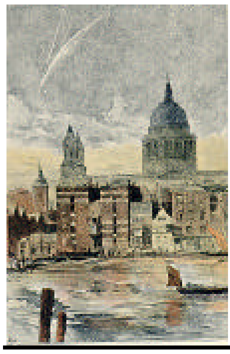

THE COMET'S TALE

Newsletter of the Comet Section of the British Astronomical Association

Volume 7, No 2 (Issue 14), 2000 October

WHAT IS THE DIFFERENCE BETWEEN ASTEROIDS & COMETS?

From Science-Week via CCNet

Other than the moons of the various planets, the chief small bodies of the solar system are comets and asteroids.

In general, a comet is a kilometre-size chunk of ice and associated dust and debris. The Oort cloud is an apparent spherical shell of comets 10,000 to 100,000 AU from the Sun and the proposed source of comets that orbit the Sun. The cloud is at the extreme edge of the Sun's influence, halfway to the nearest star, and it is believed that when the cloud is perturbed by passing stars, comets may be sent into a solar orbit. The size and structure of the Oort cloud have been deduced from statistical studies of the orbits of comets; there is no direct evidence for the cloud's existence. Approximately 900 comets are known.

Asteroids (also called "minor planets") are small rocky objects, most of which orbit the Sun in a belt between the orbits of Mars and Jupiter. A few asteroids follow orbits that bring them into the inner Solar System, and several asteroids occasionally pass within a few tens of millions of miles of Earth. Some asteroids are located in the orbit of Jupiter, and some asteroids have been detected as far away as the orbit of Saturn. There are approximately 7200 known asteroids, and a million asteroids are believed resident in the Solar System. The consensus view is that asteroids are composed of material that failed to build a planet at a distance of 2.8 astronomical units from the Sun, perhaps due to the influence of massive Jupiter just outside the asteroid belt. Until recently, the shapes and surface features of asteroids were a matter of conjecture; during the past decade, however, significant direct observations of asteroids have been relayed back to Earth from spacecraft.

Classical astronomers have categorised comets and asteroids as distinctly different entities with different histories and compositions, but recent evidence is blurring the conceptual boundary between these two groups of small Solar System bodies, and there are several newly discovered objects that are considered to be both comets and asteroids on the basis of their characteristics.

Don Yeomans (California Institute of Technology, USA) presents a review of recent research on comets and asteroids (Small bodies of the Solar System. Nature 20 Apr 2000 404:829), the author making the following points:

1) Recent observations have revealed comets in asteroid-like orbits and asteroids in comet-like orbits. Both comets and asteroids can evolve from the Oort cloud into highly inclined, even *retrograde, orbits about the Sun, so orbital behaviour is no better than physical behaviour for distinguishing comets from asteroids. The author suggests that attempts to categorise comets and asteroids as distinctly separate entities have failed, and that astronomers should now consider these objects as members of highly diverse family: the small bodies of the Solar System.

2) If all comets were solid dirty balls of water ice, then their bulk densities would be approximately 1 gram per cubic centimetre. But some comets have apparent low-density structures that are made from several bits held together by little more than their own self-gravity. This conclusion arose after some comets were observed to break up as a result of tidal forces from either the Sun or Jupiter, and more than two dozen other comets have split apart for no obvious reason at all. In addition, comets that have apparently transformed from active to quiescent objects suggest that some cometary bodies do become defunct and join the ranks of the asteroids. Low-density extinct comets can probably explain a significant fraction of the near-Earth asteroid population, "so we cannot assume that all objects that threaten Earth will have the same composition or structure."

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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 spring was a fairly quiet time for comet observing, with nothing within reach of moderate apertures. The summer brought comet LINEAR 1999 S4, although observing conditions from the UK were often poor in the east and then the comet disintegrated. More details of the event are described in the review of observations. The end of the year brings another possible binocular comet in the shape of 1999 T1 (McNaught-Hartley) and at least this one is intrinsically brighter than 1999 S4 so there is less chance of it disappearing.

Michael Oates has continued scouring the SOHO archives and has now discovered nearly 70 comets out of the SOHO total of 204. I've found a couple more, including one which could have been observed by large telescopes in the Southern Hemisphere. Rather surprisingly no SOHO comets were discovered during September.

A partially revised edition of the Section Guide to Observing Comets is now available as a PDF file on the Internet. It is quite a large file, and I intend to produce a printed version as well. This should be ready early next year.

Only a few imagers have adopted the format suggested in the last issue and I would encourage the remainder to use it. Just to remind you, the procedure is to name image files as comet_yyyymmddl_obs.img and auxiliary files as comet_yyyymmddl_obs.txt, where yyyy is the year, comet is the comet identifier, obs the first three letters of the observers surname, l a serial number assigned by the observer (which can be omitted) and img the image format. As an example 1999s4_19991128a_mob.jpg would be the first jpeg image that Martin Mobberley took of 1999 S4 on that date and if he felt that further information was needed there would be a supporting file 1999s4_19991128a_mob.txt. The second gif image of 141P/Machholz 2 by David Strange on the same date would be 141p_19991128b_str.gif.

Since the last newsletter observations or contributions have been received from the following BAA members: Sally Beaumont, Denis Buczynski, Len Entwisle, John Fletcher, Maurice Gavin, Massimo Giuntoli, Werner Hasubick, Guy Hurst, Nick James, Geoffrey Johnstone, Alastair McBeath, Cliff Meredith, Martin Mobberley, Terance Moseley, Michael Oates, Gabriel Oksa, Roy Panther, Jonathan Shanklin, David Storey, David Strange, Melvyn Taylor, Cliff Turk and Alex Vincent

and also from: Jose Aguiar, Mark Allison, Alexandr Baransky, Jeffrey Barham, Nicolas Biver, John Bortle, Jean-Gabriel Bosch, Reinder Bouma, Nicholas Brown, Christian Buil, Paul Camilleri, Eddie Carpenter, Jose Carvajal, Clive Curtis, Sauro Donati, R Ferrando, Stephen Getliffe, Bjorn Granslo, Bernhard Haeusler, Andreas Kammerer, Heinz Kerner, Atilla Kosa-Kiss, Martin Lehky, Rolando Ligustri, Pepe Manteca, Michael Mattiazzo, Maik Meyer, Antonio Milani, Andrew Pearce, Stuart Rae, Juan San Juan, Richard Schmude, Carlos Segarra, Oddleiv Skilbrei, Vince Tuboly Jean-Francois Viens and the Ageo Survey Team

(KenIchi Kadota and Seiichi Yoshida) (apologies for any errors or omissions).

Without these contributions it would be impossible to produce the comprehensive light curves that appear in each issue of *The Comet's Tale*. At the moment I'm finding it quite difficult to get the time to reply immediately to letters and emails due to a large number of commitments. Please be patient and I will try and reply when time permits. My commitments have also meant that this issue of *The Comet's Tale* is later and less comprehensive than I would like. Any contributions to the next issue will be very welcome.

Comets under observation were: 2P/Encke, 29P/Schwassmann-Wachmann 1, 47P/Ashbrook-Jackson, 1995 O1 (Hale-Bopp), 1997 BA6 (Spacewatch), 1999 H3 (LINEAR), 1999 J2 (Skiff), 1999 K5 (LINEAR), 1999 K8 (LINEAR), 1999 S4 (LINEAR), 1999 T1 (McNaught-Hartley), 1999 T2 (LINEAR), 1999 U4 (Catalina-Skiff) and 1999 Y1 (LINEAR).

I will again be visiting the Antarctic this winter, departing in mid November and returning in mid January. During my absence I can still be contacted by email (see contact details) or you can write to me in the Falkland Islands. I should have more time for writing whilst I'm on board ship!

Jonathan Shanklin

Tales from the Past

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

150 Years Ago: In the May MN an extract of a letter from Professor Schumacher to the President on Petersen's comet includes "It is very desirable that this comet should be observed after its perihelion passage. M Gauss is even of opinion that it is not *proved* that a *comet* must, after having passed the perihelion, move in the same orbit as before." In June a note discussed a comet seen by the Rev. T M Jenkins ("for whose liberality Georgetown College, Washington, was indebted for its observatory") on his voyage to Rio Janeiro. On November 28, 1849 when 10°S, 30°W "We saw a comet to the westward nearly in the track of the sun, about 14° above the horizon, as measured with the quadrant. The nucleus very distinct, about as large in appearance as Mars, the tail curved and pointing towards the south (SW.), quite bright and nearly a degree in length as seen by the naked eye, but much longer when viewed with the glass. It was seen by all the crew for about twenty minutes, when a cloud obscured it and it was seen no more." Mr Jenkins unfortunately died at Rio but the master of the *Maryland* established that the comet had also been seen on November 15 at 7:30 pm at an altitude of 48°. This was irreconcilable with the expected return of a long period comet (the great comet of 1556, 1556 D1) predicted to return in 1848 by Mr Hind. [The positions were not sufficient to calculate an orbit and the comet is not listed by Kronk (1984) or Vsekhsvyatskii]

100 Years Ago: Nothing much of note occurred and the annual report in the October Journal notes "Very few comets have been observable during the year, and only one has been conveniently placed for the possessors of telescopes of moderate size in this country." Interestingly the Journal in those days was bilingual, with a paper on Jupiter appearing in French.

50 Years Ago: A review of a paper by O Struve which was in the February S&T appears in the May Journal. In it the new hypothesis by J H Oort of a distant aggregation of comets was reviewed. This is now known as the Oort Cloud. A report on the comets of 1948 appears in the July Journal. This was a forerunner to the present series, but unfortunately only 1946 - 1949 were published. A comment on the Eclipse comet of 1948 is still true today: "The magnificence of the brilliant comet, with its 25°-long tail, seems to have paralysed the abilities of most observers to make observations of scientific value." The 1949 report appeared in the October Journal and followed the pattern of the others with descriptions of observations and light curves of well-observed objects.

WHAT IS THE DIFFERENCE BETWEEN ASTEROIDS & COMETS?

Continued from Page 1

3) Asteroids have been classified according to the light reflected from their surfaces -- their optical spectra. Although no two spectra are exactly alike, most asteroids fall into one of two groups, the C-type (carbonaceous) and S-type (silicaceous). C-type asteroids have low reflectance (albedo) and may contain mixtures of hydrated silicates, carbon, and organic compounds. S-type asteroids have higher albedos and can contain pyroxene (silicates containing magnesium, iron, and calcium), olivine (magnesium and iron silicates), and nickel-iron metal. The C-type asteroids are most common in the outer part of the main asteroid belt, and the S-type asteroids are mostly found in the inner asteroid belt.

4) Meteorites are asteroid collision fragments that have fallen to Earth, and as such are thought to hold clues regarding the early history of asteroids. Because most asteroid fragments are rocky, they can survive the passage through the atmosphere of the Earth. In contrast, debris from comet streams nearly always burns up in the atmosphere, sometimes producing spectacular meteor showers in the sky, but leaving little evidence on the surface of the Earth. The most common meteorite is the ordinary chondrite, which is composed mostly of rocky silicates, and so has not experienced the chemical differentiation associated with melting. Such chondrites are thought to be some of the most primitive rocks in the Solar System, although their parent asteroid type is not clear. On 22 March 1998, and ordinary chondrite was observed to fall to Earth by 7 boys in Monahans, Texas (US), and within 48 hours

the meteorite was under examination at the Johnson Space Center in Houston, Texas. Laboratory analysis of the Monahans meteorite detected salt crystals embedded with water in the form of brine, and the salt crystals were dated to the very beginning of the Solar System, approximately 4.6 billion years ago. This suggests the presence of liquid water on the parent asteroid of this meteorite, and unless this water derived from a collision with a salt-bearing icy comet, the parent asteroid itself must have had flowing water within its interior structure. Far from being the dry rocky bodies they were once believed to be, it would seem that some asteroids, along with comets, might be significant sources of water.

Comment's on "IWCA II Method-Related Brightness Estimate Differences and the Delta Effect by Joseph N. Marcus"

Charles S. Morris, Associate Editor, ICQ

Joe Marcus and I have been at each other's throats for most of the last couple of decades, mostly in a friendly way. The long standing disagreement on the delta effect (or lack of it) has been the primary thorn in our scientific relationship. That being said, this little rant by Joe concerning my talk at the IWCA II should win a prize for being grossly off-topic.

My talk at IWCA II had almost nothing to do with the delta-effect theory. In the amateur community, there are many observers who produce very professional observations. However, when amateurs attempt to do research with the data collected (and publish papers), they often do very poorly. In large measure, this is because they have never been through the experience of publishing a real research paper. At the ICQ, we treat submitted papers in the same manner as other professional research journals. The papers are sent to anonymous referees who review the paper and offer comments and suggestions to the author. Often amateurs get easily frustrated when their paper is reviewed and it is suggested that additional work is required before it can be considered for publication. The point of my talk at the IWCA II was to point out common mistakes made by amateurs doing research and writing papers. One of the goals of the ICQ is to publish useful research articles produced by amateurs without sacrificing professional standards. I had hopped to encourage this with my talk.

In my talk, I discussed the use of statistics because statistical analysis is the basis for most papers submitted to the ICQ. One example (out of many presented in the talk) involved the dangers of performing multiple regression on correlated variables. If two variables are strongly correlated, as r and delta often are for comets, it is impossible to unambiguously and correctly separate the computed parameters. I used solving the light curve equation with a delta effect term included as an example of this problem. It is a valid example. Joe correctly pointed out that you can check the correlation coefficients to determine whether or not r and delta are significantly correlated. The bottom line is that you can not *routinely* solve for the "delta effect" coefficient without confirming that that r and delta are not significantly correlated. If you do, your results are, at best, suspect and, at worst, simply wrong. This is a valid example because on some occasions I have seen *general* light curve analyses that included the delta effect (not by Joe) that have ignored this potential problem. [All of Joe's extensive wordage proving that this concern doesn't apply in specific cases misses the point completely.]

For using this example, I received a lengthy rant by Joe in *The Comet's Tale* concerning one of his favourite topics, the delta effect.

Comments on the Delta Effect.

1) If you listen to Joe, you would think that the delta effect is a fully accepted theory, it is not. The delta effect in comet light curve research is applied to visual observations by a limited number of researchers, mostly amateur. The references in their papers are to Joe's work, mostly to his *Comet News Service* articles. That is the problem. To my knowledge, Joe's complete version of the delta effect/magnification effect theory has never been published and certainly not in a refereed journal. (If I am wrong, Joe, send me a reprint.) It is difficult to review or comment on a theory that is put forth in bits and pieces in unrefereed publications, much of it in *Comet News Service* of which Joe was author, reviewer, and editor. I have suggested many times, by the way, that Joe publish his theory in the ICQ or other refereed publications to no avail.

2) For every case of the delta effect being observed in light curves, the observed effect was just as likely to have been caused by other observing circumstances (poor location in the sky, etc.). Even the case that everyone points to, C/1979 Y1 (Bradfield), as the best example, has an alternative explanation. I had a long string of observations that suggested that this comet had the characteristics of a flare in brightness near closest approach to the Earth. The value of n can change after a brightness flare. This would explain the observed light curve. What about comets that should have had a significant delta effect, C/1983 H1 and C/1996 B2, for instance. My analyses show no sign of such an effect. I'm sure that Joe has explanations for this, as well.

3) I do not agree with Joe (as he suggests in his rant) that "the best way to look for a delta effect, is not through the light curve itself." If it doesn't show up in the light curve, why should we care about it? This is one of those ignore the data arguments, if theory is correct (and of course, it must be), who cares if the data actually shows the effect?

Before leaving this subject, I want to state that I do not rule out the possible existence of a delta effect. Joe does make some compelling arguments for his theory, particularly when applied to the instrument effects problem. Accepting that his theory might be valid for the instrument effects, does not necessarily mean that the delta effect is real, however. I do not know for a fact that applying magnification is exactly the same thing as bringing an object closer when one observes a comet, for instance.

Finally and most importantly, I was greatly offended at the implication by Joe that the International Comet Quarterly would reject a paper simply because it dealt with a subject such as the delta effect. Daniel Green, ICQ editor, and I go to great pains to be fair to all submissions made to the ICQ. This is particularly true where we may disagree with the author(s). Papers are reviewed by a number of different referees, not just us. We would welcome a well-done paper on the delta effect, even from you Joe. I have tried to get Joe to submit such an article to the ICQ for many years. Joe, perhaps you will submit something now?

[Interestingly the latest issue of A&G has a letter relevant to this subject (Astronomy & Geophysics, ***41****, 5.8, October 2000). The author, John McFarland, claims that C/1999 S4 (LINEAR) shows an 'Opik Law' (delta effect) and refers to papers published by E J Opik in the Irish Astronomical Journal between 1963 and 1977. I will attempt to review these in the next issue. Jonathan Shanklin.]*

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.

I've received two reprints from Zdenek Sekanina about the SOHO sungrazing comets. The first looks at the distribution of the comet fragments and deduces from the fact that several comet pairs have been observed that low velocity fragmentation has probably occurred after perihelion and perhaps all the way to aphelion. The second looks at their tails and finds no evidence for electrostatic repulsion, so that only gravity and solar radiation pressure control the form of the tail. He finds evidence for microscopic silicate dust particles, which stopped being produced some 20 - 30 solar radii pre-perihelion.

The following abstracts (some shortened further for publication) are taken from the Cambridge Conference Network (CCNet), which is a scholarly electronic network devoted to catastrophism, but which includes much information on comets. To subscribe, contact the moderator Benny J Peiser at <b.j.peiser@livjm.ac.uk>. Information circulated on this network is for scholarly and educational use only. The abstracts, taken from daily bulletins, may not be copied or reproduced for any other purposes without prior permission of the copyright holders. The electronic archive of the CCNet can be found at http://abob.libs.uga.edu/bobk/cccmenu.html

ULYSSES'S SURPRISE TRIP THROUGH COMET'S TAIL PUTS HYAKUTAKE IN RECORD BOOKS RAS Press Notice from Jacqueline Mitton,

Comet Hyakutake, a bright comet seen by many people in 1996, developed the longest comet tail ever recorded. At 570 million km (360 million miles) it beat the previous claimed record of 330 million km (206 million miles) held by the Great March Comet of 1843. [Not really, one is a visual observation, the other by spacecraft] The discovery was made recently, when Dr Geraint Jones and Professor Andre Balogh of Imperial College, London, together with Dr Tim Horbury of Queen Mary and Westfield College, London analysed 1996 data from the Ulysses spacecraft. Their analysis of the magnetic field data returned from Ulysses on 1 May 1996 led them to conclude that Ulysses had passed through a comet's tail on that date. They then found that the tail belonged to Comet Hyakutake. The discovery is reported in the journal 'Nature' on 6 April 2000.

The joint European Space Agency-NASA spacecraft Ulysses was launched in 1990, and is in an orbit taking it over the poles of the Sun. It makes continuous measurements of the stream of charged particles called the solar wind which flows outwards from the Sun past the spacecraft. On 1 May 1996, Ulysses was 560 million km (347 million miles) from the Sun, when decidedly unusual things happened to the solar wind. The first odd feature to be noticed was a dramatic drop in the number of protons at Ulysses, which was reported in 1998 by another team of scientists led by Dr Pete Riley, then of the Los Alamos National Laboratory. They mentioned that a comet could explain some aspects of the odd results.

Comet nuclei are small bodies that were formed when our solar system Was young. They are typically a few kilometres across, and are composed of a mixture of ice and dust. When their orbits bring them close to the Sun, the rise in temperature makes them release gas and dust. The tiny dust particles are pushed away from the Sun by the pressure of sunlight, forming a dust tail. The gas particles eventually become electrically charged, forming ions. These ions join the solar wind flowing away from the Sun, forming an ion (or plasma) tail. When Jones and colleagues looked closely at the data returned from Ulysses's magnetometer instrument at the time, they realised that the solar wind's magnetic field lines displayed a herringbone pattern - a sign that the centre of whatever Ulysses had crossed had been moving slower than its edges. This is expected at comets, because the comet's ions slow down the solar wind when near the nucleus. This convinced them that the event was indeed due to a comet; so they began to search for the comet to which the tail belonged.

Finding the comet in question was not simply a case of looking for known comets between the spacecraft and the Sun on May 1 -

as Ulysses was so distant, the solar wind flowing at 750 kilometres per second could take days to reach the spacecraft. This gave time for the comet to move away from the Sun-Ulysses line, making it trickier to find. Comet Hyakutake (official designation C/1996 B2) had given Earth-bound observers a spectacular display during late March and early April, 1996, when it approached close to the Earth. Discovered by Japanese amateur astronomer Yuji Hyakutake in January 1996, the comet was at perihelion (its closest point to the Sun) on May 1 - the day of Ulysses's tail crossing. When Jones looked at where Hyakutake had been 8 days earlier, on April 23, it turned out that it had indeed been on the Sun-Ulysses line, and that from that point, it would take 8 days for the ion tail to be carried to Ulysses. Using the magnetometer data, the team found that the tail was the right size to belong to Hyakutake, and that it was parallel to the comet's orbital plane, as expected. The comet had been identified.

Apart from the great scientific value of an encounter with a fourth comet (comets Giacobini-Zinner, Halley and Grigg-Skjellerup have been visited by other spacecraft), several aspects of the tail crossing are particularly intriguing. The tail's length is most surprising - Hyakutake's tail was over 570 million km (350 million miles) long. This breaks the record for the longest measured tail, which is generally regarded to have been previously held by the Great March Comet of 1843, which had a visible tail around 330 million km (205 million miles) long. Had Hyakutake's tail been visible at the time from the Earth, it would have stretched over 80 degrees across the sky - a very impressive length for a comet so far away. However, at this time, it was invisible from Earth because its head was very close to the Sun in the sky.

Comets' ion tails are generally thought of as pointing almost straight away from the Sun. The magnetometer data from Ulysses reveal that at the spacecraft, the tail was definitely not doing this - it was travelling almost sideways. Jones and colleagues explain this by the comet's rapid motion around perihelion. Like the jet of water from a lawn sprinkler, Hyakutake's tail started out pointing away from the Sun. The further it got from the Sun however, the more it twisted away from the anti-sunward direction, as a lawn sprinkler spray twists. Ion tails are therefore curved, especially when comets are around perihelion. This has implications for some Earth-based comet observations. "A few weeks before Ulysses's tail crossing, some observers reported tail lengths for Hyakutake that were much longer than possible if comet tails are assumed to be straight, and pointing away from the Sun", says Jones. "The Ulysses magnetic field measurements show that these assumptions aren't true.", he continued, "Although it can't quite fully account for some of the longest tail lengths reported in late March and early April 1996, Hyakutake's tail would have been curved in the correct way around the Earth for observers to see a tail longer than previously thought possible."

When Ulysses crossed the tail, the comet's head was being observed by the LASCO coronagraph aboard the SOHO spacecraft, even though it could not be seen from Earth. "At this time," says Jones, "what was happening at the head of the comet didn't have any relevance to the tail at Ulysses. If you want to study the part of the tail crossed by Ulysses, you need to look at images of Hyakutake obtained around April 23. Unfortunately, few images were obtained then, as Hyakutake was sinking into twilight as seen from Earth." Nevertheless, the Ulysses results are providing unique information on the magnetic structures of ion tails.

The discovery, and identification of the parent comet by Jones and colleagues are only the beginning of the event's analysis. The study of the data returned from other Ulysses instruments will undoubtedly lead to a fuller picture of what happened when a distant spacecraft crossed an incredibly long tail. In the same issue of 'Nature', colleagues of Jones and co-workers, led by Professor George Gloeckler of the University of Maryland, report their independent discovery of cometary ions during the same event using another instrument aboard the spacecraft.

Several items appeared about comet 1997 K2. This is one.

Astronomers Find Fleeting Comet by Maia Weinstock, Space.com

In the spring and early summer of 1997, stargazers were treated to a beautiful sky show with the passing of wispy-tailed Comet Hale-Bopp. But scientists now say that while all eyes were on this dazzling sight, another near-Earth comet slipped quietly through the sky unnoticed.

Astronomers analyzing archived data from the European Space Agency/NASA Solar and Heliospheric Observatory (SOHO) spacecraft have recently reported the presence of a never-before-detected comet, which flew close to Earth in 1997. The comet, C/1997 K2, was apparently brighter than every comet discovered by astronomers in the six months preceding its appearance, adding to the mystery of how such a prominent comet may have zoomed past Earth unseen.

"To say we were surprised would be a bit of an understatement," said Finnish astronomer Teemu Makinen, lead author of a paper in Nature, which describes the new comet discovery. "It sounded quite unlikely [to us] that a comet of such magnitude could elude both professionals and amateurs alike."

Despite its brightness, Comet K2 would not have been visible to the naked eye. Yet even "inexpensive amateur equipment would have sufficed" for stargazers to see the comet, said Makinen. "I believe that many amateurs were lured by the spectacular display of the concurrent Comet Hale-Bopp," he explained.

Professional astronomers could have easily spotted the comet, since the equipment they use is much more powerful than the average telescope. So here's the question: how did they miss it? The combination of vast expanses of space and limited resources with which to scan them are the most likely reasons, experts say. "Our records are patchy, especially at high latitudes," said Makinen. "It was probably missed by dedicated surveys because of its trajectory, which went through the southern ecliptic pole."

Though it slipped by unnoticed by human eyes, evidence for the K2 comet was captured by SOHO's Solar Wind Anisotropies (SWAN) instrument from May to July of 1997.

The SWAN instrument is not dedicated to comet discovery. Rather, it was designed to observe emissions of hydrogen around the sun at ultraviolet wavelengths. But these emissions, known as Lyman-α emissions, are also given off in high quantities by comets. As a result, though its resolution is relatively poor, the instrument is also sensitive to comets.

The discovery of Comet 1999 K2 raises an interesting question: How prepared are we to track near-Earth objects, including comets and asteroids. If we missed this comet, some experts ask, what are the chances that we'll miss a comet that's heading straight for Earth?

A great deal of work has taken place to locate and categorize near-Earth objects like comets and asteroids. Although it may sound like science fiction, scientists say that the threat of comet impacts on Earth is very real.

So what are the chances of a comet hitting Earth, or of astronomers missing a potentially dangerous on-coming object. No one really knows. What astronomers do know, however, is that better funding for continual sky scans would help them map all comets that streak through the solar system.

"It is just a matter of prioritization. Do we want to use limited resources on preventing something that is likely to happen every day and cause moderate casualties -- like traffic accidents -- or something that will happen once in 30 million years but has potential for wiping out all of humankind?" asked Makinen. "In such situations, unfortunately, myopia is usually bliss."

I commented that a few points seem to have been missed in the information released about the comet:

1. It is not a near earth comet. The closest it approached was 1.17 AU.
2. The comet was not observable from most of the Northern Hemisphere. The discovery clearly shows that there are some objects that would always be missed by a Northern Hemisphere search program.
3. Looking at a comet catalogue doesn't tell you if the comet was observable. Of the six LASCO comets mentioned in the Nature review only one was actually observable, even by the search programs.
4. Some of the amateur discoveries are close to the sun rather than out of the ecliptic. This area is not searched by most programs.
5. The comet is very unlikely to have been visible in binoculars when its brightness is estimated to have not exceeded 11th magnitude.
6. The comet passed around 5 degrees north of the Large Magellanic Cloud around 1997 July 7 when it could have been near 11th magnitude. It might show on some amateur pictures as the moon was then near new.
7. Assuming that the comet followed a fairly normal light curve it is reasonable to suppose that to the search programs it would be 4 magnitudes fainter than indicated by visual observations and would follow an inverse square law for brightness. It is fairly easy to calculate where the comet would be and how bright it might be, although the orbit is not highly accurate. The comet would probably have been visible from the LINEAR site from January to May 1998 when it was probably brighter than 19th magnitude. The search plots on the LINEAR web site suggest that the likely area through which the comet passed was searched. It was therefore presumably fainter than the detection limit at the time.

In a commentary accompanying another article, astronomer Michael A'Hearn of the University of Maryland said that the failed detection of the comet three years ago may be a sign that current search efforts are skewed towards asteroids 1 km or larger in diameter, despite the fact there are likely many more smaller bodies that could wreak major damage if they struck the Earth.

Jeff Larsen added this comment: This was a failure in detection from three years ago, and not from the "current search efforts". Three years ago, out of the relatively major (all sky coverage surveys), none were in full operation yet (Spacewatch was, but it doesn't cover the sky each lunation). In other words, most likely a 1-km object would have escaped detection as well. I think the question more appropriately should be would such an object, if it were in the sky this year, escape the current system?

Working for a search group, I am the last person who would argue against additional resources. Obviously, we need to start pushing faintward to complete the inventory to smaller and smaller objects. There is a balance, however, in what can be accomplished and what can be accomplished with reasonable (or available) resources. Three years ago I started working for Spacewatch. Since then, I have seen nothing but a steady increase in capability of the search programs. I have not the growth in search capability mentioned as a variable in any comments regarding the theory of surveying.

Comet P/Gehrels 3: spectroscopic observations and nucleus models. M.C. DeSanctis*), M. Lazzarin, M.A. Barucci, M.T. Capria, A. Coradini: ASTRONOMY AND ASTROPHYSICS, 2000, Vol.354, No.3, pp.1086-1090

In the framework of an observational campaign for increasing the knowledge on the relationship between cometary nuclei and asteroids, we performed spectroscopic observations of P/Gehrels 3. The Jupiter family comet P/Gehrels 3 moves on a particular orbit, with a very high Tisserand invariant with respect to Jupiter, that makes the encounters with the planet very effective. This implies that the comet spends part of its life as a temporary satellite of Jupiter, on an orbit that shows similarity with those of Trojans. This comet has been observed when it was far from the Sun, with the aim to acquire data on the nucleus status. In order to study from a theoretical point of view the possible status and evolution of a body on this orbit we have developed different nucleus models using a numerical code for the thermal evolution of the nucleus. Copyright 2000, Institute for Scientific Information Inc.

NOBLE GAS DETECTED IN COMET HALE-BOPP Southwest Research Institute (SwRI) Press Release

San Antonio, June 5, 2000 -- Astronomers announced today at the American Astronomical Society meeting in Rochester, New York, that they have detected argon, a scientifically valuable noble gas, in comet Hale-Bopp. This discovery constitutes the first-ever detection of a noble gas in a comet. Noble gases provide valuable tracers of the thermal history and, therefore, clues to the origins of comets. The discovery was made by a team of four astronomers from Southwest Research Institute, based in San Antonio, Texas, collaborating with three colleagues from the University of Colorado, the University of Maryland, and the Observatoire de Midi-Pyrenees in France. The study was supported by NASA. The data on comet Hale-Bopp were obtained in the form of ultraviolet spectra during a NASA high-altitude suborbital research rocket flight on the evening of March 29, 1997, just as comet Hale-Bopp made its closest approach to the sun. According to team leader and Principal Investigator Dr. Alan Stern, director of the SwRI Space Studies Department, "The argon signals are weak, but unmistakable. We had previously suspected their presence, but were able to recently confirm the result when we cross-compared two independent spectra obtained by our rocket instrument back in 1997."

Adds co-investigator Dr. David Slater, a senior research scientist at SwRI, "Hale-Bopp was among the brightest comets ever witnessed, and surely the brightest comet in modern times. The detection of argon would not have been possible except for Hale-Bopp's unusually high brightness."

Because noble gases do not interact chemically with other elements and because noble gases are easily lost from icy bodies like comets at very low temperatures through processes much like evaporation, their presence or absence provides a way of measuring the thermal history of comets. University of Maryland astronomer and team member Dr. Michael A'Hearn explains, "That's the reason cometary astronomers have wanted to detect noble gases for so long. The advance of technology combined with the brightness of Hale-Bopp made this goal a reality." Interestingly, the team's spectra showed that the argon abundance in Hale-Bopp was so high that it indicates the comet has always been quite cold and likely formed in the deep outer reaches of the solar system, far beyond its once-suspected birthplace in the somewhat warmer Jupiter zone. "Our results indicate that Hale-Bopp was likely formed in the Uranus-Neptune zone," says Stern. The high argon abundance of Hale-Bopp may also help explain the unexpected findings by the Galileo Jupiter entry probe, which found that Jupiter has an argon abundance similar to comet Hale-Bopp. "Perhaps Jupiter was seeded with extra argon by the impact of many comets like Hale-Bopp early in the history of the solar system," remarks Stern.

The detection of argon in Hale-Bopp has whet the scientists' appetite for more noble gas data on comets. The team is preparing an instrument called the ALICE Ultraviolet Spectrometer for NASA to fly to comet Wirtanen aboard the European-U.S. Rosetta comet orbiter mission to be launched in 2003. The team has proposed a series of additional NASA rocket launches in 2002 and 2003 to search for argon and other noble gases, even before the Wirtanen orbiter mission is launched. Stern says, "Using this even more sensitive generation of instruments, we look forward to comparing different comets to one another to learn about the diversity of cometary birthplaces."

COMET LINEAR BREAKUP IS BOON TO SCIENTISTS By Ray Villard, from Space.com

The swift and untimely breakup of the doomed Comet Linear is much more than simply a curious celestial fireworks show.

For the first time in history, astronomers have gotten a detailed look at how the amalgam of dust and ice in a comet nucleus is actually packaged. This comes from spectacular close-up pictures taken several days ago by the Hubble Space Telescope and follow-up observations by the Very Large Telescope in Chile. Hubble first showed that the icy nucleus - the fountainhead of the comet's gossamer tail -- fell apart into a cluster of "mini-comets." Each fragment is probably smaller than a football field.

Seeing the "subassembly" of a comet nucleus provides a clear blueprint of the internal structure of comets and helps settle the debate over whether they are flying "gravel piles," or are built up from consecutively smaller pieces, like the Russian Matrushka toy of nested dolls.

The comet's solid nucleus was assembled from these mini-comets -- or cometesimals -- at about the time of the birth of the planets in our solar system 4.5 billion years ago. Seeing the comet come apart in such fine detail is like opening a time capsule containing the long-sought relics of the early solar system.

In estimating the number of planets in our galaxy, astronomers need to know how they formed around stars. Astronomers have seen both ends of the planet construction process. They've cataloged over 50 extrasolar planetsand Hubble has surveyed over 100 embryonic disks of fine dust around stars out of which the planets will presumably condense. But the process itself cannot be seen, so astronomers must look for fossil evidence within our own solar system.

Like the planets, comets were built up from micron-sized grains of dust no larger than the thickness of a human hair. Over tens of millions of years, the dust clumped together with ice to form snowball-like frozen bodies measuring dozens of feet (meters) wide.

These "cometesimals" gently merged, sticking together to build up comet nuclei, which then grew to a few miles (kilometers) across. Some of these nuclei continued to coalesce to form the icy solid cores of the gas-giant planets. Once the giant planets formed, they gravitationally captured or tossed the remaining comet nuclei out of the solar system to create the Oort cloud.

Knowing how comets are put together offers clues on how to deflect or destroy a wayward comet that might collide with Earth. © 2000, Space.com

NEA SURVEY STATUS FROM DON YEOMANS
Minutes taken during the Near-Earth Object Observers meeting held August 15, 2000 during the IAU General Assembly in Manchester England

This gathering was the second meeting of the Near-Earth Object (NEO) observers to discuss efforts to maximize the NEO discovery rate among the entire international observing community. The first meeting, which included only the NASA supported search efforts, took place September 20-21, 1999 at MIT's Lincoln Laboratory in Cambridge, Massachusetts.

Don Yeomans opened the meeting at 11:00 and welcomed the community of NEO observers and several interested IAU attendees. Yeomans noted that the goal of this meeting was to discuss plans to maximize the discovery rate of NEOs among the international community of NEO observers and to investigate the extent to which coordination among the various teams would help reach the Spaceguard goal. The Spaceguard goal is to discover 90% of the near-Earth asteroids (NEAs) larger than one kilometer within 10 years. The assumption is made that a NEA with an absolute magnitude (H) less than 18.0 has a diameter larger than one kilometer. Recent work by Rabinowitz et al. (2000), Bottke et al. (2000), and Harris (2000) suggest that the total population of near-Earth asteroids (NEAs) larger that one kilometer (H < 18.0) is about 700, 900, and 1000 respectively. In an earlier session of the IAU Working Group on NEOs (D. Morrison, Chair), Yeomans presented charts that showed a dramatic increase in the NEA discovery rate in recent years (over 400 NEAs larger than one km through July 2000). During the same WGNEO meeting, Al Harris presented his analysis suggesting that at the current rate of discovery, the Spaceguard goal of discovering 90% of the NEAs larger than one kilometer in ten years, would be reached not in 2009 but rather in about 2015. Harris noted that to achieve the Spaceguard Goal would require large NEA discoveries at roughly twice the current rate. Hence we may be 40 - 50 % of the way toward meeting the Spaceguard goal in terms of raw numbers, but certainly not in terms of the time interval required.

Appendix: Short summaries of the status of the survey efforts.

Catalina Sky Survey (S. Larson):
The Catalina program consists of both a northern and southern hemisphere search and follow up capability. In the north, the Catalina Schmidt 0.7m (f/1.6) telescope is used for search while the Mt. Lemmon 1.5 m (f/2.0) is used for follow up observations. In the south, the Siding Spring Uppsala Schmidt 0.6 m (f/3) is currently being used for search while the co-located 1.0 m (f/8) telescope is used for follow up. Upgrades are in progress for the Catalina Schmidt (corrector plate, new computers, dome control), the Uppsala Schmidt (declination drive and control room), and Mt. Lemmon (declination drive, computer controls, coma corrector). Proposed upgrades include a thinned 4K x 4K chip for the Catalina Schmidt, a 0.9 m (f/1.7) optical system redesign for the Uppsala Schmidt and a larger 4K x 4K chip for the Mt. Lemmon telescope.

LINEAR (G. Stokes):
While efforts to utilize the U.S. Air Force one meter aperture Ground-based Electro-Optical Deep Space Surveillance (GEODSS) telescopes for discovering NEAs go back several years, it was in March 1998 that the LINEAR program began routine operations using a special 1960 x 2560 CCD camera. This CCD is a thinned, back side illuminated, frame transfer device that allows very fast readouts. In October 1999, a second co-located GEODSS telescope was added to the LINEAR survey and the combination of these two telescopes now accounts for roughly 70% of all NEA discoveries.

LONEOS (E. Bowell):
The LONEOS 0.6 m Schmidt telescope (f/1.9) is currently making about 15,000 asteroid detections per lunation. With the recent improvements in computer software (Sextractor) and the new camera (two 2K x 4K thinned backside illuminated CCDs), the current detection rate is about twice what it once was. Ted Bowell noted that while an improvement to the current thermal environment might increase the system efficiency somewhat, the current system has gone about as far as it can so that plans are underway to investigate the use of the USNO 1.5 m telescope in Flagstaff for future NEA searches.

NEAT (E. Helin):
NEAT began operations with the 1.0 m GEODSS telescope at Haleakala, Maui, Hi in 1995. In 1999, NEAT was moved to the use of the MSSS 1.2 m telescope at the same location and began operations there in February 2000. The current telescope not only has a larger aperture but is available 18 nights per month whereas the GEODSS telescope was only available about 6 nights/month. In addition, upgrades are already in progress to convert the Palomar 1.2 m Schmidt telescope into a NEA search instrument with operations expected to begin in October 2000. The Maui MSSS 1.2 m telescope uses a 4Kx4K CCD with a field of view of 2.6 sq. degrees whereas the Palomar Schmidt will utilize an array of three 4Kx4K CCDs for a field of view of 3.9 sq. degrees.

Spacewatch (R. McMillan)
The Spacewatch telescopes include the 0.9 m and the 1.8 m. When used with the 4 x (4.6K x 2K) mosaic CCD, the 0.9 m has a field of view of 2.9 sq. degrees. When brought on line at the end of 2000 *[it found its first asteroid on September 14]*, the 1.8 m telescope will have a field of view of 0.32 sq. degrees and utilize a 2K x 2K CCD. The average rate of discovery of NEAs with H < 18.0 has been about 7 per year since 1995. The Spacewatch telescopes are used primarily for deep searches in limited areas for NEAs and Kuiper-belt objects (KBOs) rather than the wide area NEA searches provided by the other search programs. As a result, Spacewatch finds many of the smaller NEAs, some KBOs and recently, the 17th satellite of Jupiter.

PHYSICAL PROPERTIES OF THE NUCLEUS OF COMET 2P/ENCKE Y.R. Fernandez, C.M. Lisse, H.U. Kaufl, S.B. Peschke, H.A. Weaver, M.F. A'Hearn, P.P. Lamy, T.A. Livengood, T. Kostiuk: ICARUS 147: (1) 145-160 SEP 2000

We report a new study of the nucleus of Comet 2P/Encke, which the CONTOUR spacecraft is scheduled to encounter in November 2003. During the comet's close approach to Earth in July 1997, we measured the mid-infrared thermal and optical scattered continua with data from the TIMMI instrument (imaging) at the ESO 3.6-m telescope (wavelength lambda from 8 to 12 mu m), the ISOPHOT instrument (photometry) aboard ISO (3.6 mu m less than or equal to lambda less than or equal to 100 mu m), and the STIS instrument (imaging) aboard HST (5500 Angstrom less than or equal to lambda less than or equal to 11000 Angstrom). The optical images show the nucleus with very little coma contamination, and the ISO photometry allowed us to separate the comatic and nuclear contributions to the ESO images. We used the Standard Thermal Model for slow rotators to calculate an effective nuclear radius of 2.4 km +/- 0.3 km. The comet's mid-IR light curve implies a nuclear rotation period of 15.2 h +/- 0.3 h, although some subharmonics of this also satisfy the data. If we assume that the nucleus is a triaxial ellipsoid in principal short axis rotation with the axis direction in 1985 as derived by Sekanina (1988, Astron. J. 95, 911), then by combining our data with light curves from the 1980s we find that the nucleus' angular momentum vector migrates, making a would-be circle in less than 81 years, and that one axial ratio is at least 2.6. The nucleus' optical linear phase coefficient is 0.06 mag/degree, making it one of the most phase-darkened objects known. The surface is also rougher than that of most asteroids, The visual geometric albedo is 0.05 +/- 0.02, within the range found for other cometary nuclei. (C) 2000 Academic Press.

COMETS MAY BE A WORRY BUT ARE STILL RATHER PREDICTABLE From Brian G. Marsden

Certainly, Bob Kobres is right to point out the close approach of Lexell's Comet to the earth in 1770, despite the fact that this comet had a perihelion distance of 3 AU prior to its Jovian encounter three years earlier. I used a somewhat fictionalized version of the Lexell story in my presentation of some spoof "eighteenth-century IAU Circulars" at an NEO conference in Sicily seven years ago. We must indeed be aware that comets can surprise us in unusual ways.

But Bob speaks of PHOs. Appropriately homonymous though this term may be, I have not advocated its use for comets. At the U.N. NEO conference in 1995 I introduced the term PHA for an asteroid with an orbit coming within 0.05 AU of that of the earth (and of absolute magnitude 22.0 and brighter, although maybe we need now to extend this to intrinsically fainter objects) but remarked that the corresponding PHC was not a useful concept. This was precisely because almost all asteroids would not switch from PHA to non-PHA status (or vice versa) over the course of a century or so (and it is quite sufficient to take the earth's orbit to be a fixed circle for this purpose), whereas Jupiter can frequently and dramatically change the paths of the rather smaller number of known short-period comets, and we need to--and usually can--specifically study such changes.

As Bob indicates, the study of the motions of comets is also complicated by the effects of the loss of material associated with the sublimation of ices. One can indeed be suitably wary of active comets. But, as he says, it is also clear that there are *inactive* comets, therefore indistinguishable from asteroids in appearance. Of course, if they are truly inactive, either having lost all their ices or having the ices completely smothered by nonvolatile material, their motions are quite gravitational. We in fact know of some comets that are only mildly active, and we have seen that their motions are affected little, if any, by outgassing. Much cometary outgassing is in fact rather predictable.

Might we be missing such activity on what we think of as asteroids when they are near perihelion? That is something I have wondered about from time to time, particularly when the perihelion distance is small enough that the object can not then be observed in a dark sky. What one *can* say is that the orbits of well-observed, small-perihelion objects like Icarus and Phaethon are completely compatible with point-mass dynamics (including relativistic terms, of course), even though the former is just coming up its 46th passage some 28 million km from the sun since discovery.

This is not to say that an "asteroid" could not surprise us in this way, to the extent of making the difference between an impact and a miss a Century hence for an object whose orbit we think we know very well. But the predicted miss would surely be enough of a "near-miss" to interest us, and we still get to monitor the object, including its physical appearance, between now and then, thus steadily improving the prediction until the outcome is clear.

Review of comet observations for 2000 April - 2000 October

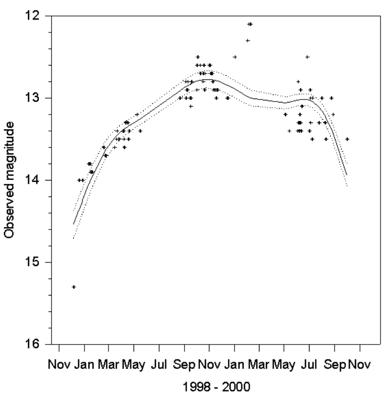
The information in this report is a synopsis of material gleaned from IAU circulars 7398 – 7505 and The Astronomer (2000 April – 2000 September). Note that the figures quoted here are rounded off from their original published accuracy. Lightcurves for the brighter comets are from observations submitted 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.

Hale-Bopp (1995 O1) is still being observed from the Southern Hemisphere, but only just. Andrew Pearce managed to spot it at around 14th magnitude in early July, but there have been no recent positive observations.

Spacewatch (1997 BA6) is another 'old' comet still under observation, but it is now beginning to fade. Southern

Hemisphere observers will be able to follow it for the remainder of the year. The uncorrected preliminary light curve is m = 4.6 + 5 log d + 9.8 log r from 97 observations.

Comet Spacewatch (1997 BA6)

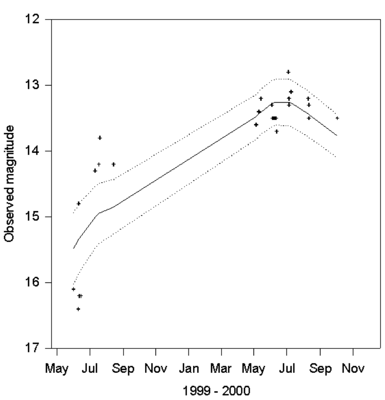


Werner Hasubick made a final couple of observations of **1999 H3 LINEAR** in May and June, when it was 14th magnitude.

A few further visual observations of **1999 J2 Skiff** were made, although the comet was 15th magnitude.

T. Fukushima, T. Nakajima, and J. Watanabe, National Astronomical Observatory of Japan (NAOJ), reported that I-band CCD images of comet 1999 J2 taken with the NAOJ 0.50-m telescope showed a dust anti-tail at the large heliocentric distance of 7 AU (the comet having passed perihelion on April 5). The earth crossed the comet's orbital plane on May 10.4 [IAUC 7415, 2000 May 5]

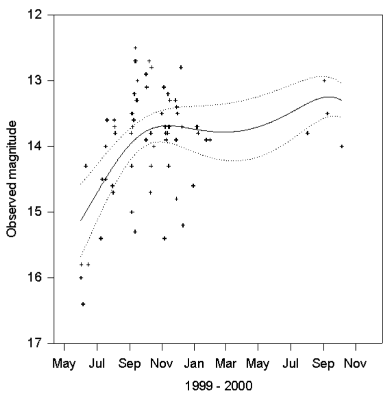
Comet LINEAR (1999 K5)



1999 K5 LINEAR is currently around 13th magnitude visually, and has now passed perihelion, at high southern declination. Michael Mattiazzo reported it at 13.2 on July 4. 27 observations received so far give an uncorrected preliminary light curve of 6.7 + 5 log d + 8.2 log r

Scattered observations of **1999 K8 LINEAR** have continued, with observers estimating it at around 14th magnitude. Now past perihelion, it is at its brightest because the distance from earth is at its smallest. 72 observations give an uncorrected preliminary light curve of -2.1 + 5 log d + 19.7 log r

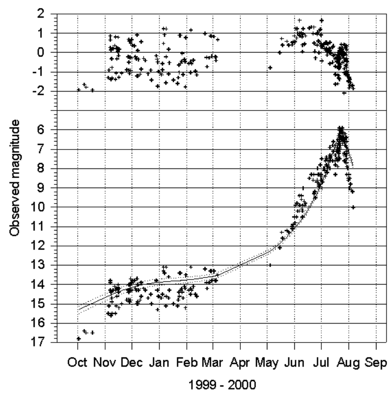
Comet LINEAR (1999 K8)



1999 S4 LINEAR brightened quite slowly, which seems to be a feature of ‘new’ comets. Astrometric observations show that it is making its first visit to the inner solar system and therefore behaviour in a similar fashion to comet Kohoutek was expected.

D. Schleicher, Lowell Observatory; and C. Eberhardy, University of Washington, used the Hall 1.1-m telescope at Lowell Observatory to obtain narrowband photometry of comet C/1999 S4, with the following averaged results: June 10-12, log Q(OH) = 28.41, log Q(CN) = 25.54, log Af(rho) = 2.83 (cf. IAUC 7342); July 13 (seven sets), log Q(OH) = 28.24, log Q(CN) = 25.45; log Af(rho) = 2.55. The equivalent log Q(water; vectorial) is 28.42 for July 13, and no significant temporal or aperture variations were observed. Significant variability was observed during the June observations, with the gas-production rates on June 11 being 30--50 percent larger than on June 10, and then on June 12 dropping to 10 percent less than on June 10. [IAUC 7455, 2000 July 16]

Comet 1999 S4 (LINEAR)



Brian Marsden issued several orbital updates. Although earlier orbital elements predicted the comet's position to at worst 0'.1, many users were unable to reproduce the ephemeris correctly for themselves because of the need to incorporate the nongravitational parameters. These parameters are quite large for this comet, and their effect on the ephemeris computed back from the standard 2000 Aug. 4 epoch was augmented by the rather small value of Delta. Some users also commented on the fact that the eccentricity in the nongravitational solution is significantly smaller than that in a gravitational solution, such as that on MPEC 2000-N15. This is a normal phenomenon and does not alter the likelihood that this is a "new" comet in the Oort sense. [MPEC 2000-O07, 2000 July 19]

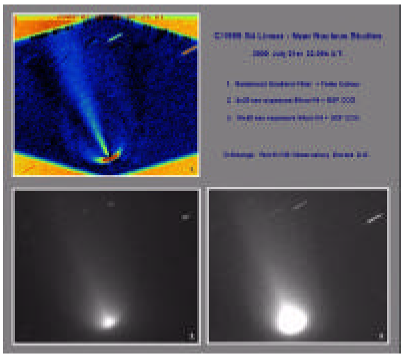
H. Weaver, Johns Hopkins University, on behalf of the Hubble Space Telescope (HST) ToO comet team, reports the following results: "HST images of the comet show a dramatic increase in activity on July 5, with the flux in a 0".15 square aperture increasing by a factor of about 1.5 in just under 4 hr (from July 5.776 to 5.940 UT). During HST observations one day later (July 6.717-6.889), the activity levels were decreasing and were about 3 times lower for the final observation, compared to the peak value from the previous day. The flux in the last HST image (on July 7.961) was about 7 times lower than the peak value measured on July 5. On July 7, at least one 'fragment' is seen 0".85 (460 km, projected) from the nucleus in the tailward direction, and a sharp tailward spike of emission is observed, reminiscent of the morphology observed during the outburst in C/1996 B2

(Hyakutake) in late-March 1996. HST spectroscopic data taken on July 5 with STIS show evidence for emissions from CO, C, H, O, and possibly S. S_2, CS, and OH were detected during STIS observations on July 6, and OH, CS, NH, and possibly S_2 were detected on July 7. Preliminary production rates are 5 x 10**26 (July 5), 1.4 x 10**24 (July 6), and 1.2 x 10**29 (July 6) for CO, S_2, and H_2O, respectively, but the CO and S_2 values could change by a factor of about 2 or so, pending final analysis. Nevertheless, one firm conclusion is that CO is strongly depleted in C/1999 S4, relative to the observed abundances in C/1996 B2 and C/1995 O1." [IAUC 7461, 2100 July 20 (sic)]

C. Lisse and D. Christian, Space Telescope Science Institute; K. Dennerl, Max-Planck-Institut fur Extraterrestrische Physik; F. Marshall, R. Mushotzky, R. Petre, and S. Snowden, NASA/Goddard Space Flight Center; H. Weaver, Johns Hopkins University; B. Stroozas, University of California; and S. Wolk, Harvard-Smithsonian Center for Astrophysics, report the first detection of x-ray line emission due to charge exchange between cometary neutrals and solar-wind minor ions using Chandra and EUVE: "Using a 960-s ACIS-S observation of comet C/1999 S4 on July 14.20 UT, the comet was detected with a rate in the S3 chip of 0.3 count/s, with a total integral flux of 8 x 10**-13 erg s**-1 cm**-2 over 0.2-0.7 keV and a total x-ray luminosity of 6 x 10**14 erg/s. The ACIS-S spectrum showed a strong line at 570 eV detected at greater than 10 sigma, due to charge exchange to O VII. Other lines due to charge exchange are also present (e.g., N VI, N VII at 300-500 eV, O VIII at 650 eV) at lower S/N. The best fit to the preliminary spectrum is the MEKAL multiple-line emission model (Mewe et al. 1986, A.Ap. Suppl. 65, 511) using solar elemental abundances with enhanced oxygen and nitrogen abundances, and a plasma temperature of 0.17 keV. The EUVE Lexan B count rate at July 14.21 was 0.06 count/s in 5400 s, for an equivalent luminosity of 1 x 10**15 erg/s at 0.16 keV. The observed emission was found to be highly time variable on the order of hours, enhanced by a strong solar flare propagating radially from the sun." [IAUC 7464, 2000 July 25]

I. de Pater, University of California, Berkeley, with M. R. Hogerheijde, M. C. H. Wright, R. Forster, W. Hoffman, L. E. Snyder, A. Remijan, L. M. Woodney, M. F. A'Hearn, P. Palmer, Y.-J. Kuan, H.-C. Huang, G. A. Blake, C. Qi, J. Kessler, and S.-Y. Liu, report the detection of HCN from comet C/1999 S4 at the Berkeley-Illinois- Maryland-Association (BIMA) Array in autocorrelation mode: "The peak antenna temperature in a 130" beam, averaged over July 21-24 (about 10 hr total on source), was 3.5 +/- 1 mK (a signal suggesting an outgassing rate a few percent that of C/1995 O1). No signal was detected in cross-correlation mode with the combined Owens Valley Radio Observatory and BIMA data (the virtual Combined Array for Research in Millimeter-wave Astronomy). This suggests a source size slightly larger than expected for a Haser model." M. Kidger, Instituto de Astrofisica de Canarias, writes that nightly observations made since July 23 in U, B, V, R, and Z broadband filters with the 1-m Jacobus Kapteyn Telescope show what appears to be the complete disruption of the comet's nucleus: "The central condensation was highly condensed and showed the typical 'teardrop' form on July 23.9 and 24.9 UT, although its brightness decreased by a factor of about 3 between the two nights. On July 25.9 the central condensation was seen to be strongly elongated (length about 15") in p.a. 80 deg, with a very flat brightness distribution. The condensation's brightness faded further and its length increased to about 30" and 45"-50" (p.a. 80 deg) on July 26.9 and 27.9, respectively. On July 27.9, there was no evidence of any local brightness peak that would indicate the presence of subnuclei. The expansion velocity of the condensation is about 40 m/s, indicating that it is particulate material and not gas. The gas tail, which virtually disappeared between July 23.9 and 24.9, has reformed as an extension of the major axis of the central condensation." [IAUC 7467, 2000 July 27]

J. Licandro, G. Tessicini, and I. Perez, Centro Galileo Galilei; and S. Hidalgo, Instituto de Astrofisica de Canarias, report that the inner coma of C/1999 S4 appears extremely elongated in the tailward direction on J, H, and K_s images obtained with the 3.6-m Telescopio Nazionale Galileo (+ ARNICA camera) at La Palma on July 26.9 and 27.9 UT. There is no clear central condensation, but the photometric peak appears to move from the anti-tailward border of the coma toward p.a. 81 deg on July 26.9 and 84 deg on July 27.9, with a velocity of 7".4/day (26 m/s). The brightness of the central coma decreased from J = 8.83 +/- 0.04 on July 26.9 to 9.46 +/- 0.07 on July 27.9, as measured in a 30"-diameter aperture around the peak. Color maps do not show any major structure, the mean colors being J-K = +0.61 +/- 0.05, and H-K = +0.12 +/- 0.06 on July 26.9. These data suggest that a major event has occurred in the nucleus of the comet. A. V. Filippenko and R. Chornock, University of California at Berkeley, report that inspection of a CCD spectrum (range 320-1000 nm) of this comet obtained on July 28 UT with the Shane 3-m reflector at Lick Observatory reveals no clear emission lines superposed on the solar reflection spectrum, unlike the case in spectra they obtained with the same instrument on July 6 and June 27. There is no evidence for the normally strong CN emission near 380 nm. The comet's morphology is peculiar, lacking an obvious head that is brighter than the adjacent tail, although the leading edge of the head/tail combination is very sharply defined. S. Nakano, Sumoto, Japan, writes that A. Asami (Bisei Spaceguard Center) was unable to find a peak in the comet's central-condensation brightness to determine an astrometric position from a CCD image taken in fair conditions on July 28.490 UT with a 0.25-m f/5 reflector. [IAUC 7468, 2000 July 28]



Further to their item on IAUC 7468, Filippenko and Chornock report that full reduction of their CCD spectrum obtained on July 28 shows that CN emission near 380 nm is actually present; the CN was not initially noticed in the two-dimensional spectrum because it spans the entire slit, making it resemble a night-sky emission line. In contrast, the continuum (reflected sunlight) is visible only on part of the slit, ending abruptly (as mentioned on IAUC 7468). [IAUC 7470, 2000 July 30]

Z. Sekanina, Jet Propulsion Laboratory, reports: "The unusually large nongravitational forces found by B. G. Marsden (MPEC 2000-O07) suggest that comet C/1999 S4 was a trailing fragment of a more massive comet that has been moving in the same orbit, arrived at perihelion long (centuries?) ago but (not surprisingly) was missed. Trailing fragments of known comet pairs have a tendency to sudden disintegration (e.g., Sekanina 1997, A.Ap. 318, L5). If much of the comet's mass did indeed dissipate into a cloud of dust in the recent event, as suggested by M. R. Kidger (IAUC 7467) and others, the total mass involved could be estimated by further monitoring the tail. Experience with the past initially bright comets that later became headless and disappeared shows that a narrow, bandlike tail--a developing synchronic formation--should survive the head by several weeks or even longer (Sekanina 1984, Icarus 58, 81). A very preliminary analysis suggests that the event may have begun as early as July 23.6 UT and involved submillimeter-sized and larger dust (repulsive accelerations up to 0.024 of the solar attraction). The position angle and approximate length of this tail feature are then predicted to reach: July 30.0 UT, 90 deg, 2'; Aug. 4.0, 98 deg, 4'; 9.0, 102 deg, 7'; 14.0, 104 deg, 10'; 19.0, 105 deg, 12'; 24.0, 106 deg, 15'; 29.0, 106 deg, 17'. Especially toward the end of this period, the predicted length probably is a crude upper bound. If no such tail persists, the comet's upper mass limit should be tightly constrained, or the amount of dust lost in the event did not represent a substantial fraction of the total mass." [IAUC 7471, 2000 July 30]

M. Kidger, Instituto de Astrofisica de Canarias, reports analysis of continued observations of C/1999 S4 at La Palma: "A 100-s exposure in R, taken by R. Corradi and N. O'Mahoney (Isaac Newton Group of Telescopes) on Aug. 1.9 UT with the Wide Field Camera on the 2.5-m Isaac Newton Telescope, shows no evidence of a nuclear condensation or subnuclei within the coma. The seeing (measured from a short exposure at the same airmass) was 1".5. It is thus highly improbable that any fragments of the nucleus of significant size exist within the coma. The coma shows a similar structure to that reported previously, with a well-defined sunward boundary to the coma similar to the point of a lance, although the brightest part of the coma is now displaced 1' tailwards. The tail can be traced at least 20'." [IAUC 7472, 2000 August 3]

Further to IAUC 7472, M. Kidger reports that the limiting magnitude for a 5-sigma point source detection in the Isaac Newton Telescope images taken on Aug. 1.9 UT is R = 22.0. He adds that the continued presence of a well-defined leading edge or point to the coma suggests that an unresolved fragment of the nucleus in this position continues to release dust. However, this structure has faded considerably since the disruption occurred. Measurements of the coma brightness distribution indicate that the maximum of light is about 75" from the leading border of the coma. [IAUC 7474, 2000 August 5]

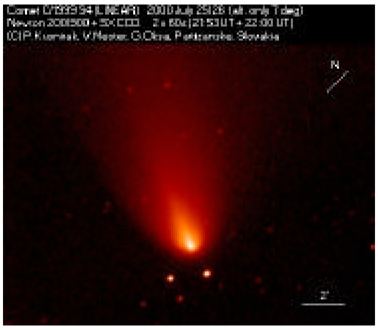
D. Schleicher and L. Woodney, Lowell Observatory, write: "We used the Hall 1.1-m telescope (+ 95"-diameter aperture) at Lowell Observatory to obtain narrowband photometry of comet C/1999 S4 (centered at the nominal ephemeris position; cf. MPEC 2000-O02), yielding the following production rates: log Q(OH) = 27.4; log Q(CN) = 24.4; log Af(rho) = 1.5 (cf. IAUC 7342). The equivalent log Q (water; vectorial) is 27.6. The values are 8-10 times less than those measured on July 13 (cf. IAUC 7455)." [IAUC 7475, 2000 August 7]

H. Weaver, Johns Hopkins University, and R. West, European Southern Observatory, on behalf of a large group of collaborators, report the following results: "Hubble Space Telescope (HST) images taken during Aug. 5.167-5.396 UT and Very Large Telescope (VLT) images (image quality about 0".6) taken during Aug. 6.978-6.999 revealed about a dozen active fragments, most of them located within about 20" of the western tip of the dust tail (cf. IAUC 7474). The correspondence between fragments in the HST and VLT images is generally very good, but the brightest fragment in the HST image is not seen in the VLT image, indicating rapid variability in the activity levels. The dynamic nature of the fragments was further highlighted by a dramatic change in the appearance of the fragments in VLT images taken during Aug. 9.976-9.996, when they were barely detectable. Although the latter images were taken under mediocre observational conditions (image quality about 1"-1".3, thin cirrus, and nearly full moon), that alone seems unlikely to account for the observed changes. A very preliminary estimate for the R magnitude, within a circular aperture of radius 0".23, of one well-isolated fragment is about 24. A completely inactive fragment with a diameter of 100 meters observed under these conditions (r = 0.79 AU, Delta = 0.69 AU, Phase = 86o) would have R about 25.9 (assuming a 4-percent albedo and 0.04 mag/deg phase law). We urge ground-based observers to continue monitoring the comet and to report any unusual changes near the 'tip', both in brightness and morphology." [IAUC 7476, 2000 August 10]

Professional observations show highly variable emissions. The orbit requires large non gravitional parameters and this combined with the faint absolute magnitude suggests that it is a small variably active object. As described above recent observations suggest that it may have fragmented, though there is some 'hype' on the topic, for example from Space Science. Note the amateur observations suggest that a burst of activity between July 20 and 21, caused a brief brightening of the comet, followed by a more rapid fade, although the professionals persist in giving a later date. Indeed there is evidence from the light curve that fading may have started as early as late June. Hubble images taken on August 5 show the the comet fragmented into a number of cometisimals, confirming the concept that comets are a loose aggregation of smaller bodies, cemented together by ice and dust. Further images taken the next day by the ESO VLT show significant changes to the distribution of the cometisimals.

KenIchi Kadota succeeded in recovering the comet on May 4, when he estimated it at 13.0, though at very low altitude. Several observers recovered it at the beginning of June with C Segarra reporting it at 10.5 visually. Rolando Ligustri imaged it with CCD on June 1 when it was 9.9 and on June 4, June 23, July 1, July 2, July 6, July 18 July 20, July 21, July 26, July 30. Pepe Manteca imaged the comet on June 9, June 22, June 28, July 2, July 12, July 14, July 22. Martin Mobberley imaged the comet on June 22 when it was about 9th mag and on July 17. Denis Buczynski imaged it on June 26, June 27, July 03, July 04, July 11, July 15/16, July 16/17, July 19, July 23. David Strange imaged it on June 26, July 21 and on July 25 as it fragmented. Nick James imaged it on July 2, July 18 July 19 July 20. R Ferrando imaged it on July 9, July 28. John Fletcher imaged it on July 20. Maurice Gavin imaged the comet on July 16 and also obtained a spectrum. Christian Buil imaged the comet and obtained spectra on July 17. Gabriel Oksa imaged the comet on July 25.

I picked up the comet in my 20cm LX200 x75 on June 7.05, it was mag 9.9, DC3, coma diameter 1.1'. I did not seen again for 34 days due to a lengthy spell of cloudy weather over eastern England. I saw it again on July 11.94 it was 7.4 in 20x80B, coma diameter 3.1', DC5. Unusually it cleared as it became dark on July 14 and I made another observation on July 14.9, the comet was 7.1 in 20x80B, DC5, coma diameter 3', tail 20' in pa 310. On July 16.9 the comet had brightened to 6.8 in 20x80B despite the nearly full moon. It was a similar magnitude on July 18.9 and 19.9. It was markedly brighter on July 21.9 than it was on July 20.9 with a prominent stellar condensation. Observations with 8x30B on July 21.9 gave a mag of 6.0 suggesting it could be seen with the naked eye from a really dark site. No positive observations were made after August 6.

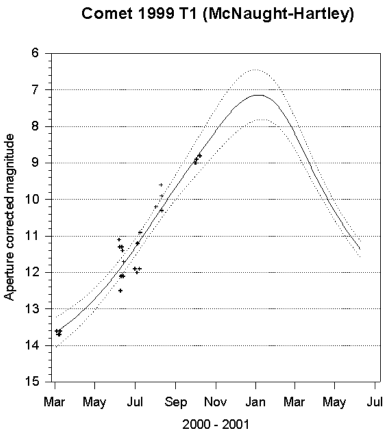


292 observations give an uncorrected preliminary light curve of 9.1 + 5 log d + 5.6 log r

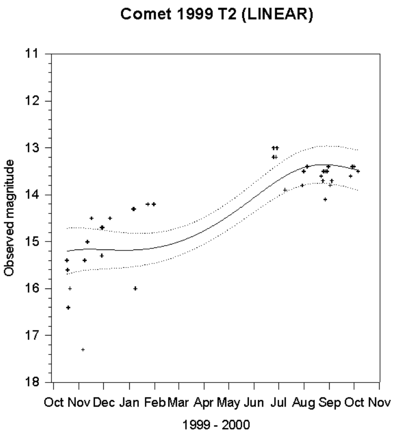
1999 T1 McNaught-Hartley
According to the preliminary light curve the comet should reach binocular brightness. Initially at far southern declinations it will come within range of binoculars in October. It moves far enough north for observation by UK observers in December when it reaches perihelion and moves through Hydra, Virgo and Libra.

Andrew Pearce and Stuart Rae picked up the comet at around 13th magnitude in early June. It was 12.7 when Stuart Rae observed it on July 7.7. Recent observations from Andrew and Michael Mattiazzo make it a little brighter than 10th mag.

26 observations give an aperture corrected preliminary light curve of 5.8 + 5 log d + 7.5 log r



1999 T2 LINEAR will reach perihelion in November, but is already at its brightest. Denis Buczynski imaged it on 2000 May 31.04 I estimated it as fainter than 13.1 around the same time and Denis' image shows that it was significantly fainter than this.

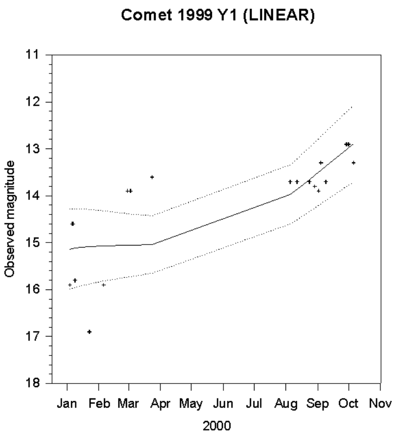


Rolando Ligustri imaged the comet on August 26. Pepe Manteca imaged the comet on August 9, August 16, August 17, August 25, August 28, September 4, September 5 September 7, September 9 September 10. I observed the comet on September 26.8 and estimated it at 13.6, with a small, moderately condensed coma.

39 observations give an uncorrected preliminary, very uncertain light curve of 7.7 + 5 log d + 6.4 log r

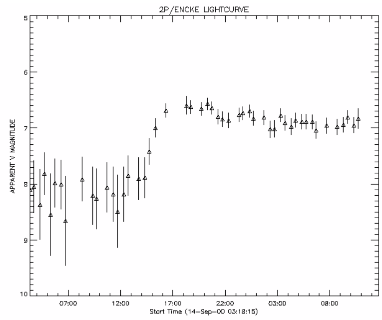
1999 U4 Catalina-Skiff is very distant, but could brighten to 14th magnitude when at perihelion in 2001. Pepe Manteca imaged the comet on August 25.

1999 Y1 LINEAR could reach 12th mag at the end of the year. Pepe Manteca imaged the comet on August 10, August 18, August 25. 19 observations give an uncorrected preliminary light curve of 7.1 + 5 log d + 6.6 log r



Comet 2P/Encke made its 58th observed return to perihelion since its discovery by Mechain in 1786. The orbit is quite stable, and with a period of 3.3 years apparitions repeat on a 10 year cycle. This year the comet is not particular well seen, but there was a short observing window from the Northern Hemisphere prior to perihelion in September. There is currently another short window from the Southern Hemisphere. There is some evidence for a secular fading and any observations will help confirm this. Another suggestion is that Encke has two active regions, an old one with declining activity, which operates prior to perihelion and a recently activated one present after perihelion. The comet is the progenitor of the Taurid meteor complex and may be associated with several Apollo asteroids.

A few observers spotted the comet in early August, estimating it at around 11th mag. Pepe Manteca imaged the comet on August 10 and August 14. The comet was visible in the SOHO C3 coronagraph, but was fainter than expected and was only 8.8 on September 7.1. It suddenly brightened on September 14 at around 15:00 to 6.5.



Comet 9P/Tempel 1 was first observed in 1867, but was lost between 1879 and 1967 following an encounter with Jupiter in 1881 which increased the perihelion distance from 1.8 to 2.1 AU. Further encounters in 1941 and 1953 put q back to 1.5 AU and calculations by Brian Marsden allowed Elizabeth Roemer to recover it in 1967. Alternate returns are favourable, but perturbations will once again increase the perihelion distance in the middle of the next century. This return is an unfavourable one and no observations were made. It is an important comet to observe as it is a potential target for the Deep Impact mission and a special request for observations has been made.

It is a difficult target for amateur observation and may be around 17th magnitude. There were special observing efforts over the weekends of July 8/9 and August 5/6 and there was a further one over September 2/3. Karen Meech attempted observations from Hawaii over August 19/21.

Comet 17P/Holmes Pepe Manteca imaged this faint comet on August 10.

The space technology mission Deep Space 1 is on its way to comet **19P/Borrelly**.

Comet 29P/Schwassmann-Wachmann 1 is not well placed for observation from the UK, but may be seen from locations further south. It passes through Ophiuchus and into Sagittarius and is in solar conjunction in December. Unfortunately opportunities for UK observers may be limited, as its altitude does not exceed 11° from this country.

This annual comet has frequent outbursts and over the past couple of years seems to be more often active than not, though it rarely gets brighter than 12m. It is possible that its pattern of behaviour is changing. In the first half of 1998 it was in outburst on several occasions and this also occurred in 1999. The randomly spaced outbursts may be due to a thermal heat wave propagating into the nucleus and triggering sublimation of CO inside the comet. **This comet is an ideal target for those equipped with CCDs and it should be observed at every opportunity.** Jose Aguiar reported as possibly being in outburst on July 1

Comet 47P/Ashbrook-Jackson. Michael Mattiazzo recovered the comet at 14.0 on July 4. 7 observations received give an uncorrected preliminary light curve of m = 2.1 + 5 log d + 25.9 log r.

Comet 75P/Kohoutek may become visible in large apertures towards the end of the year.

Comet 97P/Metcalf-Brewington G. V. Williams, Minor Planet Center, identified this comet with an asteroidal LINEAR object of 19th mag, 1.1 deg from the prediction (MPC 31663). The nominal correction is Delta(T) = +3.5 days, but lacks literal meaning because of the 1993 passage <0.11 AU from Jupiter. [IAUC 7487, 2000 September 5]

Comet 110P/Hartley 3 is another comet which may become visible in large apertures towards the end of the year.

SOHO Kreutz group comets
2000 H2 SOHO (IAUC 7412, 2000 May 01)
2000 J3 SOHO (IAUC 7422, 2000 May 11)
2000 J4 SOHO (IAUC 7426, 2000 May 19)
2000 L1 SOHO (IAUC 7439, 2000 June 14)
2000 L2 SOHO (IAUC 7439, 2000 June 14)
2000 L3 SOHO (IAUC 7439, 2000 June 14)
2000 L4 SOHO (IAUC 7445, 2000 June 29)
2000 L5 SOHO (IAUC 7445, 2000 June 29)
2000 M1 SOHO (IAUC 7445, 2000 June 29)
2000 M2 SOHO (IAUC 7450, 2000 July 08)
2000 M3 SOHO (MPEC N26, 2000 July 12)
2000 M4 SOHO (MPEC N26, 2000 July 12)
2000 M5 SOHO (MPEC N26, 2000 July 12)
2000 M6 SOHO (MPEC N31, 2000 July 13)
2000 M7 SOHO (MPEC N31, 2000 July 13)
2000 M8 SOHO (MPEC N31, 2000 July 13)
2000 P1 SOHO (MPEC Q08, 2000 August 19)
2000 P2 SOHO (MPEC Q08, 2000 August 19)
2000 T1 SOHO (MPEC T33, 2000 October 10)
were discovered with the SOHO LASCO coronographs and have not been observed elsewhere. They were sungrazing comets of the Kreutz group and were not expected to survive perihelion.

On June 14 SOHO-135 was discovered on C2 by Michael Boschat, Maik Meyer and Xavier Leprette. I had looked a few minutes earlier, but failed to spot the comet.

For me success came again on June 15. I had been into Cambridge to set up a display for the Cambridge Natural History Society Conversazione (an annual exhibition) and had then gone home to mend a puncture. On returning to work I started to download the latest real-time movie sequence, but then had to extract some images of meteorological equipment for a colleague. On returning to the movie I initially didn't spot anything, but then saw the Kreutz group object moving towards the sun from the bottom right hand corner of the image. I quickly sent out a message and at almost the same time got a message from Michael Boschat saying that he had also found it. Michael Oates sent a message saying that he was just downloading the images and we had beaten him to it. I then measured the positions and sent them off to Doug. (SOHO-138)

I made an independent discovery of SOHO-169 in the closing moments of the second test against the West Indies. I downloaded the C2 loop and in the interval between overs had a quick look and spotted a Kreutz comet moving into the frame on images from 16:00 onwards. I mailed Doug at 17:50 and in the meantime England inched towards victory. I downloaded the C3 and spotted a comet moving in towards the sun since 08:42 and deduced that it was probably the same one and had already been discovered. England won and I sent another message to Doug and then lightning struck the local area and there was a power glitch and everything went down. I restarted the PC and then checked Doug and Maik's page to find that SOHO-169 had been discovered on C3 by Maik. Then there was another lightning hit and I took the hint to quit before the computer blew up. This was my first discovery from home and although not an original one it is nice to make an independent find. I also made an independent discovery of 171 on July 2, originally not knowing about Terry's find, but on checking noted that it had been found on July 1 so thought it might be a different object.

2000 G1 P/LINEAR F. Shelly, for the Lincoln Near-Earth Asteroid Research project, reports, in connection with the discovery on April 7.45 of a fast-moving 18th mag object, that Lisa Brown-Manguso noticed that the object showed clear cometary activity. [IAUC 7396, 2000 April 8] Subsequent observations confirmed that it is a periodic comet, with a perihelion distance of 1.003 AU and perihelion on March 9.8. The period is 5.4 years. The comet passed only 0.10 AU from Earth in late February and early March, when it could have reached 14th mag, but was at high southern declination. It is intrinsically very faint. The comet was moved into its present orbit in February 1987 when an encounter to within 0.15 AU of Jupiter made significant changes to the elements. The comet could potentially have an associated meteor shower. This would be maximum around March 30 and the meteors would appear to radiate from 5h 08m -16.

2000 G2 D/LINEAR Another 18th magnitude object with unusual motion that was reported as asteroidal by LINEAR on April 4.39 has been noted by other observers, following posting on the NEO Confirmation Page, as being cometary in appearance. G. Hug, Eskridge, KS, reported a diffuse appearance on several CCD images taken with a 0.3-m reflector during Apr. 21-29, and Klet CCD observations by J. Ticha, M. Tichy, and Z. Moravec (0.57-m reflector) indicated a coma diameter of about 6" on Apr. 22.9 UT. A 300-s R exposure taken by C. Hergenrother with the Steward Observatory 2.3-m telescope on Apr. 30 confirms that this object has a 6" coma and a 20" tail in p.a. 117 deg. The comet reached perihelion on 2000 February 6.1 with a perihelion distance of 2.72 AU. [IAUC 7411, 2000 May 1]

A/2000 GH147 The asteroid 2000 GH147 was discovered with NEAT on 12 April 2000. It was subsequently followed up by many observers worldwide, including J. Ticha, M. Tichy at Klet, P. Kusnirak at Ondrejov, M. Hicks, D. Deaver, at Table Mountain. This 1.5 km (1 mile) asteroid is unusual with a high-inclination (50 degrees), high-eccentricity (0.48) orbit that takes it from near Mars' orbit to inside Jupiter's. It is therefore an extinct comet candidate. [NEAT web page]

A/2000 GQ132 MPEC-2000-J19 reported a second cometary asteroid discovered by NEAT on April 12.51. This object of 18th mag is in a 5.9 year orbit with inclination of 30 degrees and a perihelion distance of 1.5 AU. [2000 May 06]

2000 H1 LINEAR A 19th mag object reported by LINEAR on 2000 April 26.39 and posted on the NEO Confirmation Page has been noted to be diffuse at Klet (Apr. 27.0 UT), Ondrejov (Apr. 27.1), and Modra (Apr. 29.0). M. Hicks (Table Mountain Observatory) reported a 7" central condensation and 20" tail in p.a. about 120 deg on Apr. 29.4. [IAUC 7410, 2000 April 29] The comet is in a distant parabolic orbit and is just past perihelion.

2000 J1 Ferris An apparently asteroidal object of 19th mag reported by LONEOS (observer W. D. Ferris, measurer B. W. Koehn) on May 4.32 that was posted on the NEO Confirmation Page has been found to have a faint 10" tail in p.a. 150 deg (mag R = 19.6 in a 5" aperture) on CCD images taken by M. Hicks with the Kitt Peak 2.13-m reflector on May 8.3 UT. [IAUC 7416, 2000 May 8] The object will fade.

2000 J2 SOHO D. A. Biesecker, Emergent Information Technologies, Inc., and Goddard Space Flight Center, reports observations of another comet found in LASCO C2 data on May 7.24 by M. Oates via the SOHO website. The comet brightened from V = 7.8 on May 7.254 UT to 7.1 on May 7.368, but had faded to V = 8.3 on May 7.452, and it was not seen in the C3 instrument. No tail was evident. Astrometry (measured by Biesecker, reduced by B. G. Marsden) and orbital elements appear on MPEC 2000-J32; this comet is evidently not a Kreutz sungrazer.

A/2000 HR24 Details of unusual asteroid 2000 HR24=1995 XH5 appear on MPEC 2000-J50. The object was first spotted by Spacewatch in December 1995, and then independently discovered by LONEOS in late April this year. Prediscovery images have been found in LINEAR and NEAT data. The asteroid has an 11.1 year period, with a perihelion distance of 4.1 AU and passed 0.76 AU from Jupiter in 1941 August. The 18th mag object, which appears stellar, will fade. [MPEC 2000-J50, 2000 May 13] The encounter with Jupiter made relatively small changes to the orbit.

A/2000 HD74 Details of unusual asteroid 2000 HD74 appear on MPEC 2000-J56. The object has a high inclination short-period (5 year) cometary type orbit, but shows no cometary activity. The 18th mag object was discovered by LONEOS on April 30.38. It is closest to earth towards the end of this month, and reaches perihelion at 1.19 AU in July when it will be at a high southern declination. [MPEC 2000-J56, 2000 May 15]

2000 K1 LINEAR F. Shelly, Lincoln Laboratory, Massachusetts Institute of Technology, reported that LINEAR discovered a comet (LINEAR-47), of 18th mag on May 26.31. [IAUC 7430, 2000 May 26] The comet is a distant one and will fade, though it could be several magnitudes brighter to visual observers than its discovery magnitude indicates. The comet was linked to asteroids LW24 and NF13 observed by LINEAR in 1999 and a new hyperbolic orbit is given on MPEC 2000-K29.

2000 K2 LINEAR Shelly also reported that LINEAR discovered another comet (LINEAR-48) on the same night. It was a little brighter and showed a tail in p.a. 240 deg. Ticha reported the comet to be slightly diffuse, and Kusnirak reports a faint tail about 20" long in p.a. 220 deg; Galad reported cometary appearance. [IAUC 7430, 2000 May 26]. The comet will brighten a little.

A/2000 LK Another interesting asteroid was reported on MPEC 2000-L14. Discovered by LONEOS, this object has a perihelion distance of 0.11 AU and an eccentricity of 0.95, which takes it out nearly to Jupiter's orbit.

A/2000 NL10 This asteroid approaches the sun to 0.17 AU and has an eccentric orbit which takes it out to 1.68 AU. It was discovered by LINEAR on July 10 [MPEC 2000-N28, 2000 July 12]. Further observations from Paolmar from 1952 and 1992 have been discovered and an improved orbit is given on MPEC 2000-O17 [2000 July 23]

2000 O1 Koehn B. W. Koehn, Lowell Observatory, reported his discovery of a possible 18th mag comet in the course of the Lowell Observatory Near-Earth-Object Survey on July 20.36. The comet is a distant one and won't become brighter than 17th mag [IAUC 7462, 2000 July 23] MPEC 2000-O22 shows the identification, by B. G. Marsden, of this comet with the LINEAR "asteroidal" objects 1998 XA_70 and 1999 UJ_10, together with improved orbital elements: T = 2000 Jan. 27.35 TT, Peri. = 55.11 deg, Node = 88.86 deg, i = 148.10 deg (equinox 2000.0), q = 5.9219 AU, e = 1.0009. [IAUC 7465, 2000 July 25]

2000 O2 P/Kushida C. E. Delahodde, European Southern Observatory, reports the recovery by O. R. Hainaut and herself of comet P/1994 A1 (= 1994a = 1993 XX) with the 3.6-m reflector on July 25.33. The indicated correction to the prediction by S. Nakano on MPC 31664 is Delta(T) = -0.10 day. Further observations and improved orbital elements are given on MPEC 2000-O32. [IAUC 7467, 2000 July 27]

2000 O3 SOHO I discovered another comet at 10:45 (UT) on July 31. I had given a lecture in the centre of Cambridge and didn't get into the office until after 10:00 (11:00 BST). First I checked the emails, including several Antarctic ones which had data that needed processing. Then I had a look at various web pages, including the latest MPECs, finally I had a look at the SOHO real time movies. I first looked at C2; there were no obvious Kreutz objects but I noted something that appeared to be moving opposite to the stars. I quickly found that it was moving consistently and emailed Doug and the group with details of the possible object. I then checked C3 in case it was visible and downloaded the real-time gif images to measure the positions. I found that it came into view at 21:30 on July 30 and was visible until 03:30 on July 31, moving horizontally from right to left just above the level of the occulting disc and below the beehive cluster. At its brightest (00:06) it was around 7th mag. I think the biggest surprise is that no-one else had picked up this object! Subsequently the comet came into view again, on images from 05:54 till after 12:00. The apparent fading around 03:30 may be due to phase effects playing a part. If it was then between us and the sun it would have zero phase and be difficult to see. The phase effect partly explains why many Kreutz comets are seen during May as this is when they are on the far side of the Sun and fully illuminated.
The orbit was finally published on MPEC 2000-Q09 [2000 August 19], after Brian Marsden returned to the USA following the IAU meeting in Manchester. It seems that the IAU had commanded all three senior members of the CBAT to attend the meeting. The comet had been at perihelion on July 30.94 at a perihelion distance of 0.054 AU. Potentially it was observable from the ground at an elongation of 50 degrees in late August, though at a magnitude of near 20. The orbit shows that it passed on the far side of the sun, so phase effects do not explain the fading.

Further to IAUC 7472, D. Hammer has provided measurements of a comet detected by the SOHO C2 and C3 instruments and found by J. D. Shanklin via the SOHO website. The reduced measurements and orbits by B. G. Marsden, together with a search ephemeris, are given on MPEC 2000-Q09. G. J. Garradd, Loomberah, N.S.W., reports that his search for this object around Aug. 21.4 UT, out to about 0.5 deg ahead of its predicted position, yielding nothing to mag about 18. [IAUC 7479, 2000 August 21]

2000 OF$_8$ Spacewatch Details of an unusual asteroid with a 190 year period, a high inclination orbit and a perihelion distance of 2.0 AU were given on MPEC 2000-P03. The 20th magnitude object was discovered by Spacewatch on July 24.32 and won't reach perihelion until next year. It is currently 4.4 AU from the Sun and it is possible that it will develop cometary activity as it gets closer. Further observations did indeed show cometary activity and a parabolic orbit was published on MPEC 2000-Q43. The comet reaches perihelion in August 2001 at 2.2 AU. The comet could reach 14th mag next summer.

2000 Q1 SOHO James Danaher discovered a faint non Kreutz object on C3 images from August 28. It tracked diagonaly across the upper left quadrant. The orbit published on MPEC 2000-Q42 suggests that it could be visible from the ground, but will be a very faint southern hemisphere object.

2000 R1 P/Shoemaker-Levy 5 The LINEAR team reported that one of their objects observed on Sept. 6 was cometary, and T. Spahr and Dan Green noted that this was about 0.6 deg northwest of the prediction for P/1991 T1 = 1991z = 1991 XXII (MPC 29882, 39661), corresponding to Delta(T) = -1.4 day. Following a request from the Central Bureau, D. Balam reported that images taken with the 1.82-m Plaskett telescope of the National Research Council of Canada show this object to have a well-condensed coma and a fan-shaped tail extending 30" in p.a. 250 deg; his R magnitude of 18? was obtained in a 10" aperture. [IAUC 7488, 2000 September 7] The 18th mag object will brighten a little.

2000 R2 P/LINEAR A 19th mag object reported as asteroidal by the LINEAR team on September 3.15, and subsequently posted on the NEO Confirmation Page, has been reported as cometary in appearance on various CCD exposures: Sept. 7.2 UT, condensed 9" coma (D. Balam, Victoria, 1.82-m reflector); Sept. 7.9, object seemed diffuse with a faint east-west tail about 10" long (M. Tichy, Klet, 0.57-m reflector); Sept. 18.51, near-stellar condensation with a fairly narrow 40" tail in p.a. 90 deg (R. H. McNaught, Siding Spring, 1.0-m reflector + 100-s R frames). The available astrometric observations are given on MPEC 2000-S04, where orbital elements show this to be a short-period comet with perihelion distance of 1.39 AU and period of 6.26 years. It has a very faint absolute magnitude of 18.0 [IAUC 7492, 2000 September 18]

2000 S1 P/Skiff B. W. Koehn, Lowell Observatory, reports the discovery by Brian A. Skiff of a comet on images from September 24.30 taken in the course of the LONEOS program. [IAUC 7496, 2000 September 25] Prediscovery observations made by LINEAR on August 26, together with additional astrometry on September 26, are given on MPEC 2000-S60 and show that the comet is periodic with a period of 17.1 years. [IAUC 7497, 2000 September 27] The comet is reported as around 15th mag, but may be brighter visually. It is near opposition in Cetus and will fade.

2000 S2 P/Shoemaker-LINEAR F. Shelly and R. Huber, MIT Lincoln Laboratory, reported the discovery by LINEAR of a 19th mag comet with a tail in p.a. about 280 deg, on September 27.44. Confirmation of cometary appearance on September 29.1 was received from P. Pravec and P. Kusnirak at Ondrejov (coma diameter 0'.2 with a 0'.2 tail in p.a. 260 deg) and from J. Ticha and M. Tichy at Klet (object diffuse with 14" tail in p.a. 265 deg). Available astrometry and preliminary parabolic orbital elements (T = 2000 July 27.6 TT, q = 1.305 AU, i = 20.2 deg) were published on MPEC 2000-S67. [IAUC 7498, 2000 September 29] S. Nakano, Sumoto, Japan, then identified comet C/2000 S2 with comet D/1984 W1 (Shoemaker 2), the comet now being off from his prediction (cf. ICQ 2000 Comet Handbook) by Delta(T) = +23.2 days or about 7.5 deg in sky position. [IAUC 7499, 2000 September 29]

2000 S3 On October 1, B. W. Koehn communicated his measurements of a comet, later reported as discovered by B. A. Skiff on images taken on September 29.27 by M. E. Van Ness in the course of the LONEOS program at Lowell Observatory. Skiff described a nearly circular coma of diameter 15" with moderate condensation. Following tentative linkage by B. G. Marsden, Center for Astrophysics, to one (mag about 19) of about 2000 asteroidal objects recorded on September 20 by LINEAR, a tentative ephemeris was provided on the NEO Confirmation Page. This linkage was confirmed by observations obtained on Oct. 2 by J. G. Ries with the 0.76-m reflector at McDonald Observatory. Skiff adds that observations by L. H. Wasserman with the 1.1-m telescope at Lowell Observatory on Oct. 2 showed a 14" x 11" coma, elongated east-west. [IAUC 7501, 2000 October 2] The comet is periodic, with a period of 40 years and was at perihelion in mid July at a distance of 2.66 AU. It will fade.

2000 S4 Tom Gehrels reported his discovery of a faint (20th mag) comet on October 2.15 images taken with the Spacewatch telescope at Kitt Peak, noting it to have a 4" tail in p.a. 170 deg. T. B. Spahr, Minor Planet Center, linked it to an asteroidal object observed on September 23 and 26 reported earlier by LINEAR and then found LINEAR observations made on September 1. At the request of Gehrels, P. Massey obtained images of the object in subarcsecond seeing with the 4-m Mayall Telescope at Kitt Peak on October 3.25 UT, showing the comet to have a fan-shaped structure 4" long spanning p.a. 0-80 deg. [IAUC 7502, 2000 October 3] The comet is close to perihelion at 2.3 AU and has a period of around 19 years.

For the latest information on discoveries and the brightness of comets see the Section www page: http://www.ast.cam.ac.uk/~jds
or the CBAT headlines page at http://cfa-www.harvard.edu/cfa/ps/Headlines.html

Comet Prospects for 2001

2001 sees a couple of good returns of periodic comets. 19P/Borrelly, which was well observed at the last return, is predicted to be the brightest, and may reach 9^m in the northern autumn. 24P/Schaumasse also has a good return and reaches 10^m. Several long period comets discovered in previous years are still visible and there are some poor returns of short period comets. Theories on the structure of comets suggest that any comet could fragment at any time, so it is worth keeping an eye on some of the fainter periodic comets, which are often ignored. This would make a useful project for CCD observers. Ephemerides for new and currently observable comets are published in the *Circulars*, Comet Section Newsletters and on the Section, CBAT and Seiichi Yoshida's web pages. Complete ephemerides and magnitude parameters for all comets predicted to be brighter than about 18^m are given in the International Comet Quarterly Handbook; details of subscription to the ICQ are available from the comet section Director. The section booklet on comet observing is available from the BAA office or the Director; a new edition is in preparation.

Alphonse Borrelly discovered comet **19P/Borrelly** in 1904 from Marseilles, France, during a routine comet search with a 160mm refractor. It was put into its discovery orbit by an encounter with Jupiter in 1889, which only made minor changes, and subsequent returns slowly became more favourable. Despite having had several further moderately close approaches to Jupiter the orbit has only changed a little and the comet will next approach Jupiter in 2019. This will be its 13th observed return, with two poor ones having been missed. At its best return in 1987 it reached 7.5^m. This return is only a little worse and the brightness should peak at around 9.5^m towards the end of September, shortly after perihelion. UK observers are likely to first pick up the comet as it passes through Orion in mid August when 10^m, though more southerly observers will already have had it under observation for a couple of months. The solar elongation only slowly increases, but the comet moves north, although remaining a morning object. Slowly fading as it passes through Gemini (September), the Leos (October) and into Ursa Major (November), the comet begins to move north more rapidly and ends the year at 11^m in Canes Venatici.

Alexandre Schaumasse discovered comet **24P/Schaumasse** during a visual search with the 400mm coude equatorial at Nice, France in 1911 December as a 12^m diffuse object and it reaches a similar magnitude at average returns. The 1952 return was very favourable and the comet reached 5^m, though there may have been an outburst. The orbit is relatively stable and this will be its 10th observed return. UK observers may pick up the 13^m comet in the evening sky in February as it brightens on its way to perihelion. Moving northwards in Aries, it passes into Taurus in mid March when it should be a magnitude brighter. It is at its brightest tracking through Auriga at the end of April and early May when it should be at nearly 10^m. Passing into Gemini we will loose it low in the summer twilight by the end of the month.

29P/Schwassmann-Wachmann 1 is an annual comet which has frequent outbursts and seems to be more often active than not at the moment, though it rarely gets brighter than 12^m. It spends the year in Sagittarius reaching opposition in early July and solar conjunction in January 2002. The comet is an ideal target for those equipped with CCDs and it should be observed at every opportunity. Unfortunately opportunities for UK observers are limited, as its altitude does not exceed 13° from this country.

Horace Tuttle was the first discoverer of **41P/Tuttle-Giacobini-Kresak** in 1858, when he found a faint comet in Leo Minor. Nearly 50 years later, Professor Michael Giacobini discovered a 13^m object whilst comet hunting, which was observed for a fortnight. Andrew C D Crommelin linked the apparitions in 1928 and made predictions for future returns, but the comet wasn't recovered and it was given up as lost. In 1951, Lubor Kresak discovered a 10^m comet in 25x100 binoculars whilst participating in the Skalnate Pleso Observatory's program of routine searches for comets. After further observations the comet was identified with the lost comet and a better orbit computed. At the 1973 return, which was similar to the 1907 return, it underwent a major outburst and reached 4^m, before fading and then undergoing a second outburst. Alternate returns are unfavourable and this is one of them, but the comet has been observed at a few of them and it should be possible to observe it near perihelion in January from equatorial regions, though it will be little brighter than 12^m. If it undergoes a further outburst, more widespread observation may be possible.

45P/Honda-Mrkos-Pajdusakova makes its 10th observed return since discovery in 1948 (it was missed in 1959). It has had several close encounters with Jupiter, the most recent in 1983 which made dramatic changes to ω and Ω. The perihelion distance has steadily decreased and is now the smallest it has been for the last 200 years. It can approach quite closely to the Earth and will do so in 2011 (0.06 AU) and 2017 (0.08 AU). At present the MPC only lists eight approaches closer than 0.06 AU, and five of these are by periodic comets. It was well observed at its last return in 1995/96. The comet will be in the field of the SOHO LASCO coronagraphs in March, though it may be too faint to be seen. Observers at low northern latitudes should be able to observe it as it recedes from the sun during April and early May.

47P/Ashbrook-Jackson was discovered in 1948 following an approach to Jupiter in 1945, which reduced the perihelion distance from 3.8 to 2.3 AU. Although intrinsically relatively bright, the large perihelion distance keeps it faint. Alternate returns are favourable, but this is not one of them and the comet will be in solar conjunction after perihelion in January. The comet may be seen in early January by Southern Hemisphere observers at 13^m.

Professor Arnold Schwassmann and Artur A Wachmann of Hamburg Observatory discovered their third periodic comet on minor planet patrol plates taken on 1930 May 2. Initially of magnitude 9.5 it brightened to nearly 6^m, thanks to a very close approach to Earth (0.062 AU) on June 1. The initial orbit was a little uncertain and the comet wasn't found at the next or succeeding apparitions until 1979. The comet passed within 0.9 AU of Jupiter in 1953, and 0.25 AU in 1965. In August 1979, Michael Candy reported the discovery of a comet on a plate taken by J Johnston and M Buhagiar while searching for minor planets; this had the motion expected for **73P/Schwassmann-Wachmann 3**, but with perihelion 34 days later than in a prediction by Brian Marsden. Missed again at the next return, it has been seen at the last three returns. At the last return, in 1995, the comet underwent a major outburst near perihelion, reaching 5^m when it was only expected to be 12^m. Subsequently four components were observed, though calculations by Sekanina suggested that the fragmentation occurred after the outburst. The comet will be brightening towards the end of 2000 on its way to perihelion in late January 2001. If it maintains the level of activity seen at the last return it might be glimpsed in the morning sky around the beginning of December, although the solar elongation is not good. More likely the comet will have returned to a quiescent state and will not be observed. If an outburst does occur near perihelion, it is still unlikely to be observed as the elongation does not become favourable until May, but then the comet could be observed for the rest of the year as it slowly fades.

The comet's 1930 approach to Earth is ninth on the list of well determined cometary approaches to our planet. In May 2006 it will make another close approach (0.082 AU), when it could again reach 7^m or brighter. This small miss distance makes it a convenient spacecraft target, and the Contour mission is scheduled to intercept it, as well as comets 2P/Encke and 6P/d'Arrest and possibly a new discovery. Following its outburst in 1995, 73P/Schwassmann-Wachmann 3 is expected to show fresh cometary surfaces, whilst 2P/Encke is an old comet and 6P/d'Arrest an average one. With the orbit approaching so closely to the Earth, an associated meteor shower might be expected, and the come`t has been linked to the Tau Herculid shower, though the radiant now lies in the Bootes - Serpens region. Strong activity was reported in 1930 by a lone Japanese observer, but little has been seen since then. It is likely that any future activity would be in the form of a short-lived outburst, confined to years when the comet is at perihelion.

97P/Metcalf-Brewington. Howard J Brewington of Cloudcroft, New Mexico discovered a comet with his 0.41-m reflector on 1990 January 7. This was subsequently found to be the first observed return of P/Metcalf (1906 V2), which had been lost since 1907, though a good prediction for its return in 1975 had appeared in the Journal. A prediscovery image on January 5 showed the comet at about 15^m suggesting that it was found during an outburst. The failure to find it during its first few returns and also in 1975 and 1983 indicate that it is normally inactive. A close approach to

Jupiter in 1993 has drastically altered the orbit and q has increased to 2.6 AU, so that it is unlikely to be observable visually unless it undergoes another outburst. Perihelion occurs in April, and a substantial pre perihelion outburst could bring it within visual range, though the elongation is poor and gets worse as it closes in on perihelion. It was recovered by LINEAR in 2000 September, several degrees from its nominal position.

Several recently discovered parabolic comets will be visible during 2001. **1999 T1 (McNaught-Hartley)** is the brightest of these comets and should be fading from binocular brightness. It tracks northwards through Serpens and Hercules and then loops through Draco where it will remain visible until the autumn. **1999 T2 (LINEAR)** is unlikely to be better than 13^m at the beginning of the year and will fade. **1999 Y1 (LINEAR)** spends much of the year at around 13^m and crosses into the Southern Hemisphere in April. **2000 OF_8 (Spacewatch)** may reach 14^m around the time of its perihelion, but is a Southern Hemisphere object.

95P/Chiron is 17^m when at opposition in June on the border of Ophiuchus and Sagitarrius. CCD V magnitudes of Chiron would be of particular interest as observations show that its absolute magnitude varies erratically.

Comets reaching perihelion in 2001

Comet	T	q	P	N	H1	K1
47P/Ashbrook-Jackson	Jan 06.5	2.31	7.46	7	5.0	15.0
41P/Tuttle-Giacobini-Kresak	Jan 07.0	1.05	5.43	8	7.0	15.0
74P/Smirnova-Chernykh	Jan 15.6	3.55	8.49	4	5.0	15.0
73P/Schwassmann-Wachmann 3	Jan 27.8	0.94	5.36	4	5.5	7.0
1992 G3 (P/Mueller 4)	Feb 07.9	2.65	9.01	1	11.5	10.0
44P/Reinmuth 2	Feb 20.0	1.89	6.63	8	10.5	15.0
113P/Spitaler	Feb 25.9	2.13	7.09	2	12.5	5.0
75P/Kohoutek	Feb 27.3	1.79	6.68	3	10.5	10.0
110P/Hartley 3	Mar 21.4	2.48	6.88	2	8.0	15.0
1999 Y1 (LINEAR)	Mar 24.1	3.09			5.5	10.0
107P/Wilson-Harrington	Mar 26.6	1.00	4.30	5	15.0	5.0
45P/Honda-Mrkos-Pajdusakova	Mar 29.9	0.53	5.25	9	10.7	11.1
97P/Metcalf-Brewington	Apr 13.7	2.61	10.5	2	4.6	15.0
1993 X1 (P/Kushida-Muramatsu)	May 01.2	2.75	7.44	1	8.0	10.0
24P/Schaumasse	May 02.7	1.20	8.25	9	7.6	24.2
61P/Shajn-Schaldach	May 08.8	2.33	7.46	5	10.0	10.0
51P/Harrington	Jun 05.9	1.57	6.77	5	12.0	10.0
86P/Wild 3	Jun 18.6	2.31	6.93	3	8.5	15.0
2000 CT_{54} (LINEAR)	Jun 19.5	3.16			8.5	10.0
1994 A1 (P/Kushida)	Jun 27.8	1.43	7.58	1	11.5	2.1
16P/Brooks 2	Jul 19.8	1.83	6.86	14	8.8	15.0
2000 OF_8 (Spacewatch)	Aug 05.0	2.17			9.5	10.0
82P/Gehrels 3	Sep 03.1	3.63	8.45	3	6.0	15.0
19P/Borrelly	Sep 14.7	1.36	6.86	12	7.0	12.7
1987 Q3 (P/Helin)	Sep 26.3	2.53	14.1	1	5.0	20.0
1999 U4 (Catalina-Skiff)	Oct 28.4	4.92			4.5	10.0
133P/Elst-Pizzaro	Nov 23.7	2.64	5.61	3	12.0	10.0
11D/Tempel-Swift	Dec 12.1	1.59	6.37	4	13.0	10.0

The date of perihelion (T), perihelion distance (q), period (P), the number of previously observed returns (N) and the magnitude parameters H1 and K1 are given for each comet.

Note: $m_1 = H1 + 5.0 * \log(d) + K1 * \log(r)$

Several other comets return to perihelion during 2001, however they are unlikely to become bright enough to observe visually or are poorly placed. 16P/Brooks 2, 44P/Reinmuth 2, 82P/Gehrels 3, 107P/Wilson-Harrington, 1993 X1 (Kushida-Muramatsu) and 1994 A1 (Kushida) have unfavourable returns. 51P/Harrington, 61P/Shajn-Schaldach, 74P/Smirnova-Chernykh, 75P/Kohoutek, 86P/Wild 3, 110P/Hartley 3, 133P/Elst-Pizarro, 1987 Q3 (Helin), 1992 G3 (Mueller 4), 1999 U4 (LINEAR) and 2000 CT_{54} (LINEAR) are intrinsically faint or distant comets. Ephemerides for these can be found on the CBAT WWW pages. 11D/Tempel-Swift has not been seen since 1908 and the time of its return to perihelion is uncertain by many months.

Looking ahead, 2002 doesn't see any particularly good returns of periodic comets. Perhaps the most interesting is that of **96P/Machholz 1**. The orbit is very unusual, with the smallest perihelion distance of any short period comet (0.13 AU), which is decreasing further with time, a high eccentricity (0.96) and a high inclination (60°). Studies by Sekanina suggest it has only one active area, which is situated close to the rotation pole and becomes active close to perihelion. The comet may be the parent of the Quadrantid meteor shower. It is rarely sufficiently well placed to see visually and this return is no exception. Although it may be as bright as 6th magnitude at the end of 2001, the elongation is only 18°. At perihelion on 2002 January 8 it is only a few degrees from the Sun and may be seen in the SOHO LASCO coronagraphs from January 5 to 11. **6P/d'Arrest** is another of 2002's comets, but we should be able to recover it at the very end of 2001 as it brightens past 14th magnitude.

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Why Study Comets?

Don Yeomans, Jet Propulsion Lab

Life on Earth began at the end of a period called the late heavy bombardment, some 3.8 billion years ago. Before this time, the influx of interplanetary debris that formed the Earth was so strong that the proto-Earth was far too hot for life to have formed. Under this heavy bombardment of asteroids and comets, the early Earth's oceans vapourised and the fragile carbon-based molecules, upon which life is based, could not have survived. The earliest known fossils on Earth date from 3.5 billion years ago and there is evidence that biological activity took place even earlier - just at the end of the period of late heavy bombardment. So the window when life began was very short. As soon as life could have formed on our planet, it did. But if life formed so quickly on Earth and there was little in the way of water and carbon-based molecules on the Earth's surface, then how were these building blocks of life delivered to the Earth's surface so quickly? The answer may involve the collision of comets with the Earth, since comets contain abundant supplies of both water and carbon-based molecules.

As the primitive, leftover building blocks of the outer solar system formation process, comets offer clues to the chemical mixture from which the giant planets formed some 4.6 billion years ago. If we wish to know the composition of the primordial mixture from which the major planets formed, then we must determine the chemical constituents of the leftover debris from this formation process - the comets. Comets are composed of significant fractions of water ice, dust, and carbon-based compounds. Since their orbital paths often cross that of the Earth, cometary collisions with the Earth have occurred in the past and additional collisions are forthcoming. It is not a question of whether a comet will strike the Earth, it is a question of when the next one will hit. It now seems likely that a comet struck near the Yucatan peninsula in Mexico some 65 million years ago and caused a massive extinction of more than 75% of the Earth's living organisms, including the dinosaurs.

Comets have this strange duality whereby they first brought the building blocks of life to Earth some 3.8 billion years ago and subsequent cometary collisions may have wiped out many of the developing life forms, allowing only the most adaptable species to evolve further. Indeed, we may owe our pre-eminence at the top of Earth's food chain to cometary collisions. A catastrophic cometary collision with the Earth is only likely to happen at several million year intervals on average, so we need not be overly concerned with a threat of this type. However, it is prudent to mount efforts to discover and study these objects, to characterise their sizes, compositions and structures and to keep an eye upon their future trajectories.

As with asteroids, comets are both a potential threat and a potential resource for the colonisation of the solar system in the twenty first century. Whereas asteroids are rich in the mineral raw materials required to build structures in space, the comets are rich resources for the water and carbon-based molecules necessary to sustain life. In addition, an abundant supply of cometary water ice can provide copious quantities of liquid hydrogen and oxygen, the two primary ingredients in rocket fuel. One day soon, comets may serve as fueling stations for interplanetary spacecraft.