dayside cleft (aurora type 4); quiet, red, noontime aurora to the relatively high-flux, low-energy electrons of the solar wind flowing directly through the cusp (aurora type 5); and the discrete arcs of postnoon aurora to the 170eV population of electrons coming through the lower latitude boundary and entry layers (aurora type 6).

Similarly, discrete polar cap, 1400h MLT aurora and theta aurora (Division IIa) have been described as separate entities as they can be differentiated quite easily by their visual appearance, their occurrence in different geomagnetic time sectors and by the way in which the geomagnetic and solar alignment of their arcs varies with geomagnetic

longitude. Nevertheless, 1400h MLT aurora and theta aurora can be regarded as special forms of discrete polar cap aurora.

Of the diffuse polar cap aurorae (Division IIb), polar rain and polar showers seem to be closely related as both are generated by two low-energy electron populations coming through the full breadth of the polar cap. Indeed, as noted above, Hardy and his colleagues<sup>31</sup> have suggested that polar showers may be a weakly accelerated form of polar rain. Diffuse polar glow aurora however, is an entirely different type of aurora being generated by energetic protons from flares at times of great solar activity.

From the above description of stable auroral red arcs (Division III) and their geophysical properties, it is clear that this type of aurora stands in a class of its own.

As indicated above, this classification of auroral types is based on their geophysical characteristics and properties some of which are summarised in Table 1. It is hoped that this classification will bring some law and order to the seeming complexity and endless variety of auroral types. It might also be useful as a scheme for identifying presently-recognised types or as a framework for classifying types yet to be described.

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## A classification of auroral types

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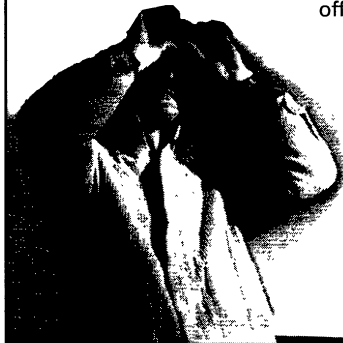
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# Light pollution and the law: what can you do?

Penny Jewkes

This paper describes the most effective ways in which the ordinary citizen can use the legal and planning systems to minimise inconvenience and damage from unwanted light.

## Introduction

Although the term Light Pollution is not recognised as a legal concept, many of the problems caused by it come within the scope of legal remedies. Potential light pollution controls may be found in many places. For example the Civil Aviation Act 1982 provides that the Secretary of State may restrict the installation of cables, mains, pipes and wires over any land for reasons of safety and efficiency connected with civil aviation purposes. The Secretary of State's powers can extend to lights on private property which interfere with aircraft landings. There are local authority bylaws and the Health and Safety at Work etc. Act 1974. Crime prevention measures, energy and nature conservation legislation may also be relevant.

However the two most relevant and effective areas are the town and country planning system and the common law of nuisance.

## Town and Country Planning

There are two aspects of town and country planning: strategic planning and development control. Strategic planning means that policies which are incorporated into statutory plans are taken into account in the decision-making process. Under development control, local authorities consider planning applications and decide whether to authorise or refuse permission to develop. They also have powers to take enforcement action where there are breaches of the law.

As a step towards making the town and country planning system more democratic and open, measures were taken in 1990 to ensure that the development plan became a central policy document to which everyone could refer in order to find out what to expect in terms of land use in a given area. Now a local planning committee, whenever they are making any determination under the Town and Country Planning Act, must have regard to the development plan and make their decision in accordance with it unless there are very good reasons to the contrary. A light pollution policy in the development plan is an important factor in the decision making process.

Many local authorities have already adopted light pollution policies in their development plans. The Council for the Protection of Rural England (CPRE) conducted a survey in March 1996 and identified 22 local authorities with such policies. One good example is found in the Canterbury District Local Plan which provides that: 'permission will not normally be granted for developments which consist of or include new outdoor lighting unless the applicant demonstrates that the proposals are so designed as to minimise light pollution. Where the impact of lighting cannot be reduced to an acceptable level the proposed development will not be permitted. Lighting proposals which would adversely affect residential dwellings, sites of nature conservation importance and rural areas in which dark skies are an important part of the nocturnal landscape, will generally be regarded as unacceptable.' Not only is a local planning authority entitled to refuse a planning application on the grounds of light pollution where there is a relevant policy in the local plan, but planning officers may refer to it in their negotiations with developers.

Central government has issued several planning policy guidance notes encouraging local authorities to take light pollution and other environmental issues into consideration when preparing their development plans. It is also important to remember that, as part of the development plan process, draft plans are available for public consultation. At this point, representations by interested persons may be made. Astronomers should be aware of the development plan relating to their area, (and of subsequent reviews of it), and seek to ensure that full light pollution policies are incorporated into these plans.

The control of development takes



The effects of poor planning: at Tower Park, Poole, Dorset, a mass of globe lights and similar designs has erased the night sky over one of Europe's biggest housing estates. (Photo: Les Fry, courtesy Bob Mizon)

place in the context of the plan policies and the statutory definition of development. A developer must apply for permission if the proposal amounts to 'development'. This expression has a very specific meaning given to it by the Act, and many small installations, e.g. the DIY domestic security light, fall outside the definition and thus outside local authority control. Even floodlights attached to buildings are probably outside the definition of development. However larger installations, such as free-standing floodlights at a football stadium, which need a lighting engineer's expertise, will come within the definition. Lights which are attached to a listed building or are in a conservation area, are governed by stricter rules than those under general planning legislation. As a result, many minor alterations or erections (including exterior lighting) may come under local authority control if the building is listed or in a conservation area.

Where planning permission is granted for a development, the local planning authority can impose conditions to address light pollution concerns. These may restrict (amongst other things) the duration and time of outside lighting, the use to which it is put, the limit of light levels, the identity of the user and the design and positioning of installations. These mechanisms may not only reduce specific light pollution problems but also reduce the cumulative effect of urban lighting which contributes towards skyglow.

### **The civil law and the common law action for nuisance**

The common law action for nuisance has become one of the most common methods of asserting a private environmental claim. A nuisance arises from a substantial interference with an individual's use and enjoyment of his or her property. The action can only be pursued by the individual whose rights have been affected.

In such an action, where one party is alleging that another party is affecting their rights in this way, the judge has to carry out a delicate balancing exercise between the competing uses of land. To do this, numerous factors will be taken into account; the locality where the complaint has arisen, how often the activity occurs, whether one neighbour is more sensitive than normal and whether the other party has a good reason for carrying out the activity complained of.

It is worth noting that in principle the courts have accepted that trespass floodlighting can interfere with an individual's use or enjoyment of their property. A 1995 case illustrates this: one Mr Racti brought an action against his neighbour, Mr Hughes, who had installed floodlights (and camera surveillance equipment) in his garden. Every time Mr Racti went into his garden at night the sensor-activated floodlights from the Hughes garden were switched on illuminating both gardens. Racti felt unable to use his backyard in the way that he had done before the floodlights had been installed next door. The court held that this constituted an actionable nuisance and ordered Mr Hughes to stop using the light.

The law will only protect the rights of a person of 'ordi-



A neighbour's obtrusive light which has seriously affected an astronomer's observing. (Photo courtesy CfDS)

nary sensibility'. This means that the light complained of must be of a sufficiently strong intensity to interfere with an occupation which is 'no more than ordinarily susceptible to light'. Whether an astronomer who wishes to use his back garden to look at the sky at night is a person of ordinary sensibility is an interesting point. Carrying out a hobby or activity can be part of the reasonable use and enjoyment of one's home, but is stargazing a sensitive activity or an ordinary hobby? There are strong arguments to support the latter view, and a recent Scottish case, which is discussed below, is a relevant and persuasive authority. Other issues, for example motive, would also be relevant: a person who floodlights his garden in order to spite his astronomer neighbour might find the judicial scales tipped against him.

In the recent Scottish case, the Stonehaven and District Anglers Association brought an action against the Stonehaven Tennis Club, whose floodlights were spilling over onto the River Cowie and affecting the anglers' trout fishing. It was held that the Tennis Club had caused a nuisance to the anglers to such an extent that it was almost impossible to fish whilst the floodlights were switched on. The Sheriff made an order forbidding their use during the trout fishing season. This is an example of a hobby which is intrinsically sensitive to artificial light, and protected under the law of nuisance. Although it does not set down any hard and fast rule, its relevance to astronomers would seem clear.



A poorly-mounted, over-bright 'security' light at a previously dark New Forest location. By concealing what is behind it, the light defeats the purpose for which it was installed. (Photo: Bob Mizon)

### Other remedies

Apart from the two significant areas of planning control and the common law of nuisance, there are some other useful remedies. Local authorities have powers to regulate illuminated advertisements under the Control of Advertisements Regulations 1992. These regulations are based on two precepts, the interests of amenity and public safety. Many outdoor advertisements require consent, although several groups of advertisement are exempted from that rule. The definition of advertisement is important. It is any word, letter, model, sign, placard, board, notice, awning, blind device or representation, whether illuminated or not, in the nature of and employed wholly or partly for the purposes of advertisement announcement or direction. These regulations may be used to control laser beams and other strong high-powered lights which are directed skywards as a means of attracting the public's attention. Whether or not such an activity is controlled by these regulations partly depends on the motive for the light display. If it is not wholly or partly for the purposes of advertisement it falls outside the regulations. Therefore a creation of light-beams with no commercial element and solely for the purpose of artistic or religious expression would probably not constitute an advertisement. Another requirement is that it must come within the inclusive list above, i.e. any word, letter, model, sign etc.

In a case in the High Court in 1996 the problem of laser displays was considered at some length. Great Yarmouth Borough Council refused an application for express consent for a 'space-flower' searchlight which was positioned on the flat roof of an amusement arcade. The powerful light beam reflected off a series of mirrors to create shafts of light in the night sky. In the right conditions a floral pattern on the underside of a cloud-base was created. The flower patterns were visible in the night sky from nearby residential areas and rural areas further away. The point of law which the judge was called upon to decide was whether or not such a beam of light was an advertisement and thereby subject to control under the regulations. The judge held that the beams

in the sky were indeed advertisements because they amounted to a sign used for the purposes of advertisement.

Another area of law often referred to in connection with light pollution is that known as statutory nuisance. Unfortunately it is not very helpful. Local authorities have powers to inspect their area from time to time to detect a nuisance such as emissions of smoke, fumes, smell and noise which emanate from premises and cause a state of affairs which is prejudicial to health or a nuisance. Light is not included in this list and it would be difficult to argue that any of the statutory nuisances could be construed to include any form of light pollution.

Light pollution is an environmental consideration and general provisions relating to the environment may also be relevant. An Environmental Assessment (EA) is a technique for assessing a project's potential environmental effects. These may then be taken into account by the relevant decision-making body before a planning application is decided. An EA is mandatory for 'Schedule 1' projects which include major developments such as oil refineries. A 'Schedule 2' project will need an EA only where it is likely to have significant effects on the environment. However many developments which may give rise to environmental effects because of light spill fall outside the Schedule 2 list. Notable omissions include sports stadia and riding ménages. However motorway service stations, industrial and urban development projects and race tracks are included. There is a new government proposal to include golf driving ranges within Schedule 2 which is a response to changes in European Community law and in recognition of their lighting impact in rural areas.

### Conclusion

In this article it has only been possible to give a very brief resumé of some of the legal responses to the problem of light pollution. One of the conclusions which may be drawn is that it may be best (from an astronomer's point of view) to approach the problem from the town and country planning perspective, i.e. amenity, rather from the more general concern of protecting the night sky. It is also important to remember that local authorities have limited powers and it is better to approach a problem with a realistic idea of what can be achieved. In forming a pressure group (for example a group of astronomers who wish to object to a new development) a well-organised and focused approach stands a much greater chance of success, and will be taken more seriously from the start. The key to success involves understanding the system and pushing at doors which have the potential to open, rather than trying to walk through a brick wall.

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# Report of the Council

for the session 1997 August 1 to 1998 July 31

To be presented to the members of the Association at the Annual General Meeting on 1998 October 28

The Council of the British Astronomical Association presents its Report for the session ended 1998 July 31 and Accounts for the period ended 1998 June 30. By resolution of a Special General Meeting held on 1998 March 25, the financial year of the Association was changed to end on June 30. The Accounts presented here therefore represent the business for eleven months only.

The excess of income over expenditure for the financial year was £4,188. This amount, together with legacies totalling £4,523, has been transferred to reserve.

**M. P. Mobberley**, *President*

**H. R. Hatfield**, *Treasurer*

## Officers and Council

During the year ended 1998 July 31, the following members of the Association served as elected Officers or as members of Council (the names being in alphabetical order): Laurence Anslow, Mark Armstrong, Rossie Atwell, Georgina Bone, Owen Brazell, Alan Dowdell, Maurice Gavin, Neville Goodman, Cdr Henry Hatfield, Peter Hudson, Guy Hurst, Nick James, Ron Johnson, Dr John Mason, Michael Maunder, Dr Richard McKim, Dr Richard Miles, Dr Jacqueline Mitton, Martin Mobberley, Dr Patrick Moore, Ian Wood, John Wrigley.

During the same year, the following members served as Directors of Sections and, by virtue of their office, were also Members of Council (the names being in alphabetical order): Richard Baum, Neil Bone, David Graham, Bruce Hardie, Dr Nick Hewitt, Dr Andrew Hollis, Anthony Kinder, Ron Livesey, Dr Richard McKim, Howard Miles, Dr Bob Neville, Gary Poyner, Dr John Rogers, Jonathan Shanklin, Gordon Taylor, Alan Wells.

## Membership

	1996 July 31	1997 July 31	1998 July 31
<i>Subscription type</i>			
Ordinary [O]	2203	2018	1997
Senior [S]	572	558	568
Junior [J]	65	55	35
Intermediate [I]	34	36	52
Associate [A]	43	45	52
Honorary [H]	62	69	69
Life [L]	48	44	44
<i>Members</i>	3026	2825	2817
<i>Societies</i>	77	70	64
<i>Associate Societies</i>	2	3	3
<b>Total</b>	<b>3105</b>	<b>2898</b>	<b>2884</b>

270 new members and Societies were elected to the Association during the session.

BAA membership outside the United Kingdom, by country:

<i>Europe</i>					
Austria	3	Denmark	5	Hungary	1
Belgium	11	Finland	1	Iceland	2
Canary Is.	1	France	7	Ireland	15
Cyprus	2	Germany	14	Italy	17
Czech Republic	1	Greece	2	Malta	4

Netherlands	4	Romania	1	Sweden	5
Norway	1	Slovakia	1	Switzerland	2
Portugal	4	Spain	7		

### *Outside Europe*

Australia	37	Hong Kong	2	Oman	3
Bahamas	1	India	9	Saudi Arabia	3
Bermuda	2	Israel	2	Singapore	1
Botswana	1	Japan	11	South Africa	6
Brazil	2	Kenya	2	Sri Lanka	6
Canada	10	Kuwait	1	UAR	2
Chile	1	Malaysia	1	USA	48
Gambia	1	New Zealand	6	Zimbabwe	1

The Council records with regret the deaths of the following members:

Mr T. Almond, Mr E. A. Beet, Mr R. S. Cambray, Mr H. J. T. Carpenter, Mr R. Chantray, Mr J. A. F. Cornick, Mr E. G. Crisp, Mr P. B. Doherty, Mrs M. K. Goodman, Cdr H. D. Howse, Mr S. W. Milbourn, Mr T. J. E. Palmer, Mr G. J. B. Phillips, Dr J. E. Ranklin, Mr M. F. H. Stobie, Mr S. Szczyrbak, Mr D. F. Trombino, Mr E. W. P. Turner, Mr J. C. Vincent, Mr L. R. Watkiss-Thomas, Mr E. R. Wood, Mr J. P. Young.

## Meetings

Ten Ordinary Meetings were held, five on Saturday afternoons and five on Wednesday evenings. Two Out of London meetings were held, the first at the University of East Anglia in Norwich in September 1997. This meeting included talks by Dr Cathy Clarke on 'The Formation of Stars in Clusters', Nick James on 'LY Delphini – A new eclipsing binary' and Jonathan Shanklin on 'Big Comets and Little Comets'. The second Out of London meeting, in April, was at the University of Birmingham. Professor Mike Cruise addressed the meeting on 'Dark Matter – what can the matter be?' Nine speakers then gave their illustrated accounts of the February total solar eclipse.

The Exhibition Meeting was held in June at the London Guildhall University. This was jointly organised by Dr John Mason and Alan Dowdell, with invaluable help from Pat Barber, Peter Hudson and Bob Marriott. The remaining meetings were held at 23 Savile Row, London, W1.

The three meetings with the highest attendance were the Exhibition Meeting (255), the Christmas Lecture (150) and the April Out of London meeting in Birmingham (146).

Dr Mike Warner of Imperial College gave the Christmas Lecture, speaking on 'The Chicxulub Impact Crater Unveiled'. Other speakers this year were Dr Patrick Moore ('Restoring the Birr Castle Reflector'), Dr Alan Rodger of the British Antarctic Survey ('Sun, Space Weather and the Aurora; The Link Explained?'), Dr Nick Hewitt ('Variable Nebulae'), Dr John Mason ('The 1997 Leonids'), Andrew Elliott ('East Meets West; the European Symposium on Occultation Events'), Bob Marriott ('The BAA Instrument Collection'), Dr Martin Barstow ('Extreme Ultraviolet Astronomy'), Guy Hurst ('Discovery Procedures'), Tony Kinder ('Aspects of the Scientific Revolution'), Neil Bone ('Meteor Prospects for 1998'), Dr David Walker, University College London ('Modern Methods for Large Optics'), Roger Pickard ('Photoelectric Photometry'), Jonathan Shanklin ('Recent

Comet Observations'), Michael Covington ('What's New in Astrophotography?'), Dr Jacqueline Mitton ('Pluto'), Dr John Spencer, Lowell Observatory ('Latest News from Io and the other Galilean Satellites'), Owen Brazell ('The Search for Faint Planetary Nebulae'), and Ron Arbour ('My First Supernova Discovery'). Maurice Gavin delivered his second Presidential Address on 'Amateur Spectroscopy'. Martin Ratcliffe spoke at the Exhibition Meeting on news from the recent American Astronomical Society meeting and planetarium developments in Kansas.

Martin Moberley was persuaded to continue his popular monthly 'Sky Notes' at our regular meetings, despite the extra duties arising from his role as President of the Association. Alan Dowdell and Bob Marriott continued to meet the increasingly varied demands made on the projection arrangements at Savile Row and other venues. Edward Hanna has provided excellent meeting reports for publication in the *Journal*, which have always been promptly written up and dispatched to our Editor.

**Laurence Anslow**, *Meetings Secretary*

## Publications

The 1998 *Handbook*, the 77th issue, was edited by Neville Goodman under the direction of Gordon Taylor. Mr Goodman has now retired from the Editorship after 22 years in the post, and in recognition of this service was elected a Vice President of the Association for this session by the Council. He is replaced as Editor by Dr Jacqueline Mitton, who served from 1987–1993 as Editor of the *Journal*.

Six issues of the *Journal* were published, edited by Mrs H. W. McGee. Colour printing was used in 1997 December and 1998 June. Messrs Springer–Verlag helped to finance a colour cover for the June issue by purchasing a back page advertisement, and our appreciation of this assistance is acknowledged. With its spectacular colour photographs of Comet Hyakutake and an outstanding Presidential Address by Maurice Gavin, many members felt that the 1998 June *Journal* was one of the finest the Association has produced, in terms of both content and production. Again we are happy to thank our printers, University Printing Services of Cambridge, for a friendly professional service of exceptional quality and efficiency. During the year the Editor and Council conducted the regular three-yearly review of the costs of printing the *Journal*, and are happy to report that our current arrangements also remain competitive in the market.

A copy of the *Newsletter* was distributed to members with every *Journal* and its informal up-to-the-minute content is much appreciated. Although retiring this year as Business Secretary, Miss Rossie Atwell will continue to edit the *Newsletter*. Five *Circulars* (nos. 764–768), edited by Don Miles, were published during the year. Richard Miles assisted by Jonathan Shanklin continued to manage the BAA World Wide Web site which is hosted on the server at Cambridge University, and now contains home pages or links for nearly every Section of the Association. The *Journal* web site on the UCL Starlink server carries a summary of the contents of each issue as it is published, and continues to be a 'shop window' to the public for the work and activities of the Association.

**Hazel McGee**, *Editor*

## The Library

During the 1997–1998 session the Library has seen a recorded 73 visitors (mainly on meeting days). This number is however considerably less than the actual, as on a number of occasions the library was so busy that not all members signed the visitors' book.

The policy of buying appropriate books for the library has continued, and the librarian is grateful for the gifts and donations made by members. In particular mention must be made of the complete 16-volume set of *The Hipparcos and Tycho Catalogue* received from the European Space Agency. The revised catalogue

of books by subject and by author, and a catalogue of slides and videos are still available on request for which a charge will be made. Members are strongly recommended to enquire what the charge will be before submitting an order, as it will depend upon the paper and postage costs; please contact the librarian at his home address.

A member, Mr Eric Hutton, is using the volumes of the *English Mechanic* which are held by the Association in order to produce an index of the astronomical references that appeared in it. Although this is a personal project, it does show that there is still some important, albeit time-consuming and labour-intensive, work which can be undertaken. I would like to take this opportunity to thank all those who have made donations to the library, all of which are greatly appreciated. If any donor has not received an acknowledgment, please let me know. Rose Waller and the Office staff have continued to provide an invaluable service to members in manning the library, and I would like to take this opportunity of acknowledging this.

**Anthony J. Kinder**, *Honorary Librarian*

## Instruments

Except for the return of one instrument and the loan of two small items, the collection has remained dormant. No instruments have been added, and the collection has not been depleted. All requests for loan concerned equipment which the Association does not possess.

**R. A. Marriott**, *Curator of Instruments*

## Campaign for Dark Skies

The extent to which the message about well-directed lighting and the prevention of skyglow has been instilled into the public consciousness is gratifying. Manufacturers too are mindful of the problem, and are making a point of promoting 'sky-friendly' designs: reports by CfDS committee members Dr Chris Baddiley and Alan Penman, who attended *Light '98*, the industry's major Spring exhibition at the NEC, Birmingham, stated that most lamps showed good light control, and the mood was one of progress towards achieving the aims set out in the Institution of Lighting Engineers' *Guidance Notes for the Reduction of Light Pollution*, and CfDS' *Starry Starry Night*.

Our 84 local officers continue to work hard at persuading council planning and environment departments throughout the UK that the lack of central regulation on private lighting needs to be compensated for by positive local action, and many councils now have written policies on the subject, a result of which has been the suppression of 'skybeams' in several places during 1998. Some councils are now seeking CfDS' advice on the wording of local plan clauses concerning lighting practice. Increasing interest in the light pollution debate among the legal profession is noted; also, some retailers of security lights are following the example of B&Q, who, after dialogue with CfDS, have promised to include instructions on sensitive mounting in packaging, and amend designs for better control of light spread.

The campaign was represented at the Paris *Rencontres du Ciel et de l'Espace* in May 1998, when the coordinator met representatives of similar movements from six European countries to compare results and strategies. A talk (in French!) on our aims and methods was warmly received. Recognition has also come from the International Dark-Sky Association, based in Tucson, Arizona, who in June 1998 presented CfDS with their Award of Appreciation for liaison and support over the last ten years.

We still need more officers in Scotland, if any BAA member has the time to spare. Finally, thanks to Dr Chris Baddiley for all his hard work on the BSI lighting technical standards committee; he has stepped down recently to be replaced by Roy Henderson.

**Bob Mizon**, *Coordinator*

## Sections

### Solar Section

Solar activity remained at a low level throughout 1997 and Cycle 23 seemed reluctant to take off. It was not until 1998 March that activity started to increase. In contrast prominence activity continued at a slightly higher and more consistent level throughout this time. This is due mainly to prominences covering a much wider range of latitudes, many being found outside the sunspot zones. We now have 16 members who can make prominence observations using H-alpha filters, 12 of whom can also detect and report flares on the solar disk.

During 1997 the Director processed 10,051 observations from the membership covering 365 days. There were 71 spotless days scattered throughout the year. In the first six months of 1998 only January had spotless days (5).

The membership continues to be around 120 with 68 dedicated members sending in regular monthly observational reports. Several new observers from overseas have joined the Section in 1998, including Emmanuel Kazanidis (Greece), Paulo Roberto Moser (Brazil) and Victor Troshenkov (Murmansk, Russia). Nearer home seasoned observers Michael Hendrie, Harold Hill and Lou Marsh have joined us. We also welcome Gladys Morris (Newark) and Christine Parfitt (W. Sussex) to the team.

The total solar eclipse which took place on 1998 February 26 across the Caribbean was a great success. One of the highlights was the observation of shadow bands just before and after totality (see report in the 1998 June *Journal*). Eric Strach made an excellent recording of the phenomenon with a video camera mounted above a white screen.

The Solar Section again mounted a display at the Exhibition Meeting in London on 1998 June 27. Geoff Elston and myself had a busy day answering queries and meeting old and new friends. A number of members have started to experiment with building CCD cameras for solar work. The Director was very impressed with the work done both in white-light and H-alpha by Bill Barton and Tony Rickwood. The setting up of a Solar Section World Wide Web site was discussed by members and Mike Beales has kindly let us use his site on an experimental basis to set up a BAA Solar Section page. This can be found at: [http://ourworld.compuserve.com/homepages/M\\_Beales](http://ourworld.compuserve.com/homepages/M_Beales). We hope to update it 24-hourly to provide flare alerts.

Section data continues to be sent to professional solar organisations worldwide including NOAA Boulder, SIDC Brussels, Upice and Ondrejov Observatories (Czech Republic), RDC Research and Data Systems Corporation (Greenbelt USA) and the Royal Astronomical Society Library. Also most amateur solar groups worldwide receive and exchange data with the Section. The Section monthly newsletter is sent to members as well as the solar community and other interested parties both home and abroad.

The Director as in previous years continues to receive correspondence from the general public on solar and related matters and interest in the 1999 total solar eclipse is growing. Several television companies have been asking for details on where and how to record it. The task ahead is for the Section to maintain its daily data without a break over the next eleven years of Cycle 23.

**Bruce Hardie**, *Director*

### Lunar Section

Section membership remains the same as in previous years, but has seen an increasing use of more modern methods in its work. The hard work of the membership and their willingness to help others remains key to the Section.

The year has seen some changes in the subsection coordinators, these being the loss of Andrew Johnson from Topography and

Gerald North from TLP. The years of dedicated service to the subsection that these two have given, have been very much appreciated by all the people who have been helped and guided by these excellent coordinators. It is hoped that they will continue to be involved with the Section's work. Colin Ebdon has kindly offered to look after the Topographic subsection and Dr Patrick Moore will take on the TLP subsection. These subsections will continue the excellent work of the previous coordinators and build on the knowledge gained over the past years.

During the period when the Topographic subsection was without a coordinator, Sally Beaumont produced some excellent articles in the Lunar Section *Circular* on drawing the Moon. Some of these fine drawings were shown as part of the subsection's work at the Exhibition Meeting. The interest in using some of these basic methods of recording the surface features of the Moon continues to play a major role in the work of the subsection and remains a key method of gathering information.

The Section was greatly diminished by the untimely death of Bert Carpenter, who had contributed so much over so many years especially in the field of occultation studies. Andrew Elliott continues the work of the Occultation subsection in both graze and total events, to enable the timing and submission to ILOC and links to IOTA. This work is supported by a small but dedicated team of observers who make timings of occultation events on a regular basis. Cloud Watch data collection continues under the vigilant eye of Andrew Bytnar and enables the subsection to compare the relative cloud amounts over a large area for any given period.

John Hill has developed a Lunar Section Web page and has obtained a range of useful programs for the computing subsection. The monthly production of libration and physical data enables planning of observations to be done. Images are now submitted from video and CCD camera systems and provide valuable comparison images to some of the drawings.

The *Circular* is now produced on a monthly or bi-monthly basis according to local circumstances and carries articles from the coordinators and members of the Section. More images have been included over the previous year to accompany articles. Recent changes to its electronic format have made it more accessible via e-mail to those members who now receive it in this form. The electronic version can now include colour images that cannot be produced in the hard-copy format. The distribution particularly to overseas members is much quicker than the traditional mail system, making time-related data in the *Circular* more relevant.

The Section remains committed to recording and gathering data by both conventional and new methods as well as collaborating with others engaged in similar work.

**Alan Wells**, *Director*

### Mercury and Venus Section

Venus passed through inferior conjunction on 1998 January 16, having been at greatest elongation East on 1997 November 6 (47°), and greatest elongation West on 1998 March 27 (47°). It is now heading for superior conjunction on 1998 October 30. During this period the planet was observed on 78 days out of a possible total of 365 days by R. Braga (Italy), C. E. R. Brook, D. Fisher, D. Gray, A. W. Heath, L. T. Macdonald, R. McKim, R. Middleton, D. Niechoy (Germany), R. W. Schmude Jr, (USA), J. Shanklin, R. M. Steele, and P. Wade who together submitted over 340 drawings, in addition to diagrams, notes and phase estimates. Owen Rogers e-mailed several CCD images noteworthy for their sharpness and clarity, and showing truncation of the north cusp. Lee Macdonald had a clear view of the twilight arc two days before inferior conjunction. He used setting circles on his 60mm refractor. R. W. Schmude Jr., in daylight on 1997 August 3, figured a bright spot which appeared to project (irradiate?) beyond the line of the terminator.

In the interval immediately following inferior conjunction,

Braga described the planet's appearance as very 'clean, with few details only. On three occasions I have seen what could be a terminator indentation or dark area close to the south cusp. At first I believed it to be an illusion due to 'turbulence waves' but after repeated observations with red and yellow filters I am now thinking ... it could be real.' Other than that he found only 'modest limb brightening and terminator shadings.' Coincidentally C. E. R. Brook described a terminator indentation just north of the south polar hood on 1997 December 4. Visibility of the dark side as darker than the sky was reported by R. M. Steele during the early evening of 1997 August 14, but he inferred this was most probably a contrast effect. At the same time he thought the cusps were somewhat duller than the disk in general. R. W. Middleton had the same experience on 1997 December 30. Earlier (October 19) he noted a very bright streak on the south limb, well seen in integrated light, W15 (yellow), W58 (green) and W29 (red), but curiously as green with W44A (blue).

David Gray's intriguing studies of banding with the 415mm Dall–Kirkham at Kirk Merrington, Co Durham, continue to arouse considerable interest and in consequence have been put into historical context in 'Venus – a mystery unresolved' (*Journal* 107(6), 336–337, 1997) and 'Venus: the enigma of phase-locked cloud structure and the UV syndrome' (*Journal* 108(4), 216–219, 1998). Significantly R. McKim reminds us of detail cited by E. C. Slipher, and W. H. Stevenson (1924), when on 1997 February 28 he remarked: 'Suspicion of some horizontal bands at a small angle to the horizontal, but not held. The central mid-disk vaguely lighter than the mid-disk around the cusps, suggesting horizontal shadings about the latter. Both horns equally sharp.' Dr McKim used an 100mm refractor. Gray's interesting observation of 1996 July 25 is accounted in 'An unusual dark spot on Venus' (*Journal* 108(1), 4, 1998).

Peter Wade completed his in-depth examination of intensity variations of Venus' terminator region, especially in relation to subjective factors, the structure of the planet's upper atmosphere, and the height of the planet in the sky at the time of observation. One of his conclusions is of particular importance as it revives interest in an idea promulgated by NASA investigator J. J. Goldstein who in 1990 conjectured that aerosol particles injected into the haze layer by volcanic action might explain phase-locked cloud structure. Mr Wade's paper is to appear in the *Journal*.

Well placed for observers in northern latitudes in mid-September 1997 and mid-March 1998, and at greatest elongation East on 1997 August 4 (27°), November 28 (22°), March 20 (19°), and July 17 (27°), elusive Mercury caught the attention of G. Adamoli (Italy), R. W. Middleton, L. T. Macdonald and D. Niechoy who each submitted useful observations. Brightening of the north cusp was described by Middleton on 1997 September 23. Comparing the telescopic aspects of Mercury and Mars in late 1997 July, Adamoli commented: 'Given the right conditions, I could appreciate that this planet exhibits strong contrasts on its tiny disk, apparently more than Mars.' At the time the two bodies were of similar apparent diameter and height above the horizon. Though perforce of a fragmentary nature, such reports provide useful insights into the physiology and psychology of planetary observation and broaden the perspective of visual understanding, and therefore are always welcome.

The Section is once more indebted to Hans-Jörg Mettig of Dresden, for supplying photocopies of material relevant to our interest, this time a series of papers by Dr W. W. Spangenberg, the well known German physician and amateur planetary observer, which appeared in *Die Sterne* for the years 1964, 1965, 1974, 1977, and 1980, and one by W. Weiss, 'Die Physiologie der visuellen astronomischen Beobachtung' also from *Die Sterne* (1972). Detlev Niechoy has sent a photocopy of his contribution to a recently published compilation by G. D. Roth on the observation of the Moon and planets.

Thanks are extended to everyone who has contributed to the work of the Section over the past year, including the many who have made general enquiries pertinent to their particular enthusiasms.

Richard Baum, *Director*

## Mars Section

As the session began, *Pathfinder* already stood upon the martian surface, in the Ares Vallis floodplain. Growing geological evidence now supports the 'early wet Mars' theory, and throughout this session and the last there has been enormous public interest in the NASA mission, expressed in popular articles and in many sites on the Internet. Being so readily accessible, no summary of them was written up for the *Journal*. (A useful list of Mars Websites appeared in the new RAS journal, *Astronomy & Geophysics*, 38(5), 23 (1998).)

An international conference ('Mars Telescopic Observations –II') was held in Tucson, Arizona, on 1997 October 2–3, to coordinate ground-based and spacecraft observations of Mars, and the writer was one of the invited speakers. This was the second meeting of its type to be held, and was organised by Drs Jim Bell and Ann Sprague. The undersigned described his work on the BAA Dust Storm *Memoir* before an enthusiastic and appreciative audience of 31 professionals and 4 amateurs, mostly from the USA. A poster presentation was also given by the writer, and there was the chance to meet for the first time his opposite numbers in the ALPO Mars Section, namely Don Parker, Dan Troiani and Dan Joyce. The Conference *Proceedings* have since been published, containing abstracts of all the papers given, and are available for loan to any member interested. During the conference delegates were able to see the very latest images and weather reports from *Sojourner*, but the little craft stopped responding during the proceedings. By then however, the mission was already an enormous success, paving the way to a whole series of planned low-budget probes to Mars. The Director is grateful to the Lunar and Planetary Institute for paying for his flight, and to Jim Bell for the invitation to attend.

Another highlight of the session was the final completion of the text of the Dust Storm *Memoir*, and its acceptance by Council (at its May meeting) for publication. Work needs to be done upon the illustrations, but it is hoped that this will not take long. The *Memoir* is in five parts. Part 1 is an historical introduction; part 2 chronicles the ground-based observations of dust storms from the earliest observations to the present day, the first time such a narrative has been attempted; part 3 is a summary catalogue of all the events; part 4 is a discussion of the material, and part 5 a conclusion. Appendices include a record of the names of BAA observers of the planet since 1892, and a complete list of sources. The *Memoir* will contain a reference map, a portrait gallery of observers past and present, and numerous illustrations of events, many of which have never been published before. This publication will be advertised in the *Journal* when ready.

Observations continued to come in for the 1996–97 apparition, some observers continuing until nearly the end of last year. More are awaited. The total number of observations is still somewhat below that for 1994–95, but higher than the writer had originally expected: the material gives an excellent extended summary of the meteorological phenomena for the apparition. Work on the 1994–95 and 1996–97 Reports has continued in a low-key manner, and it is hoped that more time for these analyses will become available with the completed publication of the aforementioned *Memoir*.

Numerous enquiries have been dealt with during the session. Most recently the Director was asked to supply illustrations about former Mars Section Director E. M. Antoniadi's work to the Greek edition of *National Geographic* magazine to illustrate a topical Mars article. In the same vein, he was delighted to receive a copy of Antoniadi's book on the St Sophia Basilica from Section observer Iakovos Stellas of Athens. (This modern reprint of Antoniadi's work contains a previously unpublished picture of Antoniadi from circa 1907, as well as other documents not published in the original.)

It will soon be time to start observing Mars again, and I hope that many members, especially those in more southerly latitudes, will join in the Section's work during the next few increasingly favourable apparitions.

Richard McKim, *Director*

## Asteroids and Remote Planets Section

The current session has been a curate's egg as far as the Section is concerned – parts of it very good, some less so.

Firstly a Section review and report on Pluto has been completed and accepted for publication in the *Journal*, which marks a first for the Association. Progress on the reports of observations of Uranus and Neptune has been frustrated by the Director's recent illness – however this frustration is only temporary and by the time this report is published at least one of them should be with the referees. There is still some work to be done in preparing an *Excel* spreadsheet to allow analysis of the visual magnitudes of the minor planets, and with the assistance of Nick James hopefully this should be resolved in the near future.

Despite poor weather we achieved some success in timing the mutual phenomena of Jupiter's satellites during the event season which concluded in 1998 April. Once all the data have been assembled we intend to prepare a consolidated report for this, previous and Saturn events observed in recent years.

One of the main complaints during the life of the Section has been the shortage of accurate magnitudes for the comparison stars used in asteroid photometry. The difficulty is with the tendency of asteroids to move relative to the stellar background (a fundamental result of their membership of the Solar System) necessitating continual selection of new comparisons. The publication of photometric catalogues from *Hipparcos* (fairly precise) and *Tycho* (lower precision but acceptable for visual observers) has revolutionised and probably eliminated the comparison problem. Provided the comparisons used are identified on a field chart we can now get an acceptably accurate magnitude from the catalogues (also available on such planetarium programs as *Guide 6* etc). Sufficient information is published by the Section in the Association's *Handbook* to enable identification of the asteroid, so there is no reason why all the asteroids brighter than mag 11.5 or so cannot be followed by a serious observer, and the results can subsequently be processed and used.

Predictions for asteroid occultations are prepared and published, on the Web and in the *Circulars*, by Richard Miles. These are now more accurate and there is a good chance of success if you are on the track, and the sky is clear. As the orbits are refined and the *Hipparcos* astrometric positions for the stars are more used the predictions will improve in accuracy even more. These were discussed in September at the European Symposium on Occultation Projects (ESOP XVI) at the RGO in Cambridge and it looks as though we are heading for a golden age in occultation studies.

The start of the main part of the NEAR mission will be with us soon as it closes on 433 Eros and begins its path tracking the asteroid for more than a year.

The Section Officers are to be thanked for their efforts during what has been a difficult session administratively. Hopefully this has not proved too big an obstacle to serious observing; after all, that is what the Section (and indeed the Association) is all about.

**Andrew J. Hollis**, *Director*

## Jupiter Section

The Jupiter Section has continued monitoring the planet during the 1997 and 1998 apparitions, with particular attention to tracking features of possible interest to the team managing the *Galileo* spacecraft which continues to study the planet from orbit. Two Section Circulars have been issued during the session, and one BAA *Circular* article. An interim report on 1997 was published in the *Journal* (1997 December).

For the 1997 apparition, observations were received from at least 10 observers in Britain and 20 overseas. Summaries of other reports were kindly sent by Marc Bosselaers (Belgium), Yuichi Iga (Japan), and Wynn Wacker (USA). The numerous CCD images by Isao Miyazaki (Japan) and Don Parker (USA) were

again the most important contributions. British observers were still hampered by the low altitude of the planet, although this is improving from this year onwards.

In 1997 the jovian system was roughly edge-on to Earth, so there were unusual satellite phenomena. There was particular interest in the simultaneous disappearance of all four satellites on August 27/28, and a triple shadow transit across the planet on September 21/22.

The most important event on the planet has been the merger of the long-lived white ovals BC and DE in the South Temperate region, which occurred during solar conjunction in early 1998. Mergers of large anticyclonic circulations such as these have been predicted by atmospheric models, but never observed until recently. However in 1997 May a 10-year-old white oval in the South Tropical Zone merged with the Great Red Spot, and now, ovals BC and DE have merged. They began to converge in late October, 1997, and in 1998 January they were only 10 degrees apart while smoothly accelerating. They merged soon thereafter, before the end of March. This was originally reported in May by observers at the Pic du Midi Observatory, and quickly confirmed by Isao Miyazaki. The merged oval 'BE' is larger and faster-moving than its predecessors. It has already been imaged by the Hubble Space Telescope, but planned imaging by the *Galileo Orbiter* was lost when the whole E16 encounter was aborted in 1998 July. It will be worth looking out for further changes in the South Temperate domain. It is possible that a new generation of ovals could appear, in the same way that the present generation did around 1940.

**John Rogers**, *Director*

## Saturn Section

Saturn came to opposition on 1997 October 10. The *Cassini* mission to the Saturn system got away to a successful start five days later with a spectacular launch from Cape Canaveral on October 15. Providing all goes to plan, the spacecraft will rendezvous with Saturn in 2004 July and will monitor the ringed planet and his family of moons for the following four years (*Journal* 107(6), 338–339, 1997). *Cassini* should generate considerable interest in Saturn among both the planetary science community and the media, probably more so if the Huygens probe to Titan functions as planned, all serving to enhance the value of the Association's long term ground-based record of the planet. Continuity of observation is vital if long-term change in the appearance of the visible belt and zone structure is to be uncovered and in doing so, the evolution of short-term transient events such as the famous white spots may also be followed.

Saturn's Equatorial Zone was the site of a significant storm in 1996, a further account of which appeared in press (*Journal* 107(4), 172–173, 1997). The apparition of 1997 was comparatively quiet with no activity reported to the Section which would rank on a scale to that seen the previous year. However the months around opposition were not without their surprises, notably the blue colour of the planet's northern hemisphere and glimpses of fine structure within the rings (*Journal* 108(3), 133–135, 1998 and 108(4), 189–191, 1998). Work continues, albeit at a slow pace, on the formal reports, though this task will be greatly facilitated once certain key observations are communicated to the Section. At the invitation of Thomas Dobbins, the Director paid a second visit to Ohio last October, providing the opportunity to establish contact with several American planetary enthusiasts including Thomas Cave and Donald Parker, in addition to observing Saturn close to opposition under favourable sky conditions.

The 1997 apparition saw three occultations of Saturn by the Moon, one of which was conveniently timed for observation from Britain on November 12. True to form, the Director was clouded out barely seconds before the beginning of the event but several other observers were more fortunate.

A Saturn Section home page has been established with a direct

link to the Association's Web site and is kindly maintained by Dr John McCue. With over 300 visits by the start of July, an introduction to the work of the Section, current observations and CCD images are all posted on the site. At the instigation of Martin Mobberley, it is hoped to expand the Saturn ephemeris provided in the BAA *Handbook* to include central meridian tables, as has long been the case for Jupiter. Meanwhile data for 1998 prepared by Jonathan Shanklin may be found on the Web site.

**David Graham, Director**

## Comet Section

Comet discoveries reached a new peak during the 1997–98 session thanks to the SOHO spacecraft and several asteroid search patrols. A mammoth 63 comets were assigned provisional designations and one further SOHO comet has yet to receive one. Five were recoveries of previously-known periodic comets, four were new discoveries by amateurs and 55, of which four were periodic, were new discoveries by professionals. SOHO found the majority of them (41), and of these all but two were Kreutz group sungrazers. CCD asteroid search teams found a further twelve and two were by Schmidt survey teams. Six comets received new permanent numbers. SOHO now has the record number of discoveries (55) but unfortunately control of the spacecraft was lost in late June. The Lincoln Laboratory Near Earth Asteroid Research Project (LINEAR) is proving very prolific at discovering comets and has already found eight in only four months of operation.

No great comets have appeared during the year, although the first SOHO comet observed from the ground (1998 J1) did come close. Observations of comet Hale–Bopp (1995 O1) are still coming in and there are now over 3200 magnitude observations and over 750 drawings, photographs and images logged in the Section files. Over 20 other comets have been visible to members, though few observers attempt them when fainter than 11th magnitude. Light curves and observations of comets were displayed at the Exhibition Meeting in June and are published in the Section newsletter. Guy Hurst has continued to publish the Section's observations in *The Astronomer* magazine and they have also appeared in the *International Comet Quarterly*.

Papers on the comets of 1991 and 1992 by the Director and a paper on comet Hyakutake by Nick James were published in the *Journal*. Papers on the comets of 1993 and 1994 by the Director and on comet Bennett 1970 by Michael Hendrie were accepted for publication. The Director prepared two issues of the section newsletter *The Comet's Tale* and the comets section of the 1999 *Handbook*. Exchanges of our newsletter with numerous overseas comet-observing groups continued and many now contribute their observations by e-mail. The Director helped several professional astronomers with research inquiries. The Section World Wide Web pages continue to provide up-to-date information and are used by many observers and professionals. Around 50 members attended the Section meeting held in Cambridge in February.

Sadly the deaths of Section members Stan Milbourn and Paul Doherty occurred during the session; their obituaries have appeared in the *Journal*. The Comet Section's Keedy prize for 1997 was presented to Melvyn Taylor at the Birmingham Out of London meeting. Thanks are due to David Keedy for making this award possible. Two Section members were again successful in obtaining Ridley grants: Gabriel Oksa to purchase a CCD camera and Chris Taylor to purchase digital setting circles.

**Jonathan Shanklin, Director**

## Meteor Section

Moonlight and poor weather proved the dominant influences on the Meteor Section's work in the past session. The Perseids of 1997 August attracted the bulk of observers' interest, with a good

deal of watch data being collected. Observers in the south of the UK had best skies on August 11–12, those in the north being favoured on August 12–13. Once again, and somewhat unexpectedly, the additional peak ahead of the long-established August 12–13 maximum was recorded, from the United States, albeit much diminished. A preliminary report (*Journal* 108(1), 3–4, 1998) gives more or less the full account on the 1997 Perseids.

Among the other showers, the Orionids received some coverage. The Leonids were badly affected by moonlight, and only a handful were reported by Section members struggling with cloudy conditions. Reports from the US and Far East show a continuation of the broad span of good activity seen in 1996, and the prospects for very high activity in 1998/99 are still considered excellent.

Moonlight more or less wiped out the Geminids in December. The New Year opened with high winds and poor conditions for the Quadrantids. Maximum was expected in late afternoon on 1998 January 3–4, and the few available UK observations show declining rates in the evening. Very few Lyrids were seen, again owing to poor weather.

Perhaps the most surprising event of the session was an outburst from the Pons–Winnecks on 1998 June 27–28, reported by a number of observers in the British Isles and elsewhere. Observed rates were comparable to that of the Perseids at their normal maximum (about one per minute). The shower had previously produced outbursts in 1916, 1921 and 1927, but has been considered essentially extinct in the later half of the century.

Leading contributors to the Section's visual programme were Chris Hall and Jonathan Shanklin. Photographic work by Steve Evans and his collaborators, including Andrew Elliott, Tim Haymes and Mike Maunder, has been productive in generating orbital data for the Geminid stream. While moonlight has restricted observing opportunities, a considerable amount of useful analytical work has been undertaken.

Alex Pratt has performed some interesting experiments in meteor recording using an Astrovid camera. Tony Hopwood and Nick Quinn have made useful forward scatter radio observations of several of the major showers.

A successful Section meeting was held at Liverpool Museum on 1997 October 18. Thanks are expressed to Liverpool Astronomical Society as our hosts.

As in past years, the Director has been assisted by Brian Kelly and Colin Steele acting as local/regional contacts. Len Entwisle has taken on the role of Photographic Fireball Coordinator, with the long-term aim of reviving the photographic patrol. Howard Miles has continued his invaluable work in following up visual fireball reports. The Director, Assistant Director John Mason, and other members of the Section Committee have found themselves much in demand for local society talks as the possible end-of-century Leonid outbursts approach.

A Section Newsletter was issued to regular contributors in August, outlining recent results and plans for the coming session. The 1998 Perseids will be affected by moonlight, but prospects for the autumn are excellent. Observing runs are planned up visual fireball reports. The Director, Assistant Director John Mason, and other members of the Section Committee have found themselves much in demand for local society talks as the possible end-of-century Leonid outbursts approach.

**Neil Bone, Director**

## Aurora Section

Auroral and magnetic activities have been slow to develop at the commencement of Solar Cycle 23. From 1997 July to 1998 May some 465 auroral reports have been received from Alaska, Canada, the USA, Ireland, the UK, Iceland and from ships and aircraft. Our formal register of auroral sightings, including those provided by Bob Evans, Director of the RASNZ Aurora Section, contains over 11,580 entries between January 1976 and December 1997. Mike

Boschat of Halifax, Nova Scotia provided details of aurorae observed at North American meteorological stations.

Dr Alastair Simmons paid his annual visit to Spitsbergen from 1997 December 17 to 1998 January 31 and observed a total of 79 visual and 48 instrumentally detected auroral events. Unfortunately the Black Brant research rocket project could not take place during the course of his visit this year. During a previous winter he had been the visual aurora observer connected with the earlier firing of a Black Brant rocket. Further observations of aurorae in high latitudes were made by Detrie and Katlin Hanson at Fairbanks, Alaska, and Terry Ashton at Reykjavik. Terry has produced some magnificent photographs of Icelandic aurorae, some of which feature at the Exhibition Meetings in London. Marine observations, unfortunately, have almost ceased.

Jay Brausch has continued his long series of observations and photography of the aurora at Glen Ullin, North Dakota and has now recorded some 1537 event nights between 1981 January and 1998 May, and some of his photographs appear regularly at Exhibition and other meetings.

UK aurora observers have had a lot of cloud to contend with and only three aurorae were widely observed in 1997, with poor coverage in 1998. The big magnetic storm at the beginning of 1998 May, however, related to a large auroral event best seen in North America. Fainter aurorae low down on the horizon which are mostly only detected by the work of dedicated amateur observers are often not seen or are ignored by professional mariners or meteorologists engrossed in their other duties. In spite of the paucity of auroral events in the region of the British Isles our team of loyal regular observers has sent in reports whenever they could, undaunted by periods of cloudy conditions or auroral inactivity. It is gratifying to note how the observing network springs to life given an auroral event and clear skies.

David Pettitt and the seven other regular members of the Magnetometry Group have continuously monitored activity in the Earth's magnetic field. After a period of very low activity in 1997 when it was sometimes difficult to distinguish real events from background noise, the field became more disturbed at the end of 1997 and into 1998. Tony Hopwood has maintained his array of instruments recording states of radio propagation, cosmic particle counting, solar UV and Earth current measurements.

The summer of 1997 was another good year for noctilucent cloud (NLC) activity. Dr David Gavine co-ordinated the collection and processing of observations made throughout northwest Europe and a report will be prepared for publication in the *Journal*. In a paper on secular changes in NLC occurrence,<sup>1</sup> Dr Michael Gadsden, recently retired Secretary General of the International Association for Geomagnetism and Aeronomy, acknowledged that observations of the NLC and collation of the data under the aegis of the BAA, overseen successively by James Paton, Dr McIntosh and Dr Gavine, deserved public recognition and commendation. The provision by the BAA of NLC observations to the scientific community for research purposes, I believe, is probably one of the most important functions that the Aurora Section undertakes.

After many years as collator of auroral observations for *The Astronomer* (TA) magazine Dr Gavine has handed on the task to Tom McEwan, Director of the Aurora Section in the Society for Popular Astronomy, with whom we work closely with regard to the collection of auroral observation reports.

Dr Gadsden published a paper on the ability to see noctilucent clouds in the BAA *Journal* of 1998 February. In April Ron Livesey published a paper on four cycles of auroral activity seen from the UK, and his paper on the effect of solar activity on mankind's technologies appeared in August. The 1996 Aurora Report appeared in the June *Journal* as did a paper by Tony Rickwood describing the Gillingham Magnetometer. Quarterly reports on marine observations of the aurora, prepared by Ron Livesey on behalf of the Meteorological Office, have appeared in the *Marine Observer*. Dr Gavine is preparing the 1997 NLC report and Dr Alastair Simmons' paper on the classification of auroral types with respect to their magnetospheric origins appears in the 1998 October *Journal*.

The Director wishes to acknowledge the work put in by observers and correspondents without whom there could be no Section. The two Assistant Directors, Dr David Gavine and Mr David Pettitt have provided considerable support to the Section for which the Director is very grateful.

**R. J. Livesey, Director**

## Reference

- 1 Gadsden M., 'The Secular Changes in Noctilucent Cloud Occurrence, Study of a 31 year Sequence to Clarify the Cause', *J. Adv. Space Res.*, **20**, 11, 2097 (1997)

## Variable Star Section

### *Binocular & telescopic programmes*

During 1997 52,790 visual observations from 70 observers and two observing groups – SPA VSS & RASNZ VSS – were reported to the VSS secretaries, in both paper or electronic form. Over 540 stars, binocular and telescopic, were monitored during this period. This is an increase of 8,990 observations on 1996 for the same number of observers. Observations of variable stars which are reported to *The Astronomer* magazine continue to be included in the VSS database. As in previous years those observations which are incomplete i.e. without any estimate or comparison star reference, are flagged as provisional. These include some 6,119 observations of the grand total. Once again cataclysmic variables remain the most popular with VSS observers.

Contributions were received from the following observers: G. Poyner 15,489 observations; T. Markham 2,899; I. Middlemist 2,706; B. Granslo 2,530; M. J. Gainsford 2,463; W. Worraker 2,298; M. D. Taylor 2,086; J. Toone 2,072; R. Patterson 1,572; D. Stott 1,501; S. Albrighton 1,738; L. Brundle 1,438; J. S. Day 1,413; B. Dryden 1,130; A. R. Baransky 858; G. M. Hurst 800; R. J. Bouma 759; L. A. G. Monard 662; N. M. Bone 631; B. R. M. Munden 600; D. Gill 505; J. Meacham 496; J. Stubbings 476; M. Clarke 431; M. Nicholls 394; R. J. Livesey 361; D. Storey 360; J. Andujar 302; M. Westlund 302; W. Albrecht 235; S. Godwin 220; R. B. I. Fraser 218; M. D. Overbeek 211; S. Johnston 200; K. G. Andersson 195; E. H. Horsley 191; C. Newman 182; J. D. Shanklin 169; R. E. Kelly 161; J. Coates 151; M. Barrett 133; M. Komorous 131; M. Lehky 130; C. Henshaw 125; J. Thorpe 122; R.W. Middleton 117; G. Pointer 100. The following 23 observers each reported fewer than 100 observations: T. Cragg, R. Fleet, D. Gavine, M. Gill, E. Harries-Harris, G. Hanson, G. Herdman, J. Hers, S. Inman, P. Jenkins, S. Jenner, A. F. Jones, K. Lloyd, A. Liu, P. Nelson, A. Pearce, G. Salmon, G. Stephanopoulos, N. Taylor, J. Tilbrook, V. Tuboly, P. Williams.

In addition to the above, John Mackey reported CCD V-band observations and astrometry of several recurrent objects reported to be in outburst, as well as supernovae. Graham Salmon presented a series of CCD V-band observations of SS Cygni.

### *Recurrent objects programme*

Over 6,500 observations were submitted to the coordinator (the Director) of this programme during the year from seven observers. Despite the Recurrent Objects Programme being integrated in the Telescopic Programme several years ago, a separate database is still maintained. The table lists the confirmed outbursts and the observers who detected them. Many of these long period objects are now being monitored by observers around the world, and usually reports of outbursts detected by non-UK observers are taken from VSNET. The Belgian and German observers Tonny Vanmunster and Patrick Schmeer remain the exception, where regular telephone calls reporting outbursts are made to the Director, as well as taking time out to make confirmations.

*Eclipsing binary programme*

A grand total of 1,772 visual observations from 16 observers were reported to the EB secretary Tristram Brelstaff during the year. Contributing observers and their final totals are as follows: D. Conner (433), M. D. Taylor (430), S. Johnston (243), T. Markham (170), M. Clarke (143), C. Newman (102), S. Godwin (96), G. Pointer (40), M. Barrett & E. H. Horsley (24), D. Storey (20), S. Jenner (14), S. Inman (13), J. Coates (11), G. J. Kirby (7), R. B. I. Fraser (2). Many of these observers are members of the SPA Variable Star Section, and the observations were reported by Tony Markham on their behalf. These observations are awaiting analysis, and results will appear in the *VSS Circular* in due course.

*VSS officers: Changes in duties*

Following an officers' meeting in 1997 October, it was decided that the computer archive secretary Dave McAdam would replace Melvyn Taylor as the Section secretary, and would be responsible for receiving both electronic and paper observations during the year. Melvyn Taylor would become Assistant Director, paying particular attention to binocular observers and observations, and providing increased feedback to observers on these bright stars. These changes were announced in the 1998 March *VSS Circular*, and became effective from that time.

*The VSS database*

During 1997 over 163,000 observations were entered into the database. This brought the total number of observations which are now entered to 1,162,546 by the end of the year. Phil Barnard continued his work on the 1925–34 papers and totalled more than 78,000 entries during the year – a wonderful achievement. Dennis Gill completed long runs on several stars, and Terry Miles and others at Crayford Manor House AS tackled some of the very early Section records. Of equal importance are the contributions made by observers who report electronically – now much the preferred way of reporting observations to the secretary (although written reports are valued just as highly). Those observers who have reported electronically during the year are Day, Gainsford, Gill D., Gill M., Hanson, Hurst, Markham, Newman, Poyner, Salmon, Shanklin, Thorpe and Worraker.

The data in the archive continue to be in demand from astronomers in both the professional and amateur communities. During the year 591,907 observations were supplied. This includes a massive 270,671 observations of cataclysmic variables to Luca Zangrilli, Università di Padova, Italy. Other recipients of VSS data

were Dr Guillermo Gonzalez, Washington; Fred Ringwald, Pennsylvania State University; Stan Walker, NZ; F. M. Bateson, RASNZ; Les Thomas, Keele and Eric Broens, Belgium. Data were also supplied to UK amateur John Greaves, whose results of analysis are soon to be published in the *Journal*. Light curves produced from observations in the database were seen on display at the Winchester weekend in March, the BAA Exhibition Meeting in June, and the TA AGM in October.

The archive continues to be backed up regularly on Birmingham Starlink, thanks to the cooperation of Starlink management at Birmingham University.

*Special observing projects*

Between February 20–26, selected observers were asked to monitor six dwarf novae (DNe) in response to a request made by Dr Warren Skidmore, Keele University, who had observing time on the William Herschel Telescope (WHT) to monitor for DNe oscillations. The stars in question were U Gem, SY Cnc, V1159 Ori, KT Per, CN Ori and Z Cam. Charts for these objects were distributed to active DNe observers by the secretary at the request of the Director. It was requested that observers make nightly reports on the status of these stars, and telephone these to the Director, who would then in turn e-mail to Dr Skidmore at the WHT. Observers were asked to monitor for outbursts during the observing window.

During the dates, all of the stars were either in outburst, or fading from outburst. U Gem obliged with an outburst at the start of the observing window. Nightly observations by the Director and Bill Worraker of all the stars were e-mailed to Dr Skidmore on the run-up to, and including the target dates.

A project to monitor the eclipsing UGZ star EM Cyg was set up by Bill Worraker following a request made by Les Thomas (Keele University). Observers were notified of this project through the *VSS Circular*, and asked to monitor EM Cyg for standstills. This project is ongoing.

The International OJ287 (now to be known as BLAZAR 2000) project continued through the year, with regular reports of both visual and CCD observations forwarded to the OJ287 international database in Finland and Mark Kidger weekly by e-mail.

*Photoelectric photometry*

PEP of variable stars in the UK continues to be dominated by Crayford Manor AS, Kevin West and John Saxton. Crayford report a total of 2,549 photoelectric differential magnitude estimates made by the Jack Ells APT operated by Malcolm Gough and Roger Pickard. Eclipsing binaries formed 1,226 of these estimates, with the Delta Scuti star AO CVn a further 500, the suspected variable SAO 28567, 804, and the Ina variable AE Aur, 19. The eclipsing binary observations produced 5 times of minima, and were reported to the coordinator. Kevin West produced over 320 photoelectric differential observations of 20 stars on his observing programme. John Saxton managed 447 photoelectric measures of 6 objects, including a complete light curve for AH Vir, despite electrical problems later in the year. Reports on PEP activity have appeared in the *VSS Circular* during the year.

*Pro-Am Liaison Committee*

Two Pro-Am Liaison Committee meetings were held at University College London during the year. The committee is chaired by Roger Pickard, and BAA representatives include the Director, Guy Hurst, Dave McAdam and Storm Dunlop.

*World Wide Web pages*

These continue to be managed by the Secretary, Dave McAdam, and consist of light curves, statistical data, information on the archive and observing programmes, articles taken from the *Circular* and more recently a selection of charts. Several requests by professional astronomers for data have been made through the Section's Web pages.

**Outbursts of recurrent objects during 1997**

<i>Star</i>	<i>Date</i>	<i>Mag</i>	<i>Observer</i>	<i>Confirmed</i>
BZ UMa	Jan 09	14.4	Hanson G.	Vanmunster T. (CCD)
EY Cyg	Jan 11	12.8	Pietz J.	Hanson G.
GO Com	Feb 07	14.0	Schmeer P.	Stewart R.
DM Lyr	Feb 26	14.3	Hanson G.	Kinnunen T.
HT Cas	Feb 28	13.4	Poyner G. & Bortle J. *	
AQ CMi	Mar 28	14.5	Pietz J.	Poyner G.
V795 Cyg	Apr 07	13.0	Schmeer P.	Poyner G. / Worraker W.
DV UMa	Apr 08	14.0	Vanmunster T. & Kinnunen T.	
AK Cnc	Apr 23	13.2	Poyner G.	Vanmunster T. (CCD)
DM Lyr	May 25	15.1	Vanmunster T.	Poyner G.
V632 Cyg	Jul 08	14.5	Poyner G. & Hanson G. *	
V337 Cyg	Aug 20	15.6	Manek J. (CCD)	Jensen L. T. (CCD)
V1251 Cyg	Sep 07	13.8	Poyner G.	Vanmunster T. (CCD)
SW UMa	Oct 19	11.1	Hanson G.	Pietz J.
V635 Cas	Oct 28	14.8	Poyner G.	Vanmunster T. (CCD)
EF Peg	Nov 02	11.4	Burrows T. & Schmeer P. *	
V1028 Cyg	Nov 16	13.4	Pietz J.	Dill A.
DM Lyr	Nov 29	14.5	Hanson G. & Poyner G. *	
V632 Cyg	Dec 10	13.1	Chapple G.	Hanson G.

\* = Independent detection

## Publications

Four *Circulars* were issued by the editor Karen Holland during the year – numbers 91–94. Many articles, light curves, images etc. which appear in these *Circulars*, are later added to the VSS Web pages. The *Circular* continues to be sent to many professional astronomical institutions around the world.

### Journal papers published using VSS data, or by the Section

‘Visual observations of TT Crt at minimum’, Brelstaff & Fleet, 1997 February;  
 ‘C. R. d’Esterre and the mysteries of UV & UW Persei’, Mobberley *et al.*, 1997 April;  
 ‘The periods of Mu Cephei’, Brelstaff *et al.*, 1997 June;  
 ‘T Cas – a predictable variable’, Howarth, 1997 October.

**Gary Poyner**, Director

## UK Nova/Supernova Patrol

After the discovery by Mark Armstrong of a supernova in NGC 673, as detailed in the previous report, the value of his extensive library of images was again proved when Reiki Kushida of Japan reported her discovery of a supernova in NGC 3631 recorded on 1996 Nov. 14.793UT. Almost immediately Mark found he had recorded the object on Nov. 14.212UT. Although he was disappointed he had not found the object, it turned out this pre-discovery image was extremely faint at about magnitude 18.

Mark Armstrong was again in the news when on 1997 Feb 26 he recorded a possible supernova in NGC 3041. A detailed analysis of a sequence of CCD images showed the object was moving, however the asteroid was not apparently known. The discovery of an asteroid is useful but this demonstrates the need for extreme care, especially when monitoring galaxies near to the ecliptic.

The fifth supernova for the patrol was found by Stephen Laurie of Church Stretton on 1997 April 7 using a 0.25m Schmidt–Cassegrain telescope and SBIG ST7 CCD camera. He had only started a systematic search program in February but had already secured some 1,500 images by the time of his discovery. This further supernova find, together with the four novae found earlier by members, brought the number of major discoveries for the patrol to nine since we started in 1976. The discovery details appeared in IAU *Circular* 6616.

Mark Armstrong, Stephen Laurie and Michael Schwartz (USA), all with supernova successes to their credit, came together at the AGM of *The Astronomer* on 1997 October 11 to produce a memorable gathering and series of talks on how major discoveries are made. The aim was to encourage more participants in the patrol.

This immediately worked when yet another supernova was found, this time by patrol member Tom Boles of Wellingborough. The discovery was made in the early hours of October 29 in NGC 3451 and brought the total number of supernovae found from England to three. Only a year or so before there had been none found from England in living memory!

The final act of the patrol for 1997 was left to the coordinator who decided to take the plunge and obtain a Starlight Xpress CCD. The first image was of a lamppost outside his office, which helped calibrate focus using a 50mm lens. But the long-term aim will be to start nova patrolling with standard camera lenses and I hope to detail further progress in my next report. Discoveries of novae are conspicuous by their absence and this needs to be addressed.

However the year has been quite remarkable for the supernova discovery successes, and our congratulations go to all concerned. A dramatic number of further discoveries occurred in the early part of 1998 as detailed in the report of the Deep Sky Section.

**Guy M. Hurst**, Coordinator

## Deep Sky Section

### Supernovae

What a year! After the excitement of the first UK supernova discovery in 1996 October by Mark Armstrong, who could anticipate my reporting the SEVENTH supernova discovery by 1998 July! Can so many new discoveries ever have been made by British amateurs in such a short span of time? The discoveries have spurred on others in the search for these important cosmological phenomena, and a healthy friendly rivalry is developing between those successful to date. Since the 1996–97 report, there have been five further successes:

SN 1997dn in NGC 3451 by Tom Boles on 1997 October 29 (April *Journal* pp.112 & 120)  
 SN 1998V in NGC 6627 by Mark Armstrong on 1998 March 12  
 SN 1998an in UGC 3683 by Ron Arbour on 1998 April 6 (June *Journal* p.131)  
 SN 1998aq in NGC 3982 by Mark Armstrong on 1998 April 13 (August *Journal* p.225)  
 SN 1998bp in NGC 6495 by Mark Armstrong on 1998 April 29

Tom Boles set the ball rolling with his early morning discovery, and his careful scrutiny of a difficult image needs a special mention. A less diligent observer could easily have overlooked the faint speck. Mark Armstrong’s extraordinary feat of three successes in 50 days was a measure of his skill and endurance, and catapulted him high in the league of amateur supernova discoverers. But I am sure that the whole British amateur astronomy community felt a huge warmth when Ron Arbour finally bagged his supernova after so many years searching. Ron, founder of the Deep Sky Section, has been searching for more than two decades, and has been a major influence on the British Deep Sky scene throughout the 1970s, 1980s and this decade. He has been notable as being amongst the foremost imagers, whether using photography or CCD, and has inspired the current generation to try to emulate his achievements. Certainly, Mark Armstrong and Tom Boles have benefited greatly from his knowledge and aspirations. It was fitting that these observers (and Michael Schwartz from the USA) helped confirm Ron’s find, demonstrating the teamwork developing in the supernova patrol field.

### Other observations

Plenty of CCD images have been received this year and the quality improves annually. It is quite extraordinary to think that it is only 8 years since the first crude, but exciting, ST4 images were seen in this country. Regular monochrome images from John Fletcher and David Strange continue to whip down the telephone wires, while some breathtaking colour work from Adrian Catterall, George Sallit, Nik Szymanek and Ian King has been made available for the Section’s use.

One newcomer to the BAA and Deep Sky Section deserves special mention. Damian Peach has sent a large series of quality images using a Meade LX200 and ST7 CCD. He has a particular interest in galaxies, especially if interacting or peculiar (as in the catalogue of Halton Arp) or in compact groups (as in Hickson’s catalogue).

### Active Galactic Nuclei

Sadly, the Section’s input into this exciting and important field has been negligible this year. This is a pity especially as one AGN in particular has been exhibiting most interesting behaviour. Gary Poyner, Director of the Variable Star Section, pointed out that OJ287, a BL Lac object in Cancer, was entering a low state in the spring. He managed to confirm the fade visually and hoped that CCD observers could follow the fade as deeply as possible. No such results were obtained from DSS members, an opportunity missed, I feel.

### Variable nebulae

Hind’s nebula (NGC 1555) remained elusive, though David Strange clearly demonstrated change in Hubble’s Variable Nebula (NGC 2261) on CCD images. Stewart Moore ventured to La Palma and sent observations of the third genuine variable nebula, NGC

6729 in Corona Australis. Stewart remains the most reliable provider of visual observations within the Section.

#### Section meeting

The annual meeting of the Section took place on 1997 November 15 in Northampton, some 70 attending. The talks were all well received and spanned a wide range of topics, from 'The Southern Milky Way', an overview by Richard Fleet of the treasures in our own galaxy as seen from southern latitudes, to '...from Supergiants to Brown Dwarfs' in which Karen Holland described her two projects, on variables in the Double Cluster and on the dynamics of Praesepe, in association with Leicester University. Dr Mike Merrifield from the University of Southampton described 'The Clusters and Associations of the Milky Way Galaxy' and current views on their importance in our understanding of stellar evolution and galactic rotation, amongst other topics. Owen Brazell spoke on the proliferation of 'Star Catalogues' and problems inherent in attempting to derive atlases from them. Tom Boles was to deliver his talk describing his journey from imager to supernova patroller entitled 'From pretty pictures to pretty tired!', but with almost perfect timing on the part of the Director, Tom was able to detail his discovery of Supernova 1997dn, the 3rd UK supernova discovery.

#### The Section

Numbers have increased a little over the year. Owen Brazell, Assistant Director for many years, felt a break was needed and has left the post, which currently remains unfilled. I am indebted to Owen for his enthusiasm for the Deep Sky, his wise counsel regarding meetings and publications, and seemingly unlimited knowledge of both resources and people in the Deep Sky field. Fortunately he has not fully escaped my grasp as he has been elected back onto BAA Council, and I hope will remain as an adviser.

Mark Armstrong is guardian of *Real Sky* for the Section, and he is willing to help with any serious enquiries with which this resource may be helpful. The Web page, launched in June 1997, has changed its URL. Find it now on <http://www.teg1.demon.co.uk/deepsky/>. David Tegerdine is now Webmaster and we hope that the Web page will be regularly updated and increasingly useful.

Finally, two Section newsletters, Nos. 9 and 10, were issued this year; both were produced by Bob Marriott, whose individual touches and skill in this area should ensure that his Section publications become collectors' items in future years.

**Nick Hewitt, Director**

## Instruments and Imaging Section

During the last year the Section newsletter has been issued in 1997 December and 1998 July. The improved direct-laser printing has allowed the high standard of image and text presentation and layout to be maintained in the creative style of Bob Marriott. Both issues were on display at the Exhibition Meeting in June. Bob was also principally responsible for the excellent annual Section meeting held at the Humfrey Rooms, Northampton on 1998 May 30, with an attendance of 68, including a veritable Who's Who of amateur and professional engineers, scientists and observers. A full account of this meeting appears in the current *Journal*.

The Section has no single object of observation, but its members and advisers have produced a rich and varied range of articles in the *Journal*, including 'Faint image detectivity: CCD vs. film' and 'Spectrum of the night sky' (R. Neville), 'UBVRI photometry' (R. Miles), 'The Jack Ells APT' (R. Pickard), 'Comet Hyakutake' (N. James) and 'Amateur Spectroscopy' (M. Gavin). In addition, Mark Armstrong, Tom Boles and Ron Arbour have been pre-eminent with their supernova discoveries and Brian Manning has recently exceeded the record of the English observer, J. R. Hind, for discovering asteroids.

The Director and Editor welcome comments, articles and images on all topics related to establishing and improving observational techniques, and look forward to continuing to promote best practice in the key fields of instruments and imaging.

**R. J. Neville, Director**

## Computing Section

As usual the main work of the Section has continued to be the production of the annual *Handbook*. There are some changes in the 1999 edition, mainly the inclusion of extra material concerning the total solar eclipse of 1999 August 11.

Sadly two stalwart members have passed away since the last report was issued. S. Milbourn served as Assistant Director since 1985, and was responsible for all the cometary work of the Section. His obituary appeared in the June *Journal*. Proof-reading the *Handbook* is shared by several people, and for many years we have relied quite heavily on E. R. Wood. He also provided the pages of the phenomena of the satellites of Jupiter, a laborious job, done by hand. His contribution to the *Handbook* will be sorely missed.

Dr Jacqueline Mitton has been appointed Editor of the *Handbook* following the retirement of Neville Goodman. A number of other members have also contributed to the *Handbook*. Owen Brazell was appointed Assistant Director of the Section.

The Coordinator of the Program and Data Library, R. Harrod, who had announced his resignation, has since found it possible to remain in the post and has continued to distribute software packages on request to members. The Information Technology Group continues under the leadership of Dr L. Hobbs, though very few members have expressed interest in this new field.

The Computing Section continues to assist other members and also other Sections, on request.

**Gordon E. Taylor, Director**

## Historical Section

During the 1997–1998 session the Director has continued to receive requests for assistance. The *Journal* published several papers of an historical nature, one of particular importance being John Rogers' two-part paper on the origin of the constellations. The comprehensive cumulative index to historical references in the *Journal* (from volume 100) continues to be produced by Ian Howard-Duff, and is available in the library for reference. Barry Hetherington likewise continues to produce his lists of centenary events due to occur, and if any member would like to write on one of these please contact me. A great deal of work and effort goes into these compilations, and I would like to personally express my thanks to Ian and Barry for all their hard work.

The revised edition of the *Who's Who in the Moon* is still in progress. Unfortunately it has been subject to a number of delays, hence the delay in publication. It is because of the work required for this that the *Newsletter* has not been issued this year. I would like to take this opportunity to correct an error that appeared in the last Section report, in that issue no. 4 in fact has not been produced. At the time of writing the 1996–1997 report, a draft had been written, but it did not advance beyond this.

Books of a historical or biographical nature that appeared during the year included Alan Cook's *Edmond Halley* (the first major treatment since Colin Ronan's *Genius in Eclipse*) and Frances Willmoth (editor) *Flamsteed's Stars*, the first major treatment of Flamsteed for many years. The late Cdr Derek Howse produced a second edition of his earlier work on Greenwich time, under a new title *Greenwich Time and the Longitude*, a copy of which he donated to the library. Finally, a new journal called *The Journal of Astronomical History and Heritage* (JAH<sup>2</sup>) has appeared, under the editorship of John Perdrix. It is being produced under the auspices of the IAU Commission 41, and will appear twice a year,

price \$US20. Details can be obtained from Mr J. Perdrix, Astral Press, PO Box 107, Wembley, WA 6014, Australia; email [geochem@techpkwa.curtin.edu.au](mailto:geochem@techpkwa.curtin.edu.au).

**Anthony J. Kinder**, *Director*

## Artificial Satellites Section

As with previous years, predictions have been issued at weekly intervals for the majority of the brighter satellites and sent to members who have provided stamped addressed envelopes. The predictions have covered both the evening and morning visibility periods for the British Isles. Unfortunately the number of members requesting the service has fallen dramatically, due to a possible fall off in interest except for the Russian Space Station *Mir*, but mainly due to the fact that the prediction data have been readily available on the Internet at much less cost.

The present Director has provided a prediction service to members for just under 40 years and feels that now interest in satellite observing is at an all time low (apart from times when *Mir* is visible) and that the data are now available on the Internet, it is an appropriate time for Council to consider the future of the Section. The Director has therefore offered his resignation to take effect at the end of the session.

The Section and the Association wish to express their sincere thanks to the RGO and the staff at Herstmonceux for the provision of the data and their prompt help when difficulties have arisen.

It is planned that a paper will be offered for publication in the *Journal* outlining the work carried out by the Section during the last 40 years.

**Howard Miles**, *Director*

## Fireball Survey

Three major fireball events have occurred during the session. The first, on 1997 September 23, was widely seen over northern Scotland, the Orkneys and Shetland Islands, but unfortunately the data received were not sufficiently detailed to enable an accurate ground track to be determined.

The second event was seen by many in the southern half of England on 1998 March 15. A report on this event appeared in the June *Journal*.

The last of the major events occurred on 1998 June 11. Although seen by many observers, their reports were of a general nature and

it has not been possible to determine an accurate track. An added difficulty was the fact that the object travelled roughly up the English Channel, well away from the south coast of England. It had a typical appearance, a green coloured ball which broke into numerous red fragments at the end of its visible track. In addition some single or double reports of isolated events which occurred during the year have been received but no analysis of these was possible.

**Howard Miles**, *Fireball Coordinator*

## The New South Wales Branch

Membership of the BAA (NSW) Branch during the last session was 72. The Branch regrets to announce that a former Vice President of the Branch, Ken Thompson, passed away during the last year.

Activities pursued by branch members include solar observations and minor planet astrometry. Monty Leventhal made 205 solar observations during 1997 and his results were presented at the monthly meetings of the Branch. Monty was also the winner of a prize presented by *Southern Astronomy* magazine for his fine solar photographs taken using a hydrogen alpha filter. Stephen McAndrew has performed astrometry on southern sky unnumbered minor planets and the results have been reported to the Minor Planet Center.

The Branch holds its meetings on the third Wednesday of each month at 19.30 at Sydney Observatory. Speakers at the monthly meetings have been Prof. John Storey (Astronomy in Antarctica), Tanya Hill (Active Galaxies), Dr Lewis Ball (Tenth Anniversary of Supernova 1987A), Ralph Buttigieg (Human Journey to Mars), Dr Brian Boyle (Star Eating Monsters at the Edge of the Universe), Fred Watson (Binocular Astronomy), Andrew James (Strange Stories and Unsolved Mysteries in Astronomy), Lucyna Kedziora-Chudzer (New Discoveries in Quasars), Ken Petersen (Light Pollution) and Dr Nick Lomb (Colonial Astronomy).

Office bearers for the 104th session, 1997–1998, are listed below:

President	Ralph Buttigieg
Senior Vice President	Dr Nick Lomb
Vice Presidents	Monty Leventhal, John Collocott
Hon Secretary	Elizabeth Cocking
Hon Treasurer	Michael Chapman
Councillors	Janette West
	David Gough
	Stephen McAndrew
	Tony Plumridge

**Stephen McAndrew**

## Report of the Council 1997–98

## Section Officers

The following list of Section Officers was current at 1998 July 31.

**Solar**

*Assistants to the Director*  
Pam Spence  
Geoff Elston

**Lunar**

*Occultation coordinator* Andrew Elliott  
*TLP coordinator* Patrick Moore  
*Computing coordinator* John Hill  
*Topographic coordinator/*  
*Editor, The New Moon* Colin Ebdon

**Mercury & Venus**

*Assistant Director* David Graham

**Asteroids & Remote Planets**

*Assistant Director* Richard Miles  
*Visual coordinator* John Toone  
*Occultation assistant* Andrew Elliott

**Jupiter**

*Assistant Directors* Richard McKim  
Michael Foulkes

**Saturn**

*Section Committee* Alan Heath  
Andrew Hollis  
Richard McKim

**Comet**

*Assistant Director* Guy Hurst  
*Photographic adviser* Michael Hendrie  
*CCD adviser* Nick James

**Meteor**

*Assistant Director* John Mason  
*Photographic coordinator* (vacant)  
*Photographic fireball coordinator* Len Entwisle  
*Telescopic coordinator* Malcolm Currie  
*Northern coordinator* Brian Kelly  
*Midlands coordinator* Colin Steele  
*British Fireball Survey* Howard Miles  
*Committee member* George Spalding

**Aurora**

*Assistant Director/*  
*Noctilucent Cloud coordinator* David Gavine  
*Assistant Director/*  
*Magnetometry coordinator* David Pettitt

**Variable Star**

*Assistant Director* Melvyn Taylor  
*Secretary/ Computer secretary* Dave McAdam  
*Nova/supernova coordinator* Guy Hurst  
*Chart secretary* John Toone  
*Pro-Am Liaison Committee secretary/*  
*PEP adviser* Roger Pickard  
*Eclipsing binary secretary* Melvyn Taylor  
*Circulars editor & CCD adviser* Karen Holland

**Deep Sky**

*Secretary* Lee Macdonald  
*Supernova search coordinator* Guy Hurst  
*Photographic group coordinator* John Fletcher  
*General adviser* Ron Arbour  
*Double star adviser/*  
*Newsletter editor* Bob Marriott

**Instruments and Imaging**

*Meeting secretary/*  
*Newsletter editor* Bob Marriott

**Computing**

*Editor of the BAA Handbook* Jacqueline Mitton  
*Assistant Director* Owen Brazell  
*Assistant to the Director* Howard Miles  
*Program and Data Library* Robert Harrold  
*Information Technology Group* Lilian Hobbs

**Artificial Satellite**

*Section Committee* Gordon Taylor  
Neil Bone  
John Mason

**Notice**

The Notice below is a formal addendum to the Accounts on page 273. Note that '...in accordance with the Companies (Consolidation) Act, 1908, Sections 112 and 113, or any statutory modification thereof for the time being in force... the Council shall be treated as the Directors and the Members shall be treated as the Shareholders mentioned in these sections.' (Articles of Association, paragraph 37.)

**Statement of Directors' Responsibilities**

The Directors are required by UK Company Law to prepare financial statements for each financial year which give a true and fair view of the state of affairs of the Association at the end of the financial year and of the profit or loss, and total recognised gains or losses of the Association for that period. The Directors confirm their responsibility to ensure that appropriate accounting policies have been used and applied consistently, and reasonable and prudent judgements and estimates have been made, in the preparation of the financial statements for the year ended 30th June 1998. The Directors also confirm their responsibility to prepare the financial statements on a going concern basis unless it is inappropriate to presume that the Association will continue in business. The Directors are responsible for maintaining adequate accounting records, for safeguarding the assets of the Association, and for taking reasonable steps to prevent and detect fraud and other irregularities.

## Report of the Council 1997-98

**British Astronomical Association****Accounts for the 11 months ended 1998 June 30****Balance sheet as at 1998 June 30**

	1998		1997	
	£	£	£	£
<b>Fixed assets</b>				
Furniture and equipment .....		22,534		16,419
Additions.....		1,995		6,115
Less depreciation – 1st August.....	22,534		16,419	
– Charged in year .....	<u>1,995</u>		<u>6,115</u>	
		<u>24,529</u>		<u>22,534</u>
		–		–
<b>Investments at cost (Schedule 2)</b>				
General fund (MV £374,965:1997 £357,805) .....	301,360		311,379	
Bequest and other funds (MV £16,262:1997 £16,069) .....	<u>16,262</u>		<u>16,069</u>	
		317,622		327,448
<b>Current assets</b>				
Debtors – Income tax recoverable.....	7		107	
– Sundry.....	3,868		3,046	
Bank and cash balances – General fund .....	<u>16,666</u>		<u>3,117</u>	
	20,541		6,270	
<b>Creditors – Amounts falling due within one year</b>				
Subscriptions and fees received in advance.....	5,658		15,109	
Sundry.....	<u>20,499</u>		<u>15,314</u>	
		(5,616)		(24,153)
		<u>£312,006</u>		<u>£303,295</u>
<b>Represented by: Reserves (Schedule 1)</b>				
General fund .....		94,729		90,486
Bequest funds.....		16,262		16,069
General bequest fund .....		<u>201,015</u>		<u>196,740</u>
		<u>£312,006</u>		<u>£303,295</u>

Approved by the Council on 1998 September 9 and signed on its behalf.

MARTIN MOBBERLEY – *President*  
HENRY HATFIELD – *Hon. Treasurer*

**Notes to the Accounts**

1. No credit has been taken for Members' subscriptions and affiliation fees in arrear.
2. The Association is a company limited by guarantee and is a registered charity. Each Member's liability would be limited to an amount not exceeding 53p in the event of the Association's winding up.
3. Instruments on loan or in store, and also library books, are not included in this balance sheet. This is because they were either gifts to the Association or have been charged to revenue on acquisition.
4. Council acknowledges funds received from the estate of R. A. Richards, and bequests received in earlier years from J. M. Mackenzie, A. M. Newbegin, M. J. Stonelake, H. B. Ridley and J. L. Houghton, left by them to the British Astronomical Association for general use.
5. The Council wishes to thank the Royal Astronomical Society for the donation of £300 towards computerisation of VSS records and for their request that we treat this as a yearly donation in future.
6. Commercial Union and General Accident merged companies and are now known as GCU.

**Report of the Auditors to the Members of the British Astronomical Association**

We have audited the accounts on pages 273 to 276 which have been prepared under the historical cost convention.

**Respective responsibilities of Directors and Auditors**

As described on page 272 the Association's Directors are responsible for the preparation of financial statements. It is our responsibility to form an independent opinion, based on our audit, on those statements and to report our opinion to you.

**Basis of Opinion**

We conducted our audit in accordance with auditing standards issued by the Auditing Practices Board. An audit includes examination, on a test basis, of evidence relevant to the amounts and disclosures in the financial statements. It also includes an assessment of the significant estimates and judgements made by the Directors in the preparation of the financial statements, and of whether the accounting policies are appropriate to the Association's circumstances, consistently applied and adequately disclosed.

We planned and performed our audit so as to obtain all the information and explanations which we considered necessary in order to provide us with sufficient evidence to give reasonable assurance that the financial statements are free from material misstatement, whether caused by fraud or other irregularity or error. In forming our opinion we also evaluated the overall adequacy of the presentation of information in the financial statements.

**Opinion**

In our opinion the financial statements give a true and fair view of the state of the Association's affairs as at 30th June 1998 and of its results for the year then ended and have been properly prepared in accordance with the Companies Act 1985.

KING & GROVE *Certified Accountants; Registered Auditors*  
145 Windmill Road, Croydon CR0 2XT  
September 1998

## Report of the Council 1997-98

## Income and expenditure account for the 11 months ended 1998 June 30

	1998		1997	
	£	£	£	£
<b>Income</b>				
Subscriptions.....		75,672		77,011
Inland Revenue re covenants .....		9,075		9,877
Affiliation fees .....		1,520		2,139
Circulars subscriptions.....		5,470		5,840
Advertising revenue.....		1,578		3,666
Sales: - the <i>Journal</i> .....		4,805		5,410
- the <i>Handbook</i> .....		3,123		3,636
- other publications and sundry items .....		3,822		8,938
Winchester Course - net receipts.....		(209)		280
Dividends and interest .....		20,721		23,598
Profit or (loss) on investments .....		283		-
Bequests: - R. A. Richards.....		5,050		25,009
- J. V. Thomson.....		-		2,000
- E. A. Beet.....		5,000		-
Sale or gift re Instruments held.....		465		-
Birmingham meeting .....		-		(458)
Norwich meeting .....		(397)		-
Donations .....		1,111		1,564
		<u>£137,089</u>		<u>£168,510</u>
<b>Expenditure</b>				
<b>Publications</b>				
The <i>Journal</i> : Printing and despatch .....	36,782		35,567	
Editorial costs .....	5,930		6,365	
<i>Handbook</i> .....	9,168		9,583	
<i>Newsletters</i> .....	4,051		4,624	
<i>Circulars</i> .....	2,879		4,521	
<i>Deep Sky Catalogue</i> .....	-		608	
Sales catalogues .....	-		1,395	
<i>Observers' Guide</i> .....	886		-	
Other .....	786		896	
		60,482		63,559
<b>Section expenses</b> (see analysis on page 275) .....		3,506		3,942
<b>Library</b> .....	2,005		1,699	
Less: contribution from Gaythorpe Bequest.....	(784)		(904)	
		1,221		795
<b>Office and other expenditure</b>				
Staff: Salaries (2).....	22,998		24,724	
National Insurance .....	2,048		2,156	
Pension contributions for Staff.....	1,897		2,470	
Pensions (2) .....	3,354		3,538	
Rent of premises .....	6,252		6,524	
Meetings .....	5,547		4,227	
Postage and telephone.....	4,992		6,008	
Printing and stationery .....	3,546		5,145	
Audit fees.....	2,700		2,600	
Depreciation - furniture and equipment .....	1,995		6,115	
Sundry sales items (ties, postcards, T-shirts etc.).....	2,176		5,108	
Sundry expenses .....	5,170		5,054	
Bank charges.....	219		380	
Approved donations.....	275		390	
		63,169		74,439
		<u>£128,378</u>		<u>£142,735</u>
<b>Surplus/(deficiency) of income over expenditure transferred to Reserves:</b>				
General fund .....	4,188		1,072	
Bequest and other funds.....	4,523		24,703	
		<u>£8,711</u>		<u>£25,775</u>

## Report of the Council 1997-98

	1998		1997	
	£	£	£	£
<b>Analysis of Section expenses</b>				
Solar.....	496		539	
Lunar.....	286		286	
Mercury and Venus.....	233		336	
Mars.....	205		251	
Asteroids and Remote Planets.....	238		284	
Jupiter.....	112		77	
Saturn.....	-		171	
Comet.....	137		370	
Meteor.....	-		131	
Aurora.....	196		202	
Variable Star.....	600		855	
Less: RAS donation (see note 5).....	-		(300)	
Deep Sky.....	362		233	
Instruments and Imaging.....	79		240	
Computing, including Program & Data Library.....	(37)		(53)	
Artificial Satellite.....	213		266	
Campaign for Dark Skies.....	242		54	
Radio Astronomy group.....	144		-	
		<u>3,506</u>		<u>3,942</u>

### Funds held at 1998 June 30

#### Schedule 1

	1998	1997
	£	£
<b>General fund</b>		
Balance at 1st August.....	90,486	89,305
(Deficiency)/excess transferred from Income and Expenditure Account.....	4,188	1,072
Subscription from Merton Bequest Fund.....	55	109
Balance at 30th June.....	<u>£94,729</u>	<u>£90,486</u>
<b>General bequest fund</b>		
Balance at 1st August.....	196,740	174,731
R. A. Richards bequest.....	5,050	25,009
Ridley Grants: Dr G. Marsh.....	-	(350)
Mr J. Abbott.....	79	(150)
Dr G. Oksa.....	(525)	-
Mr C. Taylor.....	(250)	-
Transfers to Merlin, Merton and Horace Dall Funds.....	-	(2,500)
Balance at 30th June.....	<u>£201,015</u>	<u>£196,740</u>
<b>Bequest funds</b>		
<i>Gaythorpe Library Bequest</i>		
Balance at 1st August.....	11,065	11,065
Interest and dividends received.....	784	904
Contribution towards upkeep of Library.....	(784)	(904)
Balance at 30th June.....	<u>£11,065</u>	<u>£11,065</u>
<i>Goodacre Medal and Gift</i>		
Balance at 1st August.....	1,262	1,213
Interest and dividends received.....	89	99
Gift and engraving expenses.....	(54)	(50)
Balance at 30th June.....	<u>£1,297</u>	<u>£1,262</u>
<i>Merlin Medal and Gift</i>		
Balance at 1st August.....	1,336	282
Interest and dividends received.....	96	108
Gift and engraving expenses.....	(54)	(54)
Transfer from General Bequest Fund.....	-	1,000
Balance at 30th June.....	<u>£1,378</u>	<u>£1,336</u>
<i>Merton Bequest</i>		
Balance at 1st August.....	1,312	316
Interest and dividends received.....	93	105
Contribution to General Fund by order of Fund Committee.....	(55)	(109)
Transfer from General Bequest Fund.....	-	1,000
Balance at 30th June.....	<u>£1,350</u>	<u>£1,312</u>
<i>Horace Dall Memorial Fund</i>		
Balance at 1st August.....	1,094	608
Interest and dividends received.....	78	90
Gift and engraving expenses.....	-	(104)
Transfer from General Bequest Fund.....	-	500
Balance at 30th June.....	<u>£1,172</u>	<u>£1,094</u>
<i>Total of bequest fund balances at 30th June.....</i>	<u>£16,262</u>	<u>£16,069</u>

## Report of the Council 1997-98

## Investments held at 1998 June 30

### Schedule 2

Nominal value		If listed	Cost £	Market value £
<b>General fund</b>				
£5,731	5.5% Treasury Stock 2008-12.....	Yes	5,568	5,688
£15,000	9.5% Conversion Stock 2004.....	Yes	14,948	17,573
£10,000	9.75% Treasury Stock 2002.....	Yes	10,216	11,156
£10,000	8.75% Treasury Stock 2017.....	Yes	9,741	13,553
£5,000	9% Treasury Stock 2012.....	Yes	4,950	6,526
£9,901	9% Conversion Stock 2000.....	Yes	10,000	10,185
£10,358	8% Treasury Stock 2002-06.....	Yes	10,000	10,895
£10,000	8.5% Treasury Stock 2007.....	Yes	9,797	11,765
£10,147	7.75% Treasury Stock 2012-2015.....	Yes	10,000	11,976
£10,000	7% Treasury Stock 2001.....	Yes	10,144	10,103
£5,044	8.5% Treasury Stock 2007.....	Yes	5,000	5,934
£10,302	8% Treasury Stock 2003.....	Yes	10,000	11,026
£10,000	7.5% Treasury Stock 2006.....	Yes	9,619	11,006
15,744	COIF fixed interest units.....	Yes	20,000	21,723
20,311	CAF balanced growth units.....	Yes	17,500	26,526
6,953	Charishare units.....	Yes	17,500	25,837
2,355	COIF Investment Fund units.....	Yes	17,500	23,790
10,674	Charity Equity Fund units.....	Yes	17,500	23,982
	COIF Charities Deposit Fund.....	No	55,233	55,233
	Woolwich 2-year Bond.....	No	30,030	30,030
760	GCU shares (see note 6).....	Yes	2,450	8,496
760	Merchants Trust 25p shares.....	Yes	92	3,116
3138.38	Save & Prosper Equity Income Fund.....	Yes	3,296	9,162
3,000	Invesco Unit Trust (UK Growth).....	Yes	276	2,960
2,050	Woolwich plc shares.....	Yes	-	6,724
	<i>Total General fund</i> .....		<u>£301,360</u>	<u>£374,965</u>
<b>Bequest and other funds</b>				
<i>Goodacre Medal and Gift</i>				
	COIF Charities Deposit Fund.....	No	1,297	1,297
<i>Merlin Medal and Gift</i>				
	COIF Charities Deposit Fund.....	No	1,378	1,378
<i>Gaythorpe Library Bequest</i>				
	COIF Charities Deposit Fund.....	No	11,065	11,065
<i>Merton Bequest</i>				
	COIF Charities Deposit Fund.....	No	1,350	1,350
<i>Horace Dall Memorial Fund</i>				
	COIF Charities Deposit Fund.....	No	1,172	1,172
	<i>Total Bequest and other funds</i> .....		<u>£16,262</u>	<u>£16,262</u>

### Movement in investments during the year

	Values at Cost	
	General fund £	Bequest and other funds £
Balance at 1997 August 1.....	311,379	16,069
Additions.....	49,683	1,140
	<u>361,062</u>	<u>17,209</u>
Disposals during year.....	59,702	947
<i>Balance at 1998 June 30</i> .....	<u>£301,360</u>	<u>£16,262</u>

## Enigmatic bright objects near the Sun

As global conflict engulfed Europe in the hot summer of 1914, strange lights sparked in the daylight skies of England. Writing to *The Observatory* magazine G. W. Atkins of Elstree, Hertfordshire, described what he saw on August 13: 'Setting up my Transit at noon to correct my time, I noticed a bright trail of light cross the field when watching for the Sun's appearance, then several others all passing from West to East. Thinking that my eye was abnormal, I changed to the other, with the same result. I followed the Sun for about an hour, using the telescope as an altazimuth, and the meteors came across at the rate of about five per minute in a field of  $1\frac{1}{2}^\circ$  diameter... At 3.30 p.m. the stream was still going on... The real direction of the meteors (?) was from East to West, owing to the reversal right and left of the diagonal eye-piece employed.' The objective of 24 inches focal length had an aperture of  $1\frac{5}{8}$  inches 'but was stopped down to  $\frac{1}{2}$ -inch diameter, with an experimental ground-glass perforated disc to cut down the light and to illuminate diffusely the webs – which it does perfectly and allows the use of a much lighter shade.' Atkins was in London on the 14th and could not observe. The 15th was cloudy, but Sunday the 16th was bright and clear. To his astonishment the objects were still streaming by at roughly the same rate as on the 13th but the direction had altered. 'On the 13th,' he remarked, 'the meteors followed up in the same direction as the apparent motion of the Sun, i.e. from the eastward, but on the 16th the line of direction was some  $30^\circ$  to the westward of the nadir direction at the time of observation (3 p.m.). 'These bodies,' he further noted, 'were only visible in the region close to the Sun, as when the telescope was pointed away, say  $3^\circ$ , nothing was seen; they were best observed when the Sun was just out of the field in the line of their direction.' The direction of traverse was the same on the 17th although there was a noticeable reduction in numbers. By the next day the display had ceased.<sup>1</sup>

Almost a month later on September 9, again around midday, W. H. Steavenson pointed his 3-inch equatorial at Mercury, then about  $8^\circ$  from the Sun, when 'a round bright object, about the size of Mercury, but much brighter' passed centrally across his telescope field. It first came into view at the south following edge, and left it at the opposite, or north preceding side. The traverse of 25 arcminutes was accomplished in approximately three seconds. 'A few seconds later,' Steavenson reported in this *Journal*, 'another appeared, following the same position angle as regards the direction of its motion, though it did not pass quite centrally across the field. After this more appeared, and the display was kept up, at the rate of about one every five seconds, till at least

three o'clock, when the sky became overcast. In the three hours during which they were seen several hundreds were observed... The average time taken to cross the field centrally was about three seconds; some took five or six, others no more than one, or even half a second. Their apparent diameter averaged about  $5''$ . In shape about half of them were perfectly round, but the rest were elongated with thickened ends, being somewhat dumb-bell shaped. It was particularly noted that the direction of their elongation was always at right angles to a line drawn to the Sun, which suggests that the elongation observed was due to phase. All the objects were well defined, and the prevailing colour was yellowish white... The telescope was pointed for several minutes three or four degrees east and west of Mercury, but no bright objects were seen. All the objects observed were intrinsically a good deal brighter than Venus, and, of course far outshone Mercury.<sup>2</sup>

'Observations of this kind have been recorded repeatedly,' commented American astronomer Edward Emerson Barnard later that same month, 'I have often seen these objects at the Lick Observatory and elsewhere when examining the sky near the Sun with a small telescope.'<sup>3</sup>

A phenomena of more shadowy aspect was described by E. W. Barlow, Bournemouth, England, on 1907 May 8. He was looking at a watery sun through light, quickly-moving clouds with a power of 40 on a refracting telescope, when he noticed the 'clouds projected on the sun had a coarse, granulated appearance.' On closer inspection this was resolved into 'thousands of little bodies,' which Barlow thought might be 'a cloud of hailstones.'<sup>4</sup> Col. E. E. Markwick countered by describing his own experiences in 1879 and 1906, but was doubtful if 'particles of hail would be large enough to be seen separately' in very small apertures. More likely, he averred, the phenomenon was due to snow.<sup>5</sup> Precipitation may also explain what observers at the Radcliffe Observatory, Oxford, saw on June 5, 18 and July 10 of that same year.<sup>6</sup>

Yet another enigma excited Lt Herschel in 1869. Writing to his brother Professor A. S. Herschel from Bangalore, India, on October 20–25, he told how, at noon on 1869 October 17, he was preparing to make spectroscopic observations of the Sun. Suddenly he became aware of small shadowy objects flitting across the Sun's disk. After a few minutes he realised they were in reality 'luminous moving images beyond [the sun's] border.' Initially he had difficulty making out their correct form, and for a long time he had the impression of a 'half-moon moving diameter forwards, or sometimes edgeways. Then the feeling was that the[y] were large luminous snowflakes of various

sizes, the smaller ones being almost stellar in their distinctness and brilliancy.' Focusing on a distant cloud he discovered 'they seemed with one accord to take a tangible and real shape, a kind of double crescent with a bar across, and wings or phantom-like appendages.' At seven o'clock the following morning the bodies were still 'passing in a continuous stream.' Later in the afternoon he noted; 'The particles... were intensely brilliant, and many of them moved so slowly as to take many seconds crossing the field of view.' Finally one of the objects 'paused, hovered, and whisked off.' In that instant; 'There was no longer any doubt; they were locusts or flies of some kind. The next morning (October 19th) they were still streaming by in hundreds, in the same direction. It remains to be seen,' Herschel continued, 'if the appearances will continue. As it was, the continuous flight for two whole days, in such numbers, in the upper regions of the air, of beasts that left no stragglers is a wonder of natural history, if not of astronomy.' It is relevant to mention that at the time large numbers of locusts had descended upon parts of India, while newspaper reports told of famine at Jerusalem due to the 'destruction of every green herb there by... innumerable locusts.'<sup>7</sup>

'A winged tribe' was cited to explain a similar phenomenon observed from North America at the solar eclipse of 1869 August 7 some twenty-five minutes before totality.<sup>8</sup> Calling attention to the motion of certain of these objects Professor Henry Morton remarked: 'It is worthy of note, that the direction of motion in the three last of these bodies corresponded with that of the wind blowing at the time, but that of the others did not, ... they are thus, as also for other reasons, unlike the plant seeds noticed some years ago by the Rev. W. R. Dawes.'<sup>9</sup>

Here reference is to the investigations Dawes carried out in the years 1850 and 1851 after a fellow cleric, the Rev. W. Read reported; 'On Wednesday the 4th of September [1850], about half-past nine a.m., while engaged in adjusting my equatorial for observing the planet Mercury, I was much surprised to find great numbers of self-luminous bodies traverse the field of view of the telescope.'<sup>10</sup> Dawes recalled how he too had seen similar objects though not in the numbers reported by Read, and had satisfied himself as to their real nature while observing in daylight during his residence at Cranbrook.<sup>11</sup>

However, the publication of Read's observation prompted further enquiry. A little before noon on 1851 September 9 Dawes prepared to observe the Sun with his 8.5 ft refractor. As he looked through the finder which was fitted with a sun filter, a bright object dashed into sight, moving approxi-

mately east to west. A few seconds later another sped into view, then four or five more.

On previous occasions Dawes had identified such appearances as out of focus images of feathered seeds, especially those of thistles, floating with the breeze. With that thought in mind he unclamped the circles of the equatorial, and moving the telescope freely with one hand, applied the other to the sliding adjusting-tube of the ocular. In this way he was able to follow many of the more conspicuous objects and bring them correctly into focus. The largest rotated and rolled over. Others were covered in feathery down. Focal adjustment on different objects varied greatly, 'showing that they were at different distances; and in almost every instance the smallest objects were the most distant.'

From his studies Dawes thought it probable the objects were airborne seeds, 'of several very different plants... floating together in the air, besides those of various species of thistle (*Cnicus lanceolatus* and *Cnicus arvensis*), such as the seeds of dandelion, groundsel, and some kinds of willow (*Salix triandra* especially).' He further remarked that at the time the weather was beginning to break after a prolonged calm, dry spell.<sup>12</sup>

The experience is reminiscent of one a colleague confided to me many years ago. It occurred in summer as he was travelling through the higher parts of Switzerland. The day was bright, the sun hot, the sky an illimitable blue void, unmarked by cloud or mist. Suddenly at not too great an angular distance from the Sun, the azure serenity was speckled with countless glistening stars, each shining like silver in the sunlit air above as masses of thistledown drifted over the gloomy valley. The sight provided a moment of rare pleasure, felt all the more for being unexpected.

But these luminous specks or Licht flecken, as Heinrich Schwabe referred to them in his sunspot report for 1846, are not exclusively attributable to the gyrations of windborne seeds, dust or pollen.<sup>13</sup> Barnard tells how he saw something of the kind in winter when they were doubtless due to snow or frost crystals. He also defined another cause. 'I have frequently seen with the naked eye spider-threads floating across the sky, drifting with the wind, and brilliantly illuminated by the Sun. I remember one day in November of 1911, while at the Solar Observatory on Mount Wilson, California, Mr. Adams and Mr. Ellerman were silvering the great mirror in the dome of the five-foot reflector. The observing slit was open in the direction of the Sun. By hiding the Sun with the dome, we could see great numbers of spider-webs floating across the sky to the south-east and shining brilliantly in the Sun as they twisted in the wind. It was a very interesting sight. I do not recall that any spiders were seen on these floating threads, although I have heard they sometimes so transport themselves.'<sup>14</sup> A charming account of the phenomenon as it

appeared to Gilbert White at daybreak on 1741 September 21, is to be found in his celebrated *The Natural History of Selborne* (first published 1789).<sup>15</sup>

Writing to *The Observatory* magazine from Bishopston, Bristol, in October 1914, W. F. Denning objected to the application of the label 'meteors' to phenomena of this kind. However, the tradition derives from an earlier century when atmospheric phenomena in general were categorized as 'meteors.'<sup>16</sup> Even so, as telescopic phenomena seeds, insects, dust, pollen, birds, snow and hail, still divert the curious and perplex the unwary, though not in the manner of Charles Fort, who in his search for the strange, the extraordinary and the inexplicable, offered interpretations of these 'meteors' at once irregular and contrary.<sup>17</sup>

**Richard Baum**

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count their experiences or comment on the phenomenon. The *Astronomical Register*, *Astronomische Nachrichten*, and *English Mechanic* in particular yield a rich treasury.

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# White clouds on Io?

John H. Rogers

This paper reports rapid changes in the distribution of bright white patches in one region of Io, close to the subjovian point and the caldera Karei Patera. A stable pattern of white patches in this region was recorded by *Voyager* in 1979. A strikingly different pattern was shown in the first *Galileo*-G1 image (1996 June). However, the patterns in another *Galileo*-G1 and several *Galileo*-G2 images (1996 September) were similar although not identical to that seen by *Voyager*. Hubble Space Telescope images in 1994 and 1995 also resembled the *Voyager* pattern. The changes in the first *Galileo* image are not easily attributable to differences in lighting and viewing angles, and appear to be real physical changes, which occurred over a matter of days during the *Galileo*-G1 encounter. They also do not have the characteristics expected of surface deposits. I suggest that some of these white patches may be drifting opaque white clouds. They may be emitted from volcanic sources which have recently been reported in this area.

## Introduction

The surface of Io is entirely shaped by volcanism.<sup>1,2</sup> The active volcanoes were discovered by the *Voyager* spacecraft in 1979, and some of them have been monitored subsequently by ground-based infrared telescopes. In pictures from the *Voyager* and *Galileo* spacecraft, sites of current or recent volcanic eruptions can be identified in several ways. First, there are the visible eruptive plumes, made largely of sulphur dioxide (SO<sub>2</sub>) gas which is rapidly condensing into SO<sub>2</sub> 'snow'. They appear blue on the limb, and are mostly translucent, although the densest parts are opaque and dark against the disk because of entrained dark particles. Plume shapes are consistent with ballistic trajectories as the gas is ejected into what is essentially a vacuum. Second, the plume deposits on the surface can be recognised as white or dark rings around the vents, and some eruption products are highly reflective in the near-infrared so that they appear 'red' in *Galileo* images. Third, there are white patches on the surface attributed to SO<sub>2</sub> from fumaroles or fountains, though these have not yet been seen to change in response to identified eruptions. Near the surface, a thin atmosphere of SO<sub>2</sub> is present, but the maximum pressure is only 10<sup>-7</sup> bar (measured by *Voyager 1* over one of the largest active volcanoes, Loki).

One of the main aims of the *Galileo Orbiter* mission is to observe changes that have occurred on Io since the *Voyager* encounters in 1979, and to correlate them with eruptions that are observed from Earth and from *Galileo* itself. Indeed, significant changes were seen at several sites in the very first Io image released (Figure 2a),<sup>3</sup> taken during the *Galileo*-G1 encounter in 1996 June, as compared with a *Voyager* view of the same site (Figure 1a). Among these was a region of white patches near the right-hand limb, noted by the *Galileo* team,<sup>3</sup> which is the subject of this paper. It is obvious that the distribution of these white patches is different in Figure 2a and Figure 1a. However in Figure 2b, another *Galileo*-G1 image taken just over one day after Figure 2a, the pattern appears to have reverted to that in the *Voyager* images (Figures 1a, 1b). Further images from the *Galileo*-G2 encounter (Figures 3a, 3b) confirm that these white patches are variable. How can such extensive changes happen so fast?

This paper gives a preliminary description of this phenomenon from publicly released NASA images.<sup>4</sup> More

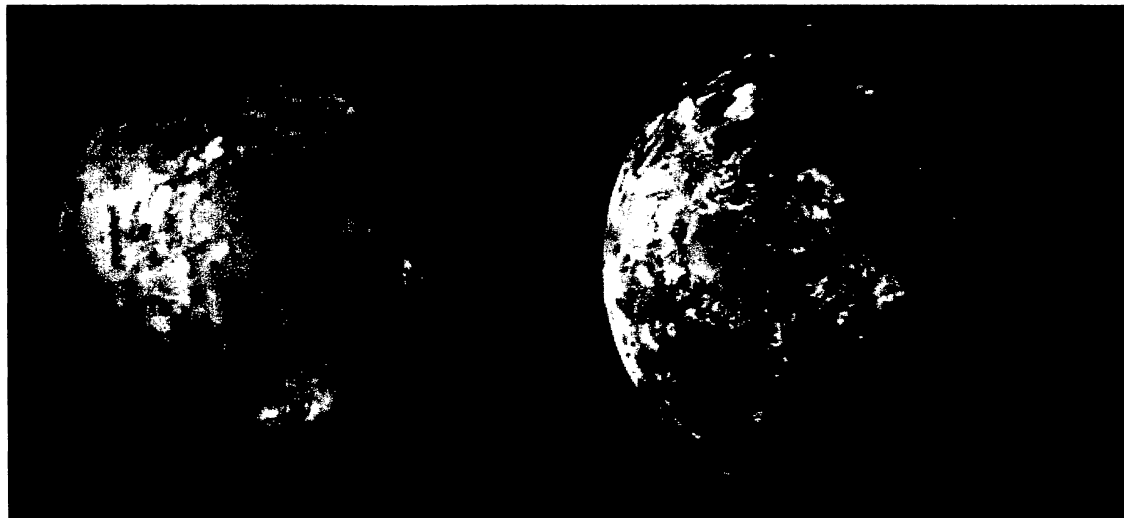
precise analysis of the images is under way by members of the *Galileo* team. Descriptions of colours are based on the publicly-released images and are not realistic, as these images were compiled from a different range of wavelengths than is used by the human eye: violet to orange for *Voyager*, and violet to near-infrared for *Galileo*.

## Observations

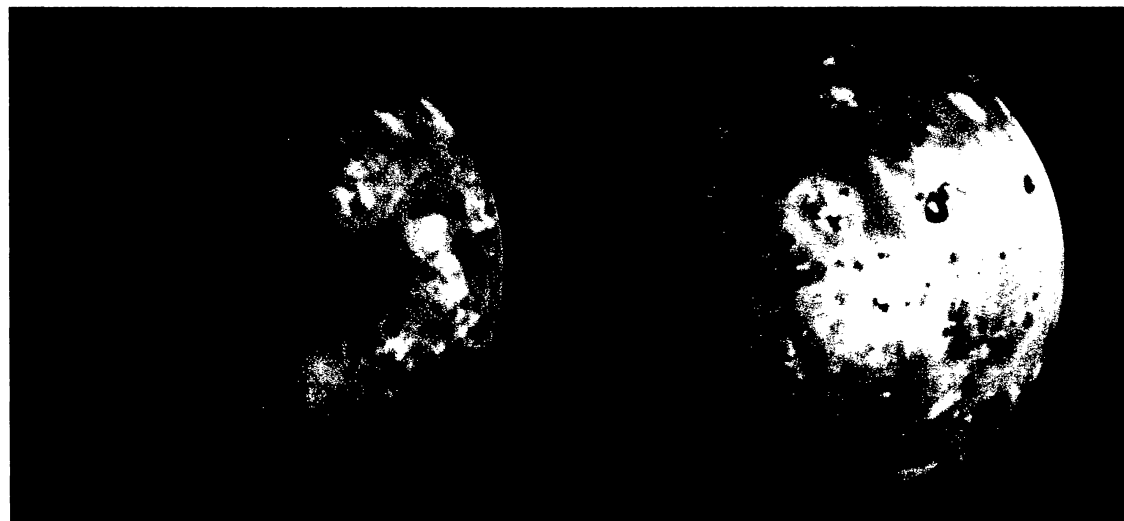
In Figures 1–3 (overleaf), the left-hand images are centred around longitude ~70–80° west (in Media Regio), and show the 'white patches' area near the right-hand (evening) limb. The right-hand images are centred around longitude ~330° west (near Ra Patera), and show the 'white patches' area near the left-hand (morning) limb. Both images of Figure 4 are also centred near Ra Patera. (All images have north up, though only approximately for the *Voyager* images; west is to the left.) In the left-hand images, a line of three calderas provides reference points. They have proposed names Hi'iaka Patera (pale in the *Voyager* image but very dark in the *Galileo* images, presumably following a recent eruption); Shamshu Patera (near the centre); and Kanehekili (the large dark 'footprint' at about 4 o'clock, which has been a persistent eruption centre according to Earth-based observations since 1989).<sup>1,5</sup> In the right-hand images, reference points are Ra Patera (near centre; covered with striking bright deposits in the HST 1995 image [Figure 4b] and in the *Galileo* images, following a major eruption that started in 1994/95), and Loki (the large dark complex in the upper right quadrant, which is almost always a major eruption centre).<sup>1,5</sup> The variable white patches are at 20–30° west, just to the left of a dark spot provisionally named Karei Patera, which is at 2°N, 16°W. (The name, proposed by a working group chaired by A. McEwen, is that of the thunder god of the Semangan people on the Malay Peninsula.)

The most prominent white patches are labelled in Figure 5. The pattern appears to be identical in the two *Voyager* images (Figures 1a and b), including a bright white arc along the left (west) side of Karei Patera (a). However the first *Galileo*-G1 image (Figure 2a) shows an obviously different pattern: instead of the white arc (a), there is a bright white patch on the lower left (southwest) edge of Karei Patera (b), and a diffuse, very bright white arc further away to the northwest (c), partially masking another dark spot.

## White clouds on Io?



**Figure 1.** Views of Io from *Voyager* in 1979. (a, left): From *Voyager 1*, 1979 March, images 16357.xx. North is towards 'one o'clock'. (b, right): From *Voyager 2*, 1979 July, images 20641.xx. North is up, in this and all subsequent images. NASA data from the *Voyager Imaging Team* (leader B. A. Smith), obtained from CD-ROM purchased from the National Space Science Data Center, were compiled into colour images by Simon Mentha.



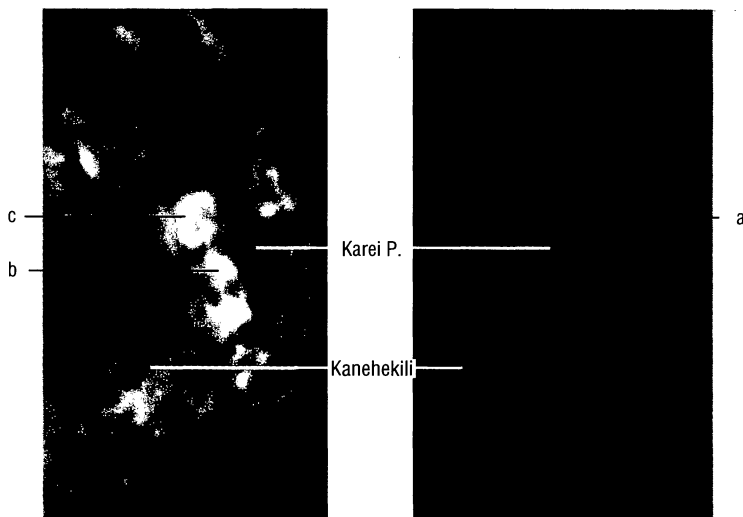
**Figure 2.** Views from *Galileo* at the G1 encounter in 1996 June. (a, left): June 25, central meridian longitude 69° west. (b, right): June 26/27, 338° west; the Karei Patera region has just passed through one ionian night since image (a). NASA data from the *Galileo SSI team* (leader M. J. S. Belton) [refs. 3, 4].



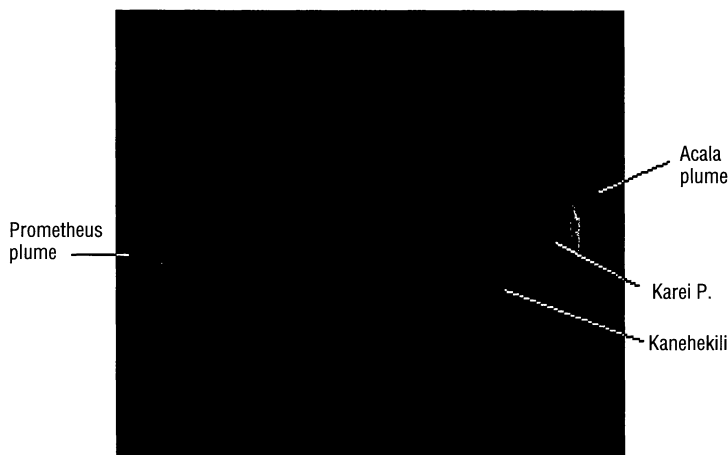
**Figure 3.** Views from *Galileo* at the G2 encounter in 1996 September. These are images from a full rotation movie. NASA data from the *Galileo SSI team* (leader M. J. S. Belton) [ref.4].

But in the second *Galileo*-G1 image (Figure 2b), taken after the region had just passed through one ionian night, the pattern has reverted to that seen by *Voyager* (although the white arc (a) may be brighter). At the next *Galileo* encounter, G2 in 1996 September, the spacecraft took images for a rotation movie (Figures 3a and 3b), and these show a pattern similar but not identical to that seen by *Voyager*, which does not change over one ionian day; bright patch (b) is present but there is no very bright arc west of Karei Patera. An even more recent image, from the C9 encounter in 1997 June, is the first to show this region close to the central meridian, and it again looks the same as in the *Voyager* images.<sup>4</sup>

Lower-resolution images from HST (Figure 4)<sup>6</sup> also appeared to show changes in these white patches between 1994 and 1995. However these may be due merely to different lighting and viewing angles. The 1994 'image' was actually constructed from a map using images which originally had a different longitude and phase from the 1995 image.<sup>6</sup>



**Figure 5.** Enlargement from Figure 2, showing the major bright patches discussed (a,b,c) and landmark volcanic calderas.



**Figure 6 (left).** View of Io in eclipse, from *Galileo* at the G8 encounter on 1997 May 6. As Io is in total darkness, the image shows glows from the volcanic vents and from aurorae over plumes at the limb. The image was taken with the SSI clear filter, sensitive to visible wavelengths and up to 1.05 microns, and is colour-coded so the most intense features are red, weaker ones yellow; they mark the sites of high-temperature lava. The double red spot at about 4 o'clock is the volcanic caldera Kanehekili. The *Galileo* team point out a field of bright spots near Io's sub-Jupiter point (right-hand side), which coincides with the region of white patches discussed here. There are extended diffuse auroral glows on the equatorial limbs over active volcanic plumes, Prometheus on the left, and a new one on the right. *NASA data from the Galileo SSI team (leader M. J. S. Belton) [ref.4].*



**Figure 4.** Views from the Hubble Space Telescope in 1994 and 1995 [ref.6]. *Left*, 1994 March; image reconstructed from images with central meridian longitudes 303° and 41°, phase angle -8°. *Right*, 1995 July; true image with central meridian longitude 333°, phase angle +7°. Both data sets match *Voyager 2* images with similar central meridian longitudes. Taken with the *HST* WFPC2 camera; J. Spencer (Lowell Obs.) and the Space Telescope Science Institute.

This map was indistinguishable from a *Voyager 2* map in the 'white patches' region, while the 1995 image seems indistinguishable from a *Voyager 2* image (Figure 1b) with the white patches close to the limb.

## Discussion

These images show several variable white patches, the most striking of which is the brilliant white 'curl' (c) in the first *Galileo*-G1 image, and its disappearance by the next ionian day. These features were noted by the *Galileo* team, who suggested that they were 'perhaps due to unusual photometric scattering or active phenomena'.<sup>3</sup> Three possible explanations can be considered: fixed patches with unusual reflective properties; variable volcanic deposits; or drifting clouds.

First, are these changes merely due to different lighting and viewing angles? Striking changes with illumination have indeed been noted by the *Galileo* team.<sup>7</sup> For example, patches near the volcano Marduk, and a long, sinuous border to the dark areas on the north edge of Colchis Regio, appeared grey in the 'full-moon' image taken in transit during G2, but brilliant white when seen towards the bright limb in gibbous phase

during the G1 and C9 encounters. Some such features are probably present near Karei Patera, and a mixture of surfaces with different phase dependences could possibly produce apparent changes such as are seen. However, the evidence argues against this as the explanation for all the changes, especially white arc (c) in Figure 2a.

- (i) The white patches show differences between Figure 1b (*Voyager 2*) and Figure 2a (*Galileo G1*), although in each case they are near the bright limb in gibbous phase. So if the changes are due to a curious dependence on phase angle, it is not symmetrical, unlike the effect observed near Marduk.
- (ii) The white patches show no differences during a complete passage across the disk in the *Galileo-G2* rotation movie (Figure 3). So if the changes are due to a curious dependence on viewing angle, it is not evident at this wavelength.

If the differences are not due to lighting or viewing angles, they must be real physical changes. Could the patches be surface deposits from volcanic vents or geysers? Their shapes are not typical of lava flows or fallout deposits, and they do not correlate with time of day, as might be expected for 'frost' condensing and evaporating around fumaroles. It remains possible that some white patches are deposits from short-term eruptions at several small vents. Indeed, there is other evidence for unusual current volcanism in this region:

- (i) A *Galileo* image of Io taken in eclipse during the G8 encounter (1997 May 6; Figure 6), with the same central meridian as Figure 2a, shows volcanic vents glowing in visible or near-infrared light. They include a strong double hotspot at Kanehekili, a very weak hotspot at Karei, and a line of 4 weak hotspots running north-south between the two which coincides with the line of variable white patches. This line of weak hotspots was also shown in another eclipse image, from the E4 encounter (1996 December 17).<sup>8,9</sup> Is this a line of geysers which differ from the larger volcanoes?
- (ii) There was a very hot eruption in or near Karei Patera just one week before the G2 encounter.<sup>5</sup> It was first detected on 1996 August 28, when John Spencer at the NASA Infrared Telescope Facility on Mauna Kea reported a very bright but small eruption with temperature around 1100K. It had already faded threefold by September 6 when G2 imaging began. Similar brief, hot eruptions occur several times a year on Io.

So this area is volcanically active. But again, these hotspots cannot explain how white arc (c) disappeared within one day.

The remaining possibility is that the most conspicuous white patches, especially (c), are clouds. This would be consistent with their sporadic but rapid changes, their diffuse edges, and their curved shape (concave towards Karei Patera in the G1 images). They must be largely opaque in order to mask other surface features, including the dark grey patch that is partly hidden by white arc (c) in Figure 2a. Such clouds have not previously been reported on Io.

There are two obvious problems with the idea of opaque

drifting clouds on Io. First, how can they be supported, given that the maximum atmospheric pressure is only  $10^{-7}$  bar? On other planets, substantial clouds are known only at pressures down to about  $10^{-5}$  bar (the geyser plumes on Triton, and noctilucent clouds in Earth's stratosphere). Further study will be needed to establish whether Io's atmosphere can support opaque clouds. Second, what happens to the cloud particles: where did the material of cloud (c) go to overnight? If it was an aerosol during the ionian afternoon, it can hardly have evaporated during the night. Possibly the particles settle onto the ground and become much less reflective, due to either physical or chemical changes.

I therefore suggest that small geysers in this region produce short-lived white clouds which drift away from the vents; feature (c) in the first G1 image was one of these, and perhaps feature (b). The material then settles onto the ground in the more stable white and grey patches that surround the region, including feature (a). The variations in their relative brightness may be partly due to viewing and lighting angles, but also due to episodic deposition and ageing of the 'snow'.

Quantitative analysis of these and other images, by the *Galileo* investigators, will no doubt show whether this hypothesis is viable. Whatever the outcome, something very interesting has been happening in this region of Io.

## Acknowledgments

I am grateful to Dr John Spencer for helpful discussions, especially about the possibility that these ionian phenomena are merely photometric effects.

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- 9 (Note added in proof): An even better eclipse image of this region was taken during the C10 encounter on 1997 Sep. 18 and released on the Web site. It confirms the line of faint hotspots. It also shows other faint hotspots in the region, plus a general flow attributed to gaseous emission centred around the sub-Jupiter point. The *Galileo* team attributes these vents and emissions to the tidal deformation, which is greatest at the sub-jovian and anti-jovian points on Io. The white-cloud emissions proposed in this paper would be another manifestation of this regional activity.

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# An inexpensive focusing mount

Arthur Missira

A focusing mount with the ability to take a range of government surplus eyepieces was required for a home-made 60mm refractor. After considering machining one from brass bar/tube an almost ready-made solution was found.

## Introduction

About 18 months ago I purchased a 63mm diameter f5.6 photographic lens for £5 along with some 12mm and 25mm f.l. eyepieces at a similar price from a well known government surplus depot in Nottingham. The low price of the objective was due to its having a faulty iris; this was removed within a matter of minutes and the lenses carefully cleaned, reassembled and tested. I decided to use these components to make a compact RFT refractor/ large finder and was quite pleased to find that the brass objective cell fitted neatly into a spare piece of 4" diameter aluminium central heating boiler flue duct.

A 5" diameter aluminium pulley wheel was found in my scrap box and was turned on the lathe to fit the other end of the tube; all that was required now was a focusing mount to take the government surplus eyepiece and the telescope would be complete.

## Solution

The cost of a commercial focusing mount (about 6x the cost of the rest of the telescope) ruled itself out as uneconomical. I was also reluctant to obtain suitable tubing etc. from a non-ferrous metal stockist as the cost of this plus the effort of designing and machining it would not show much saving over a readymade mount.

Thus I decided to pay a visit to the local DIY superstores for a browse round the plumbing section to see if any of the brass compression fittings would form a suitable starting point for a mount. I eventually recognised the potential of an item called a 'tank connector'. This is, as the name says, a brass interface

between the copper pipe and the cold water supply tank. These connectors are available in three sizes; 15mm, 22mm and 28mm. The 28mm was the one used.

Figure 1 shows the tank connector split into its four component parts with a view of the finished mount fitted to the refractor body. The olive and compression nut are not used and may be discarded.

The only essential machining operation is to open up the 28mm diameter bore of the tank connector body to take the intended eyepiece; this was done using a boring bar on the lathe. For aesthetic reasons I decided to reduce the size of the flange on the tank connector body whilst imparting a better finish during the process. The clamp nut was also put in the lathe and the hexagonal faces were carefully turned off to get rid of the 'big nut' appearance. Finally, the clamp nut flange was just skimmed with a finishing tool to give a clean flat surface ready for bonding to the telescope back plate.

Cyanoacrylate adhesive was applied to the flange of the clamp nut and the nut applied to the refractor back plate. Using 'superglue' may be frowned on by some purists but it is now a recognised industrial method of securing parts and I can certainly vouch for the strength of this particular bond.

All that remains is for the tank connector body to be screwed into the clamp nut and the eyepiece fitted and focused.

## Performance

The thread pitch is 1.8mm and the thread length is 28mm, and with the 1" eyepiece fitted, (measured depth of field about 2mm), this gives a fine focusing action with plenty of travel. The play in the thread was found to be in the order of 0.18mm which, although insignificant for my application, can easily be removed by several simple methods.

## Conclusion

As stated earlier, this focusing mount was intended to take a range of various non standard eyepieces and this is achieved quite simply by purchasing several of these tank connectors, cost about £2.60 each, and boring them out to suit the individual eyepieces. Then to change eyepieces all that is required is to unscrew one assembly and fit another.

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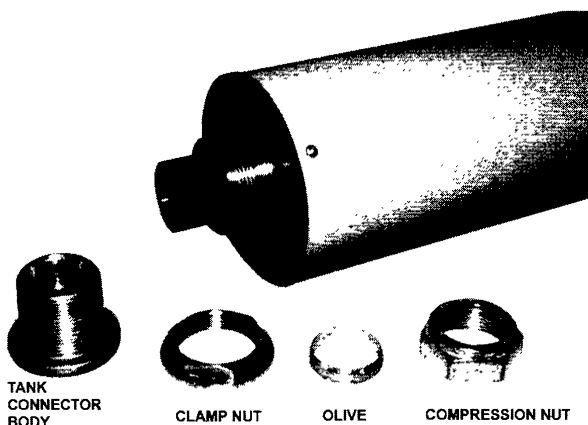


Figure 1. The tank connector components and the completed mount.



## Ordinary Meeting, 1998 May 27

### held at the Scientific Societies' Lecture Theatre, 23 Savile Row, London W1

**Martin Mobberley, President**

**Laurence Anslow and Nick James, Secretaries**

The President welcomed members and visitors to the eighth meeting of the 108th session, and gave a special welcome to Gary Cameron of Ohio, USA, who is Historical Section Director of the Association of Lunar and Planetary Observers. Laurence Anslow read the minutes of the April 25 OM, which were approved by the members and signed by the President. The meeting applauded the donors of four books:

*The Solar Corona* by L. Golub & J. Pasachoff

*After Contact: the Human Response to Extraterrestrial Life* by A. A. Harrison

*The Dobsonian Telescope: A Practical Manual for Building Large Aperture Telescopes* by D. Kriege & R. Berry, all donated by Hazel McGee;

*Hubble's Universe* by S. Goodwin, donated by P. Norman.

The President said that fourteen candidates were being proposed for membership, and the meeting confirmed the election of fourteen new members proposed at the last meeting. Mr James read out the titles of three papers approved for publication in the *Journal*:

*An investigation of the incidence of solar eclipses at the Chinese new year* by Darren Beard

*Intensity variations of Venus' terminator region* by Peter Wade

*The Association's awards and medals* by Bob Marriott

The President reminded members about the BAA Exhibition Meeting, which Martin Ratcliffe would attend, and the Instruments and Imaging Section meeting in Northampton.

He then introduced the main speaker, Dr John Spencer of Lowell Observatory. Dr Spencer had studied geology at Cambridge and planetary sciences at Arizona, had worked for four years at the University of Hawaii and then moved to Lowell. A recipient of the Kuiper Memorial Prize, he had used the Hubble Space Telescope (HST) to observe Jupiter's moons. Dr Spencer now brought the latest news from Io and the other Galilean satellites.

### *Galileo* and the Galilean satellites

Dr Spencer said that the Galilean satellites of Jupiter formed a miniature solar system; with increasing distance from the planet, satellite density decreased while surface

age increased. Io, Europa and Ganymede were linked by a 4:2:1 orbital resonance caused by mutual gravitational interactions. These perturbations had important consequences.

Regarding size, density and distance from the primary, Io was similar to the Moon but looked nothing like it and was volcanically highly active. Io's elliptical orbit and systematic rhythmic perturbations by Ganymede and Europa created a 10km high bulge on Io's Jupiter-facing side. The bulge size varied by 1%, with Io's surface going up and down by 100m per day. Volcanic calderas, rugged topography, high mountains and multi-coloured pyroclastic haloes abounded. Silicate rocks at depth underpinned the sulphurous surface which was not by itself strong enough to support 10-12km mountains.

The biggest volcano found by *Voyager* was Loki, which had since been routinely detected from Earth, giving some feel for its long-term behaviour. Dr Spencer used the NASA InfraRed Telescope on Hawaii and the 72-inch Lowell reflector to obtain infrared images two or three times a month. From Earth, Io had an apparent diameter about one arcsecond, so that with the one-third arcsec. seeing from Hawaii its disk could be resolved. In the 3.5-micron methane band, Jupiter was virtually invisible and we could observe Io without interference when it emerged from behind Jupiter. All we saw was volcanoes; Dr Spencer showed a dramatic movie featuring Loki. From repeated monitoring, his team had worked out vent positions and built up a long record of eruptions. Imaging at several different wavelengths had shown the surface temperature of eruptions to exceed 1000K. Fire fountains and lava lakes were around ten times larger than on Earth. Dr Spencer remarked how he could look at the glow of Hawaii's Kilauea volcano after observing volcanoes on Io!

Probing the gravitational, magnetic and plasma environments of Io, *Galileo* indicated a large iron or iron sulphide core and a magnetic field deep within that of Jupiter. However, was this caused by Io itself or interaction with Jupiter's field?

We could compare recent *Galileo* with 1979 *Voyager* and HST images of Io; HST resolved twenty pixels across the satellite. There were few broadscale changes; the surface regionally repainted itself, then reverted to its original colour. But strangely, Prometheus had moved 70km without changing its appearance. One large change was a new plume at Pillan Patera which deposited a large area of dark greyish sur-

face material between April and September 1997. Pele was also active, and a new fissure eruption at Zamama produced dark material.

HST Near Infrared Mapping Spectrometer (NIMS) 5-micron images were similar to those from Mauna Kea. but had a five or six times better resolution, showing better volcanic detail. A CCD image at 1 micron (UV) revealed glowing gases, hot volcanoes and Jovian aurorae; the volcanic glow suggested that volcanoes, with inferred temperatures up to 1500K, were too hot to comprise 'ordinary' basaltic magma, but were analogous to terrestrial flows enriched in silica. Dr Spencer said that we didn't understand the volcanic chemistry.

Io was leaking 1 tonne/sec. of material, mainly sulphur but also some sodium, into a gaseous torus around Jupiter. A banana-shaped cloud close to Io closely followed the moon in its orbit. Plasma went to form Jupiter's polar aurorae. Io's surface spectrum was dominated by sulphur and sulphur dioxide. Surface colourings were caused by different forms of sulphur while infrared spectrum details were due to SO<sub>2</sub>.

Europa had a very clean and uncratered surface but, like Io, it had an iron core. Tidal heating had possibly melted some of the interior to form subsurface water which, together with internal heat, raised the intriguing question of possible life. The fractured, icy surface varied in composition. There was an almost infinite succession of cross-cutting ridges. Dr Spencer said that it almost looked like something was knocking on the bottom of the surface, trying to get out! This was evidenced by bulges and shattered, submerged pieces of crust spread out like ice rafts which had shifted, sometimes by hundreds or thousands of km, relative to each other. An eroded appearance at the highest resolution was possibly caused by sputtering or sandblasting. The impact crater Pwyll was very subdued with a broken rim. NIMS surface analysis had revealed either Epsom salts or sodium chloride.

Was Europa's subsurface composed of water or warm, slushy ice? Dr Spencer thought that there was some but not conclusive evidence for a subsurface ocean. The surface was probably very young, perhaps only a few tens of million years, but might be as old as 1 billion year – in which case Europa would be geologically dead and have no ocean. The jury was still out on this all-important question.

Ganymede had both dark, heavily cratered and grooved terrain. The biggest surprises were on the inside, where *Galileo*

unearthed an iron core, rocky layer and probably frozen icy mantle. Its discovery of a magnetic field, which produced a unique 'magnetosphere within a magnetosphere' and underwent complex interaction with Jupiter's plasma, was totally unexpected. There was probably not enough tidal heating to melt the ice. Intense faulting of the grooved terrain indicated tectonic resurfacing but many surface craters suggested that this probably happened a long time, perhaps a billion years, ago. But some young craters were very smooth. The cratered terrain was also complex and contained grooves, valleys and strange hills which did not seem to have been produced by cratering. Earth-based spectra had revealed ozone and oxygen on Ganymede's surface, mostly on the trailing side. Hydrogen, produced from dissociation of surface water ice, streamed out into space.

Callisto had a dark, dirty surface covered with some ice and an unidentified gunk. Consistent with the dead surface, it was only slightly differentiated and any heating was very modest. There were multi-ring basins and bright, fresh craters, and Callisto's surface was saturated with a myriad overlapping craters. Large smooth areas at the lkm scale denoted craters blurred by dark material, due either to sublimation, collapse and migration of material to high latitudes or an electrostatic force. The surface distribution was complex and there was evidence for CO<sub>2</sub>, SO<sub>2</sub> organic compounds and a very tenuous CO<sub>2</sub> atmosphere fed by surface frost.

In summary, *Galileo* had found Jupiter's main satellites to be even more complex and varied than previously suspected. The extended *Galileo* Europa Mission included five more flybys of Europa, four of Callisto to realise perijove, and two of Io in late 1999. By that time the spacecraft would have been subjected to five times its design dose of radiation. An Europa Orbiter was planned to spend 30 days in Europa orbit around 2007 to search for an ocean.

The President said that he did not think he had ever seen a laptop presentation done so skilfully, and invited questions. John Rogers asked whether very hot volcanic vents on Io had particular characteristics? Dr Spencer said that hotter material cooled faster, in a few weeks. Nearly all the volcanoes were 1000K, and involved hot silicate rock and not just sulphur flows. In reply to a question about Io's surface flexure, Dr Spencer explained that the crust was broken up but did not move up and down.

Henry Hatfield enquired whether the tidal forces acting on Io were the same as those producing Earth's bulge, with two tides per day? Dr Spencer replied that Io with its synchronous orbit was unlike Earth, and orbital eccentricity caused the tides. Nick Hewitt asked whether there were any plans to image the non-Galilean satellites with

*Galileo*? The answer was that Amalthea and Thebe had been imaged slightly better than from *Voyager* but there were no plans to image the outer satellites. These were presumably like outer belt asteroids but with unusual surface composition, so there might be surprises. Jacqueline Mitton queried whether Io's volcanoes had a mountainous structure or places where the ground sank down? Dr Spencer thought that the sub-surface was so hot that it couldn't support big weights, and confirmed that volcanic conduits were below datum. Dr Rogers asked about the origin of diffuse surface material, and it was answered that this had either fallen down or been left after evaporation.

Dr Spencer was enthusiastically applauded for his fascinating talk and thanked by the President who then proceeded to give his night sky notes.

### Sky notes for June

Mr Moberley said that after seeing a mag -7 event, which looked like an approaching plane, he wasn't quite sure whether to be impressed or disgusted by Iridium satellite flares. Events ranged up to mag -9 locally, but observer position was critical. The Web site for current predictions was <http://www2.gsoc.dlr.de/scripts/satvis/satvis.asp>.

Peter Meadows' solar sketch showed a few spot groups. Binocular asteroids, Hebe and Melpomene, lay in Ophiuchus, and well above was Comet Stonehouse which Jonathan Shanklin said was a very diffuse and difficult to spot mag 12 object, although David Strange had secured a CCD image. Returning comet Giacobini-Zinner might produce a meteor display around October 9 but the Moon would then be just past full. Most asteroid occultation tracks for June/July were quite narrow and there was little chance of seeing them. Pluto was due to occult a star on July 9 but, with the Sun only 9-12 degrees below the horizon, observing this would need quite a large telescope, probably with a CCD and possibly an image intensifier. Mr Moberley remarked that these events always seemed to have some kind of snag!

Comet Soho, which was discovered by the SOHO coronagraph and reached an absolute magnitude of -8, was moving south and Gordon Garrard had some nice images. Some amateurs had observed it with a CCD when the comet lay only 10° from the Sun. Mr Moberley commented that Comet Soho could not have been discovered by amateurs as, when it was at all bright, its elongation was appalling. Currently in the Orion/Sirius area, there was not much hope of seeing it from the UK.

Mr Moberley described the recent

wealth of supernova discoveries; UK observers now tallied seven discoveries which this year included three by Mark Armstrong and one by Ron Arbour. Another recent find was 1998bn in NGC 3368 by the Italian Mirko Villi. Maurice Gavin had obtained a supernova spectrum – thought to be the first by an amateur – of 1998bu, and Mr Moberley said this was extremely impressive. Mr Gavin said that the main absorption line of Si<sub>2</sub> coincided with his CCD camera's peak sensitivity, and he showed how he had shortly beforehand stuck the apparatus together with sellotape!

The President then invited Ron Arbour to speak.

### My first supernova – at last

Mr Arbour's discovery of SN 1998an in UGC 3683 (in Lynx) ended a twenty-year search for his first supernova. He used a Starlight Xpress CCD camera and 30cm LX200 telescope programmed for automated searching. At the time of discovery on April 6 the Moon was three days past first quarter and high-level fog was thickening. He had imaged the field eight times since February 3 and knew it very well.

Mr Arbour ran through a careful check list for suspected supernova discoveries: (1) check the master image; (2) use *Megastar* or *Guide* software to rule out known asteroids and variable stars; (3) do a detailed deep-sky check using either the Digitised Sky Survey (DSS), a Palomar image or *Real Sky*; (4) use the Central Bureau for Astronomical Telegrams (CBAT) minor planet checker for an up-to-date list of asteroids near the host galaxy; (5) also check CBAT for recent supernovae discoveries; (6) then use an astrometric program to obtain a precise position and calculate the offset; (7) after at least half-an-hour, go back to the telescope and remeasure for detected movement; (8) obtain confirmatory CCD images from an experienced observer; (9) contact CBAT or Guy Hurst. Only then was the potential discoverer allowed to panic!

Mr Arbour stressed that one must take all possible steps to avoid a false alarm, as misleading images could for instance be produced by a camera artefact or a cosmic ray. DSS was made by the Palomar Schmidt telescope, and its image including UGC 3683 penetrated to mag 20. *Megastar* ruled out high-declination asteroids, and the suspected supernova was definitely not Planet X!

Tom Boles and Michael Schwartz provided confirmation. Mr Arbour said that for 48 hours after his find, he couldn't get any sleep and was anxious for spectroscopic confirmation. After nine days, Japanese observers found the blue-shifted absorption signature of Si<sub>2</sub> which indicated a reces-

sional velocity of  $10^4$  km/sec. Showing a league table of amateur supernova discoverers, Mr Arbour said that he was the fourth UK discoverer, and Mark Armstrong had made incredible leaps upward to rank as fifth in the world. The world leader, Bob Evans, had found 36 supernovae.

Mr Arbour tried to avoid the press as much as possible but the story was splashed all over his local rag with misquotes such as 'Supernovae are stars which have exploded in space light years ago... (it exploded) so long ago that it's no longer there... (and) Ron's was believed to have blown up 100 million years ago'!

Mr Arbour was warmly applauded by the meeting and thanked by the President, who then called on Owen Brazell.

## Observing planetary nebulae

Mr Brazell said that planetary nebulae (PNe) are the end points of life for stars between 0.9 and three or four solar masses. Rich in processed elements from their stars' cores, they have lifetimes of about 20–30,000 years. Some are symmetrical about the central star, while others look like spiral galaxies – someone had probably been looking for years for supernovae in these!

Popular lists included Messier with 4 PNe, NGC with 76 – most of them visible with a 10-inch telescope – Caldwell with 13, and Sky Catalogue 2000. In the 1950s George Abell discovered PNe on Palomar Observatory Sky Survey (POSS) plates; Abell list PNe tended mainly to be large, extremely faint and nearby. Conversely, Minkowski list PNe were small and needed high power. A more dubious list, the PIZ devised in 1967, listed M1 as a PN, and had left a legacy in some American books. Probably the most complete list was the PNG compiled by the French at Strasbourg in 1992. The Hynes catalogue and handbook, *Webb Society Deep Sky Observers' Handbook Vol. 2*, included recalibrations and was considered more accurate.

Suitable paper charts included *Uranometria* and the *Millennium Star Atlas*, although using them to search for fainter PNe could be a challenge. They were complemented by computer software including *Megastar*, *Guide* and *The Sky*, and photographic media such as the POSS. Unfortunately Palomar stopped selling prints several years ago but CD-ROM versions were available. For example, *Real Sky* included the southern sky but had lost a huge amount of contrast; DSS was less compressed and therefore contained more information but cost \$3500 for 110 CD-ROMs.

Nebula filters, invented in the early 1980s, were useful in selectively transmit-

ting oxygen lines of many PNe while blocking out skyglow and airglow; however, high-pressure sodium streetlights were more difficult to filter out than low pressure sodium. Books and catalogues provided information on PNe emission line strength. Mr Brazell recommended using high powers for finding PNe. For challenging objects, he suggested making a drawing of the field of view and marking the suspected position.

*Guide* could read in the US Naval Catalogue which showed stars to mag 22; its magnitude values were way out but it gave two-band colours.

Following applause, the President thanked Mr Brazell and all the speakers and adjourned the meeting until 1997 June 27 at London Guildhall University.

**Edward Hanna**

## New members

The British Astronomical Association cordially welcomes the following new members:

*Elected 1998 April 25*

**Al-Farisi** Lubab, 22 Winchester Court, Vicarage Gate, London W8 4AD

**Andrews** Martin, 36 Bissley Drive, Maidenhead, Berks. SL6 3UZ

**Bandaragodage** Wijeratne Chanukah Kumarini, 119/c Nuwara Eliya Road, Gampola 00094, Sri Lanka

**Bartha** Lajos, H-1023 Budapest II, Frankel Leo VT 36, Hungary

**Clark** Maurice, 11 Lodge Avenue, Great Baddow, Chelmsford, Essex CM2 7EA

**Crellin** Robert Samuel David, Glenbrook, Claremont Road, Bath BA1 6LX

**Devall** Joan Kathleen, 36 Hadley Road, New Barnet, Herts. EN5 5QS

**Efthymiou** Karima, 133 Gosspatrick Road, Wood Green, London

**Evans** Peter, 68 Tisbury Road, Hove, East Sussex BN3 3BB

**Firth** Anthony, 31 Parkway, Ratton Manor, Eastbourne, East Sussex BN20 9DX

**Fletcher** Robert Paul, 21a Glynne Avenue, Kingswinford, West Midlands DY6 9PT

**Francis** Peter William, Flat B, 4 Canonbury Street, Essex Road, London N1 2TD

**Frassati** Mario, Viale de Martiri 9, 13044 Crescentino (VC), Italy

**Goldberg** Geoffrey, 139 Leaside Crescent, Golders Green, London NW11 0JN

**Hennessey** Roger Anthony Sean, 29 Redgrove Park, Hatherley Lane, Cheltenham, Gloucs. GL51 6QY

**Lawlor** Frank, 'Farnworth', Poringland Road, Upper Stoke Holy Cross, Norwich NR14 8NW

**Lawrence** Howard John, 16 Monson Way, Oundle, Peterborough, Cambs. PE8 4QJ

**Lefevre** Jacques, 19 Rue Jean Pauly, 4432 Alleur, Belgium

**Malin-Smith** Konrad George, 8 Mead Way, Shirley, Croydon, Surrey CR0 8BQ

**Manifold** Kirsty, 29 Sitka Close, Royston, Barnsley, South Yorkshire S71 4NA

**Manifold** Philip, 29 Sitka Close, Royston, Barnsley, South Yorkshire S71 4NA

**Millan** Max, 25 St Mary's Way, Chigwell, Essex IG7 5BX

**Olof** Brian Eric, Guiles, Froxfield Green, Petersfield, Hants. GU32 1DQ

**Robinson** Brian, 9 Stammers Road, Colchester, Essex CO4 5LX

**Smith** Ian Charles, 9 Blewitt Court, Littlemore, Oxfordshire OX4 4PB

**Vialls** Janet Christine, 20 Bishops Way, Great Paxtow, Huntingdon, Cambs. PE19 4YN

**Vincent** Mark, c/o Unit 23, The Green Business Centre, The Causeway, Staines, Middx. TW18 3AL

**Wilkinson** David, 17 Speedwell Road, Birmingham B5 7PS

**Worland** David Roy, 34 Bathurst, Orton Goldhay, Peterborough, Cambs. PE2 5QH

### *Affiliated Societies*

**Blatchington Mill School AS**, Holmes Avenue, Hove, East Sussex BN3 7LF

**Havering Astronomical Society**, 133 Severn Drive, Upminster, Essex RM14 1PP

### *Elected 1998 May 27*

**Clarke** Christopher David, 29 Ashfield Drive, Anstey, Leics. LE7 7TA

**Daysh Pilkington** Linda May, 21 Josselin Close, Earls Colne, Essex CO6 2SE

**Denman** Colin James, 29 Fareham Way, Houghton Regis, Dunstable, Beds. LU5 5RE

**Edwards** Steven Adrian, 28 Greenmeadow, Cefn Cribwr, Bridgend, South Glam. CF32 0BJ

**Griffiths** Geoffrey Bransom, 5 Monkams Avenue, Woodford Green, Essex IG8 0HB

*continued on page 295*

## Meeting of the Instruments and Imaging Section

held at the Humfrey Rooms, Castilian Terrace, Northampton on 1998 May 30

This was the fourth meeting of the Instruments and Imaging Section, held in the rooms of the Northamptonshire Natural History Society, and as in previous years it proved an unqualified success. Bob Marriott's formula of thirteen short talks separated by extensive lunch and tea breaks again proved very popular with the audience, which constituted a *Who's Who* of British amateur and professional engineers, scientists and observers.

Michael Maunder started the proceedings by explaining the construction and operation of a portable system for solar eclipse photography. Although light, the system is very rigid and extremely flexible, and bears all the hallmarks of the experienced photographer.

Graham Salmon, who had journeyed from Truro, followed with a revealing explanation of UVBRI photometry, dispelling the myth that it is mathematically too complex for most observers. However, it is not easy to achieve high precision results, and the photometric accuracy produced is dependent on the care and skill applied in making and reducing the observations.

Norman Walker put forward the professional's point of view regarding the selective use of photons. Apart from astrometry, he described why the appropriate choice of filters enables real science to be undertaken, in that colour changes in objects – particularly supernovae – combined with a wide range of wavelength responses for various detectors, lead to a wide scatter in derived magnitudes. Norman also showed his multi-filter unit, which achieves accurate positional registration and is available commercially.

The last speaker of the morning session was Roger Pickard, who presented an account of the operation of the Jack Ells Automatic Photometric Telescope – a remarkable instrument, able to make accurate repetitive measurements over a period of many hours, completely unattended.

A long and leisurely lunch-break followed: some took the excellent fare provided, whilst others adjourned to local hostelrys.

Ron Arbour began the afternoon session by describing how he eventually succumbed to an off-the-shelf computer-controlled telescope for his supernova patrolling, how he persuaded it to work 'decently', and how he finally discovered his first supernova.

The first of the British supernova discoverers, Mark Armstrong, then spoke about one of his four supernovae – 1998aq. He described his work as an 'obsession', but it takes that kind of dedication to not just locate these elusive objects, but also to be the first to announce their discovery. In this case he was particularly pleased at discovering the supernova probably 18 days before maximum light, thereby providing professionals with a very early record of what is usually the poorly observed rising phase.

Tom Boles – another supernova discov-

er and discussion, Patrick Miles described an elegant system he has invented for remote detection of a clear sky. The principle lies in registering the difference between upward and downward infrared radiation flow in the absence of cloud cover. Under a cloudy sky there is very little difference, and by setting an appropriate imbalance threshold, the system can indicate clear or cloudy conditions with a reliability of at least 95%. This has important implications for the effective operation of remote or automated telescope systems.



A focus of opticians: Norman Walker, Jim Hysom, David Sinden and John Wall. (Photo: Bob Neville)

erer – talked this time about adaptive optics, and how the technology is progressively entering the amateur domain. Tom gave an excellent illustrated description of how professional systems work and of their ultimate cost-effectiveness. Although the Hubble Space Telescope achieves diffraction-limited resolution because it is above the atmosphere, its aperture is only 2.4 metres, and ground-based systems such as the Keck Telescopes – which cost far less than the HST – can approach this resolution from the tops of mountains.

Nik Szymanek then presented a stunning series of what he called 'pretty pictures', in contrast to the subjects of previous talks. With Ian King, he makes regular trips to La Palma and observes from the top of the mountain alongside the William Herschel Telescope and other giants. He described the seeing as normally some of the best on the planet, and his mastery of the photographic art certainly did it justice.

After another long and useful break for

Tom Patrick, of University College London, next presented a fascinating insight into some of the engineering problems encountered while working on space satellites – in particular, the Infrared Space Observatory (ISO), which has recently successfully completed 18 months of observations employing detectors at only 4° above absolute zero. He had to design a stepper motor which would work reliably at these extremely low temperatures at which helium is a liquid. Tom also referred to an unusual set of telescope optics manufactured by another eminent member of the audience – David Sinden.

Bob Neville then had to follow all this, and described a tilting-plate method for precise image-shifting during the tracking and detection of faint, fast-moving objects. These Near Earth Objects (NEO) have had quite a press recently (1998FX2), and continue to be discovered daily by several dedicated professional systems. The method – or an equivalent system – would enable

quite modest telescopes of 20cm aperture and above to provide scientifically useful astrometric data on these potentially hazardous objects.

Michael Maunder next read a contribution by Marcel Le Masson concerning the construction and use of a simple, folding cover for an observatory. Of a design used for sea-going boats, the cover has proved very effective, whilst taking up only a small amount of space.

There then followed two additional short contributions, the first being from Maurice Gavin, who showed the first amateur spectrum of a supernova – a considerable achievement. John Wall then described his latest project: an impressive 30-inch diameter lens, rendered achromatic by a multi-element system close to the focus.

Finally, Bob Marriott briefly described BAA Instrument No.93, a 12¼-inch Calver reflector acquired by T. E. R. Phillips around the turn of the century. Phillips died in 1942, and in 1946 the instrument passed to the Association, since when it has been on loan to Frank Holborn for 17 years and to Alan Heath for 34 years. In July 1997 it was placed in the capable hands of Bob Steele, whose ingenious swing-back hut was described in the August *Journal*.



Speakers at the I&I meeting (l. to r.): Roger Pickard, Patrick Miles, Norman Walker, Graham Salmon, Mark Armstrong, Mike Maunder, Bob Neville, Tom Boles, Bob Marriott, Ron Arbour, Tom Patrick, Maurice Gavin and John Wall. (Photo: Bob Neville)

The meeting began at 11.00 and finished at 18.45 (slightly later than planned), but most of the 68 participants stayed until the end. Many then headed for *The Fish*, where lively discussion continued unabated; and for some there was a later adjournment to an

Indian restaurant. It had been a long day, but it was a very stimulating and rewarding experience, and we hope to be back again next year.

**R. J. Neville**

### Obituary

#### E. W. P. Turner, 1928 – 1998

Although born in Hackney Eric Turner was brought up in Walthamstow, East London. As a child he showed a keen interest in science and the natural world. When World War Two seriously threatened life in the big cities Eric, along with many other school children, was evacuated to the relative security of the countryside, in his case to the mining district of Blaenavon, now in Gwent. He soon took an interest in the local wildlife and especially in the local geology, frequently returning to his hosts' home with a collection of bits of rock and fossils.

On reaching the age of fourteen, he returned to Walthamstow. Although under age, he forged his mother's signature to get into Civil Defence and when on fire-watching duties he managed to do quite a bit of star-gazing, having become fascinated by the clear skies of Wales. He saved up and brought his first telescope. As soon as he was old enough he joined the Army, not waiting to be called up for National Service. Most of his periods of leave were spent in Wales or Devon where he became an avid fossil hunter, in fact he found a fossil unknown to science and passed it on to the Geological Museum.

On a visit to Torquay Museum he met Angela, a member of the museum staff, and later married her when he left the Army. Eric joined the BAA in 1945 and gained much experience and satisfaction from his membership, and was rewarded with Honorary Membership after completing 50 years as a member. He became a member of the Council and, for a few years, was Curator of Lantern Slides until the Library took over the slide collection. He had great admiration for the great characters of the BAA such as Dr Steavenson and Mr F. J. Sellers from whom he learnt much.

In the early 1950s some Council members felt that the BAA was not doing enough to encourage the youngsters, so in 1952 Eric and two fellow councillors, Patrick Moore and Ernest Noon, founded the Junior Astronomical Society. The story has often been told that the first committee meeting of the JAS took place on the steps of the Royal Astronomical Society's apartment at Burlington House. Eric served for many years as Secretary of the new society helping to guide it through some early 'teething troubles'.

Eric and Angela settled in Basingstoke where Eric became a local council officer.

The Turners were great animal lovers with a special interest in wild birds and they often rescued injured birds so that their home resembled a bird hospital. The birds were returned to the wild where possible, but there were two exceptions. Peeper, a one-winged starling, lived happily in the lounge pecking holes in the long curtains. She learnt to say her name and to imitate the Greenwich time signal, once sending Eric out too early to catch the bus to work. The other was a sparrow whose name was Tweetie and, as Eric played classical records, the little bird developed a liking for Beethoven and a recording of Tweetie singing to a Beethoven symphony was once featured in a BBC Natural History programme.

In recent years Eric concentrated on writing his own and family memoirs. He contributed a number of papers for Walthamstow Museum on his evacuation experiences, and an account for the Imperial War Museum of his grandfather's service in Belgium in 1914–1918 and in India 1918–1920.

Eric Turner is survived by Angela and their daughter Mira.

**Rossie Atwell**



## Norton's Star Atlas and Reference Handbook (19th Edition)

by Ian Ridpath (Ed.)

**Longman, 1998. ISBN 0-582-31283-3 (hbk), 0-582-35655-5 (pbk.) Pp. xii + 180, £25.00/£17.99.**

When in 1989 Ian Ridpath rejuvenated the 79-year-old *Norton's Star Atlas*, a great classic in the annals of amateur astronomy was made available to new recruits to the hobby and more useful to its many devotees. Though much loved, it was old-fashioned and out of date. But under Ian Ridpath's expert guidance, the maps were totally redrawn, their epoch advanced from 1950.0 to 2000.0 (the effects of 50 years' precession taken into account), and the handbook section completely rewritten.

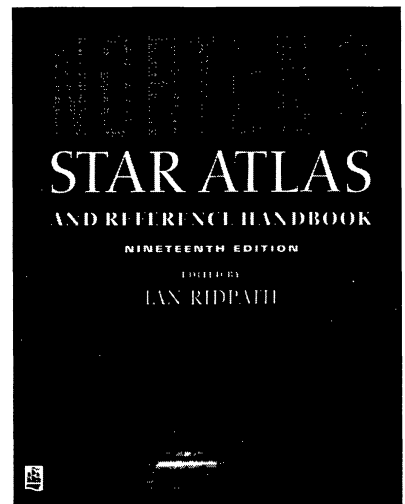
Nine years on (can it really be so long?), there is yet another edition but the changes to content are relatively minor. Some 350 corrections have been made on the maps and 100 more stars have been added. The text

has been amended as necessary, to include the new system of designating comets, for example. Many of the diagrams have also been improved.

A good book is more than its contents, however. Design and quality of production are also important. These are beyond the control of authors and editors, firmly in the hands of the publisher. And in this case the quality of printing is a little disappointing. The text is an insipid grey instead of crisp black and, on the maps, the constellation boundaries, which were faint in the previous edition, have seriously broken up in many places. One excellent feature is that the double-page maps are printed on single sheets inserted in the binding with reinforcement, so they lie flat easily. I am not so sure about the long-term durability of the paperback binding and cover. The cover of the review copy took a battering in the mail.

Only time will tell how long the paperback binding survives the rigours of the observatory. Someone intending to use *Norton's* frequently should consider whether the hard cover will give better service in the long run.

When I reviewed the 18th edition in 1990 (*J. Brit. Astron. Assoc.*, **100**(1), p.37), I commented on the way the paper had become whiter and thinner with successive editions and jokingly predicted that the



## A practical guide to CCD astronomy

by Patrick Martinez & Alain Klotz

**Cambridge University Press, 1997. ISBN 0-521-59063-9 (hbk), 0-521-59950-4 (pbk.) Pp xix + 243, £35.00/£16.95.**

This is an invaluable guide in a field with few comparable publications. Inevitably with a fast moving topic like CCDs, information can rapidly date and it does not help that this book is translated from the French. A clue is provided in the Bibliography – most of the references date from the mid-1980s to early 1990s – the latest to one author's publications in 1994. There is a natural bias towards French cameras (so don't expect reference to SBIG or Starlight Xpress) but this does not detract from the principles.

The book is profusely illustrated with monochrome diagrams and images: the latter are consistently and unacceptably poor in reproduction and provide little encouragement to the newcomer to this field. Nevertheless the comprehensive text is commendable.

Subjects covered include the various types of CCD detector, their performance and effects of cooling and importance of flatfields and darkframes. An invaluable section on matching camera to telescope highlights the problems of coupling a lens (refractor or regular camera lens) to a CCD with its extended infrared (IR) sensitivity. A

chapter on image display and enhancement via various software filters is comprehensive. Advice is given on producing screen hardcopy to paper or slide and 3D, contoured and blink screen displays and their use.

A section on amateur applications extends the options beyond those covered in other publications. Subjects mentioned (not necessarily in great depth) include IR astronomy in the 700nm–1000nm range, and hi-res double star, lunar and planetary imaging (including various map projections). Faint objects both within the solar system (comets, asteroids etc.) and beyond in nebulae, clusters and galaxies are included. Spectroscopy and photometry of both stellar and extended sources is covered in some detail including rapid-time resolution of occultations and time delay integration (TDI) scan mode which allows the sky to drift across a static camera.

There are a few typos or factual errors – a book for all CCD enthusiasts at any level of experience.

**Maurice Gavin**

*Maurice Gavin currently serves as a Vice President of the Association. He is a convert to the digital age and uses CCDs exclusively in his still, video and astro cameras, primarily for immediacy of results.*

edition of 2001 would be printed on luminous tissue paper. So I was particularly curious to see whether the trend continues – and indeed it does! The paper is such a brilliant white I tested whether it glows in the dark, but unfortunately it is not quite bright enough to read without a torch. And as to thickness – the 192 pages of the 18th edition are together about 10mm thick, those of the new edition only 8mm thick, though the show-through of printing on the reverse sides of pages is no worse.

To sum up, *Norton's* is not a book I would like to be without. The maps have retained their popularity because they are easy to use, and the handbook section is a valuable resource of carefully compiled basic information. Ian Ridpath is to be congratulated on keeping this treasure in working order. If you don't have it already, it can be heartily recommended. But I am not sure I would trade in my hard-cover 18th edition in favour of a new paperback.

**Jacqueline Mitton**

*Dr Jacqueline Mitton is a writer, and the Public Relations Officer of the Royal Astronomical Society.*

## The RGO Guide to the 1999 Total Eclipse of the Sun

by Steve Bell

Royal Greenwich Observatory, 1997. ISBN 0-905-087-03-8. Pp 28 + 4 colour plates, £5.99 (pbk.)

## The Sun in Eclipse

by Michael Maunder and Patrick Moore

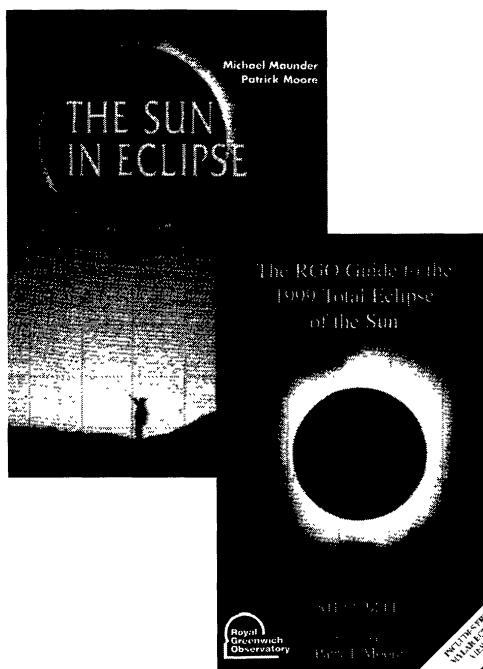
Springer-Verlag, 1998. ISBN 3-540-76146-2. Pp viii + 211, £19.00 (pbk.)

With the approach of 1999, publishers could be expected to be busy producing popular books on solar eclipses for the European and British markets, but so far there have been remarkably few. These two volumes fill some of the gaps.

*The RGO Guide to the 1999 Total Eclipse of the Sun* is a thorough and relatively technical sourcebook for all the information that readers of this *Journal* might require, and should be on every BAA member's bookshelf. Tables of the local circumstances of the partial and total eclipse are given for 165 towns and cities in Britain, and 80 European cities. Good track maps (particularly of Cornwall and the West Country) translate the numbers into reality on the ground, right down to village level. A map of the whole of Britain, similar to that given by Peter Macdonald in the 1995 December BAA *Journal*, shows the appearance of the maximum partial phase at different locations. There is also a sky diagram of totality, from which we can see that while Venus and Mercury will be prominent near the Sun, Saturn and Jupiter will be close to the Western horizon and Mars will not be visible.

The pamphlet is written for the general public, and consequently also includes an excellent but necessarily brief summary of the origin of eclipses, how they are predicted, the nature of the Sun and how observations of eclipses in the past helped to discover it, and what may be seen during an eclipse. The section on 'Observing the eclipse', with the required warnings prominent, is especially good. The meaning of the tables and maps is carefully explained for the layperson, and four carefully-chosen

*The RGO Guide to the 1999 Total Eclipse of the Sun* is available from Tor Mark Press, United Downs Industrial Estate, St Day, Redruth, Cornwall TR16 5HY, £6.99 post free, and from all good bookshops. See also the Web page at <http://www.ast.cam.ac.uk/eclipse99>.



colour plates, together with the eye-catching cover, give some idea of what to expect. Finally a Mylar viewer (of the brightly coloured 'eclipse glasses' type) is provided, and notes on its correct use are given.

All in all, this is a thoroughly excellent booklet which packs an astonishing amount of information into 28 brief pages. It will be of value to everyone next year, even those outside the track of totality, so make sure your local bookshops have plenty of copies in the run-up to next August.

*The Sun in Eclipse* by Patrick Moore and Mike Maunder also provides an introduction to eclipses, although the book is aimed more at the experienced observer and photographer than the lay reader. The book is general in scope and does not provide much specific information on the 1999 event – for example the brief tables give circumstances for only 54 places altogether in the whole of Britain and Europe, and the only 1999 diagram provided, a track map of totality in Cornwall, is barely adequate. Chapters include a general introduction to the solar

system, the Sun as a star, observing the Sun, the origin of eclipses, historical eclipses, eclipse chasing, and eclipses in the future. There is detailed and technical coverage of the various types of filters available and of eclipse photography. The book is liberally illustrated with Michael and Patrick's pictures although as so often seen these days, the quality of reproduction is poor.

These volumes have their different places on the shelf as we approach 1999, but a good full-length British book for the general public, not too daunting technically and trying to convey the subtlety and beauty as well as the science of the event to come, still remains to be published.

Hazel McGee

*The editor of the Journal saw her first total eclipse in Indonesia in 1983 and admits to being addicted to the drama and excitement of the spectacle.*

## Planets Beyond the Solar System, and the next generation of space missions

by David R. Soderblom (Ed.)

ASP Conference Series (no.119), 1997. ISBN 1-886733-39-2. Pp xx + 293, \$50.00 (hbk.)

In this book there are 15 transcripts of invited talks and 18 papers, reporting research. Style varies from the accessible to the almost impenetrable. The best feature is the conciseness of the papers – always less than ten pages – but the worst is the overabundance of acronyms and other abbreviations, some of which seem to spring unheralded upon the reader. David R. Soderblom, the Editor, has done a fine job in harmonising the contributions and putting them in an order which makes sense as you work your way through.

The breadth is fascinating and a bit breathtaking. Contributors report data gathered by satellite observations, by ground-based telescopes, using astrometric and spectroscopic techniques and with varied statistical methods of analysis. The upshot of it all is that they are finding candidate planets all over the place. I was impressed by the diligence, ingenuity and skill of the investigations.

The second part of the book covers possible space missions to detect extra-solar planets. I was staggered! It was almost a relief to see the illustration of the proposed Darwin mission, which looks like a small squadron of flying saucers. There are no proposals here for actual expeditions to other stars, but the section includes details of a large, binocular (terrestrial) telescope as an essential precursor to such a venture.

The illustrations are all in monochrome, but one certainly caught my attention. ►



## Planetary nebulae

by H. J. Habing & H. J. G. Lamers

**Kluwer Academic Publishers, 1998.**  
ISBN 0-7923-4892-3. Pp xxxviii + 507,  
£109.00 (hbk).

Planetary nebulae have been important to our understanding of the Universe for over two hundred years. William Herschel's astute observation of NGC 1514 in 1790 suggesting a stellar core surrounded by a thin gaseous envelope set the ball rolling, culminating in William Huggins' spectroscopic analysis of NGC 6543 in 1864 proving the nature of the class. The last few decades have seen these apprentice stellar corpses being dissected with increasing precision at all wavelengths, and in the last few years advances are more rapid than ever. We can all marvel at the quality and detail of Hubble Space Telescope images of planetary nebulae and the professional astronomers are having a field day with the wealth of data now available. Many other advanced observatories, both terrestrial and space, also accumulate valuable data.

This volume represents a summary of the proceedings of the 180th Symposium of the International Astronomical Union held in Groningen, Netherlands during 1996 August 26–30. As S. R. Heap stated in his paper, 'It's a good thing that we're starting to meet every four years rather than every five. There has been tremendous progress in understanding... planetary nebulae since the

► This showed the famous Eagle Nebula 'elephant trunks' in infrared, where they were just pale ghosts. The many line drawings and graphs are of high standard, clearly labelled and uncluttered, and the same applies to the many tables.

The contributors all gave papers to a Workshop held at the Space Telescope Science Institute in October 1996. There is quite a sense of getting a glimpse of a closed and separate world. The atmosphere is slightly hothouse; most papers refer to at least one other, but the tone is generous. The general reader might find the book tough going, but there is an immense amount of information and a lot of inspiring ideas. The familiar astronomical sense of 'trying to find out' is there in ladlefuls. The effort is worth it.

My favourite among many striking passages explains that the surface area of dust grains made from a ground-up Earth is  $10^{13}$  times that of the Earth itself, so 'it is much easier to detect a planet... before it is a planet'.

**Roger O'Brien**

*Roger is still teaching astronomy to anyone who will listen, and intends to carry on while they do.*

last meeting in Innsbruck in 1992 (IAU Symposium 155).<sup>7</sup> Certainly several observatories were not even in existence in 1989 when IAU symposium 103 was held.

Each chapter contains substantial papers followed by brief posters. The initial chapters are of a general nature; the first concentrating on basic data and classification matters. The second deals with the thorny problem of the distances to planetary nebulae. The subsequent chapters present more detailed research on central stars, outer envelopes and evolutionary considerations, ('Asymptotic Giant Branch stars to planetary nebulae' and then 'Planetary nebulae to white dwarfs'). The final chapters cover 'Planetary nebulae in a Galactic context', 'Planetary nebulae in Extragalactic Systems' and 'The future of planetary nebulae research'.

The book is aimed at the professional astronomer, and all working in the field of planetary nebulae as well as stellar evolution and the ISM will want to have access to it, either directly or through an academic library. The non-professional will need a

detailed knowledge of both astrophysical principles and the current jargon to get much out of it, although the papers dealing with broader concepts will have some interest to the informed amateur enthusiast. An undergraduate degree in physics, or enrolment in, for example, one of the splendid Open University courses should enable the arguments to be followed. It is not for the average British amateur deep sky observer, however. Production is generally adequate, though illustrations are purely functional. There are minor irritations in places, such as immediate repetition of NGC numbers in early chapters, but overall the layout, print quality and references are as you would expect in an academic publication.

*Planetary Nebulae* will remain a valuable reference for all involved in research in the field, at least for the next four years!

**Nick Hewitt**

*Nick Hewitt is Director of the Deep Sky Section and despite a wide range of observing interests retains a particular fascination for studying planetary nebulae both visually and using a CCD.*

  
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## Solar Fraunhofer lines with a diffraction grating

From Mr B. G. W. Manning

There is an apparently anomalous effect with diffraction gratings whereby one can view the solar Fraunhofer lines at quite high definition by simply holding the grating at a near-grazing incidence to the Sun's rays. This point was raised by Maurice Gavin in his Presidential Address,<sup>1</sup> but with reference to using a CD-ROM as a grating, which he suggested might have a focusing effect due to the curved tracks. Since then, he has noticed that the effect is much better with a parallel ruled grating and contacted me for an explanation. It so happens that I first observed this effect about 40 years ago when engrossed in actually ruling optical diffraction gratings and arrived at an explanation as outlined below, which I think is correct, but have never seen confirmed in print.

As everyone knows the Fraunhofer lines seen in a spectroscope are images of the slit and without a slit a continuous spectrum is formed; in effect due to the overlapping of a multitude of slits. This can be looked at in another way. A plane wavefront from a narrow slit incident at  $0^\circ$  to a diffraction grating, will of course encounter all the lines or grooves simultaneously (diagram A) and the diffracted wavefronts in different orders can be constructed as shown. If the slit is widened, wavefronts from different parts of the slit will be inclined (diagram B). There will be a path difference to each successive line where there was none before, and the new wavefronts for the different orders will be in new directions. The result is a fuzzy image as with a lens or mirror with wavefront errors. In the case of light from the Sun with a range of incidence angles up to  $\frac{1}{2}^\circ$ , there is total confusion.

In diagram C, which is the case we are interested in, with the Sun on the left, the light from one limb of the Sun is at grazing incidence i.e.  $90^\circ$ . The beam from the other limb would be at  $89^\circ.5$ , but is much exaggerated in the diagram. Even so it can be seen that the path of the two beams is of very similar length, hence wavefronts even from the two limbs will only have small phase differences for quite large lengths of grating, and the diffracted wavelets from both limbs can form a common wavefront and produce a clear image when focused by the lens of the eye.

There is actually a steady

progression from normal to grazing incidence, the path difference being  $[\sin(I_1) - \sin(I_2)]L$  where  $I_1$  and  $I_2$  are the greater and lesser angles of incidence respectively, and  $L$  is the operative length of the grating. Working directly in Ångstrom units ( $10^{-10}$  metre), the line spacing of a 600 line per mm grating is  $16667\text{Å}$ .

For  $I_1=0^\circ.5$ ,  $I_2=0^\circ$ , we have  $0.0087265 \times 16667 = 145.445\text{Å}$  per line. With eye pupil  $3\text{mm} = 1800$  lines this is  $261801\text{Å}$ ; in the green at  $5500\text{Å}$  this equals 47.6 wavelengths path difference. For  $I_1=85^\circ.5$ ,  $I_2=85^\circ$ , the path difference is 3.94 wavelengths, and even though a little blurred the Sodium D lines are still clearly visible in the third order.

For  $I_1=90^\circ$ ,  $I_2=89^\circ.5$ , the path difference is 0.207 wavelengths. This is better than Rayleigh's limit and good resolution is still obtained using a small telescope or binocular of 10 to 15mm aperture to view the spectrum even though the path difference is then over two wavelengths. In the third order two lines between D1 and D2 are visible and the Mg triplet is very clear.

Using the standard grating equation  $\pm n\lambda = (\sin\alpha + \sin\beta)$ , with  $\alpha=85^\circ$  the third order wavelength visible at  $\beta=0^\circ$  would be  $5534.5\text{Å}$ . With  $\alpha=85^\circ.5$  the wavelength is  $5538.54\text{Å}$ . From  $[(\sin 85 - \sin 85.5) \times 16667]/206265$ , the angle between the two is  $2.48'$ , not too much different from the resolution of the eye. Alternatively as pointed out by Mr Eades, it is the same as viewing two lines  $0.18\text{mm}$  ( $0.007$  inches) apart at  $250\text{mm}$  ( $10$  inches) distance.

These figures really represent the situation for two separate sources separated by an angle of  $\frac{1}{2}^\circ$ . In fact, the position is better than this as a more complete calculation is required to account for the effect of the differing intensities and path differences from the whole of the disk.

The method is of limited practical use because the photometric efficiency is very low. It is handy however for demonstrating a solar spectrum without having to carry a spectroscope. A cheap replica transmission grating could be used. As a matter of interest the same effect can be seen with a prism, although not nearly so well, but is not advised. I have tried it with a dense flint  $60^\circ$  prism and could detect the merged D lines and a couple in the green and blue, also I think one of the calcium lines, this probably because the spectrum was so bright. In fact a word of WARNING for anyone who tries it: due to the small dispersion of a prism the light could be nearly as bright as looking directly at the Sun, and even at grazing incidence and a low sun, I had an unpleasant after image for quite a time.

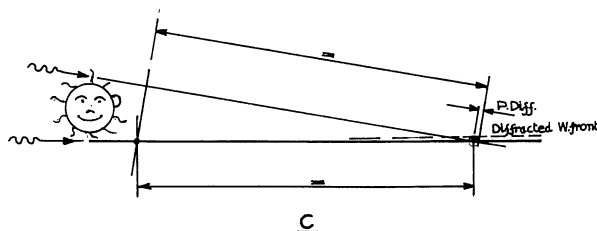
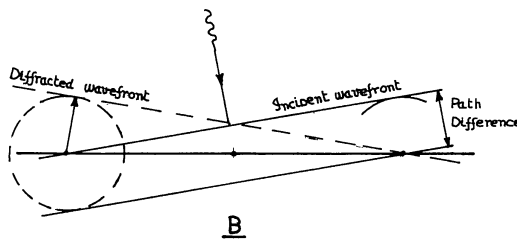
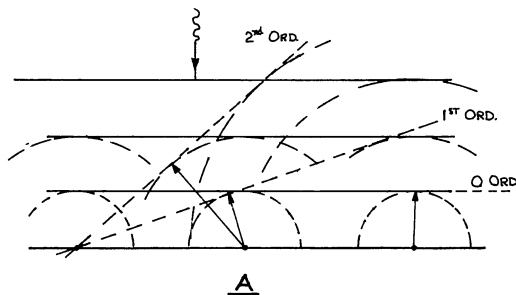
Finally, Maurice Gavin has drawn my attention to a reference in *The Observer's Guide to Astronomy* vol. 2, chapter 18, 'Spectroscopy' by Oliver Saint-Pé. A formula for resolution is given with suggestions for photographic recording. I have not yet had time to follow this up.

**Brian Manning**

*Moonrakers, Stakenbridge, Church-ill, Kidderminster, Worcs. DY10 3LS*

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## Aircraft condensation trails

From Mr Michael Hendrie

I agree with John Vetterlein (Letters to the Editor, JBAA 1998 June) that aircraft condensation trails have been a problem for astronomers in many parts of the world for many years. While more noticeable during the day they are often present at night too.

Near Colchester we are in the Clacton-on-Sea air traffic control sector which, I understand, is the busiest in the British Isles, covering as it does London Heathrow, Gatwick, Luton and Stansted flights to and from the Continent and further east, as well as other routes overflying the area. At night there are usually at least half a dozen bright aircraft lights visible at any one time, many the equal of Jupiter or even Venus. Ever increasing numbers of civil aircraft now cause serious interference with daytime observations, for example of the Sun.

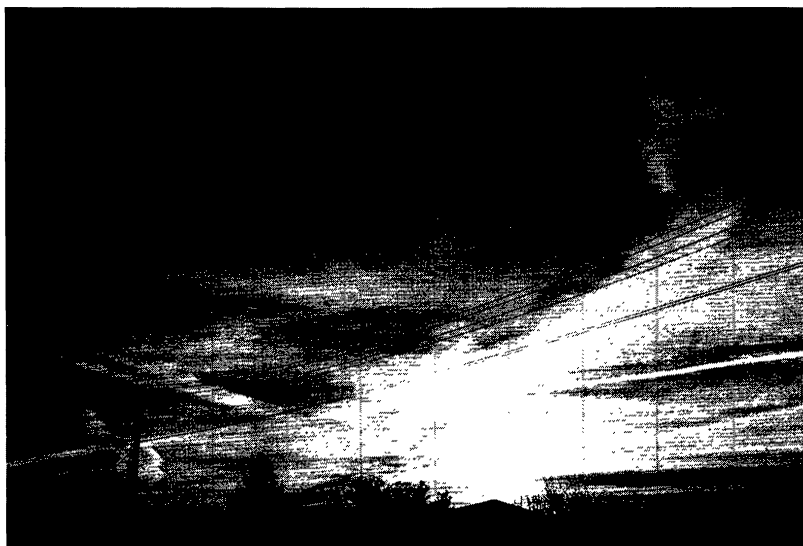
Flights into Stansted, the nearest airport, are no problem by day even though they fly directly over the observatory as the aircraft are below the level at which contrails normally form, but high enough to make the sound unobtrusive. Most other routes pass to the south of us where they can be joined by aircraft coming up from the south. These are at a height where, given the right conditions, condensation trails form readily and may persist for hours, gradually spreading and merging to form an amorphous mass of high cloud. A beautiful bright blue morning sky can be turned into a game of noughts and crosses in under an hour. The picture (which Turner might have called 'A winter sunrise with contrails') is one of many I have taken in the past few years and is by no means an extreme example, though in fairness there is probably some thin natural cloud present also.

Light pollution has largely destroyed our visual and photographic view of the night sky and aircraft condensation trails are now destroying the daytime sky. One might have thought that light pollution would have been the greater problem, but electronic detection and processing methods have helped to mitigate the worst effects. I wonder what are the chances of a development to nullify the obscuring and sometimes turbulent effects of aircraft condensation trails on astronomical observation? These may yet turn out to be the more serious problem.

It seems strange to me that while we are being urged to leave the car at home and turn down the central heating in order to save the world, the growth in cheap air travel and all that comes with it is accepted as inevitable and above serious challenge or discussion.

**M. J. Hendrie**

'Overbury', 33 Lexden Road, West Bergholt, Colchester, Essex CO6 3BX



Aircraft condensation trails mar the daytime sky near Colchester, Essex. (M. J. Hendrie)

## The Sky at Night

From Mr Pieter Morpurgo

As producer of the BBC TV *The Sky at Night* programme, I am due to retire at the end of this month. The programme itself with – of course – Patrick Moore is due to run for maybe even another forty-one years.

May I through the pages of your journal thank all of those in the astronomical community with whom I have worked over the past most pleasurable eighteen years on *The Sky at Night*. There are far too many people to write to individually, as we have had help, advice and suggestions from observatories both amateur and professional, universities, and scientific establishments throughout not just Britain but across the world.

We have been welcomed everywhere with the greatest friendship and warmth, and encouragement to continue our efforts to bring the fascinating world of astronomy to the public. But we could not continue to achieve that without the help of the astronomical community. I am sure that you will help my successor, Ian Russell, in the same way.

Thank you all so much. Working with you all has been a very great pleasure. In fact, as many of you will have heard me say, 'It's been better than working for a living'.

**Pieter Morpurgo**

Producer, *The Sky at Night*, 1981–1998

BBC, White City, 201 Wood Lane, London W12 7TS

## Amateur spectroscopy

From Mr Gerald North

In his excellent paper on spectroscopy for the amateur, Maurice Gavin gives the first edition of my book *Advanced Amateur Astronomy* as a reference. Readers will be frustrated if they attempt to seek this edition as it is now out of print.

However, there is a new edition, published by Cambridge University Press in 1997. It has been reviewed in a recent *Journal*.<sup>1</sup> In this new edition I have expanded the chapter on spectroscopy (Chapter 15 in the new edition) to include details of the spectrograph that I built onto my own telescope. It was easy and cheap to make and I show how readers can design and build such a unit for themselves based on the underlying principles discussed in the chapter.

I very much wish to echo the call Maurice Gavin makes for more amateur involvement in spectroscopy – great things may ensue as a result.

**Gerald North**

9, Camperdown Street, Sidley, Bexhill-on-sea, East Sussex, TN39 5BE

<sup>1</sup> Gavin M., *J. Brit. Astron. Assoc.*, **108**(3), 137 (1998)

<sup>2</sup> Mobberley M., *J. Brit. Astron. Assoc.*, **107**(6), 305 (1997)

## Solar eclipses at a given place

From M. Jean Meeus

Inspired by the letter of Mr Peter Macdonald in the 1998 June *Journal* (108(3), p. 136), I calculated for some places the number of solar eclipses visible between 1901 and 2200.

My results are as follows:

London	126	107
Moscow	116	98
New York	100	89
Tokyo	106	93
Johannesburg	121	95
Sydney	121	101
Montevideo	111	95
North Pole	128	128
South Pole	120	120

For each place, the first number is that of all solar eclipses of which at least a part takes place above the horizon. The second number is that of the eclipses for which the maximum occurs above the horizon. Of course, almost all the eclipses are partial at the given place.

In some cases, the eclipse is practically unobservable. This was the case for the eclipse of 1944 January 25, where at London first contact occurred only seven minutes before sunset. Nevertheless, for completeness such odd cases are included in the totals.

In other cases, while the eclipse is wholly visible, its magnitude is very small. This was the case at the eclipse of 1983 December 4, when at London only 3 percent of the diameter of the solar disk was covered by the Moon.

For the North and South Poles, the two numbers are equal, which is not surprising. At these places, the Sun remains the whole day either below or above the horizon, except on two dates during the year.

The rather larger number of eclipses visible at London is remarkable. Compare London and New York! Even if we consider the much longer period from A.D. 1001 to 3000, we find that London is still slightly favoured: 826 eclipses at London, 762 at New York.

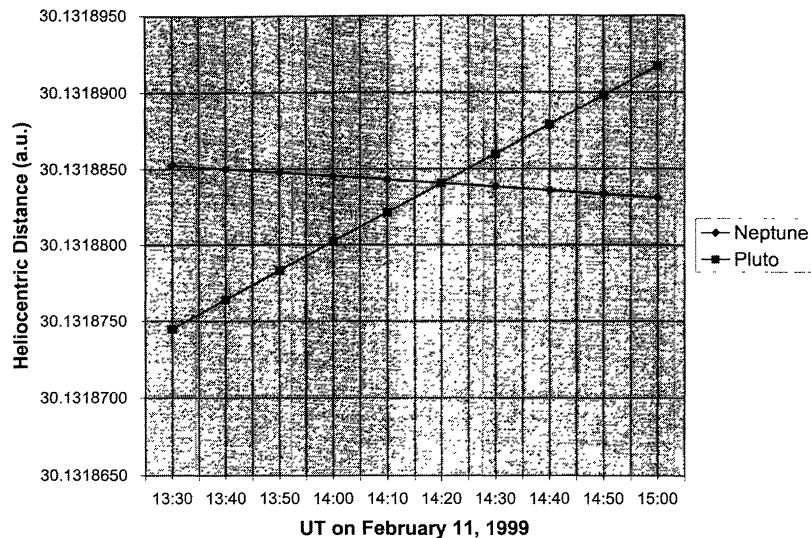
From the above, it results that at a given place the number of visible solar eclipses is about 38 per century, of which 32 have their maximum phase above the horizon. Their distribution over time is irregular, however. For instance, while *two* solar eclipses were visible at London in 1982, there was a ten-year gap without any eclipse from 1984 to 1994.

Jean Meeus

Heuvestraat 31, B-3071 Erps-Kwerps, Belgium

## Pluto – the ninth planet

### Neptune/Pluto Heliocentric distance



From Mr Martin Ratcliffe

In the course of some research I was doing for an article about Pluto, I needed the date for the moment Pluto returns to being the ninth planet in order of distance from the Sun. Since 1979, Pluto has been closer to the Sun than Neptune, a situation caused by its highly eccentric orbit. Pluto is due to return to its position as the ninth planet sometime during 1999.

The JPL *Space Calendar*<sup>1</sup> on the Web page of the Jet Propulsion Laboratory (JPL) indicated the event would take place on 1999 February 10. However, a further reference I often use is Guy Ottewell's *Astronomical Calendar*.<sup>2</sup> In his 1998 edition, he indicates that the event occurs on 1999 January 14. To make matters even murkier, Michael Seed's college text, *Horizons: Exploring the Universe*<sup>3</sup> gives yet another date, 1999 March 14.

This spurred me to do my own research, so armed with access to JPL's *Ephemeris Generator*, I compiled a daily ephemeris for Neptune and Pluto. This ephemeris generates the heliocentric distance for each planet. What I discovered was that all three dates were in fact wrong. The date that Pluto becomes farther from the Sun than Neptune is 1999 February 11.

Not satisfied with that result, I went one step further and generated an ephemeris for every 10 minutes around that date, and plotted the results. The graph shows clearly that Pluto becomes the ninth planet again at 14:20 Universal Time ( $\pm 5$  minutes) on 1999 February 11.

I hope this information will be useful and avoid future confusion.

Martin Ratcliffe

Director of Theaters and Media Services, The Exploration Place, 711 W Douglas Ave, Suite 101, Wichita, KS 67213, USA [martinr@southwind.net]

- 1 <http://newproducts.jpl.nasa.gov/calendar>
- 2 Ottewell G., *Astronomical Calendar 1998*, Universal Workshop
- 3 Seeds, Michael A., *Horizons: Exploring the Universe*, Wadsworth Publishing Co., 1998

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New members continued from page 286

**Isaaks** Denzil Joseph, 37 Acacia Road, Hampton, Middx. TW12 3DP

**Marshall** Peter, 37 Weardale Avenue, South Bents, Sunderland SR6 8AS

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Send typed or clearly printed advertisements (with remittance if necessary) to the BAA office at Burlington House, Piccadilly, London W1V 9AG, England.

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Readers are advised that the British Astronomical Association cannot be held responsible for the accuracy of any descriptive statements or for the quality of goods advertised.

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### Wanted

**BAA Journals, Vol. 1-35**, early BAA *Memoirs*, RAS *Memoirs* Vol. 1-10, Goodacre's *The Moon*, RAS *Scientific papers of William Herschel* (1912). Also wanted, old brass refractors and accessories by Cooke, Tulley, Dollond and Wray. Please contact Andy Stephens, 01242 675719 (Cheltenham).

**Sky & Telescope** magazine before June 1960, will pay £3 per copy; 1966, 1968, 1969, 1971 (£2 per copy); after 1990 (£1 per copy); all plus postage. Tel. Leverington, 01799 550822 (Essex).

**Setting circles** for Fullerscope Mark IV equatorial mount. Please contact Stewart Moore, 01252 624088 (Hampshire).

## Part-time Accountant required based in the BAA Office

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Applicants should be familiar with the management of VAT returns, dealing with covenants and the Inland Revenue and basic book-keeping activities. The post also involves managing staff salaries and pensions, preparation of monthly

accounts for the Council and the annual Accounts/Balance Sheet presentation to the Auditors. The nature of the work can best be appreciated by studying the Association's Accounts, published in the current *Journal*. Salary and hours of work are negotiable.

Applicants should write in the first instance giving details of their expertise, age, salary expectations and availability for the post to the following address:

**Treasury position  
British Astronomical Association  
Burlington House  
Piccadilly  
London, W1V 9AG**

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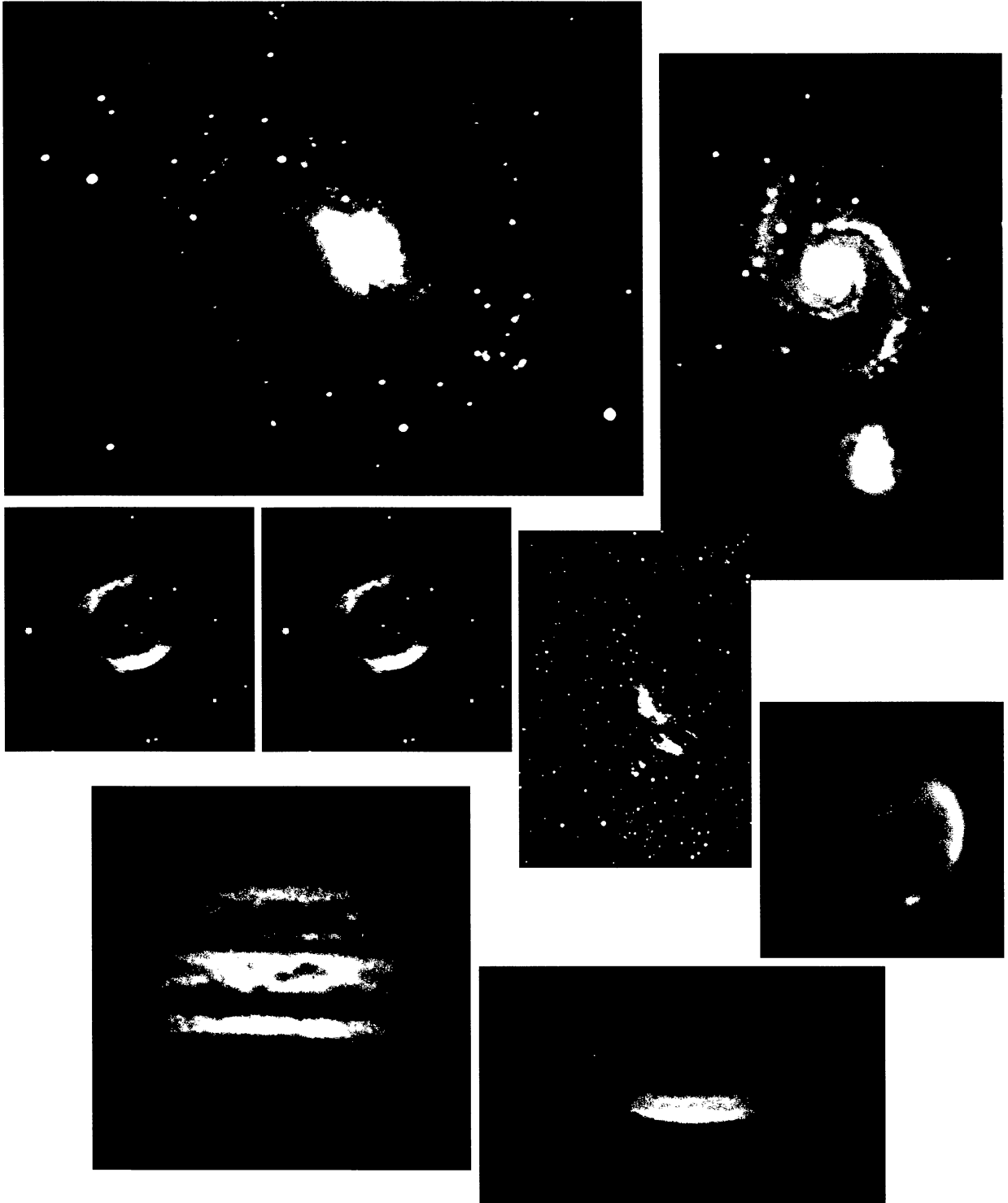
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# Journal of the British Astronomical Association

1998 December  
Vol. 108 No. 6



**Amateur images with CCD cameras**

# Officers and Council

## Session 1998–99

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*Secretary (Papers):* Nick James, 11 Tavistock Road, Chelmsford, Essex CM1 6JL. Tel. (01245) 354366. Fax: (01245) 602081. E-mail: ndj@astro1.demon.co.uk

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*Treasurer:* Michael Chapman, 18 Frenchs Forest Road, Seaforth, NSW 2092, Australia.

### Cover

CCD imaging by UK amateurs. Top row: Spiral galaxy M83; the 'Whirlpool' galaxy M51 (*Nik Szymanek & Ian King*). Centre: The 'Ring' nebula M57 (*Robert Dalby*); Globular cluster M13 (*Adrian Catterall*); the 'Swan' nebula M17 (*Dalby & Catterall*). Planetary images: Jupiter, 1998 Sept. 20, 00.45 UT; Saturn, 1998 August 19, 03.02 UT; Mars, 1997 March 10, 23.50 UT (*Terry Platt*).

# Journal of the British Astronomical Association

Editor and Advertising Manager

Mrs Hazel McGee

Papers Secretary: Nick James

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The Association is not responsible for individual opinions expressed in articles, letters, reviews or reports of any kind. Material published in the *Journal* does not necessarily express the views of the Council.

## Contributions

**Papers (three copies)** should be sent to the Papers Secretary at the address shown inside the front cover of this issue. They will be refereed, and, if approved by Council, published as soon as reasonably possible. Those wishing to speak at a meeting should contact the Meetings Secretary.

**All other contributions** should be sent to the Editor. As well as *Letters to the Editor*, she will be pleased to receive contributions to *Observers' Forum*, particularly interesting astronomical photographs providing they are not submitted or published elsewhere. Colour as well as black and white photographs are welcomed. Photographs will be returned only if a suitable stamped addressed envelope is enclosed.

## Advertisements

**Small advertisements** should be sent to the Office, accompanied by the appropriate remittance. (See conditions printed on page 346 of this issue).

**Display advertisements and loose inserts:** For a rate card and further information, contact the Editor.

## Deadline

Material for typesetting must be received by the following dates:

Issue	Date
April 1999	February 1
June 1999	April 1

Later dates apply to camera-ready advertising copy for which space has been reserved. Short letters and notes may be accepted up to the 10th of the month of the previous issue.

## Membership of the BAA

The annual subscription, for ordinary membership of the Association for the 1998-99 Session is £32.50. For details of concessionary rates, and other membership information, see page 323 of this issue. Subscriptions are due on 1st August each year and may be paid under a Deed of Covenant by members who pay income tax in order to benefit the Association, which is a registered charity. The annual subscription to *BAA Circulars* is £4.

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# Notes and News

## From the President

At the October Council Meeting, Council voted to employ the services of Manuel Grove (of King & Grove, Chartered Accountants) to take over the tasks which our Assistant Treasurer, Lionel Mayling, has carried out for the last twelve years. It had become increasingly obvious that no suitable volunteers were going to step forward to fill the rôle, and a paid Assistant Treasurer was urgently required. The Treasurers and myself investigated a number of options over the summer months, but at £6000 p.a. the quote from King and Grove was by far the most attractive. (The nearest competitor quoted three times as much, emphasising the debt we owe to Lionel for his 12 years of unpaid service). Henry Hatfield and Lionel will be working with Manuel Grove over the next few months to ensure a smooth transition.

Now that we have delegated the more onerous tasks of the Treasury department to Manuel, I am hoping that a suitable volunteer will step forward to fill Henry's place at the Council table. The rôle of the new Treasurer will be to act as an interface between Manuel and the Council and to assist in making the major decisions regarding BAA expenditure, investments, salaries and subscription rates. It would be a pity if the Treasurer's post was again to remain vacant on the ballot paper, especially as the rôle then largely defaults to the President and Officers, whose workloads are already substantial.

Although Henry has now retired, his contribution to the BAA continues: he has agreed to donate all royalties from the revised *Hatfield Photographic Lunar Atlas* (recently published by Springer-Verlag) to the BAA. This is a most generous donation and one which will benefit all BAA members.

I am now past the half-way point in my two year ~~Presidential~~ term, i.e. the point at which, customarily, I should propose my

successor. I recently consulted with the past Presidents and Officers as to who should be my successor from October 1999, and the overwhelming favourite candidate was Dr Nick Hewitt, our Deep Sky Section Director.

Nick has attended virtually every Council meeting since his appointment as Deep Sky Section Director in 1992 and, unusually, is both a visual and a CCD observer. I believe he has all the qualities necessary to lead the BAA into the 21st Century and I will be proposing him as the 56th President on next summer's ballot form.

Moving on to observational matters, few web-browsers can have missed the recent incredible images of Jupiter and Saturn secured by Terry Platt, also featured on the cover of this '*Journal*'. Terry is no stranger to any BAA member; he is simply the best planetary imager in Europe and the man who brought affordable CCD imaging to UK amateurs. Terry is also extremely approachable and highly tolerant of questions from CCD novices. (So often, brilliant minds are guilty of 'not suffering fools', an attitude which must surely turn many away from astronomy... when an innocent question yields an aloof and sarcastic response, what chance 'observer encouragement'?)

In a recent discussion with our meetings secretary, Laurence Anslow, we decided that Terry Platt would make an ideal Christmas Lecturer and we are delighted that Terry has agreed to fill this rôle on December 19 at 23 Savile Row. With Jupiter and Saturn so well-placed in our winter skies, this will be an especially topical meeting.

May I take this opportunity of wishing you all a Happy Christmas and clear skies in 1999, especially on August 11 in Cornwall, and in the early hours of November 18 for the Leonids over Europe!

**Martin Mobberley**

## Comet Section

### Comet prospects for 1999

The comet predicted to be brightest in 1999 is P/Machholz 2, which may reach 7th magnitude. This comet split into several fragments at its discovery return in 1994 and both the ephemeris and expected magnitude are a little uncertain. A couple of long period comets discovered in previous years are still visible and there are several reasonable returns of short period comets.

Recent theories on the structure of comets

suggest that any comet could fragment at any time, so it is worth keeping an eye on some of the fainter periodic comets, which are often ignored. Last year 52P/Harrington-Abell was unexpectedly bright when it outburst several months before perihelion.

Ephemerides for new and currently observable comets are published in the *Circulars*, Comet Section Newsletters and on the



## Comets reaching perihelion in 1999

Comet	<i>T</i>	<i>q</i>	<i>P</i>	<i>N</i>	<i>H1</i>	<i>K1</i>
C/LINEAR (1998 M5)	Jan 24.5	1.74			5.5	10
52P/Harrington–Abell	Jan 27.9	1.76	7.53	6	13.5	15
60P/Tsuchinshan 2	Mar 08.2	1.77	6.79	5	10.5	15
D/Skiff–Kosai (1977 C1)	Mar 09.1	2.79	7.45	1	8.5	15
102P/Shoemaker 1	Mar 15.4	1.98	7.24	2	8.0	15
136P/Mueller 3	Mar 20.5	3.01	8.71	1	11.0	10
D/Schorr (1918 W1)	Apr 03.6	2.85	8.5	1	10.0	15
105P/Singer–Brewster	Apr 06.4	2.03	6.44	2	12.5	15
P/Bowell–Skiff	Apr 27.6	1.97	16.1	1	11.5	15
P/Shoemaker–Levy 6	May 02.4	1.13	7.55	1	10.5	10
37P/Forbes	May 04.2	1.45	6.13	8	10.5	10
4P/Faye	May 06.1	1.66	7.52	19	6.0	20
P/Ge–Wang	Jun 26.9	2.50	11.2	1	11.0	10
50P/Arend	Aug 03.8	1.92	8.24	6	9.5	15
84P/Giclas	Aug 25.1	1.85	6.96	4	8.7	15
10P/Tempel 2	Sep 08.4	1.48	5.47	19	5.0	25
59P/Kerns–Kwee	Sep 16.3	2.34	9.45	4	7.5	15
D/Denning (1894 F1)	Nov 20.3	1.08	7.2	1	10.5	15
C/Spacewatch (1997 BA6)	Nov 27.7	3.44			5.0	10
P/Machholz 2	Dec 07.5	0.75	5.21	1	12.5	30
135P/Shoemaker–Levy 8	Dec 10.6	2.72	7.49	1	6.5	20
106P/Schuster	Dec 16.2	1.55	7.29	2	10.0	15
63P/Wild 1	Dec 27.4	1.96	13.2	2	10.5	15

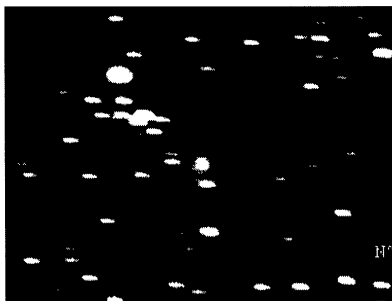
The date of perihelion (*T*), perihelion distance (*q*), period (*P*), the number of previously observed returns (*N*) and the magnitude parameters *H1* and *K1* are given for each comet.

Note:  $m_1 = H1 + 5.0 \log(\Delta) + K1 \log(r)$

Section and CBAT web pages, with predictions for returns in the *Handbook*<sup>1</sup> and on Seiichi Yoshida's web pages.<sup>2</sup> Complete ephemerides and magnitude parameters for all comets predicted to be brighter than about 18<sup>m</sup> are given in the International Comet Quarterly *Handbook*;<sup>3</sup> details of subscriptions to the ICQ are available from the Comet Section Director. The Section booklet on comet observing<sup>4</sup> is available from the BAA office or the Director.

**Comet Hale–Bopp (1995 O1)**, the great comet of 1997, is fading slowly and could still be 11<sup>m</sup> at the beginning of the year, fading to 13<sup>m</sup> by the year's end. It is only observable from Southern Hemisphere locations as it loops round the Large Magellanic Cloud.

**Comet LINEAR (1998 M5)** is at perihelion in January at around 10th magnitude and moves north from Lyra, passing very close



Comet LINEAR (1998 M5) imaged by Martin Moberley on 1998 September 21.86 UT. 7×1min CCD exposures with a 0.49m f/4.5 Newtonian.

to the pole in mid-March. Heading south it passes through Camelopardalus and Lynx, reaching Cancer mid-year when it will have faded to 13th magnitude. It will then be too faint and close to the Sun for further observation.

**21P/Giacobini–Zinner** will still be visible at the beginning of the year in Cetus and Eridanus as it fades from 10th magnitude. It fades quite rapidly and will be lost by the end of February. It is not well placed for observation from the UK, but will be visible from further south.

**29P/Schwassmann–Wachmann 1** is an annual comet which has frequent outbursts and seems to be more often active than not at the moment, though it rarely gets brighter than 12<sup>m</sup>. In the first half of 1998 it was in outburst on several occasions. The randomly spaced outbursts may be due to a thermal heat wave propagating into the nucleus and triggering sublimation of CO inside the comet. This year it is at opposition in May on the borders of Hydra and Libra. It is in solar conjunction in November, passing into Scorpius. This comet is an ideal target for those equipped with CCDs and it should be observed at every opportunity. Unfortunately opportunities for UK observers may be limited as its altitude does not exceed 15° from this country.

**10P/Tempel 2** makes its 20th observed return since its discovery by William Tempel (Milan, Italy) as a 9th magnitude object in 1873. Several unfavourable returns were missed in the earlier years. The orbit is very stable, which is one reason why it is a

favoured target for planned spacecraft missions. In 1983 the IRAS satellite detected an extensive dust trail behind the comet. Normally the light curve is highly asymmetric with a late turn-on. There is a rapid rise in brightness as perihelion approaches, which continues more slowly for a couple more weeks after perihelion, followed by a slow decline until activity switches off. With a 5.5 year period alternate returns are favourable and this is one of them. The comet may be picked up in large telescopes in April when it is in Ophiuchus and it should reach 10th magnitude in June. It is closest to the Earth in July (0.65 AU) when it could be 9th magnitude and UK observers should be able to follow it until August, but it then moves too far south. More southerly observers may be able to observe it until the end of the year as it fades.

**P/Machholz 2 (1994 P1)** was discovered by Donald Machholz with his 0.25-m reflector at 10<sup>m</sup> in 1994 August. It proved to have multiple components, first reported by Michael Jager (Vienna, Austria). The four secondary components could all be described by the same orbit, but with perihelion delayed by up to half a day from the primary. At times there seemed to be a faint trail of material linking the components. The comet has a short period of 5.2 years with a perihelion distance of 0.75 AU and aphelion just inside the orbit of Jupiter. The orbit has been slowly evolving, with progressive changes occurring about every 50 years, thanks to approaches to Jupiter. The most recent close approach was in 1982. With a relatively stable perihelion distance, which is slowly increasing, it is perhaps surprising that the comet was not discovered earlier. There was a favourable return in autumn 1978 when it might have reached 8th magnitude and very favourable returns in the autumns of 1920, 1937 and 1957 when it might have reached 6th magnitude. The fact that it was not discovered at any of these returns suggests either that the orbital evolution is slightly inaccurate, or that the absolute magnitude at the 1994 return was not typical. At present the earth passes about 0.25 AU outside the descending node and the orbital evolution will slowly decrease this distance, raising the possibility of a meteor shower from the comet in a few hundred years time.

This return is moderately favourable with the comet moving rapidly eastwards through Serpens (October), Scutum and Aquila (November), Aquarius and Capricornus (December) as it brightens from 14th to 7th magnitude. The date of perihelion is uncertain by up to a day and more accurate ephemerides will be available when the comet is recovered. UK observers should be able to observe it from November at 10th magnitude, though more southerly observers may find it a month earlier.

**52P/Harrington–Abell** reaches perihelion and opposition in late January. This is the seventh observed return of the comet since its discovery in 1954 and it has never become brighter than 17th magnitude at previous returns. Normally it would not be expected to get brighter than 15th magnitude at this return, however it was found in outburst at 12th magnitude in July 1998 and was 7 magnitudes brighter than expected. It will be well placed for UK observation, and if the outburst continues it could be visible in binoculars.

A number of fainter comets may be of interest to CCD observers. These include: Meunier–Dupouy (1997 J2) (fading from 13<sup>m</sup> in January), 37P/Forbes (13<sup>m</sup> between April and June), 88P/Howell (fading from 13<sup>m</sup> in January), 93P/Lovas 1 (fading from 13<sup>m</sup> in January), 95P/Chiron (16<sup>m</sup> at opposition in late May in Libra) and 114P/Wiseman–Skiff (brightening from 14<sup>m</sup> in November). Ephemerides for these can be found on the CBAT WWW pages. CCD V magnitudes of Chiron would be of particular interest as observations show that its absolute magnitude varies erratically.

Several other comets return to perihelion during 1999, however they are unlikely to become bright enough to observe or are poorly placed. 4P/Faye, 9P/Tempel 1, 50P/Arend, 59P/Kearns–Kwee, 63P/Wild 1, 84P/Giclas and 102P/Shoemaker 1 have unfavorable returns. Spacewatch (1997 BA6), 60P/Tsuchinshan 2, 105P/Singer–Brewster, 106P/Schuster, 135P/Shoemaker–Levy 8, 136P/Mueller 3, P/Bowell–Skiff, P/Shoemaker–Levy 6, P/Ge–Wang and D/Skiff–Kosai are intrinsically faint or distant comets. D/Schorr and D/Denning have not been seen for many years and are unlikely to be recovered.

Looking ahead, 2000 sees favourable returns of comets 2P/Encke, which may reach 9th magnitude, and 73P/Schwassmann–Wachmann 3. The expected magnitude of 73P is uncertain because it outburst at the last return, but it could reach 7th magnitude.

**Jonathan Shanklin, Director**

## References

- 1 Taylor G. E., *The Handbook of the British Astronomical Association for 1999* (1998)
- 2 <http://www.info.waseda.ac.jp/muraoka/members/seiichi/index.html>
- 3 Nakano S. & Green D. W. E., Eds., *International Comet Quarterly 1999 Comet Handbook*, (1998)
- 4 Shanklin J. D., *Observing Guide to Comets* (1996)

## Solar Section

### 1998 July

Cycle 23 seems at last to be under way, with an increase in activity this month. Again some of this activity was due to a number of short-lived spots appearing spasmodically in both hemispheres. The activity from June had by July 4 moved west of the CM with two of the four groups becoming flare active. These groups were at mean lat.  $-23^\circ$  long.  $48^\circ$ , Bri and lat.  $-21^\circ$  long.  $15^\circ$ , Cro.

From the 1st to the 11th two medium H type spots were on the disk. One dominated the northern hemisphere at mean lat.  $+17^\circ$  long.  $338^\circ$  the other in the south mean lat.  $-20^\circ$  long.  $348^\circ$ . The northern spot developed small satellite spots and had an elongated penumbra with two or more umbrae within it, classification Hko. The southern group remained symmetrical throughout its passage across the disk, Hhx. From July 13 to 21 an interesting Dai group was

recorded at mean lat.  $-20^\circ$  long.  $215^\circ$  until it crossed the CM on the 16th, the largest spot of the group was the follower. After that the group reversed itself to the usual form of the leader being the dominant spot, however it reduced in size becoming Bxo on July 18. Over the next two days it increased again becoming Cao. A large H type spot came around the SE limb on the 21st, by the 24th when well on the disk a number of following penumbra spots were seen making it into a probable Dho group mean lat.  $-21^\circ$  long.  $62^\circ$ . On the 21st a small single spot was seen at lat.  $+30^\circ$  long.  $62^\circ$ . This seems to have developed rapidly to a Cso group on the 23rd and then Dai on the 24th. The group was hard to define as after this it became a collection of closely packed penumbral and other spots. By July 26 they had combined together to give one irregular penumbra area containing several umbrae.

Prominence MDF for July 7.41. This month there were a number of filaments on the disk, Ken Medway on July 13 reporting twelve. From the 4th to the 11th filaments were seen escorting the two H type spots at  $+17^\circ$  and  $-22^\circ$  mentioned above. From the 6th to the 15th long filament activity was observed in the south, mainly in an E/W direction. The north had a number of shorter filaments laying more in a NE/SW direction. A number of active prominences were also reported. On July 21 at 22.00 UT Monty Leventhal noted a rapid prominence ejection at the SW limb, but there was no sign of it at 23.15. Harold Hill observed a brilliant and quite sudden eruption near the E point of the disk on July 18. This is displayed on the Section Web page.

### 1998 August

There has been a sustained increase in white-light activity this month. One of the largest and complex groups lay in the southern hemisphere. The leader appeared around the SE limb on August 2, by the 5th it had developed into an Eao group. It crossed the CM on the 8th after which it became more compact and flare active with the southern leader increasing in size. The group spanned some  $13^\circ$  of longitude, class Eki, with mean lat.  $-20^\circ$ – $-24^\circ$  long.  $273^\circ$ – $261^\circ$ . On August 10 an attendant group of small spots broke out behind the main group at mean lat.  $-21^\circ$  long.  $255^\circ$  Bso. (The close proximity of this group might have influenced observers to include it with the larger group making the whole complex Fki.) Another small B group appeared at mean lat.  $-27^\circ$  long.  $249^\circ$ , lasting two days.

From August 7 to 19 two compact naked-eye spots were in the northern hemisphere, the first at lat.  $+30^\circ$  long.  $211^\circ$ , Hhx. Within the large penumbra several dark umbra could be seen, and by the 10th the main

### BAA sunspot data, 1998 July–August

Day	July		August	
	g	R	g	R
1	8	110	6	71
2	8	100	8	92
3	8	107	6	72
4	8	124	5	68
5	7	123	5	73
6	6	73	6	101
7	4	52	7	103
8	4	60	5	84
9	2	25	6	90
10	4	50	7	128
11	4	56	8	141
12	6	76	6	108
13	3	43	6	96
14	3	39	5	77
15	4	52	5	72
16	6	97	7	95
17	5	75	6	83
18	4	50	8	103
19	3	48	9	113
20	5	60	8	107
21	6	74	7	97
22	7	98	6	87
23	6	90	5	69
24	7	106	5	80
25	4	65	5	63
26	4	73	7	96
27	4	68	6	95
28	7	95	5	83
29	5	78	7	114
30	5	64	7	113
31	7	81	5	84
MDFg	5.29		6.25	
Mean R		71.67		92.83

### North and south MDF of active areas g

	MDFNg	MDFsg
July	2.322	2.967
August	3.70	2.55



### Flares recorded by members during 1998 July and August

Day	UT	Lat.	Long.	Imp.	Obs
<i>July</i>					
1	0805	+26°	38°E	Sf	ES
4	1050	-20°	05°W	Sb x2	BH
4	1131-1145	-22°	37°W	Sb x2	BH
4	2220	-26°	45°E	1b x2	ML
5	1135-1201	+17°	23°E	2b	BH
5	1815-1830	-26°	60°W	Sn	KM
11	2230-2240	-22°	50°E	1b	ML
15	1050-1058	-30°	85°E	1b	ES
15	1110-1115	-20°	09°E	Sn	ES
16	0800	-19°	04°W	Sf	ES
16	1020	-30°	53°E	1n	ES
16	1020	-22°	18°E	Sf	ES
19	1320	-15°	20°W	Sf	KM
19	1325	-17°	39°W	Sn	KM
24	1115	+28°	50°E	Sf	ES
28	1055-1150	-21°	04°W	1b	BH
<i>August</i>					
2	0900	-20°	80°E	1n	ES
5	1322	-22°	45°E	Sn	BH
5	1805	-21°	41°E	Pulsating	KM
9	1700	+16°	54°E	1b	WB
9	1724-1751	+16°	53°E	2b	BH
9	1715-1725	-22°	18°W	1b rib.	KM
10	1040-1045	+45°	50°E	1n	MH
10	1105-1112	+14°	50°E	1n	BH
10	1116-1138	-23°	27°W	Sb knts	BH
10	1142-1152	-23°	25°W	1n	MH
19	1411-1444	+30°	NE	1b rib.	KM
19	1429-1449	+30°	82°E	2b	BH
22	1505-1512	+29°	48°E	1b	KM
22	1648-1745	+25°	40°E	2b rib.	KM
24	2220	+28°	CM	2b	ML
27	0922-0927	+20°	05°E	Sb	MH
30	0940-0955	+20°	30°W	2b rib.	KM
30	1645	-28°	60°E	1b	KM
30	1725-1738	-28°	60°E	1b	KM

The above list for August shows only the most significant flares recorded by members. A number of small importance S flares were also observed.

penumbral area had divided giving it a small close follower; by the 15th additional accompanying spots were seen. The second spot group at lat.+15° long. 197° had its leading penumbral spot changing from day to day, from a fairly symmetrical shaped spot to initially an elongated penumbral spot containing two almost equally large umbrae. By the 15th this area had split into two separate penumbra areas, each including one of the large umbrae seen on the 12th. This group produced a 2b flare on the 9th while still a conventional Dko type group.

Another high latitude group was seen in the north at mean lat +31° long. 35°. This group was preceded on August 18 with a fine eruptive prominence at the NE limb. On the 19th a large spot could be seen at the limb and again eruptive prominence activity was recorded. By the 22nd the group could be well seen and consisted of a large irregular

penumbral area within which were a number of umbrae, it also had two leading small spots and extended for 9° of solar longitude. After crossing the CM on the 25th it lost these leading spots but gained a number of followers mostly in close proximity to the large main spot.

Another complex group in the north started life as a single Axx spot on August 24. By Aug 27 when near the CM it had developed into a close grouping of small spots, and on Aug 28 some of the leading and following spots developed penumbrae. By Aug 30, the leading spot had increased in size making the group Ekc, mean lat.+19°/+21° long. 13°-4°. It was followed by another group Cso at lat.+23° long. 354° and yet another single Axx at lat.+23° long. 339°.

The month ended with another large group, this time in the south at mean lat.-21° long. 276°, Ekc, on Aug 28. This was the return of the southern group seen earlier which rounded the SW limb on Aug 15. As

can be seen from the counts a number of smaller groupings and single spots were also seen throughout the month.

Prominence MDF for August 8.12. Prominence types ranged from small quiescent through to active sunspot and flare stimulated surges. On a number of days 14 separate prominences were observed around the solar limb. Harold Hill states that on the afternoon of August 24 he counted 20. He attributes this high count to a sudden real increase of prominence activity down the W limb. At 0745 UT this increase was not evident. Many filaments were also recorded. On August 7 a long dark filament dominated the disk in the north, laying roughly in a N/S direction. Eric Strach notes: 'It may be sufficient to say high latitude filaments were prevalent in the south in the first half of the month whilst towards the end of the month many were recorded in the north around the 50° parallel.'

**Bruce Hardie, Director**

## Aurora Section

The aurora is becoming more actively visible in the UK. Tony Hopwood phoned on August 26 to report a magnetic storm sudden commencement (SSC) at 06.50 UT as recorded on his instruments. David Pettitt and the magnetometry group observed a magnetically active period between August 26 and 28, the storm conditions coinciding with widespread aurora on the night of 26/27 and to a much lesser extent on the following two nights. A total of 18 observations has been processed so far, including nine Scottish, four English and five overseas contributions. Auroral rays reached the zenith during the course of the night as noted by Dave Wheeler on Fair Isle and to 60° reported by Dr Gavine at Edinburgh. The storm was recorded as all-sky by Jay Brausch at Glen Ullin in North Dakota and rays were seen as far south as Lyon in Colorado by Dennis Ward. NOAA at Boulder, Colorado had reported increased solar activity for the week preceding the above geophysical outburst of activity. In the UK the most southerly observations of the aurora came from H. Brown Greaves and Ms A. Peters, participating in the Astrocamp at

Ashdown Forest in Essex where active rays up to an elevation of 30° were recorded at 01.00 UT, the same time as they reached their peak in Edinburgh.

In September there was a sharp magnetic storm on the 18th detected by David Pettitt's team, when Raymond Minty at Banff on the Moray Firth observed an active rayed arc to 30°. A second period of magnetic activity spanned from September 24 to 26 with storm conditions on the 25th. RAF Kinloss reported a rayed arc while Jay Brausch experienced another all-sky aurora. Auroral rays were also noted by Fort Collins meteorological station in Colorado.

There have been other nights when auroral activity has been picked up, particularly of a quiet nature in Scotland. With recent reports of more active aurorae coming in from Carlisle, Morpeth, the Isle of Man, the Irish Republic and other more southerly latitudes, observers are encouraged to look for more auroral activity as the Sun becomes progressively more active.

**R. J. Livesey, Director**

## NOTICE

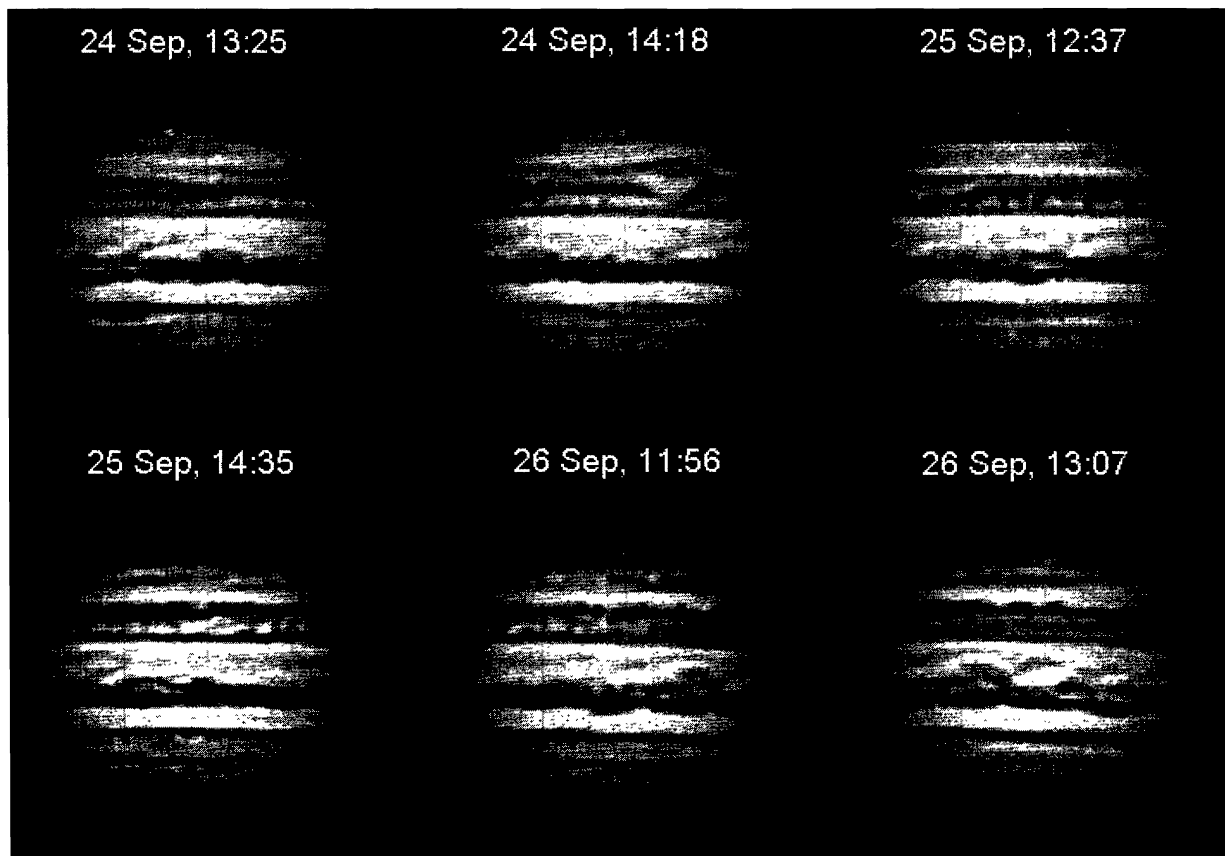
### Change to Meeting date, 1999 March 31

Members are advised that due to events at 23 Savile Row on the afternoon of 1999 March 31, the hall is unlikely to be available in time for the normal BAA evening meeting. The Council have therefore decided to change the date of the Ordinary and Special General Meetings to Saturday March 27 from 2.30-5.30 p.m.

Please make a note in your diaries. We apologise for any inconvenience caused.

## Jupiter Section

## Jupiter in 1998: an interim report



**1998 September 24–26.** A complete circuit of the planet imaged by Isao Miyazaki, coinciding with the *Galileo* E17 encounter. Features of note include: South Temperate region: Ovals BC and DE have merged. The resulting larger oval 'BE' is  $40^\circ$ . p. oval FA, with a small cyclonic white oval between them (image 5). Also note a small, extremely dark spot on STBs (image 3). South Tropical region: A dark grey South Tropical Band has emerged p. the GRS (images 1 & 2). A new Mid-SEB Outbreak of prograding white spots is in progress (the continuing source is close to a satellite shadow in image 5). North Tropical region: Within the NEB, a turbulent white 'rift' is disturbing the blue projections on the south edge (images 5 & 6). The NEB has withdrawn to its usual borders after the 1996 expansion event, leaving dark red-brown 'barges' strung along its north edge; these are now starting to disappear.

Jupiter has shown interesting activity in several latitudes in the first half of the 1998 apparition. Many fine CCD images have been received from observers in Japan, USA, Canada, Australia, Germany, Spain, and England, and an increasing number of good visual observations as well.

The most important event was the merger of the famous white ovals BC and DE in the South Temperate region. They had been familiar features for over 50 years, gradually shrinking, and in late 1997 they began to converge. They merged during solar conjunction, some time between 1998 January 17 and March 27. The merged oval 'BE' was slightly larger than its predecessors, and of low contrast, but distinct in good images. The *Galileo Orbiter* imaged it in detail at the E17 encounter in September. At first oval BE was moving unusually fast ( $-16$  degrees per month) but since June it had a more typi-

cal drift of  $-12$  deg/month. It is at  $\lambda_2 = 243$ , with oval FA  $40^\circ$  following it. (Longitudes are given in System II at opposition, 1998 September 16). Another interesting spot in the South Temperate region is a small, extremely dark spot on STBs, which is a cyclonic feature, at  $\lambda_2 = 164$ . It will be worth looking out for further changes in the South Temperate domain. It is possible that a new generation of ovals could appear, in the same way that the present generation did around 1940.

In the South Equatorial Belt, there is a major new 'mid-SEB outbreak' of turbulent white spots prograding rapidly from a slow-moving source in the belt, which is at  $\lambda_2 = 282$  ( $-14$  deg/month). It began during solar conjunction and new spots were still appearing in September, by which time the disturbance had spread most of the way around the planet.

The Great Red Spot is stationary at  $\lambda_2 =$

67. Its form is typical, as in the *Voyager* era. In August the internal reddish area became smaller, and the south rim became a dark grey arch prograding into a S. Tropical Band. The northern EZ and NEB are quite disturbed, with a maze of faint streaks and spots, and NEBs dark bluish projections that are unusually prominent and changeable in some sectors; there are also some bright white spots or plumes.

The NEB is narrower than last year; it has reverted to its usual width after the expansion event of 1996. Along its north edge, there have been many dark red-brown spots and streaks, which are the array of 'barges' that formed in early 1997 as part of the expansion event. Some of them are disappearing as is typical after 1–2 years.

**John H. Rogers**, *Director*  
1998 October 11

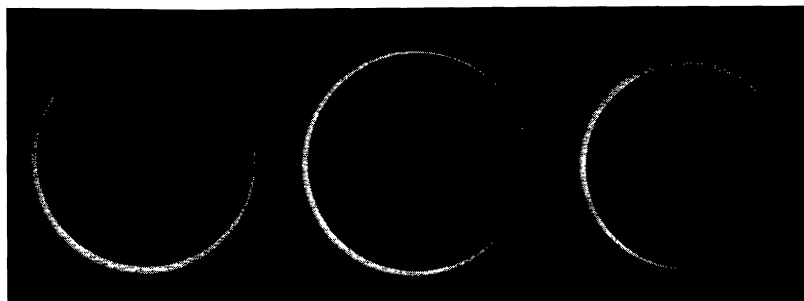
## The annular solar eclipse, 1998 August 22

A friend and I joined a small group of geologists and astronomers to observe the annular eclipse in Sumatra, Indonesia.

The eclipse started just before sunrise at about 6.10 a.m., and as we were only two degrees north of the equator the Sun rose almost vertically. During the eclipse the motion of the Moon carried it straight down across the solar disk and it soon became clear that the Moon was significantly smaller than the Sun in the sky. Half way through the partial phase the crescent Sun started to extend more than half way round the Moon. This was quite different from the total eclipse we saw in February where the crescent began to shrink as totality approached.

For several minutes before second contact Bailey's Beads were seen at the cusps of the crescent Sun. Unlike a total eclipse however they were not dazzling points of light seen against the corona but were simply detached parts of the photosphere as seen through the dense filters we were using.

Second contact arrived at around 7.15 a.m. and the Moon was completely en-



Annular eclipse of 1998 August 22 photographed with a 1000mm telephoto lens by Mike Harlow. *Left:* second contact; *centre:* mid-eclipse; *right:* third contact. *M. J. Harlow*

veloped by the Sun. Although this eclipse covered just over 97% of the Sun the sky and landscape were still brightly lit by the remaining 3%, again strikingly different from a total eclipse. The annular phase was predicted to be just over two minutes. In common with a total eclipse the time rushed past as the Moon slid across the Sun's disk. We were slightly north of the centre line so

that the Moon at mid-eclipse was not quite concentric with the edge of the Sun.

Our observing site was about 5km southwest of Tarutung, Sumatra, on the road to Sibolga, at approximately 2°00'N, 98°54'E.

### Mike Harlow

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## Bosscha Observatory, West Java

During our time in Indonesia we also visited Bosscha Observatory, near Bandung in West Java. Even before we landed in Indonesia we could see why this area is so interesting for geologists. After our long flight from Gatwick on our descent into Bali we saw an ash cloud rising from a distant volcano. Then on only the second night in Java a small earthquake shook our hotel in Bandung. This really is an active part of the planet.

The telescopes are situated on a hill in Lembang just a few miles north of Bandung, at 6°57'S, 107°34'E. The observatory was founded in 1923 using money donated by K. A. R. Bosscha, a German who had made his fortune from tea plantations in Java, its date of foundation putting the observatory just second behind the Cape Observatory, South Africa, as the oldest in the southern hemisphere. The buildings are surrounded by tropical plants and flowers as well as some fearsome-looking yellow and black spiders. Their webs can be seen draped between the trees and bushes... not a place to walk around in the dark! Being so close to Bandung with a population of two million people means that light pollution is becoming a problem. However, by concentrating on carefully chosen observing programmes good use can be made of the 200 clear nights per year.

The largest instrument is a double refractor completed in 1928 with each telescope having a 60cm Carl Zeiss lens of 11m focal

length. Mounted together in a single tube they are held in an English type yoke mount. As the observatory is only 6° south of the equator the mount is at a very odd angle with the polar axis appearing almost horizontal. The telescopes are used for double star work and high-resolution photography of clusters.

There are a number of run-off roof type



The 60cm double refractor at the Bosscha Observatory.

buildings housing smaller instruments, one of which is a 45cm Cassegrain built in Japan and given to the observatory in 1989 as part of the Indo-Japan project. It is used for photometry of close binaries and spectroscopy. We were also shown the 51cm Schmidt camera, which was inaugurated on 1960 May 28. The corrector and the 70cm primary mirror, made at Yerkes Observatory in Chicago, combine to give an  $f/3.5$  instrument that can cover a five-degree field on 11cm square glass plates. The camera is used for studies of the structure of the Milky Way. One student was using it to measure the rotation curve of our galaxy by taking images using an objective prism giving 312Å/mm dispersion. The spectra of the stars can be used to work out their velocities around the galactic centre.

The hospitality of our host, Dr Bambang Hidayat, made us feel like visiting royalty. We were welcomed with tea and cakes on the lawn by the Director, many of his staff and students. Our tour leader was interviewed by local and national press about our eclipse expedition and an article appeared in the newspapers the following day. Along with the solar eclipse this was the high point of our trip to Indonesia.

### Mike Harlow

More details of Bosscha observatory and its history can be found in *Astronomy in Indonesia* by B. Hidayat, *J. Korean Ast. Soc.*, Vol 29, S455-457, 1996.

# The comets of 1993

J. D. Shanklin

*A report of the Comet Section (Director: J. D. Shanklin)*

This report is the fourth in the present annual series<sup>1,2,3</sup> which gives for each comet: the discovery details, orbital data and general information, magnitude parameters and BAA Comet Section observations. Further details of the analysis techniques used in this report are given in an earlier paper.<sup>4</sup> Ephemerides for the comets predicted to return during the year can be found in the ICQ Handbook.<sup>5</sup> Analysis of the observations of the degree of condensation (DC) suggests that observers need to study the figures in the Comet Section Handbook for Observing Comets.

**Table 1. Orbital data for the comets of 1993<sup>6</sup>**

Comet	<i>T</i>	<i>q</i>	<i>e</i>	<i>P</i>	$\omega$	$\Omega$	<i>i</i>
a A1 Mueller 1994 I	94 Jan 12.8834	1.937531	1.001779		130.6569	144.7224	124.8778
b 87 P/ Bus 1994 XVI	94 Jun 28.1444	2.183112	0.374643	6.52	24.4040	182.2214	2.5730
c 9 P/ Tempel 1 1994 XIX	94 Jul 3.3085	1.494152	0.520255	5.50	178.9021	68.9853	10.5519
d F1 Mueller 1992 XX	92 Aug 4.5903	5.900821	1.005641		62.0038	77.5149	53.9402
e F2-Q D/ Shoemaker-Levy 9 1994 X	94 Mar 30.2298	5.379401	0.207429	17.7	355.0085	220.9268	5.8232
f 37 P/ Forbes 1993 IV	93 Mar 14.6322	1.446844	0.568049	6.13	310.5365	334.4555	7.1591
g 44 P/ Reinmuth 2 1994 XVIII	94 Jun 29.6759	1.893065	0.464111	6.64	45.8765	296.1700	6.9819
h K1 Shoemaker-Levy 1994 IV	94 Feb 2.0272	4.849239	1.000298		232.4553	30.3282	67.7670
i 17 P/ Holmes 1993 VII	93 Apr 10.7467	2.176756	0.410415	7.09	23.2227	328.0461	19.1704
j 42 P/ Neujmin 3 1993 XVI	93 Nov 13.0380	2.001304	0.586031	10.6	147.0117	150.4254	3.9869
k 61 P/ Shajn-Schaldach 1993 XVII	93 Nov 15.9828	2.344551	0.387678	7.49	216.5548	166.8929	6.0772
l K2 P/ Helin-Lawrence 1993 XI	93 Jun 30.3660	3.090216	0.308874	9.45	163.7345	92.0350	9.8831
m M1 110 P/ Hartley 3 1994 XII	94 May 20.6289	2.461212	0.317011	6.84	168.4240	287.8817	11.6956
n 36 P/ Whipple 1993 XXXII	94 Dec 22.4272	3.093878	0.258714	8.53	201.8754	182.4952	9.9271
o 76 P/ West-Kohoutek-Ikemura 1993 XXI	93 Dec 25.3476	1.576783	0.543283	6.41	359.9771	84.1677	30.5410
p Q1 Mueller 1994 IX	94 Mar 26.2797	0.967275	1.000278		261.0330	193.7890	105.0260
q U1 112 P/ Urata-Nijijima 1993 XII	93 Jul 13.5783	1.456645	0.587865	6.64	21.4823	31.9126	24.2141
r U2 113 P/ Spitaler 1994 III	94 Jan 28.2341	2.133112	0.422316	7.10	50.2072	14.5125	5.7724
s W1 P/ Mueller 5 1994 XXV	94 Sep 12.0365	4.250042	0.260543	13.8	30.0045	100.6624	16.4657
t X1 P/ Kushida-Muramatsu 1993 XIX	93 Dec 10.1499	2.745172	0.277295	7.40	348.2876	93.7118	2.3670
u X2 114 P/ Wiseman-Skiff 1993 IX	93 Jun 4.3173	1.509225	0.567806	6.53	171.9101	271.6565	18.1856
v Y1 McNaught-Russell 1994 XI	94 Mar 31.0970	0.867641	0.993512		353.4698	166.3593	51.5868

The epoch of the elements for each comet is the Julian Date ending in zero, closest to the date of perihelion. New style designations for the comets are also given. The elements for 1993e are for fragment Q.

**Table 2. Magnitude parameters of comets observed by the Comet Section**

A correction for aperture of 0.0033mm<sup>-1</sup> and the observer corrections derived in previous papers<sup>1,2,3,4,7,8</sup> have been applied and the H1 value is reduced to zero aperture. No comet had a sufficiently large coma to warrant including the coma correction. In addition to BAA/TA observations, some observations obtained from the Internet have been used to augment the data available for the analyses.

Comet	<i>No</i>	$\Delta R$ (AU)	<i>H1</i>	<i>dev</i>	<i>K1</i>	<i>H10</i>	<i>dev</i>	<i>H15</i>	<i>dev</i>
a Mueller	833	1.9–4.5	5.5±0.1	0.6	6.9±0.2	4.3±0.1	0.7	2.4±0.1	1.0
c 9P/ Tempel 1	206	1.5–2.0	5.2±0.3	0.6	23.4±1.2	8.1±0.1	0.7	7.0±0.1	0.6
e D/ Shoemaker-Levy 9	6	5.5				2.1±0.1	0.3	-1.6±0.1	0.3
g 44P/ Reinmuth 2	5	1.9–2.3				9.8±0.4	0.8	8.3±0.4	0.9
m 110P/ Hartley 3	2	2.6				8.1±0.1	0.1	6.0±0.1	0.1
o 76P/ West-Kohoutek-Ikemura	4	1.6				12.0±0.2	0.4	11.0±0.2	0.3
p Mueller <sup>a</sup>	303	1.0–3.3	7.4±0.1	0.7	6.6±0.3	6.3±0.1	0.9	4.7±0.1	1.3
r 113P/ Spitaler	1	2.2				11.5		9.8	
v McNaught-Russell <sup>b</sup>	773	0.9–1.5	8.6±0.1	0.8	7.7±0.6	8.7±0.1	0.8	8.9±0.1	0.8
29P/ Schwassmann-Wachmann 1	14	6.0–6.1				0.5±0.1	0.5	-3.4±0.1	0.5

a Comet Mueller faded dramatically about a month after perihelion and the values given here apply up to 1994 April 20 only.

b CCD and photographic magnitudes were not used in the analysis because they are substantially fainter than visual estimates for this comet.

The magnitude of the comets can be calculated from the equation:

$$m = H1 + 5.0 \log(\Delta) + K1 \log(r)$$

For most comets there are insufficient observations to calculate K1 accurately and so a value of 10 or 15 is assumed, which gives the constant H10 or H15 respectively. The formal error is given for each coefficient, followed by the rms deviation of the observations from the fitted curve.

## The comets with year letter designations

### a *Mueller* (1993 A1, 1994 I)

On January 2.4, Jean Mueller discovered a 15.5 magnitude comet with the 1.2m Oschin Schmidt on Mt Palomar during the course of the 2nd Palomar Sky Survey (PSSII) [IAU Circular 5657, 1993 January 4]. The comet was approach-

**Table 3. List of visual observers**

Andre J. Ayme de Rosamond	Australia
Sally Beaumont	Windermere, Cumbria
John E. Bortle	USA
Eric Broens	Belgium
Paul Camilleri	Australia
Matyas Csukas	Romania
Haakon Dahle	Norway
Alfons Diepvens	Belgium
Steve Evans	Towcester, Northants
James Fraser	Alness, Rosshire
Gordon Garrard	Australia
Bjoern Haakon	Granslo, Norway
Werner Hasubick	Germany
Roberto Haver	Italy
Paul Haworth	Ravensthorpe, Northants.
Lars Trygve Heen	Norway
Guy M. Hurst	Basingstoke, Hants.
Albert F. Jones	New Zealand
Graham Keitch	Manaton, Devon
Attila Kosa-Kiss	Romania
James Lancashire	Cambridge
Andreas Lauvstad	Norway
Martin Lehky	Czech Republic
Oernulf Midtskogen	Norway
Herman Mikuz	Slovenia
Raymond Minty	Banff, Scotland
Roy W. Panther	Walgrave, Northampton
Alfredo Jose Serra Pereira	Portugal
Gary Poyner	Birmingham
Richard W Schmude	USA
David A. J. Seargent	Australia
John Seach	Australia
Jonathan D. Shanklin	Cambridge
Christopher E. Spratt	Canada
Tony Tanti	Malta
Melvyn D. Taylor	Wakefield, Yorkshire
Maura Tombelli	Italy
Frank Ventura	Malta
Peter F. Williams	Australia
Graham W. Wolf	New Zealand
C Wyatt	Australia
Mauro Vittorio Zanotta	Italy

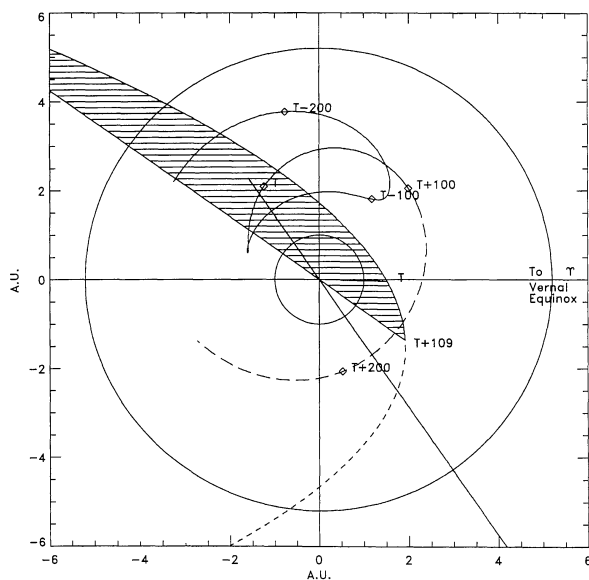
**Table 4. List of astrometric, CCD and photographic observers**

Observer	Site	IAU Sm. No.
Ron Arbour	South Wonston, Hants	
Andrea Boattini	Italy	108/552
Cecil Gilbert	Newcastle upon Tyne	
Bev Ewen-Smith	Portugal	
Werner Hasubick	Germany	
Nick James	Chelmsford, Essex	970
Martin Lehky	Czech Republic	
Brian Manning	Stakenbridge, Worcs	494
Jean-Claude Merlin	France	504
Herman Mikuz	Slovenia	106
Roy Mitchell	Eglington, Co Londonderry	
Martin Moberley	Galleywood, Suffolk	477/480
Bob Neville	Greens Norton, Northants.	967
David Strange	Worth Matravers, Dorset	
Alex Vincent	Worthing, Sussex	
Peter Wroath	Newbury, Berks.	

ing opposition and still over a year from perihelion, moving slowly northwest in Ursa Major.

After discovery the comet continued moving westwards into Lynx, where it completed its retrograde loop in early May. It then moved back into Ursa Major, crossing into Ursa Minor and reached its highest declination in mid-October. Heading south east, it passed through Draco and Cygnus, reaching perihelion in Pegasus on 1994 January 12. Its motion southeast slowed and when last seen in mid-April it had reached the border of Pisces and Aquarius.

Section observations span the range T-371 to T+96 days. Herman Mikuz was able to secure images<sup>9</sup> of the comet almost immediately after the discovery announcement, making it 14<sup>m</sup> on January 6 with his 0.20m Schmidt and ST-6 CCD system. Werner Hasubick was able to photograph it at the end of February, but the first visual observation was not made until late April when Martin Lehky obtained visual estimates of 12.6 with a 0.20m refractor. It was a low circumpolar object for mid-latitude northern hemisphere observers from mid-May until mid-August. Oernulf Midtskogen picked it up at 12.0<sup>m</sup> on August 14 with his 0.32m reflector  $\times 130$ . As it moved towards the Pole and brightened, more observations were made. Jonathan Shanklin found it mag 11.1 on September 24 with the Thorowgood 0.20m refractor at the University of Cambridge. By mid-October it had brightened further and had a larger coma diameter; Roy Panther estimating it at 9.8<sup>m</sup> with a coma diameter of 8' on October 18 in his 0.25m reflector  $\times 35$ . A photograph by Martin Moberley taken on



**Figure 1.** The orbit of comet Mueller 1993a. **a)** Viewed from the north ecliptic pole. The orbits of the Earth and Jupiter are shown for scale. The shaded part of the comet's orbital plane lies above the ecliptic. **b)** Viewed from the ascending node of the comet's orbit looking towards the Sun. From this viewpoint the orbit appears as a straight line, showing the inclination of the comet's orbit. **c)** Viewed from a rotating reference frame, centred on the Earth with the Sun at top. In this frame the true distance to the comet is shown but the angular elongation from the Sun is viewed from the ecliptic pole; the 6 o'clock position corresponds to the comet at opposition and the 3 o'clock position to the comet at morning quadrature. The path is shown dashed when it lies below the ecliptic. The comet was discovered at T-375; observations used in the analysis cover the range T-371 to T+96.

1993 October 16 was published in the *Journal*.<sup>10</sup> The comet was at its brightest in November, with Sally Beaumont estimating it at 8.7<sup>m</sup> in her 0.13m refractor on November 20. It had faded a little by December and was moving south, but had developed a short tail. Nick James photographed it on December 4.<sup>11</sup> James Lancashire observing with the Thorowgood telescope  $\times 40$  on December 11 estimated it at 9.2<sup>m</sup> with a 0°.1 tail in p.a. 30°. Around perihelion in January it was becoming much harder to observe, low in the twilight, but Graham Keitch, observing under the clear skies of Dartmoor was able to follow it until early February; his last observation, with 25 $\times$ 150B on 1994 February 7, making it 9.6<sup>m</sup>. After this only one further observation was received, although the ephemeris predicts that it should have been observable for some time from the southern hemisphere. Paul Camilleri, observing from Cobram, Victoria, Australia made it 10.5<sup>m</sup> in 20 $\times$ 80B on April 19.

The coma diameter increased from around 1' at discovery to 7' a little before closest approach to the Earth in 1993 November (three months before perihelion), shrinking again to around 2' three months after perihelion. In real terms this corresponds to an increase from 150,000 km at discovery, to a broad maximum of around 400,000 km between 150 days before (T-150) and 25 days after perihelion (T+25). There is no significant pattern to the DC observations, with observers reporting values between 0 and

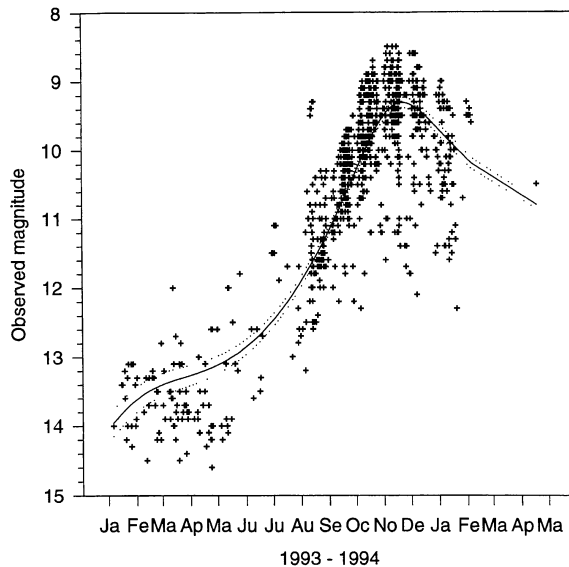


**Figure 2.** Comet Mueller 1993a photographed by Bob Neville on 1993 October 18<sup>d</sup> 20<sup>h</sup> 23<sup>m</sup> with a 0.30m f5 reflector, exposure 10 minutes on Tmax 400 developed for 7 minutes in D-19.

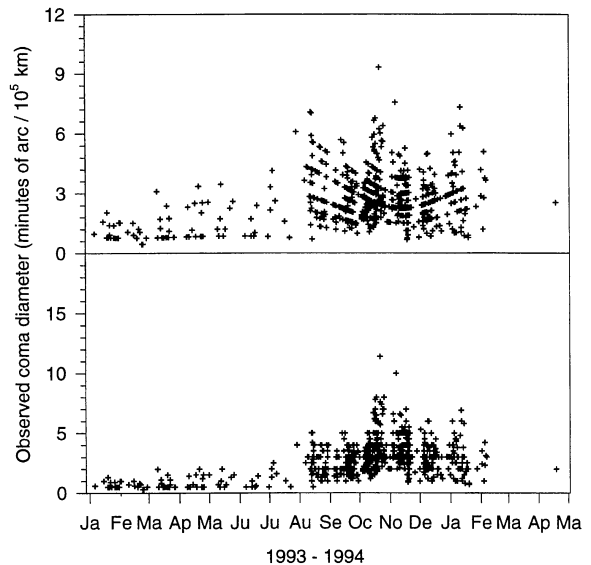
**Table 5. Ephemeris for comet Mueller 1993a**

Magnitudes calculated from  $m = 5.7 + 5.0 \text{ Log}(\Delta) + 7.7 \text{ Log}(r)$   
Latitude: 53.0°N Longitude: 0.0°W

Day	R.A. hh mm.m (2000.0)	Dec ° mm (2000.0)	Mag	$\Delta$ AU	R AU	Observable hh.mm to hh.mm	Elong. °
1993 January							
02/03	9 46.1	47.11	13.7	3.79	4.57	20.48 to 6.40	138
12/13	9 32.7	49.52	13.5	3.65	4.48	19.30 to 6.36	144
22/23	9 15.3	52.23	13.4	3.55	4.40	18.09 to 6.29	145
1993 February							
01/02	8 54.3	54.35	13.3	3.49	4.31	18.11 to 6.16	142
11/12	8 30.7	56.15	13.2	3.46	4.22	18.28 to 6.01	135
21/22	8 06.4	57.20	13.1	3.47	4.13	18.46 to 5.42	126
1993 March							
03/04	7 43.4	57.50	13.1	3.51	4.05	19.04 to 5.01	116
13/14	7 23.3	57.52	13.1	3.57	3.96	19.22 to 4.05	106
23/24	7 07.2	57.34	13.0	3.64	3.87	19.42 to 3.09	96
1993 April							
02/03	6 55.3	57.06	13.0	3.71	3.78	20.03 to 2.16	86
12/13	6 47.3	56.33	13.0	3.79	3.70	20.25 to 1.26	77
22/23	6 42.9	56.02	12.9	3.85	3.61	20.49 to 0.40	69
1993 May							
02/03	6 41.4	55.35	12.9	3.91	3.52	21.14 to 23.59	60
12/13	6 42.3	55.15	12.8	3.95	3.43	21.42 to 23.23	53
22/23	6 45.3	55.03	12.7	3.97	3.35	22.11 to 22.50	46
1993 June							
01/02	6 50.1	54.60	12.6	3.96	3.26	Not observable	41
11/12	6 56.3	55.06	12.5	3.94	3.18	Not observable	36
21/22	7 03.7	55.22	12.4	3.88	3.09	Not observable	34
1993 July							
01/02	7 12.3	55.49	12.3	3.81	3.01	Not observable	33
11/12	7 21.8	56.28	12.1	3.70	2.92	Not observable	34
21/22	7 32.4	57.21	12.0	3.58	2.84	01.45 to 01.55	38
31/32	7 44.0	58.32	11.8	3.43	2.76	21.49 to 21.50 00.21 to 02.24	42
1993 August							
10/11	7 56.8	60.02	11.6	3.26	2.68	21.20 to 2.50	47
20/21	8 11.1	61.58	11.3	3.07	2.60	20.51 to 3.15	54
30/31	8 27.5	64.24	11.1	2.87	2.53	20.23 to 3.38	60
1993 September							
09/10	8 47.6	67.27	10.8	2.66	2.46	19.55 to 3.59	67
19/20	9 14.6	71.15	10.6	2.45	2.39	19.28 to 4.19	74
29/30	9 58.0	75.52	10.3	2.25	2.32	19.03 to 4.38	81
1993 October							
09/10	11 33.1	80.51	10.0	2.06	2.26	18.39 to 4.55	88
19/20	15 28.4	82.32	9.7	1.90	2.20	18.17 to 5.13	94
29/30	18 25.9	76.25	9.5	1.78	2.14	17.58 to 5.30	97
1993 November							
08/09	19 33.1	66.52	9.4	1.72	2.10	17.42 to 5.46	98
18/19	20 08.2	56.29	9.3	1.72	2.05	17.29 to 6.02	95
28/29	20 31.8	46.30	9.3	1.78	2.01	17.21 to 1.59 06.01 to 6.16	88
1993 December							
08/09	20 50.2	37.40	9.4	1.89	1.98	17.17 to 23.53	81
18/19	21 05.7	30.15	9.5	2.03	1.96	17.18 to 22.32	72
28/29	21 19.5	24.14	9.6	2.19	1.95	17.24 to 21.27	62
1994 January							
07/08	21 32.0	19.23	9.8	2.36	1.94	17.34 to 20.30	53
17/18	21 43.7	15.29	9.9	2.52	1.94	17.47 to 19.38	44
27/28	21 54.6	12.19	10.1	2.66	1.95	18.02 to 18.50	36
1994 February							
06/07	22 04.9	9.42	10.2	2.79	1.96	Not observable	27
16/17	22 14.6	7.30	10.3	2.89	1.99	Not observable	20
26/27	22 23.8	5.35	10.4	2.96	2.02	Not observable	15
1994 March							
08/09	22 32.5	3.51	10.5	3.00	2.05	Not observable	14
18/19	22 40.6	2.14	10.6	3.02	2.10	Not observable	18
28/29	22 48.0	0.37	10.6	3.00	2.15	Not observable	26
1994 April							
07/08	22 54.7	-1.02	10.7	2.96	2.20	Not observable	34
17/18	23 00.5	-2.50	10.7	2.89	2.26	Not observable	43
27/28	23 05.2	-4.51	10.8	2.80	2.32	Not observable	52



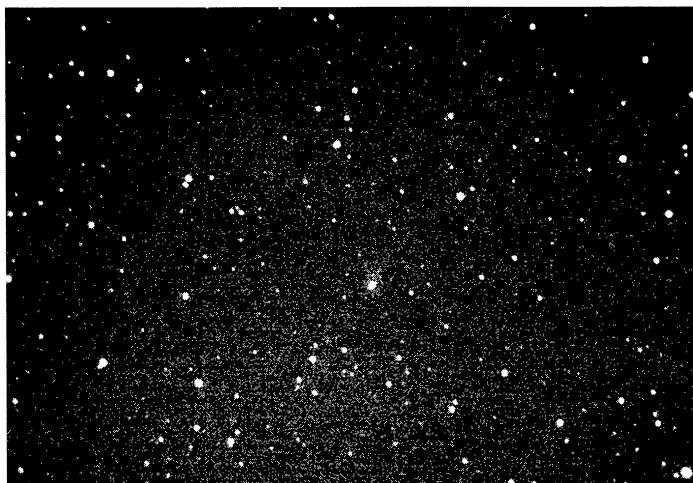
**Figure 3.** The observed magnitude of comet Mueller 1993a. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1993 January. The scatter is accentuated by the mix of visual and CCD observations.



**Figure 5.** The coma diameter of comet Mueller 1993a. The lower panel shows the observed coma diameter in arc minutes and the upper panel the true diameter in 100,000km.

**Table 5. Ephemeris for comet Mueller 1993a (continued)**

Day	R.A. hh mm.m	Dec ° mm (2000.0)	Mag	$\Delta$ AU	R AU	Observable hh.mm to hh.mm	Elong. °
1994 May							
07/08	23 08.6	-7.11	10.8	2.69	2.39	Not observable	62
17/18	23 10.5	-9.56	10.8	2.57	2.46	Not observable	72
27/28	23 10.3	-13.13	10.7	2.44	2.53	Not observable	83
1994 June							
06/07	23 07.6	-17.07	10.7	2.32	2.61	Not observable	95
16/17	23 01.6	-21.43	10.7	2.20	2.68	Not observable	107
26/27	22 51.6	-26.57	10.7	2.11	2.76	Not observable	120
1994 July							
06/07	22 36.8	-32.38	10.8	2.06	2.84	Not observable	132
16/17	22 16.5	-38.22	10.8	2.05	2.93	Not observable	143
26/27	21 50.8	-43.36	11.0	2.09	3.01	Not observable	150
1994 August							
05/06	21 21.1	-47.51	11.2	2.18	3.09	Not observable	149
15/16	20 50.1	-50.51	11.4	2.32	3.18	Not observable	142
25/26	20 21.3	-52.38	11.6	2.50	3.26	Not observable	132



**Figure 4.** Comet Mueller 1993a photographed by Alex Vincent on 1993 December 4<sup>d</sup> 20<sup>h</sup> 30<sup>m</sup> using a four minute exposure on Fujichrome 400 slide film at the prime focus of a 0.30m f5 reflector.

9. Generally the DC was around 3 to 4. The wide scatter in DC observations suggests that observers were not reporting this correctly. (Sketches of representative DC values are given in the Section *Handbook*, and these are also available on the Section Web page.) A short tail was observed from T-150 to T. Maximum observed length of around  $0^{\circ}.2$  occurred at T-50, corresponding to a real length of 0.02 AU.

#### *b* 87P/Bus (1994 XVI)

Recovered by James V Scotti of the Lunar and Planetary Laboratory, University of Arizona with the 0.91m Spacewatch CCD telescope at Kitt Peak (SWT) on January 1.2, just past opposition in Taurus [IAUC 5696, 1993 January 22]. The comet was 22<sup>nd</sup> magnitude and still over 18 months away from perihelion. The comet was only predicted to reach 16<sup>m</sup> and no Section observations were made.

When discovered at Siding Spring in 1981, on a UK Schmidt plate taken for asteroid search purposes, the comet was 16.5<sup>m</sup>. It was a fairly favourable return, and similar to the present one. The comet was perturbed into its present orbit following a very close approach to Jupiter in 1952 which swapped the perihelion of the previous orbit to the aphelion of the new one. Next century a further encounter with Jupiter will increase the perihelion distance from 2.2 to 3.6 AU.

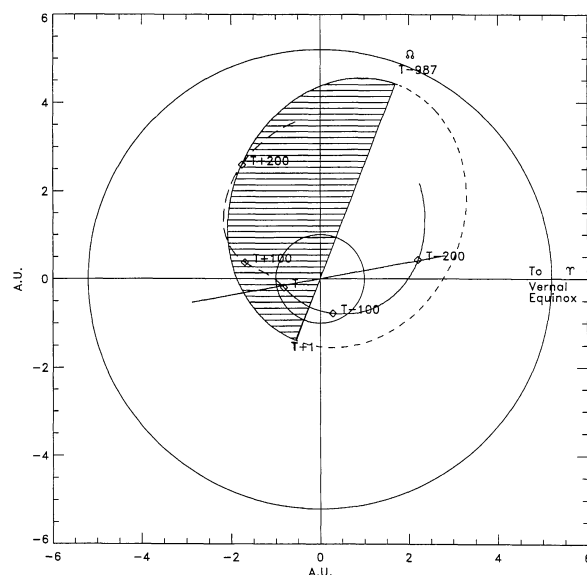
#### *c* 9P/Tempel 1 (1994 XIX)

Recovered nearly 18 months before perihelion by James Scotti with the SWT on January 21.2 at 21<sup>st</sup> magnitude. The comet was just past oppo-

sition on the borders of Auriga and Gemini [IAUC 5698, 1993 January 27]. This was a favourable apparition of a short period comet first observed in 1867, but which was lost between 1879 and 1967 following an encounter with Jupiter in 1881 which increased the perihelion distance from 1.8 to 2.1 AU. Further encounters in 1941 and 1953 put  $q$  back to 1.5 AU and calculations by Brian Marsden allowed Elizabeth Roemer to recover it in 1967. Alternate returns are favourable, but perturbations will once again increase the perihelion distance in the middle of the next century.

Section observations span the range  $T-147$  to  $T+61$  days. In early March 1994 the comet began its retrograde loop in Virgo, which it completed in May, heading south and east through the zodiacal constellations of Libra, Scorpius and Sagittarius which it entered in October.

Herman Mikuz picked it up with his CCD system on 1994 March 5 and Graham Keitch found it visually with 25×150B a day later. It was 13.2<sup>m</sup> in the CCD system, but visually was nearly two magnitudes brighter at 11.4<sup>m</sup>. It slowly brightened: James Lancashire made it 10.5<sup>m</sup> with the Thorowgood on April 14. Closest approach to the Earth occurred in early May when most observers were estimating it at around 9<sup>m</sup>–11<sup>m</sup>. Attila Kosa–Kiss estimated it at 10.1<sup>m</sup> on May 5 in his 0.16m reflector ×54 and Werner Hasubick observing on June 1 with 25×100B made it 9.5<sup>m</sup>. It continued brightening towards perihelion in early July, but was becoming harder to observe from the UK. Jonathan Shanklin made the last UK observation with his 0.33m reflector ×85 on July 1 when it was approximately mag 10.1. After this it became a southern hemisphere object, Graham



**Figure 6.** The orbit of comet Tempel 1 1993c. **a)** Viewed from the north ecliptic pole. **b)** Viewed from the ascending node of the comet's orbit looking towards the Sun. **c)** Viewed from the rotating reference frame. Observations used in the analysis cover the range  $T-147$  to  $T+61$ .

**Table 6. Ephemeris for comet P/Tempel 1 1993c**

Magnitudes calculated from  $m = 5.4 + 5.0 \text{ Log}(\Delta) + 25.0 \text{ Log}(r)$   
Latitude: 53.0°N Longitude: 0.0°W

Day	R.A. hh mm.m	Dec °mm (2000.0)	Mag	$\Delta$ AU	R AU	Observable hh.mm to hh.mm	Elong. °
1994 March							
08/09	13 34.0	10.41	12.1	0.97	1.87	22.16 to 5.09	146
18/19	13 33.0	11.35	11.6	0.88	1.82	21.11 to 4.44	153
28/29	13 28.7	12.21	11.1	0.80	1.77	20.08 to 4.18	159
1994 April							
07/08	13 21.8	12.45	10.7	0.75	1.72	20.13 to 3.51	160
17/18	13 13.4	12.33	10.3	0.71	1.68	20.36 to 3.23	156
27/28	13 05.4	11.34	9.9	0.69	1.63	21.01 to 2.55	148
1994 May							
07/08	12 59.5	9.45	9.7	0.69	1.60	21.27 to 2.26	140
17/18	12 57.2	7.11	9.5	0.70	1.57	21.56 to 1.57	132
27/28	12 59.1	4.00	9.3	0.71	1.54	22.26 to 1.29	125
1994 June							
06/07	13 05.4	0.23	9.3	0.74	1.52	22.54 to 0.41	119
16/17	13 15.8	-3.30	9.3	0.78	1.50	23.15 to 23.49	113
26/27	13 30.0	-7.32	9.3	0.82	1.50	Not observable	108
1994 July							
06/07	13 47.6	-11.33	9.5	0.87	1.49	Not observable	104
16/17	14 08.1	-15.27	9.6	0.93	1.50	Not observable	101
26/27	14 31.2	-19.06	9.9	0.99	1.51	Not observable	98
1994 August							
05/06	14 56.6	-22.26	10.2	1.07	1.53	Not observable	95
15/16	15 24.0	-25.21	10.5	1.15	1.56	Not observable	92
25/26	15 52.8	-27.47	10.9	1.24	1.59	Not observable	89
1994 September							
04/05	16 22.8	-29.43	11.3	1.33	1.62	Not observable	87
14/15	16 53.5	-31.08	11.7	1.44	1.66	Not observable	84
24/25	17 24.4	-32.02	12.2	1.56	1.71	Not observable	81

Wolf being able to follow it until September 2 when it was 10.5<sup>m</sup> in his 0.21m reflector ×105.

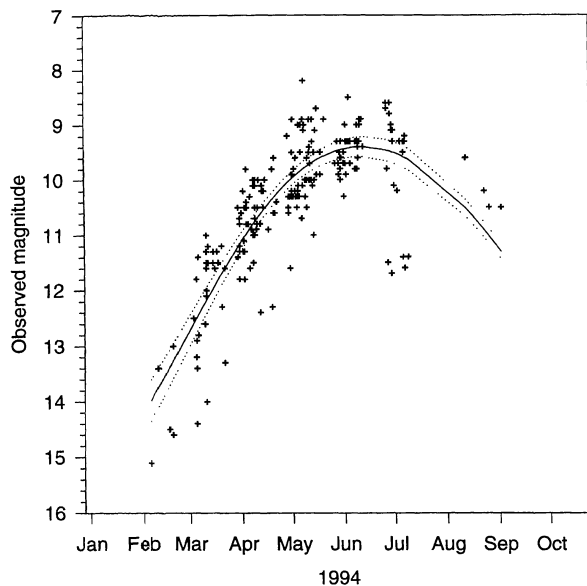
The coma diameter increased from around 1' in early March to 4' in early June, after which it decreased rapidly to 1' in early July. In real terms this corresponds to an increase from 50,000 km to 150,000 km. Again there is no clear pattern to the DC, with observers reporting values between 1 and 7 throughout the apparition. Overall there is an indication that it increased from 2 at  $T-120$  to 4 at  $T-60$ , reducing back to 2 at perihelion.

#### d Mueller (1993 F1, 1992 XX)

Jean Mueller discovered a 17<sup>m</sup> comet on a 75-minute exposure plate taken with the 1.2m Oschin Schmidt during PSSII on March 19.3 [IAUC 5723, 1993 March 24]. The comet was near opposition and nine months past perihelion, moving slowly west on the borders of Ursa Major and Draco. It faded after discovery.

#### e D/Shoemaker–Levy 9 (1993 F2, 1994 X)

The story of the demise of this celebrated comet is well recorded in the *Journal*,<sup>12,13,14</sup> *The Astronomer*<sup>15</sup> and elsewhere. Discovered by the team of Carolyn S. and Eugene M. Shoemaker and David H. Levy (SLT) during the search for near-Earth asteroids with the 0.46m Palomar Schmidt (PS) as a 14th magnitude 'string of pearls' [IAUC 5725, 1993 March 26], it spectacularly ended its life in a series of impacts with the planet Jupiter in July 1994.



**Figure 7.** The observed magnitude of comet 1993c. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1994 January.

Images of the comet were received from several observers,<sup>16,17</sup> but reduced magnitude estimates were much rarer. Mikuz obtained estimates of around 14<sup>m</sup> between 1993 April 1 and 1993 June 19 with his CCD system. Tombelli was able to observe the comet visually with his 0.44m reflector  $\times 222$  on April 24, making it 13.5<sup>m</sup>.

#### f 37P/Forbes (1993 IV)

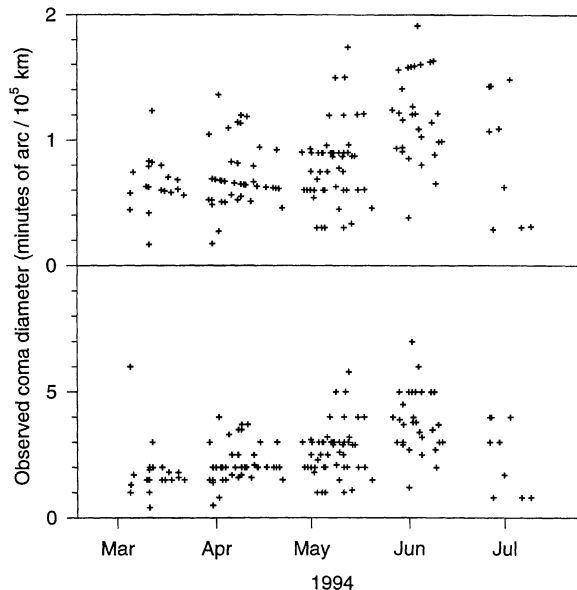
This comet was recovered by G. Lowe with the 0.33m astrograph at Perth Observatory on March 21.8, as it emerged from solar conjunction. The discovery was reported by former Section Director Michael P. Candy on *IAUC* 5728 [1993 March 28]. The comet was at 14<sup>m</sup> close to perihelion in Sagittarius.

At a good return the comet can be a 10th magnitude object, however this return was not a favourable one and no Section observations were reported. Discovered in 1929 by A. F. I. Forbes during a routine comet search with a 0.20m reflector from Hermanus, South Africa, the comet's orbit has been fairly stable this century. An encounter with Jupiter in 1990 started progressive changes, though there is little immediate change in the perihelion distance.

#### g 44P/Reinmuth 2 (1994 XVIII)

Recovered by James Scotti with the SWT on February 26.5 at 22nd magnitude whilst still 16 months from perihelion. It was past morning quadrature on the borders of Libra and Centaurus [*IAUC* 5772, 1993 April 22]. Section observations span the range T+41 to T+156 days.

The comet was discovered in 1947 and the orbit is relatively stable. It has been seen at every return since, though it only occasionally gets as bright as it did at this one. Mikuz, observing in mid-August 1994 with his CCD system made the comet 15<sup>m</sup>. In mid October 1994 Werner Hasubick was able to obtain photographs of the comet, when it was 13.5<sup>m</sup>.



**Figure 8.** The observed coma diameter of comet 1993c. The tick marks indicate the first of each month from 1994 March. The lower panel shows the observed coma diameter in arc minutes and the upper panel the true diameter in 100,000km.

Mikuz made a final observation in early December when it was again 15<sup>m</sup>.

#### h Shoemaker–Levy (1993 KI, 1994 IV)

Discovered by the SLT with the 0.46m PS on May 23.2 at photographic magnitude 16.5. [*IAUC* 5803, 1993 May 25]. When discovered the comet was past opposition in Centaurus, moving very slowly south west. It was a very distant comet and faded after discovery.

#### i 17P/Holmes (1993 VII)

Recovered by Tsutomu Seki at Geisei, Japan with his 0.6m reflector at photographic magnitude 18 on May 24.8 in Pisces as the comet emerged from conjunction [*IAUC* 5804, 1993 May 26].

When discovered in 1892 by E. Holmes while observing M31 with a small reflector from London, the comet was brighter than M31 which was close by. It was evidently in outburst and one photograph showed a double nucleus, perhaps showing a similar event to that which occurred in P/Schwassmann–Wachmann 3 in 1995. In 1899 and 1906 it was only 14–15 magnitude and was lost for the next seven returns until recovered by Elizabeth Roemer following a prediction by Brian Marsden. The orbit is relatively stable at the moment with occasional distant encounters with Jupiter changing the perihelion distance by a small amount. For the last few returns it has been no brighter than 17<sup>m</sup>.

#### j 42P/Neujmin 3 (1993 XVI)

Recovered by James Scotti with the SWT on May 25.3 at 21st magnitude when it was just past opposition in Libra [*IAUC* 5805, 1993 May 27]. The comet was only predicted to reach 16<sup>m</sup> and no Section observations were made.

The comet was perturbed into its present orbit after a close approach to Jupiter in 1850 which reduced the perihelion distance from 2.7 to 2.1 AU. Discovered in 1929, it has been missed at alternate apparitions ever since. The pre-1850 orbit is almost identical to that of 53P/Van Biesbroeck and it is probable that the two comets split from a common parent in 1849 prior to the encounter.

*k 61P/Shajn–Schaldach (1993 XVII)*

Recovered by James Scotti with the SWT on May 27.4 at 20th magnitude when it was nearing morning quadrature on the borders of Pisces and Aquarius [IAUC 5807, 1993 May 28]. The comet was discovered in 1949, following a close approach to Jupiter in 1946 which converted the perihelion of the old orbit into the aphelion of the new one. It wasn't seen in 1957 or 1964, but a prediction by Brian Marsden enabled to be recovered in 1971. Although at discovery it reached 12<sup>m</sup> it has not done as well on subsequent returns.

*l P/Helin–Lawrence (1993 K2, 1993 XI)*

Discovered by Eleanor F. Helin and Kenneth J. Lawrence with the PS on May 17.4 at magnitude 16.5 when at opposition and near perihelion in Ophiuchus. [IAUC 5810, 1993 June 2]. It faded after discovery.

*m 110P/Hartley 3 (1993 M1, 1994 XII)*

Recovered when still 11 months from perihelion by James Scotti with the SWT on June 23.4 at magnitude 19.5. It was emerging from conjunction on the borders of Aries and Pisces [IAUC 5826, 1993 June 29]. Section observations span the range T–153 to T–110 days.

This was the first return of the comet, which was discovered with the UK Schmidt telescope from Siding Spring in February 1988 and it reached perihelion 0.25 days later than predicted by Dan Green in the *ICQ Handbook* for 1993. It was perturbed into its present orbit following an encounter with Jupiter in 1949.

Mikuz observed the comet on 1993 December 18 and 1994 January 30 with his CCD system, when the comet was around 15<sup>m</sup>.

*n 36P/Whipple (1993 XXXII)*

Recovered by James Scotti with the SWT on June 25.4 at 21st magnitude when it was nearing opposition in Aquila [IAUC 5827, 1993 June 30].

The comet is in a somewhat chaotic orbit and experiences quite large changes in perihelion distance due to slow encounters with Jupiter. It was discovered in 1933 after an approach to Jupiter in 1922 reduced the perihelion distance to 2.5AU. Only 13<sup>m</sup> at discovery, it has never been brighter than this, and a subsequent encounter with Jupiter in 1981 has pushed *q* back out to 3.1AU.

*o 76P/West–Kohoutek–Ikemura (1993 XXI)*

Recovered by James Scotti with the SWT on July 20.5 at 20th magnitude when it was nearing morning quadrature in

Eridanus [IAUC 5832, 1993 July 23]. Section observations cover the range T–37 to T+36 days.

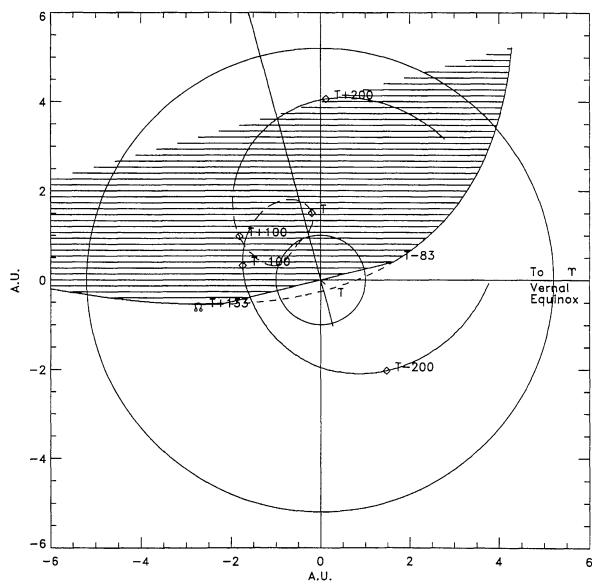
The comet was discovered in 1975 following a very close encounter with Jupiter in 1972 which produced one of the largest reductions of perihelion distance on record, reducing *q* from 5.0 to 1.4AU. Lubos Kohoutek was actually taking a confirmation plate for a second comet (75P/Kohoutek) discovered 18 days earlier and then lost. Although 12<sup>m</sup> at the discovery apparition, it is another comet which has not done so well on subsequent returns.

Mikuz observed the comet between 1993 November 17 and 1994 January 30 using his CCD system. The comet was near perihelion and between mag 13 and 15.

*p Mueller (1993 Q1, 1994 IX)*

Jean Mueller discovered a 14.5<sup>m</sup> comet on a plate taken with the 1.2m Oschin Schmidt during PSSII on August 16.4 [IAUC 5846, 1993 August 18]. The comet was past morning quadrature and seven months from perihelion, moving slowly northeast on the borders of Perseus and Andromeda. Its motion slowly accelerated as it passed through Pegasus but slowed again as it crossed Aquarius, reaching perihelion in Sculptor. It began to accelerate again and passed through Phoenix, Eridanus, Horologium, Pictor and was last seen in Puppis. Section observations cover the range T–218 to T+48 days.

The comet was essentially a northern hemisphere object prior to perihelion and a southern hemisphere object after perihelion. Mikuz was able to image the comet as early as 1993 August 20 when it was 14<sup>m</sup>, but visual observation did not begin to any great extent until October. Graham Keitch made it 11.5<sup>m</sup> on October 9, with a weakly condensed 2' diameter coma in 25×150B. Martin Moberley photographed it on October 17.<sup>10</sup> It slowly brightened and Keitch



**Figure 9.** The orbit of comet Mueller 1993p. a) Viewed from the north ecliptic pole. b) Viewed from the ascending node of the comet's orbit looking towards the Sun. c) Viewed from the rotating reference frame. The comet was discovered at T–222; observations used in the analysis cover the range T–218 to T+48.

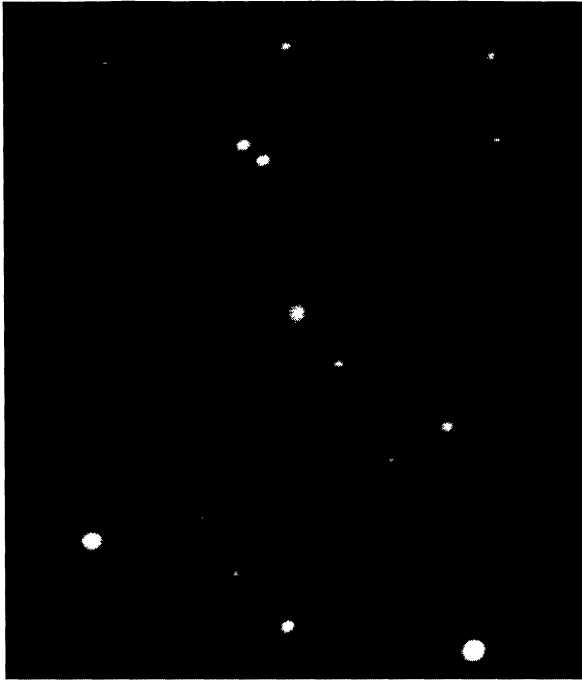


Figure 10. Comet Mueller 1993p imaged by Ron Arbour on 1993 November 14<sup>d</sup> 22<sup>h</sup> 07<sup>m</sup>.

made it 10<sup>m</sup> by mid-January. Moving south, and heading towards perihelion on March 26, it was in solar conjunction until early April when it was picked up by David Seargent at mag 8.7 on April 1 in 15×80B. It continued to brighten and Albert Jones made it 7.2<sup>m</sup> on April 11 in his 78mm refractor ×30, with a 2' diameter, moderately condensed coma. After this it faded rapidly and became much more diffuse, Jones making the final observation on 1994 May 13 when it was 10.8<sup>m</sup> in his 0.32m reflector ×63, with a 1' diameter coma and DC1. It seems likely that activity

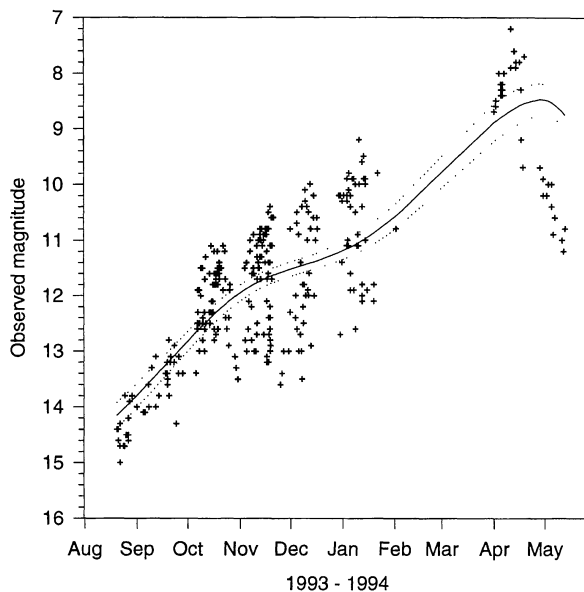


Figure 11. The observed magnitude of comet 1993p. The curve is a best fit over the apparition, with no corrections applied. The comet's activity declined dramatically after 1994 April. Tick marks indicate the first of each month from 1993 August.

switched off as the decline is much more precipitate than that predicted by the light curve. Exposures taken by A. C. Gilmore (Mount John University Observatory, New Zealand) on May 4.4 showed a diffuse, roughly parabolic patch with no hint of the condensation that was visible on April 14.3. SWT exposures taken by Robert Jedicke on June 2.2 showed an elliptical diffuse image, with a total coma magnitude near 10.5, but any remaining nucleus must have been fainter than about 18.5<sup>m</sup>. [IAUC 6004, 1994 June 8].

The comet never approached the earth or Sun much closer than 1AU and throughout the apparition the coma diameter remained small. It increased from around 0.4' to reach a peak of 3' in mid-November, slowly declining to 1' in 1994 May. In real terms the diameter increased from 50,000km to a peak of 200,000km. Again a wide range of DC values was reported (0–9). The data are consistent with DC3 throughout the apparition, perhaps declining a little towards the end.

#### *q* 112P/Urata–Nijjima (1993 U1, 1993 XII)

Recovered by James Scotti with the SWT on October 20.5 at magnitude 19.5 when it was emerging from conjunction in Leo Minor [IAUC 5882, 1993 October 21].

This was the first return of the comet which was discovered at a very favourable return in 1986, following an encounter with Jupiter in 1982/83. The predicted ephemeris required a correction of +0.24 days. The return was a poor one and the comet was not expected to exceed 19<sup>m</sup>.

#### *r* 113P/Spitaler (1993 U2, 1994 III)

On October 24.3 James Scotti found a 17<sup>m</sup> comet with the SWT moving west on the borders of Pisces and Aries. He suggested that it might be P/Spitaler, which had not been seen since its discovery apparition in 1890. Syuichi Nakano

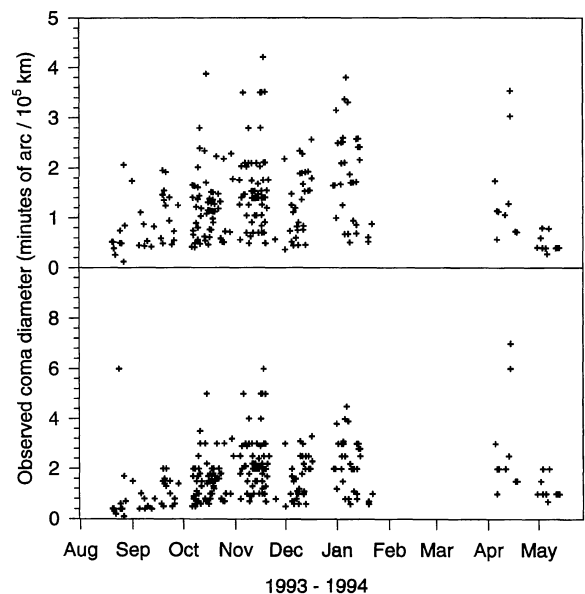


Figure 12. The coma diameter of comet 1993p. The lower panel shows the observed coma diameter and the upper panel the true diameter in 100,000km. Tick marks indicate the first of each month from 1993 August.

had predicted that it might return to perihelion on October 4.0 and the comet was close to the line of variation for  $\Delta T = +108.7$  days. Computation by Brian Marsden confirmed the identity. [IAUC 5885, 1993 October 28]. It was near opposition.

At its discovery the comet reached 12<sup>m</sup> in a very favourable apparition, however the present magnitude suggests that it may then have been in outburst. The orbit is comparatively stable and was well enough determined that it should have been recovered if the discovery magnitude had been typical. Richard Buckley had made a prediction for its return in 1979 in the *BAA Journal*<sup>18</sup> commenting that of all the 'missing comets' he was considering, it had one of the better chances of recovery.

Martin Mobberley obtained an astrometric CCD image<sup>19</sup> of the comet using his 0.47m reflector at Galleywood, Chelmsford on 1993 November 12, when it was about 17<sup>m</sup>. The comet was then 77 days before perihelion.

#### s *P/Mueller 5 (1993 W1, 1994 XXV)*

Jean Mueller discovered an 18<sup>m</sup> comet on a plate taken with the 1.2m Oschin Schmidt during PSSII on November 20.4 [IAUC 5891, 1993 November 21]. The comet was approaching opposition and ten months from perihelion, moving slowly north east in Gemini. It is a distant, short period comet, which encountered Jupiter in 1964.

#### t *P/Kushida–Muramatsu (1993 XI, 1993 XIX)*

Yoshio Kushida and Osamu Muramatsu of Yatsugatake South Base Observatory, Japan, photographically discovered a 16.5<sup>m</sup> comet on December 8.7 using a 0.25m f/3.4 reflector. At discovery the comet was moving east and was diffuse with a central condensation and a coma of about 1'–2' diameter. [IAUC 5903, 1993 December 12]. The comet was near opposition in Taurus and at perihelion and faded after discovery.

#### u *114P/Wiseman–Skiff (1993 IX)*

Suspected weak images of this comet on CCD frames were obtained by B. Schmidt with the Multiple Mirror Telescope at Mt. Hopkins on 1993 February 2. They were confirmed with an independent recovery by Jim Scotti in Spacewatch images obtained by Tom Gehrels at Kitt Peak on 1993 December 16 (low altitude, twilight, rather poor seeing), after which Scotti found the comet on a single frame obtained on December 10. On December 16, the 21<sup>m</sup> comet showed a coma 13" in diameter, with a faint 0'.34 tail in p.a. 286°. [IAUC 5908, 1993 December 16]. The comet was emerging from conjunction, moving south east on the borders of Corvus and Hydra.

A close approach to Jupiter in 1984 diverted the comet

**Table 7. Ephemeris for comet Mueller 1993p**

Magnitudes calculated from  $m = 7.9 + 5.0 \text{ Log}(\Delta) + 7.3 \text{ Log}(r)$   
Latitude: 53.0°N Longitude: 0.0°W

Day	R.A. hh mm.m (2000.0)	Dec ° mm	Mag	$\Delta$ AU	R AU	Observable hh.mm to hh.mm	Elong. °
1993 August							
10/11	1 47.7	49.33	14.3	3.18	3.39	22.53 to 2.50	93
20/21	1 42.8	49.59	14.0	2.93	3.28	21.45 to 3.15	101
30/31	1 33.8	50.08	13.7	2.68	3.17	20.35 to 3.38	110
1993 September							
09/10	1 20.3	49.48	13.4	2.44	3.05	19.55 to 3.59	119
19/20	1 02.1	48.45	13.0	2.21	2.94	19.28 to 4.19	128
29/30	0 39.9	46.38	12.7	2.01	2.82	19.03 to 4.38	136
1993 October							
09/10	0 15.5	43.11	12.4	1.84	2.70	18.39 to 4.55	142
19/20	23 51.5	38.13	12.1	1.72	2.58	18.17 to 4.38	143
29/30	23 30.2	31.56	11.8	1.63	2.46	17.58 to 3.12	138
1993 November							
08/09	23 13.4	24.50	11.6	1.60	2.34	17.42 to 1.45	128
18/19	23 01.5	17.36	11.5	1.61	2.22	17.29 to 0.22	115
28/29	22 54.3	10.47	11.3	1.66	2.10	17.21 to 23.03	102
1993 December							
08/09	22 51.2	4.42	11.2	1.73	1.97	17.17 to 21.50	89
18/19	22 51.5	-0.33	11.1	1.80	1.85	17.18 to 20.43	77
28/29	22 54.6	-5.03	11.0	1.88	1.72	17.24 to 19.40	66
1994 January							
07/08	23 00.0	-8.58	10.8	1.95	1.60	17.34 to 18.41	55
17/18	23 07.3	-12.27	10.6	1.99	1.48	Not observable	46
27/28	23 16.3	-15.40	10.4	2.02	1.37	Not observable	37
1994 February							
06/07	23 26.8	-18.45	10.2	2.01	1.26	Not observable	30
16/17	23 38.9	-21.53	9.8	1.98	1.16	Not observable	25
26/27	23 53.0	-25.10	9.5	1.90	1.08	Not observable	24
1994 March							
08/09	0 09.7	-28.44	9.2	1.79	1.01	Not observable	27
18/19	0 30.7	-32.43	8.9	1.64	0.98	Not observable	33
28/29	0 58.8	-37.14	8.6	1.47	0.97	Not observable	41
1994 April							
07/08	1 39.9	-42.15	8.4	1.28	0.99	Not observable	50
17/18	2 45.2	-47.16	8.2	1.09	1.04	Not observable	60
27/28	4 27.9	-49.46	8.2	0.95	1.12	Not observable	70
1994 May							
07/08	6 31.7	-45.16	8.3	0.90	1.21	Not observable	79
17/18	8 09.1	-34.29	8.7	0.96	1.32	Not observable	84
27/28	9 11.2	-23.28	9.3	1.12	1.43	Not observable	84
1994 June							
06/07	09 51.8	-15.07	9.9	1.34	1.55	Not observable	81
16/17	10 20.7	-9.21	10.5	1.60	1.67	Not observable	76
26/27	10 43.2	-5.24	11.1	1.87	1.79	Not observable	70

into its present orbit and it was discovered in December 1986. This was its first return after discovery and the predicted ephemeris required a correction of -0.08 days. The 6.5 year period means that alternate returns are unfavourable and this was a poor one.

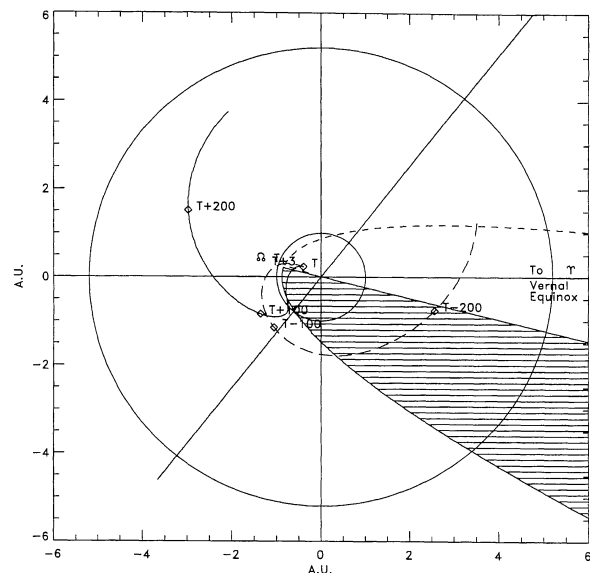
#### v *McNaught–Russell (1993 Y1, 1994 XI)*

Robert H. McNaught discovered a 17<sup>m</sup> comet on a UK Schmidt Telescope plate taken by Kenneth S. Russell on December 17.5. The comet showed a coma of diameter 8" and a very faint tail 10" long in p.a. 20°. [IAUC 5910/5911, 1993 December 18]. The comet was at evening quadrature, moving west in Horologium and three months from perihelion. The comet has a long period of around 1500 years. Calculations by Nakano and Hasegawa [IAUC 5943, 1994

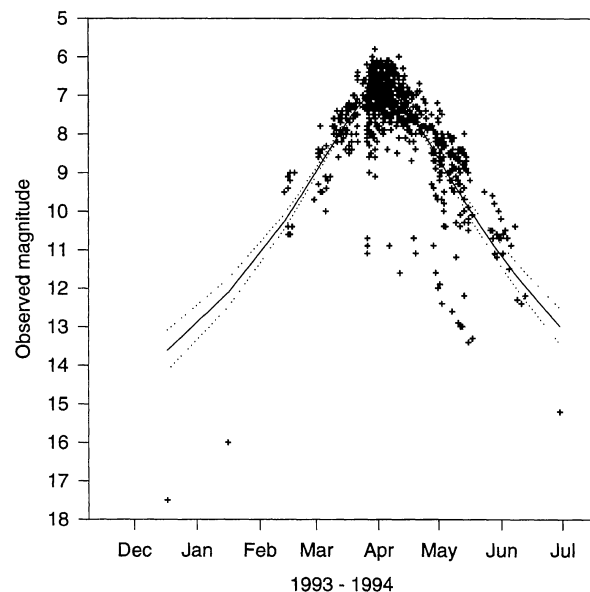
March 2] suggest a possibility that the comet may be identical with one seen in 574, although the residuals are over a degree.

Section observations cover the range T-103 to T+90 days. The comet moved along Eridanus and reached perihelion in Taurus. It continued moving rapidly north through Auriga and Camelopardalis, reached its highest northern declination in Draco and was last seen in Hercules.

Early visual observations showed that the comet was much brighter than expected from the discovery photographs, once again showing that it is worth attempting



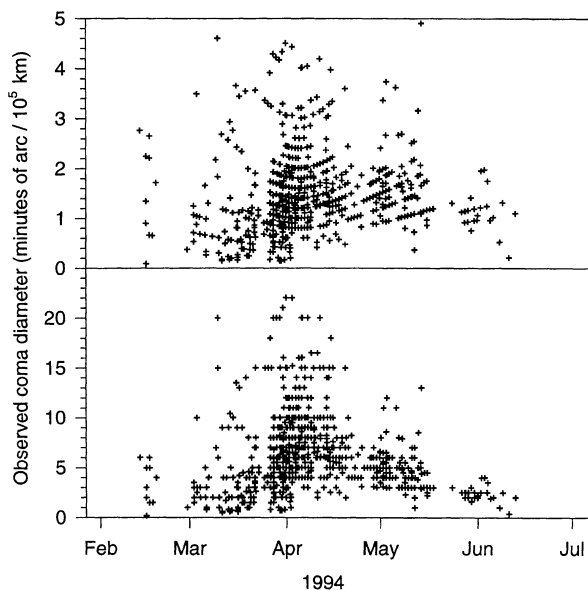
**Figure 13.** The orbit of comet McNaught-Russell 1993v. **a)** Viewed from the north ecliptic pole. **b)** Viewed from the ascending node of the comet's orbit looking towards the Sun. **c)** Viewed from the rotating reference frame. The comet was discovered at T-103; observations used in the analysis cover the range T-46 to T+74.



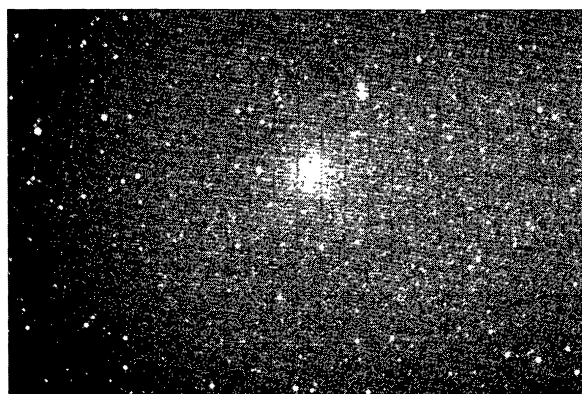
**Figure 14.** The observed magnitude of comet 1993v. The curve is a best fit over the apparition, with no corrections applied. Photographic and CCD observations lie much below the visual light curve. Tick marks indicate the first of each month from 1993 December.

visual observation of comets which have only been observed photographically or with CCD detectors by large aperture telescopes. Because of the large discrepancy between visual and CCD/photographic magnitudes for this comet, only observations in the range T-46 to T+74 have been used in the analysis of the light curve. Other comets imaged during the year have not shown such a large discrepancy, so this may reflect an unusual emission spectrum as the coma is not markedly unusual.

Initially a southern hemisphere object it was not observed visually until mid-February, though in retrospect the light curve suggests that it could have been observed several weeks earlier. Albert Jones, observing from Stoke, New Zealand, made the comet 10.6<sup>m</sup> in his 0.32m reflector  $\times 100$  on February 15. It brightened rapidly moving north and Jonathan Shanklin was able to pick it up low in the evening twilight on March 16 when it was about 7.3<sup>m</sup> in 10 $\times$ 80B. A few observers were able to glimpse it during



**Figure 15.** The coma diameter of comet 1993v. The lower panel shows the observed coma diameter and the upper panel the true diameter in 100,000km. Tick marks indicate the first of each month from 1994 February.



**Figure 16.** Comet 1993v photographed by Alex Vincent on 1994 April 11<sup>d</sup> 21<sup>h</sup> 15<sup>m</sup> using a five minute exposure on Fujichrome 400 slide film at the prime focus of a 0.3m f5 reflector.

the BAA Winchester weekend (March 25–27), despite the light of a full moon. As it moved higher in the sky more observers were able to find it and peak brightness was reached in early April; Guy Hurst observing on April 3 made it 6.9<sup>m</sup> in 15×80B. A short tail became apparent: Atilla Kosa–Kiss observing on April 4 estimated it at 1°.5 long in p.a. 50. Several observers obtained photographs around this time.<sup>20,21,22</sup> By mid April it was already fading, Melvyn Taylor making it 8.0<sup>m</sup> in 16×80B on April 18. As it faded it became less condensed; Werner Hasubick observing on May 14 estimating it at 9.7<sup>m</sup>, DC2 in 25×100B with a 3' diameter coma. A few observers followed it into June, Jonathan Shanklin making it 11.5<sup>m</sup> on June 5 in his 0.33m reflector ×85. Mikuz was able to find it

with his CCD system on June 30, measuring the magnitude at 15.2, considerably fainter than predicted by the visual light curve.

The coma diameter increased from 2' in February to around 10' in early April, declining to 1' by mid-June. Many observers reported diameters greater than 10' in early April, some up to 22'; this may imply a faint outer coma, but more probably there was confusion between the coma and tail. The true diameter increased from around 100,000km in February to 200,000km in early April, declining back to 100,000km in June. The DC figures again show a wide range (0–8), but the mean curve shows a clear increase from DC2 at T–45 to DC4 at T, becoming very diffuse (DC0) by T+60. The tail appeared between T–10 and T+40, with a

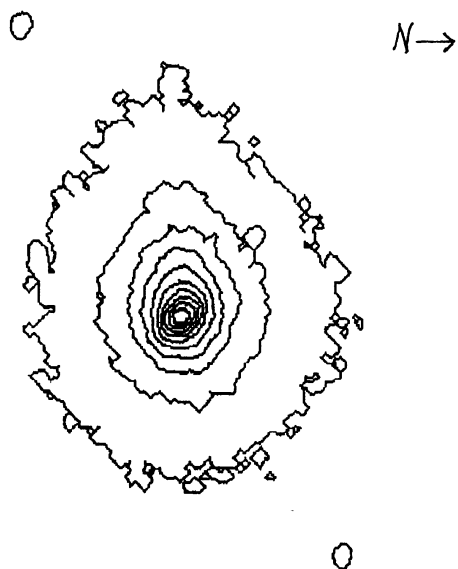


Figure 17. Isophot of Comet McNaught–Russell 1993v prepared by Bev Ewen–Smith on 1993 April 2<sup>d</sup> 20<sup>h</sup> 58<sup>m</sup> using a 0.3m reflector and 120-second integration on an ST4 CCD.

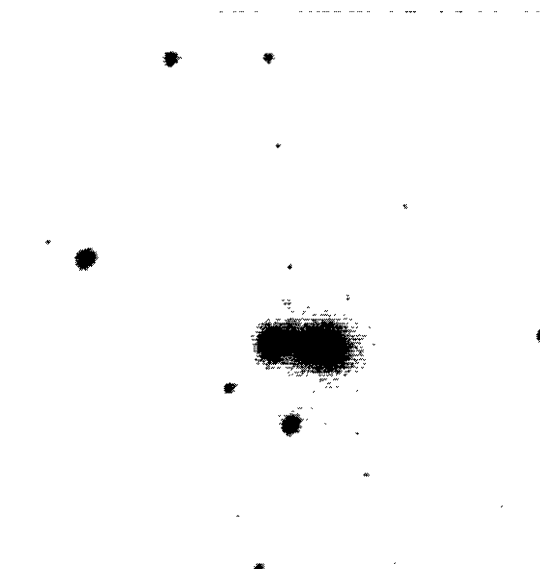


Figure 19. Comet 1993v imaged by Roy Mitchell on 1994 April 13<sup>d</sup> 21<sup>h</sup> 56<sup>m</sup> using a 0.25m f4.5 reflector and 20 second integration on an ST4 CCD.

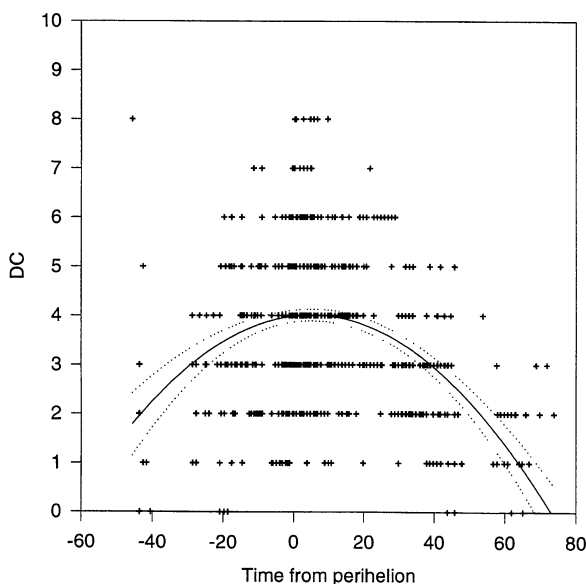


Figure 18. The DC of comet 1993v. The curve is a best fit 2nd order regression with 95% confidence limits.

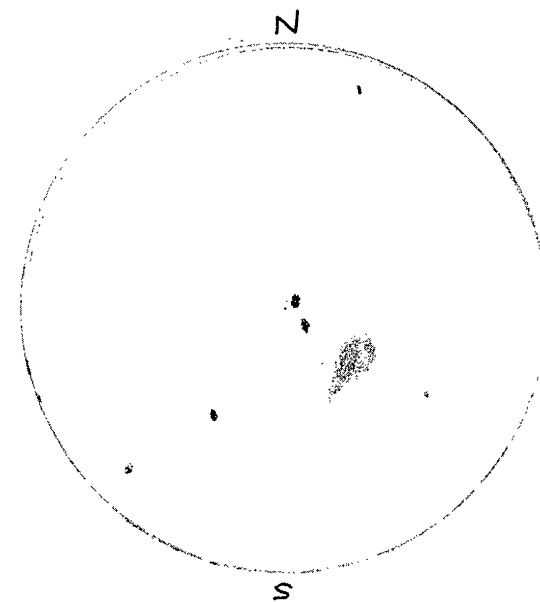


Figure 20. Comet 1993v drawn by Sally Beaumont on 1993 April 8.88 using a 0.13m refractor ×20.

**Table 8. Ephemeris for comet McNaught–Russell 1993v**

Magnitudes calculated from  $m = 9.0 + 5.0 \text{ Log}(\Delta) + 8.5 \text{ Log}(r)$   
 Latitude: 53.0°N Longitude: 0.0°W

Day	R.A. hh mm.m (2000.0)	Dec ° mm (2000.0)	Mag	$\Delta$ AU	R AU	Observable hh.mm to hh.mm	Elong. °
1994 January							
07/08	2 40.9	-54.26	11.6	1.44	1.65	Not observable	83
17/18	2 37.1	-52.17	11.2	1.35	1.52	Not observable	79
27/28	2 38.9	-49.28	10.7	1.25	1.39	Not observable	76
1994 February							
06/07	2 46.1	-45.54	10.1	1.14	1.27	Not observable	73
16/17	2 58.5	-41.20	9.5	1.01	1.15	Not observable	70
26/27	3 15.7	-35.13	8.9	0.87	1.04	Not observable	68
1994 March							
08/09	3 37.2	-26.27	8.1	0.72	0.96	Not observable	66
18/19	4 02.7	-13.01	7.4	0.58	0.90	19.32 to 20.03	63
28/29	4 32.4	7.29	6.9	0.49	0.87	19.52 to 21.58	60
1994 April							
07/08	5 08.0	33.14	6.9	0.47	0.88	20.13 to 0.36	61
17/18	5 56.2	55.31	7.4	0.53	0.93	20.36 to 3.23	66
27/28	7 13.4	69.37	8.1	0.65	1.00	21.01 to 2.55	71
1994 May							
07/08	9 20.7	76.02	8.8	0.78	1.10	21.27 to 2.26	75
17/18	11 39.2	76.05	9.5	0.92	1.22	21.56 to 1.57	78
27/28	13 07.6	72.47	10.2	1.05	1.34	22.26 to 1.29	81
1994 June							
06/07	13 57.7	68.26	10.8	1.18	1.46	22.54 to 1.03	83
16/17	14 29.5	63.49	11.3	1.31	1.59	23.15 to 0.46	85
26/27	14 52.7	59.08	11.8	1.44	1.72	23.17 to 0.49	87
1994 July							
06/07	15 11.4	54.29	12.3	1.58	1.85	22.58 to 1.11	88
16/17	15 27.9	49.56	12.7	1.72	1.98	22.32 to 1.40	89
26/27	15 43.1	45.32	13.1	1.86	2.11	22.04 to 1.58	89

maximum observed length of 1°.5 just after perihelion, corresponding to a true length of only 0.01AU.

### Other comets

#### 29P/Schwassmann–Wachmann 1

Mikuz continued studying the comet with his CCD system, finding it in outburst at up to 13<sup>m</sup> in February,<sup>23</sup> March, April, late October–November and December. During its February outburst Jean–Claude Merlin photographed it on February 15<sup>24</sup> and Werner Hasubick on February 26. Somewhat disappointingly no Section observers followed it visually, though observations were reported on *IAUC*.

Infrared observations on October 22, November 11 and 12 by M. C. Senay and David Jewitt with the JCMT on Mauna Kea suggested a CO production rate of 2000 kg s<sup>-1</sup>, which is sufficient to drive the observed dust activity in the comet [*IAUC* 5929, 1994 February 4]. This was the first direct evidence that activity in comets beyond the orbit of Jupiter can be powered by carbon monoxide.

#### McNaught–Tritton 1978 G2 (1978 XXVII)

On *IAUC* 5866 [1993 September 18] Rob McNaught reported finding an image of a comet on a UK Schmidt plate

which confirmed an earlier image reported on *IAUC* 5471 [1992 March 10]. It was subsequently found on other plates taken at Siding Spring in 1978 April and 1980 January. The comet, which has a large perihelion distance of 6.3AU, did not receive an old style year letter, but was assigned a perihelion number for 1978.

### Comets not recovered

#### D/Lovas 2 1986 WI

Predicted to be at perihelion in early June, the return was a little unfavourable, but it should have attained about 15<sup>m</sup> at a reasonable elongation.

### Acknowledgments

Thanks are due to the late Harold Ridley for preparing the excellent series of prospects for comets, which were distributed with the Section newsletters for many years. Some of the background material to this present series of papers comes from these and also from his unpublished work in the Section archives. Thanks are also due to Guy Hurst for the long hours spent in preparing cometary material for publication in *The Astronomer* magazine.

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# Measurement and analysis of radio emission from the quiet Sun

J. C. D. Marsh

A description is given of the measurement of solar radio emission at a wavelength of approximately 2m, together with a method of calculating radiated power at this wavelength and an estimate of the coronal temperature. Some results are given which agree reasonably well with the theoretical figures.

## Introduction

The apparatus, discussed briefly below, has been described in detail in a previous paper<sup>1</sup> in which measurements were made of the flux from the radio sky at 2m which were then converted into a simple radio map of the sky.

Whilst taking these measurements, the radio emission from the sky background was often obscured by emission from the Sun for a considerable time, as the beamwidth of the aerial was such that it took the Sun something in excess of four hours to traverse the beam. These measurements however were taken when the Sun was in an active phase. In this note the principal aim is to record, measure and analyse the solar radio emission during the quiet period of the solar cycle so that the results, if taken daily, would be a useful record which could then be correlated with measurements of different parameters recorded by other solar observers. Additionally the results should also confirm within reasonable experimental limits the published values of temperature and radiated power to be expected from the Sun.

## The radio telescope receiver

The receiving system consists of an 8-element Yagi aerial, the output from which is connected by low loss cable to a low noise preamplifier which in turn feeds the main receiver. The input frequency at 151.5 MHz is changed to an intermediate frequency of 29.0 MHz which is then amplified, detected and further amplified before being fed to a

chart recorder. The system bandwidth is 300kHz and has an overall gain of  $1.8 \times 10^6$  (125dB). The output circuits of the detector have a variable time constant switchable in five steps from 0.5 seconds to 20 seconds.

The aerial is oriented due south and elevated to an angle corresponding to declination =  $0^\circ$ . The horizontal polar diagram is shown in Figure 1, and since the vertical polar diagram is very similar to the horizontal diagram it means that the Sun, in passing through transit, always traverses the beam, though not necessarily exactly through the centre. It is not considered that this invalidates the readings as they are meant to be comparative from day to day rather than absolutely accurate, and in fact the displacement from the centre of the beam can be allowed for very simply in the calculations.

It has been found through experience that a receiver time constant of 20 seconds is about right. Anything much shorter and the trace of the pen recorder becomes impossibly noisy and prone to short spasms of interference e.g. from passing cars and tractors, but it is sufficiently short to register fairly short bursts of solar radiation which often indicate a disturbance emanating on or above the photosphere. Other types of interference signals are dealt with later in this paper.

## Theoretical considerations

It has been well established<sup>2</sup> that most of the radio emission from the Sun at wavelengths of around 2m originates in the corona, which is mainly ionised hydrogen. The radio emission from ionised gas comes from electrons detached from their parent atoms. These free electrons possess no definite energy levels and their radiation is in the form of a continuous spectrum generated by the acceleration of the electron as it is deflected when passing by a proton. Since the electron is only temporarily influenced by the interaction this interaction is called free-free transition. At metre wavelengths it can be shown<sup>3</sup> that the flux density of the emission varies inversely as the square of the wavelength as in the case of a thermal black body, hence the term thermal emission. This being so, the brightness of a black body, the effective radiated power flux per unit bandwidth, may be determined from the Planck equation:

$$B = 2hf^3/c^2 \times 1/(e^{hf/kT} - 1) \text{ (Wm}^{-2} \text{ Hz}^{-1}) \dots [1]$$

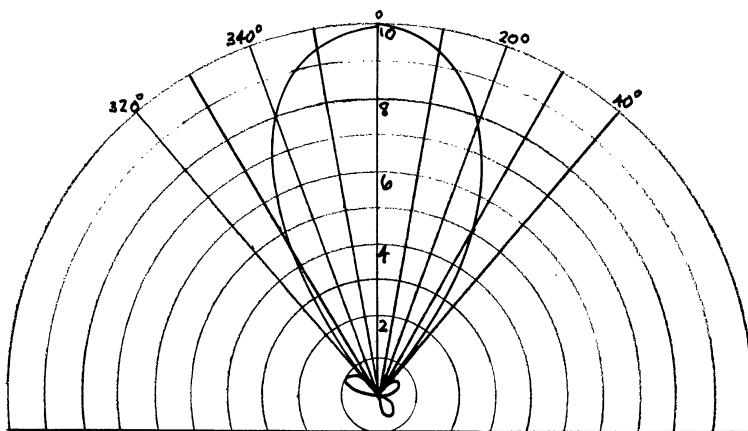


Figure 1. Polar diagram of an eight-element Yagi aerial.

## Radio emission from the quiet Sun

where  $h$  = Planck's Constant,  $6.6254 \times 10^{-34}$  joule sec  
 $f$  = frequency, Hz  
 $c$  = velocity of light,  $3 \times 10^8$  ms $^{-1}$   
 $k$  = Boltzmann's Constant,  $1.3805 \times 10^{-23}$  joule K  
 $T$  = temperature, K  
 $\lambda$  = wavelength, m

The Planck equation may be much simplified by setting  $hf/kT = x$ , so that Eq.[1] becomes

$$B = 2hf^3/c^2 \times 1/(e^x - 1) \quad \dots [2]$$

Expanding  $e^x = 1 + x + x^2/2! + x^3/3! \dots$  .... [3],

if  $x$  is very small  $x^2/2!$  and  $x^3/3!$  etc. become negligible, therefore Eq. 3 becomes  $e^x = 1+x$ , and Eq. 2 may be written

$$B = 2hf^3/c^2 \times 1/(1 + x - 1) = 2hf^3/c^2x \quad \dots [4]$$

But  $x = hf/kT$ , so Eq.[4] becomes

$$B = 2hf^3/c^2 \times kT/hf = 2kTf^2/c^2 \quad \dots [5].$$

Recalling that  $f^2/c^2 = 1/\lambda^2$ ,

$$B = 2kT/\lambda^2 \quad \dots [6].$$

This is valid for  $f = 151.5$  MHz and for  $T = 10^6$ K since

$$x = hf/kT = 6.63 \times 10^{-34} \times 151.5 \times 10^6 / 1.38 \times 10^{-23} \times 10^6 = 7.27 \times 10^{-9},$$

i.e.  $x$  is indeed very small so equation [6] is valid.

For a discrete source such as the Sun the brightness is equivalent to the flux generated by the free-free emission and is usually designated:

$$S = 2kT/\lambda^2 \quad (\text{Wm}^{-2} \text{ Hz}^{-1}) \quad \dots [7]$$

To arrive at the equivalent temperature of the radiation it should be recalled that since the radiation is electromagnetic and decreases in intensity with distance according to the square law, it may be assumed that by the time the radiation reaches Earth its intensity is reduced by

$$[R_{\odot}/d]^2$$

where  $R_{\odot}$  = solar radius,  $925 \times 10^6$ m  
and  $d$  = 1 AU,  $1.5 \times 10^{11}$ m

It should be noted that at a wavelength of 2m the effective diameter of the radio Sun exceeds the optical diameter,  $696 \times 10^6$ , by a factor of about 0.3 since the radiation is emitted from the outer corona.<sup>4</sup>

Therefore the solar flux reaching Earth is given by

$$S = 2kT/\lambda^2 [R_{\odot}/d]^2 \quad (\text{Wm}^{-2} \text{ Hz}^{-1}) \quad \dots [8]$$

Rearranging this equation allows  $T$  to be calculated:

$$T = S\lambda^2/2k [d/R_{\odot}]^2 \quad (\text{K}) \quad \dots [9]$$

### System characteristics

The parameters of the receiver are as follows:

Voltage gain	1800000 = 125 Db
Input impedance	50 ohms
Bandwidth	300 kHz
Effective aerial aperture	4m <sup>2</sup>
Polarisation	linear vertical
Sensitivity of chart recorder	100mV/cm

The voltage gain was measured by using as an input a 0.5 microvolt matched impedance source. The sensitivity of the chart recorder was checked by means of a standard battery, and the bandwidth by means of a Marconi signal generator.

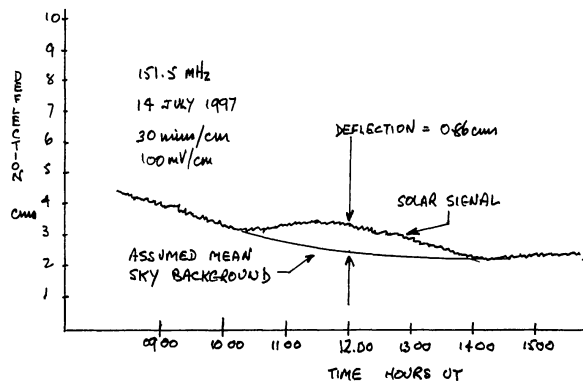


Figure 2. The typical deflection from the quiet Sun.

The effective aerial aperture of 4m<sup>2</sup> is that given for an 8-element Yagi array, taken from the VHF/UHF Manual, Evans & Jessop.<sup>5</sup> Hence, making the reasonable assumption that the emission from the Sun is that of a black body, the solar flux can be calculated from the recordings of the chart recorder applied to the simplified Planck equation.

### Results

Figure 2 shows the trace of the radio emission from the Sun transiting the aerial beam between approximately 09.25 UT to 14.30 UT on 1997 July 14. It may be noted that the deflection above the estimated sky background level amounted to about 0.86cms. It is this figure which is used for the calculations later in this paper. It may be mentioned here that this is a typical deflection which has been recorded daily for the past two years or so. Variations in magnitude have been minimal. Figure 3, taken on 1997 July 3, shows a low mean level of activity from a quiet solar transit but includes the result of a multimedia computer being switched on and run for about 45 minutes. It is not known exactly from where this interference originates in the computer but the result is so clearly defined that it may be ignored or allowed for when taking measurements. The computer was about 20m from the receiver.

The trace of Figure 4 shows clearly the effect of a thunderstorm. This effect is not unlike a burst of radiation from the Sun but fortunately a thunderstorm is fairly noticeable. The writer is unable to offer an explanation of the pattern of radiation from the storm, in particular the 'dip' part way along the trace. Suggestions would be appreciated.

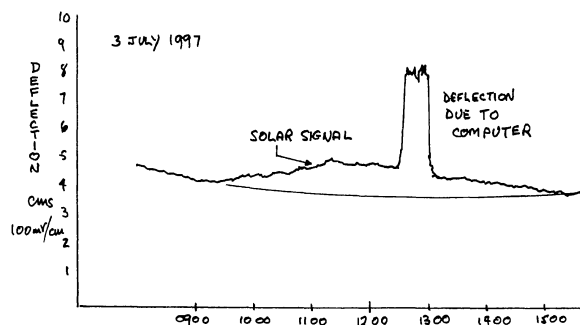


Figure 3. Interference due to a personal computer.

## Radio emission from the quiet Sun

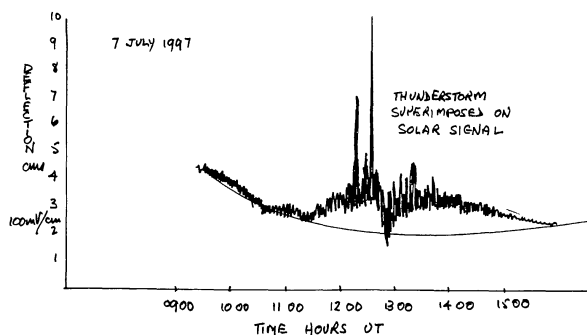


Figure 4. Interference from a thunderstorm.

Figure 5 shows the effect of fixed and mobile radio communications (in this case a local taxi firm) breaking through. This was identified by listening to the audio output from the receiver. It may be of interest to note that a true burst of solar radiation has a very distinctive audio sound; it has been likened to waves of the sea coming ashore.

### Calculations

The specimen calculation of solar flux from the quiet Sun was calculated by measuring the deflection of the trace shown in Figure 2 at the mid-point of the solar transit and from that deflection, deriving the effective measured output voltage. Using the receiver parameters given above,

$$\begin{aligned} \text{Deflection of trace} &= 0.86 \text{ cm} \\ \text{Equivalent output voltage, } V_o &= 0.086 \text{ volts} \\ \text{Input voltage, } V_{in} = V_o/\text{gain} &= 0.086/(1.8 \times 10^6) \\ &= 4.8 \times 10^{-8} \text{ volts} \end{aligned}$$

Allowing for the single polarisation of the aerial,  $V_{in}$  should be doubled, therefore true  $V_{in} = 9.6 \times 10^{-8}$  volts.

Further correcting for the displacement of the Sun from the centre of the beam by a factor of 1.45 due to the difference in declination of some  $23^\circ$ ,

$$\begin{aligned} \text{Corrected } V_{in} &= 1.4 \times 10^{-7} && \text{Volts} \\ \text{Input power, } P_{in} &= V_{in}^2/R \\ &= (1.96 \times 10^{-14})/50 \\ &= 3.92 \times 10^{-16} && \text{W} \end{aligned}$$

For an aerial aperture of  $4\text{m}^2$ , input power at receiver terminals is given by

$$P_{in}/4 = 9.8 \times 10^{-17} \text{ Wm}$$

and for a bandwidth of 300 kHz the input flux  $S = 3.27 \times 10^{-22} \text{ Wm}^2/\text{Hz}$ .

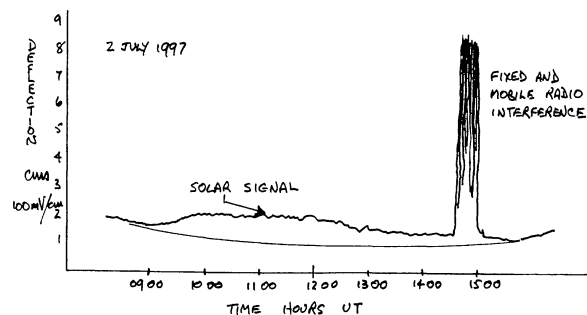


Figure 5. Interference from fixed and mobile radio communications.

From this figure the temperature of the source can be calculated from:

$$3.27 \times 10^{-22} \times 4/2 \times 1.38 \times 10^{-23} [1.5 \times 10^{11}/925 \times 10^6]^2$$

whence the temperature =  $1.25 \times 10^6\text{K}$ .

### Conclusions

The results, happily, have been much as expected. During the current period of the quiet Sun the power measured corresponds with what is normally expected, i.e., typically  $10^{-22} \text{ W.m}^{-2}\text{Hz}^{-1}$ , corresponding to a temperature of approximately  $10^6\text{K}$ . The figure arrived at for the temperature from the above calculations is not claimed to be exact, but allowing for errors, principally in measuring by hand the displacement of the solar signal from the assumed mean sky background, any error in the published theoretical aerial polar diagram and the assumed diameter of the radio Sun, the order of magnitude is correct and is repeatable. Realistically the errors would not be expected to exceed  $\pm 20\%$ . The system is seen to suffer from various forms of interference but over the course of a regular series of observations it is clearly possible to monitor the general behaviour of the quiet Sun.

A measure of improvement might be to remove some of the directors of the Yagi aerial so as to widen the beamwidth. There would be a resulting loss of sensitivity but that would probably be insignificant and might be more than compensated by the time the Sun was within the aerial beam, so as to allow a longer period of observation. This however is not important since the flux from the quiet Sun does not vary significantly and as long as a sufficient duration of observation is obtained to establish the mean background level and the deflection due to the solar transit, the present setup is considered adequate. An interferometer would lessen the effect of interference but again it has been shown that with care most forms of interference can be allowed for.

The incorporation of the ability to measure frequency drift in the event of emission from solar flares would be extremely useful. Authorities, including Hey,<sup>2</sup> Kraus<sup>3</sup> and Piddington,<sup>6</sup> discuss the frequency behaviour of the various categories of solar flares and such an investigation might well form part of a future programme. Ideally the observational programme should be carried on throughout the 11-year solar cycle, but no promises are made.

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# A report on the Mira variable R Aquilæ

John Greaves

*A report of the Variable Star Section (Director: G. Poyner)*

Observations from 1908 to 1997 of the Mira-type variable R Aquilæ are presented and analysed.

## Introduction

The Mira star R Aql is one of the most popular variable stars in the Section's telescopic/binocular programme. Varying between magnitudes 4.9 to 12.7, it can reach naked eye visibility, but is more usually observed with binoculars when near maximum brightness. At minimum brightness, it still lies within easy reach of a 200mm telescope. The BAAVSS archive contains some 12,118 visual observations in machine-readable form dating from the period 1899 to 1997.

Positive observations from 1908 September to 1997 January, amounting to 109 cycles, were taken from this full 1899 to 1997 BAAVSS archive and separated into 9 sequential groups of exactly 12 cycles each (with 13 cycles in one instance where a maximum had been missed due to seasonality). Observations prior to 1908 were insufficiently complete to be of any real value. Unfortunately there was a complete gap in the archive for the years 1934 to 1938 inclusive, which would have meant having to start the investigation from 1939. In order to avoid this problem, and further so as not to waste the excellent data between 1908 and 1934, this interregnum was filled via the AFOEV public domain archive at the CDS, Strasbourg.<sup>1</sup> The resulting subsets of data are illustrated by Figures 1a-1i inclusive, where the abscissa represents the Julian Day minus 2400000 and the ordinate represents the star's magnitude.

## Period

An average period was derived for each of these cycle groups with software<sup>2</sup> utilising Phase Dispersion Minimisation, the results being shown in Table 1. A mean rate of

**Table 1. Average periods derived by the phase dispersion method**

Subset	Period (d)	$\delta P$ (d)	No. of data points
1	315.5		1425
2	309.5	-6.0	1984
3	303.0	-6.5	1598
4	300.0	-3.0	863
5	298.0	-2.0	854
6	292.5	-5.5	739
7	283.5	-9.0	1548
8	280.5	-3.0	1856
9	277.0	-3.5	1049
Mean		-4.8	

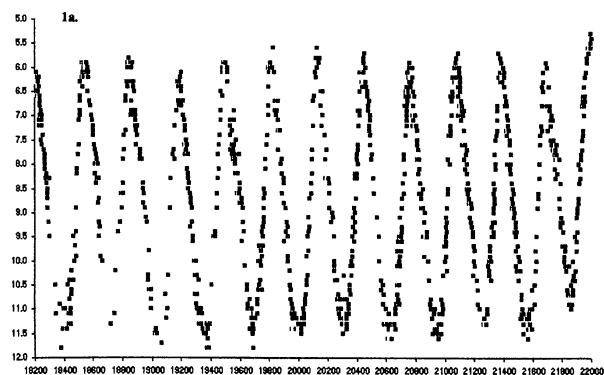
**Table 2. Predicted maxima**

Cycle	Maximum	Cycle	Maximum
110	1997 Oct 13	119	2004 Jul 06
111	1998 Jul 14	120	2005 Apr 04
112	1999 Apr 15	121	2005 Dec 31
113	2000 Jan 13	122	2006 Sep 27
114	2000 Oct 13	123	2007 Jun 24
115	2001 Jul 13	124	2008 Mar 20
116	2002 Apr 12	125	2008 Dec 15
117	2003 Jan 09	126	2009 Sep 10
118	2003 Oct 09	127	2010 Jun 05

0.4 days change in period per cycle is given, which using a crude approximation [ $0.4 \times (13 \times 365.25)/277$ ] leads to the prediction of an average period of around 270 days by the year 2010, as shown in Figure 2.

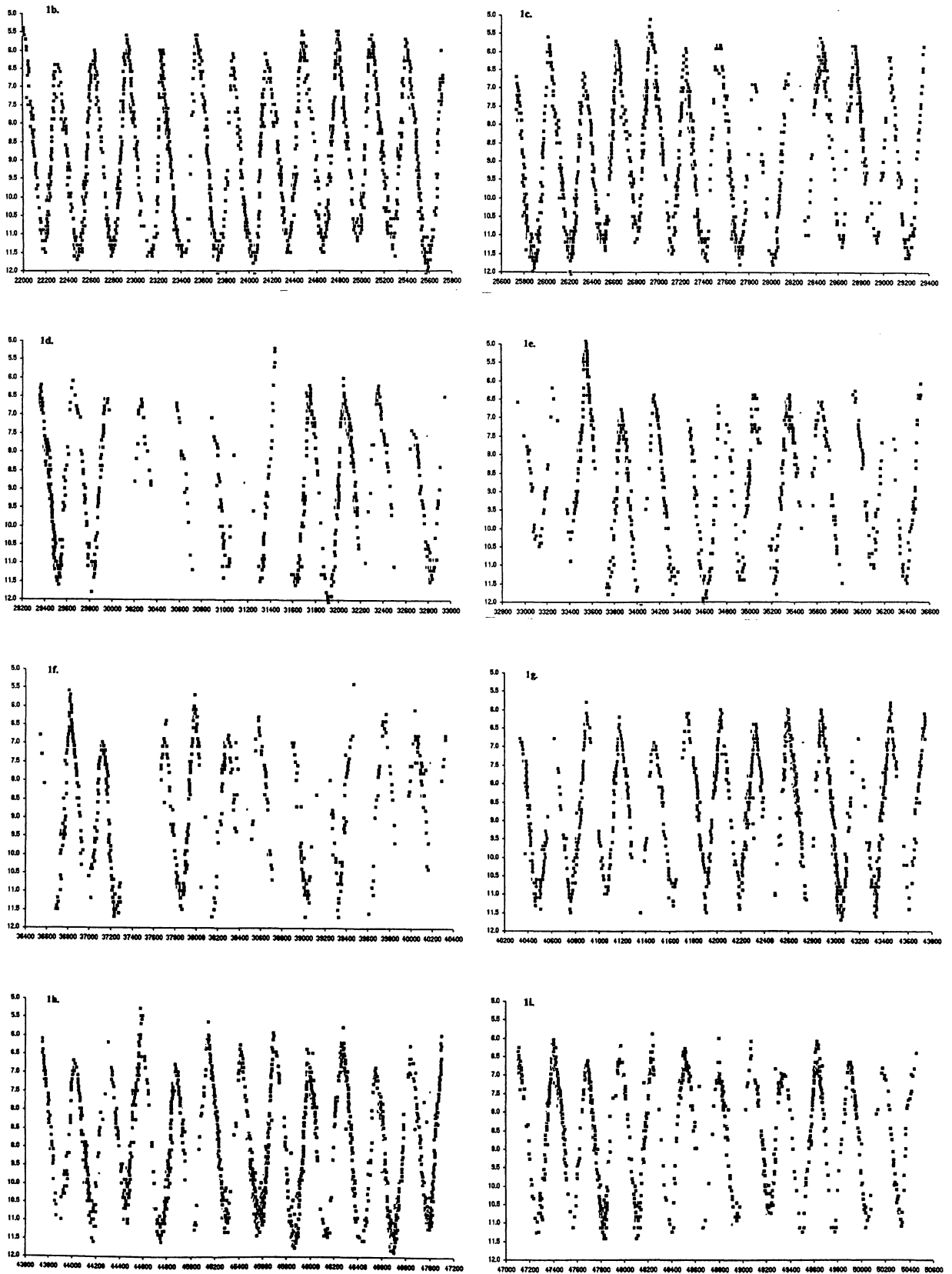
It should be noted, however, that there is a large scatter for the period's rate of decline between subsets, and the decline is not necessarily as smooth as shown. All the averages quoted had an index level of better than 0.2 on an inverse scale ranging from 1.0 (essentially random) to 0.0 (infinitely accurate) that is defined as being the variance of the dataset divided by the mean of the data bin's variances<sup>2</sup> for each trial period; that is the less the scatter for an individual period the better the fit and the lower the numerical value derived for the index.

The data were independently processed to generate an Observed minus Calculated (O-C) diagram. The zeroth maximum of JD 2418213 was defined as the base epoch and 315.5, the value derived from the first subset (above), was defined as the period. Times of maxima were laboriously derived for as many of the 109 cycles as possible (104 in



**Figure 1.** (Continued on opposite page). Lightcurves of R Aql from nine subsets of BAAVSS and AFOEV data.

Report on *R Aquilae*



Figures 1b–1i. Lightcurves of *R Aql* from nine subsets of BAAVSS and AFOEV data.

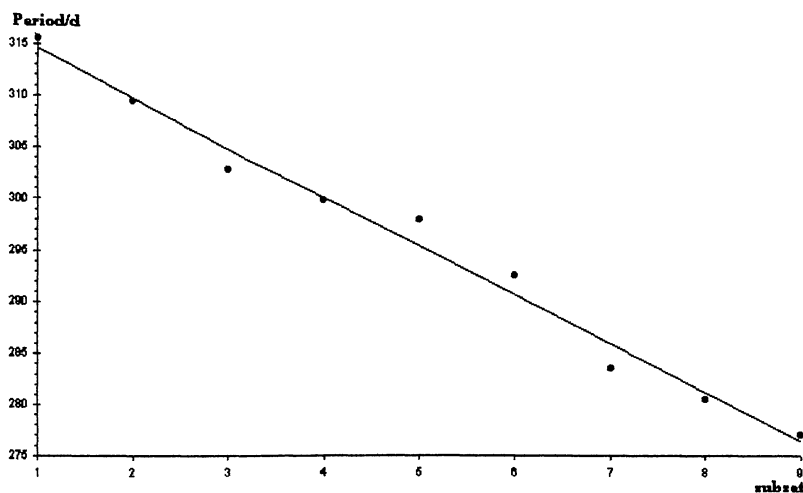


Figure 2. Average periods per 12 cycles for R Aquilæ from 1908 September to 1997 January. The 'best fit' line has a slope of  $-4.8$ .

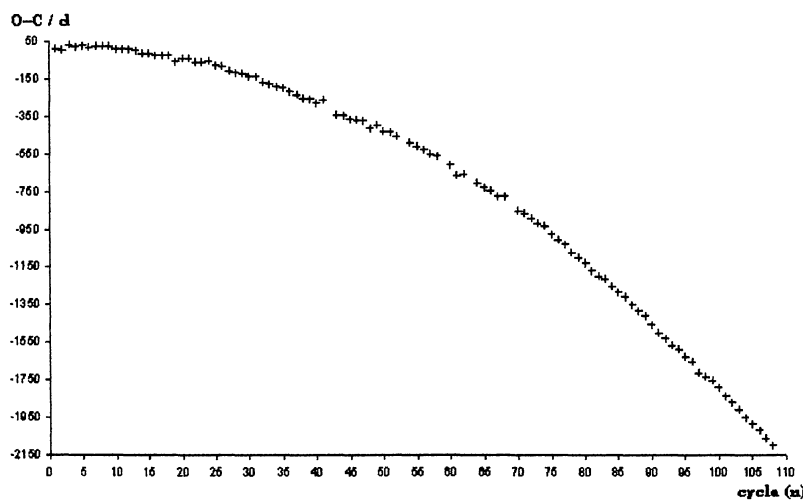


Figure 3. Observed - Calculated epochs in days plotted against their cycle number,  $n$ . Base epoch is JD 2418213, cycles are folded on a period of 315.5 days.

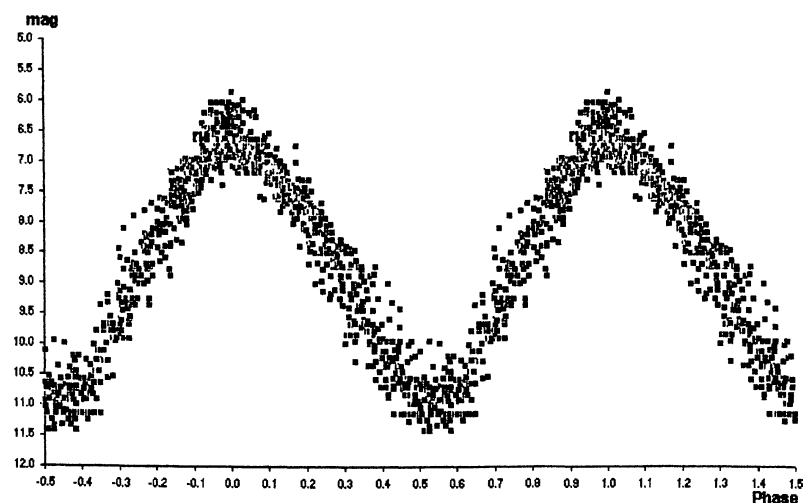


Figure 4. Representative phase diagram of R Aquilæ using subset 9 folded on 277 days.

total). The derived observed minus calculated epochs were then plotted against cycle number as shown in Figure 3.

The resultant curve is fitted by the quadratic function

$$y = -0.1871x^2 + 0.5402x + 20.011.$$

Using this value for  $\Delta P/P$  in the formula:<sup>3</sup>

$$(O-C)_n = (\Delta P/P)n^2$$

and noting that  $(O-C)_n/P$  denotes the total discrepancy that has occurred between the observed epoch and the base epoch for the current calculated epoch, we can substitute within it to give the predicted maxima as shown in Table 2.

By simply subtracting the previous date from each of the current ones and assuming an (unreal) smooth decline in period, as these predictions suggest, we find that by 2010 the period has declined to around 269 days, not greatly dissimilar from the 270 days derived by the completely independent approach used above.

## Phase diagram

Finally, by folding the BAAVSS data for the last twelve complete periods around their derived average period of 277 days we obtain the phase diagram shown in Figure 4, which is included both as a representative lightcurve and an indication of the 'goodness of fit' of the data (two complete cycles are shown for illustrative purposes).

## Acknowledgments

I would like to thank the VSS Director Gary Poyner, without whom this paper could not have reached a form suitable for the JBAA. I also thank Tristram Brelstaff for his constructive comments on a preprint of the paper, the VSS computer secretary Dave McAdam for prompt and efficient provision of the data for R Aql from the BAAVSS archive, and Steven Gregory who by allowing unstinting access to the Internet has enabled the author to find the minutiae of information that are so well hidden thereon.

Report on *R Aquilæ*

The VSS Archive is supported in part by the Royal Astronomical Society and the Star Gazers' Trust.

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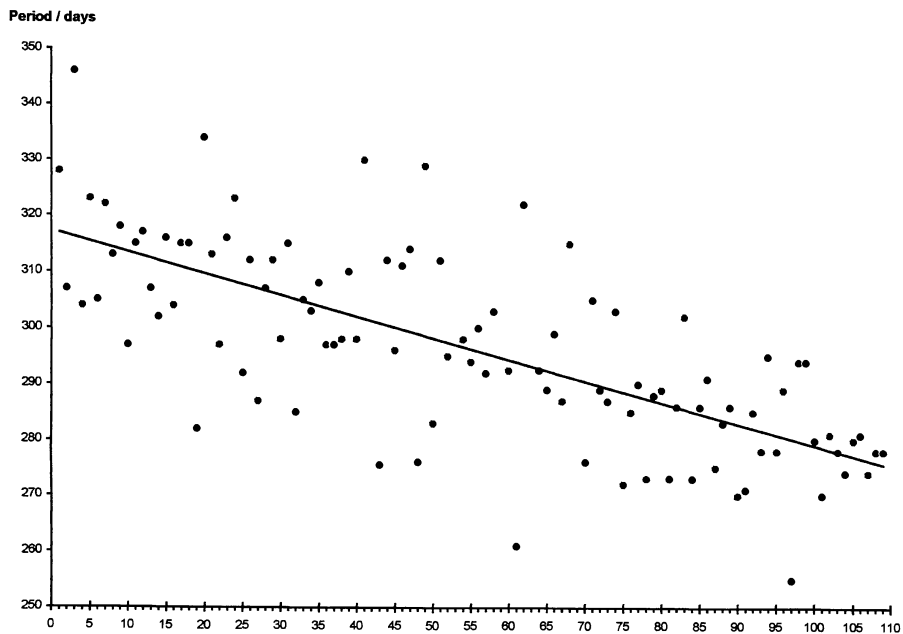


Figure 5. A linear least-squares fit to a plot of the periods between maxima against cycle number also gives a slope of  $\sim -0.38$  (i.e. a decline of roughly 0.4 days per cycle) without needing to have recourse to any of the above calculations.

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# February with no Full Moon

Peter Macdonald

As the Moon's synodic period is  $29\frac{1}{2}$  days, it is possible for a lunation to straddle the month of February, even in a leap year. This paper examines cases involving the Full and the New Moon.

## Introduction

There is believed to exist, somewhere near Dublin, a brass plate on which is engraved: '...the month of February 1866 was one of the most remarkable inasmuch as it had no Full Moon. January had two Full Moons and so had March, but February had none. This has not occurred since the creation of the world, and it will never occur again.' Such a statement is asking to be checked and I thought it would be interesting to do that.

## The calculations

A program was written which calculates the instants of the lunar phases. Based on algorithms by Jean Meeus,<sup>1</sup> this routine is accurate to within about three minutes, quite sufficient for our purpose – to identify the years in which February is without either a Full or a New Moon.

## The results

Starting from the middle of the last century, it was soon found that, indeed, in 1866 not only did February have no Full Moon, but also that January and March had two each,

**Table 1. Februaries with no Full Moon, 1851–2150**

Date and time of Full Moon, TDT					
h m			h m		
<b>1866</b>	Jan 1	6 47	<b>2018</b>	Jan 2	2 25
	Jan 30	20 28		Jan 31	13 28
	Mar 1	11 51		Mar 2	0 52
	Mar 31	4 31		Mar 31	12 38
<b>1885</b>	Jan 1	5 26	<b>2037</b>	Jan 2	2 37
	Jan 30	16 19		Jan 31	14 06
	Mar 1	4 00		Mar 2	0 29
	Mar 30	16 39		Mar 31	9 55
<b>1915</b>	Jan 1	12 22	2067	Dec 31*	14 42
	Jan 31	4 42		Jan 30	10 31
	Mar 1	18 33		Mar 1	4 44
	Mar 31	5 38		Mar 30	20 11
1934	Dec 31*	20 54	2094	Jan 1	16 55
	Jan 30	16 32		Jan 31	12 40
	Mar 1	10 27		Mar 2	7 39
	Mar 31	1 17		Apr 1	0 16
1961	Jan 1	23 06	2113	Jan 2	4 25
	Jan 31	18 47		Jan 31	21 02
	Mar 2	13 35		Mar 2	14 48
	Apr 1	5 49		Apr 1	8 34
<b>1999</b>	Jan 2	2 51	<b>2143</b>	Jan 1	16 36
	Jan 31	16 08		Jan 31	3 33
	Mar 2	7 00		Mar 1	13 32
	Mar 31	22 50		Mar 30	23 05

exactly as stated on the brass plate. I was surprised to find that the phenomenon occurred again in 1885 and in 1915. Two other years have been without a February Moon in this century – 1934 and 1961 – but in these cases the second Moon is missing from either January or March. So, already, the 'unique' event of 1866 has happened on two further occasions, and when, we wonder, will it occur again? We do not have long to wait, since the phenomenon is due to take place in 1999.

Tables 1 and 2 list the relevant phases during the years in which February has no Full or New Moon, respectively, from 1851 until 2150. The instants are expressed in Terrestrial Dynamical Time. It is estimated that even by the middle of the twenty-second century the difference TDT–UT will not exceed a few minutes, thus the dates may be regarded as Universal Time. Years in which both January and March have two Moons are shown in **bold** type. An asterisk indicates that the phase takes place on the last day of the previous year.

**Table 2. Februaries with no New Moon, 1851–2150**

Date and time of New Moon, TDT					
h m			h m		
1870	Jan 2	0 07	<b>2014</b>	Jan 1	11 15
	Jan 31	15 42		Jan 30	21 41
	Mar 2	8 42		Mar 1	8 03
	Apr 1	2 00		Mar 30	18 48
<b>1889</b>	Jan 1	21 09	<b>2033</b>	Jan 1	10 18
	Jan 31	9 11		Jan 30	22 01
	Mar 1	22 02		Mar 1	8 25
	Mar 31	11 39		Mar 30	17 54
<b>1900</b>	Jan 1	13 51	<b>2052</b>	Jan 2	3 07
	Jan 31	1 22		Jan 31	18 32
	Mar 1	11 25		Mar 1	7 38
	Mar 30	20 31		Mar 30	18 29
1911	Dec 31*	16 21	<b>2071</b>	Jan 1	12 18
	Jan 30	9 45		Jan 31	7 19
	Mar 1	0 32		Mar 2	0 35
	Mar 30	12 39		Mar 31	15 07
<b>1919</b>	Jan 2	8 24	2090	Dec 31*	20 00
	Jan 31	23 07		Jan 30	14 37
	Mar 2	11 12		Mar 1	9 49
	Mar 31	21 06		Mar 31	3 52
<b>1938</b>	Jan 1	18 58	<b>2109</b>	Jan 1	10 06
	Jan 31	13 35		Jan 31	0 53
	Mar 2	5 41		Mar 1	17 34
	Mar 31	18 53		Mar 31	11 10
<b>1957</b>	Jan 1	2 14	<b>2128</b>	Jan 2	7 35
	Jan 30	21 25		Jan 31	19 04
	Mar 1	16 13		Mar 1	7 45
	Mar 31	9 20		Mar 30	21 32
<b>1995</b>	Jan 1	10 57	<b>2147</b>	Jan 2	8 03
	Jan 30	22 50		Jan 31	18 48
	Mar 1	11 50		Mar 2	5 23
	Mar 31	2 11		Mar 31	15 50

**Table 3. Februaries with no Full Moon: leap years 1583–3000**

Date and time of Full Moon, TDT					
h m			h m		
<b>1608</b>	Jan 2	5 06	<b>2792</b>	Jan 1	12 37
	Jan 31	23 34		Jan 31	8 00
	Mar 1	18 37		Mar 1	1 18
	Mar 31	12 24		Mar 30	15 31
<b>2572</b>	Jan 1	11 16	<b>2944</b>	Jan 1	14 51
	Jan 31	6 15		Jan 31	9 02
	Mar 1	1 21		Mar 1	4 05
	Mar 30	19 07		Mar 30	22 35

It is not surprising to note that the metonic cycle of 19 years, after which lunar phases repeat on or about the same dates, features prominently. For example, in Table 1, the 1999 event is the first of a 'series' of three. The cycle is evident in much of Table 2. From 1900 it can be traced until the end of the table, with one exception – in 1976 when New Moon fell on leap year's day for the only time this century.

A similar list was published by Gaythorpe.<sup>2</sup> This covers a longer period but gives only the years. It does not consider the New Moon, nor does it distinguish between my bold and normal type cases. I found two leap years, 2052 and 2128, with no February New Moon, but none in which the Full Moon is absent. Gaythorpe mentions that February without a Full Moon in a leap year is a rare event; indeed, his table, which covers seven centuries from the Gregorian reform in 1582 shows just one instance – that of 1608. Moreover, he is unable to say when it will occur again. Calculating purely for leap years outside the limits of Tables 1 and 2, I could not find a more recent event than 1608, and the next, I believe, will occur in 2572.

Table 3 gives the relevant phases during the leap years in which February has no Full Moon from 1583 until 3000. The construction is the same as in the previous tables. For the three events in the future, the value of  $\Delta T$  is likely to have increased considerably, but not sufficiently to shift the dates. It seems, therefore, that very nearly one thousand years will have elapsed before February is again without a Full Moon in a leap year.

Because February has fewer than 30 days, it is not possible for two similar phases to occur in that month. As the other months all have at least 30 days, any may contain a complete lunation. It must be noted that the data given in the tables is valid only for dates expressed in UT. The adoption of another standard time may give different results. As an example, in 1999, the second 'January' Moon occurs during the first morning of February in far eastern longitudes. For these places, the event does not exist. Conversely, some locations experience events which do not appear in the tables.

In a common year, where a phase is absent between January 31d 11h (UT) and March 1d 13h (UT), it is reasonable to conclude that it does not occur in any time zone during February. Such cases appear in 1915 and 2143 for the Full Moon and in 1889, 1957, 2071 and 2109 for the New Moon. In a leap year, the phase is always present between these instants, as the interval (30d 02h) exceeds

the longest lunation (29d 20h). Consequently, the phase always occurs for some time zone in February in such years.

## The brass plate

I heard about the brass plate in a radio broadcast by the late Dr Porter.<sup>3</sup> This referred to correspondence which had appeared in a Sunday newspaper during 1934, and a visit to the British Library Newspaper Library at Colindale revealed two letters regarding the February Moon,<sup>4,5</sup> although nothing about the plate. Then I came across a note in the Association's *Journal*<sup>6</sup> for the same year. This mentions the brass plate, and I believe that it was Porter's original reference. As the plate was believed to belong to a Dublin family,<sup>3,6</sup> I contacted Astronomy Ireland. I was referred to a children's book by Neil McAleer<sup>7</sup> which mentions the 1866 event. I wonder if the brass plate could have been the author's reference, but unfortunately, I have been unable to contact Mr McAleer. An appeal for information has also been placed on the Internet. There have been some replies, but none concerning the plate.

It was my intention to give a brief history of the brass plate and to include a photograph, but alas, this has not been possible. I have not been able to obtain any information regarding its whereabouts; I have no idea why it was made, or by whom. And yet it presents a curiosity, since while we imagine the author to have had an astronomical interest, the supposed singularity of the 1866 phenomenon is without foundation – indeed it had occurred twice previously during the same century, in 1809 and in 1847.

If any reader has any knowledge or information about the brass plate, then I shall be very pleased to receive correspondence at the address below.

## Acknowledgments

I am grateful to John Davis of the BBC Written Archive Centre at Reading for supplying a copy of Dr Porter's script, to Tony Ryan, secretary of Astronomy Ireland for referring me to Neil McAleer's book, and to Rob Harrold, the Association's Program and Data Library Coordinator for placing the request for help on the Internet.

**Address:** 46 Vista Way, Harrow, Middlesex, HA3 0SL

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# The practical application of transfer and Fabry lenses

John Wall

Many amateur and commercially built telescopes do not cater for an extended focal plane, which excludes the use of CCD equipment, or a photographic facility. The use of transfer and Fabry lenses is proposed as a solution to this problem.

## Introduction

If CCD imaging or other advanced use of the telescope is desired, it is often found that the focal plane is not accessible to the new equipment that the observer wishes to fit onto the end of the telescope. The problem can be solved by using a Barlow lens, but this will result in an increase of power, and a reduction of sky field, whereas a transfer lens can be applied not only to give increased magnification, but alternately, reduction of power, or even unity (i.e. one to one translocation of the focal plane well away from the telescope). In this way the focal plane is made accessible to the equipment.

It is the purpose of this paper to give some practical advice on how to apply transfer lenses and Fabry lenses and what may be used. Emphasis is placed on the use of 'off the shelf' lenses that may be acquired from camera shops, and ex-government surplus suppliers. I will not discuss ray tracing techniques, or dwell on grinding lenses from scratch, as these topics are beyond the scope of this paper. There are available to hand, adequate lenses for application to the task, which are well corrected for the use that will be demanded of them. Two types will be discussed: binocular objective lenses, and 35mm standard camera lenses of 50mm focal length.

## Transfer lenses

A transfer lens essentially translocates the focal plane of the telescope to a new position. This distance can be quite large; a Barlow lens on the other hand, only produces a small translocation of the telescope's focal plane, but produces a large increase in magnification, whereas a transfer lens will not if so desired. Transfer lenses can be arranged to give higher magnification or even reduction, but a Barlow will only give magnification. The disadvantage of using transfer lenses is the need to use long extension tubes in which to mount them, so this aspect must be weighed against the advantage gained. Refer to Figure 1 which shows Barlows versus transfer lenses.

### Binocular objective lenses

These are well suited to building a transfer lens set. Two are required; 7×50 or 7×30 will do, and the larger size will probably not require a Fabry lens (to be discussed later). The lenses are placed face to face, i.e. convex surfaces nearly touching. The two conjugate focal points will be equal and equivalent to the infinity focus for each. It is well to analyse the optical system first, by drawing it out on paper to scale. The ray cone that emerges from the telescope focal

point, the primary focus, must enter the aperture of the transfer lens with a little to spare (Figure 2). Next, the required focal plane diameter must be considered, as the off-axis ray cone must also enter the transfer lens. For CCD work the current chip diagonal is around 10mm and for a 35mm film format it will be around 43mm diameter. By drawing in a new optical axis struck from the centre of the telescope mirror or objective lens, to the edge of the required focal plane diameter, a new off-axis ray cone can be produced around the new axis. All the rays must enter the lens set; if not, then a Fabry lens will be required; but before this is considered, all of the ray cone on-axis must also enter the lens set (this must be determined first). However, binocular lenses are usually large enough to accommodate all rays entering the system if the telescope aperture

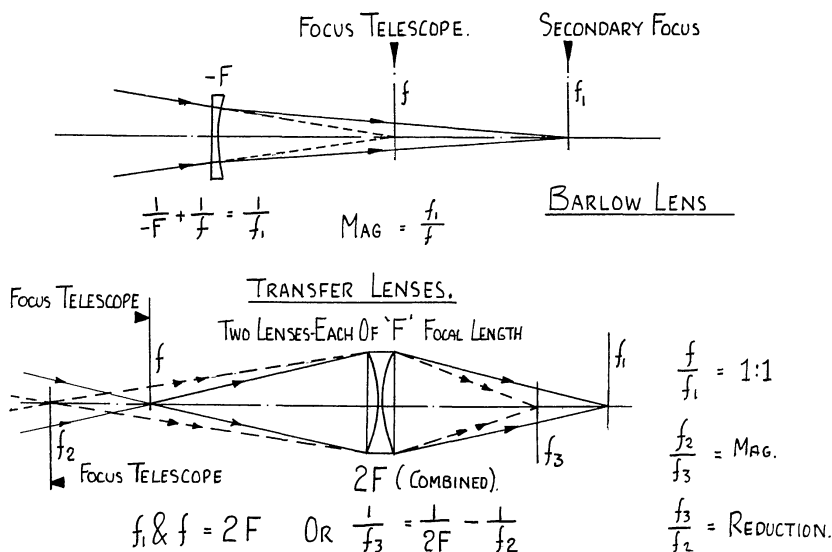


Figure 1. Diagram of a Barlow lens (top) and transfer lenses (bottom).

Transfer and Fabry lenses

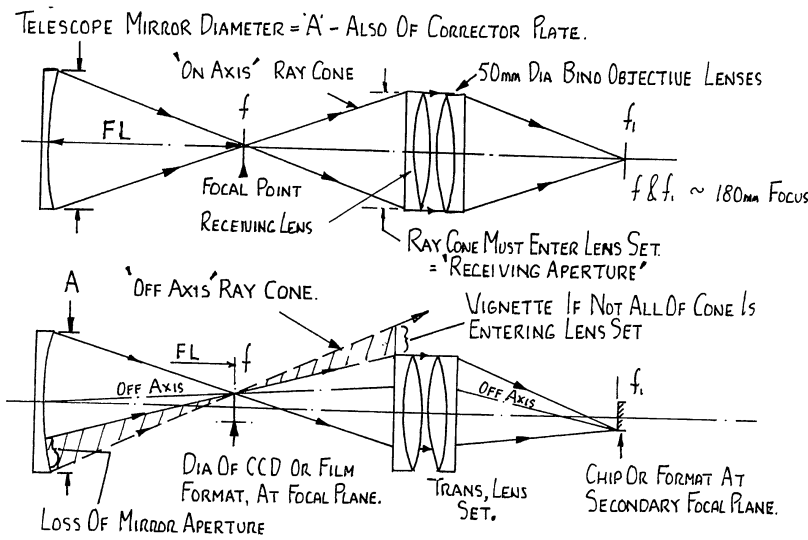


Figure 2. Using binocular objectives to form a transfer lens set.

ratio is not less than about F/8. For a Schmidt-Cassegrain, take the correcting plate diameter for the aperture. For all other telescopes it will be either the mirror diameter, or that of the OG (this is designated A in Figure 2, the focal length being designated as FL).

Now produce the ray cone by drawing lines from the aperture diameter A to pass through the focus and up to the back surface of the nearest binocular lens. If the cone diameter is less than the receiving aperture then the lens will do. Now determine if a Fabry lens is required. Draw a line from the centre of the mirror through to the extremity of the focal plane diameter required; this is the new off-axis. Now reproduce the ray cone again. If it still enters the receiving aperture, all is well; if not a Fabry lens is needed. As an alternative the ratio of the conjugate focal lengths, f and f<sub>1</sub> can be changed, making f shorter until the off-axis cone enters the receiving aperture. However, the new position of

f<sub>1</sub> will have to be calculated (Figure 1) as it will be longer, so that now the system will magnify by a ratio of f<sub>1</sub> divided by f.

Camera lenses

We now refer to Figure 3. An alternative to binocular lenses is the use of 35mm camera lenses of 50mm focal length. These can be obtained from camera dealers. Many lenses are coming on the secondhand market now as the old style 35mm camera is replaced by the new all-singing and dancing automatic cameras, which are eminently unsuited for astrophotography. When a lens is obtained, the trick is to extract the lens set from the mounting (i.e. the focusing ring assembly and other parts). They are fiendishly put together, but it can be

done. If possible remove the lenses and strip out the stop leaves; I have done this by prying them out with a screwdriver. However if this is too daunting then the whole lens assembly can be used intact, but set the stop at its widest aperture and superglue the setting ring. Camera lenses are more compact than binocular lenses, and are well corrected for use as transfer lenses.

The conjugate focal points f and f<sub>1</sub> can be found by trial and error, by focusing an illuminated pinhole onto a card and measuring the focal distances from the lens surfaces to the focal points. These focal points are the conjugate focal points f and f<sub>1</sub>, i.e. when the lens is not focused on infinity. By adjusting the slides carrying both the pinhole and the focusing screen, the distances f and f<sub>1</sub> can be made equal and will be approximately 93mm, depending on the make of the lens used. I have ignored discussion about nodal planes to keep things simple; the distances f and f<sub>1</sub> will be

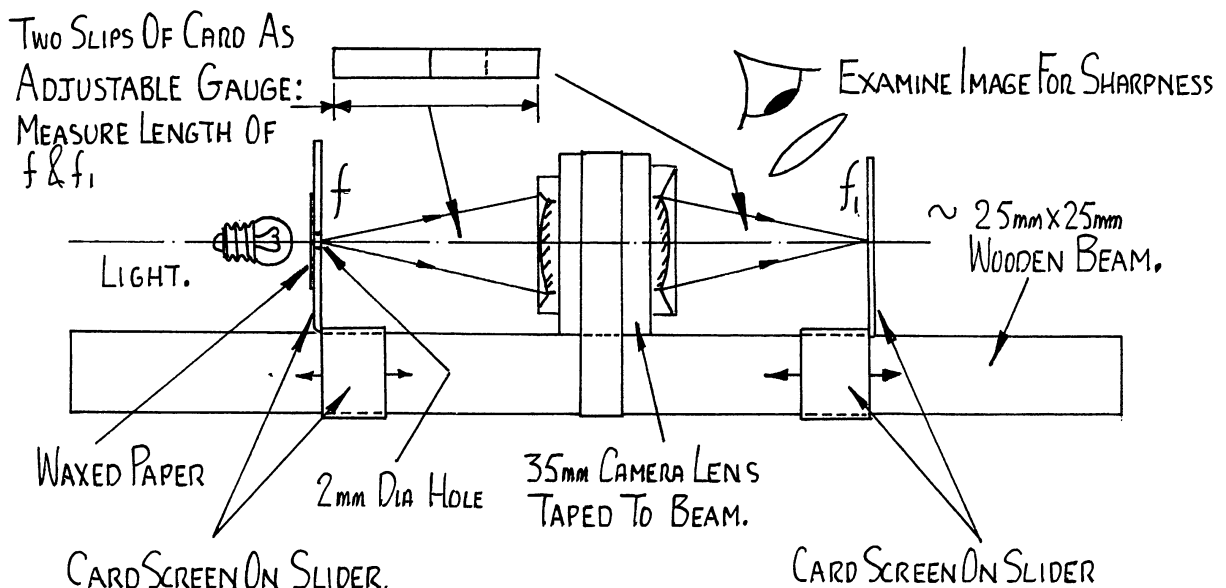


Figure 3. A simple optical bench for finding conjugate foci, f & f<sub>1</sub>, of a 35mm camera lens.

found to be less than double the infinity focal length, as these distances are measured from the lens surfaces and not the nodal planes. However, to make  $f$  and  $f_1$  equal will be sufficient for our purposes, and will give a rough one to one ratio. To find the nodal planes of a camera lens requires some sophisticated optical bench work and a lot of iterative calculation.

## Fabry lenses

When it is found that the receiving aperture of the lens is too small to admit the off-axis cone, a Fabry lens must be used at or near the primary focal plane of the telescope. The Fabry lens has no effect on magnification, but acts as a guide to feed all of the light into the receiving aperture; it works independently of the transfer lens. The Fabry lens creates an image of the telescope aperture on the receiving aperture of the transfer lens. When it does this then all rays, whether on- or off-axis must enter the transfer lens. Figure 4 depicts the action of a Fabry lens, and Figure 5 the action in conjunction with a transfer lens; note that all off-axis rays are entering the system. In practice it is advisable to set the Fabry lens slightly away from the primary focal plane in order that dust particles and lens surface imperfections do not show up at the secondary focus. This offset will not make a great deal of difference in practical terms to the overall performance, as long as all the light enters the system.

### Practical application of Fabry lenses

Returning to the optical diagram for the inclusion of transfer lenses into the telescope system, Figures 4 and 5, it is best to discuss a few parameters. Firstly, the sine of the angle of the off-axis is half the required focal plane diameter, divided by the focal length of the telescope. The diameter of the receiving aperture of the transfer lens is the diameter of the telescope aperture multiplied by the ratio  $f_1$  over  $f$ . For a telescope of 254mm aperture at F/15, when FL is 3810mm and  $f$  is 180mm, the diameter of the on-axis cone at the receiving aperture will be 12mm. This will also be the size of the telescope mirror or OG image formed at the receiving aperture. Now the off-axis cone will have the same receiving aperture diameter as far as we are concerned. If the off-axis cone is now drawn on the off-axis set at the angle calculated, the overall diameter of the ray cone entering the receiving aperture will be much larger. Binocular objectives will probably be large enough to receive all of the ray cone, but camera lenses will not. However the Fabry lens will bend the optical axes so that

### Transfer and Fabry lenses

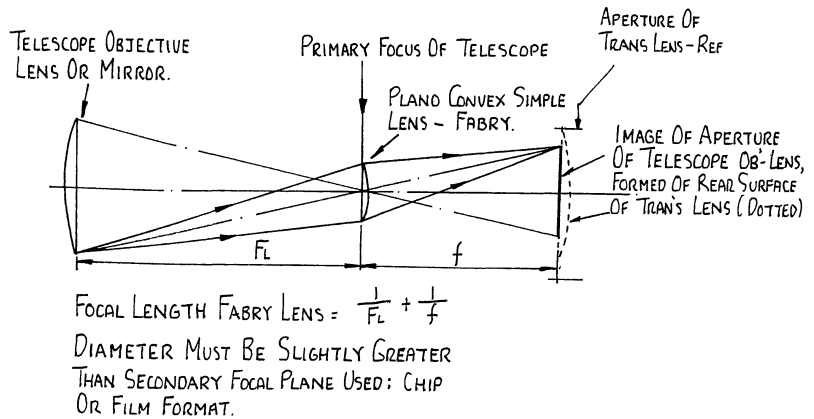


Figure 4. Parameters for a Fabry lens.

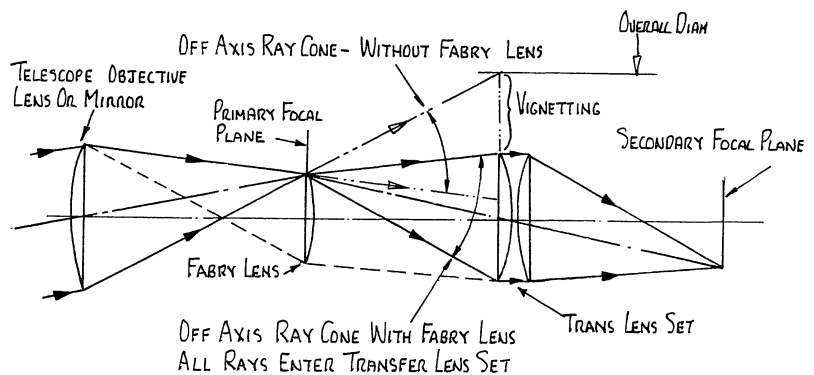


Figure 5. Optical ray diagram with Fabry and transfer lenses.

the off-axis ray cone will enter the receiving aperture, as long as it is equal to the diameter of the image of the telescope aperture formed by the Fabry lens. Study Figures 4 and 5 to clarify these points.

To find the focal length of the Fabry lens required, add the reciprocals of the focal lengths of the telescope FL and the conjugate focal distance  $f$  of the transfer lens. Having done this it is a matter of obtaining a simple plano-convex or double convex lens of sufficient diameter, i.e. greater than the focal plane diameter used and near enough to the focal length calculated. This does not have to be exact as the parameters are fairly loose. Differing focal lengths will cause the image of the telescope mirror etc. to fall either in front or behind the receiving aperture of the transfer lens. By rearranging the formula in Figure 4,  $f$  can be found i.e. the reciprocal of the focal length of the Fabry lens minus the reciprocal of the focal length of the telescope. These functions can be done on a pocket calculator (remember to find the reciprocal of the answer to obtain a whole number for  $f$ ). Now draw in the position of the image formed at this new focal distance for  $f$ ; the image diameter will be a ratio of  $f$  over FL times the telescope aperture; then draw in the off-axis cone. If the rays still enter the receiving aperture then all is well.

For a telescope having an aperture of 254mm and an FL of 3810mm, and if the binocular transfer lens  $f$  is 180mm, then the focal length of the Fabry lens will be 172mm. The diameter will have to be 43mm for a 35mm format and only

## Transfer and Fabry lenses

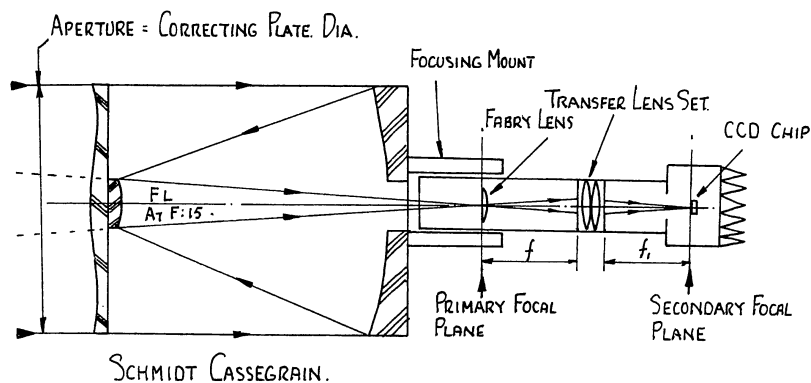


Figure 6. Diagrammatic arrangement for a transfer lens on a Schmidt-Cassegrain telescope.

10mm for a CCD chip; however it would be advantageous to use a lens of, say, 20mm diameter.

The Fabry can be obtained from ex-government equipment; a simple lens will do, but if an achromatic doublet is obtainable, so much the better. The simple lens will not introduce appreciable chromatic aberration into the image, as it is placed at the primary focus.

The lenses should be mounted in an extension tube with the camera fixed to one end, the whole unit passing into the focusing mount (Figure 6). It is important that the unit should move as a whole during focusing with all the elements maintained at their correct spacings. The inside of the extension tube should be lined with matt black art paper to cut out internal reflections. Do not paint matt black between the lens cells, as you may have to disassemble the lens set at some time.

I have built several transfer lens sets with Fabry lenses fitted. I made the separate lens cells from aluminium alloy,

paxolin or nylotron, in fact whatever came to hand; the lens cells must be a tight sliding fit inside the tube for accurate adjustment, and can be secured by a No.4 BA screw tapped into the cell. Adjustment is carried out using a depth gauge, registering from one end of the mounting tube. Making up extension tubes requires some lathe work for the job to be done accurately, but the ingenious worker will no doubt find a way around this; all part of the fun of telescope construction.

## Conclusion

We have discussed some optical design parameters for constructing transfer lens systems as extra kit for commercially built telescopes, or as an inclusion into the optical systems of telescopes under construction by amateur builders. No attempt has been made to go into rigorous and tedious optical ray tracing, this being unnecessary as well-designed lenses are used. Neither have I dwelt on the engineering of mounting them as this latter requirement is a task for the already skilled telescope maker and engineer. The paper is aimed at those who are considering the application of extra instrumentation to their telescope systems, where, for instance, a society telescope is under construction, or an observer who has practical skills wishes to update equipment.

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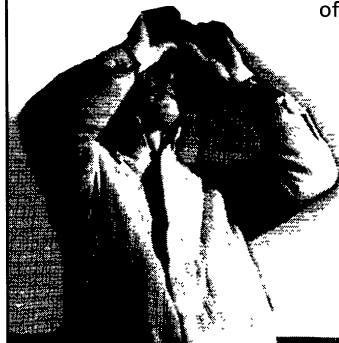
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## Some alternative spectrohelioscope designs

Maurice Gavin's stimulating 1997 Presidential Address, published in the June 1998 issue of the *Journal*, prompts me to suggest some alternative spectrohelioscope designs which may be of interest.

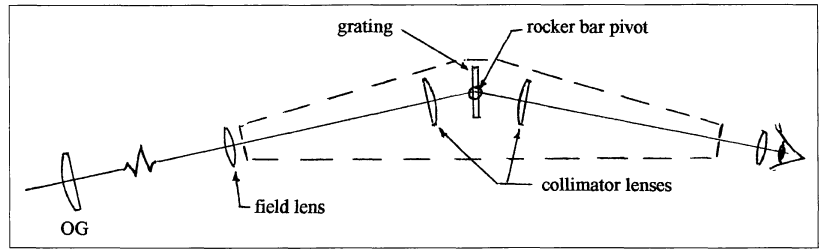
First, may I point out that it *is* possible to move two slits in opposite directions with high precision, if they are rigidly attached to a lightweight pivoted bar (Figure 1). The stability of the system can be improved if the collimator lenses and grating are also fixed to this bar, which therefore carries a complete monochromator unit in permanent adjustment. Provided the overall length of this unit is not too small, and the diameter of the solar image is not too large, the fact that the slits move in a short arc rather than a straight line is unimportant.

Figure 2 shows a neater alternative system in which the monochromator section is stationary and image scanning is achieved by two reflections from an oscillating mirror. Wavelength adjustment is made by tilting the reflector which follows the transmission grating.

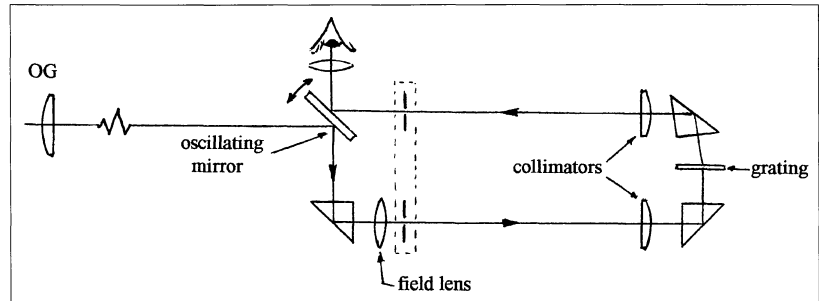
In both diagrams, a field lens precedes the entrance slit to ensure correct pupil imagery.

**George Y. Haig**

35 Dalmahoy Crescent, Bridge of Weir, Renfrewshire PA11 3JB, Scotland.

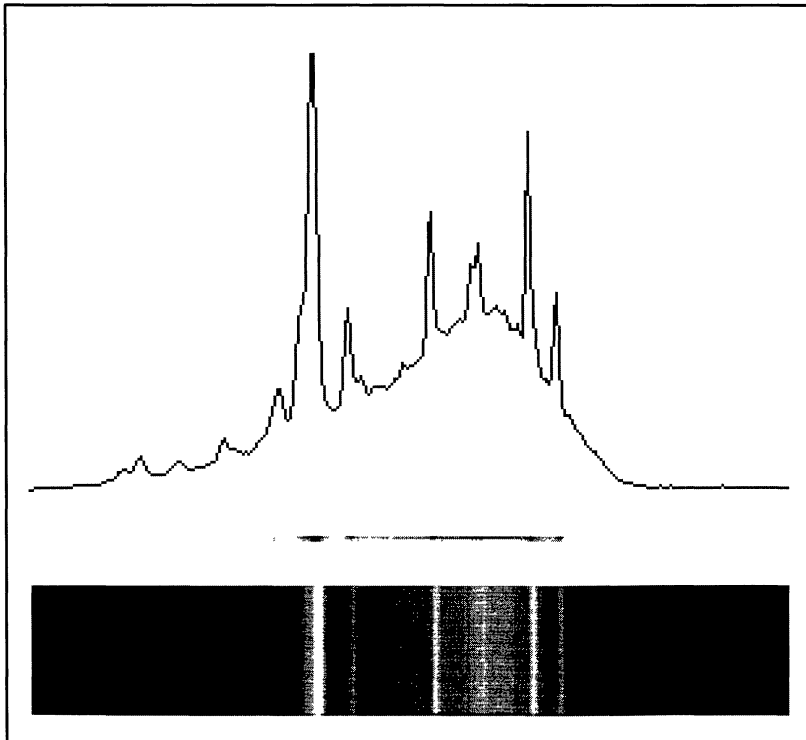


**Figure 1.** Monochromator slits mechanically coupled by rocker arm (broken line).



**Figure 2.** Oscillating mirror spectrohelioscope. As an alternative, scanning could of course be performed by vibrating the slit carrier.

## A spectrum of a Wolf-Rayet star

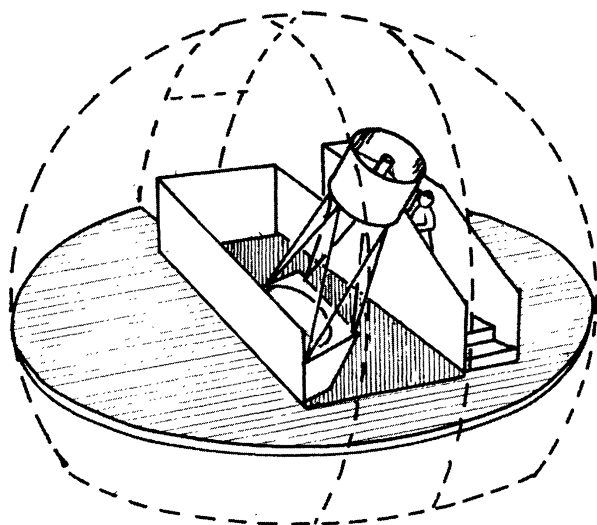


A low-resolution spectrum of the Wolf-Rayet star HD192163 in Cygnus, obtained by Maurice Gavin on 1998 August 17 at 00.28 UT at his Worcester Park Observatory in Surrey. The star is assumed to be associated with the adjacent emission nebula NGC 6888. 30sec exposure with spectroscope + 30cm SCT, MX5-16 CCD. Trace from original spectrum via PIXWIN software. *M. V. Gavin.*

# The Norwich Astronomical Society's observatory: Re-build of telescope and upgrade to drive control

Brian Mitchell & Frank Lawlor

In two earlier papers,<sup>1,2</sup> Brian Mitchell has reported to the Association the main features of the six-metre dome that houses the Norwich Astronomical Society's 0.76 metre Newtonian reflecting telescope. The whole observatory complex has recently been relocated close to Seething Airfield, some 16 kilometres south of the city of Norwich where the sky is less light-polluted than in its previous position, near the University of East Anglia in Norwich itself. During the reconstruction of the 0.76m telescope, the drive mechanisms and controls were improved by Frank Lawlor, and the new setup provides a user-friendly facility for Society members and for visits by the general public.



## The dome

The dome design was entirely directed by the need to enable normally able-bodied but not necessarily experienced members of the public to enter the observatory, move about inside and use the telescope, in low light conditions with a good standard of safety. With the telescope having an eyepiece position about 4.5m above the base level, the requirement produced a solution that is probably unique. The telescope is fork-mounted and the 'observing floor' is set at telescope trunnion level as is fairly common with instruments of this size, but here the similarity ends, for in this dome, the floor rotates with the dome.

From Figure 1 it can be seen that the floor has a slot down the middle, allowing the telescope to swing only in the direction of the slot. Full sky coverage is achieved by rotating the dome with the floor and slot attached. The slot is surrounded by a safety wall which is incorporated into an observing platform, with steps on the trailing side; the platform is about 1m above the main floor level. The slit in the dome is in line with the slot in the floor, with two covers which slide upwards towards the door at the rear, and downwards. To allow this latter downward move-

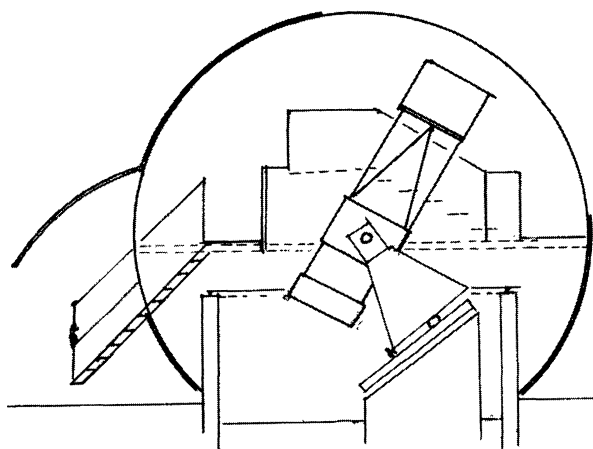


Figure 1. Drawings of the observatory showing the slot in the observing floor and the opened slit.

ment, the dome is extended below floor level to present somewhat closer to the shape of a sphere. The whole is mounted on eight wheels on a rail on top of a circular wall enclosing the lower reaches of the building. The public

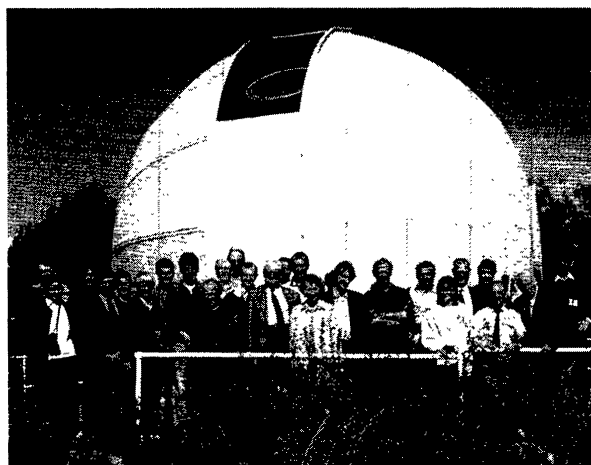


Figure 2. BAA members and guests at Seething Observatory during the 1997 Out-of-London weekend.

ordinarily do not have access to this area which holds the equipment for handling the telescope mirror.

### The telescope

The origin of the instrument was a 0.76m disc of glass given to the Society by Cambridge Observatories in the early 1970s, shortly followed by John Hindle's much-copied grinding machine. The glass was made tidy, and ground on the machine to  $f/5$ . Polishing and figuring was by hand, using a 15.24cm pitch lap and Horace Dall's null test in about 20 hours over a period of about three years.

The tube is of conventional design with a Serrurier truss and the eyepiece mounted on a rotatable drum (Figure 3). The mirror, only 7.5cm thick, rests on an 18-point suspension. The mirror cell was constructed from a redundant spin-dryer from a hospital laundry. The fork is mounted on a 1.8m diameter steel ring of very robust section, with drive coming to it by friction from the support wheel at the bottom of the support framework. (Figure 4).

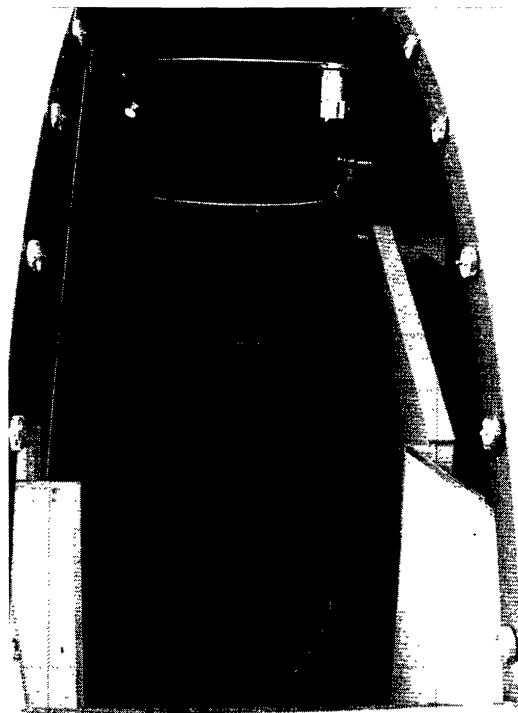
### The controls

There are now three electronic rate-servo drives associated with the observatory. The first is required to rotate the dome through  $\pm 180^\circ$ . The second drives the telescope with respect to the dome in declination over an angle of just over  $90^\circ$ .

The third is the right ascension drive for the telescope.



**Figure 4.** The telescope mounting. The drive mechanism is inside the box at the bottom edge of the 1800mm support wheel.



**Figure 3.** The 30-inch (0.76m) telescope and dome interior.

All three drives are controlled from the observer's handset, a schematic picture of which is shown in Figure 5. A two-axis joystick shown at the top of Figure 5 controls the telescope in declination and right ascension in all modes except that of sidereal drive (D).

### The dome drive

The dome rate-servo slew-drive is controlled from the centre-biased switch at the bottom of the handset (Figure 5). Moving the switch to right or left moves the dome at a given preset rate in the required direction. Once the switch is released, the drive is removed and the dome decelerates and eventually after a few seconds, comes to rest. There are a number of refinements to the control circuitry which ramp the speed up gradually when starting, and ramp it down again when stopping.

This minimises the strains which would otherwise be caused by the immense inertia of the dome. An electronic interlock prevents the dome from being driven in the opposite direction before it has had time to come to rest from a previous drive demand. The power drive incorporates a phase-controlled thyristor circuit which powers an armature-controlled d.c. motor.

### Declination and right ascension drive systems

Around 1979, the Society inherited a couple of high-grade servo-motors. One of these was used at the time in the construction of an RA drive, controlled from a hand-held electronic control box. The other became a 'spare'. Those were days before the common use of stepper motor drives. In his recent drive upgrade Frank Lawlor has continued to use the analogue servo-motor concept simply because the servo-motors were there. With the upgraded control electronics, excellent stability has been achieved during tracking. The 'spare' servo-motor has however been incorporated to provide a declination drive to the telescope as outlined below. Of course, stepper motors would provide more accurate rate control, but the cost of large stepper motors and the electronics required to cover the speed range for both 'slew' and 'sidereal rate' was not considered justified in view of the small improvements to be gained. The 5m Hale telescope on Palomar Mountain used to track very well using a  $\frac{1}{2}$  horse power analogue motor and drive system.

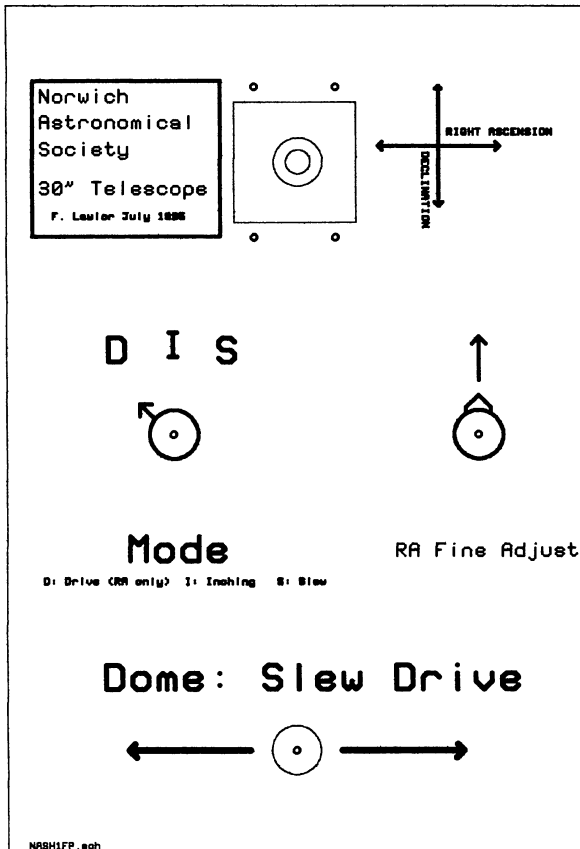


Figure 5. Schematic of the drive controls.

### The declination drive

This closed loop rate-servo uses a McLennan servo-motor and gearbox (type RM563) to provide power drive and an integrated tacho generator to provide rate feedback. The motor speed is proportionally controlled by the vertical deflection of the joystick on the operator's handset (Figure 5). 'Fast Slew' and 'Inching' are two speed ranges selected by the appropriate position of the mode selection switch, (S and I respectively). When the mode switch is in position (D), (sidereal Drive), the declination drive is inoperative. A 100 watt d.c. amplifier converts the voltage signal from the handset to power the servo-motor. The telescope's declination axis is driven via a belt linking it with the gearbox.

### The RA drive

This closed loop rate-servo (Figure 6), is almost identical to that controlling the declination axis. However the telescope is connected to the servo output via a chain rather than a belt. Proper tensioning of this chain is required for good tracking. The speed of the RA servo-motor is controlled by the horizontal deflection of the handset joystick. 'Fast Slew' (S) and 'Inching' (I) facilities are selected by the mode selection switch in a similar fashion to that of the declination drive. (In fact, the mode switch is ganged so that both declination and RA servos are switched into the same mode simultaneously). The Drive position (D) of the mode selection switch drives the telescope at sidereal rate. Whilst in

this mode, fine control of sidereal speed can be implemented by adjusting the RA fine adjust knob (Figure 5), the joystick being inoperative. The sidereal rate is monitored, and is indicated by a series of red LED digits on the control panel of the system. (This is simply achieved by the use of a digital voltmeter monitoring the voltage produced from the tacho-generator (V2 of Figure 6)). The accuracy of the drive is maximised by using closed loop negative feedback within the servo loop as shown in Figure 6, and by using two stages of voltage/current stabilisation for the critical paths determining the final RA output voltage from the handset control box which provides the input demand ( $V_{in}$ ) to the rate servo (Figures 4 and 5).

The operation of the servo drive(s) shown in Figure 6 is explained in Appendix A. The operation of the declination and right ascension handset amplifiers are considered in more detail in Appendix B. (Figure 7 shows the RA amplifier.)

## Possible drive enhancements

The three drives currently operate separately but it is possible to integrate them through a computer. The celestial coordinates of a desired object could then be entered through the computer keyboard or called up from memory. The telescope and dome would then slew to the position of the object concerned and tracking would commence, the dome 'position' being automatically updated as tracking continued. Though expertise exists within the Society to achieve this objective, expending the time and money needed to realise it is not considered either appropriate or necessary, and it has been agreed that this option will not be pursued.

## The observatory in use

Over the ten years that the observatory has been in use, originally at the Society's site on the western edge of Norwich and latterly in the darker countryside 16km south of that city, many thousands of people have visited and used its facilities. A queue of people can approach the eyepiece and observe with little risk of tripping, head bumping or falling down holes. A number of seats are fitted around the dome and it is easy to address a visiting group and explain the workings of a reflecting telescope. The observatory is the leading attraction on the site which also holds a 3m dome with a 25cm telescope, a run-off roof observa-

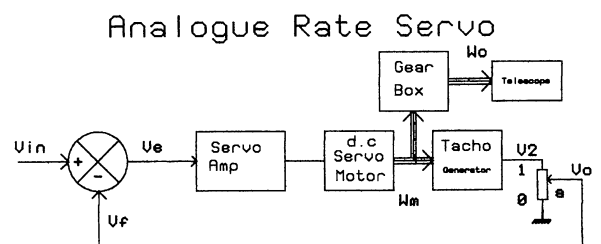


Figure 6. Schematic of the drive rate servos.

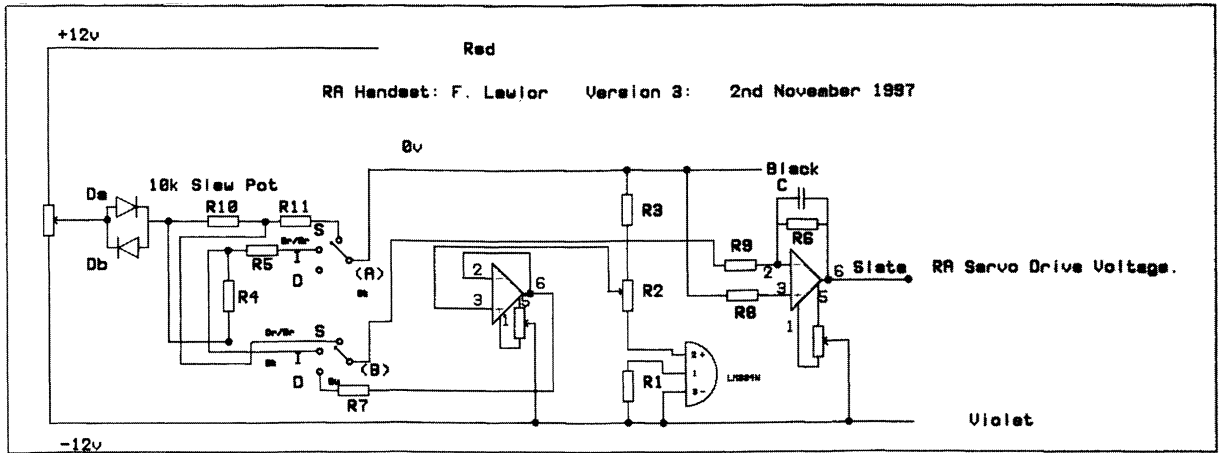


Figure 7. Diagram of the RA amplifier.

tory and a large clubroom with kitchen, workshop and stores.

Brian Mitchell recently completed the rebuilding of the above-mentioned 25cm telescope and Frank Lawlor has designed and fitted an RA stepper motor drive to this instrument, which provides exceptional rate stability. The Society holds monthly open nights and the observatory always proves to be popular, even if only for the short ride as the dome rotates.

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### References

- 1 Mitchell B., *J. Brit. Astron. Assoc.*, **84**(2), 123 (1974)
- 2 Mitchell B., *J. Brit. Astron. Assoc.*, **90**(2), 164 (1980)

### Appendix A: Declination and RA rate servo analysis

Figure 6 is a schematic of the telescope rate servos used in the Norwich 0.76m observatory. Both declination and RA drives conform to this model. The output speed  $\omega$  (rads/sec), is determined by the amplitude of the input voltage  $V_{in}$  for a given setting of the potentiometer ratio 'a'. The input voltage to the servo is the voltage produced by the handset controller. In the analysis of the performance of the rate servo, we shall assume that physical friction is negligible. The torque 'T' produced by the motor at the telescope is proportional to the system error voltage  $V_e$  (equal to  $(V_{in} - V_f)$ ) which represents the error between demanded speed and actual speed. In the absence of friction, this torque is the accelerating torque which accelerates the telescope against its inertia J. We thus have:

$$T = A.K_m.N.V_e \quad \text{i)}$$

$$\text{and } T = J.d\omega/dt \quad \text{ii)}$$

$$\text{so } J.d\omega/dt = A.K_m.N.V_e = A.K_m.N.(V_{in} - V_f) \quad \text{iii)}$$

where A is the amplifier gain, N is the gearbox ratio and  $K_m$  is the motor torque constant.

$$\text{Now the feedback voltage } V_f = \omega.N.K_t.a \quad \text{iv)}$$

where  $K_t$  is the tachogenerator constant, so equation iii) becomes:

$$J.d\omega/dt + A.K_m.N^2.K_t.a.\omega = A.K_m.N.V_{in} \quad \text{v)}$$

Equation v) is a first order differential equation whose solution will give the steady state and transient performance of the telescope speed control system. The transient part of the solution is of less interest than the steady state response to a constant input demand ( $V_{in} = \text{constant}$ ). This part of the solution can be readily obtained by inspection, because under a constant input demand, after the telescope has accelerated up to speed, the speed becomes constant. Consequently  $d\omega/dt$  will be zero. Under these conditions, equation v) becomes:

$$A.K_m.N^2.K_t.a.\omega = A.K_m.N.V_{in}$$

$$\text{so } \omega = V_{in}/(N.K_t.a) \quad \text{vi)}$$

The accuracy of the final output speed is thus dependent on the accuracy of  $V_{in}$ , as N,  $K_t$  and 'a' are all constant. The term  $(1/N.K_t.a)$  is known as the calibration constant of the servo, because it determines how much speed a given input voltage will produce. Notice this is a function of the pot setting 'a' which can be adjusted on the servo amplifier.

Equation iii) shows that as long as the actual speed is equal to the desired sidereal speed (perfect tracking), the feedback voltage  $V_f$  is equal to the input voltage  $V_{in}$  and thus the error voltage  $V_e$  is zero. Under these conditions, there is no acceleration or deceleration of the servo as  $d\omega/dt$  is zero. The output speed must then be constant at sidereal rate. Any factor within the closed servo loop which attempts to alter the output speed will cause  $V_e$  to increase from zero (with appropriate polarity). This will cause an acceleration (of appropriate polarity), which will eventually result in sidereal rate being re-established, whereupon  $V_e$  once more becomes zero and the acceleration ceases. The steady-state speed is therefore independent of variations in the loop but proportional to the input voltage only. The input voltage representing sidereal rate must therefore be held perfectly steady.

The value of  $V_{in}$  required to obtain sidereal rate can be found by introducing values into equation vi). The values shown below are for illustration only and are not the ones used in the system.

From equation vi) we have:

$$V_{in} = \omega.N.K_t.a$$

and so using  $\omega = 0.0000116$  revs/sec (sidereal rate),  $N = 400$ ,  $K_t = 20$  volts/rev/sec. and 'a' = 1, this gives  $V_{in} = 0.0928$  volts to achieve sidereal rate.

## Appendix B: Handset amplifiers

### Sidereal rate drive

It was argued in Appendix A that to obtain a constant output speed from the right ascension rate servo during tracking, we must provide an appropriate constant voltage to the servo from the handset. This voltage is effectively derived (Figure 7) from the constant current produced by the LM 334 passing through R3 (470 ohms) and the potentiometer R2 (1000 ohms). The constant current (I) has a value of say 100  $\mu$ A for simplicity. Consequently the range of voltage produced with these figures as the potentiometer is varied between maximum and minimum is:

$$V_{\text{lowest}} = I \times R3 = 0.047 \text{ volts}$$

$$V_{\text{highest}} = I \times (R3 + R2) = 0.147 \text{ volts}$$

Voltage is thus 0.097 volts when the potentiometer is in the centre of travel.

This voltage is heavily dependent upon I and the values of R2 and R3. As the voltage supply ( $\pm 12$ V d.c.) is stabilised to one part per thousand and the constant current source LM334 has a regulation of 0.02%, the stability of the voltage produced from the potentiometer is dependent on the stability of the resistors R2 and R3. High stability components are therefore chosen. Note also the use of the buffer amplifier (voltage follower) which prevents electrical loading of the potentiometer. Temperature compensation can

also be introduced around the LM334 but this has proved to be unnecessary.

Diodes Da, Db, Dc, and Dd are placed in series with the centre-sprung joystick wipers thus ensuring that small mechanical offsets of the pot joystick from centre zero, do not result in servo drive (creep) when in Inching or Slew modes. Various values of voltage division are used to vary the effective 'gain' of the servo drives when in Slew and Inching modes. The four-pole three way ganged 'Mode' switch allows both RA and Declination servos to behave appropriately in Slew, Inching and Drive modes.

### Fast slew rate

Using equation vi) and the values for N,  $K_t$  and 'a' from Appendix A, we can calculate the maximum slew speed of the right ascension servo as follows. In Slew mode with a maximum output voltage from the handset of +12 volts feeding the rate servo we have:

$$\omega = V_{\text{in}} / (N \cdot K_t \cdot a) \quad \text{where } \omega \text{ is the telescope output rate}$$

If  $V_{\text{in}} = +12$  volts,  $N = 400$ ,  $K_t = 20$  volts/rev/sec and 'a' = 1,

$$\omega = 0.0015 \text{ revs per second (0.54 degrees per second).}$$

Thus an object  $180^\circ$  from the current position can be picked up in around 5.5 minutes.

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