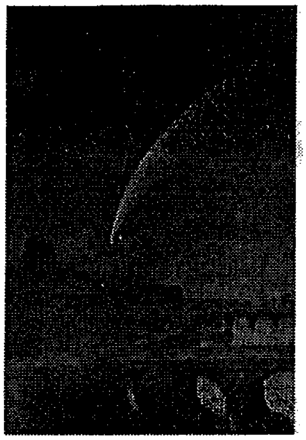


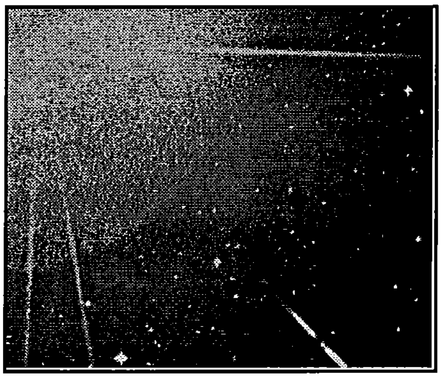
THE COMET'S TALE

Newsletter of the **Comet Section** of the **British Astronomical Association** 1994 Nov

The collision between Shoemaker-Levy 9 and Jupiter

David W. Hughes, Department of Physics, The University, Sheffield

NEVER before in the history of astronomy have we been able to predict when two solar system bodies would collide and then sit back and witness the event nearly a year and a half later. During 1994 July 16–22 twenty or so fragments of the Jovian cometary satellite Shoemaker-Levy 9 hit Jupiter. The comet came off worse.



Last days of the comet! ESO's view of the gravitationally-elongated dust comae (lower right) against scattered light from Jupiter.

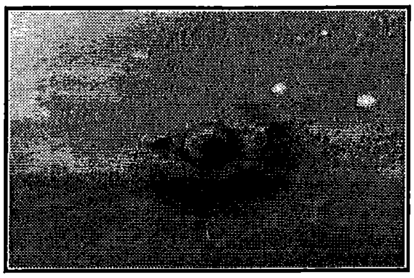
A global network of ground-based observatories and a small armada of spacecraft (Hubble Space Telescope, Galileo, Voyager-2 and Ulysses) observed the event. It was the largest concerted observational programme ever embarked upon in the history of astronomy. Before July astronomers see-sawed between predicting that little would be seen and foretelling a celestial spectacular.

In fact much was seen, but very little was learnt. If you want to learn about comets it is clear that smashing them to smithereens with a planetary hammer moving at 60 km s^{-1} and then violently stirring the bits into a swirling cloudy atmosphere, is not a good experimental plan. And if you want to do cosmic physics, by inputting a specific amount of material and energy into the Jovian atmosphere it helps if you have a good idea as to the amounts in question.

This, unfortunately, was not the case. Such fundamental quantities as fragment size, density and mass were unknown.

Cometary nuclei are dirty snowballs and not rocky ice-balls. Cometary experts guess that their densities are around 200 kg m^{-3}. An analysis of the way in which the comet split apart as it passed inside Jupiter's Roche limit indicated that the diameter of the precursor was about 1 km. So the biggest fragment was probably about 0.25 to 0.5 km across. Thus the maximum fragment impact was between about 3×10^{18} and 2×10^{19} J (36,000 to 300,000 "Hiroshima" bombs).

In mid-July it was soon realised that the intensity of the impact phenomena was only roughly related to the pre-impact brightness of the incoming cometary fragment. The cometary string consisted of fragments A, C, D, E, G, H, K, L, Q, R, S, U, V and W which were on a straight line and fragments B, F, N, P, and T which were off this axis. Fragments G, H, K, Q and S were very bright, E, L and R were bright, A, B, C, F and T were of medium intensity and D, N, M, U and V were faint. Fragment A produced a bright impact signature whereas fragment B's impact resulted in an almost undetectable blemish. Fragments that were off the axis of the main "string of pearls" were complete flops. They were probably dust clouds not solid fragments.



Hubble image of impact site G (with earlier site D to left) on July 18.

All the impacts occurred at a Jovian latitude of -44°. They also hit the side of Jupiter that was facing away from both the Earth and the Sun. The comet path was inclined at 45° to the Jovian cloud layers. *continued on page 3*

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Comet Section contacts

Director: Jonathan Shanklin, 11 City Road, CAMBRIDGE, CB1 1DP, England.
Phone: +44 1223 571250 Fax: +44 1223 62616
E-Mail: JDS @ MAIL.AST.CAM.AC.UK *or* J.SHANKLIN @ BAS.AC.UK

Assistant Director (Observations): (and also Editor of *The Astronomer* magazine) Guy Hurst, 16 Westminster Close, Kempshott Rise, BASINGSTOKE, Hampshire, RG22 4PP, England.
Phone & Fax: +44 1256 471074
E-Mail: GMH @ AST.STAR.RL.AC.UK *or* GMH @ GXVG.AST.CAM.AC.UK

Assistant Director (Newsletter): (and also any general correspondence) James Lancashire, 21 Warkworth Street, CAMBRIDGE, CB1 1EG, England.
Phone: +44 1223 329031
E-Mail: JALAN @ MAIL.AST.CAM.AC.UK

CCD Advisor: Nick James, 11 Tavistock Road, CHELMSFORD, Essex, CM1 5JL, England.
Phone: +44 1245 354366
E-mail: NDJ @ GEC-MRC.CO.UK *or* NDJ @ ASTRO1.DEMON.CO.UK

Photographic Advisor: John W Smith, 27 Forest Road, Winford, SANDOWN, Isle of Wight, PO36 0JY, England.
Phone: +44 1983 865451

Editorial

Many thanks for your kind comments relating your satisfaction with your new-look newsletter. Do keep in touch by letter or e-mail with any thoughts and, in particular, any articles or observing notes, or general illustrative material!

Computer technology changes so quickly that not only is it hard for one to keep up-to-date, but that very dynamism forces one to continually adapt. Owing to this, I have had to use a different desk-top publishing package to produce this issue. I hope this program (if not the version number!) will be around for some time. So there are necessarily some (hopefully) minor changes in design and layout.

I have consequently been rather busy at the production stages, and I must thank all the contributors. Those articles and images (mostly arriving in electronic form) have saved me hours at the keyboard and also many trips to libraries in search of content for this issue. I have been able to devote my time to actually *editing* the newsletter!

On to observational matters. No sooner had my charts appeared in May showing the prospect of four comets over the summer than some of these comets started to fade and become more diffuse. I can accept responsibilty only for terrestrial matters I'm afraid!

The summer, though, was notable for split comets: in addition to Shoemaker-Levy 9, comets 1994o and 1994g displayed several components. I saw two of the components of 1994o – how many did you see?

I have avoided any mention thus far of the great comet crash, when SL9's fragments impacted Jupiter during the third week of July. This is for numerous reasons.

First, amateurs *were* rewarded by an amazing sight of *Jupiter's* southern hemisphere pock-marked with dark impact scars, but this newsletter is not the place to discuss *those*.

Secondly, the leading article by Dr David Hughes is on this very subject, and he is more competent that I to deal with the theoretics involved.

And thirdly, much analysis of the vast amounts of data from every observatory on Earth remains uncompleted, after which the interpretation will no doubt change drastically our perspectives on comets and on planetary atmospheres. But this process will take months, if not years to complete. So we are now in transit, a knowledge *interregnum* if you like, from one set of models to the next, and I believe that unfounded speculation during this period is undesirable.

Having said that, some professional astronomers have met already at conferences, notably at the International Astronomical Union, at the Hyper-velocity Impact Symposium and at the Division of Planetary Sciences of the Association of Lunar and Planetary Observers. ESO will hold a meeting in the New Year.

For amateur astronomers, particularly in Europe, the Planetary Observers in Germany invite you to MEPCO '95 – see details elsewhere.

The comet and Jupiter sections of the BAA are meeting on Saturday, 1995 March 18 in Cambridge for a full day's discussion of the SL9 event. Again, details are given elsewhere and I hope that you will be able to attend.

The UK weather since the summer has been rather autumnal(!), with frontal systems following each other across the Atlantic and hardly any clear observing sky in between. There have been odd clear nights but these seem to have occured around Full Moons, so the few comets have simply been drowned out.

The prospects for 1995 aren't too good at the moment – see Jonathan's article. Observers with a CCD should try to follow P/Schwassmann-Wachmann 1 and note any outbursts.

Finally, if you haven't sent any sub to Jonathan then this will be your last issue until he has your £3 (for those active) or £5 (for others) to cover two years.

Once again, may I urge you to read, subscribe and contribute!

James Lancashire

The collision between Shoemaker-Levy 9 and Jupiter

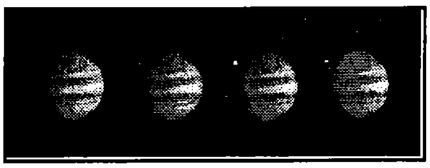
continued from page 1

Meteors and fireballs provide the best clue to the impact process. In the Earth's atmosphere a meteoroid starts ablating at a pressure of 10^{-7} bar. The lower molecular weight of the hydrogen and helium in Jupiter's atmosphere causes ablation to start at around 10^{-6} bar. The only "observed" Earth-comet impact was Tunguska. Here the comet blew up 8.5 km above the Earth's surface, where the pressure was 0.1 bar. In the Jovian case we multiply by a factor of ten (owing to the atmospheric constituents) and by another factor of ten for the additional mass of the impactors. The comet explosion thus occurs at a pressure of 10 bar, i.e. above Jupiter's clouds.

Each bit of Shoemaker-Levy 9 was expected to break up when the differential dynamic pressure across the fragment exceeded the tensile strength. When this happened the surface area of the ablating comet increased by a huge amount, the deceleration increased enormously and the comet dumped all its remaining energy more or less instantaneously. This produced a "hydrogen bomb" type explosion. Material was blown way above the Jovian cloud layers, and then fell back under gravity after a few minutes. The observation of this short-lived material plume signalled "friable comet". A stronger asteroidal fragment would not have undergone this explosive deceleration process.

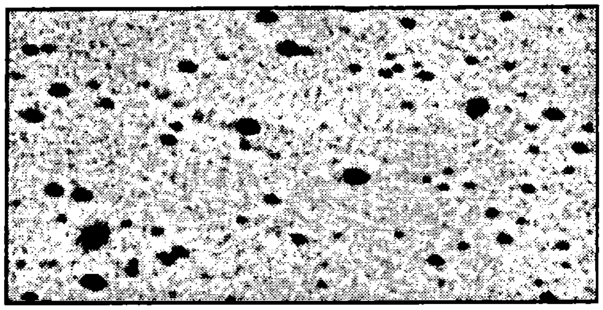
What was seen

(1) The fireball flash at the instance of impact was only imaged by the Galileo Spacecraft. Impacts L and W were spectacular. All the impacts occurred on the Jovian face pointing away from Earth, but as Jupiter rotates every 10 hours the site soon came into view.



Galileo's direct view of impact W over 7 s on 1994 July 22: the impact occurs just round the limb as seen from Earth, on Jupiter's 'dark side', at latitude 44° south (top here)

(2) The plume, the short-lived "H bomb like" cloud that rose and then fell back, was seen by the Hubble Space Telescope. In the case of the G impact the gas went up to a height of at least 3000 km (remember that Jupiter has a radius of 71,300 km) and fell back in about 18 minutes.



A remarkable amateur view of SL9: David Strange's image on 1994 March 17 taken with a Starlite Xpress CCD attached to a 20-inch f/4 Newtonian using ten 80 s exposures. The galaxy IC 4476 is tto the bottom left

(3) The expanding meteor train was easily observed (much more easily than expected). Here the highly energetic cometary material mixes with, excites, and warms up the jovian material. Dilution occurs extremely rapidly. As the cometary atoms and ions have an initial velocity of 60 km s^{-1}, their random walk away from the impact track means that within minutes they have mixed with many thousand times their own mass of Jovian material. A comet moving at 60 km s^{-1} has an equivalent "temperature" of 2,500,000 K. Within tens of minutes this has dropped to temperatures that are best detected in the near and far infra-red.

The expanding meteor train could be seen as a scar in the Jovian south-south temperate zone at latitude near 44° south. On average there was a hit every 7 hour and after a time this zone became a confused battle-field. For example F hit the E impact site; D, G and S ploughed into the same region; and W merged with K.

The spectral signature from the cooling impact region was dominated by methane. Visually the scars were dark whereas in the infrared they were bright. At visual wavelengths the train cloud region had a reflectivity that was lower than the underlying Jovian clouds. As time passed the train clouds sank, became assimilated by the normal clouds and disappeared from view. In the infrared K band at 2.2 microns the impact site shone like a beacon against the dark cold surface of Jupiter.

The Kuiper Airborne Observatory detected C_2H_2 (acetylene), C_2H_6 (ethane) and water vapour. The JCMT on Hawaii observed CO and HCN. S_2 and CS_2 and NH_3 have been seen in the UV. These molecules and radicals came from both the disruption of the comet and the Jovian ammonium hydrosulphide and ammonium clouds.

(4) cometary remnants. The pre-impact comet was a dirty snow-ball with an internal temperature of typically 140 K. Its 60 km s^{-1} impact with Jupiter released sufficient energy to completely atomise the material and excite the atoms. Any dust left over was expected to be a very small fraction of the initial dust content. The vast majority of the dust mass was smashed into excited atoms of Ca, Na, Fe, Mg, Si and O. The Intermediate Dispersion Spectrograph on the Isaac Newton Telescope showed a profusion of metal lines when the fresh meteor trains were observed.

Needless to say it is very difficult to vapourise all the dust. A cometary fragment of 0.5 km diameter contains about 4 x 10^9 kg of dust. If only one part in a million remains you are still sprinkling 4 tonnes of dust into the Jovian cloud layer, and this dark dust could produce a dark expanding cloud.

The cometary snow is mainly H_2O. For every twenty water molecules there is one carbon dioxide. Again only a small percentage of the cometary molecules survive the impact. Just try hitting water and carbon dioxide with a 60 km s^{-1} hammer. The usual end-product is very excited H, O and C.

The plasma in the meteor train contained many electrons. Some of these spiralled off along Jovian field lines. Their subsequent deceleration produced decimetric radio emissions.

Section news from the Director

Dear Section member,

Comet Shoemaker-Levy 9 has now killed off the Jovian dinosaurs, but we're still not sure if it was really an icy comet or a pulverised asteroid. What is clear is that there is a wide range of different types of bodies in the outer solar system, some of which turn into fully fledged comets. In many cases it will be amateur observations that will help to elucidate their nature, so keep sending in your observations. As you will see elsewhere in the newsletter we are going to have a meeting to discuss the comet next March, by which time some of the scientific results should have been announced. The MEPCO meeting also promises to be a worthwhile forum for discussion, with the star attraction of Gene Shoemaker.

In the past six months observations or contributions have been received from the following BAA members:

Sally Beaumont, Denis Buczynski, Werner Hasubick, Paul Howarth, Guy Hurst, Nick James, David Keedy, James Lancashire, Brian Manning, Glyn Marsh, Oernulf Midtskogen, Martin Mobberley, Bob Neville, Roy Panther, Jonathan Shanklin, Melvyn Taylor and Alex Vincent

and also from:

John Bortle, Eric Broens, Paul Camilleri, Matyas Csukas, Vidican Dan, Alfons Diepvens, Bjorn Granslo, Roberto Haver, Graham Keitch, Atilla Kosa-Kiss, Martin Lehky, Antonio Milani, Herman Mikuz, Alfredo Pereira, Richard Schmude, David Seargent, Chris Spratt, Tonny Vanmunster and Vittorio Zanotta;

and of comets:

P/Encke, P/Schwassmann-Wachmann 1, P/SchwassmannWachmann 2, Mueller 1993a, P/Tempel 1 1993c, P/Shoemaker-Levy 9 1993e, P/Reinmuth 2 1993g, P/Hartley 3 1993m, P/West-Kohoutek-Ikemura 1993o, Mueller 1993p, P/McNaughtRussell 1993v, P/Kushida 1994a, Takamizawa-Levy 1994f, Takamizawa 1994i, P/Brooks 2 1994j, P/Borrelly 1994l, Nakamura-Nishimura-Machholz 1994m, Machholz 2 1994o and Machholz 1994r.

Briefly looking at the comets observed since the last newsletter came out: **1993v** faded rapidly after mid May and was last seen in mid June when it was 12^m. **1994f** reached a peak brightness of 8^m in early June. Observations continued until mid July by which time it had faded to nearly 11^m. **1994i** reached 9.5^m, though observations are rather scattered. The last observations put it near 12^m in early July. Comet Borrelly, **1994l**, is not quite living up to initial expectations and has only reached 8.5^m, which is consistent with $H_{15} = 7.0^m$, similar to that recorded at the last apparition in 1987, suggesting that the high r coefficient used elsewhere may be an artifact. It has shown an interesting anti-tail as it crosses through the nodal plane. If it continues with a 15 log r behaviour it should be 8^m throughout November, and will then slowly fade into the new year.

1994m was well observed and a full report will appear in the Journal in due course. It was around 9.5^m when discovered in early July and peaked at around 8^m. It became steadily more diffuse and was last seen in mid September at 10^m. **1994o** was a curious object which split into several components, though it seems likely that the major components (A and D) separated some time ago. Its position in the morning sky discouraged many observers, though it was interesting to see two comets in the same field. It peaked at around 7^m in early September and it was around 9.5^m in mid October after which it was too far south for UK observation. **1994r** was the third Machholz discovery of the year which puts him ahead of David Levy with nine visual discoveries, but still behind Anton Mrkos (11) and Bill Bradfield (16). It is a diffuse 11^m object and is unlikely to become any better.

I have completed reports on:

- The Analysis of Comets,
- Comet Levy 1990c, and
- Comet Shoemaker-Levy 1991a_1

which have been accepted for publication in the Journal and also on the comets of 1990 which has just been submitted to the Papers Secretary.

Prospects for comets in 1995 appear elsewhere in the newsletter, and will also appear in the Journal as the readership of the two publications is slightly different. Further papers on the history of the BAA comet section and on the measurement of DC have been submitted to the ICQ; the former appeared in the October issue and the latter will appear in January. The measurement of DC is not at all consistent, despite the apparent consensus reported in the last issue. It turns out that Charles Morris, John Bortle and myself are all using different interpretations. For the moment continue to use the interpretation given in the last issue and I hope to report the final word next time.

Whilst preparing the report on the comets of 1990 I found a distinct lack of drawings and photographs in the section archives. Please make sure that you submit copies of any worthwile photographs and drawings directly to me, so that I can illustrate future articles. If you have material from 1950–1990 which has never been submitted, do send it in to me, as sooner or later I hope to do reports on the archival observations. The priority will be to complete reports on periodic comets that have been observed several times by section members.

The comet section *Keedy award* for 1993 has been awarded to **Atilla Kosa-Kiss** from Romania, who has been contributing comet observations to the section for several years. He lives in a small town on the border with Hungary and has been an observer for over 24 years. He graduated from a hydrometeorological college in 1975 and is a technologist in a water treatment works. He has published about 200 papers on his observations in various magazines and journals. The 1994 award goes to **James Lancashire** for his excellent work in producing this newsletter. This is an annual award and you can submit nominations at any time; if anyone has suggestions for the 1995 award please let me know.

As a new service I can obtain copies of two American publications for BAA members. The CBAT 9th Catalogue of Cometary Orbits is available for £21 in book form, £35 by e-mail and £75 on floppy disc. Subscription to the *International Comet Quarterly* (comet observations, occasional articles, charts, predictions and an annual handbook which gives elements and ephemerides for all comets due to return during the year) costs £25 for 4 issues (or £15 by surface mail); if enough members want to subscribe it will be possible to offer a reduction on this to £21 (£12 by surface mail). Group subscription has to have at least five subscribers and they must all subscribe at the same time. The handbook by itself costs £12. Please contact me if you are interested in subscribing; if there is sufficient interest I will send in a group subscription in April.

I will be away visiting the Antarctic again from mid-December to late-March (and will probably miss the section meeting). During this time any urgent correspondence should be sent to James Lancashire, and observations should go to Guy Hurst as usual. I hope to continue with data entry from the archives whilst I'm away and will also complete formatting the data from 1991 and 1992 which I've had scanned from *TA*. This should enable me to complete reports on all the comets from these years, so you may find rather a glut of comet papers in the Journal!

Best wishes,

Jonathan Shanklin

Michael Philip Candy M.Sc, FRAS (1928–1994)

Mike Candy and his comet-seeker taken shortly after the discovery of comet Candy (photograph 78 in* BAA Memoir *Vol 42 part 2* The Second Fifty Years*)

MEMBERS will be sorry to hear that Mike Candy died on 1994 November 2. He collapsed at work in Perth, Australia, with a brain haemorrhage and never regained consciousness. We offer our sympathy to his family and friends.

Michael Candy was born on 1928 December 23 and elected to the BAA on 1950 November 29. His main interest was in comets and meteors and as well as being an active observer he was adept in computing ephemerides and orbits for newly-discovered comets. Before electronic calculating was available, log tables or hand-cranked calculating machines had to be used and this involved the burning of much midnight oil.

Dr Gerald Merton was Director of the BAA Comet Section when the first few observations of comet Arend-Roland came to hand in 1956 November. Candy quickly computed a preliminary orbit. This was followed by an accurate orbit which he described at the Association's meeting on 1957 March 27. Candy was the first to see the comet after perihelion from this country, on the evening of April 20. He was appointed Assistant Director of the Section four days later.

Mike Candy was a professional astronomer at the Royal Greenwich Observatory, then at Herstmonceux Castle, Hailsham, Sussex and amongst other things observed double stars with the 28-inch refractor. He also worked with the 13-inch astrographic telescope on occasion.

Upon Gerald Merton's retirement from the directorship in 1958 April, Candy was appointed to run the Section and edit the BAA Circulars, which he did with great enthusiasm until the end of 1967 when he left the RGO to take up an appointment at the Perth Observatory, Bickley, Western Australia. He remained in Australia and continued to take an active part in study of the smaller bodies of the Solar System for the rest of his life.

During his term as Director, Mike Candy greatly encouraged both established Section members and newcomers. He had a friendly manner and was always approachable. He found time to reply to all letters and acknowledged observations, usually by postcard, in his own clear hand, adding useful bits of information or an extended ephemeris.

On 1960 December 28 Candy was testing an eyepiece in his 5-inch short focus refractor (a comet-seeker made for him by Horace Dall). Observing from an upstairs window at his home in Hailsham he discovered comet Candy 1961 II, then about 8th magnitude and in Cepheus. Although he undertook searches for new comets after that, this was to be his only discovery.

In addition to his observational work Candy also did much work on periodic comet orbits and on the orbits of meteor streams.

In later years Mike Candy was much involved in the world-wide effort to obtain accurate astrometric data for the 1986 return of Halley's Comet. The official IHW records show that Perth Observatory reported the highest number of positions of any station, 538 in number, of which Candy was personally involved in obtaining 412.

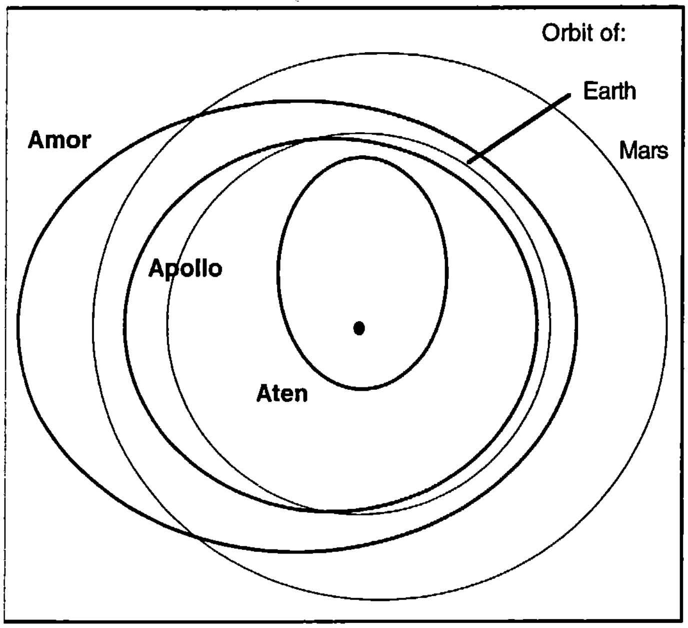
Many of us had not seen Mike for nearly thirty years but we can remember the time when he was active in the BAA Comet Section with pleasure. He was enthusiastic, energetic, helpful and had a good sense of humour. He made us feel that a foot or two of snow was no excuse for missing an observation. There were some good comets around and their study had yet to become quite respectable amongst professional astronomers. Mike Candy personally did much to make it a memorable time for us to be observing comets.

Mike Hendrie

Near Earth Objects

APART from the main asteroid belt between the orbits of Mars and Jupiter which contains many minor planets, there are hundreds of small bodies orbiting the Sun farther in and away. Some come near to the Earth and are known as Near Earth Objects (NEOs).

There are three classes of NEO: Amor, Apollo and Aten. The orbits of **Amor** asteroids cross the orbit of Mars, but do not come inside that of the Earth; **Apollo** asteroids come inside the orbit of the Earth; and the **Aten** asteroids stay mainly inside the orbit of the Earth.



Typical orbits of three classes of Near Earth Objects

Some of these objects are no more than about 6 or 9 m in diameter and one of them known as 1991 BA flew past the Earth on 1991 January 18 at a distance of only 171,000 km – less than half the Moon's distance. It is quite likely that some of the large meteorites on Earth may well have been one of these smaller Near Earth Objects before plunging into our atmosphere.

It is possible that these Near Earth Objects are the nuclei of extinct comets which have used up all their volatiles. A comet is a mixture of ice and dust and on each orbit it loses a vast amount of material, particularly as it passes through perihelion. Eventually, once its volatiles are gone, only the nucleus will be left. Thus nothing remains of the comet but a large lump of rock.

When some comets (for example P/Schwassmann - Wachmann 1) are quiescent, they have the colour and brightness of RD asteroids, whilst other comets such as Arend-Rigaux resemble S-type asteroids when quiescent. When these comets have used up all their volatiles, they will not be distinguishable from asteroids. Comet Arend-Rigaux is on its way to becoming an asteroid.

Asteroid No 3200 "Phaethon", discovered in 1983, approaches the Sun at a distance of only 21,000,000 km (0.14 AU) at perihelion and goes out to 295,000,000 km (1.97 AU) at aphelion. It is 5 km in diameter and has a revolution period of 522 days. It shares the orbit of the Geminid meteor stream which peaks in December every year.

It has always been known that meteor streams are associated with comets, for example the Perseids with comet Swift-Tuttle, but the Geminids seem to be associated with an asteroid. This may explain why the Geminid meteoroids are more dense than those associated with comets which are more fluffy in nature. It could be due to the asteroid crumbling away or even the crumbling nucleus of an extinct comet. The Geminids may have been more fluffy in the past.

Some of the sporadic meteors which are not members of any showers may be associated with NEOs. A large stream of these objects may be orbiting the Sun in the inner Solar system

Asteroid No 4015 discovered by Eleanor Helin in 1979 is identical with Comet Wilson-Harrington which was discovered in 1949. The period of this comet is now calculated to be 4.3 years, but it was cometary only at its discovery. So it seems that some of these near Earth objects are the nuclei of dead comets and the author suggests that they be termed "cometoids".

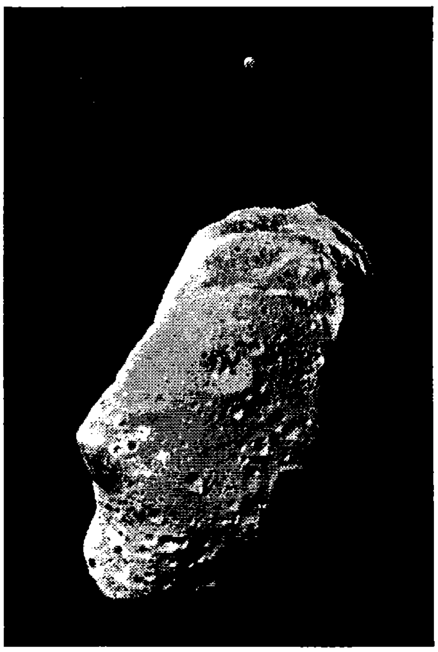
Some of the NEOs may be fragments of a comet or comets which broke up, as in the case of Comet Biela. Some comets may have fragmented, which may have occurred at (or near) their perihelion passage or during a close encounter with a planet like Jupiter. Some asteroids orbit the sun in a comet-like fashion, for example Icarus, Adonis, Hidalgo and Oljato, and are probably ex-comets.

The spacecraft Clementine which has been photographing the Moon is due to fly past and photograph a Near Earth object called Geographos. This would have been the first to be looked at close range but the spacecraft's motors failed. Clementine would have approached Geographos to within 100 km on 1994 August 31. Geographos lies 122,000,000 km from the Sun at perihelion and 243,000,00 km at aphelion.

Plans have been made for spacecraft to visit other near Earth objects in the near future. If these NEOs are extinct or dormant comets then the probes may reveal a dark object resembling a cometary nucleus. The probes may also reveal some other cometary material such as ice, gases, dust and other volatiles which these near Earth objects may still retain.

Alex Vincent

Galileo's view of Ida with Dactyl



IAU resolution on the designation of comets

THE FOLLOWING resolution concerning designations and names of comets was adopted by the International Astronomical Union at its General Assembly in The Hague on Aug. 24:

1. Commission 20 of the IAU, considering that:

(a) there is essentially a 1:1 correspondence between the provisional (year/letter) and definitive (year/Roman numeral) designation systems for comets;

(b) the procedure for interpolating old discoveries of comets into the existing designation systems is unsatisfactory, particularly when orbit determinations are not available;

(c) the application of a new designation at each return of a periodic comet to perihelion is an unnecessary complication, particularly when the comet's recovery can be described as "routine", or for the rapidly increasing number of periodic comets that are followed all around their orbits; and

(d) there can be confusion whether a newly-discovered object is a comet or a minor planet,

proposes to replace the present designation systems for comets with a system that closely resembles, but is not identical to, the designation system for minor planets.

2. Specifically, it is resolved that the year/letter and year/Roman numeral systems be replaced by one in which each cometary discovery is given a designation consisting of the year of observation, the upper-case code letter identifying the halfmonth of observation during that year according to the procedure used for minor planets, and a consecutive numeral to indicate the order of discovery announcement during that halfmonth. Each new designation shall be supplied by the IAU Central Bureau for Astronomical Telegrams when the discovery is announced in one of its Circulars. For example, the third comet reported as discovered during the second half of February 1995 would be designated 1995 D3.

3. The nature of an object can further be indicated by an initial prefix. In particular, such prefixes should be applied in cases where comets have possibly been mis-designated as minor planets, or *vice versa*. If necessary, the prefix A/ would precede a comet designation that actually refers to a minor planet (or asteroid). For comets the acceptable prefixes are P/ for a periodic comet (defined to have a revolution period of less than 200 years or confirmed observations at more than one perihelion passage) and C/ for a comet that is not periodic (in this sense), with the addition of X/ for a comet for which a meaningful orbit can not be computed and D/ for a periodic comet that no longer exists or is deemed to have disappeared.

4. If a comet is observed to return (or have its periodicity established by observation through aphelion or from identifications), the P/ (or D/) shall be preceded by an official sequential number (e.g., 1P/1682 Q1 = Halley), the list to be maintained by the Minor Planet Center and published in the Minor Planet Circulars. Subsequent recoveries shall be acknowledged with further designations only when the predictions are particularly uncertain.

5. The practice of providing future predictions for the returns to perihelion of all periodic comets for which there is a reasonable chance of future observations will continue. While this currently means, for example, the publication of predictions for the comets for the year n in the batch of Minor Planet Circulars for May of the year $n - 3$, the elements being for the 40-day date closest to perihelion passage, it is to be expected that this process will be supplemented – and perhaps eventually supplanted – by one that provides the orbital elements for these comets routinely at epochs 200 days apart, as in the case of minor planets.

6. In the case of a comet that has separated into discrete components, those components should be distinguished by appending -A, -B, etc., to the designation (or to the P/ or D/ periodic comet number).

7. Noting that some redundancy of nomenclature is desirable, it is proposed to retain in general terms the tradition of naming comets for their discoverers. In this framework, a committee has been formed to establish more precise procedures to ensure fairness and simplicity.

8. It is proposed that comet names be announced in the IAU Circulars only following consultation between the Central Bureau for Astronomical Telegrams and the Commission 20 Small Bodies Names Committee.

9. Whereas the new designation system for comets implies the possibility of confusion (if incorrect spacing is used) with that for new planetary satellites, it is proposed to indicate satellites with the prefix S/.

10. It is proposed that the new designation system for comets be introduced at the beginning of the year 1995. In the interests of avoiding confusion and maintaining continuity, Roman numeral designations will be published in the Minor Planet Circulars for pre-1995 comet discoveries/recoveries passing perihelion in 1993 and 1994, and new-style designations will be supplied for pre-1995 comets, together with lists of correlations with both the year/letter and the year/Roman numeral systems.

Brian Marsden

Central Bureau for Astronomical Telegrams

Jonathan Shanklin adds:

Following the above statement, comet **Halley**, which was recovered on 1982 October 16 at its last apparition, would have been designated comet **1982 U1** under the new scheme. Periodic comets which are observed to return, or observed through aphelion, are also numbered in order of the computation of the orbit, so the full designation of comet Halley would be **1P/1982 U1**.

The tradition is to continue of naming comets after their discoverers, rather than after the person who first computed the orbit (like Halley, Encke or Crommelin).

The prefix D/ would now give **D/Shoemaker-Levy 9** !

Prospects for 1995

THE PROSPECTS for observing comets in 1995 can easily be summed up: they are not good! None of the 1994 comets discovered up to the end of September will be visible by 1995, and those periodic comets predicted to return are all relatively faint.

Ephemerides for currently observable comets are published in the Circulars and comet section Newsletter and instructions on comet observing may be obtained from the Director of the comet section.

P/Schwassmann-Wachmann 1 1989 XV

This annual comet has frequent outbursts and seems to be more often active than not, though it rarely gets brighter than 12^m. It is at opposition in early February and should be observable until late May. It is then in conjunction until early October, when it will be observable for the rest of the year. This comet is an ideal target for those equipped with CCDs and *it should be observed at every opportunity.* Orbital elements for the comet are given in Table 1.

P/d'Arrest 1989 II

This comet will be making its 17th observed return and may be briefly visible from July until mid August. It was first observed by La Hire in 1678 and only three other periodic comets (Halley, Swift-Tuttle and Tempel-Tuttle) have a longer observational interval. At a good return it can reach naked-eye brightness, but orbital perturbations have increased its perihelion distance over the past few returns and it is unlikely to get brighter than 11^m, though it can flare post perihelion which is in late July.

Table 1. Orbital elements for comet P/Schwassmann-Wachmann 1989 XV from 661 observations 1902–1991.

Epoch 1989 Nov 10

T 1989 Oct. 26.7238
q 5.771764
e 0.044661

	2000	1950
ω	49.8702	49.8974
Ω	312.8479	312.1226
i	9.3722	9.3674

P/Jackson-Neujmin 1987 VIII

This comet will be making its 5th observed return having been missed between discovery in 1936 and 1970. It should be observable from August to September, and at a reasonable elongation from the sun, but is not predicted to get brighter than 11^m. The circumstances are similar to the discovery apparition when it reached a photographic magnitude of 12, so it is quite possible that it will appear brighter than the predictions to visual observers.

P/Perrine-Mrkos 1968 VII

This comet will be making its 6th observed return, though it has not been seen since 1968. When discovered in 1896 it was 8^m, the next return was unfavourable but it was only 13^m in 1909. It was then lost between 1909 and 1955 when it was rediscovered at 9^m. It only reached 17^m in 1962 and 13^m in 1968, and was fainter than 19^m in 1975. It seems that the comet is subject to occasional outbursts, so it would be worth keeping an eye on and near the predicted ephemeris position. If an outburst does occur the comet is well-placed in the evening sky during the later part of the year.

P/Churymov-Gerasimenko 1989 VI

This comet will be making its 5th return since discovery in 1969. At a good apparition, such as in 1982, when it was well observed by the comet section, it can reach 9^m. This time it gets no closer than 0.9 AU, and may be observable from December until February 1996 in the evening sky, though it is unlikely to get brighter than 12^m.

P/Honda-Mrkos-Pajdusakova 1990 XIV

This comet will be making its 9th observed return since discovery in 1948 (it was missed in 1959). The comet is at perihelion on Christmas Day, in conjunction 20 days later and won't be visible from the northern hemisphere until late January 1996, when it may be picked up in binoculars in the morning sky as it fades rapidly from 8^m.

Other comets in 1995
Several other comets return to perihelion during 1995, however they are unlikely to become bright enough to observe.

P/de Vico-Swift was 7^m when discovered in 1844, but has been severely perturbed by Jupiter and in its present orbit won't get brighter than 17^m.

P/Finlay is having a very unfavourable apparition with closest approach being just under 2 AU. At a favourable apparition it may reach 7^m, but this time the best it does is 14^m.

P/Clark has a relatively favourable apparition and may reach 12^m, but is too far south for observation from the UK.

P/Tuttle-Giacobini-Kresak has an unfavourable apparition; at a good one it normally reaches 10^m, though in 1973 it experienced an outburst to 4^m.

P/Reinmuth 1 was 12^m when discovered in 1928, but has also been severely perturbed by Jupiter and in its present orbit won't get brighter than 15^m.

P/Schwassmann-Wachmann 3 has an unfavourable apparition this time round, being too close to the sun to observe; at the discovery apparition it reached 7^m, though at the past few apparitions it has only reached 12^m.

P/Longmore is an intrinsically faint, distant comet and won't get brighter than 17^m.

Many of the magnitude parameters given in the *BAA 1995 Handbook* are m_2 (for the nucleus) rather than m_1 (for the coma) or vice versa, and some comets are brighter than these predictions. This affects in particular comets Clark, d'Arrest and Honda-Mrkos-Pajdusakova.

Updated values for H_1 and K_1 are given in Table 2, where:

$$m_1 = H_1 + 5.0 \log d + K_1 \log r$$

1996 promises to be a little better, with a good return for P/Kopff and the possibility of a return of P/de Vico, though this was missed at its last return and hasn't been seen since its discovery in 1846.

Thanks are due to Harold Ridley for starting this series of prospects for comets, and without whose notes writing them would be much harder.

Jonathan Shanklin

References

1. Nakano, S. and Green D. W. E., Eds, *International Comet Quarterly 1995 Comet Handbook* (1994).
2. Kronk, G. W., *Comets: A Descriptive Catalogue*, Enslow (1984).
3. Taylor G. E., *The Handbook of the British Astronomical Association for 1995* (1994).

Table 2. Comets in 1995

Comet	T		q	P(yr)	N	H_1	K_1
P/de Vico-Swift	Apr	09.5	2.15	7.32	3	10.0	15
P/Finlay	May	05.0	1.04	6.76	11	12.0	10
P/Clark	May	31.2	1.55	5.51	4	10.5	15
P/d'Arrest	Jul	27.4	1.35	6.51	16	7.5	40
P/Tuttle-Giacobini-Kresak	Jul	28.6	1.07	5.46	7	10.0	40
P/Reinmuth 1	Sep	03.3	1.87	7.31	8	9.0	15
P/Schwassmann-Wachmann 3	Sep	22.8	0.93	5.34	3	12.0	15
P/Jackson-Neujmin	Oct	06.6	1.38	8.24	4	11.0	15
P/Longmore	Oct	09.3	2.40	6.98	3	11.0	10
P/Perrine-Mrkos	Dec	06.0	1.29	6.77	5	11.5	20
P/Honda-Mrkos-Pajdusakova	Dec	25.9	0.53	5.27	8	13.5	20

Elements for all these comets except P/Schwassmann-Wachmann 1 are given in the *BAA Handbook.*

Meetings in 1995

Gene Shoemaker is coming ...

... as the guest of honor and keynote speaker of the 2nd Meeting of European (and International) Planetary and Cometary Observers

MEPCO '95

in Violau, Germany (Bavaria), March 24–27, 1995

For more than ten years we, the Working Group of Planetary Observers of Germany, have been arranging the Planeten- und Kometen-Tagung (meeting of Planetary and Cometary Observers), which brings together more than 100 dedicated amateur observers from German-speaking regions every year.

Already for the second time, in the spring of 1995 we happily invite planetary and cometary observers from *all over Europe* and also the rest of the world, to continue our fruitful discussions from MEPCO'92, witness the progress in observing techniques and hear about the latest results – with emphasis, of course, on the comet collision with Jupiter. This meeting is **THE** chance to exchange observations of this remarkable event. (Other topics are permitted, too! Be they Saturn's recent white spots; past and coming Mars oppositions; observing and data analysis techniques – anything.)

We are especially proud to have among our guests one of the discoverers of comet P/Shoemaker-Levy 9, eminent geologist Eugene Shoemaker, who among many other things is being credited with the science behind the Apollo program and the discovery that the Noerdlinger Ries is indeed a major impact crater.

Official language will be English. We offer once again:
- a unique meeting atmosphere in a beautiful countryside, conference, accomodation and catering in one building, the Bruder-Klaus- Heim with the famous Violau Observatory, which is again expanding this year,
- discussions and workshops to foster Europe-wide contacts and collaboration,
- papers and posters on observational work and results in different countries,
- (new) a field trip to the Noerdlinger Ries crater, guided by Gene himself,
- and Proceedings included in the fee, which is only DEM 270.

To obtain further information, please contact:
Wolfgang Meyer, Martinstr. 1,
D–12167 Berlin , Germany.

Urgent questions can also be directed to Daniel Fischer:
by fax (xx49-2244-80298) or
e-mail (p515dfi@mpifr-bonn.mpg.de).

P.S.: Copies of the Proceedings of MEPCO'92 can still be ordered from Daniel Fischer for just DEM 10 plus postage.

Daniel Fischer
for the Organizing Committee

BAA/CUAS meeting at Cambridge

Saturday 1995 March 18

The Comet-Jupiter Collision

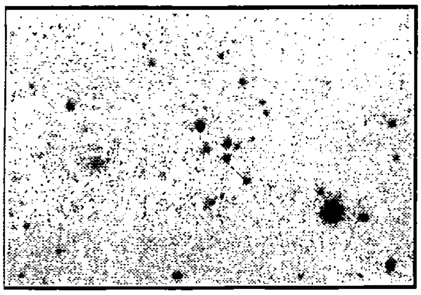
The annual Cambridge meeting will be a joint meeting of the BAA Jupiter and Comet Sections hosted by Cambridge University Astronomical Society. It will be on Saturday March 18, 10.30–18.30, at the Cavendish Lab, Madingley Rd, Cambridge. This is a full-day meeting about the comet impacts on Jupiter. Anyone interested is welcome.

Speakers will include:
- Mark Bailey (Liverpool) : Comet origins and dynamics
- Steven Miller (UCL, London): Fireball observations from Hawaii
- Peter Andrews (RGO, Cambridge): Fireball observations from La Palma
- Mark Kidger (Tenerife): Fireball observations from Tenerife
- Niel Brandt (IoA, Cambridge): ROSAT observations
- John Rogers (BAA, Cambridge): Visible impact sites
- Chris Trayner (Leeds): The Tunguska impact

There will also be an opportunity for BAA members to show slides or posters. Cars can be parked at the Cavendish. Tickets are £4 for entry or £6 (including buffet lunch). Please make cheques payable to C.U. Astronomical Society and send an s.a.e. after January 5 to:

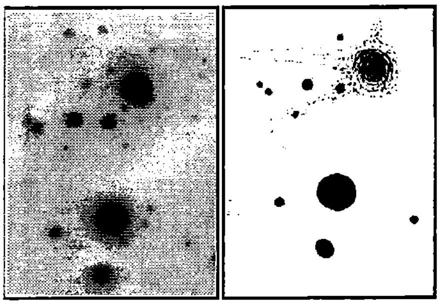
Paul McLaughlin, Trinity College, Cambridge, CB1 1TQ

Mueller (1993a)



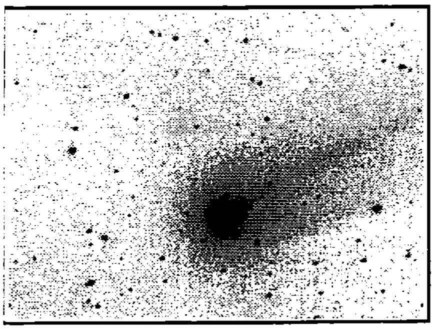
J. Danielsson's photgraph on 1993 October 16.80 from SE Sweden. He used a 200 mm telephoto lens piggy-backed to an 8-inch Celestron. The exposure was 10 min at f/4 on ISO 400 Tri-X film. [Reverse video – ed.]

McNaught-Russell (1993v)



Left: ***J. Danielsson's photgraph on 1994 April 05.81 from SE Sweden. Camera details as above. The exposure was 10 min at f/3.5 on hypered TP 2415 film. [Reverse video – ed.]*** **Right:** ***His sketch of features which are hard to reproduce here.***

P/Machholz 2 (1994o)



CCD image by Erich Meyer and Raab Herbert on 1994 August 08.09 from Linz, Austria. They used an ST-6 attached to a 288 mm f/5.2 Schmidt-Cassegrain. The image is a composite of three 20 s exposures taken for astrometric purposes. The field of view is 15' x 20' and there appears to be a faint component 5' NE of the main object. [Reverse video – ed.]

Research notes from

The rate of cometary splitting

In *Icarus* of 1994 April (Vol. 108, pp 265–271) Chen & Jewitt state that 21 comets have split during 1846–1976, with equal likelihood for both short- and long-period comets, and for both pre- and post-perihelion splitting. They have examined 49 comets with a CCD since 1986 and found that 3 (or about 6%) have split, namely P/Chernykh, P/Ciffreo & Wilson. They find the separation velocity to be 0.5 m s^{-1}.

The lifetime of the secondary is determined by the timescale for the loss of volatiles by sublimation due to solar heating, which in turn depends on heliocentric distance, size of secondary and orbital characteristics. They suggest that a body of 10 m diameter and of water ice could endure for order 1 year for sublimation at 1 AU. Given the small field of view, they estimate a lower limit for the splitting rate of order 0.01 yr^{-1} $comet^{-1}$. Although the sample is rather small, the authors suggest that, although observed rarely, splitting is statistically common among comets. This in turn suggests that each secondary is only a minor fraction (<0.1%) of the primary mass.

With the deduced rate of splitting applied to the thousand known short-period comets of 400 000 yr lifetime, the authors conclude that there are 4 million secondaries in a swarm related to the orbits of their parents. Where are these objects? The Spacewatch telescope has shown that Earth-approachers smaller than 100 m are over-abundant with respect to the magnitude-frequency distribution extrapolated from larger objects (for example, by two orders of magnitude for size 10 m). The authors state that spectral measurements suggest these small objects are debris from extinct short-period comets.

'Rubble piles' and the density of SL9

Asphaug & Benz in *Nature* of July 14 (Vol. 370, pp 120–124) state that interpretation of observations of the comet crash will depend on parameters such as mass and density of the fragments. They simulate the passage of the parent comet across the Roche zone of Jupiter over a few hours in 1992 July, with closest approach of 1.31 jovian radii resulting in a captured orbit of eccentricity 0.996.

Simple fracture mechanics show that a uniform body of low but non-zero strength and *any* realistic density (>50 kg m^{-3}) cannot form a 'string of pearls', rather it must fracture into two similarly-sized components (which may then themselves split). The authors assume that the parent comet is already broken, as a strengthless aggregate of numerous grains – a 'rubble pile' – and find that the tidally-disrupted body condenses rapidly into clumps, driven by self-gravity.

A fragment chain occurs only for density in the range 300–700 kg m^{-3}. About 20 similar-sized objects are formed for a non-rotating parent of 1.5 km diameter and bulk density 500 kg m^{-3}, suggesting that each has an impact energy of 10^{20} J. A slightly larger initial density leads to significant mass variation among the clusters and raises the possibility of a few 10^{21} J events.

For rotating comets, *prograde* rotation gives a longer fragment chain for the same initial size (for example, a 1.0 km diameter parent with a rapid 9 hr prograde rotation and bulk density 1000 kg m^{-3}, although this mass is only half that of the non-rotating example), whereas *retrograde* rotation leads to a massive central clump not seen in SL9 (this is also seen for non-rotating comets of density 1000 kg m^{-3}).

Gravitational instability condenses the clumps over a few hours after perijove. For density 500 kg m^{-3}, the authors find the same number of clumps for parents of diameter 600 m, 1.5 km and 4 km. The final mass distribution is determined quite early and the clumps continue on independent orbits.

The authors speculate finally on whether all comets are rubble piles. They estimate by scaling laws that a 1.5 km diameter ice body can be destroyed by impact with a single 1.5 m particle traveling at 50 km s^{-1} (and one such impact is likely during passage through Jupiter's ring) or by millions of hyper-velocity impacts with smaller grains. Hence, a rubble pile could be created *in situ* since Jupiter's ring contains such objects. So the passage through the Roche zone of a giant planet is hazardous in more ways than one.

selected journals

Orbital history of P/Swift-Tuttle

Yau, Yeomans and Weissman write in *Monthly Notices* of the RAS Vol. 266 pp 305–316 (1994) of their long-term integration forwards to AD 2392 and backwards to 703 BC of the orbit of comet P/Swift-Tuttle. They use two 'trial orbits': one linking the 1862 and 1992 observations and using no non-gravitational effects; and another linking those of 1737 (by Kegler), 1862 and 1992 using non-gravitational effects. The observations for 1862 October from the Cape of Good Hope are discordant (by over 10 arcsec in RA and dec in some cases) with others from that apparition and are not included. A search through Chinese records yields (pre-telescopic) returns in AD 188 and 69 BC, and the two orbits are adjusted slightly (remaining always within the formal error) to achieve best fit. The non-gravitation solution is not compatible over this longer timespan, so these effects appear to be negligible.

The authors discuss the observed returns of AD 1737, AD 188 and 69 BC, and conclude a naked-eye limit for the comet of 3.4^m. They find three returns during AD 188–1737 when the comet would have been on the borderline of visibility and two much earlier 2^m returns, but state that very few records have survived from before 200 BC. These unobserved returns fix the comet's absolute magnitude which appears not to have changed significantly ($<0.5^m$) over 2000 years. The authors make a comparison with P/Halley, which becomes a naked-eye object at mag $3.5–4.0^m$ and which is about 1^m fainter pre-perihelion. They state that P/Halley outgasses more post-perihelion leading to a brighter object and an increase in period of 4 days at each return. They estimate that P/Swift-Tuttle would return about 12 days late on each return if it had the same mass and outgassing as P/Halley, and conclude that it probably has a much larger mass. A similar conclusion was drawn in an earlier study based on comparison of the comets' meteor streams.

The authors finally state that the next return in AD 2126 will be well away from the Earth at nodal crossing so there is no danger of collision!

Gamma-ray bursts from the Oort cloud?

In the *Astronomical Journal* of 1994 May (Vol. 107 (5), pp 1873–1878) Clarke, Blaes and Tremaine examine the possibility that gamma-ray bursts originate in the Oort cloud. They state that gamma-ray bursts are isotropic on the sky but not in space, suggesting a situation in an extended halo around our Galaxy. The subject gives three major problems. First, there is no known mechanism for the rate and energy of the bursts without violating other observational constraints. Secondly, the bright source counts do not fit the models for the distribution of Oort objects. And thirdly, the isotropy of the data does not fit the expected angular distribution of Oort sources. The authors conclude that Oort cloud models of gamma-ray bursts are extremely implausible.

CO emission driving coma formation

In *Nature* of September 15 (Vol. 371, pp 229–231) Senay & Jewitt give the first direct evidence for the mechanism whereby distant comets are sometimes observed to undergo outbursts that generate a surrounding coma. They studied P/Schwassmann-Wachmann 1 in its near-circular but beyond-Jupiter orbit and detected CO with the JCMT on 1993 October 22, November 11 & 12. In all cases, the CO line was blue-shifted (by 0.4 km s^{-1}) from its anticipated geocentric velocity, indicating sublimation of CO near the sub-solar point of the illuminated hemisphere and implying a jet of gas *and dust* approximately Sunward with this excess velocity. The authors estimate a lower limit to the CO production rate of 1500 kg s^{-1}.

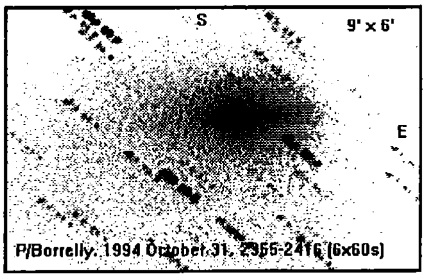
The authors consider the dust production rate derived in this work and that of others to estimate a much lower value, assuming sub-mm sizes are dominant. This indicates that it is CO, and not dust, that drives the optical dust coma.

Finally, the authors consider the likely local, rather than uniform, nature of sites emitting CO on the comet and estimate the total sublimating area to occupy 0.3–2.2 % of the surface area of the nucleus (depending on the comet's size) – this agrees well with estimates for other comets.

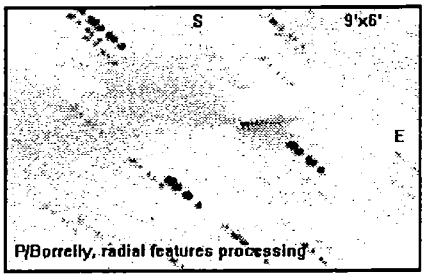
James Lancashire

P/Borrelly (1994l)

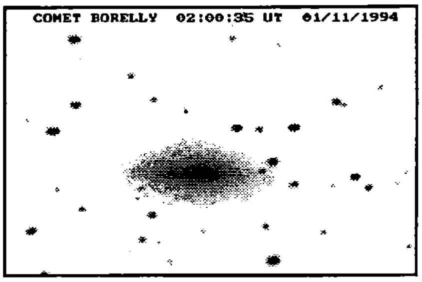
Nick James used a Sony ICX027BL CCD attached to a 0.3 m f/5.25 Newtonian for the first two images below.



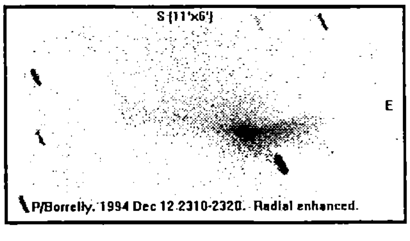
This is a composite of six 60s frames taken between 2355 and 2416 on October 31. The frames have been offset to compensate for the comet's motion and co-added after dark frame subtraction.



This is the result of processing the first frame to empasize radial detail. It shows the anti-tail quite clearly.

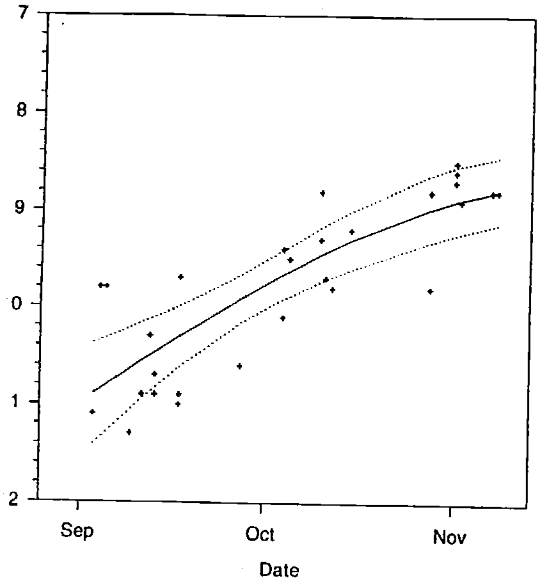


Another view later the same night! David Strange's image at 02:00:35 with a Starlite Xpress CCD attached to a 20-inch f/4 Newtonian and 40 s exposure.



A recent image by Nick James on December 3.96 (despite frame date). The tail is in pA 260° and the anti-tail in pA 110° (S at top). The geometry has changed since the second image.

Comet P/Borrelly 1994 l



Comet Nakamura-Nishimura-Machholz 1994 m