

The comets of 1999

Jonathan Shanklin

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

This report is the tenth in the annual series which gives for each comet: the discovery details, orbital data and general information, magnitude parameters and BAA Comet Section observations. Further details of the analysis techniques used in this report are given in an earlier paper.¹ Ephemerides for the comets predicted to return during the year can be found in the BAA or ICQ *Handbooks*.^{2,3}

Comets with discovery letter designations

1999 AI (Tilbrook)

Justin Tilbrook (Clare, South Australia) discovered his second comet on Jan 12.49 with his 0.2m f6 reflector×70. [*IAUC* 7084, 1999 Jan 13]. Tilbrook was intentionally looking for comets when he found this one, unlike his first comet find,



Figure 1. Justin Tilbrook. © *Astronomical Society of South Australia*.

18 months earlier, which was made accidentally during a variable star patrol. Don Machholz had swept over it on Dec 9, when he picked up galaxy NGC 6217 but missed the equally faint

comet, a couple of degrees away. Then on Jan 3, shortly after moonrise, he again swept over it when it was near Jupiter in the evening sky. Although the comet had perihelion inside the Earth's orbit and was relatively close, it was intrinsically quite faint and faded after discovery. Andrew Pearce made some early observations, reporting it at a little fainter than 10th magnitude. Moving south, it was not visible from the Northern Hemisphere. Moonlight interfered with observations after Jan 20 and the only further observation was by Andrew Pearce, who estimated it at 11.3 on Feb 17.5 in his 0.41m reflector. Thereafter the elongation decreased so that observing circumstances were poor, and although Pearce sought the comet in late March, when it was better placed again, he was unable to locate it, estimating it fainter than 13th magnitude.

1999 DI (PIHermann)

S. M. Hermann of the LONEOS team discovered a comet on images taken on Feb 20.4 [*IAUC* 7111, 1999 Feb 20]. It was an intrinsically faint short pe-

riod comet of the Jupiter family, which faded after discovery. It passed 0.5AU from Saturn in 1966, but there have been no recent significant changes to the orbit.

1999 DN₃ (183PIKorlevic-Juric)

The 19th mag, apparently asteroidal object 1999 DN₃, observed by K. Korlevic & M. Juric at Visnjan (0.41m f/4.3 reflector + CCD) on Feb 18.97 and 24.0 UT (*MPC* 33833, *MPS* 4018), was linked by G. V. Williams, Minor Planet Center, to observations on April 6 and 14 in routine asteroidal astrometry from LINEAR. Owing to the unusual nature of the orbit, computed on May 13, the object was added to the Near Earth Objects Confirmation Page (NEOCP). In response to this, further observations were reported on May 14.2 by D. A. Klingsmith III & R. Huber (Etsorn Observatory) and by G. Hug (Farpoint Observatory). Williams also identified LONEOS observations of the object on April 10. In addition, C. W. Hergenrother, Lunar and Planetary Laboratory, reported that observations made on May 14 with the 1.5m Catalina reflector showed the object to be cometary, with a compact, well-condensed 10" coma and a strongly curved 30" tail, starting in p.a. 45° and curving to p.a. 335°. [*IAUC* 7167, 1999 May 14]. The comet was distant and fading. It is a member of the Jupiter family of comets and undergoes frequent encounters with the planet. Most recently an encounter within 0.12AU in 1974 Nov pushed the perihelion distance out from

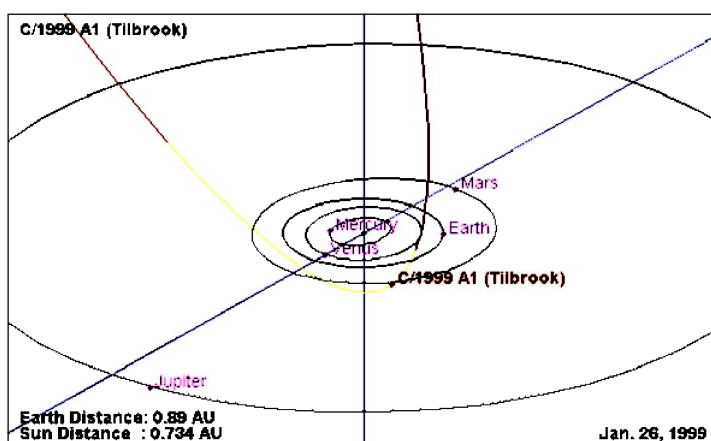


Figure 2. The orbit of comet 1999 AI (Tilbrook). Snapshot from *OrbitViewer* at http://www.users.on.net/~dbenn/Astronomy/OrbitViewer/comet_ov.html. The comet was discovered at T-17; observations used in the analysis cover the range T-16 to T+19.

Table I. Orbital data for the comets of 1999^{9, 10, 11} (sample)

<i>Comet</i>		T	q	Q	e	P	T_j	ω	Ω	i
1997 BA ₆	Spacewatch	1999 11 27.57	3.4364		0.9990			285.94	317.66	72.71
1998 M5	LINEAR	1999 1 24.57	1.7423		0.9960			101.28	333.38	82.23
1998 T1	LINEAR	1999 6 25.25	1.4677		0.9991			226.35	153.36	170.16
1998 U3	Jager	1999 3 10.07	2.1339	10.0	0.6482	14.9	2.41	180.90	303.54	19.14

(The full table is available online at www.britastro.org/jbaa supplement, and at the end of this PDF)

3.0 to 3.9AU and a future encounter in 2021 will increase it further to 4.2AU, whilst a close encounter in 2093 will bring it back to 3.0AU. At its recovery in 2006 it was numbered 183.

1999 EI (Li)

Weidong Li & M. Modjaz, Dept of Astronomy, University of California at Berkeley discovered a 17th mag comet in the course of the Lick Observatory Supernova Search (LOSS) on March 13.18 [LAUC 7126, 1999 March 16]. The object was found automatically by the Katzman automatic Imaging Telescope (KAIT), recorded by Modjaz as a supernova candidate, and recognized by Li as a comet. Li then used the equipment to make confirmatory observations three nights later. The comet showed an apparent tail in p.a. about 120° . It is in a 66-year elliptical orbit and can pass within 1 AU of Saturn, however no encounters have taken place recently. As with most intermediate-period comets it will not receive a number and P designation until it is recovered on a second perihelion passage. Comets with periods between about 20 and 200 years are often referred to as intermediate-period comets, nearly isotropic comets or Halley-type comets. The Tisserand parameter (T_J) for their orbits, a measure of their energy with respect to Jupiter, is less than 2 and they are therefore not greatly affected by Jupiter, as any encounters are short and swift. Jupiter family comets usually have T_J between 2 and 3 and can undergo longer and slower encounters, whilst asteroids have T_J greater than 3.

A few visual observations made with large reflectors suggest that 1999 E1 may have become as bright as mag 14.5.

1999 FI (Catalina)

On April 17, Tim B. Spahr, Lunar and Planetary Laboratory, reported the automatic discovery of an 18th mag object of unusual motion and stellar appearance in the course of the Catalina Sky Survey (0.41m Schmidt + CCD) on March 23.32. Spahr obtained follow-up data on April 16 and 17. Computations by B. G. Marsden suggested that the object was a long-period comet in a highly inclined orbit, yielding an identification in March 13 *Spacewatch* data. CCD images (660s total exposure) obtained with the Catalina 1.5m reflector by J. Bialozynski, D. Dietrich, C. Greenberg, E. Hooper, D. McBee, D. McCarthy, J. Pici, G. Rudnick, & C. Vedeler, and co-added by C. W. Hergenrother, show a faint coma of diameter 8"–10". [*IAC* 7148, 1999 April 20]. The comet was very distant (over 8AU) and not due to reach perihelion until 2002, but even then it was 5.8AU from the Sun.

1999 F2 (Dalcanton)

Julianne Dalcanton, University of Washington; S. Kent, Fermi National Accelerator Laboratory; & S. Okamura, University of Tokyo, on behalf of the Sloan Digital Sky Survey (SDSS), reported the discovery by Dalcanton of a comet on several SDSS images taken on March 20 through different filters; an r'-band filter showed a tail about 2' long and a sharp nucleus inside a coma of diameter about 20". Upon receipt at the Central Bureau on June 7 of the astrometry, spanning only 72s of time, G. V. Williams found a possible link with a single-night apparently asteroidal LINEAR object in archival data for March 24; this permitted Williams to find further apparently asteroidal LINEAR observations, first on Feb 23, then on May 12, and finally on 1998 June 18. At this point, the object was placed on the NEOCP in expectation that additional observations would confirm its cometary nature. In response, confirming CCD observations showing cometary appearance were received from M. Tichy & Z. Moravec at Klet on June 7.9 UT (coma diameter 15", tail 50" in p.a. 230°) and from R. A. Koff at Thornton, CO, on June 8.2 (15" coma, 35" tail in p.a. 195°). Dalcanton subsequently forwarded single-night LONEOS observations obtained on March 28 and found by G. Magnier. [*IAC* 7194, 1999 June 8]. The comet was distant, but intrinsically quite bright, and faded from 15th magnitude, although a few visual observations suggested that it might have reached a magnitude brighter.

1999 GI (LINEAR)

LINEAR discovered yet another faint comet on April 7.24. This one was in a 130 year periodic orbit, with perihelion at 4.0AU in 1998 and faded after discovery [IAUC 7140, 1999 April 10]. It is classed as a Halley-type comet.

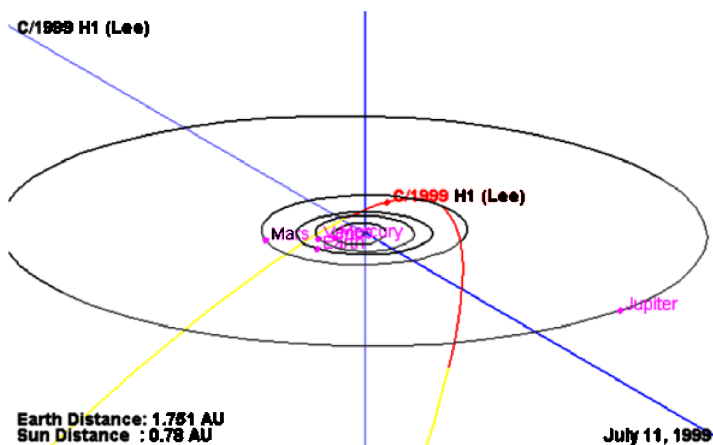


Figure 3. The orbit of comet 1999 H1 (Lee). Snapshot from *OrbitViewer*. The comet was discovered at T-86; observations used in the analysis cover the range T-85 to T+180.

1999 H1 (Lee)

Steven Lee, a night assistant at the Anglo-Australian Telescope in New South Wales, discovered this 9th magnitude comet on April 16.5 with a 0.41m f/6 Newtonian reflector (about $\times 75$) at a star party near Mudgee, NSW. [*IAUC* 7144, 1999 April 16]. Up to perihelion in early July it was essentially a southern hemisphere object, whilst following perihelion it was best seen from the north.

Andrew Pearce observed it the night after discovery, making it 9.2 in his 0.41m f/4 reflector $\times 90$, with a well condensed 2' diameter coma. It steadily brightened, and by mid-May had reached 7.6 according to Albert Jones observing with his short focus 4.5cm refractor. Although a few northern hemisphere observers were able to glimpse the comet in June, it was too low for reliable observation. From the southern hemisphere, Tim Cooper estimated the comet at 6.6 in his 20cm reflector in early June. The comet had developed a short tail, of no more than 45' in length. The solar elongation steadily decreased, and by the end of the month only Nicolas Biver observing from Hawaii was able to follow the comet. He made a final observation on July 4.26, estimating it at about 6.9 in his 26cm reflector, though sky brightness and low altitude affected the observation.

Jonathan Shanklin picked it up post-perihelion in his 14 $\times$ 100B on July 27.09 at mag 6.1, though it was a difficult

object in a bright twilight sky. By early August it was easy and Shanklin observed it low down on Aug 11.1, making it 6.9 in the 14 $\times$ 100B. Andrew Pearce, on a visit to the UK for the solar eclipse and the International Workshop on Cometary Astronomy (IWCA), also observed it in mid-August, making it a little fainter. Denis Bucynski imaged the comet on Aug 29.9. It was an easy object from the centre of Cambridge on Sept 4.1 in 14 $\times$ 100B, though it had faded to 8.3, demonstrating that cometary observation is possible from sub-urban locations. It showed a prominent anti-tail in an image by Rolando Ligustri on Sept 8. Observers reported the comet a little brighter in mid-Sept, with Roy Panther estimating it at 8.2 in his 15 $\times$ 70B on Sept 16.99. Generally observers were reporting the coma as quite large and well condensed, however the comet

became less condensed and had faded to around 9th magnitude at the beginning of October. Gabriel Oksa, observing on Oct 13.75 estimated it at 8.9 in his 15cm f/4 refractor $\times 38$, with a 6' diameter weakly condensed coma. It rapidly became very diffuse in the last week of October and Shanklin made his final observation of the comet on Nov 10.91, when it was 12.2 in the Northumberland 30cm f/20 refractor $\times 105$. A few observers were able to follow it into the new year, with Martin Lehky reporting to *TA* that it was 13.5 on Jan 6.72 in his 42cm reflector.

The reported coma diameter showed large scatter throughout the apparition, and it is difficult to deduce a great deal from the reported measurements, which at times ranged over more than 15 minutes of arc. The observations do however suggest that the coma was at its largest near perihelion and then had a diameter of around 500,000km. There was an equally wide spread in the estimated degree of condensation, with values ranging between 1 and 8 just after perihelion. The general indication is that the comet was more condensed at perihelion, with a value of around 6 near that time. The visual observations show no significant pattern to the tail development.

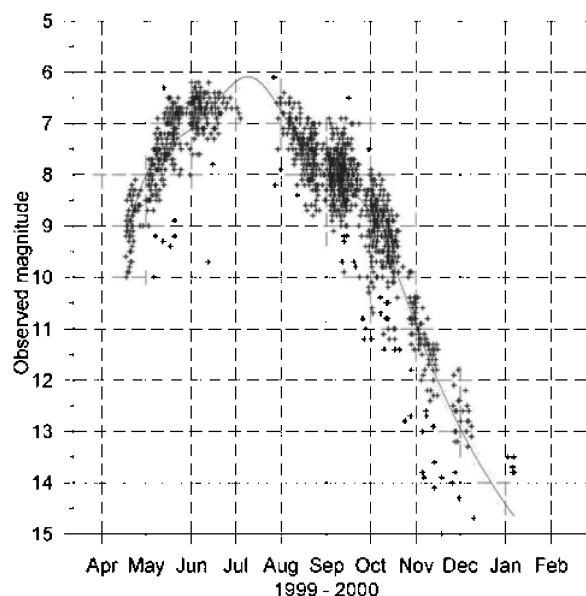


Figure 5. The observed magnitude of comet 1999 H1. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1999 April 1.



Figure 4. Steven Lee with the discovery telescope.
© Melissa Hulbert.

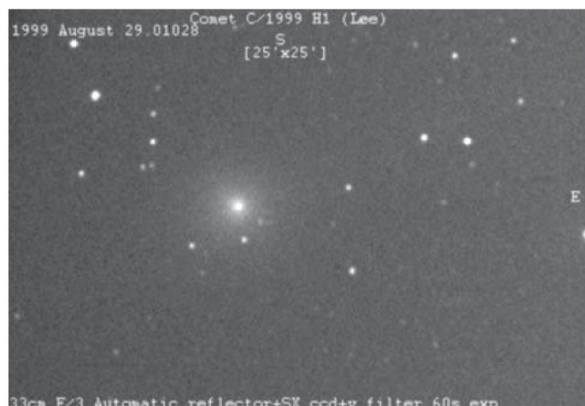


Figure 6. Comet 1999 H1 imaged by Denis Bucynski.

Shanklin: The comets of 1999

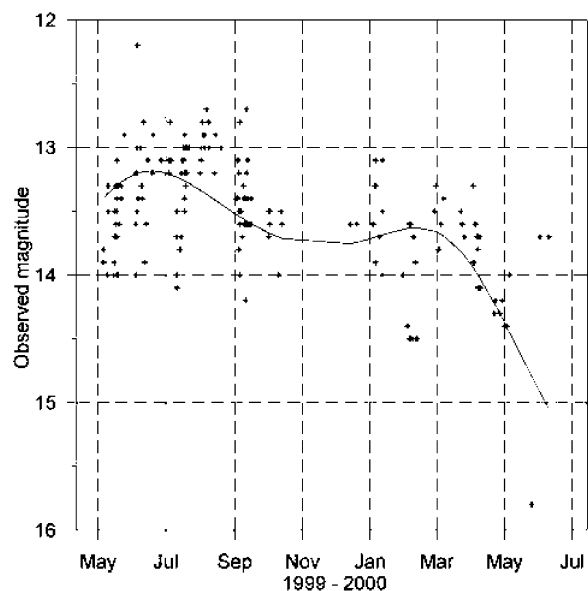


Figure 7. The observed magnitude of comet 1999 H3 (LINEAR). The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1999 May 1.

1999 H3 (LINEAR)

An apparently asteroidal 17th mag object discovered by LINEAR on April 22.31, and noted on the NEOCP, was reported as cometary by Klet and Ondrejov observers [IAUC 7151, 1999 April 23]. The comet was in a distant parabolic orbit with perihelion at 3.5 AU in August, however observers with large apertures were able to follow it for over a year. These estimates suggested that it was around 14th magnitude in early May and had brightened to 13th magnitude around the time of perihelion. Jonathan Shanklin glimpsed the comet at 13.6 in the Northumberland refractor on Sept 9.86. The comet faded very slowly, with the final visual observation making it 14th magnitude in 2000 June.

1999 J2 (Skiff)

Brian Skiff of the Lowell Observatory Near-Earth Object Search (LONEOS) team discovered a 16th mag comet on May 13.40 [IAUC 7165, 1999 May 13]. The comet was at high northern declination, and was very distant at over 7 AU, with perihelion in 2000 April. It remained near 15th mag for some time. It is one of around a dozen comets with perihelion at over 7 AU from the Sun.

T. Fukushima, T. Nakajima, & J. Watanabe, National Astronomical Observatory of Japan (NAOJ), reported that I-band CCD images of the comet taken with the NAOJ 0.50m telescope showed a dust anti-tail at the large heliocentric distance of 7 AU (the comet having passed perihelion on 2000 April 5): April 26.687, 2'.60 in p.a. 12°; May 2.576, 3'.31 in p.a. 18°. Coma diameters were about 0'.4 on both dates, and $m_1 = 15.6$ in V and 14.9 in I on April 29. The earth crossed the comet's orbital plane on 2000 May 10.4. [IAUC 7415, 2000 May 5]

Visual observers with large apertures estimated the comet at around 14th magnitude at brightest and were able to follow it for over a year.

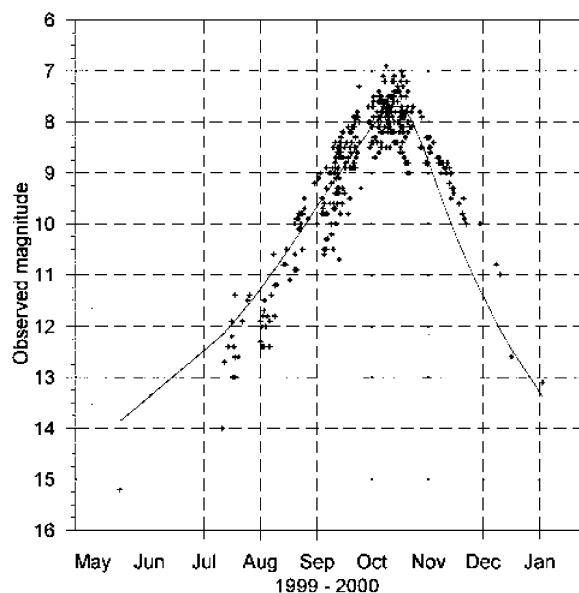


Figure 8. The observed magnitude of comet 1999 J3 (LINEAR). The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1999 May 1.

1999 J3 (LINEAR)

An apparently asteroidal 19th mag object discovered by LINEAR on May 12.28, and noted on the NEOCP, was reported as cometary by Klet observers [IAUC 7166, 1999 May 13]. With a perihelion distance of 1 AU and a closer approach to the Earth, there was a prospect that the comet would come in reach of visual observers. Few attempts were made until mid-July, when estimates put it at 12th mag. Jose Carvahal estimated it at 12.4 on August 5.9. By early September it had reached 10th mag. Jonathan Shanklin estimated that it was mag 9.6 in 20×80B from a dark sky site on Sept 12.1, rather smaller than comet Lee. Observing from his back garden in central Cambridge on Sept 18.16 Shanklin made it 8.7 in 14×100B. It was small and well condensed. On Oct 18.19 it was moderately condensed in his 14×100B at mag 8.2, although it appeared significantly brighter in smaller aperture binoculars. By now it was rapidly moving south, and had begun to fade. Stuart Rae estimated it at 9.0 in 10×50B on Nov 13.53. It then faded quickly and Andrew Pearce made a final observation on Jan 2.58, making it 13.1 in his 41cm f/4 reflector ×90.

1999 J4 (LINEAR)

Another asteroidal object reported by LINEAR on May 15.32 UT (mag 18.2–18.8) with unusual motion was noted on the NEOCP, and it was subsequently reported to be cometary in appearance by several observers, including M. Elowitz & F. Shelly from May 17 LINEAR observations. P. Pravec, U. Babiakova & P. Kusnirak (Ondrejov, 0.65m f/3.6 reflector + V filter) reported a coma diameter of 0'.2 and a tail 0'.6 long in p.a. 160°, and J. Ticha & M. Tichy (Klet, 0.57m f/5.2 reflector) noted the object to be slightly diffuse (coma diameter about 7'), on May 16.9 [IAUC 7170, 1999 May 17]. The comet was in a distant parabolic orbit and was not observed visually.

Table 2. BAA and TA visual observers

Alexander Baransky	Kiev, Ukraine
Sandro Baroni	Italy
Sally Beaumont	Windermere, Cumbria
John Bortle	Stormville, NY, USA
Reinder Bouma	Groningen, The Netherlands
Nicholas Brown	Australia
Paul Camilleri	Australia
Hugh Davies	Cirencester, Gloucestershire
Roger Dymock	Clanfield, Hampshire
Len Entwisle	Elland, West Yorkshire
Rafael Ferrando	Spain
James Fraser	Alness, Rossshire
Michael Gainsford	Burbage, Leicestershire
Stephen Getliffe	Longstanton, Cambridgeshire
Bjorn Granslo	Fjellhamar, Norway
Mark Green	Trelogan, Clwyd
Werner Hasubick	Germany
Roberto Haver	Rome, Italy
Guy Hurst	Basingstoke, Hampshire
Albert Jones	New Zealand
Andreas Kammerer	Ettlingen, Germany
Heinz Kerner	Fassberg, Germany
Attila Kosa-Kiss	Romania
Martin Lehky	Hradec Kralove, Czech Republic
Brian Manning	Stakenbridge, Worcestershire
Michael Mattiazzo	Wallaroo, Australia
John McCue	Norton, Cleveland
Haldun Menali	Turkey
Cliff Meredith	Prestwich, Manchester
Giannantonio Milani	Italy
Terry Moseley	Co Antrim, Ireland
Yurij Nesterov	Livny, Russia
Gabriel Oksa	Slovak Republic
Roy Panther	Walgrave, Northampton
Andrew Pearce	Australia
Richard Schmude	Texas, USA
Jonathan Shanklin	Cambridge
Janet Simpson	Furnace, Argyll
Oddleiv Skilbrei	Norway
David Storey	Douglas, Isle of Man
Tony Tanti	Naxxar, Malta
Melvyn Taylor	Wakefield, West Yorkshire
Vince Tuboly	Hungary
Cliff Turk	South Africa
John Vetterlein	Rousay, Orkney
Mauro Zanotta	Milan, Italy

The lightcurves make use of all observations in the *ICQ* archives, complemented with those from the BAA and *TA*. Thanks are also due to the many observers not listed here for their diligence in making the observations, and to Dan Green of the *ICQ* in compiling them into standard format.

1999 J5 (187P/LINEAR)

An apparently asteroidal 19th mag object reported by LINEAR on May 12.36 and 17, and linked by G. V. Williams to LINEAR observations on June 8 and 10 by way of a comet-like orbit, was posted on the NEOCP for additional observations. P. Pravec & P. Kusnirak, Ondrejov, reported that their June 12 CCD images showed a faint coma and a tail marginally visible to the southwest. Also, A. Sugie, Dynic Astronomical Observatory, reported strong condensation and a coma diameter of 12" on June 14. [*IAUC* 7201, 1999 June 14]. The comet was recovered as 2007 E3 and subsequently numbered.

The comet is a member of the Jupiter family and passed within 0.1AU in 1856, however there have been no dramatic changes to the orbit in recent times.

1999 J6 (SOHO) [Oates]

This SOHO comet of the Marsden group was discovered by Michael Oates on 2000 March 21 in C3 images. Subse-

Table 3. BAA and TA astrometric, CCD and photographic observers

Observer	Site	IAU Stn No.
Mark Armstrong	Rolvenden, Kent	960
Denis Buczynski	Conder Brow, Lancashire	978
Bev Ewen-Smith	Algarve, Portugal	965
John Fletcher	Mount Tuffley, Glos.	
Maurice Gavin	Worcester Park, Surrey	
Steve Goldsmith	Gillingham, Kent	
Nick James	Chelmsford, Essex	970
Geoffrey Johnstone	Burdingbury, Warwickshire	
Rolando Ligustri	Italy	
John Mackey	Werrington, Peterborough	963
Cliff Meredith	Manchester	
Martin Mobberley	Galleywood, Essex	477
Martin Mobberley	Cockfield, Suffolk	480
Bob Neville	Greens Norton, Northants	967
Gabriel Oksa	Slovak Republic	
David Strange	Worth Matravers, Devon	
Alex Vincent	Worthing, Sussex	

quently comet 2004 V9, found by Heiner Otterstedt in SOHO images in Nov 2004, was linked to this comet. The identity suggests that the comet passed 0.03AU from the Earth over 1999 June 9–11, with a minimum distance of 0.009AU, in one of the closest encounters on record. It is estimated that the object was around 41m diameter in 1999 and 35m in 2004. No observations of the comet were reported by any of the major search programmes. Comets of the Marsden group are probably associated with comet 96P/Machholz, the Kracht group of SOHO comets, the daytime Arietids and the southern delta Aquarids. Their orbital evolution has been described by Zdenek Sekanina.⁴

1999 K2 (Ferris)

William D. Ferris discovered an 18th mag comet on CCD frames taken with the 0.59m LONEOS Schmidt telescope on May 19.37. Measurer B. Koehn noted that the comet showed a well-condensed nucleus, a coma of diameter about 15", and a faint tail about 20" long in p.a. 225° on May 19. Additional astrometry appeared on *MPEC* 1999-K22. May 22 observations by J. Ticha & M. Tichy (Klet) showed the comet as diffuse with a 12" coma; observations on the same night by L. Kornos & P. Koleny (Modra) also showed a coma. C. W. Hergenrother & A. E. Gleason (Catalina 1.5m reflector) reported a 20" coma and a 20" tail in p.a. 230°. [*IAUC* 7175, 1999 May 22]. The comet was in a distant highly elliptical orbit and didn't brighten much from its discovery visual magnitude of around 16, although a few visual observers made it as bright as 15th magnitude.

Bill Ferris provides the discovery story: *I found the comet last Wednesday morning but didn't know I'd found it until later that night. Now I'm confused. Perhaps I should start at the beginning. I've been doing some observing for Lowell observatory since June 1998. I'm one of five observers on the Lowell Observatory Near-Earth Object Search (LONEOS) team. We use a 24-inch Schmidt camera to look for NEOs. It's a neat setup, a real one-person operation. We use the scope to take CCD images of 3×3-degree chunks of sky. Typically, we observe in blocks of 8 to 10 chunks or regions. Computer software compares each image with a*

Shanklin: The comets of 1999

counterpart in the database and generates a list of detections. A detection is any point source the computer determines to be moving. We scroll through the detection list and follow up on any interesting looking objects. We define interesting as any object with motion not consistent with a main belt asteroid. Recall the primary goal is to find Earth-crossing objects. If the detection appears to be a real object, unknown and with interesting motion (read an NEO), then we send in a report to the Minor Planet Center.

Two weeks ago, observer Brian Skiff discovered his fourth comet. We were joking that I would have to find a comet during my next run to keep pace. I was scheduled to observe last Monday and Tuesday nights. The first night, May 17–18, was fairly uneventful. I did find a comet. It was a real object and was definitely displaying a coma. Unfortunately for me, it turned out to be a known comet, 52P/Harrington–Abell. The next night, May 18–19, was also fairly uneventful until the last group of regions. I found an interesting object in the detection list and began the usual confirmation procedure. First, I called up the three images of that region. The computer automatically centered and placed a green circle around the detection. I told the computer to blink between the three images. Since the detection remained stationary in the center, the stars appeared to be flowing by. It was a real object.

Next, I sent the coordinates for my object to the Minor Planet Center's NEO confirmation webpage. My computer talked to their computer and displayed a list of nearby known objects. A known asteroid was just a couple arc-minutes away. Since it was an unnumbered asteroid, uncertainties in its orbit could very well have accounted for the discrepancy in position. Also, no other detection matched so well in position. So, I marked it as a known object and moved on. Fast forward to Wednesday night, May 19. First Lady Hillary Clinton was scheduled to visit Lowell Observatory. I showed up at 8:00 PM for the staff photo. Another LONEOS person, Bruce Koehn, informed me that the 'known' object in the last group might actually turn out to be an unknown comet. Mrs. Clinton arrived, we shook hands, took the staff photo and I went home excited at having met the first lady. The comet stayed in the back of my mind until last Saturday morning. The principal investigator for LONEOS is Ted Bowell. Ted sent me an e-mail on May 22 confirming the object as a comet, C/1999 K2 (Ferris), better known as comet Ferris. This is actually the second comet I've discovered. The first was P/1998 QP54 LONEOS–Tucker in Aug 1998. It wasn't showing any coma or tail when I found it so we reported it as an asteroid. Amateur astronomer Roy Tucker realized it was a comet a few weeks later. Hence the name, LONEOS–Tucker.

Bill Ferris, Amateur/Professional collaborator, Flagstaff, AZ.

1999 K3 (LINEAR)

M. Elowitz, Lincoln Laboratory, Massachusetts Institute of Technology, reported the discovery of a 19th magnitude, apparently cometary object in LINEAR data on May 20.27. Following posting of this object on the NEOCP, numerous observers confirmed the cometary appearance, and addi-

tional astrometry and an orbit were given on MPEC 1999-K23. Around May 22.0 UT, L. Sarounova (Ondrejov) reported coma diameters about 20" and 15"; Ticha & Tichy reported a 10" coma and a wide tail in p.a. 245°; and coma was also noted by Kornos & Koleny. [IAUC 7175, 1999 May 22]. The comet was past perihelion and faded from magnitude 16, although a few visual observers with large apertures estimated it at over a magnitude brighter.

1999 K4 (LINEAR)

Another apparently asteroidal object, of 19th magnitude, found by LINEAR on May 17.33, and posted on the NEOCP, was reported as cometary by M. Hicks (Table Mountain; faint coma of diameter about 5" on May 21) and by C. W. Hergenrother and A. E. Gleason (Catalina 1.5m reflector; highly condensed coma with a faint 10"–15" tail in p.a. 170° on May 22). [IAUC 7176, 1999 May 22] The comet was intrinsically faint and faded.

1999 K5 (LINEAR)

Another apparently asteroidal, 17th magnitude object discovered by LINEAR on May 20.32 and posted on the NEOCP, was reported as cometary by several observers. CCD frames taken by D. D. Balam (Victoria) on May 23 showed a condensed coma with a 16" fan-shaped tail in p.a. 303°. On May 24, L. Kornos & P. Koleny (Modra) reported a coma diameter of about 15" and a short tail in p.a. 330°, and G. Hug (Farpoint Observatory) indicated a hint of coma in p.a. about 300°. [IAUC 7178, 1999 May 24]. This was LINEAR's 23rd discovery in around 14 months. The comet reached perihelion at 3.3AU, at high southern declination, in 2000 July. Occasional visual observations were made in 1999, indicating that the comet was perhaps 14th magnitude visually. The comet was moving south and into solar conjunction, and no positive estimates were made from mid-August until Michael Mattiazzo recovered the comet at around 13.5 in early May. It was at its brightest in July with Mattiazzo and Andrew Pearce estimating it at around 13th magnitude. The two were able to follow the comet into 2001 January, by which time it had faded a magnitude.

1999 K6 (LINEAR)

Yet another apparently asteroidal object, of 18th magnitude, discovered by LINEAR on May 20.23, and posted on the NEOCP, was reported as cometary, on May 24 by L. Sarounova (Ondrejov; faint coma with condensed nucleus) and by M. Tichy & Z. Moravec (Klet; diffuse with coma diameter $\approx$ 10"). [IAUC 7180, 1999 May 25] The comet brightened somewhat, but only did a little better than 15th mag.

1999 K7 (LINEAR)

A 19th magnitude object discovered by LINEAR on May 24.34 was reported as possibly cometary by M. Elowitz, Lincoln Laboratory, with an apparent tail in p.a. about 220°. Confirmation of cometary activity was made by D. D. Balam (Victoria), who noted no tail but measured a 7" diffuse coma. [IAUC 7181, 1999 May 26]. The comet faded from its discovery magnitude.

1999 K8 (LINEAR)

Another apparently asteroidal 19th magnitude object discovered by LINEAR, on May 26.38 and posted on the NEOCP, was reported as cometary on May 27 by L. Sarounova (Ondrejov; coma diameter at least 30" with condensed nucleus), by M. Tichy & Z. Moravec (Klet; 10" coma), and by R. A. Koff (Thornton, CO; diffuse coma of diameter about 8"). [*IAUC* 7182, 1999 May 27]. The comet was a distant one, reaching perihelion at 4.2AU in 2000 April, and remained near 14th magnitude for some time. It reached opposition in Sept but Jonathan Shanklin was unable to detect any trace of nebosity in the predicted position with the Northumberland refractor on Oct 2.8 despite a limiting magnitude of around 15. Elsewhere, visual observers did follow it and reported it as bright as 13th magnitude in 2000 August just before its second and brighter opposition. The final visual reports were made in 2000 November, when Werner Hasubick estimated it at 14.0 in his 44cm f/5 reflector $\times 156$ at the beginning of the month but did not see it to 14.5 at the month's end.

1999 L2 (LINEAR)

M. Elowitz & F. Shelly reported the discovery of an 18th magnitude comet with a coma but no distinct tail in LINEAR data on June 11.24. In response to posting on the NEOCP, G. R. Viscome (Lake Placid, NY) reported that the object showed a 16" coma and moderately strong condensation, but again no discernible tail. [*IAUC* 7199, 1999 June 12] The comet was around 16th mag visually at discovery and reached perihelion in August, when a few observations suggested that it was a bit fainter than 14th magnitude.

1999 L3 (LINEAR)

An 18th magnitude apparently asteroidal fast-moving LINEAR object found on June 9.17 and posted on the NEOCP, was noted by F. B. Zoltowski, Woomera, S. Australia, as having a tail about 30" long in p.a. 100° and a rather dense coma on June 13 and 14 CCD images. P. R. Holvorcem, Valinhos, Brazil, reported a coma of about 10" on his June 12 images. [*IAUC* 7200, 1999 June 14] The comet is in a long period elliptical orbit.

The comet was visible to UK observers, and at its brightest in late January. Jonathan Shanklin observed it with his 0.20-m SCT on Jan 10.17 from a dark sky site and made it 12.3, DC2 and diameter 2.0'. A brief observation on Jan 31.0 with the Northumberland refractor revealed a well condensed object of between 11th and 12th magnitude. On Feb 8.8 it was around 11.5, but slightly less condensed than the day before. The comet faded and became more diffuse, but some visual observations continued until April.

1999 M3 (SOHO)

A possible member of the Marsden group of comets was discovered by Rainer Kracht in archival SOHO imagery from 1999 June 30 on 2002 Feb 27. In a communication to the Minor Planet Center on March 3, Kracht suggested that, on the basis of the apparent motion, there was some loose as-

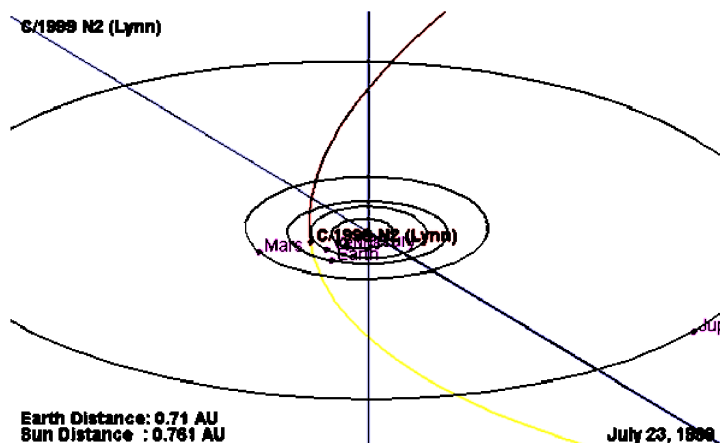


Figure 9. The orbit of comet 1999 N2 (Lynn). Snapshot from *OrbitViewer*. The comet was discovered at T-10; observations used in the analysis cover the range T-9 to T+170.

sociation between C/1999 M3 and C/2000 O3 (cf. *MPEC* 2000-Q09), despite the evident difference in the usual orbital elements. Nevertheless, it can be noted that the perihelion directions are $L = 103.9, B = +11.4$ (degrees, J2000.0) for C/1999 M3 and $L = 100.6, B = +10.8$ for C/2000 O3. On March 4, Kracht wrote that, again despite differences in the usual orbital elements, the perihelion direction for C/2000 O3 is close to the average value, $L = 102.6, B = +9.7$, for the four clear members of the Marsden group (cf. *IAUC* 4832). A more extended relationship among these comets is therefore suggested. [*MPEC* 2002-E18, 2002 March 7]. The comet family, which also includes 1999 N6 and, to date, 27 other comets, has been named the Kracht group.

1999 N2 (Lynn)

Daniel W. Lynn, Kinglake West, Victoria, Australia, visually discovered an 8th magnitude comet using handheld 10 $\times$ 50 binoculars on July 13.45 [*IAUC* 7222, 1999 July 14]. At dis-

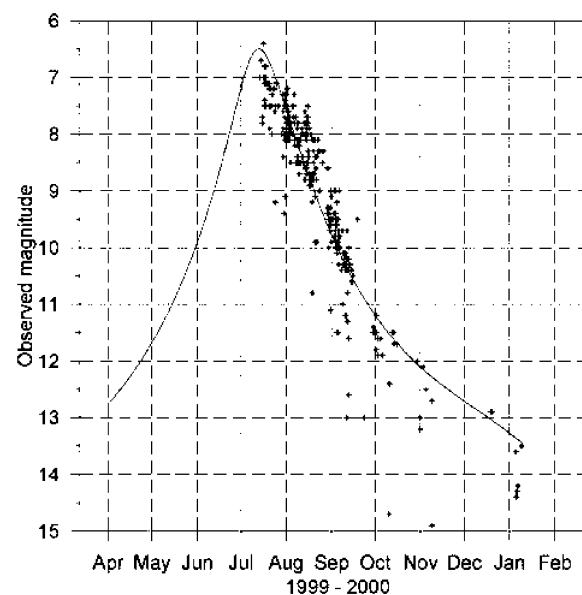


Figure 10. The observed magnitude of comet 1999 N2. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1999 April 1.

Shanklin: The comets of 1999

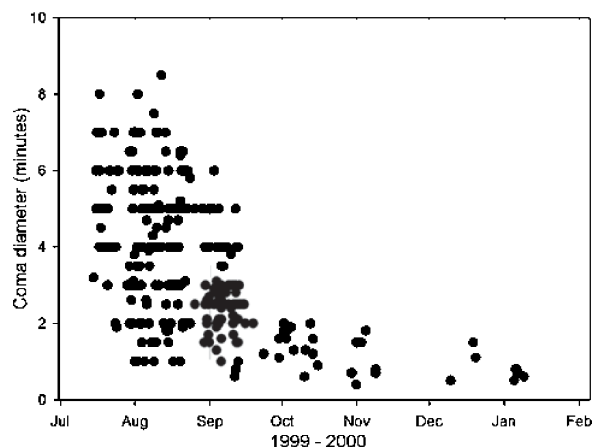


Figure 11. The coma diameter of comet 1999 N2.

covery the comet was near its brightest, in Hydra, nearing perihelion and moving north. The light curve and ephemeris suggests that it could have been discovered much earlier, although the solar elongation had been less than 60° for several months. At this time there were no Southern Hemisphere search programmes, however it would have been well within the range of any amateur visual search programme.

Jose de Sousa Aguiar and William de Souza were early observers making it 7.7 in a variety of instruments mid month. It soon became visible to UK observers and Jonathan Shanklin glimpsed it in 20×80B on Aug 5.9 at 7.7, with Jose Carvahal (Spain) also estimating it at 7.7. Shanklin made a further observation in company with Andrew Pearce in Cornwall on Aug 10.9 and estimated the comet at about 7.6 in 20×80B. It was a similar magnitude during the IWCA, which ran from Aug 14 to 16 in Cambridge. By early Sept it had faded significantly, with Gabriel Oksa estimating it at 10.1 in his 15cm f/4 refractor×48 on Sept 10.79. Relatively few observations were made after mid Sept, largely due to the observing geometry which favoured high latitudes and early morning observation. The available observations show that the comet appears to have faded slowly. Jonathan Shanklin made his final observations in early Jan, when the comet had faded to around 13.5 in his 33cm f/5 reflector×150.

The coma was around 6' in diameter at discovery, corresponding to around 200,000km, and steadily shrank in apparent diameter as the comet receded from the Sun. The actual size however increased and reached nearly double this in late August. The degree of condensation decreased from around 6 at the time of discovery to around 2 in mid Oct. It then appeared to become a little more condensed and was around DC3 at the time of the last observation.

1999 N4 (LINEAR)

On July 12.25 LINEAR discovered yet another object with unusual motion, which was placed on the NEOCP and found to have a retrograde orbit. At the request of the Central Bureau, some of the observers making astrometric observations examined their images carefully and concluded that the object was a comet. M. Tichy (Klet, 0.6m reflector) noted comae of diameter about 6" on July 14.9 and about 7" on July 15.9 UT. L. Sarounova (Ondrejov, 0.6m reflector) indi-

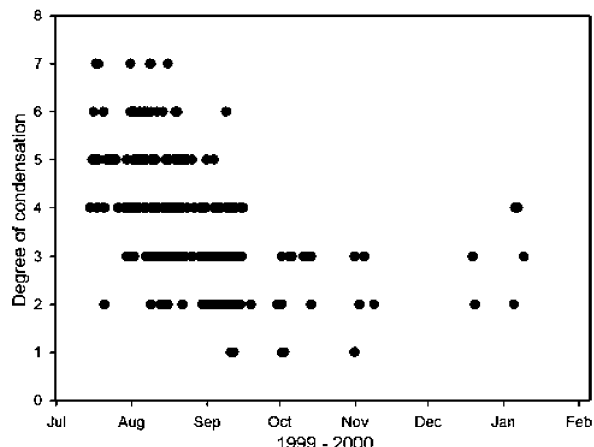


Figure 12. The DC of comet 1999 N2

cated a small coma, some lack of condensation but no tail on July 16.9. F. B. Zoltowski (Woomera, 0.3m reflector) remarked on a compact, diffuse image with an asymmetrical distribution that might indicate a small, faint tail at p.a. around 90° on July 17.6. [IAUC 7226, 1999 July 17]. This was LINEAR's 30th cometary discovery. The comet had m_2 around 18th magnitude and was a distant object reaching perihelion at 5.5AU in 2000 May.

1999 N5 (SOHO) and 1999 N6 (SOHO)

The longitudes and latitudes of perihelion (J2000.0) of the orbits for these comets, which were discovered by Rainer Kracht in SOHO C2 images on 2002 March 12, are $L=107^\circ.1$, $B=+12^\circ.0$ and $L=96^\circ.0$, $B=+10^\circ.9$, respectively. C/1999 N5 was a clear member of the Marsden group and C/1999 N6 a likely member of the more extended population (cf. MPEC 2002-E18, 2002-E25). Possibly C/1999 N6 is quite closely associated with C/1999 M3 (though not so much with C/2000 O3), but the orbit solution is not unique. [MPEC 2002-F03, 2002 March 16]. Subsequently 1999 N5 was linked with comets 2005 E4 and 2005 G2 and retracing the orbits backwards in time further suggests a link with 1999 J6, with separation of the two objects occurring near the time of the previous perihelion passage in 1993.

1999 O4 (SOHO)

This non-group SOHO comet was discovered by Rainer Kracht on 2002 Oct 20 on archival C3 images from 1999 July 18 [IAUC 8026, 2002 Dec 4].

1999 P1 (141P/Machholz)

This periodic comet was predicted to be the brightest in 1999, though it didn't live up to expectation and only reached 10th magnitude. It split into several fragments at its discovery return in 1994. This return was moderately favourable with the comet moving rapidly eastwards, through Aquila (Nov), Aquarius (Dec), Cetus (Jan), Eridanus and Orion (Feb). It was at perihelion in December, however it remained low in the evening sky for UK observers until January.

Donald Machholz discovered 141P/Machholz (1994 P1) with his 0.25m reflector at 10m in 1994 August. It proved to have multiple components, first reported by Michael Jager

(Vienna, Austria). The four secondary components could all be described by the same orbit, but with perihelion delayed by up to half a day from the primary. At times there seemed to be a faint trail of material linking the components. The comet has a short period of 5.2 years with a perihelion distance of 0.75 AU and aphelion just inside the orbit of Jupiter. The orbit has been slowly evolving, with progressive changes occurring about every 50 years, thanks to approaches to Jupiter. The most recent close approach was in 1982. With a relatively stable perihelion distance, which is slowly increasing, it is perhaps surprising that the comet was not discovered earlier.

There was a favourable return in late 1978 when it might have reached 10th magnitude and there were good returns in the autumns of 1920, 1936 and 1957. The fact that it was not discovered at any of these returns suggests that the absolute magnitude at the 1994 return was not typical. At present the Earth passes about 0.25 AU outside the descending node and orbital evolution will slowly decrease this distance, raising the possibility of a meteor shower from the comet in a few hundred years time.

Robert H. McNaught recovered component A of the comet on CCD images obtained with the 1.0 m f/8 reflector at Siding Spring on Aug 3.55. The object was of stellar appearance. The indicated correction to the prediction by B. G. Marsden on MPC 27082 (for component A) was $\Delta T = +0.8$ day. Seeing was good on Aug 4, and there was no sign of any other components within $\Delta T = \pm 1.5$ days.

Further orbital computations by Brian Marsden confirmed that if the observations were of the same object that was observed at Siding Spring on 1995 March 29 and 30 (MPC 25097), this was indeed component A. However, attempts to link all the observations (back to 1994 Aug 15), even using the nongravitational parameters A1 and A2, were not satisfactory. However, a gravitational solution gave an acceptable fit to 67 observations back to 1994 Oct 2 (mean residual

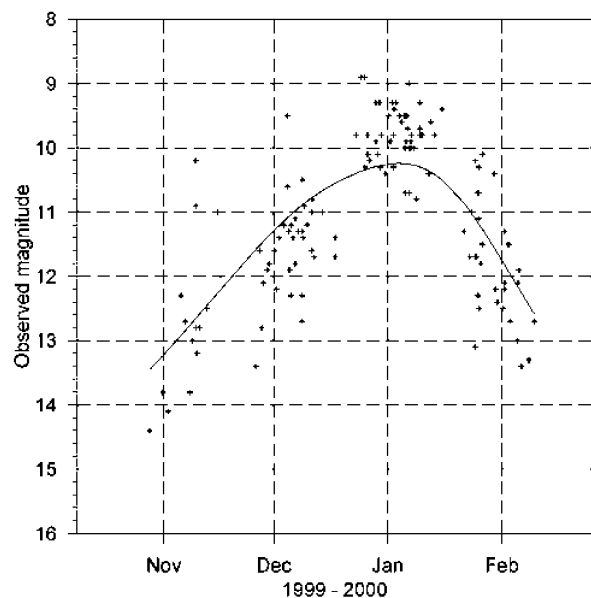


Figure 13. The observed magnitude of 141P/Machholz. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1999 Nov 1.



Figure 14. Comet 141P/Machholz imaged by Martin Mobberley.

0".9; earlier residuals increasing to 20") [IAUC 7231, 1999 Aug 04]; Z. Sekanina (1999, *A&A* **342**, 285; Table 7) tabulated the expected offsets of components B and D from component A. In terms of ΔT , these amount to +0.21 and +0.82 day, respectively. [IAUC 7232, 1999 Aug 04]

On Oct 17 R. H. McNaught, Research School of Astronomy and Astrophysics, Siding Spring Observatory, reported his single-night detection of another component of the comet, with m_2 fainter by 0.5 magnitude but with brighter m_1 and a larger coma (diameter 8", as opposed to 5") that night than the object reported on IAUC 7231 (presumed to be the 1994 component A, which he measured to be 260" to the east and 346" to the north). It seemed likely that the new object was component D. On Oct 23 S. Nakano reported an independent detection of the new component by A. Sugie, Dynic Observatory, on Oct 21 ($m_1 = 16.2$, coma 10") and 23 ($m_1 = 17.3$), and calculations by him and by Brian Marsden confirmed this to be component D, linkable to the complete 1994 arc without allowance for non-gravitational effects. October astrometry and linked orbital elements were given on MPC 36175 and 36213, the ΔT difference from component A (for which Nakano gave on MPC 35815 a complete 1994–1999 linkage using three non-gravitational components) being +0.69 day. McNaught searched for but failed to find component D on images obtained on Oct 6 and 7, when it must have been at least one magnitude fainter than component A. On Oct 31 H. Luthen, Hamburg, reported the photographic detection by M. Jager, Vienna, on Oct 27 and by Jager & G. Rhemann on Oct 29 and 31 of an object with a 1".5–2".0 coma and $m_1 = 12.8$ –13.0. Astrometry by E. Meyer, E. Obermair & H. Raab, Linz, on Nov 1 confirmed this also to have been component D, with coma 0".5 and $m_1 = 15.4$. [IAUC 7299, 1999 Nov 1]

In his paper⁵ on the comet Zdenek Sekanina notes that at discovery in August 1994, the comet consisted of five condensations, A–E, of which D later became double. They were lined up along their common heliocentric orbit (with A being the leading and brightest component) and connected by a trail of material, suggesting that the comet's nuclear fragmentation was accompanied by a copious release of large dust particles. The earliest breakup is found to have occurred in late 1987, ~600 days before the comet's 1989 peri-

Table 4. Magnitude parameters.

a). Standard visual magnitude parameters

Comet	No.	r AU	H1	dev	K1	H10	dev	H15	dev
A1 Tilbrook	30	0.7–0.8				11.2±0.1	0.4	11.8±0.1	0.5
D1 P/ Hermann	7	1.7–1.8				15.9±0.1	0.3c	14.7±0.1	0.3c
DN ₃ 183P/Korlevic–Juric	2	4.0				9.1±0.3	0.4c	6.1±0.3	0.4c
E1 Li	31	3.9–5.3	6.7±1.1	0.5c	9.6±1.7	6.4±0.1	0.5c	3.2±0.1	0.5c
F1 Catalina	12	5.8–9.0	5.1±1.9	0.6c	9.2±2.3	4.4±0.2	0.5c	0.3±0.2	0.7c
F2 Dalcanton	13	5.2–6.4				4.5±0.2	0.7c	0.9±0.2	0.7c
G1 LINEAR	4	4.5–4.6				8.2±0.2	0.3c	5.0±0.2	0.3c
H1 Lee	1436	0.7–3.0	6.3±0.0	0.5	9.9±0.1	6.3±0.0	0.5	5.6±0.0	0.7
H3 LINEAR	176	3.5–4.4	4.0±0.8	0.5	9.7±1.4	3.9±0.0	0.5	1.1±0.0	0.5
J2 Skiff	151	7.1–8.7	4.7±3.3	0.4	4.7±3.8	0.1±0.0	0.4	–4.2±0.0	0.5
J3 LINEAR	389	1.0–2.2	8.4±0.0	0.5	7.1±0.5	8.3±0.0	0.5	8.1±0.0	0.7
J4 LINEAR	1	4.1				7.6c		4.5c	
J5 187P/ LINEAR	2	3.7				7.8±0.1	0.1c	5.0±0.1	0.1c
K2 Ferris	5	5.3–5.4				2.6±0.3	0.6	–1.0±0.3	0.6
K3 LINEAR	5	2.3–2.8				7.6±0.4	0.8	5.7±0.4	1.0
K5 LINEAR	45	3.3–4.8				4.2±0.1	0.6	1.5±0.1	0.8
K6 LINEAR	23	2.2–2.3				8.4±0.1	0.3	6.6±0.1	0.3
K7 LINEAR	2	2.6–2.8				10.6±0.1	0.2	8.5±0.1	0.1
K8 LINEAR	132	4.3–5.0	–0.5±1.7	0.5	14.9±2.7	2.8±0.0	0.5	–0.5±0.0	0.5
L2 LINEAR	3	1.9				9.6±0.1	0.2	8.2±0.1	0.2
L3 LINEAR	170	2.0–2.3	7.3±1.3	0.8c	11.1±4.0	7.4±0.1	0.7	5.8±0.1	0.7
N2 Lynn	291	0.8–2.8	7.8±0.0	0.6	5.1±0.3	7.9±0.0	0.8	7.9±0.1	1.3
N4 LINEAR	10	5.5				2.3±0.1	0.2	–1.4±0.1	0.2
P1 141P/ Machholz (A)	127	0.7–1.2	13.0±0.1	0.8	10.5±1.1	13.0±0.1	0.8	13.2±0.1	0.8
P1 141P/ Machholz (D)	52	0.7–0.9				13.5±0.2	1.1	13.9±0.2	1.2
RO ₂₈ P/ LONEOS	4	1.3				18.3±0.3	0.5	17.8±0.3	0.6
S2 McNaught–Watson	11	7.9–11.1	9.5±2.1	0.4	2.4±2.3	2.5±0.2	0.5	–2.2±0.2	0.7
S3 LINEAR	176	1.9–2.3	9.7±0.9	0.6	3.6±3.3	7.9±0.0	0.6	6.5±0.0	0.6
S4 LINEAR	1032	0.8–4.0	8.9±0.0	0.6	4.7±0.1	8.8±0.0	1.3	8.8±0.1	2.2
T1 McNaught–Hartley	920	1.2–4.5	6.0±0.0	0.5	7.5±0.1	5.4±0.0	0.6	4.4±0.0	1.1
T2 LINEAR	236	3.0–4.9	8.7±0.1	0.6	1.5±1.0	4.3±0.0	0.7	1.6±0.0	0.8
T3 LINEAR	14	5.4–5.8				6.3±0.1	0.3c	2.5±0.1	0.4c
U1 Ferris	10	5.4–5.9				5.8±0.1	0.3c	2.1±0.1	0.3c
U3 P/ LINEAR	16	1.8–2.1				12.9±0.2	0.7c	11.5±0.2	0.8c
U4 Catalina–Skiff	84	4.9–7.3	8.6±1.0	0.5	0.6±1.3	1.7±0.1	0.6	–2.0±0.1	0.8
V1 P/ Catalina	7	2.9–3.2				10.7±0.1	0.2c	8.3±0.1	0.3c
WJ ₇ P/ Korlevic	16	3.2–3.9				8.4±0.2	0.6c	5.6±0.2	0.8c
X1 178P/ Hug–Bell	3	2.4–2.6				13.5±0.2	0.3c	11.5±0.2	0.4c
XB ₆₉ P/ LINEAR	3	1.6–1.8				15.3±0.3	0.6c	14.1±0.4	0.7c
XS ₈₇ LINEAR	6	3.2–3.4				9.3±0.3	0.7c	6.7±0.3	0.7c
XN ₁₂₀ P/ Catalina	3	3.3				9.5±0.1	0.2	6.9±0.1	0.2c
Y1 LINEAR	246	3.1–5.1				4.0±0.0	0.7	1.2±0.1	0.9
4P/ Faye	13	2.0–2.6	4.7±0.5	0.2	20.6±1.3	8.5±0.1	0.5	6.7±0.1	0.3
10P/ Tempel	348	1.5–2.1	6.1±0.3	0.9	26.7±1.7	9.4±0.1	1.0	8.4±0.1	1.0
37P/ Forbes	123	1.4–2.5	10.1±0.2	0.5	10.0±0.8	10.1±0.0	0.5	8.9±0.1	0.6
50P/ Arend	10	1.9–2.2				9.9±0.1	0.3	8.3±0.1	0.3
52P/ Harrington–Abell	438	1.8–2.4	9.5±0.5	0.6	7.4±1.8	8.8±0.0	0.6	7.5±0.0	0.6
59P/ Kearns–Kwee	32	2.3–3.0				8.6±0.1	0.4	6.7±0.1	0.4
60P/ Tsuchinshan	5	1.8				11.6±0.1	0.3	10.3±0.1	0.3
63P/ Wild	26	2.0–2.1				8.9±0.1	0.5	7.4±0.1	0.5
84P/ Giclas	15	1.8–2.3				10.6±0.1	0.4	9.1±0.1	0.4
106P/ Schuster	73	1.5–1.7				11.3±0.1	0.4	10.3±0.1	0.4
135P/ Shoemaker–Levy	3	2.9–3.0				11.5±0.1	0.1c	9.2±0.0	0.1c
140P/ Bowell–Skiff	15	2.0–2.1				10.0±0.0	0.1	8.5±0.0	0.1

b). Linear magnitude parameters

Comet	No.	Days	H1	K1	ΔT	Dev
S3 LINEAR	176	–42 – 112	7.8±0.1	0.0153±0.0016	15.6±3.0	0.5

The magnitude of the comets can be calculated from the standard equation: $m = H1 + 5.0 * \log(\Delta) + K1 * \log(r)$
For most comets there are insufficient observations to calculate K1 accurately and so a value of 10 or 15 is assumed, which gives the constants H10 or H15 respectively. Some comets do not follow the standard equation and are better fitted with a linear equation:

$$m = H1 + 5.0 * \log(\Delta) + K1 * \text{abs}(t - T + \Delta t)$$

where t is the Julian date, T the Julian date of perihelion and Δt an offset.

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

The magnitude equations for 1999 S3 (LINEAR) are poor fits to the light curves. The magnitude equations for 1999 S4 (LINEAR) apply up to perihelion on July 25. The magnitude equations for 52P/Harrington–Abell apply to the period after the outburst, from the beginning of October (T–118) to the end of the apparition (T+111).

helion, giving birth to fragment B and the grand precursor of A. The precursors of A and D and fragments A and C appear to have originated, respectively, ~5 days prior to and right at perihelion. The last breakup episode during that same return to the Sun was the separation of E, probably from the precursor of D, ~600 days after perihelion. The division of D into D_1 and D_2 occurred during the 1994 return.

Werner Hasubick picked up the A component of the comet at 14th magnitude in early November. By early Dec it was around 11th magnitude. The component brightened significantly in the last week of 1999 and reached its brightest of around mag 9–10 in early Jan. It faded quite rapidly and become more diffuse, with Gabriel Oksa estimating it at 11.3 in his 15cm refractor on Feb 1.73, with a 2.5' diffuse coma. The D component perhaps reached 12th magnitude in early December, but was generally several magnitudes fainter and was not reliably seen after mid Dec. The reports that were received may have confused components A and D. Several imagers had success, with Martin Mobberley imaging the comet on Dec 29.75 and Jan 9. David Strange also imaged it on Jan 9.

The absolute magnitude of the comet was around three magnitudes fainter than it was at the previous return, suggesting that the fresh material exposed during the break-up was quickly aging. This trend may have reversed at the 2005 return. There were only two observations, however these suggested a brighter magnitude than indicated by the 1999 lightcurve.

1999 RI (PISOHO)

Douglas A. Biesecker, SM&A Corporation and Goddard Space Flight Center, reported observations of what was presumably a comet, not a Kreutz sungrazer, discovered by Terry Lovejoy in SOHO/LASCO C3 data and later also recognized in earlier C2 data. It was observed from Sept 4.90 to Sept 6.26, reaching 6th mag at best and no tail was detected. [IAUC 7251, 1999 Sept 9] A movie loop showing the comet is available from the Comet Section web page. When 2003 R5 was discovered in SOHO images, several authors suggested a linkage with 1999 R1, and in particular Sebastian Hoenig published a prediction⁶ for the return in 2007. The comet duly appeared as predicted but has not been numbered. It has an unusually short period, and it remains to be determined how this arose.

1999 R2 (142P/Ge-Wang)

Jim Scotti, Lunar and Planetary Laboratory, recovered comet P/1988 V1 (=1988o=1988 VIII) with the *Spacewatch* 0.9m telescope at Kitt Peak on Sept 15.44. The nuclear magnitude m_2 was 22.1. On Sept 15 there was a coma 12" across and a tail extending 0'.53 in p.a. 266°. On Sept 16 the coma diameter was 11", and the tail extended 0'.47 in p.a. 267°. The indicated correction to the prediction by S. Nakano on MPC 27081 was $\Delta T = -5.5$ days. The comet did not become brighter than 19th magnitude. [IAUC 7255, 1999 Sept 17]. The orbit is controlled by Jupiter, but there have been no major encounters in recent times.

1999 RO₂₈ (P/LONEOS)

C. Hergenrother, Lunar and Planetary Laboratory, reported that a co-added 600s CCD exposure with the Steward Ob-

servatory 2.3m reflector on Sept 13 of 1999 RO₂₈ (discovered by LONEOS on Sept 7.33, with details given on MPEC 1999-R23) showed a stellar condensation with a faint 20" tail in p.a. 310°. M. Tichy & J. Ticha, Klet, later reported a faint coma of diameter 8" and 7" on images taken on Sept. 8.93 and 10.02 UT, respectively. Observations by J. V. Scotti with the *Spacewatch* telescope at Kitt Peak on Sept. 15.4 showed a coma diameter of 9" ($m_1 = 18.6-18.7$, $m_2 = 20.6-21.0$) and a 0'.72 tail in p.a. 308°. [IAUC 7253, 1999 Sept 15]. The comet has a 6.5 year period and is a member of the Jupiter family. Discovery took place at a very favourable opposition when it approached within 0.25AU of the Earth. It undergoes frequent encounters with Jupiter which make significant changes to the orbit. The perihelion distance was reduced from 1.9AU to 1.2AU in a 0.06AU encounter in 1874. A further close encounter to 0.05AU in 1957 further reduced it to 1.04AU but a more distant encounter to 0.3AU in 1969 pushed it out again. There is a possibility of an associated meteor shower, which might occur around Aug 30 from a radiant at 288°+14°.

1999 RE₇₀ (176P/LINEAR) = (118401) LINEAR

While monitoring members of the Themis family of asteroids for signs of cometary activity H. H. Hsieh & Dave Jewitt of the University of Hawaii imaged asteroid 118401. Images taken on 2005 Nov 26 with the Gemini North telescope showed a tail 7" long, and confirming images were taken in Dec. The asteroid was found by LINEAR. In 2006 June the Committee on Small Bodies Nomenclature agreed to name and number the comet, although the asteroidal designation will be used for archiving any astrometry.

1999 S1 (SOHO) [Shanklin]

Although just another member of group I of the Kreutz family of sungrazing comets, this one was discovered from the UK. Jonathan Shanklin discovered SOHO-86=1999 S1 on the morning of Sept 17, spotting the object on C3 frames between 15:18 on Sept 16 and 05:18 on Sept 17, which was the last one to be downloaded that morning. It was a moderately bright, though tail-less Kreutz group fragment. When it entered the C2 field of view it had a tail, but it rapidly faded. Shanklin wrote the discovery story for *TA*: *I had been looking at the real-time movies of the LASCO C3 camera (<http://www.sungrazer.com/>...) for several months on an occasional basis and was impressed by the way they show the dynamic activity of the Sun. The University of Cambridge Cavendish Laboratory hosts a 'Physics at Work' exhibition in mid-September, which is designed to get prospective GCSE students enthusiastic about following a career in physics. I usually run an exhibit about work at the British Antarctic Survey (BAS), which shows the students the physics behind measuring ozone in the atmosphere. This year we were asked to put on two exhibits and for a variety of reasons I ended up teaching the students about 'geospace'. I thought it would be a good idea to show them live images of the Sun, so during the exhibition, which ran from Tuesday Sept 14 to Thursday Sept 16, I downloaded the images every morning and showed the current movie loop. There were no comets during this period, but the planet Mercury was visible head-*

Shanklin: The comets of 1999

ing out from superior conjunction. Having packed everything up on Friday morning, I returned to BAS and decided to have a look at the latest sequence from the wide field C3 camera. A quick scrutiny showed a star-like object heading towards the Sun and brightening, but without a tail. I immediately deduced that it was a probable Kreutz group fragment and at 09:41 e-mailed Doug Biesecker of the SOHO–LASCO consortium to inform him of the object, with a copy to Dan Green at the CBAT. Doug sent an email at 12:32, which confirmed that it was a probable Kreutz group fragment and that I was the first to report it. He measured the images and passed the details on to the CBAT, and Brian Marsden was able to compute a preliminary orbit whilst the object was still visible in the coronagraphs. The positions and orbit appeared on MPEC 1999-S04, issued at 15:26 and a note recording the discovery appeared on *IAUC* 7256 at 17:08. The fragment grew a short tail, visible on the C2 frames, but then faded as it dived towards the sun. The last image to show it was taken at 16:54, after which the cameras were shut down so that new software could be loaded.

1999 S2 (McNaught–Watson)

Robert H. McNaught, Australian National University, reported his discovery of a comet on an R survey film taken with the UK Schmidt Telescope by F. G. Watson on Sept 19.72. The comet showed a very strong central condensation, a weak circular coma of diameter 20", and a diffuse tail 3'.5 long in p.a. 210°. Confirming CCD images by McNaught with the 1.0m f/8 reflector at Siding Spring taken on Sept 21.6 yielded $m_2 = 20.1$ –20.2. [*IAUC* 7260, 1999 Sept 21] The comet is intrinsically bright, but very distant with perihelion at 6.5AU.

1999 S3 (LINEAR)

M. Bezpalko reported the discovery by LINEAR of a 16th magnitude comet on Sept 24.34. Additional observations were

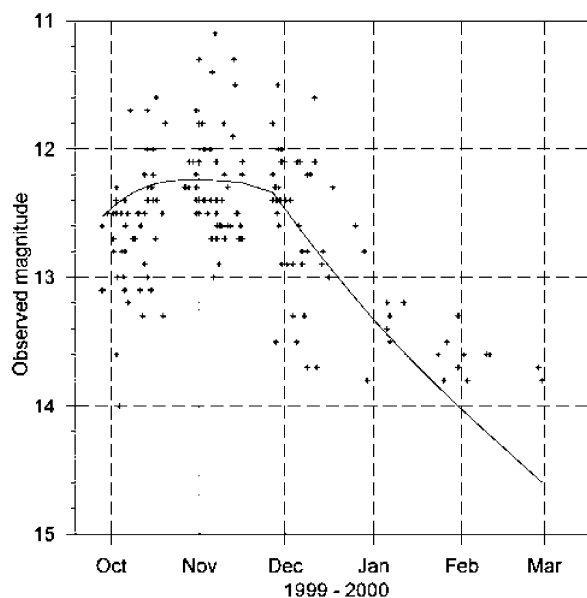


Figure 15. The observed magnitude of comet 1999 S3. The curve is a best fit over the apparition, with no corrections applied, and uses the linear form of the lightcurve. Tick marks indicate the first of each month from 1999 Oct 1.



Figure 16. Comet 1999 S3 imaged by Denis Buczynski.

reported, following posting on the NEOCP, giving m_1 near 13th magnitude. [*IAUC* 7264, 1999 Sept 24]. The comet is a Halley type in an elliptical orbit with a period of 83 years. The comet was closest to the Earth in early October and reached perihelion at 1.9AU in early Nov.

Jonathan Shanklin found the comet relatively easy to see with the Northumberland refractor on Oct 2.8, however its magnitude on the BAA RX And sequence was only 14.0. He could see a star of mag 15.6 on this sequence, rather fainter than he would normally expect to detect. His impression was that the brightness was closer to the 12.5 reported by other observers. Denis Buczynski imaged the comet a week later on Oct 10.9. It was near its brightest in early Nov, with Stephen Getliffe reporting to *TA* that it was 12.1 in his 11cm f/4 reflector on Nov 6.92. It slowly faded and by late Jan had reached around 13.5 according to observations by Werner Hasubick.

1999 S4 (LINEAR)

The most interesting of the 1999 comets was discovered as another unusually-moving asteroidal object by LINEAR on Sept 27.40. The 17th magnitude object was subsequently posted on the NEOCP, and noted to be cometary in appearance by D. Durig (Sewanee, TN, 0.3m f/7 reflector + CCD; coma diameter about 10"; tail about 20"–25" long in p.a. 200–220°) and by J. Ticha & M. Tichy (Klet, 0.57m f/5.2 reflector + CCD; comet diffuse with 8" coma and tail 10" long in p.a. 245°). [*IAUC* 7267, 1999 Oct 1].

Brian Marsden issued several orbital updates during the apparition. Although they 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 were 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 Δ . Some observers 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-

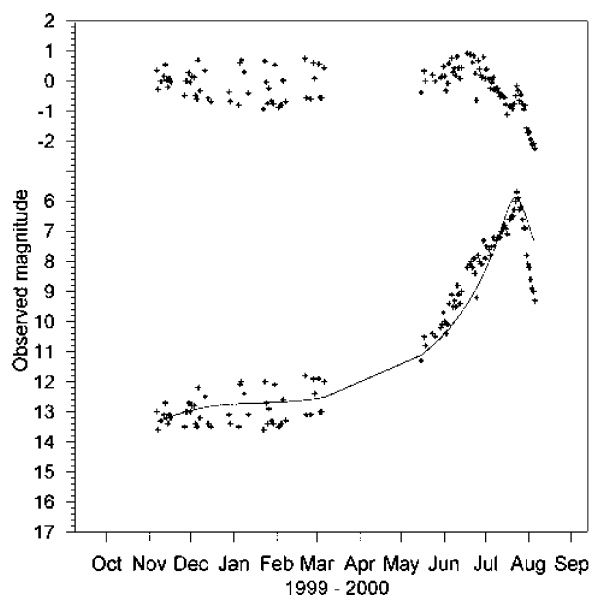


Figure 17. The observed magnitude of comet 1999 S4. The curve is a best fit to daily means over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1999 Oct 1. The residuals from the best fit are shown at top.

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].

On IAUC 7471 [2000 July 30] Z. Sekanina, Jet Propulsion Laboratory, reported: ‘*The unusually large nongravitational forces found by B. G. Marsden suggest that comet 1999 S4 was a trailing fragment of a more massive comet that had 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&A 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 previous 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).*’

Comets making their first visit into the inner solar system often brighten less quickly than expected. Professional astronomers made a wide variety of observations of the comet, issuing preliminary announcements of the results on IAUC, with follow-up papers in the scientific journals. They covered all wavelengths, from X-ray detections, through visible to microwave and radio measurements. These showed highly variable emissions as reported in IAUC. The large non-gravitational parameters combined with the faint absolute magnitude suggest that it was a small variably active object, and estimates indicate that it was perhaps 400m in diameter. Amateur observations suggest that an event just after mid-month

caused a brief brightening of the comet over a week, followed by a more rapid fade, although as noted above the professionals gave a later date for the outburst. Hubble images taken on Aug 5 show that the comet had fragmented into a number of cometsimals, 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 cometsimals. It was an unusual comet, depleted in very volatile material, and its ultimate demise added further knowledge to the physical properties of comets. Gas production declined dramatically after the outburst, and three weeks later the comet was not detectable at all.

Martin Mobberley imaged the comet on 1999 Oct 13.9. Jonathan Shanklin, observing with the Northumberland 30cm refractor, made a tentative visual observation on Nov 6.96, estimating it at about 14th magnitude. David Strange imaged the comet on Jan 23.8. The comet remained a faint object and went into solar conjunction in March.

Seiichi Yoshida reported a negative CCD observation on April 28, implying that the comet was fainter than at least 11th magnitude. Kenichi Kadota succeeded in recovering the comet on May 4, when he estimated it at 13.0, though at very low altitude. Nicolas Biver observing from Hawaii made a series of observations through May, but it remained hidden from European locations. Several observers recovered it at the beginning of June with Carlos Segarra reporting it at 10.5 visually.

Jonathan Shanklin picked up the comet from a rural site in his 20cm LX200×75 on June 7.05, when it was mag 9.9, DC3, coma diameter 1'.1. He did not see it again for 34 days due to a lengthy spell of cloudy weather over eastern England. By the end of the month it was significantly brighter, with Gabriel Oksa reporting it at 7.8 in his 15cm refractor on June 30.02. It had brightened a little more by mid July, with Roy Panther making it 7.2 in 15×70B on July 15.02. It was around this time

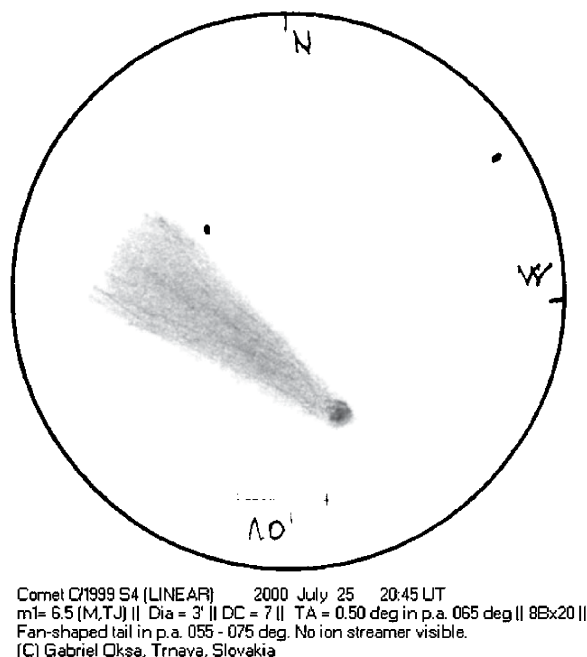


Figure 18. Comet 1999 S4 drawn by Gabriel Oksa.

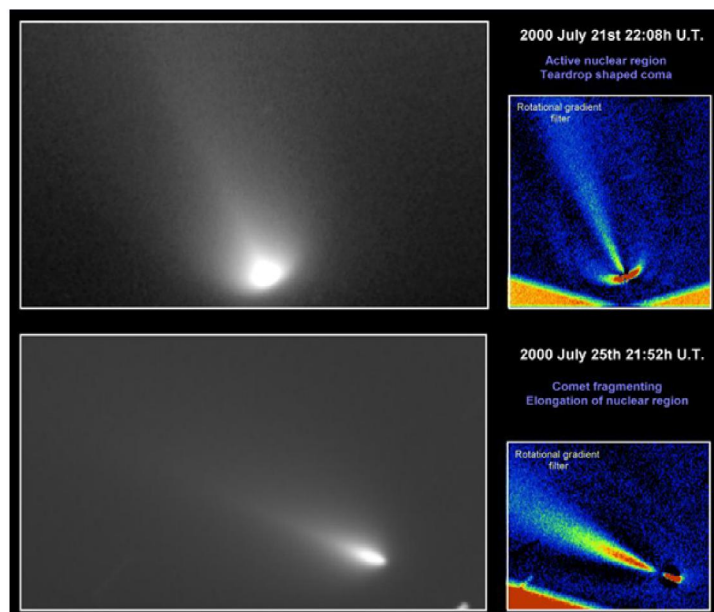


Figure 19. Comet 1999 S4 imaged by David Strange.

that the events leading to the final demise began, although there are indications in the lightcurve that a slow decline may have begun at the beginning of the month. Shanklin noted that on July 16.9 the comet had brightened to 6.8 in 20×80B despite the nearly full Moon. It was a similar magnitude on July 18.9 and 19.9, but was markedly brighter on July 21.9 than it was on July 20.9 with a prominent stellar condensation. Observations with 8×30B on July 21.9 gave a mag of 6.0, suggesting it could be seen with the naked eye from a really dark site. The comet peaked in brightness over the next few days, but then began to fade and became very diffuse. By July 29 it was around 7th magnitude, and still moderately condensed at around DC4. The next day it was mag 8 and DC2. Only a few more observations were received, the last being by Michael Mattiazzo who made it around 10th magnitude in his 20cm reflector on Aug 6.40.

CCD observers were very active. Rolando Ligustri imaged it with a CCD on June 1 when it was 9.9. Martin Mobberley imaged the comet on June 22 when it was about 9th mag and other BAA imagers including Denis

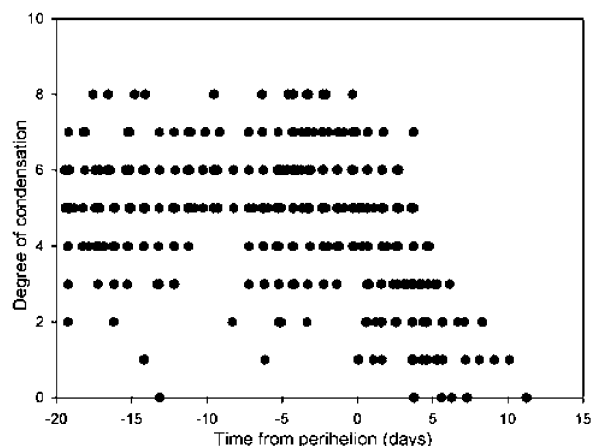


Figure 20. The DC of comet 1999 S4 in the last month of its life.

Buczynski, John Fletcher and Nick James contributed series of images. David Strange and Gabriel Oksa also imaged it on July 25 as it fragmented. Maurice Gavin imaged the comet on July 16 and obtained a spectrum.

Although the impression of most observers was that the fading began at around the time of perihelion, the lightcurve showing the daily mean magnitude, which includes the residuals, gives a rather different picture. Here the fading clearly begins around a month before perihelion, and instead of being sudden, the fade is remarkably steady, although there is a suggestion of a slight outburst around the time of perihelion.

The observed coma diameter increased towards the time of perihelion, but as with other comets there is much scatter. Its largest extent was a little over 300,000km. There is no clear pattern to the reported degree of condensation, however the final ten days of observation do show a dramatic decline from around 6 to 0 as the comet fragmented.

1999T1 (McNaught–Hartley)

Robert H. McNaught, Research School of Astronomy and Astrophysics, Siding Spring Observatory, reported his discovery of a 15th magnitude comet on a plate taken by Malcolm Hartley with the 1.2m UK Schmidt on Oct 7.64. The strongly condensed comet showed a 8" coma and a very faint 1' tail in p.a. 320°. [*LAUC* 7273, 1999 Oct 11].

As with many relatively bright comets the professional astronomers studied it at a range of wavelengths, reporting preliminary results in the *LAUC*. An interesting result was the relatively high production rate of CO in comparison to water, though different groups disagreed over the absolute amount (20–40%). Silicates were detected by some groups.

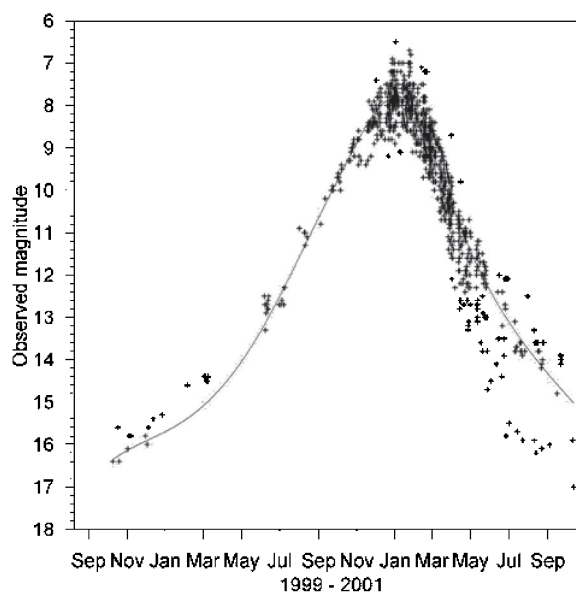


Figure 21. The observed magnitude of comet 1999 T1. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1999 Sept 1.

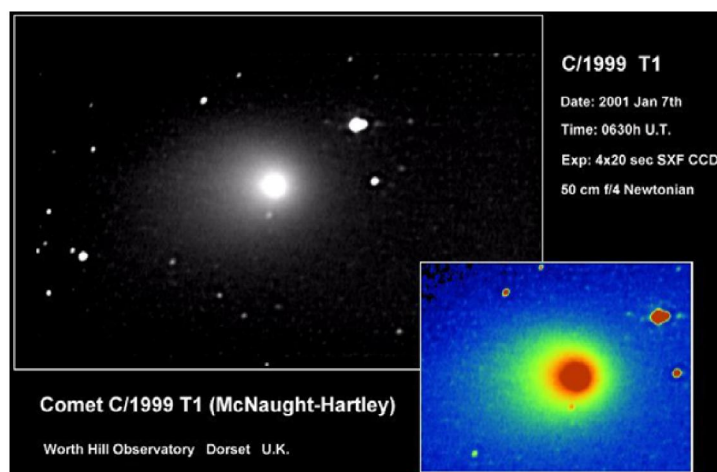


Figure 22. Comet 1999 T1 imaged by David Strange.

Initially a Southern Hemisphere object, Stuart Rae observed the comet at around 14.5 in March, before it went into solar conjunction. Michael Mattiazzo, Andrew Pearce and Rae recovered the comet at around 13th magnitude in early June. It was 12.7 when Stuart Rae observed it on July 7.7 with his 25cm reflector. Observations from Andrew & Michael Mattiazzo in Sept made it a little brighter than 10th magnitude. Jonathan Shanklin was able to observe it from the Falkland Islands on Nov 19 and 20. A gusty wind and ever brightening sky made observation difficult, however he located the 8th magnitude comet in his portable short focus 90mm refractor, noting a distinct central condensation in a 4' diameter coma. Veteran comet observer Albert Jones estimated it at 8.1 in his 78mm refractor $\times 30$ on Nov 26.6. It was brighter than 8th magnitude during Dec and Jan, and had also moved north, allowing European observers sight of the comet. John Vetterlein observed it in 20 $\times$ 80B on Christmas morning, estimating it at 7.5. It was at its brightest in early Jan, roughly a month after perihelion. Shanklin viewed the comet again on Jan 23.20 after his return to the UK when it was an easy binocular object at 7.9. In mid-Feb, Gabriel Oksa estimated the magnitude at 8.7 in 20 $\times$ 80B. By early March it had become much more diffuse and was around 9th magnitude. Werner Hasubick observed the comet in his 44cm reflector on March 24.91 at an estimated 11.9. Visual observations continued into Sept, but these were largely restricted to European observers in rural locations who possessed large aperture telescopes.

Both the observed and true coma diameter increased until a little after perihelion, when it was perhaps a little over 600,000km in size. The reported degree of condensation was rather scattered prior to perihelion, but afterwards declined from around DC5 near perihelion.

1999T2 (LINEAR)

F. Shelly reported the discovery by LINEAR of an 18th magnitude comet on Oct 14.16. Additional observations were reported following posting on the NEOCP [IAUC 7280, 1999 Oct 14].

K. Hornoch, Lelekovice, Czech Republic, reported observations (0.35m reflector + CCD) of an antitail on several oc-

casions during April and May: April 24.89 UT, 4'.0 long in p.a. 51°; May 10.92, 3'.0, 46°; 20.95, 5'.0, 57°; 24.94, 7', 50°. The main tail ranged from 1'.1 in p.a. 150° on April 24 to 1'.5 in p.a. 175° on May 20; on May 24 there was a second broad tail 1'.8 long in p.a. 104°, a very bright 0'.6 jet in p.a. 270° and a much fainter 0'.5 jet in p.a. 200°. CCD observations by J. Manteca, Barcelona, Spain (0.31m Schmidt-Cassegrain), on May 23.00 put this comet at $R = 15.0$. [IAUC 7633, 2001 May 25]

For a faint, distant comet this one was relatively well observed, and over two oppositions. The comet reached perihelion in Nov 2000 but reached 13th magnitude in the late summer. Denis Buczynski imaged it on 2000 May 31.04, and Jonathan Shanklin estimated it as fainter than 13.1 around the same time, which Denis' image confirms. Rolando Ligustri imaged the comet on Aug 26. Pepe

Manteca imaged the comet several times during Aug and Sept. Shanklin observed the comet again on Sept 26.8 and estimated it at 13.6, with a small, moderately condensed coma. The comet was still on view during the next oppositions and on 2001 April 24 Shanklin was able to see the comet clearly in the Northumberland refractor, estimating it at 13.5. It was a similar magnitude when Werner Hasubick observed it with his 44cm reflector towards the end of June.

1999T3 (LINEAR)

Linkage at the Minor Planet Center of observations by LINEAR on several nights during Oct 3.34–21 revealed an 18th magnitude object with a nearly-parabolic retrograde orbit. This orbit also represented a single-night detection of an object by E. W. Elst & S. Ipatov at Uccle on Oct 18. Following placement of an ephemeris on the NEOCP further observations were made on Oct 24 and 25. In response to enquiries, Elst remarked

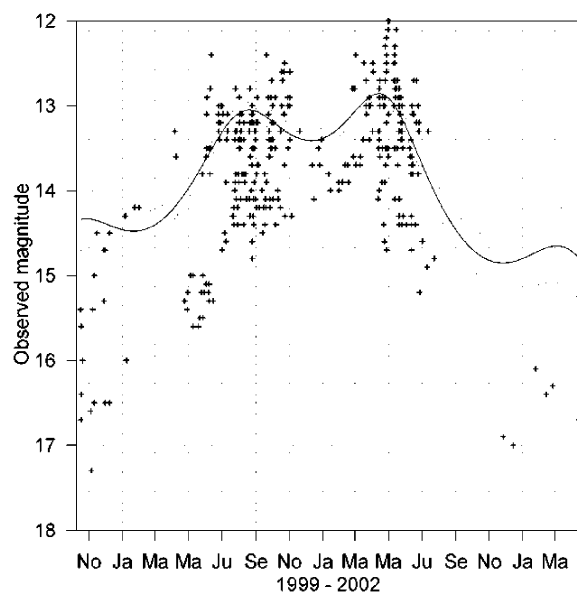


Figure 23. The observed magnitude of comet 1999 T2. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1999 Nov 1.

Shanklin: The comets of 1999

that the object was diffuse and had a possible tail to the north; J. Ticha & M. Tichy, Klet, reported the object as slightly more diffuse than stars of comparable brightness and deduced a coma size of 9"; and D. Durig, Sewanee, TN, in poor conditions (strong wind, full Moon), also noted the object's diffuse appearance. [IAUC 7289, 1999 Oct 25]. The comet was a distant one and did not get any brighter.

1999 U1 (Ferris)

LONEOS (0.59m Schmidt+CCD) reported the discovery of a 17th magnitude comet on Oct 18.38. Additional observations were reported following posting on the NEOCP [IAUC 7283, 1999 Oct 18]. The comet was at perihelion in 1998 and faded.

1999 U2 (SOHO) [Gregory–Shanklin]

Doug A. Biesecker, SM&A Corporation and Goddard Space Flight Center, reported observations of a comet (not a Kreutz sungrazer) discovered independently by S. Gregory (Stanford University) and by J. D. Shanklin (Comet Section, British Astronomical Association) in SOHO/LASCO C3 data. The comet was very faint, and not visible in very many frames. It was first visible on Oct 25.21 and remained visible until Oct 25.74. [IAUC 7292 and MPEC 1999-U29, 1999 Oct 28]

The author provided this account for *The Astronomer*: *Following my first discovery (1999 S1) I kept looking at the SOHO movies. Several more faint comets had been discovered, but I could not spot these on the movies. On Oct 15 I spotted a moving object and excitedly started preparing an email, but fortunately did a final check using Megastar and found that I had discovered Vesta. On Oct 26.35 I downloaded the movie and after carefully scanning the field spotted a faint moving object, tracing a semi-circular arc close to the Sun, clearly not an asteroid or a Kreutz group comet. I feverishly composed an email to Doug Biesecker, Brian Marsden and Guy Hurst, giving rough positions and an estimated magnitude (7) and sat back to wait. It was a much longer wait than my first discovery. A message from Doug that I read on Wednesday morning said that the comet had been discovered by Sarah Gregory (Stanford University) and might be the same object as discovered by Terry Lovejoy in early Sept (1999 R1). This had a published orbit, so I did some calculations using Kepler's laws. From the period of 50 days I calculated the semi-major axis, then the eccentricity and the aphelion distance, which came out at 0.5AU. This would correspond to an elongation of 25° from the Sun, and plugging in the discovery magnitude I found a likely brightness of 16 – 17th magnitude. At the BAA meeting that evening I gave an account of the discovery and said that perhaps Vulcan had been discovered, though of course this object would be far too small to be seen in transit across the Sun.*

There was still nothing on Thursday, but on Friday morning IAU Circular 7292 was out, announcing that I was co-discoverer of 1999 U2. Although the observational circumstances are very similar to those of 1999 R1, the orbits have very different spatial orientations and it seems unlikely that these objects are related. I now have two discoveries, so I need a third to prove that these were not flukes (or does

Vesta count as an independent discovery? – certainly I did not know it was there). Meantime there is the challenge of the supernova search group – who will make the next TA discovery?

Comet 2005 W5, found by Hua Su and Rainer Kracht in SOHO C2 images on 2005 Nov 29 was linked to the comet, which is another member of the Marsden group. Rainer Kracht found more objects later in 2005 and further developments are likely.

1999 U3 (P/LINEAR)

R. Huber reported the discovery by LINEAR of an 18th magnitude comet on Oct 30.32. Additional observations were reported following posting on the NEOCP [IAUC 7295, 1999 Oct 31]. The comet is a member of the Jupiter family, although there have been no recent close approaches to the planet. An encounter to 0.6AU in 2008 will push out the perihelion distance a little from its present 1.8AU.

1999 U4 (Catalina–Skiff)

On Oct 31 T. B. Spahr, Lunar and Planetary Laboratory, reported the discovery by the Catalina Sky Survey on Oct 31.25 of a slow-moving 17th magnitude object that was independently discovered on Nov 1.28 by B. A. Skiff (measurer B. W. Koehn) of the LONEOS survey. In response to Skiff's alert, R. L. Millis & L. H. Wasserman, on a 5-min R-band exposure with the Perkins 1.8m reflector, detected a coma extending 8" south-eastward from the nucleus. After a posting in the NEOCP, M. Tichy & Z. Moravec, Klet, also reported that the object had an 8" coma [IAUC 7298, 1999 Nov 1]. The object was very distant with perihelion at 4.9AU in 2001 Oct, but remained visible until mid 2002, reaching nearly 13th magnitude at its brightest. Pepe Manteca imaged the comet on Aug 25.

1999 VI (P/Catalina)

C. W. Hergenrother, Lunar and Planetary Laboratory, reported the discovery of another comet, of 18th magnitude, by the Catalina Sky Survey on Nov 5.44. [IAUC 7302, 1999 Nov 7] The comet was close to perihelion and in a distant periodic orbit of 17 years. It is a member of the Saturn family and approached the planet to 0.15AU in 1991 January in an encounter that reduced the perihelion distance from 3.5 to



Figure 24. Korado Korlevic at Višnjan Observatory in 2000. Photo by Rino Gropuzzo, GNU Free Documentation License.



Figure 25. Farpoint Observatory, where Gary Hug & Graham Bell discovered comet 178P/Hug–Bell. © Northeast Kansas Amateur Astronomers' League

2.9AU. With a Tisserand parameter of 4.43 it is also within Jupiter's sphere of influence.

1999 WJ₇ (203PI/Korlevic)

An apparently asteroidal 18th mag object discovered on Nov 28.94 by Korado Korlevic at Visnjan with a 0.41m f/4.3 reflector + CCD was indicated on some of his Dec images to be possibly 'fuzzy', and the cometary nature was confirmed by C. Hergenrother & S. Larson, Lunar and Planetary Laboratory, who found a 13" coma elongated in p.a. 80° on a 600s co-added R-band exposure taken on 2000 Feb. 7.25 UT with the 1.54m Catalina reflector. The comet has a perihelion distance of 3.2AU and a period of ten years. [IAUC 7368, 2000 Feb 18]. The comet is a member of the Jupiter family, and an encounter to 0.2AU in 1997 Oct reduced the perihelion distance from 3.9 to 3.2AU and made significant changes to the angular elements. The comet was numbered following its recovery in 2008.

1999 XI (178P/Hug–Bell)

Amateurs Gary Hug & Graham E. Bell, Eskridge, KS, reported their discovery of a 19th magnitude comet on Dec 10.33, showing a faint tail in p.a. 285° on CCD images taken with a 0.3m Schmidt–Cassegrain reflector during the course of their minor planet search and follow up program. Following posting on the NEOCP, L. Sarounova (Ondrejov, 0.65m reflector) obtained observations on Dec. 11.2 UT showing a tail 20" long in p.a. about 300°. C. Hergenrother, Lunar and Planetary Laboratory, reported that a co-added 1200s R-band image obtained with the 1.54m Kuiper telescope on Dec 11 showed a 15" coma and a slightly curved tail 1' long in p.a. 280°. All of the available astrometry (including predisccovery observations on Oct 10 and Dec 7 by LINEAR) gives elliptical orbital elements, with perihelion in June and a perihelion distance of 1.9AU. [IAUC 7331, 1999 Dec 11]. The comet is a member of the Jupiter family. An encounter to within 0.7AU in 1922 made only minor changes to the orbit. The comet was numbered following its recovery in 2006.

1999 X3 (SOHO) [Su]

This was a non-group comet discovered in archival C2 images by Hua Su in May 2006.

1999 XB₆₉ (P/LINEAR)

An apparently asteroidal, 18th magnitude object discovered by LINEAR on Dec 7.29, with a comet-like orbit was observed by C. Hergenrother, Lunar and Planetary Laboratory, on Feb 27 with the Catalina 1.54m reflector to show a 5" coma and a 10" tail in p.a. 80°. The comet is intrinsically faint, with a perihelion distance of 1.6AU and a period of 9.4 years. [IAUC 7370, 2000 Feb 29]. The comet is a member of the Jupiter family. An encounter to 0.4AU in 1998 April made no major changes to the elements.

1999 XS₈₇ (LINEAR)

An object that was assumed to be asteroidal was found by LINEAR on 1999 Dec 7.38 and 8, and it was later linked to observations by LINEAR on 2000 Jan 6 and 7 by G. V. Williams, Minor Planet Center. Following a request from the Minor Planet Center after seeing that the orbit appeared comet-like, M. Tichy & Z. Moravec obtained observations at Klet on Jan 11 and 12 that showed this object to be diffuse with a coma diameter of 15". [IAUC 7344, 2000 Jan 12] The comet is in a long-period orbit (73 years) and was at perihelion in 1999 Aug at 2.8AU. Although the period is similar to that of Halley's comet, it is not a Halley-type object as the inclination is low and the Tisserand parameter is 4.58.

1999 XN₁₂₀ (P/Catalina)

An apparently asteroidal, 17th magnitude object with a comet-like orbit discovered on Dec 5.19 by the Catalina Sky Survey was also observed by Hergenrother on Feb 27 with the 1.54m reflector to show a 12" coma but no tail. The comet has a perihelion distance of 3.3AU and a period of 8.5 years. [IAUC 7370, 2000 Feb 29]. This is yet another member of the Jupiter family of comets. A very close encounter to within 0.02AU in 1996 Sept reduced the perihelion distance from 5.9 to 3.3AU and made drastic changes to the angular elements. The origi-

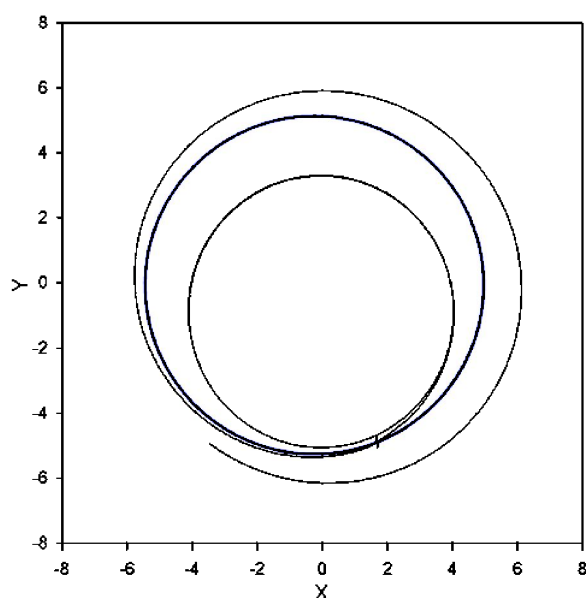


Figure 26. The orbit of comet 1999 XN₁₂₀ projected onto the XY plane of the solar system. The first point is on 1980 Jan 1. The orbit of Jupiter is shown in blue, and the position of the comet at the time of the close encounter in 1996 Sept is shown by a short vertical line.

Shanklin: The comets of 1999

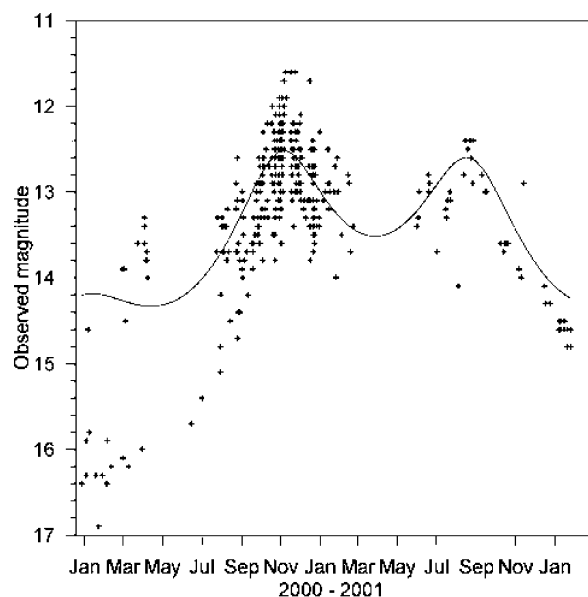


Figure 27. The observed magnitude of comet 1999 Y1. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 2000 Jan 1.

nal near-circular orbit was pulled inwards towards a more elliptical one. A further encounter in a century's time will move the perihelion outwards again.

1999 Y1 (LINEAR)

A 17th magnitude object with unusual motion and reported as asteroidal by LINEAR on Dec 20.22 was found to be cometary in appearance following posting on the NEOCP. Z. Moravec, Klet, reported that the object appeared slightly diffuse with a possible coma of diameter about 10" on images taken in poor seeing on Dec 21 and 22. G. Billings, Calgary, AB, reported an apparent nebulosity of diameter about 12" on Dec 23 CCD images taken with a 0.36m reflector, and he noted a faint tail about 20" long in p.a. 70° on Dec 27. S. Nakano, Sumoto, Japan, reported that H. Abe (Yatsuka, 0.26m reflector) found the comet to be evidently diffuse, T. Kojima (Chiyoda, 0.25m reflector) found a 10" coma and a short tail toward the northeast, and T. Oribe (Saji Observatory, 1.03m reflector) found a 20" coma and a 30" tail in p.a. 60°, all on Dec 27. A. Nakamura, Kuma, Japan, found coma diameter 0'.35 and a faint tail in p.a. 60° on Dec 27 (0.60m reflector). [IAUC 7338, 1999 Dec 27]. The orbit was parabolic with perihelion at 3.1 AU in 2001 March.

The comet had a long period of visibility, with observers estimating it between 12th and 14th magnitude from 2000 Aug to 2001 Nov. Pepe Manteca imaged the comet on Aug 10, Aug 18, Aug 25. Some visual observations brighter than 14th magnitude were reported in the first half of 2000, however the initial regression of the visual observations does not then give a physically realistic result. This possibly indicates that some of these observations, perhaps made towards the visual limit, were illusory.

1999 Y2 (SOHO) [Cernis]

Kazimieras Cernis, Vilnius, Lithuania, discovered an apparent comet at about magnitude 5 on SOHO images taken on

1999 Dec 28.28 that were posted on the SOHO website. D. A. Biesecker, SM&A Corporation and Goddard Space Flight Center, reported that the comet was visible on both LASCO C2 and C3 images and that no tail was detected. Astrometric measurements by Biesecker and D. Hammer (University of Maryland), reduced by Marsden, appeared on MPEC 2000-A36, together with parabolic orbital elements ($q=0.048$ AU, $i=111.4^\circ$), showing that the comet was not a Kreutz sungrazer. Magnitude reductions by Biesecker and Hammer show that the comet faded from magnitude 6.1 to 6.8 during Dec. 28.58–28.79, and thence from view while still in the C3 field. [IAUC 7343, 2000 Jan 10]. The comet should have still been brightening at this point, implying that its volatiles had probably been exhausted.

Kazimieras Cernis provided the following information about the discovery: *I discovered this comet due to your (Jonathan Shanklin) two discoveries and information which helped me when looking at CCD images. The object in C2 was difficult to detect at 1024×1024. I say that because I detected independently SOHO-94 with a bright tail after A. Vourlidis without problem on Dec 21. C/1999 Y2 was without tail and its brightness was similar to Sgr24 in the orange filter (about 5 mag). Then I discovered SOHO-95 at C3 images (from Dec 27 23 hours) and sent more than 20 positions to B. Marsden. D. Biesecker did not reply to me for 6 days. It was the holiday period. If the comet has an absolute magnitude about 18, it could be detectable with CCD in our evening sky at 15.5 mag with an elongation about 40° before bright moonlight comes later in January.*

The numbered periodic comets at perihelion in 1999

4P/Faye

The comet was discovered in 1843 and reached 5^m, though this has never been reached at subsequent returns. It is possible that this was a one-off caused by a slight reduction in perihelion distance from 1.8 to 1.7 AU following a close encounter with Jupiter in 1841. Several authors have suggested that the absolute magnitude of the comet is declining rapidly, but it reaches a similar magnitude at all favourable apparitions.

This return was a poor one, with the comet reaching perihelion in May, when it was in solar conjunction. A few visual observations were received in the latter half of 1998, and one in Jan 1999, suggesting that the comet was at that time brightening from 15th to 13th magnitude.

10P/Tempel

William Tempel (Milan, Italy) discovered the comet as a 9th magnitude object in 1873. Several unfavourable returns were missed in the earlier years and this was its 20th observed return. With a 5.5 year period alternate returns are favourable and this was one of them. It was closest to the Earth in July (0.65 AU), but was at its brightest in August, a little before perihelion. The orbit is very stable, which is

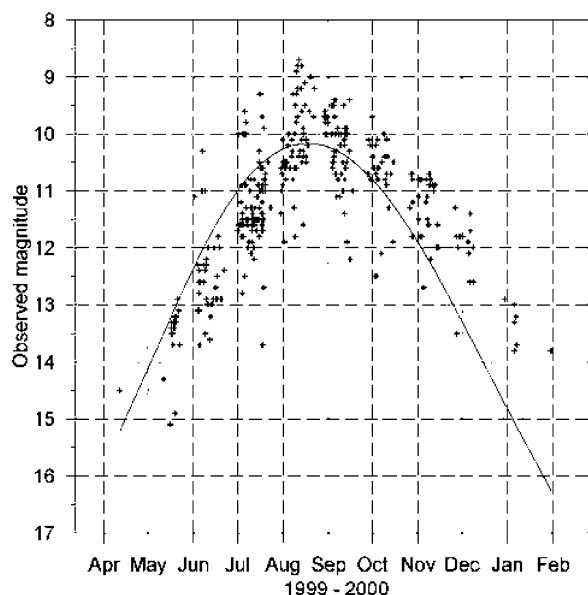


Figure 28. The observed magnitude of 10P/Tempel. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1999 April 1.

one reason why it is a favoured target for planned spacecraft missions. In 1983 the *IRAS* satellite detected an extensive dust trail both ahead and behind the comet, stretching around half an AU in length and estimated to be several hundred years old.

Traditionally the light curve is regarded as highly asymmetric with a late turn-on. There is a rapid rise in brightness as perihelion approaches, which continues more slowly for a couple more weeks after perihelion, followed by a slow decline until activity switches off. An alternative view is that the light curve is linear with a peak about a month after perihelion, which at this return occurred in early 1999 September.

The comet crept into visual range during April and May, but it was June before significant numbers of observations were reported. By this time it was brightening from 13th to 12th magnitude. David Strange obtained an image of the comet on July 10, but visual observers found it a difficult target. Jose Carvajal estimated it at 10.6 in a 32cm reflector on Aug 5.9, but Jonathan Shanklin was unable to see it with the 20cm Thorowgood refractor on the same night, perhaps because the Cambridge sky glow was outshining the diffuse coma. On Aug 10.9 Andrew Pearce and Shanklin observed it with 14×100B from just outside Penzance, Cornwall. Shanklin's estimate was 8.7 (HS) and Pearce made it a little fainter. Back in Cambridge it was a very difficult object in the 0.20m refractor, though it was observed during the International Workshop on Cometary Astronomy that took place following the total eclipse. At the end of August Andrew Pearce, now back in Australia, reported that the comet had faded to near 10th magnitude. It faded slowly and was still 12th magnitude in December.

The general consensus between observers was that the coma diameter increased to around 4' around the time of perihelion and then declined, however a discordant group of observations suggests a diameter of 5' to 6' prior to perihelion. Overall however, this indicates that the coma size in-

creased from around 40,000km four months from perihelion to 120,000km two months after perihelion. There appears to be little change in the DC during the course of the apparition, with it remaining around 3.

37P/Forbes

Discovered in 1929 by A. F. I. Forbes during a routine comet search with a 0.20m reflector from Hermanus, South Africa, the comet's orbit has been fairly stable this century. An encounter with Jupiter in 1990 started progressive changes, though there is little immediate change in the perihelion distance. At a good return the comet can be a 10th magnitude object. This return was fairly good and the comet was comparatively well observed, reaching 11th magnitude in June.

50P/Arend

Silvio Arend discovered this comet at the Royal Observatory, Uccle, Belgium in 1951 during a routine minor planet patrol with the 0.40m Zeiss double astrograph. The return was about the best possible and even then the comet only reached 14m. The period of the comet lies at the 2/3 commensurability with Jupiter and thus encounters the planet after every third perihelion passage. The latitude of perihelion is quite large at 12° and the orbit has remained relatively undisturbed since the 18th century. This apparition was not a good one, however a few observations were received, but the comet was never brighter than 14th magnitude.

52P/Harrington-Abell

The comet reached perihelion and opposition in late January. This was the seventh observed return of the comet since its discovery in 1954 and it had never become brighter than 17th magnitude at previous returns. Professional estimates put the nucleus at two to three kilometres in diameter. Normally it would not have been expected to get brighter than 15th magnitude at this return, however it was found in out-

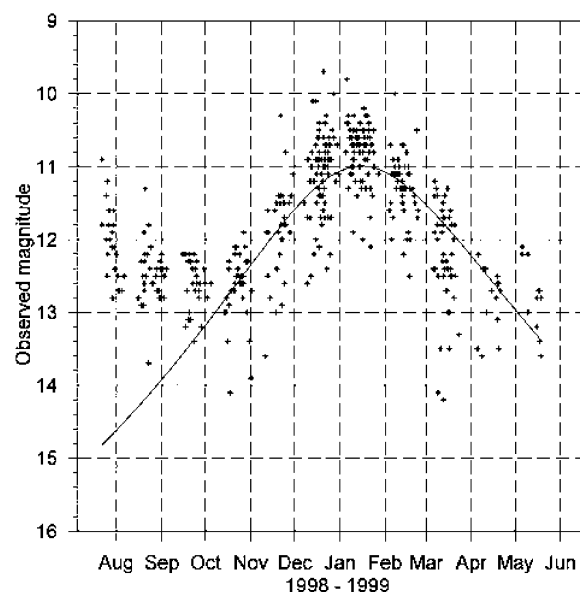


Figure 29. The observed magnitude of 52P/Harrington-Abell. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1999 Aug 1.

Shanklin: The comets of 1999

burst at 12th magnitude by Alain Maury, Observatoire de la Côte d'Azur, on CCD images taken on 1998 July 21.1 UT when its predicted magnitude was about 21. [IAUC 6975, 1998 July 25]. No fragments were detected after the outburst, suggesting that in this case a new area of the surface commenced outgassing.

Following the outburst, the comet slowly faded during Aug and Sept. Jonathan Shanklin and Werner Hasubick estimated it at around 12.5 in Aug. It began to brighten again in Oct, and thereafter had a relatively normal linear light curve peaking at around 10th magnitude a couple of weeks before perihelion. It was fading by mid-Jan, Attila Kosa-Kiss reporting it at 10.7 in his 63mm refractor on Jan 17.7. Shanklin glimpsed it a few times in mid-March with the Northumberland refractor, making it around 13th magnitude. Observing on April 9/10 with the Northumberland refractor he could not see the comet, estimating it fainter than 13.8. NGC 2455 which lay nearby was clearly visible and estimated at 13.1 compared with the catalogued magnitude of 13.2. Other observers, who normally report magnitudes brighter than average, estimated the comet at 13th magnitude into May.

The light curve shows the comet fading at around 0.0087 magnitudes per day after the outburst, until this was overtaken by a relatively normal brightening in Oct, when the comet was around 2.0AU from the Sun. This suggests that perhaps two different processes were at work – a one-off event that created the outburst, combined with the normal processes that go on in a comet. If so, this gives a rather steeper $\log(r)$ parameter of 20, with a correspondingly bright absolute magnitude. The following return in 2006 was unfavourable and no visual observations were received.

The coma diameter decreased after the first outburst from around 2' to 1' and then increased again to 3' at its largest

59P/Kearns–Kwee

During a search for the then lost comet 11P/Tempel-Swift, E Kearns and K K Kwee discovered a suspect object on Palomar plates taken on 1963 Aug 17. Once the orbit of the new object was refined it became clear that the comet had passed only 0.03AU from Jupiter on 1961 Nov 13, before which it had a longer period with perihelion at 4.4AU.

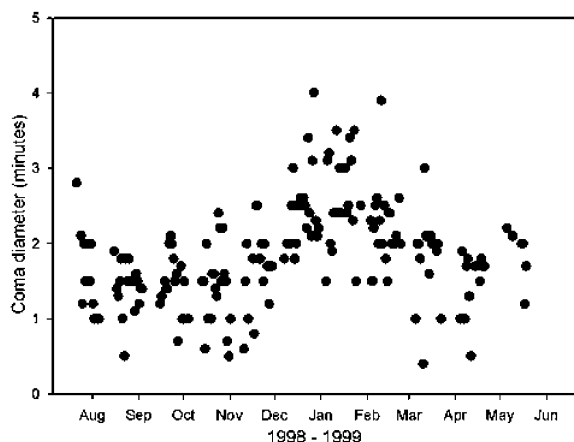


Figure 30. The coma diameter of comet 52P/Harrington–Abell.

It had a rather unfavourable return in 1999, but a few observations were made in Jan, when it was fading from a peak of around 14th magnitude in the previous autumn.

60P/Tsuchinshan

This was the second of two comets discovered at the Purple Mountain observatory in China in 1965 Jan. These were the earliest comets named for the observatory where they were discovered, something that has become almost routine with the multitude of Catalina, LINEAR, LONEOS and *Spacewatch* finds. An encounter with Jupiter in 1962 Jan reduced the perihelion distance from 1.9 to 1.8AU, and another encounter in 2009 will reduce it again to 1.6AU.

Although a few visual observations were made, no estimates put the comet brighter than magnitude 14.5.

63P/Wild

Paul Wild discovered this, his first periodic comet, on 1960 March 26 from the Berne Observatory in Switzerland. The discovery return was quite favourable and the comet reached 14th magnitude.

Nakano reported observations made by T. Kojima, Chiyoda, on Oct 24.83 of this 13-year-period comet, missed at its 1986 return. These observations confirmed a single-night detection at magnitude 22.4 by Hergenrother (1.5m Catalina reflector) on Feb 14. The prediction on MPC 27082 required a correction by $\Delta T = -0.35$ day. Further details were given on MPEC 1999-V18. Kojima (0.25m f/6.3 reflector) reported the comet at $m_1 = 16.5$ and as diffuse without a tail on Oct. 24, at $m_1 = 15.9$ and diffuse with condensation and a coma diameter of 30" on Nov 4. [IAUC 7302, 1999 Nov 6].

It was a difficult object of around 14th magnitude in the Northumberland refractor on Jan 5 and reached its brightest at around 13th magnitude towards the end of the month.

84P/Giclas

This was the comet's fourth observed return since its discovery in 1978 by Henry Giclas of the Lowell Observatory. The perihelion distance is fairly constant at present and Jupiter encounters only make significant changes to the angular elements. However around 2300, a low velocity close encounter with Jupiter will transfer the comet to an orbit outside that of the planet.

It reached 14th magnitude in the autumn of 1999 and a few visual observations were reported.

102P/Shoemaker

The comet was discovered at the very favourable return in 1984, following a close approach to Jupiter in 1980 which reduced the perihelion distance from 3.8 to 2.0AU. In 1984 it reached 11^m, but no observations were received at the 1991 return, even though it was expected to reach 12th magnitude. This was a poor apparition of the comet and it was in solar conjunction when at perihelion. No observations or images were received.

105P/Singer Brewster

The comet was discovered in 1986 after a close approach to Jupiter a decade earlier that had reduced the perihelion

distance to 2AU. No visual observations were reported at this return.

106P/Schuster

The comet was discovered in 1977 Oct at La Silla, though a month earlier it had been recorded as an asteroid. The orbit is relatively stable. It was not seen at its second return, which was unfavourable. This was its third observed return and it remained at 13–14th magnitude from late Oct into Jan.

135P/Shoemaker–Levy

This comet was recovered in 1998 as 1998 B1 and was described with the comets of that year.⁷

136P/Mueller

This comet was recovered in 1998 as 1998 K4 and was described with the comets of that year.⁷

140P/Bowell-Skiff

This comet was recovered in 1998 as 1998 X2 and was described with the comets of that year.⁷

162P/Siding Spring

This comet was discovered as a 14th magnitude object by Rob McNaught during the Siding Spring Survey on 2004 Oct 10.55. It was linked to objects seen in 1990 (by the Palomar Sky Survey), 2000 (by LINEAR and LONEOS) and by ESO, AMOS and NEAT in following years. Full details will be given in the paper on the comets of 2004.

171P/Spahr

This comet was discovered in 1998 as 1998 W2 and was described with the comets of that year.⁷ It was numbered following recovery in 2005.

Other comets at perihelion in 1999

Many comets were discovered with the SOHO LASCO coronagraphs and were not observed elsewhere. The majority were sungrazing comets of the Kreutz group and were not expected to survive perihelion. 1999 K1 was one of the brighter objects. On May 20.47 UT, the comet was about 11 solar radii from the Sun and showed a tail; on May 20.51 it was mag 6.8. A standard magnitude prediction suggested it could reach –4 magnitude, however as with most of the Kreutz group fragments it faded as it got closer to the Sun. Some of the comets show no tail at all and it is possible that some supposed observations of Vulcan were actually tiny Kreutz group comets. Table 5 lists the *IAUC* announcing the Kreutz comets and those of the Marsden and Meyer groups not previously mentioned.

Information about the latest SOHO discoveries is available from the SOHO comet web page at <http://ares.nrl.navy.mil/sungrazer/>. SOHO experienced a malfunction on 1998 June 25 and contact with it was lost. It was located by radar on July 29, communication was established in early Aug and it resumed pointing at the Sun in mid Sept. The LASCO cameras were reactivated in Oct but further problems were encountered and the spacecraft did not return to action until 1999 Feb. Further control problems were encountered in late 1999 and early 2000, but these were overcome.

There were three LASCO (Large Angle Spectroscopic Coronagraphs) on the SOHO spacecraft, which orbits the Sun at the earth’s L1 Lagrangian point, 1.5 million km ahead of the Earth. C1 had a field from 1.1 to 3 solar radii, but is not functional, C2 from 1.5 to 6 and C3 from 3.5 to 30. Brighter objects were often discovered in the real time data, but the fainter ones had to wait for the archival data to be searched which ran three or four months behind and was

Table 5. SOHO comets of 1999

Comet	IAU Circular	Comet	IAU Circular
a). Kreutz group			
1999 C1	7123, 1999 March 9	1999 N3	7222, 1999 July 14
1999 C2	7422, 2000 May 11	1999 O1	7367, 2000 Feb 15
1999 E2	7377, 2000 March 09	1999 O2	7376, 2000 March 07
1999 G2	7142, 1999 April 14	1999 O3	7376, 2000 March 07
1999 G3	7458, 2000 July 18	1999 P2	7234, 1999 August 9
1999 G4	7458, 2000 July 18	1999 P3	7367, 2000 Feb 15
1999 G5	7459, 2000 July 20	1999 P4	7376, 2000 March 07
1999 H2	7147, 1999 April 19	1999 P5	7376, 2000 March 07
1999 H4	7157, 1999 May 3	1999 Q1	7376, 2000 March 07
1999 H5	7454, 2000 July 14	1999 Q2	7376, 2000 March 07
1999 H6	7458, 2000 July 18	1999 Q3	7376, 2000 March 07
1999 H7	7459, 2000 July 20	1999 R3	7376, 2000 March 07
1999 H8	7839, 2002 March 1	1999 R4	7383, 2000 March 17
1999 H9	7839, 2002 March 1	1999 S1	7256, 1999 Sept 17
1999 J1	7162, 1999 May 10	1999 S5	7383, 2000 March 17
1999 J7	7439, 2000 June 14	1999 S6	7383, 2000 March 17
1999 J8	7439, 2000 June 14	1999 S7	7383, 2000 March 17
1999 J9	7439, 2000 June 14	1999 U5	7386, 2000 March 24
1999 J10	7439, 2000 June 14	1999 U6	7508, 2000 Oct 16
1999 J11	7439, 2000 June 14	1999 U7	7517, 2000 Nov 6
1999 J12	7459, 2000 July 20	1999 U8	7517, 2000 Nov 6
1999 J13	7839, 2002 March 1	1999 U9	7517, 2000 Nov 6
1999 K1	7173, 1999 May 20	1999 V2	7517, 2000 Nov 6
1999 K9	7204, 1999 June 18	1999 V3	7517, 2000 Nov 6
1999 K10	7204, 1999 June 18	1999 V4	7517, 2000 Nov 6
1999 K11	7439, 2000 June 14	1999 V5	8735, 2006 August 3
1999 K12	7439, 2000 June 14	1999 W1	7386, 2000 March 24
1999 K13	7439, 2000 June 14	1999 W2	7898, 2002 May 13
1999 K14	7439, 2000 June 14	1999 X2	7459, 2000 July 20
1999 K15	7439, 2000 June 14	1999 Y3	7386, 2000 March 24
1999 K17	7842, 2002 March 5	b). Marsden group	
1999 L1	7197, 1999 June 11	1999 P6	7863, 2002 March 29
1999 L4	7204, 1999 June 18	1999 P8	7863, 2002 March 29
1999 L5	7208, 1999 June 25	1999 P9	7863, 2002 March 29
1999 L6	7452, 2000 July 11	c). Meyer group	
1999 L7	7452, 2000 July 11	1999 F3	7898, 2002 May 13
1999 L8	7452, 2000 July 11	1999 K16	7842, 2002 March 5
1999 M1	7208, 1999 June 25	1999 L9	7842, 2002 March 5
1999 M2	7212, 1999 June 30	1999 P7	7863, 2002 March 29
1999 M4	8022, 2002 Nov 24		
1999 N1	7213, 1999 July 1		

Shanklin: The comets of 1999

not that efficient. The introduction of amateurs into the search process greatly increased the detection rate, however even in 2006 some comets were still being found in archival data from the 1990s.

D/Denning

The first Director of the BAA Comet Section discovered this comet in 1894 March. Possibly reaching 9th magnitude when it passed 0.27AU from Earth in January that year, it was a magnitude fainter by the time it was discovered. It was quite well observed, however it has not been seen again and Jovian perturbations have changed the orbit so much that it will only be recovered by accident. Richard Buckley published a new orbit in the *Journal* in 1977,⁸ suggesting that an approach in 1986 would give a period of around 10 years for the present epoch, and Nakano gives a 9.7 year orbit for 2007. This contrasts with the orbit given by Muraoka⁹ for this return, which has a period of 7.2 years and a perihelion distance of 1.08AU.

D/Schorr

The comet was discovered as a 14th magnitude object on photographic plates taken by Prof R. Schorr during an asteroid survey in 1918 and was followed for about a month. Despite several favourable returns since then, it has not been seen again.

D/Skiff–Kosai

This object was originally designated as asteroid 1977 DV₃ when found by Kosai in 1977 February. Nine years later Brian Skiff found a cometary image on a 1977 Palomar plate and Brian Marsden linked this with Kosai's object. The orbit turned out to be short-period, but by then the 1984 return had been missed. It was only observed for a month, giving some uncertainty in the period, which is around 7.5 years. It was not seen in 1991 and despite relatively favourable circumstances in 1999, this was the third missed return so it must be presumed lost.

1991 VI P/Shoemaker–Levy

The Shoemaker–Levy team discovered this comet, their sixth periodic object, in 1991, when it reached 11th magnitude. This return was not a good one, with the comet staying close to the Sun for most of the apparition and it was not observed. The elongation became more favourable in the autumn, but by then it was expected to be fainter than 21st magnitude.

Other comets and objects observed during the year

29P/Schwassmann–Wachmann

The comet reached opposition on the borders of Hydra and Libra in May. It was in solar conjunction in Nov, passing into Scorpius. Unfortunately opportunities for UK observers were limited as its altitude did not exceed 15°.

Andrew Pearce discovered it in outburst on 1999 March 31. It was well condensed and so relatively easy to see, but faded below 14th mag. Reports suggest another outburst to around 13th magnitude in early June. Jose Aguiar reported it in outburst once again at the beginning of July.

This annual comet has frequent outbursts and since the mid 1990s seems to have been more often active than not, though it rarely gets brighter than 12^m. It is possible that its pattern of behaviour is changing. In early 1996 it was in outburst for several months. The randomly spaced outbursts may be due to a thermal heat wave propagating into the nucleus and triggering sublimation of CO inside the comet.

95P/Chiron

The comet/centaur was 16^m when it reached opposition in early June in Libra. Maurice Gavin obtained images of the comet on 1999 July 10 and 11.

A/1999 LD₃₁ = (20461) Dioretsa and A/1999 LE₃₁

MPEC 1999-M28 and 1999-M29 provided detailed information about two apparently asteroidal objects, 1999 LD₃₁ and LE₃₁, discovered by LINEAR on June 8 and 12, respectively (with prediscoversy observations of the latter on May 17), and followed extensively by observers using the NEOCPS. In each case the orbit was found to be retrograde: 1999 LD₃₁ has $a=23.9\text{AU}$, $e=0.90$, $i=160^\circ$, $P=115\text{ years}$, $H=13.8$; 1999 LE₃₁ has $a=8.1\text{AU}$, $e=0.47$, $i=152^\circ$, $P=23\text{ years}$, $H=12.4$. All observers consistently reported 1999 LD₃₁ to be asteroidal, and only one observer suggested that 1999 LE₃₁ might have cometary appearance (although this was unconfirmed). In particular, A. Fitzsimmons, Queen's University, Belfast, reported that 250s exposures in 1" seeing by S. Collander–Brown & S. Lowry with the 1m Kapteyn telescope at La Palma on June 15 show both objects clearly to be point sources. [*IAC* 7208, 1999 June 25].

R. P. Binzel, Massachusetts Institute of Technology, reported that 0.5–1.0-micron spectra of 1999 LD₃₁, obtained on 2000 March 1.3 using the Kitt Peak 4m reflector, display a constant reflectance spectral slope of 0.12 ± 0.02 per 100nm (consistent with that of a typical D-type minor planet). [*IAC* 7376, 2000 March 7]. Both objects are in orbits typical of Halley-type comets.

A/1999 RG₃₃ = (15504)

Details of an 18th mag asteroid, discovered by the Catalina sky survey program on Sept 4.43 were given on MPEC 1999-R34 [Sept 12], with an improved orbit on MPEC 2000-A41 [Jan 11]. The asteroid is in a 29-year periodic orbit with a perihelion distance of 2.1AU and is estimated at 25km in diameter.

A/1999 XS₃₅

Details of an unusual asteroid, discovered by the LONEOS programme on Dec 2.42, were given on MPEC 1999-X19 [1999 Dec 9]. This 17th magnitude object has a perihelion distance of 0.95AU and a period of 75 years. The orbit approaches very close to the Earth at the ascending node, so the object is a PHA (potentially hazardous asteroid) and classed as an Apollo asteroid. With an absolute magnitude of 17.2 it is estimated at 2.4km in diameter.

The orbit passes only 0.008AU from the Earth and the asteroid passed this point only 2.9 days ahead of the Earth. If it produced a meteor shower, slow meteors would have been seen by Southern Hemisphere observers on or around Nov 11.1, with a radiant point of RA 17h 55m, Dec -70° . In 2000 the shower was expected to occur around Nov 10.3. No meteors were reported.

The Edgar Wilson Award

IAUC 6936 [1998 June 11] announced the establishment of an annual Edgar Wilson Award for the discovery of comets by amateur astronomers. Made possible by a generous bequest, the first Edgar Wilson Award, of around £12,000, would be shared among astronomers who discover one or more comets as amateurs using amateur equipment during the year beginning 1998 June 11. Long interested in astronomy himself, Wilson was from Louisville, Kentucky, and died in 1976. The rules for the Award state:

The Award shall be allocated annually among the amateur astronomers who, using amateur equipment, have discovered one or more new comets. Only comets officially named for their discoverers shall be included in the annual count. Since particular recognition is to be given to the amateurs who discover the most comets, identical fractions of the total Award funds shall be allocated for each comet with an eligible discoverer; except that if the same comet is credited to more than one independent eligible discoverer, each discoverer shall receive a full fraction. If the discovery is made as the result of information produced or prepared by some other person, it shall not qualify for consideration. Eligible discoveries may be made by visual, photographic or electronic means.

The Award shall be administered by the Smithsonian Astrophysical Observatory (SAO), as the beneficiary under the Will of Edgar Wilson of Lexington, KY. This administration shall specifically be through the International Astronomical Union (IAU) Central Bureau for Astronomical Telegrams (CBAT), which, with the advice of the Small Bodies Names Committee (SBNC) of IAU Division III, has the responsibility for naming comets.

It is anticipated that the funds available for the first annual Award shall be approximately US\$20 000 (twenty thousand dollars). For the purpose of this Award, a year shall be the period of twelve months beginning and ending on June 11.0 UT. The first Award shall be for the year ending on 1999 June 11.0. The Award shall be announced and made during the month of July following the end of each period.

To be eligible for the Award an individual must demonstrate:

1. *that he or she is acting in an amateur capacity, at least for the purpose of discovering the comet, and*
2. *that only amateur, privately-owned equipment was used for the discovery.*

In years when there are no eligible comet discoverers, the Award shall be made instead to the amateur astronomer(s) judged by the CBAT to have made the greatest contribution toward promoting an interest in the study of comets.

SAO employees associated with the CBAT, SBNC members, as well as members of their immediate families, are not eligible for the Award.

The Edgar Wilson Award is international in scope, and nationals of no country are excluded from consideration. An observer who suspects he or she has discovered a comet shall ensure that his or her discovery report reaches the CBAT according to the usual procedures. The CBAT shall maintain the necessary records and may contact the discoverers for eligibility documentation.

The decision of SAO (via the CBAT) is final and takes precedence over the description above.

The first Edgar Wilson award was made in 1999 July to Peter Williams (1998 P1), Michael Jager (1998 U3), Roy Tucker (1998 QP₅₄) and Justin Tilbrook (1999 A1).

Acknowledgments

Thanks are due to Guy Hurst for the long hours spent in preparing cometary material for publication in *The Astronomer* magazine, and to Dan Green for preparing the material published in *International Comet Quarterly*. Acknowledgment is also given to the British Antarctic Survey and the Institute of Astronomy, Cambridge, for the use of computing facilities. The freeware software *Ephemeris Tool 4* by Manfred Dings was most helpful in computing the circumstances of planetary encounters.

Address: 11 City Road, Cambridge CB1 1DP. [jds@ast.cam.ac.uk]

References

- 1 Shanklin J. D., 'Comet Analyses', *J. Brit. Astron. Assoc.*, **105**(6), 291 (1995)
- 2 Mitton J. (Ed), *The Handbook of the British Astronomical Association*, 1999
- 3 Nakano S. & Green D. W. E. (Eds), *ICQ 1999 Comet Handbook*
- 4 Sekanina Z., 'Origin of the Marsden and Kracht groups of sunskirting comets, I. Association with comet 96P/Machholz and its interplanetary complex', *Ap J Supp. Ser.*, **161**, 551 (2005)
- 5 Sekanina Z., 'Multiple fragmentation of comet Machholz 2 (P/1994 P1)', *A&A*, **342**, 285 (1999)
- 6 Hoenig S. F., 'Identification of a new short-period comet near the Sun', *A&A*, **445**, 759 (2006)
- 7 Shanklin J. D., 'The Comets of 1998', *J. Brit. Astron. Assoc.*, **112**(6), 325 (2002)
- 8 Buckley R. J., 'The Missing Comets', *J. Brit. Astron. Assoc.*, **87**(3), 226 (1977)
- 9 Muraoka K., <http://www.astroarts.com/comets>
- 10 Marsden B. G. & Williams G. V., *Catalogue of Cometary Orbits*, 16th edn, SAO, 2005
- 11 JPL Horizons, <http://ssd.jpl.nasa.gov/horizons>
- 12 Merlin J.-C., 'Comet 52P/Harrington-Abell', *The Astronomer*, **35**, 415 (1998)
- 13 Strange D. J., 'Comet 52P/Harrington-Abell', *ibid.*, **35**, 418 (1999)

Received 2008 October 21; accepted 2009 January 25