THE COMET'S TALE

Newsletter of the Comet Section of the British Astronomical Association

Volume 5, No 1 (Issue 9), 1998 May

A May Day in February!

Comet Section Meeting, Institute of Astronomy, Cambridge, 1998 February 14

The day started early for me, or perhaps I should say the previous day finished late as I was up till nearly 3am. This wasn't because the sky was clear or a Valentine's Ball, but because I'd been reffing an ice hockey match at Peterborough! Despite this I was at the IOA to welcome the first arrivals and to get things set up for the day, which was more reminiscent of May than February. The University now offers an undergraduate astronomy course and lectures are given in the Hoyle seminar room from 10:00 till 12:15, so the pattern of the event has changed a little from previous years, allowing a little more time for leisurely chat between the 50 or so participants.

After welcoming refreshments, members were able to tour the Royal Greenwich Observatory, perhaps for the last time, guided by Margaret Penston. Members of the Cambridge University Astronomical Society (CUAS) demonstrated the Northumberland and Thorrowgood refractors and the Schmidt telescope of the University Observatories. The Northumberland was trained on Venus, but unfortunately the Thorrowgood dome had suffered mechanical failure and the telescope could not be pointed at the Sun. After the tour, a buffet lunch, prepared by CUAS was available, though a few people were dragged off to a local pub. During lunch Roger Griffin kindly showed off the 36" reflector. Sales stands from the BAA, CUAS, David Early, Earth & Sky and TA attracted much attention and there were displays of the latest comet light curves and photographs of comet Hale-Bopp taken by Michael Hendrie and Glynn Marsh.

The formal session started after lunch, and I opened the talks with some comments on visual observation. Detailed instructions are given in the Section guide, so here I concentrated on what is done with the observations and why it is important to be accurate and objective when making them. The first task in observing a comet is finding it – not a problem with the likes of Hale-Bopp and Hyakutake, but a far harder task for the typical periodic comet. The ephemerides in *The Comet's Tale* and on the Section web page give an indication when it is possible to observe a given comet. They also give the position of the comet in B1950 co-ordinates (as used by the AAVSO atlas) and J2000 (as used by the Millennium atlas): if you use the wrong set you won't see the comet! You can use PC planetarium programs such as *Megastar* or *Guide* to produce accurate finder charts, however when you know exactly where to look it is important not to convince yourself that you can see something that isn't there. I sometimes wonder if some of the observations that I make of comets on the limit of the telescope and seeing conditions are figments of my imagination, despite the fact that they seem to lie on the light curve. The Tycho catalogue now gives a good source of magnitudes down to around 10.5 and these can be used to correct Guide Star magnitudes in the same field. If you haven't got access to this catalogue then you can always give a field sketch showing the stars you have used in the magnitude estimate and I will make the reduction. From these magnitude estimates I can build up a light curve which shows the variation in activity between different comets. Hale-Bopp has demonstrated that comets can stray up to a magnitude from the mean curve, and if such a part of the light curve is all that is used for the analysis, erroneous magnitude parameters will be determined. Measurements of the coma diameter tell me something about your observing conditions and also something about the physical size of the coma. Recent comets show a wide range of variation, with some having a diameter than appears to vary little with solar distance. The degree of condensation can vary dramatically and 73P/Schwassmann-Wachmann 3 was almost star like when it outburst, but gradually became more diffuse.

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Subscription to the Section newsletter costs £5 for two years, extended to three years for members who contribute to the work of the Section in any way. Renewals should be sent to the Director and cheques made payable to the BAA. Those due to renew should receive a reminder with this mailing.

Section news from the Director

Dear Section member,

The announcement on the IAUC of the likely close approach of asteroid FX11 has promoted a lot of bitter discussion. It is a pity that many of the contributors do not realise the amount of time and hard work that the team at CBAT devotes to verifying observations and claims of discovery. In this particular case it was fairly obvious to any regular observer that the initial observations showed a close approach, but few new observations were coming in and Brian Marsden wanted some immediate action before the asteroid faded. Goliath in the shape of NASA immediately stepped in, and is now threatening to control release of all future orbital predictions. Fortunately amateur astronomers and the internet make it unlikely that they would be able to keep such information to themselves. It is also worth remembering that Goliath came to an unexpected end!

Its been a very quiet six months for comet discoveries, with only SOHO producing them in abundance. The Section Meeting kept me busy for a while, but the winter has given me a chance to devote time to papers for the Journal. My paper on the comets of 1994 and Michael Hendrie's paper on comet Bennett have been accepted for publication. I have started on the comets of 1995 and if you have any material not previously submitted do let me have it. Michael Hendrie is well advanced on his papers on comets Kohoutek, and Kobayshi-Berger-Milon. Kenelm England is looking at the possibility of writing a paper on the Kreutz group comets. If anyone would like to contribute a paper to the Journal there are plenty of moderately bright comets which still await a report. I'd also love to see some contributions for the newsletter, as it is often a solo effort, with perhaps one or two member's contributions.

The Section meeting was a useful gathering and I was glad this time to have more of a chance to chat with you. The next big meeting is the International Workshop on Cometary Astronomy, which will take place over the weekend following the total eclipse next year. I'm arranging accommodation at a Cambridge College and there will be full details about booking in the next issue of the Newsletter. We hope to have many of the present day comet discoverers at the meeting, so it will be a chance to meet them, and to discuss ways of improving our observations. The stock of Section Observing Guides is probably sufficient to last the year, but it will soon be time to think about reprinting it. If you have any suggestions for changes or additions do let me know.

There is always a great desire to be the first to see a returning comet, the last to see a departing one, or to push the limits of the telescope and observers capability. The ready availability of PC planetarium programs with the ability to plot comet paths against Hubble or Hipparcos star fields make it very easy to observe exactly where a faint comet should be. Looking for this faint smudge of light at the limit of the telescope's light grasp it is possible to convince oneself that something is there and to produce an observation of it. It may well be there but such observations should always make it quite clear that there is some uncertainty by putting a colon (:) after the magnitude and noting the observation as reliability 3. Comets do outburst and others fade more slowly than expected, but quite a number of observations are appearing on the Internet, which appear to contradict CCD observations and visual observations made with larger apertures. These contradictory observations are often made with moderate apertures and the magnitudes quoted are usually at the limit of the telescope light grasp. They may be true, however the human imagination is a powerful thing.

Something that I have noted after using a computer at the end of an observing session and then going outside again, is that I can initially see the orange sodium sky glow quite clearly. As my eyes dark-adapt this appears to go away, but is presumably still there. I imagine that this change is due to the shift between photopic (daylight, 555-nm) and scotopic (dark, 510-nm) vision and it clearly has an implication for observing. Some comets may actually be easier to see before we are properly dark-adapted, or it may be possible to pick out features in the inner coma more easily. All comet magnitude estimates should be made with the eyes fully dark-adapted to the prevailing conditions.

Since the last newsletter observations or contributions have been received from the following BAA members:

Sally Beaumont, Paul Brierley, Denis Buczynski, Michael Foulkes, Maurice Gavin, David Graham, Werner Hasubick, Michael Hendrie, Guy Hurst, Nick James, Albert Jones, John Mackey, Nick Martin, Martin Mobberley, Bob Neville, Detlev Niechoy, Gabriel Oksa, Roy Panther, Jonathan Shanklin, James Smith, David Strange, S M Trafford, Dan Vidican, Alex Vincent, and Peter Wroath.

and also from: Jose Aguiar, Alexandr Baransky, John Bortle, Reinder Bouma, Matyas Csukas, Haakon Dahle, Stephen Getliffe, Guus Gilein, Bjoern Granslo, Valentin Grigore, Roberto Haver, Andreas Kammerer, Heinz Kerner, Atilla Kosa-Kiss, Martin Lehky, Romualdo Lourencon, Jean-Claude Merlin, Vasile Micu, Herman Mikuz, Andrew Pearce, Josep Trigo, Vince Tuboly, and Seichi Yoshida.

Comets under observation were: 29P/Schwassmann-Wachmann 1, 43P/Wolf-Harrington, 55P/Tempel-Tuttle, 62P/Tsuchinshan 1, 65P/Gunn, 69P/Taylor, 78P/Gehrels 2, 103P/Hartley 2, 104P/Kowal 2, 128P/Shoemaker-Holt 1, 129P/Shoemaker-Levy 3, 132P/Helin-Roman-Alu 2, C/Hale-Bopp (1995 O1), C/Mueller (1997 D1), C/Meunier-Dupouy (1997 J2), C/Utsunomiya (1997 T1) and C/Stonehouse (1998 H1).

Jonathan Shanklin

Section Meeting

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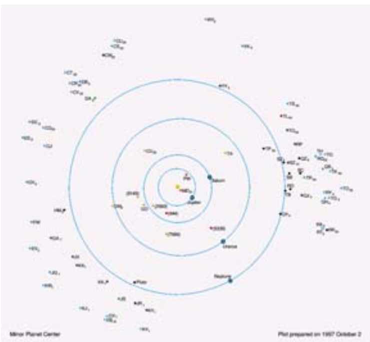
Guy Hurst spoke next about reporting the observations. He had received about 3500 observations of Hale-Bopp and although 90% of these came by e-mail a lot them did not use the TA or ICQ standard, or used malformed variants. [I have placed a data entry program, which produces the correct format output, on the Section web page, and it should be possible for observers to download this. Please send the TA output to Guy and the ICQ output to me. I can supply the program on a floppy for anyone who hasn't got web access]. Although the report forms help make analysis easier, they don't record all the information that the observer sees and a written description and drawing can help later analysis and interpretation. Tail reporting was a particular problem, some observers reporting an apparent length longer than would be seen from an infinitely long tail. A curved dust tail also presented problems: should the reported position angle refer to the start, middle or end of the tail? The ICQ procedure is to report the position angle that it leaves the nucleus, though this does not give a complete description. The ICQ procedure is also to report the longest tail as the main one, which can give inconsistent reporting when a variable length gas tail is seen with a dust tail. The apparent position angle of the tail also influences the perceived appearance and evening and morning impressions of Hale-Bopp were often quite different. Relatively few reports mentioned the inner coma detail, yet this was a prominent feature of the comet. The Millenium star atlas, based on the Tycho catalogue, is a good detailed map of the sky and the Tycho catalogue VT magnitudes are the recommended ones (coded as TT), though red stars should be avoided. The magnitude of the central condensation may be useful, though it should be made clear on the report form that this is not a total magnitude.

Mike Irwin from the Royal Greenwich Observatory takes part in a search program for Kuiper Belt Objects and explained how he goes about discovering these possibly cometary bodies. Pluto would not be classed as a planet if it were discovered today – it is just the largest of this class of solar system objects. Most KBOs are 10 times smaller and therefore reflect 100 times less light from the Sun and are similar in reflectivity to large lumps of coal. Most of the known ones are around 23rd mag in the R-band although the largest recently discovered reach 600 km diameter and as bright (sic!) as 20th mag. They have a mix of names, including centaurs, plutinos and cubewanos. Centaurs are KBOs between Uranus and Saturn, typically 50 - 100 km in diameter. The present distribution of finds is biased by the presence of the Milky Way, which makes it much harder to find them. The original KBO discoveries needed 2.2 – 2.5-m telescopes (Hawaii, INT, La Palma). Tombaugh who searched to 18th mag, discovered Pluto. Kowal extended the search to 20th mag and discovered Chiron. Luu and Jewitt used a large CCD which reached 25th mag and are now using four 4096x4096 arrays. The search has been technology driven and we have only recently had the necessary technology to carry out wide field surveys. To find one 22nd mag KBO we need to search one square degree. CCDs are also very good at detecting cosmic rays – about two per minute per square centimetre and these can mimic the objects being searched for. Real objects can be found by a number of methods: visual blinking can reveal significant motion in an hour (KBOs at 40 AU move at 3" per hour) and this has been the traditional method, even for professionals. Three frames are needed to avoid confusion with cosmic rays. An automated search subtracts pairs of images and looks for a high spot close to a low spot indicating movement between frames. Telescope time has to be carefully planned and search regions are selected to be near the zenith in a region with few bright stars and high background galactic absorption. Mike showed examples of images, including smearing and cosmic ray defects. The CBAT can predict future positions for a month or two on the basis of a circular orbit and so most aren't lost provided that there are follow up observations. There is a plan to change the naming convention for these bodies so that there isn't a wait of 250 years before naming takes place! Answering questions, he said that a sky survey plate was equivalent to a 4 Gb disk of CCD data. This again is part of the technology process as a night's CCD observing can produce up to 10 Gb of data. Detectors on a fixed telescope (ie not tracking at the sidereal rate) have problems with drift in non-equatorial fields and also if the telescope has aberrations.



Mike and his co-workers have recently discovered two more KBOs to add to those shown on this plot by the Minor Planet Centre. They lie at about 1 o'clock, just beyond the object shown well outside the orbit of Neptune.

After a break for tea, the theme switched to amateur CCD observations and Nick James put the BAA laptop through its paces for the first time in anger. After a few minor glitches with the IOA projection system, views of the laptop screen appeared on the main projection screen and the highly professional presentation commenced. Nick started by saying that you need to carry out careful calibration of the frames, with dark frames, flat fielding and correction for vignetting. Terry Platt's SX series was in use by Nick and Denis (and the Director and Assistant Director also confessed to owning them). The first step is to subtract a dark frame from the image to remove thermal noise. Next, the image is divided by a flat field, taken at twilight. A series of images, centred on the comet can be stacked together. Because of the small field of view of a CCD you are generally only looking at the central part of the coma. Here we are interested in high frequency structure, so we can use an unsharp mask. It is important not to saturate the images, and taking lots of images improves the signal to noise ratio which goes as $\sqrt{n}$. A linear stretch of the original image doesn't show any detail, but using an unsharp mask with a 15x15 median filter, dividing one by the other and then stretching does show the high frequency detail. Nick's image processed in this fashion showed that Hale-Bopp changed fairly dramatically in terms of jet structure at the end of 1997 January. It isn't always possible to see all the detail in one single image, and several different techniques may be needed. As well as processing CCD images it is possible to use similar techniques on scanned slides or negatives, and to remove the effects of vignetting (especially common in fast lenses). Offset guiding was a traditional photographic technique, but it is difficult and sometimes goes wrong. With CCDs short exposures can be stacked or made into a movie and Nick showed clips of 55P/Tempel-Tuttle taken by himself and Hale-Bopp taken by Terry Platt. He has written a batch program to process images to get the movie sequence, which makes life much easier. In response to a question Nick said that the SX is linear over 5 magnitudes with a V band filter.

The professional Starlink organisation has written image processing software which normally runs under the unix operating system, but a version is available which runs under PC linux. This has been made available to the amateur community and Nick is the UK amateur co-ordinator. He uses PISA for astrometry and photometry.

Bob Neville now started us thinking about CCD photometry. We have the problem of looking at a diffuse object through a light polluted atmosphere. The apparent brightness of a diffuse image changes with box size. Using an image of 81P/Wild 2 taken on 1997 March 1 as an example, he showed that a 1x1 box gave a magnitude of 14.5 for the central condensation. Increasing this to 5x5 gave a brighter value of 12.1, 11x11 gave 11.3 and 21x21 (equivalent to 1') 10.6, which was still 3 units (on a 256 scale) above the sky background of 20. He could actually see 3'x5' on the monitor so the total magnitude would be even brighter, however visual observers reported even larger coma sizes. He had tried a couple of mathematical models of the coma brightness:

$I_r = I_0 e^{-r}$ (a straight line on a log plot)

$I_r = I_0 (1/(1+r^2))$ (a damping curve on a log plot)

The observations suggest that a damping curve is more likely. Mathematically integrating this as a circularly symmetric function gives $\pi \ln(1+b^2)$, which doesn't converge, so a cut off is needed at some point, but could add to 3 – 4^m on the central value. The integral of the first function converges to 2π, which corresponds to approximately $+2^m$ on the central value of the 1x1 box. The model suggests that even if you sample down to 3% there could still be a 1^m error in the total magnitude. A 1 in 256 error in sky background introduces a significant error in the total magnitude. Results can be improved by:

1. Cooling a low noise chip.
2. Exposing the image as fully as possible.
3. Using a range of exposure times to avoid saturation.
4. Using LPR filters (note that the Johnson V magnitude band includes the sodium D line).
5. Careful attention to flat fielding.
6. Find an area with similar background to obtain sky subtraction.

7. Persuade software writers to produce variable size/shape aperture for photometry.
8. Try for darkest skies at midnight with the comet at the zenith!

Bob concluded by suggesting a project to try and correlate visual and CCD observations, particularly with a view to quantifying the degree of condensation in terms of photometric profiles.

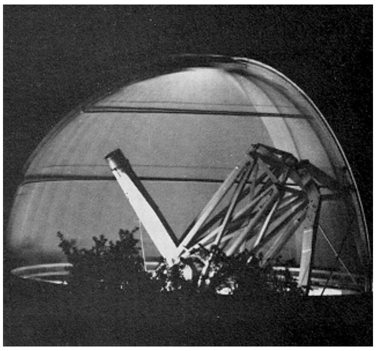
Our final main speaker was Denis Buczynski who presented an illustrated history of the BAA involvement in cometary astrometry. Today, measurement of images is almost a kids computer game, with a click of the mouse and it is done. But it has taken some getting there and it was a very different storey in the past. Then it was a laborious task of using a measuring machine, now we can use a PC and make more, quicker, fainter and more accurate measurements. A C D Crommelin was the 3rd Director of the comet Section and reigned from 1897 to 1939 (I have no intention of serving this long!). His photograph clearly showed that it was essential to have a long white beard to be a Victorian professional astronomer.

He predicted the return of 1P/Halley to within three days, which earned him an honorary degree from Oxford (despite being a Cambridge graduate). His main interest was positional measurement and there are few descriptive accounts of comets from this period. Observers used filar micrometer measurements, which have a personal error, need a time source and the positions of the reference stars. Denis commented that whilst researching his paper he found that old Journals record much more in the way of discussions at meetings, something that is rather lacking in modern times. [At this point I started making more note of discussions….]. Projection of a photograph onto graph paper was tried as a method, but the computation of positions was difficult and the observers of the time generally distrusted photographic methods. Gerald Merton (1945 – 1958) was a supporter of photographic methods which he said were twice as accurate as visual if done properly. Reginald L Waterfield, who had been observing comets since he was 13, made a plate measuring machine from bits cobbled together from the waste bins of Oxford and Cambridge Universities. He was active in the field from 1936 to 1986, despite being crippled by polio, and reported his first position in 1939. Very intricate steps had to be followed just to get the position of the reference stars (63 steps for just 3 stars), even before starting the positional measurement of the comet. Michael Candy was Director from 1958 – 1968 and discovered a comet in 1960 whilst testing an eyepiece. Brian Marsden, a Cambridge graduate, was a section member, working on comet orbits and now heads the CBAT. Michael Hendrie participated in Waterfield's observations and eventually built his own measuring machine and telescope. Harold Ridley used a Zeiss measuring machine, purchased by the BAA, which is now used by Glyn Marsh. Brian Manning became interested in measuring positions as a result of seeing measurements published in TA, and obtained very accurate results, receiving an IHW award. Denis started in 1984, encouraged by Waterfield and has continued to date. The number of measurements dropped in the 1970s, particularly after 1978 when they were no longer routinely reported on IAUC, however PCs have revolutionised the position. It is important to be timely, and the IHW asked for 48 hours turnaround, which was often bettered despite virtually all observations being photographic. Better catalogues have led to better positions. Before the PPM there were not many stars, hence a wide field was needed. The GSC has many stars and so CCDs became practical for astrometry on amateur telescopes. They also enabled shorter exposures to be used, so the problem of offset guiding was largely overcome and several people in the UK (including Mark Armstrong, Nick James, Stephen Laurie, John Mackey, Martin Mobberley, Bob Neville and Denis himself) are now contributing observations. Future improvements include new catalogues such as the USNO, GSC #2, and new software such as astrometrica. Easy electronic communication now makes astrometric observations almost routine, however there is a need to go to fainter magnitude comets. The BAA has a hard earned reputation and we should not rest on our laurels.

Nick James commented that the USNO catalogue was possibly not as good as it looked. Dennis Buczynski wondered if there was any point in photographic astrometry. Michael Hendrie thought probably not as CCDs were so much easier. Guy Hurst noted that not many, if any, positions were now reported photographically.

David Graham concluded the formal session with slides of his 6" reflector and 16" f/5 Newtonian that he'd used to view Hale-Bopp. He showed well executed drawings of the jets and shells seen with a magnification of x200 and described the experience of standing in a dark graveyard with the comet hanging over the church. His final slides showed the comet with bright zodiacal light.

It had been clear all day, so after downing a fortifying cup of tea or coffee we headed for the Northumberland and Thorrowgood telescopes, hoping to have views of Saturn and 55P/Tempel-Tuttle as the twilight faded. Saturn was easily acquired in the Northumberland, but I had trouble with 55P in the Thorrowgood. Using the traditional technique of star hopping I found the field relatively easily, but was a bit perplexed that the fainter stars seemed to be disappearing. A quick check of the OG showed it wasn't dewing up, but a look outside showed that cloud was coming in. The East was still clear, but we couldn't move the slit, so I took the group down to my 0.33-m Odyssey Dobsonian. I couldn't manage to find M35 in Gemini, but did succeed in locating M42!



The Northumberland refractor photographed on a time exposure by Neil Boyce and Tony Darlison

Thanks to all those making the journey to Cambridge, and particularly to the speakers, CUAS and the IOA for making it such a worthwhile meeting. There will be a meteor Section meeting here at the end of October and there is to be an ICQ International Workshop on Cometary Astronomy in August 1999 following the total eclipse.

Inevitably I was going to forget something, and I should have presented the Keedy award to Melvyn Taylor at the meeting. Fortunately Melvyn attended the out of London meeting in Birmingham at the end of April and I was able to present it to him then. Melvyn has been contributing observations to the Section for over 25 years and also makes extensive contributions to the Meteor and Variable Star Sections. Very often such stalwarts of the Association receive little thanks for all their hard work and the Keedy award makes a fitting tribute.

Jonathan Shanklin

Close-Approach Comets

The table lists close approaches to the Earth by comets observed prior to 1998 March 31 and those predicted to occur up to 2031. The table is sorted by close-approach distance from closest to farthest. Only past close-approach distances *less than* 0.11 AU are included in the table. The table is taken from the web page by Alan B. Chamberlin of the Solar System Dynamics Group at the Jet Propulsion Laboratory, with future predictions taken from the CBAT web page.

Name	Designation	Date of Close Earth Approach	Distance (AU)	Distance (LD)	
Comet of 1491	C/1491 B1	1491-Feb-20.0	0.0094	3.7	*
Lexell	D/1770 L1	1770-Jul-01.7	0.0151	5.9	
Tempel-Tuttle	55P/1366 U1	1366-Oct-26.4	0.0229	8.9	
IRAS-Araki-Alcock	C/1983 H1	1983-May-11.5	0.0313	12.2	
Halley	1P/ 837 F1	837-Apr-10.5	0.0334	13.0	
Biela	3D/1805 V1	1805-Dec-09.9	0.0366	14.2	
Comet of 1743	C/1743 C1	1743-Feb-08.9	0.0390	15.2	
Pons-Winnecke	7P/	1927-Jun-26.8	0.0394	15.3	
Comet of 1014	C/1014 C1	1014-Feb-24.9	0.0407	15.8	*
Comet of 1702	C/1702 H1	1702-Apr-20.2	0.0437	17.0	
Comet of 1132	C/1132 T1	1132-Oct-07.2	0.0447	17.4	*
Comet of 1351	C/1351 W1	1351-Nov-29.4	0.0479	18.6	*
Comet of 1345	C/1345 O1	1345-Jul-31.9	0.0485	18.9	*
Comet of 1499	C/1499 Q1	1499-Aug-17.1	0.0588	22.9	*
Honda-Mrkos-Pajdusakova	45P/	2011-Aug-15.40	0.0601	23.4	
Schwassmann-Wachmann 3	73P/1930 J1	1930-May-31.7	0.0617	24.0	
Sugano-Saigusa-Fujikawa	C/1983 J1	1983-Jun-12.8	0.0628	24.4	
Comet of 1080	C/1080 P1	1080-Aug-05.7	0.0641	24.9	*
Great comet	C/1760 A1	1760-Jan-08.2	0.0681	26.5	
Comet of 1472	C/1471 Y1	1472-Jan-22.9	0.0690	26.9	*
Comet of 400	C/ 400 F1	400-Mar-31.1	0.0767	29.8	*
Schwassmann-Wachmann 3	73P/	2006-May-12.00	0.0816	31.8	
Honda-Mrkos-Pajdusakova	45P/	2017-Feb-11.38	0.0829	32.3	
Comet of 1556	C/1556 D1	1556-Mar-13.0	0.0835	32.5	*
Schweizer	C/1853 G1	1853-Apr-29.1	0.0839	32.7	
Bouvard-Herschel	C/1797 P1	1797-Aug-16.5	0.0879	34.2	
Halley	1P/ 374 E1	374-Apr-01.9	0.0884	34.4	
Halley	1P/ 607 H1	607-Apr-19.2	0.0898	34.9	
Comet of 568	C/ 568 O1	568-Sep-25.7	0.0918	35.7	*
Messier	C/1763 S1	1763-Sep-23.7	0.0934	36.3	
Tempel	C/1864 N1	1864-Aug-08.4	0.0964	37.5	
Wirtanen	46P/	2018-Dec-21.03	0.0977	38.1	
Schmidt	C/1862 N1	1862-Jul-04.6	0.0982	38.2	
Comet of 390	C/ 390 Q1	390-Aug-18.9	0.1002	39.0	*
Hyakutake	C/1996 B2	1996-Mar-25.3	0.1018	39.6	
Seki	C/1961 T1	1961-Nov-15.2	0.1019	39.7	
Hartley 2	103P/	2010-Oct-20.89	0.1198	46.7	
Tuttle-Giacobini-Kresak	41P/	2017-Mar 27.37	0.1362	53.1	

* - Distance is uncertain because the comet's orbit is relatively poorly determined.
LD Miss in earth-moon distance units

Tales from the Past

This section gives a few excerpts from past RAS Monthly Notices, BAA Journals and Sky and Telescope.

150 Years Ago: Several issues of MN carried search ephemerides, based on computations by Mr Hind, for the expected return of the comet seen in 1264 and 1556. [No such comet was seen and the 12th Catalogue lists two separate comets with parabolic elements]. In January Professor Challis published a paper giving a method for computing a comet's orbit from three positions. Caroline Herschel died at Hanover on January 9th aged 98. She discovered eight comets, of which five carry her name (1786 P1 (Herschel), 1788 W1 (Messier), 1790 A1 (Herschel), 1790 H1 (Herschel), 1791 X1 (Herschel), 1793 S2 (Messier), 1795 V1 (2P/Encke), 1797 P1 (Bouvard-Herschel).

100 Years Ago: An address by Andrew C D Crommelin (the new Director of the Section) was published in the November Journal. He divided cometary work into: 1) Sweeping, estimating that 120 hours were required per comet, 2) Astrometry, 3) Visual physical observations, 4) Photography and 5) Computation of orbits and ephemerides. Interestingly even this long ago defocussing stars to make them comparable to the comet was recommended for making magnitude estimates, and the procedure was regarded as very difficult. Tail features were regarded as important, with photography recognised as a valuable tool for precise measurements. The December Journal included a list, prepared by W F Denning, of comets expected to return over the next couple of years, which was originally published in Nature. At the March meeting Crommelin castigated British observers for not discovering any comets when Mr Perrine in America had discovered five in two years.

50 Years Ago: Comet notes in the January Journal commented on the exceptional number of comets that had been under observation, though only two were bright enough for those with moderate equipment. Comet Reinmuth 1947j (44P/Reinmuth, 1947 R1) was found to be a periodic comet and there were attempts by E Rabe in Germany to link it to 1858 J1 (Tuttle) and 1907 L1 (Giacobini) however Gerald Merton was not convinced. [Crommelin had demonstrated that these two comets were linked in 1928, but it was not recovered. Lubor Kresak discovered a comet in 1951, which was identified with the lost comet and it is now known as 41P/Tuttle-Giacobini-Kresak.] A note in the February Journal recounted the tale of the German astronomer von Zach who had humorously advised Pons that comets were more numerous when there were many sunspots. Shortly afterwards a large group of spots had appeared and Pons went out and found a fine comet. The note pointed out that when one of the largest sunspots ever recorded was seen at the end of January 1946, 29P/Schwassmann-Wachmann 1 had brightened to 9th magnitude, so there might be some truth in the tale.

The meeting at the end of December (recorded in the April Journal) reported on 1947 X1 which had reached –3 on December 9. There had been a number of UK reports of the comet, but in fact the object seen was Venus. The Journal also notes that for the first time i as well as j had been used for comet designations. [In fact both were used in 1898, but generally j was omitted to avoid confusion, as was i on occasion.] The April meeting was the Exhibition meeting and "The Computing Section (which but rarely contributes to an exhibition) was represented by an unusual item in the form of a notebook of some 200 pages showing the calculations of the perturbations of Comet Gale, exhibited by the Rev Dr C Dinwoodie.".

Although not strictly relevant to comets my eye was caught by two other items. In 1948 May "The future of the present Royal Observatory buildings at Greenwich is still under consideration." and in 1948 June "Another factor which was taken into consideration was that owing to the brightness of modern street-lighting, the long exposures necessary for photographing the solar phenomena could not be given, and solar photography plays a large part in the life of the Observatory.".

The November issue of Sky & Telescope noted that publication of the Minor Planet Circulars had begun at the Cincinnati Observatory under the Directorship of Dr Paul Herget. The February issue had several pages devoted to 'The Great Comet of 1947' (1947 X1). It was widely seen in the Southern Hemisphere on the evening of December 8 as it emerged from perihelion. With a tail more than 25° long, and a magnitude near 0, it was a splendid sight. A few days later the nuclear condensation was observed to be double. The editorial also noted that Michiel John Bester, an assistant at Boyden Station had discovered three and shared a fourth of the year's 14 comets. A follow up article in the next issue looked in more detail at comets and their link to meteors. There was also more coverage of the Great Comet. One observer noted that the comet appeared distinctly pinkish to the naked eye.

Professional Tales

Many of the scientific magazines have articles about comets in them and this regular feature is intended to help you find the ones you've missed. If you find others let me know and I'll put them in the next issue so that everyone can look them up.

Science 1997 December 12. J K Brown *et al* report on the radar detection of the nucleus and coma of comet Hyakutake (1996 B2). They used the Goldstone Deep Space Communications Complex in California to detect echoes from the nucleus and large grains in the comet's coma. These measurements suggest that the nucleus was quite small, only two to three kilometres in diameter, with a surface similar in consistency to loosely packed snow. The small size agrees with other measurements and explains the need for non-gravitational forces to fully represent the orbital motion, something quite rare in long period comets. The rotation period could not be measured, but other measurements suggest either 6.25 or 12.5 hours. The centimetre sized grains in the coma seem to be quite porous and were ejected at speeds of tens of metres per second, probably at an angle of some 40° to the sun. They are perhaps similar to very small lightly compacted snowballs, though there is also some evidence for much fluffier grains as well. Only five other comets have been detected by radar: 1P/Halley (15 x 8 km), 2P/Encke, 26P/Grigg-Skjellerup, Sugano-Saigusa-Fujikawa (< 1 km) and IRAS-Araki-Alcock (16 x 7 km).

Science 1998 April 3 and *Nature* 1998 April 23. A resume of highlights of the annual Lunar and Planetary Science Conference held in Houston in March reports on the possible recovery of dust from 73P/Schwassmann-Wachmann 3. A converted U2 spy plane has been collecting dust particles from high in the stratosphere for many years and some of them have filtered into the atmosphere from outer space. Many of these interplanetary dust particles (IDPs), have a fragile, highly porous structure and are thought to come from comets. Alfred Nier and Dennis Schlutter of the University of Minnesota analysed some collected in June and July 1991 and found that they were relatively low in helium, and more interestingly that the ratio of the helium-3 to helium-4 isotopes was the highest ever found in an IDP. This prompted Scott Messenger and Robert Walker to try and identify the source. The IDPs were minimally altered by heat, suggesting a low entry speed into the atmosphere. The low amount of helium suggested a relatively recent release of the material (within the last ten years, compared to the average lifetime of dust at 1 AU of 10,000 years), otherwise it would have picked up more from the solar wind. As radiation pressure always enlarges the orbit of dust particles, the source must come from closer to the sun than is the earth. Using these constraints, and the date of collection, they narrowed the field from 17 active earth crossing comets to four which have low eccentricity orbits. Of the four, only 73P/Schwassmann-Wachmann 3 approaches the earth at the right time (the others are 26P/Grigg-Skjellerup, P/Machholz 2 and 107P/Wilson-Harrington). Its dust trail intersects the earth in late May (producing the Tau Herculid meteor shower), which would allow just enough time for the IDPs to sink down to the stratosphere by June and July. This doesn't explain the strange isotope ratio and final explanation may have to wait until the CONTOUR spacecraft visits the comet in 2006. The comet makes a very close approach (0.082 AU) in May 2006 when it may attain 0th magnitude, although the coma diameter will be very large.

A report posted on the ESO web pages gives some highlights of the recent conference on Hale-Bopp held in the Canary Islands. The original period of the comet was 4211 years and the future period is 2392 years. It may have passed very close to Jupiter on June 7, 2216 BC and the orbit is clearly evolving rapidly. The nucleus is probably around 50 km diameter, though the range of estimates varies between 40 and 80 km, with some suggestions that it may have an elongated shape or even have multiple components. It rotates with a period close to 11.34 hours, however the direction of the rotation axis has not yet been determined. Many molecules have been seen for the first time in the comet's spectrum, however it was a very dusty comet making the gaseous components harder to see. Peak dust production reached 400 tonnes per second, however the entire mass loss during the apparition is probably still less than 0.1% of the total mass. Generally the comet was quite similar to 1P/Halley and probably formed in the region between Uranus and Neptune; it showed many similarities with interplanetary and circumstellar dust. SOHO observed an enormous Lyman-alpha halo of hydrogen, about 150 million kilometres in diameter. The discovery of a neutral sodium tail is well known, but the origin of the sodium has still to be found. The comet will be studied for a long time to come and more results are likely to be published in scientific journals over the next decade.

NASA is giving people another chance to send their name to a comet and back. They are making a second microchip that will be carried on the STARDUST spacecraft that will be launched to comet 81P/Wild 2 in February 1999 and will return samples of the coma to earth for analysis. If you want to sign up, submit your name from http://stardust.jpl.nasa.gov/microchip/signup.html

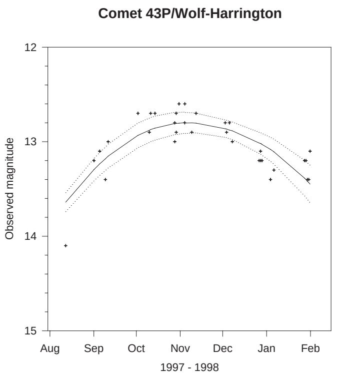
Jonathan Shanklin

Review of comet observations for 1997 November - 1998 April

The information in this report is a synopsis of material gleaned from IAU circulars 6771 - 6894 and The Astronomer (1997 November - 1998 April). Note that the figures quoted here are rounded off from their original published accuracy. Lightcurves for the brighter comets are from observations submitted to The Astronomer and the Director. A full report of the comets seen during the year will be published in the Journal in due course.

29P/Schwassmann-Wachmann 1 was glimpsed by Andrew Pearce at 14th mag in his 0.41-m reflector at the end of December 1997. Further reports suggested that the comet brightened to around 12th mag in January and then faded to 14th mag. The second outburst of the year commenced in mid March according to IAUC 6844 and the comet brightened to around 12.5 before fading in April. This comet seems to spend a lot of time in outburst and is worth monitoring with CCD cameras on a regular basis. Observers are encouraged to check the comet at every opportunity over the apparition, although it is at rather low altitude for UK observers.

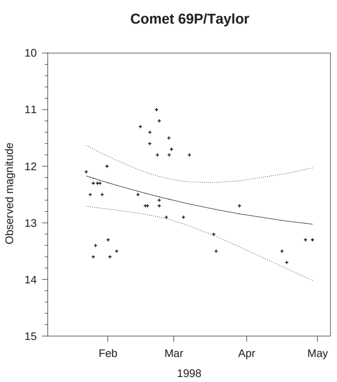
43P/Wolf-Harrington made an early morning apparition and consequently few observations were made. A small faint object, it peaked at around 13^m in early November and slowly faded, though its southern declination made it a difficult target for UK observers. Andrew Pearce made the final observation at the end of January. The 33 observations received so far give a preliminary aperture corrected light curve of :
$m = 9.9 + 5 \log d + 6.1 \log r$



62P/Tsuchinshan 1 was reported at around 13th mag in March on the IAUC and on the CBAT web pages. Martin Lehky observed it at the end of the month.

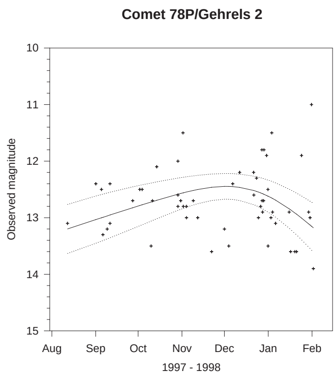
65P/Gunn was observed by Martin Lehky at the end of 1997, though at 15th magnitude it was beyond the range of most observers.

69P/Taylor was found to be unexpectedly bright at 12th magnitude in January. It seems to be slowly fading, though the actual light curve is rather indeterminate.



A series of Jupiter encounters last century reduced q from 3.1 to 1.6 AU and led to its discovery by Clement Taylor from South Africa in December 1915. It was quite bright, 9th magnitude at best, and shortly after perihelion split into two fragments, each with a short tail. The secondary nucleus became brighter than the primary, but then rapidly faded and the primary also faded more rapidly than expected. The comet was then lost until 1977, when new orbital computations led to the recovery of the B component by Charles Kowal with the Palomar Schmidt. The A component was not found.

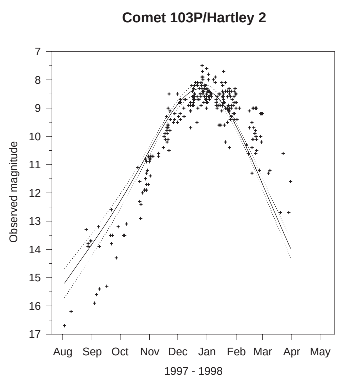
78P/Gehrels 2 peaked at around 12th mag in December and the light curve suggests that it should have faded quite rapidly in the New Year. I made a final observation of it in early February, making it 13.9 in the Northumberland refractor and was unable to see it mid month under very good conditions. Reports on the Internet however, suggest that it remained brighter than 13th magnitude into March. The 60 observations give a preliminary light curve of $10.1 + 5 \log d + 5.0 \log r$, though the fit is not very good.

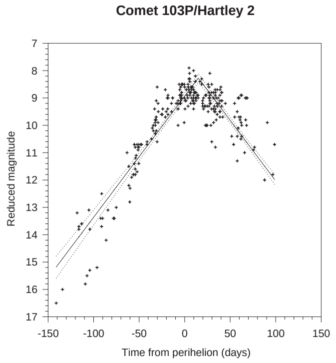


88P/Howell was brightening quite rapidly in the early spring according to estimates posted on the CBAT/ICQ web page. This suggested that the comet might be observable by the end of April and I made a tentative observation on April 28.9 with the Northumberland refractor, making it around 13.2:. Other observations will be needed to confirm this, but it should certainly be reasonably easily visible by the end of May.

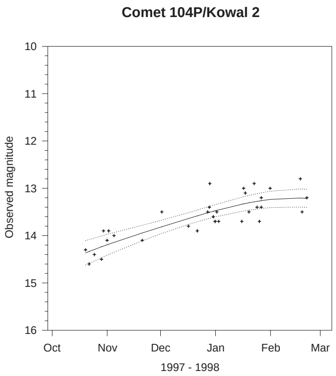
103P/Hartley 2 brightened very rapidly from around 16th magnitude in August to a peak of near 8th magnitude in early January, a week or so after perihelion. It then faded, a little more slowly than expected from the mean light curve using a log r fit. The light curve was more or less the same as at the last return, and its behaviour is fairly consistent. The comet seems to brighten more or less linearly with time, peaking a little after perihelion, then fading at the same rate. Observations received so far (257) give a preliminary standard light curve of $8.4 + 5 \log d + 20.8 \log r$ or a linear light curve of $8.3 + 5 \log d + 0.044 \text{ abs}(T-15)$ where T is the number of days after perihelion.

Comet 103P/Hartley 2 drawn by Nick Martin.





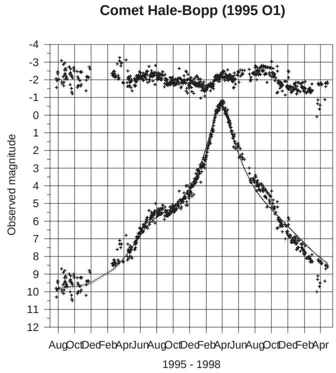
104P/Kowal 2 slowly brightened from around 14.5 in late October to a peak of near 13 when at perihelion at the beginning of March. It was then low in the twilight and this, combined with bad weather prevented many further observations. 33 observations give a preliminary light curve of 10.5 + 5 log d + 11.8 log r.



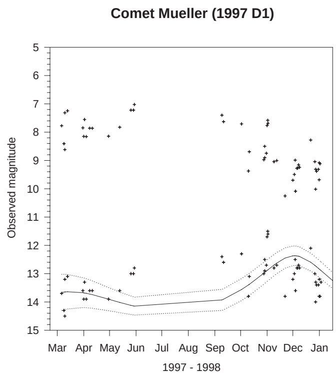
128P/Shoemaker-Holt 1 was observed by Martin Lehky at around 15[th] magnitude in late December.

129P/Shoemaker-Levy 3 was observed by Seiichi Yoshida at 14.5 at the end of January.

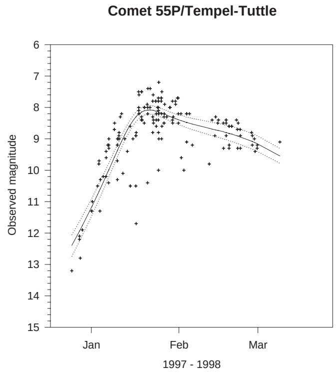
132P/Helin-Roman-Alu 2 was observed by Martin Lehky at around 15[th] magnitude during the autumn.



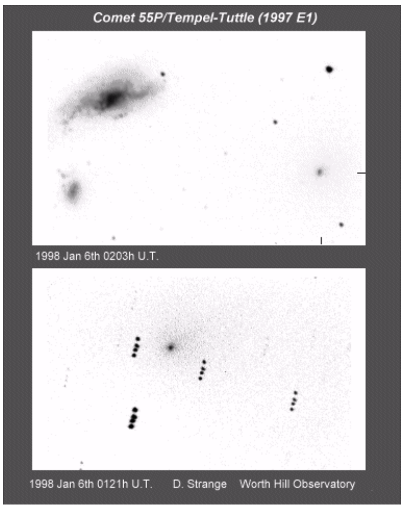
Hale-Bopp (1995 O1) is now a faint binocular object, but still reasonably easy for Southern Hemisphere observers and will continue to fade slowly. The observed arc covers 1008 days with observations made on 682 days. The equation -0.73 + 5 log d + 7.79 log r fits daily means very well, but there are long period variations about this mean light curve of around a magnitude. Between October 20 and the end of December the comet faded by about 1 mag relative to the mean curve.



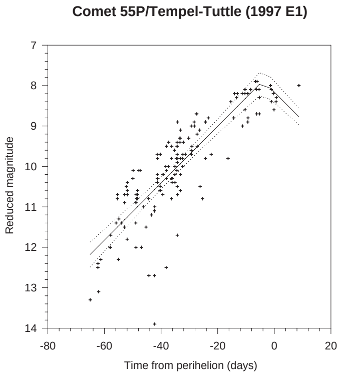
Mueller (1997 D1) was very difficult to see when it reappeared from conjunction and the early light curve overestimated its rate of brightening. The comet became difficult to see because it was very diffuse and the comet seemed to be becoming less active. The observations give a light curve of 9.5 + 5 log d + [5] log r though this is a very poor fit (curve near mag 13) and a better fit is given by either:
a) 8.0 + 5 log d + [7.5] log r or
b) 6.5 + 5 log d + [10] log r until October, followed by a fade of around 0.5 magnitude per month [shown as points near mag 8, data corrected for the distance from the earth].



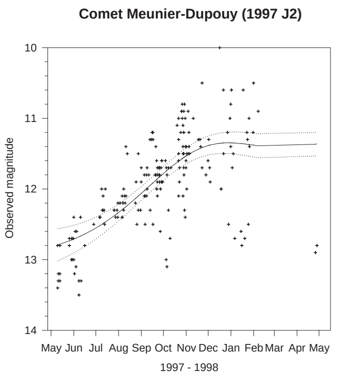
55P/Tempel-Tuttle (1997 E1) was recovered visually in late December at around 13[th] mag. We will not see it again for another 33 years. It brightened rapidly and peaked at 8[th] magnitude in late January around the time of closest approach to the earth. It faded slowly as the distance from earth increased, although it was still approaching the sun. It dropped lower and lower into the twilight and was last seen around mid March at about 9.5. The 186 observations received so far give a light curve of 8.6 + 5 log d + 25.9 log r, which is similar to that of 103P/Hartley 2. A linear curve shows a rather rapid brightening with an equation of 7.9 + 5 log d + 0.071 abs (T+4). The Hubble Space Telescope has determined that the nucleus is only about three kilometres across.



Comet 55P/Tempel-Tuttle imaged by David Strange. The two galaxies on the left of the upper *frame are NGC 4490 (10.2) and NGC 4485 (12.3)*

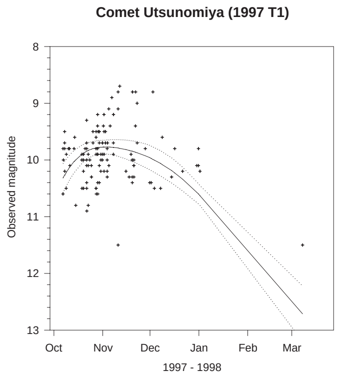


Meunier-Dupouy (1997 J2) moved from the evening sky to the morning sky at the end of January and since then has received very little attention. There is a lot of scatter in the observations, which makes the magnitude equation a little uncertain. The 190 observations received so far suggest a preliminary light curve of 5.0 + 5 log d + 7.4 log r. If this is followed the brightness won't vary much from 12th magnitude over the coming year because the changing distances from earth and sun just about balance. It is a slow moving, distant comet and will remain on view until the end of the year.



Some confusion occurred with the naming of comet **1997 L1** and it is now **Zhu-Balam.** The comet was originally named Xinglong and thought to be a main belt asteroid, but was renamed in 1998 [IAUC 6811, 1998 January 23] after the discoverer and the person who pointed out that the object was cometary. J Zhu reported observations of 5 objects detected on June 4 by the Beijing Astronomical Observatory 0.6-m Schmidt during a search program. D D Balam of Victoria noted that one of them was clearly cometary with the 1.8-m reflector of the Dominion Astrophysical Observatory.

Utsunomiya (1997 T1) was followed into the twilight at the end of December, but very few observations were made after solar conjunction when it was in the morning sky. It was brightest at the beginning of November when it was around 9th magnitude. The 122 observations suggest a light curve of 6.1 + 5 log d + 19.3 log r



1997 T3 was named **Lagerkvist-Carsenty** in early 1998. Uri Carsenty and Andreas Nathues, of the DLR Institute of Planetary Exploration, Berlin discovered a 19th mag cometary object on October 5.1 during the course of the Uppsala-DLR Trojan Survey, in collaboration with C-I Lagerkvist, S Mottola and G Hahn. [IAUC 6754, 1997 October 7]. The comet was not named until January 1998, when it was given the names of the discoverer and the person who found that it was a cometary object [IAUC 6811, 1998 January 23]

Jim Scotti recovered **134P/Kowal-Vavrova (1997 X2)** with the Spacewatch telescope at Kitt Peak on December 5.5 when it was 22nd mag. The predicted ephemeris required a correction of +5.3 days. [IAUC 6784, 1997 December 10]

A further twelve sungrazing comet fragments have been discovered by the LASCO coronographs on the SOHO spacecraft, bringing its total to 45 comets. The new comets are: 1997 H3, 1997 P3, 1997 S2, 1997 U1, 1997 W1, 1997 W2, 1997 X1, 1998 A1, 1998 E1, 1998 F1, 1998 G2 and (provisionally) 1997 G3. Brighter objects are often discovered in the real time data, but the fainter ones have to wait for the archival data to be searched which runs three or four months behind. More details are available on the Section web page.

135P/Shoemaker-Levy 8 (1998 B1) was recovered by Carl Hergenrother with the SAO 1.2-m reflector at Mt Hopkins on January 22 when it was 22nd magnitude [IAUC 6821, 1998 February 9]. The comet is unlikely to become bright enough for visual observation.

P/LINEAR (1998 G1) was discovered during CCD survey work by the Lincoln Laboratory Near Earth Asteroid Research Project using the Lincoln Laboratory Experimental Test System 1.0-m f2.15 reflector on April 2.13 [IAUC 6863, 1998 April 6]. The asteroidal object had a retrograde near parabolic orbit and follow-up images by Warren Offutt of Cloudcroft, New Mexico showed a tail but no coma. Further astrometric observations showed that it is in an elliptical Halley type orbit with a period of 45.1 years. The comet is around 18th mag, but won't become much brighter than 17th magnitude, when it reaches perihelion in November.

The most recent batch of MPC lists 35417 observations by the LINEAR team, with observations of 3424 asteroids of which 1463 are new discoveries! By contrast the same issue lists 'only' 2477 observations by the NEAT team, 1924 by Spacewatch and 1725 by LONEOS. British observers have 39 between them and no cometary astrometry is reported from the UK.

SOHO (SOHO-47 and provisionally 1998 G4) is the third non-Kreutz group comet discovered by the satellite. It was found over the Easter weekend by Kevin Schenk, but faded very rapidly. So far it has not been announced on IAUC.

Stonehouse (1998 H1) was discovered by Patrick Stonehouse of Wolverine, MI, USA on April 22.3. He was observing in Serpens Caput using a 0.44-m reflector when he noticed a diffuse object which showed motion. There was some confusion over the reported motion, but it was eventually confirmed by Alan Hale on April 26.3 [IAUC 6883, 1998 April 26]. The discovery magnitude was put at 12 - 13, though Hale estimated it at 10.7. I observed it with the Northumberland refractor on April 28.08 and made it 11.7, coma diameter 1.1', DC s3. It will fade quite rapidly, though a provisional ephemeris is given in the observing supplement.

As this issue went to press, the discovery of **SOHO (1998 J1)** was announced. This is the first comet discovered by the satellite likely to be visible from the ground. By the time this reaches you it will only be visible from the southern hemisphere, and a special supplement is included for our southern readers.

For the latest information on discoveries and the brightness of comets see the Section www page:
http://www.ast.cam.ac.uk/~jds

Comet Comments

Don Machholz

Comet Comments is a monthly column that I've been writing since 1978. I started writing it to inform other amateur astronomers of new comet discoveries and to provide information so that they can find the brighter comets. Each issue of Comet Comments is written three weeks before the "due" date, giving time for it to be distributed to the editors and placed into the newsletters. Comet Comments contains information about new comet discoveries, followed by comet news and observing tips for the comets currently visible. Carried in only one newsletter (the San Jose Astronomical Association's "Ephemeris") for the first two years, the column is now carried in some three dozen newsletters. It also appears on the Internet: America-On-Line displays it in their astronomy department (Keyword: Astronomy) and you can find it at: http://members.aol.com/cometcom/index.html.

JULY 1997: Of the 97 visual comet discovery events since 1/1/75, during which 73 comets were found and named, only four times was the comet found by accident. In early July 1975 Doug Berger and the late Dennis Milon found a comet while observing M 2. A comet hunter (Toru Kobayashi of Japan) had found it the previous day. Then, twenty years later Alan Hale and Thomas Bopp chanced upon a new comet near M 70.

AUGUST 1997: With Tabur's find, six of the last seven visually-discovered comets have been found south of the celestial equator; and 14 of the last 17 visually-discovered comets have been found in the morning sky.

SEPTEMBER 1997: Many people quote the 1700 hours it took me to find my first comet or the 1742 hours to find my second. This has been surpassed twice in recent years. In 1987 Noboru Nishikawa took 3024 hours in 2389 sessions to find his first comet (1987a). In 1990 Yuji Nakamura discovered his first comet after searching 2236.5 hours in 1558 sessions.

OCTOBER 1997: With so many comets from the Kreutz Sungrazing Group being discovered by the SOHO satellite, amateurs have taken a renewed interest in sweeping along the path by which these comets are arriving. That path is now in the morning sky, having been behind the sun this past summer. The comets are very faint in the weeks before perihelion and it may take CCD imaging to capture them. The brightest members, although rare, can still be discovered visually.

NOVEMBER 1997: Since the first day of 1975, 76 comets have been visually discovered. Some have been discovered by more than one person: ten by two visual discoverers and seven by three. This amounts to 100 visual discovery events. Thirty-two of those 76 comets were found in the evening sky with 44 found in the morning sky. Additionally, 42 were found in the north of the celestial equator with 34 found south. All of the 23 comets found by observers living south of the equator were found in the southern celestial sky. Northern Hemisphere observers found comets both north and south of the equator.

DECEMBER 1997: Since January 1975, 48 different individuals have visually discovered comets that now carry their names. What countries do they live in? Twenty-three are in Japan, nine reside in the USA, with four in Australia. Other countries represented are the old USSR, Canada, England, South Africa, Philippines, Italy, New Zealand and Norway. The most discovery events occurred in Japan (33) followed by the USA (30) and Australia (19).

JANUARY 1998: Of the last 100 visual comet discoveries, amateurs using binoculars made 28. The smallest pair of binoculars used was 7x35's by William Bradfield in 1980 to find a magnitude-six comet. Three were the 80mm size while six finds were made using binoculars with objectives of 110-120 mm. Four finds were made with my homemade binoculars (130mm), and half (14) of all binocular comet discoveries were made with 150mm (6-inch) binoculars.

FEBRUARY 1998: Of the last 100 visual comet discoveries, amateurs using refractor telescopes made 23. The smallest was Genichi Araki's 3" scope to find Comet IRAS-Araki-Alcock. Toshio Haneda used a 3.3" refractor to find his comet and three other instruments were from 4.8 to 5.2 inches in diameter. The remaining 18 refractors were 6" in size, with William Bradfield finding 12 comets since 1975 (and two before) with his 6" telescope.

MARCH 1998: Amateurs using reflectors made forty-eight of the last 100 visual comet discoveries. They range in size from 4" to 19.5". The most popular size (16" aperture) was used in 16 finds. These large reflectors were also efficient, averaging 231 hours per find compared with 391 hours for all visual comet discoveries. All five accidental comet discoveries (Berger, Milon, Hale, Bopp and Tillbrook) were made with reflector telescopes.

APRIL 1998: Of the 100 comets visually discovered since 1975, only one was found without the use of a reflector, refractor or binoculars. It was Merlin Kohler's comet discovery on Sept. 3, 1977. He used an 8" Dynascope Schmidt Cassegrain. This discovery took about forty hours of sweeping. Mr. Kohler is now retired and still living in Quincy, California.

Don's Comet Hunting Hours:
1975-1997: 6277.25
Hours through Mar. 1998: 21.50
Total hours at last discovery (10-8-94): 5589.00
Least hours in any month since I began comet hunting on 1/1/75: 4.00 (02/98), 4.50 (01/86), 5.50 (02/80)

Most hours in any month since I began comet hunting: 69.25 (05/76), 63.00 (05/78)