

The brighter comets of 2003

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A report of the Comet Section (Director: J. D. Shanklin)

This report is the first of a new series that will describe and analyse observations of the brighter or more interesting comets discovered or at perihelion during the year. Outline details of other comets seen during 2003 may be found on the Section web page.

Introduction

With increasing numbers of comets being discovered each year, the *Journal* reports on the comets of each year have steadily become longer and less interesting to the average BAA member. I have therefore made the decision to confine analysis to those comets where visual observations were submitted to the Section, or which have some general interest; where available, electronic photometric observations are used to supplement the visual ones. Orbital elements for all comets can be found on the JPL Small-Body Database Browser,¹ which will also generate ephemerides. Discovery details and some information for the other comets found or returning during the year are available on the Section web pages.²

During 2003 46 comets were assigned year designations and 14 previously numbered periodic comets returned to perihelion. 149 comets were discovered from the SOHO satellite; of these 131 were members of the Kreutz group, one a possible member of the group, seven were members of the Meyer group, two of the Marsden group, one of the Kracht group and seven were not associated with any known group. There was one amateur discovery, that of 2003 T3 by Vello Tabur, for which he gained the Edgar Wilson Award. Four periodic comets were numbered.

The comets with discovery letter designations

2003 A1 (226P/Pigott–LINEAR–Kowalski) = D/1783 W1 = 2009 R2

LINEAR discovered a 19th magnitude comet on 2003 Jan 5.07. This was LINEAR's 100th comet [IAUC 8044, 2003 Jan 8]. Although parabolic orbital elements were published, Brian Marsden noted on *MPEC* 2003-A56 [2003 Jan 8] that the object was probably of short period, and that its orbit was rather similar to that of comet D/1783 W1 (Pigott). Further observations, published on *MPEC* 2003-A86 [2003 Jan 15] confirmed the short period nature of the orbit, with perihelion at 1.91au, a high inclination of 46° and a period of 7.1 years.

The comet initially remained unnamed, but it was finally confirmed as P/LINEAR by the IAU Committee on Small Bodies Nomenclature in 2004 November. At this point there was still uncertainty over the link with D/1783 W1. On 2006 Sept 10.3 it passed 0.056au from Jupiter.

Rich Kowalski discovered a very diffuse comet during the Catalina Sky Survey with the 0.68m Schmidt on 2009 Sept 10.4, which was confirmed by several observers including Peter Birtwhistle, follow-

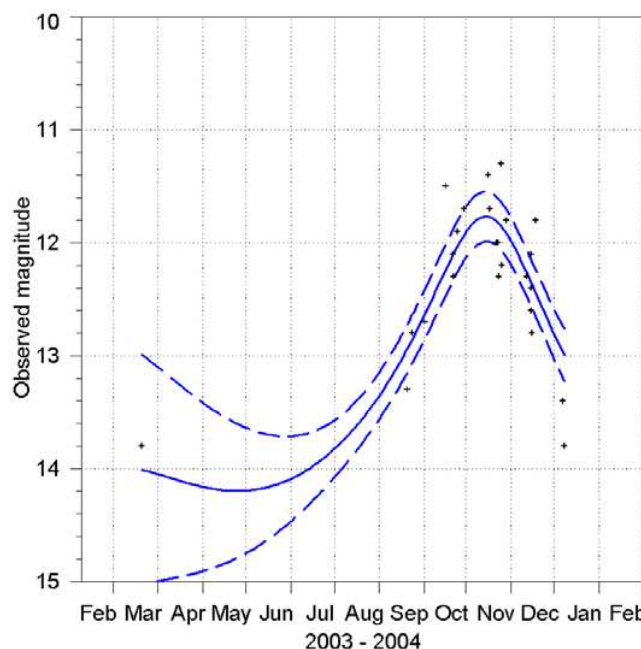


Figure 1. The lightcurve of 2003 H1 (LINEAR).

ing posting on the NEO Confirmation Page (NEOCP) as 9R1E5E6. Dmitry Chestnov linked the object to comet 2003 A1, although the linked orbit had considerably different orbital elements (notably T and q) to those predicted for 2003 A1. Brian Marsden noted on *IAUC* 9072: 'it is meaningless to indicate a Delta(T) value because the prediction is strongly influenced by a very close approach to Jupiter.' He then computed a linked orbit that satisfactorily included observations of D/1783 W1 also, and the comet was given its present name of 226P/Pigott–LINEAR–Kowalski. The discovery apparition was better than most of the following 34.

Following publication of the new orbit, Maik Meyer was able to locate images of the comet in Siding Spring data taken on 1995 Oct 29, though the residuals are quite large. The comet will make another approach to Jupiter in 2101 (to 0.24au), which will increase the perihelion distance to 2.1au.

Two observations by Tony Scarmato in mid-January 2003 suggested that the comet was around magnitude 12.5.

2003 H1 (LINEAR)

LINEAR discovered a comet on 2003 April 24.38. It reached perihelion at 2.2au in late 2004 February. Although Martin Lehky ob-

served it at mag 13.8 in 2003 July, most observers didn't start observing it until 2004 January. I was able to glimpse it under transparent Antarctic skies at Rothera station on 2004 March 16.31 estimating it at about 11.4, with a 1.3' DC2 coma in my 90-mm f5.6 refractor $\times 40$. The wind had been 15–20 knots, but dropped to 5 knots at the time of the observation, with an air temperature of -2°C . A quarter Moon only slightly brightened the sky. Under very clear skies, just outside Stanley, Falkland Islands, I made another observation, recording the comet at 11.3 with a 2.4' diameter coma in the 90-mm refractor on March 25.14. The main difficulty of observing was wind, but conditions were OK in the lee of some rocks.

2003 H4 (218P/LINEAR)

LINEAR discovered a comet on 2003 April 29.33 when it was near perihelion at 1.70au. Orbital elements from the JPL Small-Body Database Browser indicate that the comet passed 0.045au from Jupiter on 1929 May 31, before which q and P were larger. The comet approached within 0.56au of Jupiter in 2000 October and to 0.078au in 2012 April, in an encounter that reduced the perihelion distance to 1.17au. The comet will pass 0.46au from Earth in 2015 April. It can also pass close to Mars, passing the red planet at 0.099au in 2031 and 0.085au in 2036.

2003 K2 (210P/Christensen) = 2008 X4

Eric Christensen, Lunar and Planetary Laboratory, reported the discovery of a 15th magnitude comet on 2003 May 26.18 by the Catalina Sky Survey on CCD images taken with the 0.7-m Schmidt

telescope. Following posting on the NEOCP, many observers noted the obvious cometary nature of the object on CCD images taken during May 27.1–27.2, including R. Elliot (Fall Creek, WI; coma diameter about 10"), P. R. Holvorcem & M. Schwartz (near Nogales, AZ; coma diameter about 35", with a 30" tail in p.a. 106°), J. Young (Table Mountain, CA; 10" coma and a very faint 40" tail in p.a. 115° with a slight curve halfway along its length to p.a. 130°), and J. McGaha (Tucson, AZ; coma diameter 12", with slight nuclear condensation and a 6" tail) [IAUC 8136, 2003 May 27].

It was noted by numerous individuals that the preliminary orbital elements of comet 2003 K2 (*cf.* IAUC 8136) placed it close to the position of an unconfirmed object found on SWAN UV SOHO website images and reported to the Central Bureau on April 14 by X.-m. Zhou (Bo-le, Xin-jiang, China). Measurements of the object on six dates, April 5–19, were forwarded to the Central Bureau by Zhou (via D. H. Chen), by M. Mattiazzo, and by S. Hoenig; the positions differed considerably, due to the poor resolution of SWAN (uncertainty on the order of 1°). Two search ephemerides based on various positions were circulated by the Bureau to numerous visual and CCD observers in the hope of optical confirmation, but the searches (undertaken during the last week of April by Zhou, A. Hale, Mattiazzo, Y. Kushida, and Y. Ezaki) revealed nothing to as faint as magnitude 14.5 [IAUC 8138, 2003 May 30].

The comet had passed perihelion at 0.55au in April, but was intrinsically faint. At its brightest it probably reached 10th magnitude; however its elongation remained relatively small and it was not favourably placed for observation. The Earth Minimum Orbit Intersection Distance (MOID) is currently 0.17au, but it can pass closer to Venus and in 2014 Sept passed at 0.092au, with a slightly closer pass in 2076. The perihelion distance reaches a minimum of 0.52au in 2037, but will have increased to 0.7au in the early years of the next century, thanks to gentle encounters with Jupiter that make otherwise relatively minor changes to the orbit.

Alan Watson found a 10th magnitude comet on SECCHI HI1-B images taken on 2008 Dec 8.24. Rainer Kracht made measurements of the object's position and computed a parabolic orbit, from which

Table 1. Photometric observers in 2003

James Abbott, Witham, Essex	Jose Carvajal Martinez, Spain
Alexandre Amorim, Brazil	Michael Mattiazzo, Australia
Alexander Baransky, Ukraine	Maik Meyer, Germany
Mike Begbie, Zimbabwe	Giannantonio Milani, Italy
Nicolas Biver, Hawaii	Fabrizio Montanucci, Italy
Reinder Bouma, The Netherlands	Akimasa Nakamura, Japan
Tim Cooper, South Africa	Ramon Naves, Spain
Matyas Csukas, Romania	Gabriel Oksa, Slovak Republic
Jose Guilherme de Souza Aguiar, Brazil	Takaaki Oribe, Japan
Alfons Diepvens, Belgium	Roy Panther, Walgrave, Northants.
Len Entwisle, Elland, W. Yorks.	Andrew Pearce, Australia
Yuusuke Ezaki, Japan	Jacek Powichrowski, Poland
Antonio Giambersio, Italy	David Pringlewood, Zimbabwe
Juan José González Suárez, Spain	Stuart Rae, New Zealand
Bjoern Haakon Granslo, Norway	Maciej Reszelski, Poland
Piotr Guzík, Poland	Walter Robledo, Argentina
Stephen Getliffe, Haverhill, Suffolk	Juan M San Juan, Spain
Massimo Giuntoli, Italy	Krisztian Sarneczky, Hungary
Virgilio & Mario Gonano, Italy	Toni Scarmato, Italy
Werner Hasubick, Germany	Jonathan Shanklin, Cambridge to Antarctica
Roberto Haver, Italy	Marcin Siekierko, Poland
Carl Hergenrother, USA	SOHO Satellite
Kamil Hornoch, Czechoslovakia	Giovanni Sostero, Italy
Guy Hurst, Basingstoke, Hants.	William C. de Souza, Brazil
Albert Jones, New Zealand	David Storey, Isle of Man
Kenichi Kadota, Japan	Andras Sajtz, Romania
Andreas Kammerer, Germany	Toni Scarmato, Italy
Valeriy L. Korneyev, Russia	Zoltan Toth, Hungary
Attila Kosa-Kiss, Romania	Mitsunori Tsumura, Japan
Manos Kardasis, Greece	Cliff Turk, South Africa
Heinz Kerner, Germany	Koos van Zyl, South Africa
Carlos Labordena, Spain	Alex Vincent, Worthing, Sussex
Martin Lehky, Czech Republic	Seiichi Yoshida, Japan
Rolando Ligustri, Italy	

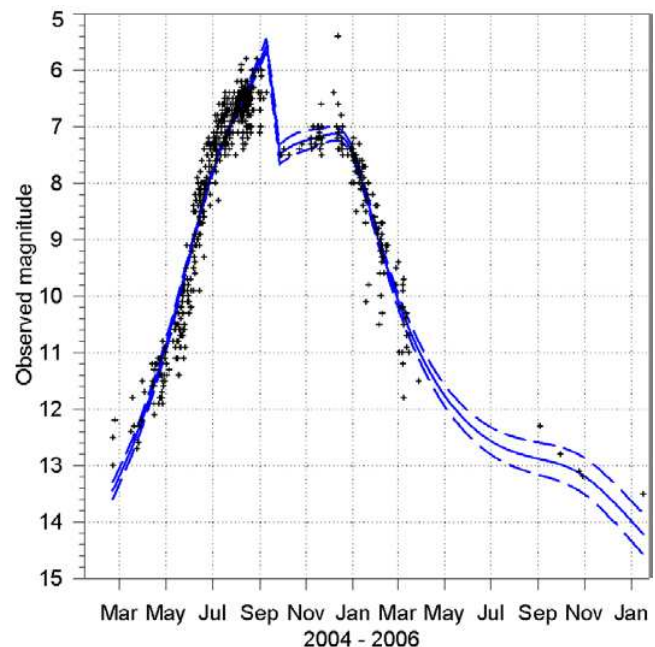


Figure 2. The lightcurve of 2003 K4 (LINEAR).

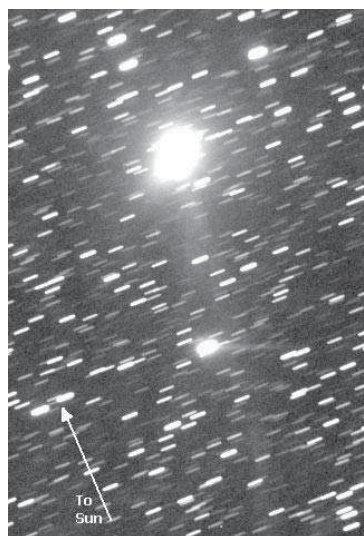


Figure 3. 2003 K4 (LINEAR) imaged by Peter Birtwhistle on 2004 June 8.

Maik Meyer suggested identity with comet 2003 K2. Rob Matson reported that the comet was visible in SWAN imagery from Dec 4, but was moving slowly in a location close to the occulting region. The comet passed through the SOHO LASCO C3 field between Dec 20 and 26, but at 9th magnitude would probably not have been detectable. However Piotr Guzik pointed out that the geometry was strongly forward scattering and the magnitude could be enhanced by 5–6 magnitudes around Dec 23. Joe Marcus also suggested that the forward scattering could be sufficiently strong to enhance the brightness by as much as 6.5 mag, making it a prominent object in the SOHO fields.

On December 21.8 it was easily visible in the C3 field at about 8.2, along with two Kreutz comets. A few visual observations were made in 2009, with the comet fading from 10th magnitude in early January to 14th magnitude in late March.

2003 K4 (LINEAR)

An apparently asteroidal object of 18th magnitude, found by LINEAR on May 28.38, was noted to be cometary by other observers.

Professional observers noted a silicate feature in the spectrum, with the underlying continuum on 2004 June 20 representing a blackbody temperature of about 235 ± 10 K, a bit higher than equilibrium. Observations in late July suggested that large amorphous carbon and silicate grains (radius approximately $>0.7 \mu$) dominated the coma. On Aug 5 a weak feature due to crystalline olivine may have been present at 11.2μ .



Figure 4. 2003 K4 (LINEAR) imaged by Rolando Ligustri on 2004 July 3.

By early 2003 August the comet had brightened to 16th magnitude (CCD). The first visual observations were made in 2004 February. Initially it only brightened slowly and reached 10th magnitude at the end of May. During June it brightened quite rapidly to 8th mag mid-month and was approaching mag 7 by the end of the month. Tail development began in 2004 June and was present

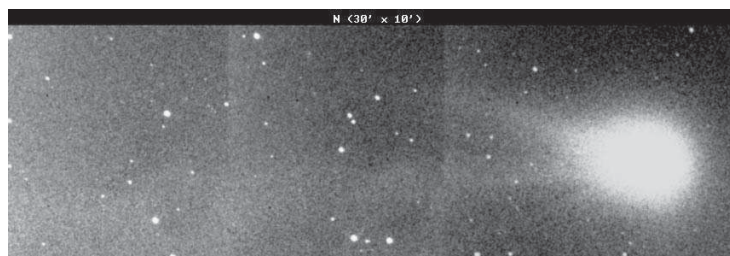


Figure 5. 2003 K4 (LINEAR) imaged by Martin Mobberley on 2004 Aug 7.

until 2005 January. At best the tail was just over 1° long. On July 15 Juan José González observing from Leon in Spain reported glimpsing the comet with the naked eye. During the rest of July and up to mid-August there was little change in brightness, with the comet remaining at around mag 6.5. As it got lower in northern skies it became harder to observe, however Jonathan Shanklin managed to make a final observation of it on Sept 1.9, estimating it at around 6.5.

It passed through the SOHO LASCO fields as a mag 7 object from 2004 Sept 27 to 2004 Oct 13, rather fainter than expected. Alexandre Amorim recovered it at 7.3 in 20×80B on Oct 26.11. Andrew Pearce reported detecting an anti-tail on Nov 13.80, when the comet was 7.2 in 20×80B. The orbital plane crossing was on 2004 Oct 11.7 according to calculations by Akimasa Nakamura. It remained a largely southern hemisphere object until late 2005 February, by which time it was around 10th magnitude. The final observation was made by Werner Hasubick in mid-January 2006, when he estimated it at 13.5 in his 0.44m reflector.

The fitted lightcurve suggests that the comet faded by about two magnitudes some time between mid- and late September 2004. During this period the comet crossed the ecliptic plane (around 2004 Sept 27), though the timing may just be a coincidence. Thereafter it followed a different lightcurve, with a much lower K parameter. A possible explanation for the behaviour is that activity on the nucleus became choked off, giving a rapid reduction in the emission of volatiles which continued at a reduced rate for the rest of the apparition. Figure 2 shows the composite lightcurve.

2003 KV2 (197P/LINEAR)

An asteroidal object of 18th magnitude discovered by LINEAR on 2003 May 23.16 was found to be cometary by other observers. It reached perihelion on July 10 at 1.06au and has a period of 4.85 years, the eleventh shortest amongst currently extant comets. It passed 0.54au from Jupiter on 2001 Jan 14, before which the perihelion distance was somewhat larger. The Earth Minimum Orbit Intersection Distance (MOID) is 0.052au, though the closest it has come so far is 0.28au in 2008 May.

2003 S4 (LINEAR)

An 18th magnitude comet was discovered by LINEAR on 2003 Sept 26.17. It was a distant object that reached perihelion at 3.9au in late May 2004. The orbit is significantly elliptical, with an eccentricity of 0.9 and a period of around 250 years. The comet split into two components, and then faded rapidly, possibly as a consequence of the break-up, with the last astrometric observations being made on Oct 17.

Z. Sekanina, Jet Propulsion Laboratory, noted: ‘Application of my comet fragmentation model (Sekanina 1982, in *Comets*, Univ. of Arizona Press, p.251) to this comet’s observed duplicity (MPECs 2004-T44 and 2004-U10) shows that component B is the principal nucleus. This result is supported by the location of component A between components B and C, a suspected third fragment, on an image taken by R. Ferrando on 2004 Oct 9 (see <http://www.aerith.net/comet/catalog/2003S4/pictures.html>).

‘The astrometric observations made in September–October 2004 allow one to determine four of the model’s five parameters for component A. The radial component of its separation velocity from B is

Table 2. BAA & TA astrometric, CCD and photographic observers in 2003

Observer	Site	IAU Station No
Ron Arbour	South Wonston, Hants.	979
Paolo Beltrame	Italy	235
Peter Birtwhistle	Great Shefford	J95
David Boyd	Wantage, Oxon	J90
Denis Buczynski	Conder Brow, Lancs.	978
Montse Campas	Spain	213
Nick James	Chelmsford, Essex	970
John Fletcher	Mount Tuffley, Glos.	J93
Martin Lehky	Czech Republic	048
Rolando Ligustri	Italy	235
Pepe Manteca	Spain	170
Martin Mobberley	Cockfield, Suffolk	480
Ramon Naves	Spain	213
Bob Neville	Greens Norton, Northants.	967
Jaime Nomen	Mallorca	620
Salvador Sanchez	Mallorca	620
Toni Scarmato	Italy	
Jeremy Shears	Cheshire	
Giovanni Sostero	Italy	473
Reiner Stoss	Mallorca	620
David Strange	Worth Matravers, Devon	
Alex Vincent	Worthing, Sussex	

indeterminate. Solutions with this velocity component assumed to point away from the Sun provide marginally better data matches. When it is limited to a range from 0 to 2 m/s, the time of splitting comes out to be between 2004 May 23 and June 17 (3 days before to 22 days after perihelion) at 3.86au from the Sun, with the differential non-gravitational deceleration decreasing from 140 to 90 units of 10^{-5} solar attraction and with the transverse and normal components of the separation velocity near 0.8 m/s in the direction opposite the orbital motion and 0.2 m/s pointing below the orbital plane, respectively. The high deceleration of the companion (nucleus A) indicates that it is a short-lived fragment with an estimated lifetime of 12–33 equivalent days.’ [IAUC 8434, 2004 Nov 10].

2003 T1 (157P/Tritton) = D/1978 C2

D/1978 C2 was recovered in outburst at around 12th magnitude on Oct 6.44 from Fountain Hills, Arizona, with a 0.12-m f/5 refractor and a 0.5-m f/4.8 reflector. Paulo Holvorcem reported that Charles Juels had found a fast-moving cometary object and this was confirmed by other observers. Following suggestions from Sebastian Hoenig, based on computations by Maik Meyer, Brian Marsden was able to confirm the identity with comet D/1978 C2 (Tritton) that had been observed for a month in 1978. The linkage shows that the period estimated from the 1978 apparition was incorrect. The original prediction was for a return in early March, based on a period of 6.32 years, however the actual perihelion was on Sept 24 and the period is 6.45 years. The unexpected brightness suggested that the object was in outburst and it faded by about a magnitude over the following month.

Encounters with Jupiter in 1937 and 1948 made significant changes to the angular orbital elements and another in 2020 will push out the perihelion distance from 1.36au to 1.57au.

Keith Tritton provides the following information about the original discovery:

‘I’m amazed (and delighted) it’s been recovered. It’s quite a story – it was very faint on discovery in 1978 (I think it may even have been the faintest comet ever discovered at that time), when I

was working on the Southern UK Schmidt Sky Survey. The comet was observed over only a very short arc. The first return was very unfavourable, so it couldn’t be seen, and the orbital inaccuracy was so large that the predictions for the second return had huge uncertainties. Nevertheless I got some plates taken at the Schmidt (this was about 1990) and sent to me in Cambridge for searching, but I never got them, they were lost in transit from Australia! So I never expected to hear anything more about it. It must be rather rare to pick up a lost comet on its fourth return, mustn’t it?’

2003 T2 (LINEAR)

LINEAR discovered an 18th magnitude object on Oct 13.44 which was found to be cometary by other observers and possibly as bright as mag 15. It reached perihelion at 1.79au in mid-November. A single visual observation by Reinder Bouma around this time put it at 13.6.

2003 T3 (Tabur)

Vello Tabur, Australian Capital Territory, discovered a somewhat condensed comet of 12th magnitude with a 30" coma on unfiltered CCD images taken with a 140-mm f/2.8 camera lens on Oct 14.48. Terry Lovejoy (Thornlands, Queensland, 0.16-m reflector) reported that a CCD exposure taken on Oct 15.5 showed a 0'.7 coma of total magnitude 11.6 and a fan-shaped tail about 1' long in p.a. 90° [IAUC 8223, 2003 Oct 15]. This circular also announced the recovery of the only named but un-numbered and lost minor planet, Hermes, after 31 revolutions.

The comet was in Pavo at discovery, and roughly at quadrature in the evening sky. It was at 3.0au from the Sun and still just over six months from perihelion.

Southern hemisphere observations in October and November all put the comet at around 12th magnitude. It was at a poor elongation for observation after December. The comet passed through the SOHO C3 coronagraph field between 2004 Feb 20 and 2004

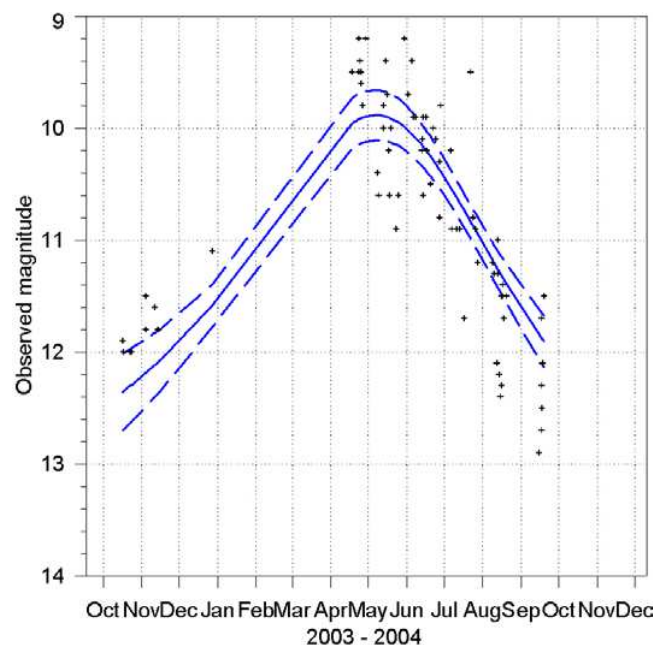


Figure 6. The lightcurve of 2003 T3 (Tabur).

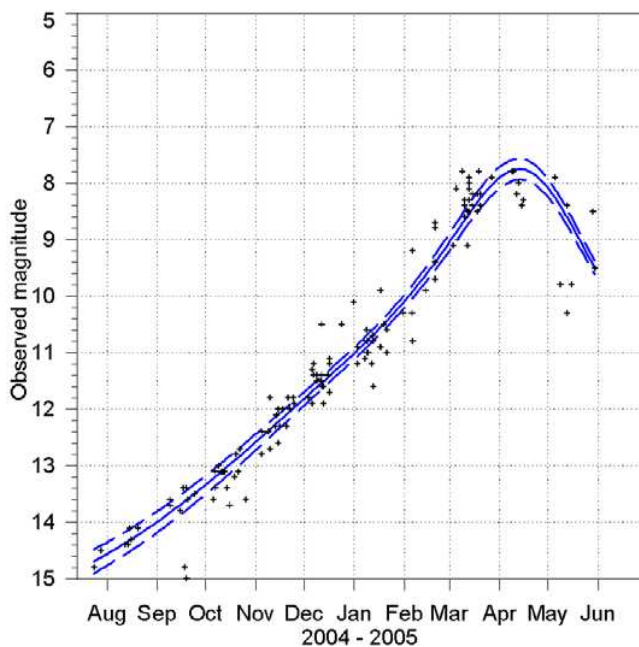


Figure 7. The lightcurve of 2003 T4 (LINEAR).

Mar 25, though there were no conclusive observations reported. It emerged from solar conjunction as a 9th magnitude object in late April, however it was low in the summer twilight and not easy to observe. Jonathan Shanklin glimpsed it in mid-June, estimating it at around 10th magnitude. Observers in mid September estimated it at around 11.5.

2003 T4 (LINEAR)

An apparently asteroidal object reported by LINEAR on Oct 13.45, and posted on the NEOCP, was found to show cometary appearance by several CCD astrometric observers, including J. E. McGaha (Tucson, AZ, 0.62-m reflector; Oct 14.4, coma diameter 6" with a fan-shaped tail 12" long in p.a. 75°), P. R. Holvorcem & M. Schwartz (Tenagra 0.81-m reflector at Nogales, AZ; Oct 14.4 and 15.4, co-addition of three 180-s exposures on each night, show a coma of diameter about 5" and total magnitude 17.7–18.3), G. R. Jones (Tucson, AZ, 0.32-m reflector; Oct 15.4, coma diameter 2", slightly elongated toward p.a. 40°), and J. Young (Table Mountain, CA, 0.6-m reflector; Oct 15.5, 6" diffuse coma surrounding a very small central core). [IAUC 8224, 2003 Oct 15].

Brian Marsden noted on MPEC 2005-G28 [2005 April 5] that the orbit was problematic. He commented: 'For the past several weeks it has been evident that the 'usual' procedure for handling orbital non-gravitational effects is not working for this comet, if the desire is to obtain a consistent representation of the observa-

tions and some degree of future predictability. A fit to the observations since 2004 October, when water-ice vaporization could be expected to become significant, seems quite satisfactory but still gives the unusually large value of $A1 = +12$; on the other hand, as is rather to be expected, the observations during the previous twelve months are fully compatible with

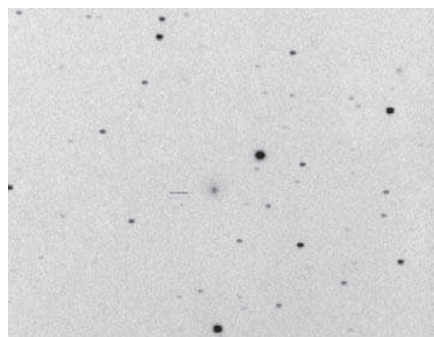


Figure 8. 2003 T4 (LINEAR) imaged by Jeremy Shears on 2004 Oct 4.

gravitational motion. An orbit was computed by S. Nakano using a formulation by S. Yabushita (1996, MNRAS 283, 347) that presumed more non-gravitational activity at greater heliocentric distances and is based on carbon-monoxide vaporization.'

Jonathan Shanklin tentatively estimated it at 13.4 on 2004 Sept 18.93 in his 0.33-m Dobsonian reflector. By November it was becoming easier to see, and had brightened to 12.5. Seiichi Yoshida noted that images taken by Giovanni Sostero on Nov 21 showed a dust trail 3.5' long. It is very unusual for non periodic comets to show a trail. Giovanni Sostero also noted that the comet appeared very red. It was not observed as much as might have been expected from November to February, possibly because it was most easily seen from higher northern latitudes in the sky below the pole, and was a morning object from mid-January until it was lost in the dawn in mid March. James Abbott observed it on Dec 16, estimating it at 11.7 in his 0.3-m reflector. After several attempts at observation that were thwarted by cloud, Shanklin observed it again on Feb 20.2 estimating it at 9.7 in the Northumberland 0.32m refractor $\times 105$ and 9.4 in 20 $\times$ 80B. It was another month before he saw it again, and it had brightened to 8.7 in 25 $\times$ 100B on March 12. It was a southern hemisphere object after mid-March, but relatively few observations were received. It was about 8th magnitude when brightest near perihelion in early April and had faded to around mag 9 when the last observations were made in late May. At best near perihelion it showed an ion tail of over 30' with a dust tail of 15' as seen by Michael Mattiazzo in his 0.3-m reflector.

2003 WT42 (LINEAR)

LINEAR discovered an unusual asteroid, of 18th magnitude, on 2003 Nov 19.26. The orbit is hyperbolic, with perihelion a distant one at 5.19au in mid-April 2006. Observations in mid-Jan 2004 demonstrated the presence of a coma, confirming the object as a comet. CCD and visual photometric observations cover the period from 2004 Sept to 2006 June, with the comet brightest at 13th magnitude around the time of perihelion.

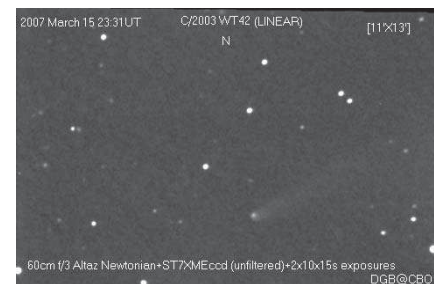


Figure 9. 2003 WT₄₂ (LINEAR) imaged by Denis Buczynski on 2007 Mar 15.

2003 YM₁₅₉ (P/LINEAR–Hill) = 2004 V5

The Catalina Sky Survey reported the observation of two cometary objects on frames taken with the 0.68-m Schmidt telescope on 2004 Nov 10.5 by BAA member Rik Hill. These were linked to an asteroidal object detected by LINEAR in October, and then to an asteroid found by LINEAR in 2003 Dec. The brighter of the two cometary objects links to the asteroid and is the primary component. The orbit is elliptical with a period of 22.4 years and perihelion at 4.4au in 2005 February. Peter Birtwistle gives further information on the discovery on his web page.³

While the initial report inferred that the discovery of comet 2003 YM₁₅₉ at Catalina was a team discovery (thus the name 'LINEAR–Catalina' given on IAUC 8433), it has since been determined that observer Rik Hill was alone in discovering, measuring, and reporting the comet, thereby allowing his name to be used in place

of the survey name (as also approved by the Catalina team). Consultation with the IAU Committee on Small-Body Nomenclature has yielded the decision to introduce for this comet the new principal designation 2004 V5 and to replace the name 'LINEAR-Catalina' with 'LINEAR-Hill'. The components A and B are defined as before, with component B having $\Delta(T) = +0.23$ day. [IAUC 8438, 2004 November 15].

Z. Sekanina, Jet Propulsion Laboratory, noted that his comet fragmentation model shows that the two nuclei of 2004 V5 broke apart around 2001.9 ± 0.3 year, at a heliocentric distance of about 6.3au and 2.5 years before perihelion. The separation velocity of the companion (fragment B) relative to the primary (A) pointed below the orbital plane and was at least 2.6 m/s. The motion of B has since been subjected to a differential deceleration of 40 ± 6 units of 10^{-5} the solar attraction. [IAUC 8440, 2004 Nov 18].

The numbered periodic comets at perihelion in 2003

2P/Encke

The comet with the shortest known period came to perihelion for its 59th observed return 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 was well seen from the northern hemisphere prior to perihelion in late December.

The comet was picked up visually in October, however it was initially very diffuse and significantly fainter than expected. In the Northumberland 0.30-m refractor $\times 230$ Jonathan Shanklin estimated it 12.9 on October 24.89 with a 0.8', DC1 coma. It was half a magnitude brighter a couple of nights later. Following reports on the comet mailing list that it was significantly brighter in binoculars, he visited a dark sky site on Oct 27.94 and found it at 9.9 in $20 \times 80B$ with a 4.5' DC3 coma. It was a very easy object in $25 \times 100B$. On Nov 16.81 he estimated it at 7.7 in $20 \times 80B$, with a 10' diameter DC2 coma. On Nov

26.73 it was 6.8 in $10 \times 50B$ with a 13' DC3 coma.

Many observers commented on the pronounced fan of material coming from a stellar nucleus. Most observers lost it in early December, but Juan José González Suárez was able to view it from a mountain location on Dec 24.28, estimating it as a stellar object of approx mag 4.7 in $25 \times 100B$. In the southern hemisphere a final observation was made by Alexander Amorim in early January, when he estimated the comet at 7.5 in $20 \times 80B$.

Professional astronomers detected HCN and water from the comet in November.

There is a suggestion that 2P/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 observations made at this apparition are not sufficient to add further evidence to this hypothesis. The observations do however confirm that there has been no secular fading of the comet. The comet is the progenitor of the Taurid meteor complex and may be associated with several Apollo asteroids.

53P/van Biesbroeck

George van Biesbroeck discovered this comet at Yerkes observatory in 1954 September. Stan Milbourn & George Lea calculated the best recovery orbit and the comet was duly recovered in 1965 May. Back calculating the orbit showed that it made a close approach to Jupiter in 1850 (0.086au), which reduced q from 2.7 to 2.4au and reversed the nodes. Another encounter in 2039 will further reduce the perihelion distance to 1.92au. The pre-1850 orbit is very similar to that of 42P/Neujmin and it is likely that they are fragments of the same parent. The comet had a relatively favourable return and just reached 13th magnitude, however it lay south of the equator and was best seen from the southern hemisphere.

65P/Gunn

65P/Gunn was discovered in 1970 after a perturbation by Jupiter in 1965 had reduced the perihelion distance from 3.29 to 2.44au. In 1980 two pre-discovery images were found on Palomar plates taken in 1954. The comet can be followed all round the orbit as it has a relatively low eccentricity of 0.32. An encounter with Jupiter in 2012 December made minor

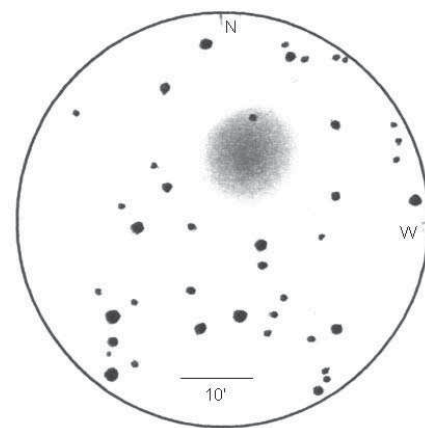


Figure 11. 2P/Encke drawn by Gabriel Oksa on 2003 Nov 12.

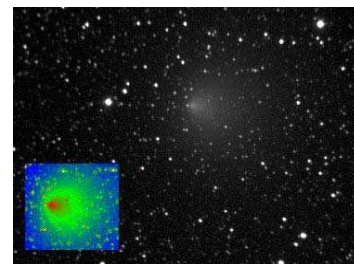


Figure 12. 2P/Encke imaged by David Strange on 2003 Nov 27

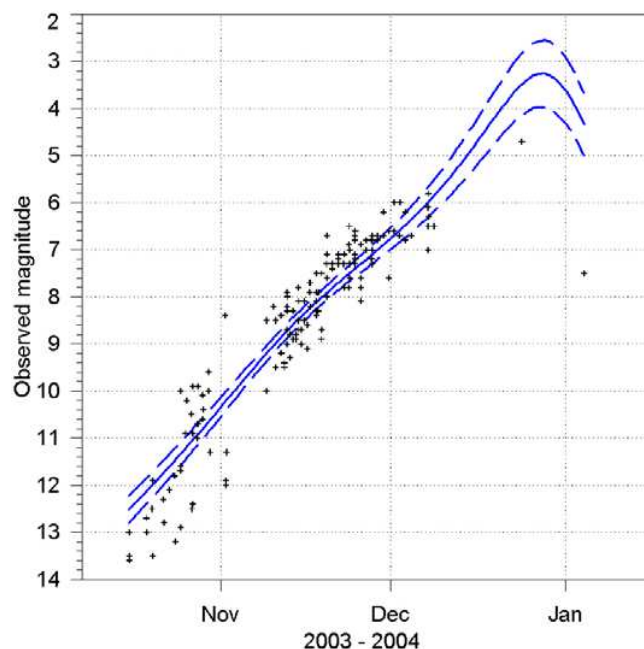


Figure 10. The lightcurve of 2P/Encke.

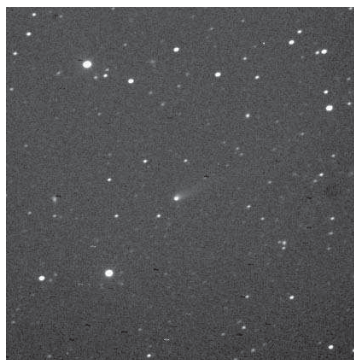


Figure 13. 65P/Gunn imaged by Paolo Beltrame on 2002 Feb 16

Table 3. Magnitude parameters of the comets of 2003

a. Standard magnitude parameters

Comet	No. obs.	r (au)	H1	K1	H10	H15	Notes
G1 (LINEAR)	3 c	6.6			4.4±0.2	0.3±0.2	
H1 (LINEAR)	26	2.2–3.3			6.7±0.1	4.8±0.1	
K4 (LINEAR)	719	1.0–5.7	4.1±0.1	9.0±0.2	3.9±0.0	2.6±0.0	
K4 (LINEAR)	555	1.2–3.5	3.3±0.0	11.5±0.2	3.7±0.0	2.4±0.0	[pre ecliptic]
K4 (LINEAR)	164	1.0–5.7	5.7±0.1	4.9±0.3	4.5±0.1	3.2±0.1	[post ecliptic]
T2 (LINEAR)	1	1.8			10.1	8.9	
T3 (Tabur)	78	1.5–2.9	6.1±0.2	6.7±0.5	5.2±0.1	3.8±0.1	
T4 (LINEAR)	118	0.9–3.7	7.4±0.1	5.1±0.2	6.3±0.1	5.1±0.2	
WT42 (LINEAR)	14	5.2–5.3			1.4±0.1	–2.2±0.1	
2P/Encke	151	0.4–1.5	10.7±0.0	13.9±0.4	10.7±0.1	10.7±0.0	
53P/Van Biesbroeck	15	2.5–2.7			7.2±0.2	5.2±0.2	
65P/Gunn	50	2.4–3.4	9.4±0.5	2.3±1.0	6.0±0.1	3.7±0.1	
66P/du Toit	9	1.3–1.4			10.1±0.1	9.4±0.1	
81P/Wild	10 c	2.3–3.4			7.5±0.3	5.3±0.2	
116P/Wild	52	2.2–2.5	8.6±2.2	4.8±6.0	6.7±0.1	4.9±0.1	
118P/Shoemaker–Levy	1	2.7			7.7	5.5	
123P/West–Hartley	7	2.2–2.4			8.2±0.1	6.4±0.1	
157P/Tritton	6	1.4–1.5			8.9±0.3	8.1±0.2	
226P/Pigott–LINEAR–Kowalski	2	1.9			7.7±0.1	6.3±0.1	

b. Linear magnitude parameters

Comet	No. obs.	Days	H1	K1	ΔT
65P/Gunn	50	–427–154	9.5±0.5	0.0044±0.0022	135±18

The magnitude of the comets can be calculated from the standard equation: $m = H_1 + 5.0 \log(\Delta) + K_1 \log(r)$. For many comets there are insufficient visual observations to calculate K_1 accurately and so a value of 10 or 15 is assumed, which gives the constant H_{10} or H_{15} respectively. Some comets do not follow the standard equation and are better fitted with a linear equation: $m = H_1 + 5.0 \log(\Delta) + K_1 \log(t - T + \Delta t)$, where t is the Julian date, T the JD of perihelion and Δt an offset. If Δt is positive the comet is intrinsically brighter prior to perihelion.

CCD observations have been used to determine the magnitude parameters of comets with insufficient visual observations; these are indicated by c after the number of observations. A correction for aperture of 0.0033 mm^{-1} and the observer corrections derived in previous papers^{5,6} have been applied and the H values are reduced to zero aperture.

66P/du Toit

Daniel du Toit discovered a comet at the Boyden Observatory in South Africa on 1944 May 16. The discovery return was a good one, with the comet approaching to within 0.5au of the Earth, and the comet reached 10th magnitude. It was not found at the 1959 return, nor was it initially found in 1974, however in 1975 January a further inspection of search plates taken ten months previously revealed a diffuse image of the comet. It has only been observed at alternate returns and its last return in 1988 was about the worst possible. This return, the third observed, was moderately favourable, however, as at the discovery return, it was essentially a southern hemisphere object. Michael Mattiazzo was the only observer and estimated it around 12th magnitude in July and August.

81P/Wild

The comet made a very close (0.006au) approach to Jupiter in 1974, which reduced the perihelion distance to 1.5au. Prior to this it was in a 40 year orbit that had perihelion at 4.95au and aphelion at 25au. The comet was discovered by Paul Wild with the 40/60-cm Schmidt at Zimmerwald on 1978 Jan 6. After perihelion it passed 0.072au from Mars. An encounter with Jupiter in 2058 will increase the perihelion distance to 1.75au.

The *Stardust* spacecraft visited the comet in 2004 taking images that showed features up to 2km across on the roughly 5.5×3.3 km nucleus. At least 10 of the features showed activity and captured material was returned to Earth in 2006. This showed the presence of organic compounds and silicates, and also evidence for iron and copper sulphide minerals that must have formed in the presence of liquid water. Taken together this assemblage indicates considerable mixing of material over a range of solar distances in the early solar system. Analysis also showed that the surface of the comet had experienced space weathering.

Only a few observations were made at the return in 1991, when the comet reached mag 13. It had reached a similar magnitude by 2003 March, but from then on its solar elongation was too small for observation.

116P/Wild

Paul Wild discovered his third comet on 1990 Jan 21.98, again with the 0.40-m Schmidt at the Zimmerwald station of the Berne Astronomical Institute. The comet was at a photographic magnitude of 13.5 at discovery. The comet was perturbed into its present orbit after a close approach to Jupiter in 1987 July. At its brightest the comet only reached mag 12, but it was surprisingly well observed.

changes to the angular elements, reduced the eccentricity further to 0.25 and increased the perihelion distance to 2.91au. At the 1996 return it reached 13th magnitude. This time it was at opposition around a month after perihelion and at its brightest then, with observers estimating it at mag 11 in early July. It was at moderate southern declination throughout the apparition and so was best seen from the southern hemisphere. Neither of the two forms of lightcurve is a particularly good fit to the data, and both look similar; the standard form is given here.

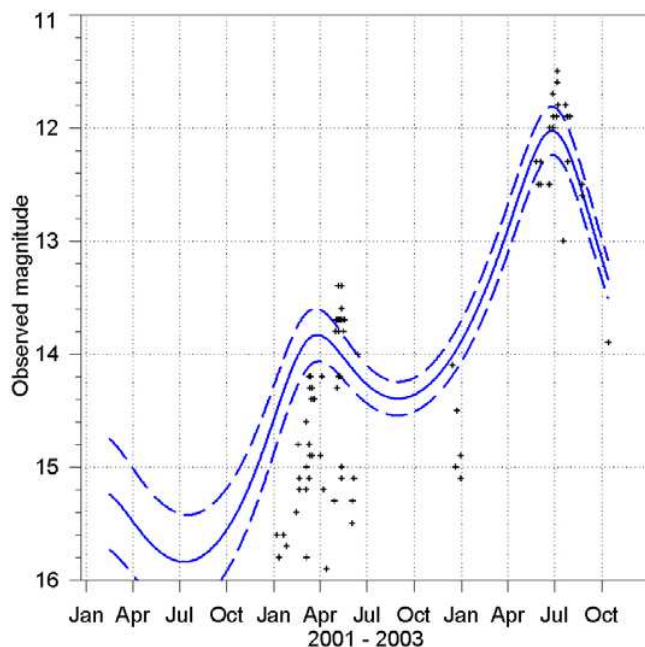


Figure 14. The lightcurve of 65P/Gunn.

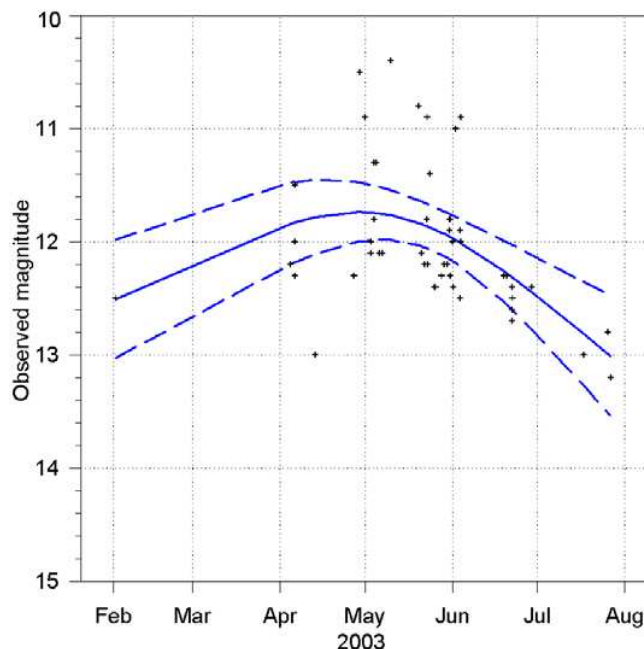


Figure 15. The lightcurve of 116P/Wild

118P/Shoemaker–Levy

This comet makes occasional approaches to Jupiter, but these have only a small effect on its orbit. One such approach in 2020 will reduce the perihelion distance from its present 2.0 to 1.8au.

The 2003 return was unfavourable and it wasn't until three months after perihelion that the comet emerged into the morning sky. It was expected to be brightest in 2004 Jan and Feb, but the only observation was made in 2004 March when Reinder Bouma estimated it at 14.3 on Mar 26 in his 0.31-m Jones-Bird reflector.

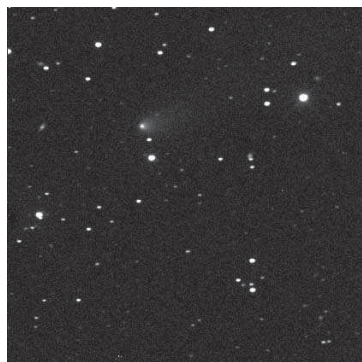


Figure 16. 123P/West–Hartley imaged by Rolando Ligustri on 2004 Mar 30.

123P/West–Hartley

This comet was discovered by Richard West on an ESO survey plate taken on 1989 Mar 14 and independently by Malcolm Hartley on a UK Schmidt plate taken on May 28. The comet has made no recent approaches to Jupiter that made significant changes to the orbit. It reached between 13th and 14th magnitude at the last return in 1996.

It achieved a similar brightness this time round, and was at its brightest between 2004 February and April after its 2003 December perihelion.

Other comets and objects observed during the year

29P/Schwassmann–Wachmann

This comet was discovered in 1927 and is in a near-circular orbit, just outside that of Jupiter. Occasional encounters with the planet make small changes to the orbit, most recently in 1974, when the orbit became more circular. In 1931 images of the comet were found on archival plates taken in 1902.

Shanklin: The brighter comets of 2003

This comet has frequent outbursts and for a number of years seems to have been more often active than not. Historically it rarely got brighter than mag 13 in outbursts, however even this is remarkable for an object that is more distant than Jupiter from the Sun. It is possible that its pattern of behaviour has changed. In the first half of 1998 it was in outburst on several occasions, and this also occurred in 1999. 2000 was exceptional for the apparent lack of outbursts, whereas it was in almost continuous outburst in 2004. 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.

In 2003 the comet was at opposition at the end of August and could have been observed from April to the end of the year, however no observations were made after October. Positive observations were made between June and October, with clearly defined outbursts in August and September. These followed the usual pattern with an initially high degree of condensation steadily becoming more diffuse. At brightest it reached around 12th magnitude.

(196256) = A/2003 EH₁

A 19th magnitude asteroid was discovered by LONEOS on 2003 March 6.11. The Amor type orbit is typical of a Jupiter family comet. It can approach within 0.3au of Jupiter and the Earth MOID is 0.21au. The object is in a 5.52 year orbit, with perihelion at 1.19au and an eccentricity of 0.62.

P. Jenniskens, NASA Ames Research Center, pointed out that 2003 EH₁ would seem to be a very strong candidate for the parent of the Quadrantid meteor stream. The orbits, from arcs of up to 48 days (MPO 48330), indicated that frequent approaches within 0.2–0.3au of Jupiter occurred, those during the past century or two evidently increasing *q* from just under 1au (with other orbital elements also very similar to those of the Quadrantids) to the present 1.19au. The current theoretical radiant for 2003 EH₁ (RA= 229.9°, Dec= +49.6°; *V*_{inf}= 41.7 km/s at solar longitude 282.94°, equinox 2000.0) is at the centre of the Quadrantid radiants measured by photographic means, the narrow dispersion implying a young (about 500 years) shower age. From that dispersion, Jenniskens *et al.* (1997, *Astron. Astrophys.* **327**, 1242) suspected that the parent was still among the meteoroids, hiding as a minor planet.

On computing a parabolic orbit for 1490 Y1, Hasegawa (1979, *Publ. Astron. Soc. Japan* **31**, 257) introduced that comet as the likely Quadrantid parent. In attempting to link the 2003 observations to those of 1490–1491, Jenniskens, and also B. G. Marsden (Center for Astrophysics), have found that most of the potential solutions with the required 1491 January perihelion date yield $0.5 < q < 0.6$ au in 1491, and this is probably too small to fit the data used by Hasegawa. Values in the more acceptable range of $0.7 < q < 0.8$ au (and $0.80 > e > 0.75$) certainly arise for $1488 < T < 1494$, however, the desired date being clearly attainable with the help also of a close approach to the Earth or, more likely, the presence of non-gravitational forces.

Further light could be shed on the problem by further observations of 2003 EH₁, which is presumably a comet and should in any case be considered a high-priority object for further study. [*IAUC* 8252, 2003 Dec 8]. Brian Marsden noted on *MPEC* 2004-N22 [2004 July 5] that this is the presumed parent of the Quadrantid meteors (*cf.* *IAUC* 8252). The observations are still insufficient to shed much light on the suggested identity with comet 1490 Y1.

This object is the first member of the inner Oort cloud to be discovered. With a perihelion distance of 76.2au, aphelion at nearly 1000au and an orbital period of over 12,000 years it is the most distant member of the solar system to be found so far. At several hundred kilometres in diameter it is smaller in size than Pluto and would be a substantial comet if it ever entered the inner solar system. It is currently just under 90au from the Sun, moving in towards perihelion, which is in about 60 years time.

The object is named for the Inuit goddess of the sea and the mother of all sea creatures. She rewards the people of the land with food from the sea. Without her blessing, hunts fail and the people starve. She is thus one of the most important figures in Inuit legend.

A/2003 WY₂₅

This object, which is currently classed as an Apollo asteroid, was discovered by the Catalina Sky Survey at 18th magnitude on 2003 Nov 22.15. It is in a 5.3 year orbit, with perihelion at 0.96au and an eccentricity of 0.68. The orbit is typical of a Jupiter family comet, and it can approach Jupiter to within 0.2au, approaching it to 0.24au in 1995 July. It is also a Potentially Hazardous Asteroid (PHA), with a MOID of 0.015au at the ascending node. It approached the Earth to 0.025au in mid-December 2003, when it reached 15th magnitude, but was of stellar appearance. It will make future close approaches in 2020 (0.08au in January) and 2035 (0.10au in November). It can also approach Mars very closely, and does so in 2063 and 2067.

M. Micheli (Italy) and Peter Jenniskens both suggested an identity with the lost periodic comet Blanpain (D/1819 W1), and Brian Marsden conclusively linked the asteroid with the comet. Harold Ridley had also tentatively linked the comet with the Phoenicid meteor shower of 1956 Dec 5 (BAA *Circ.* No. 382).

The original orbit for comet Blanpain appears to have been relatively good, however the period was around a month out. Since its discovery apparition it made a further 34 returns prior to its

recovery as an asteroid in 2003. Perihelion distance has varied between 0.87 and 1.04au, thanks to Jovian perturbations. There were close approaches to the Earth at the discovery in 1819 (0.11au in October before discovery) and 1866 (0.08au in November).

At discovery in 1819 the comet was around 6.5, with a coma of 6–7" diameter. It was observed for 59 days. Although Vsekhsvyatskiy gives an absolute magnitude of 8.5, this doesn't fit the ephemeris very well and 10.5 is more likely. The next return had perihelion in 2014 August, however it was not a good return, so confirmation of the cometary nature may have to wait until 2020.

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