The brighter comets of 2014

Jonathan Shanklin

A report of the Comet Section (Director: N. D. James)

This report describes and analyses observations of the brighter or more interesting comets discovered or at perihelion during 2014, concentrating on those visually observed or discovered by amateur observers. Magnitude parameters are given for all comets with observations. Any evolution in the magnitude parameters of those periodic comets with multiple returns is discussed. Additional information on the comets discussed here, and on other comets seen or at perihelion during the year, may be found on the Comet Section's visual observations web pages.

Introduction

85 comets were assigned year designations for 2014, and 42 previously numbered periodic comets returned to perihelion. 195 comets from 2014 were discovered from the SOHO satellite (three were returns) and four from STEREO. 165 were members of the Kreutz group, 17 were members of the Meyer group, two of the Marsden group, four of the Kracht group and eleven were not associated with any known group. There were nine amateur discoveries (2014 A4, B1, C1, E2, F2, Q2, Q3, R1 and X1) for which João Ribeiro de Barros, Gennady Borisov, Leonid Elenin, Paulo Holvorcem, Cristóvão Jacques, Terry Lovejoy, Eduardo Pimentel and Michael Schwartz may gain the Edgar Wilson Award (although at the time of writing there has been no formal announcement). 23 periodic comets from the year were numbered. Three comets – 2013 R1, 2014 E2 and 2014 Q2 – were reported as visible to the naked eye during the year.

Orbital elements for all the comets discovered and returning during the year can be found on the JPL Small-Body Database Browser,[1] which will also generate ephemerides. Discovery details and some information for the other comets found or returning during the year are available on the Section visual observations web pages,[2] which also contain links to additional background information. The raw visual observations for the year are on these pages in ICQ format and in the Comet Observations (COBS) database.[3] The full dataset from COBS is used for the multi-return analyses presented here, but otherwise only those observations submitted to the Section are used. Additional images of the comets are presented in the Section image archive.[4]

The comets given a discovery designation

2014 A4 (SONEAR)

An 18th magnitude object was discovered by Cristóvão Jacques, Eduardo Pimentel and João Ribeiro de Barros with the 0.45m telescope (given as 0.3m by the *MPEC* (*Minor Planet Electronic Circular*) at the Southern Observatory for Near Earth Research at Oliveira, Brazil on Jan 12.03. It was noted as cometary by other astrometrists [*MPEC* 2014-B03, 2014 Jan 16]. The comet had perihelion at 4.2au in 2015 September. Cristóvão Jacques provided the following discovery information:

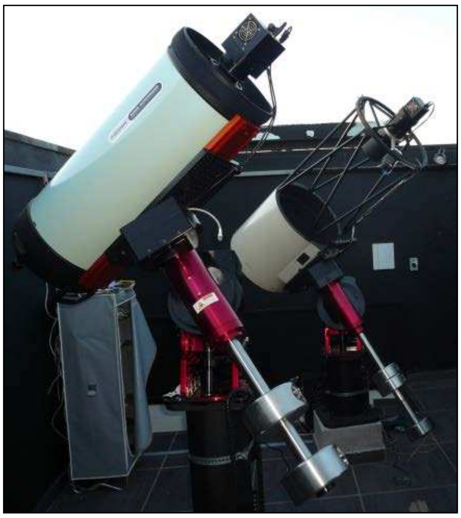

Figure 1. SONEAR 18: 457mm aperture *f*/2.9 telescope (Sandro Coletti mirror) with CCD camera at the primary focus, installed on a Paramount equatorial mount and remotely operated over the Internet. *Cristóvão Jacques*

'The Southern Observatory for Near Earth Asteroids Research (SONEAR) is located in Oliveira, a city 120km from Belo Horizonte, which is the third largest in Brazil. The sky is pretty good, although we have 1200mm annual rainfall. We began our operations in 2013 July with a 12-inch Schmidt-Cassegrain, got the Y00 code and in late October our main instrument was ready to begin operation and adjustments. Now we use an 18-inch *f*/2.9 reflecting telescope, completely made in Brazil. The mount is a Paramount MEII with an FLI Microline 16803 CCD. This system yields a 1.64×1.64° field and a plate scale of 1.44arcsec/pixel, with 8s downloads.

'Our observatory is of a roll-off roof design, with dimensions 6×4m (Figure 1). I am still not satisfied with the telescope performance because we are struggling with collimation and other small issues.

'For detection, we use software written by Paulo Holvorcem, called *Skysift*. We are now tuning the parameters, so we can better detect objects. For planning the night we use another of Dr Holvorcem's software packages, called *TAO*.[5] For telescope and CCD control, we use *ACP* and *Maxim*.

'December and January are the rainy season months in Brazil, but this year has been atypical, so we had 12 clear nights in a row. 2014 A4 was discovered on the night of Jan 12, as we were surveying the region between RA 5 & 6h, and dec. –40 & –50°. As the beginning of the survey was centralised on dec. –40°, half of the field was above this declination; so we spotted the object in dec. –39.6° as a matter of luck. Since Dec 18, we have been sending a sky coverage report to the Minor Planet Centre (MPC).[6]

'I analysed the images 12 hours after the end of the night. The object was apparently asteroidal. On the next day, Ernesto Guido e-mailed me to say that he had imaged the object from Australia and it was a little elongated. One day later, he confirmed the cometary nature using the Faulkes Telescope South.'

2014 B1 (Schwartz)

Michael Schwartz discovered a 20th magnitude comet in images taken with the Tenagra II 0.41m *f*/3.75 astrograph on Jan

28.10 [*MPEC* 2014-C03, 2014 Feb 1]. The comet reached perihelion at 9.6au in 2017 September.

2014 C1 (P/TOTAS)

The amateur Teide Observatory Tenerife Asteroid Survey discovered a 19th magnitude comet with the ESA 1.0m *f*/4.4 reflector on Feb 1.24 [*MPEC* 2014-C10, 2014 Feb 4]. The comet was at perihelion at 1.7au in 2013 December and has a period of 5.3yr.

2014 E2 (Jacques)

Cristóvão Jacques discovered a 15th magnitude comet on Mar 13.06 using the 0.45m telescope at the Southern Observatory for Near Earth Research at Oliveira, Brazil [*MPEC* 2014-E84, 2014 Mar 14]. The comet reached perihelion at 0.7au in July. The total magnitude observations suggest that it was 12th magnitude at discovery, and it continued to brighten fairly quickly.

It was initially a southern hemisphere object, but several northern hemisphere observers using remote imaging were able to make magnitude estimates. It was brightest at around 6th magnitude in July and by late in the month was visible to UK observers in the morning sky, with Stephen Getliffe seeing it with the naked eye. By the second week of August it was more conveniently placed in the evening sky, with many more observers following it. The comet faded very slowly during August, but then faded rapidly during September as the distance from the Earth increased. Some observations seem discordant, but it is not clear whether these are real, erroneous on the part of the observer, or wrongly dated.

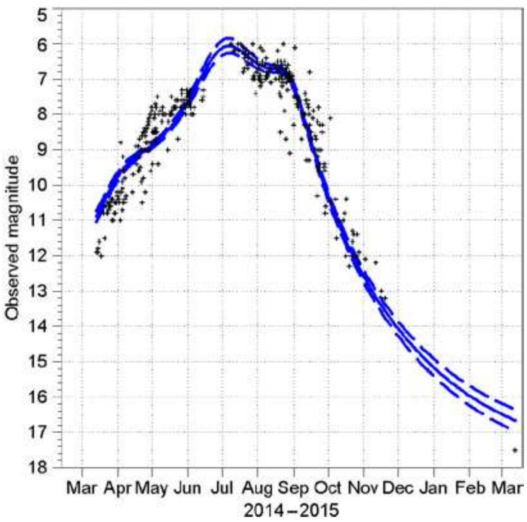

Figure 2. The observations of 2014 E2 (Jacques), with a standard light curve fitted to them. The dashed lines show the 95% confidence limits.

Figure 3. 2014 E2 (Jacques) imaged by Rolando Ligustri on 2014 Jul 26, when it was close to diffuse nebula IC 405. NM, USA Itelescope.net, IT. Apo 106/530, CCD FLI11002, L= 3×300s in bin1, RGB= 120s; field 155×205′.

Table 1. Photometric observers

James Abbott, Witham, Essex
Salvador Aguirre, Mexico
Alexandre Amorim, Brazil
Sandro Baroni, Italy
Alexandr R. Baransky, Ukraine
Denis Buczynski, Tarbatness, Ross-shire
Paul Camilleri, Australia
Mike J. Collins, England
Roger Dymock, Waterlooville, Hampshire
Len Entwisle, England
Fraser Farrell, Australia
James Fraser, Alness, Ross-shire
Michael J. Gainsford,
Stephen Getliffe, Haverhill, Suffolk
Antonio Giambersio, Italy
Massimo Giuntoli, Montecatini Terme, Italy
Marco Goiato, Brazil
Juan Jose Gonzalez, Spain
Werner Hasubick, Germany
Kevin Hills, Cheshire
Gustav Holmberg, Lund, Sweden
Guy M. Hurst, Basingstoke, Hampshire
Nick James, Chelmsford, Essex
Andreas Kammerer, Germany
Heinz Kerner, Germany
Mark Kidger, Canary Islands
Carlos Labordena, Spain
James Lancashire, Cambridge
Martin Lehky, Czech Republic
Alan Lorrain, Basingstoke
Luis Mansilla, Argentina
Michael Mattiazzo, Australia
Richard McKim, Oundle, Northamptonshire
Neil Morrison, Crawley, West Sussex
Paul Mettam, Long Eaton, Derbyshire
Artyom Novichonok, Russia
John O'Neill, Dublin, Ireland
Roy W. Panther, Walgrave, Northampton
Mieczyslaw L. Paradowski, Poland
Nirmal Paul, India
Stuart T. Rae, New Zealand
Jonathan D. Shanklin, Cambridge
William C. de Souza, Brazil
David Storey, Oxfordshire
Melvyn D. Taylor, Wakefield, Yorkshire
Graham W. Wolf, New Zealand
Chris Wyatt, Victoria, Australia
Seiichi Yoshida, Japan

To the visual observer tail development was weak, with its length mostly reported as less than half a degree even when the comet was brightest. The coma was moderately condensed before perihelion. It became quite well condensed around the time of perihelion, before steadily becoming more diffuse as the comet faded. The coma diameter was observed to be largest after perihelion, when the comet was closest to the Earth in late August; it then reached around 15′ in diameter, though a few estimates were much larger. When corrected for distance from the Earth, the coma was a similar size two months before perihelion and two months after, at around 600,000km.

2014 F2 (Tenagra)

An asteroidal object discovered on Mar 31.35 with the 0.41m astrograph at the Tenagra II Observatory, by Michael Schwartz and Paulo Holvorcem, was found to show cometary features after posting on the Near-Earth Object Confirmation Page (NEOCP)

[*MPEC* 2014-G12, 2014 Apr 3]. The comet has an orbit with perihelion at 4.3au in 2015 January, and a period of around 1800yr.

2014 L2 (P/NEOWISE)

Rachel Stevenson reported a probable comet in *Near-Earth Object Wide-field Survey Explorer* (NEOWISE) spacecraft images from Jun 7.41. Follow-up ground-based observations confirmed the comet at 16th magnitude [*CBET* 3901, *MPEC* 2014-L61, 2014 Jun 15].

The comet was at perihelion at 2.2au in 2014 July and has a period of around 16yr. It was 13th magnitude when brightest and approached to within 0.015au of Saturn in 2009 July. Prior to the encounter, perihelion was at 3.9au and it had a period of 19yr.

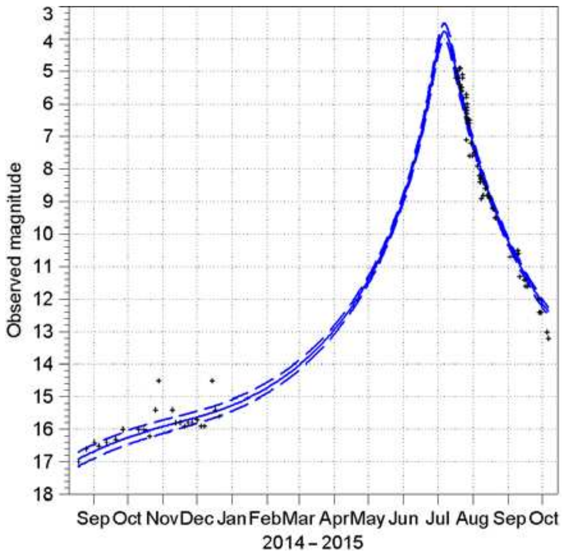

Figure 4. The observations of 2014 Q1 (PanSTARRS) with a standard light curve fitted to them.

2014 Q1 (PanSTARRS)

An 18th magnitude comet was discovered in Pan-STARRS 1 images, taken with the 1.8m Ritchey-Chretien on Aug 17.72 [*CBET* 3933, *MPEC* 2014-Q09, 2014 Aug 19]. The comet reached perihelion at 0.3au in 2015 July. The apparition was a poor one for northern hemisphere observers, but it was visible from the southern hemisphere after perihelion. Willian Souza observed it as it emerged from conjunction, recording it as 5th magnitude and with a short tail in mid-July. By early August it had faded to mag +7.5, and mid-month it was 9th magnitude.

The coma was strongly condensed at first, but steadily became more diffuse. The general trend was for the coma diameter to decrease, from around 6′ just after perihelion to 1′ some three months later. Maximum tail length for visual observers was around 2° as the comet gained darker skies after conjunction.

Figure 6. 2014 Q1 (PanSTARRS) showing a disconnection event in the ion tail, imaged by Michael Jager on 2015 Jul 16. Tak-FSQ & Moravian G3-11002; 7×100s, 2×120s.

2014 Q2 (Lovejoy)

Terry Lovejoy discovered a 15th magnitude comet in CCD images taken with his 0.2m Schmidt-Cassegrain on Aug 16.55 [*CBET* 3934, *MPEC* 2014-Q10, 2014 Aug 19].

The comet reached perihelion at 1.3au at the end of January. It was within visual range by 2014 September, with Paul Camilleri reporting it at 13th magnitude. It brightened rapidly prior to perihelion. The comet was an easy binocular and naked eye object around the time of perihelion, coming into view for UK observers around Christmas 2014. Once the Moon left the sky in January, the comet was readily visible at mag +4.

On Jan 8 the ion tail suffered a disconnection event, which was widely covered by amateur imaging from around the world. Many observers were able to see the comet with the naked eye, but the tail was generally hard to detect visually. After perihelion it faded, more slowly than it had brightened. During the first

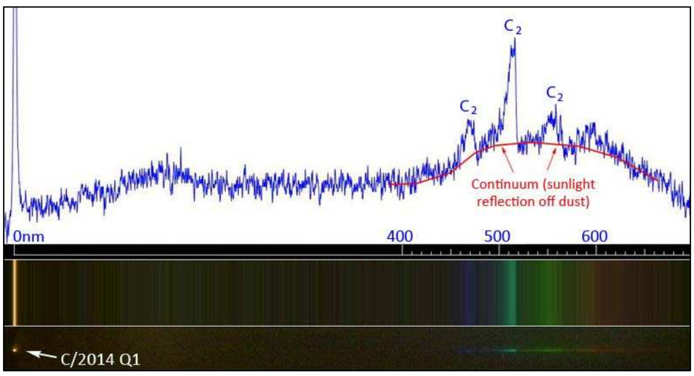

Figure 5. Low resolution spectrum of the coma of 2014 Q1 (PanSTARRS) taken by Rob Kaufman at Bright, Victoria, Australia on 2015 Jul 18. The C_2 (carbon 'Swan' bands) emission lines are superimposed on a continuum of sunlight reflected from dust. Canon 650D on Vixen Polarie, 200mm lens with Star Analyser grating; 11×25s, ISO 6400, *f*/5.6. Graph generated in *BASSProject*.

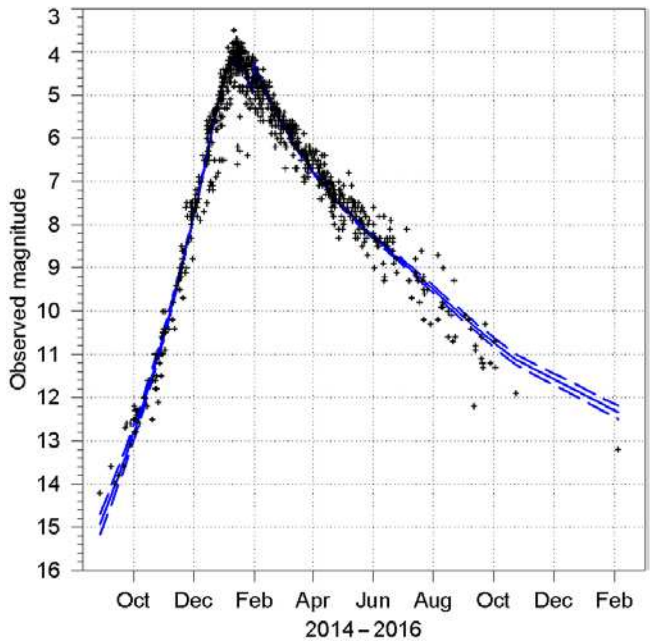

Figure 7. The observations of 2014 Q2 (Lovejoy), with separate pre- and post-perihelion light curves fitted to them.

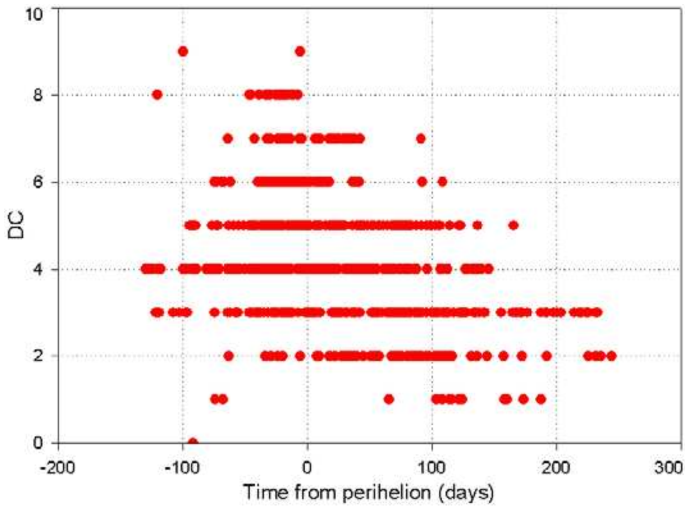

Figure 8. Degree of condensation of the coma of 2014 Q2 (Lovejoy).

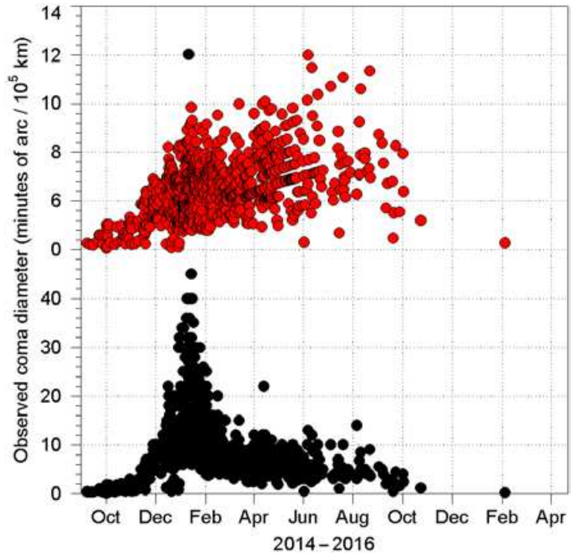

Figure 9. The coma diameter (apparent [*black dots*] and true [*red dots*]) of 2014 Q2 (Lovejoy). The true diameter for estimates much above the mean is not shown.

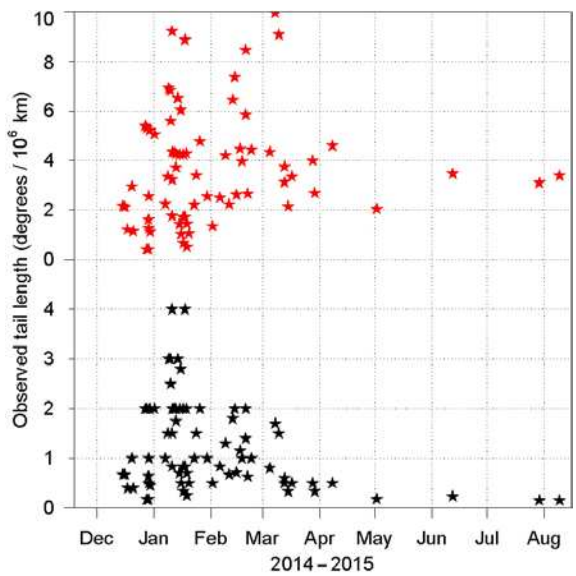

Figure 10. The tail length (apparent [*below*] and true [*above*]) of 2014 Q2 (Lovejoy).

half of February the comet remained at around 5th magnitude. By early March it was around mag +5.5 and, by the end of the month, +6.5. Surprisingly, it was still visible in Jonathan Shanklin's 25×100 binoculars from central Cambridge in early August, at around 10th magnitude.

An electronic observation in early 2016 February suggested that the comet was still 13th magnitude, but no further visual equivalent magnitude observations were received. There are a few present in the COBS database, showing the comet had faded to 16th magnitude by 2016 August.

The observations are not well fitted by a single light curve. Prior to perihelion the comet brightened very rapidly, at a rate of approximately 20 log(r). After perihelion, the comet faded slowly at approximately 5 log(r). Such pronounced and sustained asymmetry is very unusual and may indicate that the comet nucleus was inhomogeneous, either structurally or compositionally. The asymmetry was noted by professional astronomers,[7] but they did not have adequate data (six points; only one prior to perihelion) to draw robust conclusions. Professionals also monitored the molecular composition of the coma, finding 21 complex organic molecules including ethanol and a simple sugar.[8]

The coma appeared largest just before the time of perihelion (when the comet was closer to the Earth) when it reached at least 45′ in diameter to the naked eye, with one estimate putting it at 90′. In real terms the coma was larger after perihelion, reaching around a million kilometres in diameter.

The coma was moderately condensed prior to perihelion, becoming very strongly condensed when closest to the Sun. It slowly became less condensed as it receded.

Significant tail development began about six weeks before perihelion, and the visual tail was longest – at around 4° – just before perihelion. This corresponds to nearly 10,000,000km in length. Thereafter the tail shrank, but it was still under observation three months later.

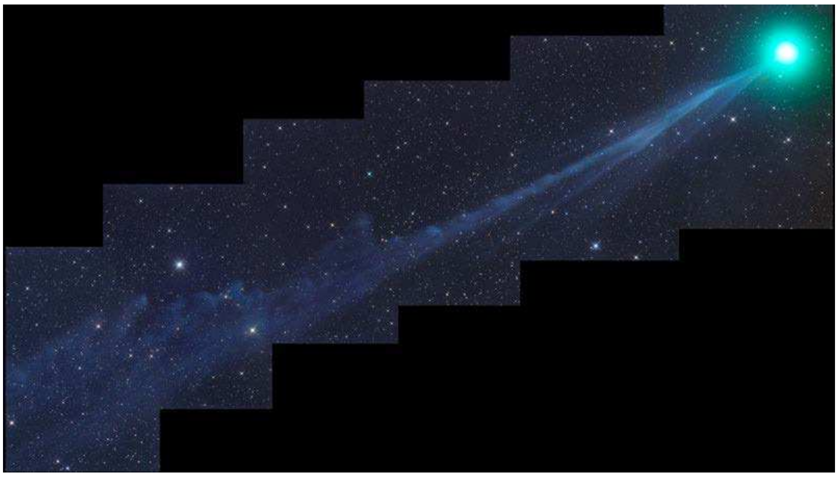

Figure 11. 2014 Q2 (Lovejoy), imaged by Gerald Rhemann on 2014 Dec 28 at 22:31. Intricate detail, including disconnection events, is shown in the ion tail. 6-panel mosaic taken from Farm Tivoli, Namibia, SW Africa. ASA 12″ *f*/3.6 telescope, FLI ML 8300 camera and ASA DDM85 mount. Exposure time: LRGB 200/300/300/300s each panel.

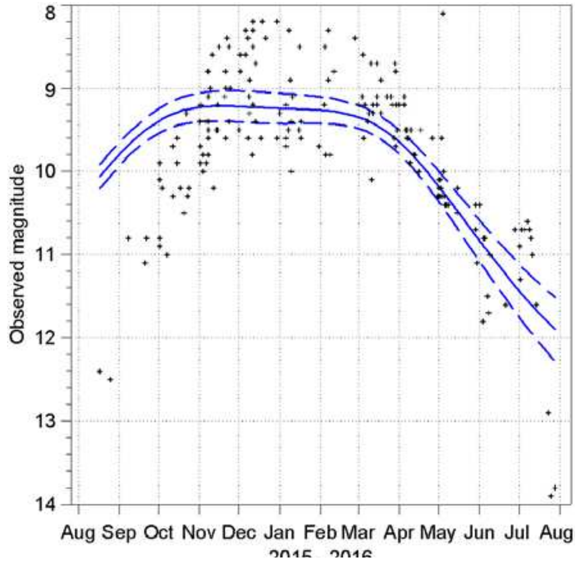

Figure 12. The observations of 2014 S2 (PanSTARRS) with a single standard light curve plotted for them, showing the poor fit.

2014 Q3 (Borisov)

Gennady Borisov discovered a 17th magnitude comet with the 0.3m astrograph at the Crimea-Nauchnij observatory on Aug 22.01. The cometary nature was quickly confirmed by Peter Birtwhistle [*CBET* 3936, *MPEC* 2014-Q38, 2014 Aug 24].

The comet has a period of around 150yr and reached perihelion at 1.6au in 2014 November. It attained 11th magnitude when brightest.

2014 R1 (Borisov)

Gennady Borisov discovered a 16th magnitude comet with the 0.3m astrograph at the Crimea-Nauchnij observatory on Sep 5.05 [*CBET* 3968, *MPEC* 2014-R64, 2014 Sep 7].

The comet reached perihelion at 1.3au in 2014 November and was around 11th magnitude when brightest.

2014 S2 (PanSTARRS)

A 21st magnitude comet was discovered in Pan-STARRS 1 images taken with the 1.8m Ritchey-Chrétien on Sep 22.47 [*CBET* 3989, *MPEC* 2014-S83, 2014 Sep 24]. The comet was at perihelion at 2.1au in 2015 December. Juan Jose Gonzalez reported it at 11th magnitude in 2015 September.

Jonathan Shanklin was able to observe the well-condensed comet in 25×100 binoculars from central Cambridge on Nov 1, estimating it at 10th magnitude. It was quite an easy object on Dec 31, at around mag +9.5. The comet was still near 9th magnitude in March and was mag +9.5 in 25×100 binoculars from central Cambridge in early April.

The observations are not fitted well by a single light curve and this comet also shows pronounced asymmetry in its behaviour before and after perihelion, brightening at approximately 30 log(r) and fading at 5 log(r).

The coma diameter measurements are rather scattered, though the coma appears to have been largest, at 6′, just before perihelion. The coma was moderately condensed for the majority of the apparition, only becoming diffuse some six months after perihelion.

2014 X1 (P/Elenin)

Leonid Elenin discovered an 18th magnitude comet in images taken with the 0.4m astrograph at the ISON Observatory near Mayhill, New Mexico on Dec 12.16. Gareth Williams found pre-discovery Pan-STARRS images from September, and Mt Lemmon images from October [*CBET* 4034, *MPEC* 2014-X66, 2014 Dec 13]. The comet was at perihelion at 1.8au in 2015 January and has a period of just under 16yr.

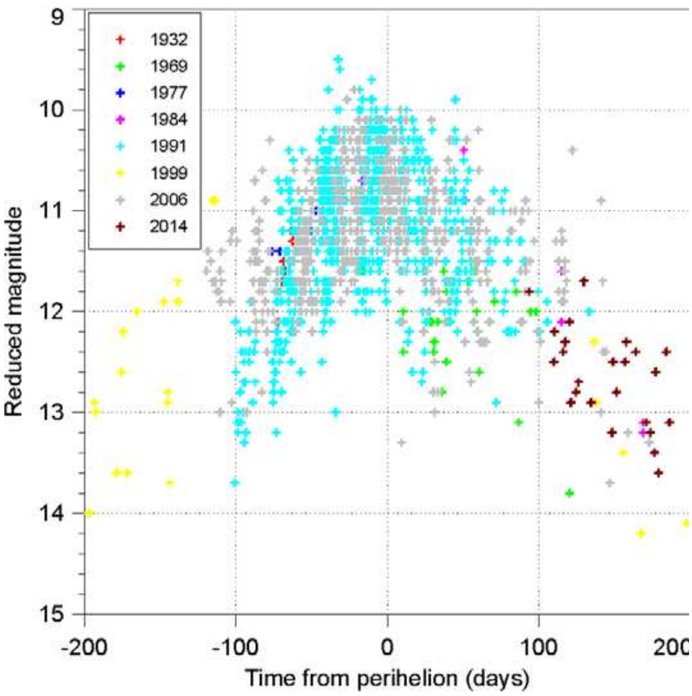

Figure 13. Composite plot showing the observations of 4P/Faye plotted against time from perihelion, corrected for the distance from the Earth. Observations from the well-observed apparitions in 1991 & 2006 plot in bands, because few observations were made when the Moon is full or close to the comet. The circumstances are such that there is a difference of about 14 days in these times with respect to perihelion in the two years.

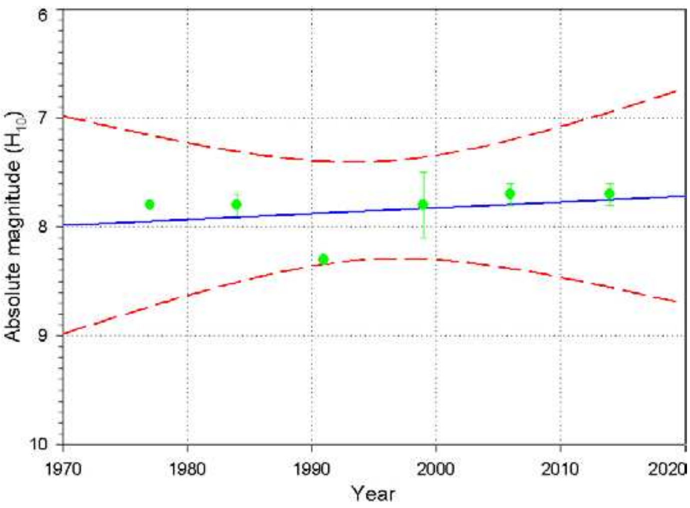

Figure 14. The change in the H_{10} absolute magnitude of 4P/Faye with time. The red dashed lines show the 99% confidence interval. There is no significant change.

The numbered periodic comets at perihelion in 2014

4P/Faye

Hervé A. Faye discovered 4P/Faye in 1843, during a visual search at the Paris Observatory with a small telescope. It then reached 5th magnitude, though this has never been attained at subsequent returns. It is possible that this was a one-off caused by a slight reduction in perihelion distance, from 1.8 to 1.7au, following a close encounter with Jupiter in 1841. Several authors have suggested that the absolute magnitude of the comet is declining rapidly. This was not a favourable return and the comet only reached 14th magnitude.

There are observations covering eight returns in the COBS database and these have been analysed for trends in the photometric behaviour. The comet has had a similar absolute magnitude H_{10} at each return since at least 1976. The observations at the returns of 1932 & 1969 were largely made using the Beyer method, giving an absolute magnitude about one magnitude fainter. The H_{10} values are consistent with no trend against perihelion distance, though this distance has not changed greatly over the period of observation.

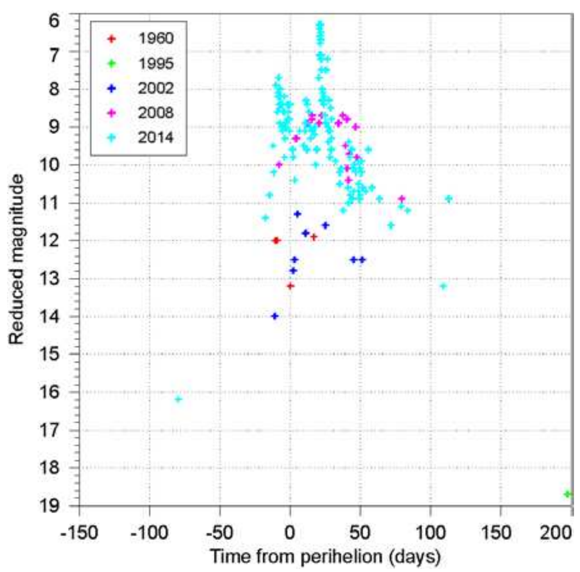

Figure 15. Composite plot showing the observations of 15P/Finlay, plotted against time from perihelion and corrected for the distance from the Earth. The outbursts at the 2014 return are most prominent.

15P/Finlay

William Henry Finlay discovered this comet from the Cape Observatory on 1886 Sep 26, with a 180mm refractor. It was around 11th magnitude at this and the following return. In 1906 it passed 0.3au from the Earth and reached 6th magnitude. Perturbations caused by Jupiter in 1910 gave an unfavourable return in 1913, but a good one in 1919. Returns were however unfavourable after that until 1953, when the comet was recovered. It has been observed at every return since 1953. A Jupiter encounter within 0.3au in 2004 reduced the perihelion distance slightly.

It is an intrinsically faint object and there are usually few visual observations. A September perihelion would give favourable observing circumstances, under which the comet could reach 5th magnitude. This will occur in 2034, when it will pass 0.19au from the Earth in mid-August.

It was reported to have brightened rapidly over the space of a few days in 2014 December, however the brightness after the outburst was roughly in line with the light curve. A further increase in brightness to 7th magnitude was reported in mid-January. Jonathan Shanklin observed it from Cambridge using 25×100 binoculars on Jan 18.75 and estimated it at mag +8.7, so the outburst appears to have been short-lived. Such short-lived events are perhaps part of the natural cascade of material ejections from a comet, but were much larger than usual in the case of 15P/Finlay.

These outbursts have been analysed in a publication by Quan-Zhi Ye *et al*. (2015).[9] The authors suggest that the short-lived outbursts commenced over 2014 Dec 15.4–16.0 and 2015 Jan 15.5–16.0. The estimated mass involved – up to 5×10^5kg (500 tonnes) – could be fitted into a large room, giving an idea of the event's small scale. They comment that although no meteor activity from the comet has been seen to date, some radio meteor activity from the outbursts might take place on 2021 Oct 6/7.

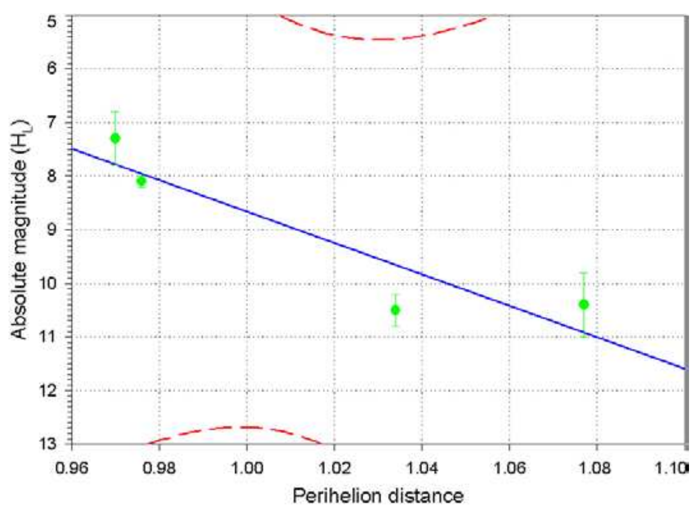

Figure 16. The change in the H_L absolute magnitude of 15P/Finlay with perihelion distance. The red dashed lines show the 99% confidence interval and indicate that there may be no real change, despite the apparently large change in absolute magnitude.

There are some observations in the COBS database for the returns of 1960, 1995, 2002, 2008 & 2014. The intrinsic brightness of the comet was clearly somewhat greater at the returns of 2008 & 2014 than it was at the returns of 1960 & 2002, though there is some scatter. Although the more recent returns were after the Jupiter encounter, the reduction in perihelion distance between 1960 & 2002 was nearly as great. The 1995 return has a single usable observation, made with a large aperture professional telescope and the photometry is inconsistent with the amateur observations.

Overall, the observations from 2008 & 2014 (excluding the outbursts) are best fitted by a linear form of light curve, with activity peaking around 23 days after perihelion. Forcing this relation for all the returns rather weakly suggests that the comet is intrinsically brighter when the perihelion distance from the Sun is least. Observations at future returns will be required to confirm whether this is the case or not.

Table 2. Astrometric, electronic, photographic & visual imagers during 2014

Observer	*Site*	*IAU Stn. No*
Tony Angel	Spain	Z85
David Arditti	London	
Alexander Baransky, *et al.*	Ukraine	585
Peter Birtwhistle	Great Sheford	J95
Gennady Borisov	Crimea	L51
Erik Bryssinck	Belgium	B96
Denis Buczynski	Tarbatness	I81
Montse Campas	Spain	213
Peter Carson	Leigh on Sea, Essex	
Jose Chambo	Spain	
Alfons Diepvens	Belgium	C23
John Drummond	New Zealand	
Roger Dymock	Waterlooville, Hampshire	G68, Q65
Leonid Elenin	Russia	N42
John Fletcher	Mount Tuffley, Gloucestershire	J93
James Fraser	Alness, Ross-shire	
Antonio Giambersio	Italy	
John Glossop	Australia	
Ernesto Guido, *et al.*	Italy	Q62
Roberto Haver	Italy	
Mike Harlow	Bucklesham, Suffolk	
Carl Hergenrother	USA	Q65
Michael Jager	Austria	
Nick James	Chelmsford, Essex	970
Manos Kardasis	Greece	
Rolando Ligustri	Italy	235
Nimal Paul	India	470, H06, Q62
Damian Peach	Selsey	
Glyn Marsh	Ramsey, Isle of Man	
Gordon Mackie	Caithness	
Massimiliano Martignoni	Italy	
Peter Meadows	Chelmsford, Essex	G68
Andrew Mickleburgh	Cleethorpes	Z99
Richard Miles	Dorset	F65
Martin Mobberley	Cockfield, Suffolk	480
Artyom Novichonok, *et al.*	Russia	Q62
Danilo Privato	Italy	
T. Prystavski	Crimea	L51
Jan Qvam	Norway	
Gerald Rhemann	Austria	
Andrew Robertson	Broome, Norfolk	
Ian Sharp	Ham, Sussex	
David Storey	Isle of Man	987
David Strange	Worth Matravers, Devon	
Teerasak Thaluang	Thailand	
Alan Tough	Elgin, Moray	

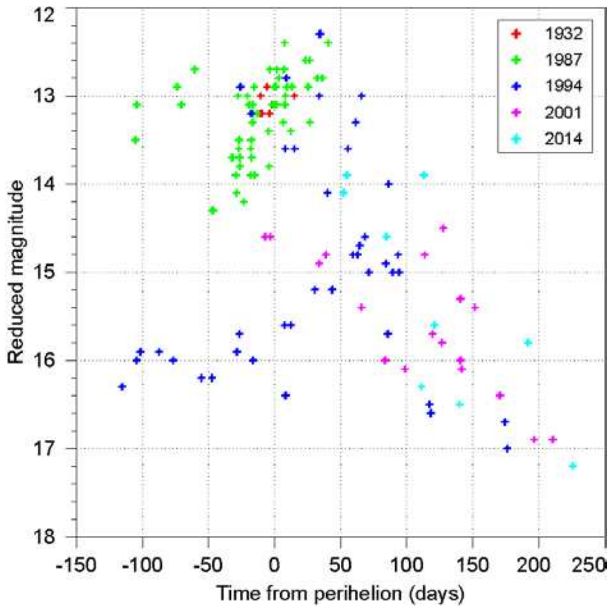

Figure 17. Composite plot showing the observations of 16P/Brooks plotted against time from perihelion and corrected for the distance from the Earth.

16P/Brooks

The discovery of the comet was described in a previous paper, on the comets of 2001.[10] The perihelion distance reduced from around 1.8 to 1.5au in 2005, though it increased again in a Jovian encounter in 2017. The comet was no brighter than 15th magnitude at this return.

There are some observations for the returns of 1932, 1987, 1994, 2001 & 2014 in the COBS database. The observations are rather scattered and some were made with large aperture professional instruments. Some of the early observations reported in 1987 are clearly inconsistent with the light curve, showing that even experienced observers may imagine seeing a comet on the threshold of the observing conditions. Because of the large scatter, only H_{10} magnitudes were determined for each return. Assessment of these shows no discernable trends with time or with perihelion distance.

17P/Holmes

The comet suffered a super-outburst in 2007, which was described in several volumes of the *Journal*.[11,12,13]. At this return the comet was at perihelion in March, but was brightest in June & July when it was about 12–13th magnitude.

Theoretical calculations suggested that the dust released during the 2007 outburst would converge one orbit later, making a dust trail visible. This was first seen in August [*CBET* 3969, 2014 Sep 7]; it was expected to be brightest in mid-September and then to slowly fade. It was still visible in 2015 February. On 2015 Jan 27 a significant outburst took place, increasing the brightness of the comet by around three magnitudes. The outburst was detected by Richard Miles in images taken

Figure 18. 17P/Holmes, imaged by Richard Miles on 2015 Jan 29 with the 2.0m Faulkes Telescope North. The field of view is 173″ square.

with the Faulkes Telescope North on Jan 28.25, which showed a dramatic change when compared to images taken on Jan 26.29.

32P/Comas Sola

The discovery and orbital details of the comet were given in the paper on the comets of 2004.[14] It reached 13th magnitude at best during this return.

There are some observations for the six returns since 1969 in the COBS database. During this time, the perihelion distance has increased from 1.77 to 2.00au. The observations are consistent with no change in behaviour, but may show weak evidence of a slight secular fading, or of fading with perihelion distance. Observations at future returns will be required for a definite conclusion.

70P/Kojima

Orbital details of this comet are given in the paper on the comets of 2000.[15] There are some observations for the five returns since 1985 in the COBS database. For the first two of these returns the perihelion distance was around 2.4au (with most observations made with large telescopes and essentially recording nuclear magnitude), whilst for the other three it was around 2.0au.

The majority of observations are post-perihelion, appearing to show a long delay of around 140 days between perihelion and peak activity. There are too few observations to draw any conclusions about trends with time or perihelion distance.

108P/Ciffreo

Jacqueline Ciffreo discovered the comet with the Caussols 0.9m Schmidt telescope in 1985, when it was not far from 1P/Halley in the sky. The comet had made a close approach to Jupiter in 1983, putting it into its present orbit. The perihelion distance has remained at around 1.7au since discovery. It reached 11th magnitude at the discovery apparition, but this time was no brighter than 13th magnitude.

There are some observations in the COBS database for all five returns since discovery. Analysis of these suggests that the appropriate parameter for comparison is H_{15}. However, the resultant H_{15} values are too scattered to draw any conclusions about trends with time or perihelion distance.

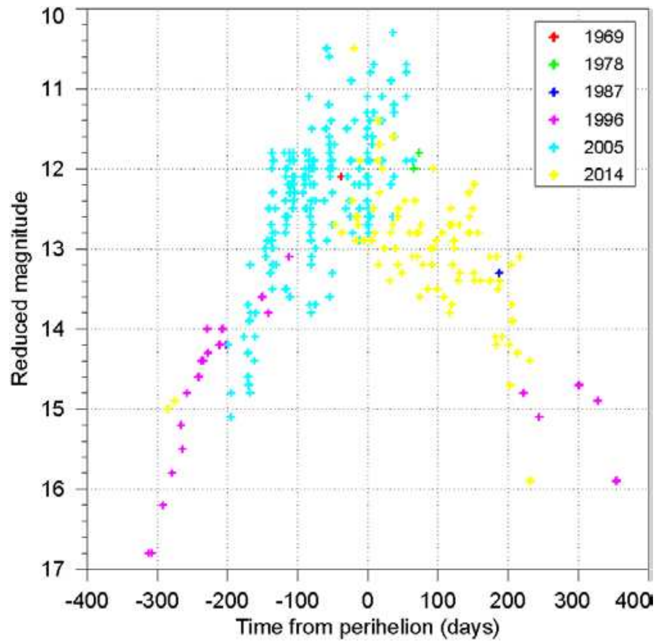

Figure 19. Composite plot showing the observations of 32P/Comas Sola, plotted against time from perihelion and corrected for the distance from the Earth.

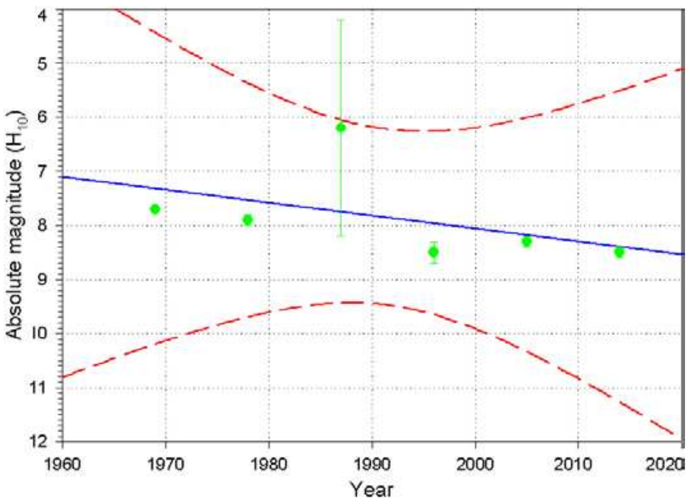

Figure 20. The change in the H_{10} absolute magnitude of 32P/Comas Sola with time. The red dashed lines show the 99% confidence interval.

110P/Hartley

The discovery of the comet was described in the paper on the comets of 2001.[10] It reached 14th magnitude at the 2014 return. Somewhat surprisingly for a faint comet, there are observations in the COBS database for all five returns since discovery. The perihelion distance has been similar at each return.

The observations are quite scattered, but suggest a slightly better fit to a linear type of light curve – peaking around 50 days

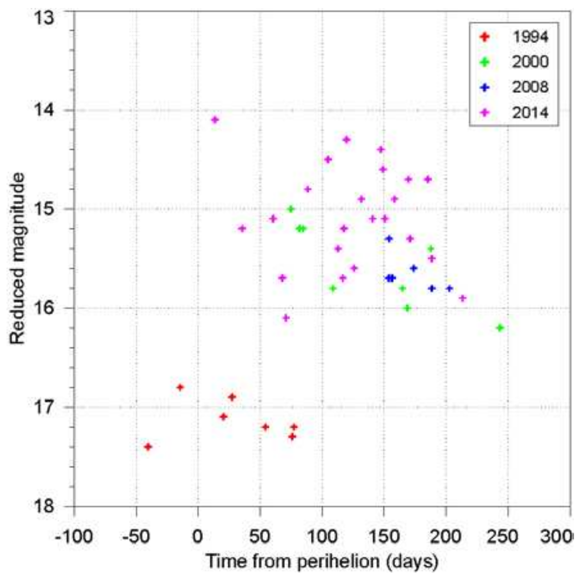

Figure 21. Composite plot showing the observations of 70P/Kojima, plotted against time from perihelion and corrected for the distance from the Earth.

before perihelion – than to a standard log(r) light curve. For the standard light curve, H_{15} is indicated as the parameter for comparison of returns, *i.e.* the comet brightens moderately rapidly. The observations are consistent with no change in behaviour, but may show weak evidence of a slight secular fading, or of fading with perihelion distance.

Table 3. Magnitude parameters of the comets of 2014

a) Standard magnitude parameters

Comet	*No. obs.*	*r (au)*	H_1	K_1	H_{10}
A4 (SONEAR)	51	4.2–6.4	5.7±1.2	7.5±1.7	4.0±0.1
AA_{52} (Catalina)	24	2.0–4.5	11.1±0.7	4.0±1.4	8.4±0.2
C3 (NEOWISE)	4	2.0–2.2			10.7±0.3
E1 (P/Larson)	11	2.1–2.3			10.9±0.2
E2 (Jacques)	341	0.7–3.8	6.6±0.0	9.3±0.2	6.5±0.0
L2 (P/NEOWISE)	20	2.2–2.6			7.9±0.1
L3 (P/Hill)	6	1.9– 2.1			11.7±0.1
N3 (NEOWISE)	33	3.9–4.6			3.9±0.1
Q1 (PanSTARRS)	82	0.4–4.9	7.1±0.0	7.8±0.1	6.8±0.1
Q2 (Lovejoy) (pre)	508	1.3–2.5	3.2±0.0	20.0±0.3	4.8±0.0
Q2 (Lovejoy) (post)	604	1.3–4.7	4.2±0.0	5.4±0.1	3.2±0.0
Q3 (Borisov)	11	1.6–1.7			7.9±0.1
R1 (Borisov)	11	1.3–1.7	7.3±0.6	11.2±3.7	7.4±0.1
S2 (PanSTARRS) (all)	178	2.1–3.3	5.7±0.4	4.5±1.0	3.6±0.1
S2 (PanSTARRS) (pre)			–2.9±1.7	30.8±5.0	4.1±0.1
S2 (PanSTARRS) (post)			5.1±0.5	5.7±1.2	3.4±0.1
W2 (PanSTARRS)	63	2.7–5.3	3.6±0.5	11.9±1.1	4.5±0.1
W6 (Catalina)	13	3.1–3.3			8.9±0.2
W11 (PanSTARRS)	37	3.4–4.4			5.1±0.2
Y1 (PanSTARRS)	2	2.3–2.7			9.2±0.9
4P/Faye (2014)	49	1.9–3.2	8.5±0.7	7.9±1.8	7.7±0.1
4P/Faye (all)	1628	1.7–5.7	8.5±0.1	8.0±0.5	8.1±0.0
15P/Finlay (2014)	128	1.0–1.8	7.8±0.1	18.1±1.9	8.1±0.1
15P/Finlay (2014 non-outburst)	80	1.0–1.8	8.4±0.1	14.3±1.8	8.6±0.1
15P/Finlay (all)	161	1.0–2.5	8.1±0.1	14.3±2.0	8.3±0.1
16P/Brooks (2014)	9	1.6–2.6			11.0±0.3
16P/Brooks (all)	134	1.6–2.6	6.3±0.9	23.5±3.1	10.1±0.1
17P/Holmes	28	2.1–4.2	7.1±1.1	8.5±2.6	6.4±0.2
32P/Comas Sola (2014)	92	2.0–3.1	7.8±0.7	12.2±1.9	8.5±0.1
32P/Comas Sola (all)	306	1.8–3.5	7.9±0.4	11.3±1.3	8.4±0.1
40P/Vaisala (2014)	7	1.8–2.2			10.6±0.4
40P/Vaisala (all)	124	1.8–2.4	5.2±1.2	27.2±4.3	10.1±0.1
52P/Harrington-Abell	10	1.8–2.0			10.7±0.2
70P/Kojima (2014)	23	2.0–2.6			10.3±0.2
70P/Kojima (all)	44	2.0–2.7	11.5±1.5	7.5±4.2	10.6±0.1
108P/Ciffreo (2014)	29	1.7–2.0			10.5±0.2
108P/Ciffreo (all)	65	1.7–2.8	7.9±2.5	16.3±9.8	9.5±0.3
110P/Hartley (2014)	32	2.5–2.6			8.6±0.1
110P/Hartley (all)	131	2.5–3.1	6.2±1.9	15.1±4.6	8.2±0.1
117P/Helin-Roman-Alu	63	3.1–5.0	5.3±0.7	10.0±1.3	5.3±0.1
119P/Parker-Hartley	24	3.1–3.5	2.0±4.4	23.5±8.8	8.8±0.1
124P/Mrkos (2014)	3	1.6–1.7			13.7±0.5
124P/Mrkos (all)	19	1.4–2.5	14.1±0.7	6.5±3.0	13.4±0.2
134P/Kowal-Vavrova	44	2.6–2.7			7.0±0.1
170P/Christensen	4	2.9			9.3±0.2
209P/LINEAR	41	1.0–1.7			16.8±0.1
284P/McNaught	32	2.3–2.5			8.6±0.1
290P/Jager	32	2.2–2.6			7.3±0.1
292P/Li	17	2.5–2.9	–7.4±3.1	49.2±7.4	9.1±0.2
294P/LINEAR	1	1.5			15.7
296P/Garradd	3	2.1–2.3			13.2±0.1
299P/Catalina-PanSTARRS	6	3.4–3.6			8.8±0.3
300P/Catalina	4	0.8–0.9			13.1±0.3
303P/NEAT	4	2.5			11.4±0.3

b) Linear magnitude parameters

Comet	*No. obs.*	*Days*	H_1	K_1	ΔT
W11 (PanSTARRS)	37	–185–376	8.6±0.3	0.0099±0.0014	–147±12
15P/Finlay (2008 & 2014 non-outburst)	100	–80–113	8.0±0.1	0.0478±0.0038	–22.8±1.5
70P/Kojima (all)	44	–40–214	14.0±0.2	0.0042±0.0036	–139±35

124P/Mrkos

The discovery of the comet was described in the paper on the comets of 2002.[16] The perihelion distance has increased from 1.41au at the discovery, to 1.65au at this return following a Jupiter encounter in 2010. As expected it was a CCD object only, becoming no brighter than 15th magnitude.

There are usable observations in the COBS database for four returns since discovery, however they are too few for any long term conclusions to be drawn from them.

Other comets observed during the year

29P/Schwassmann-Wachmann

The comet was at opposition in May and solar conjunction in December, with a moderate southern dec-

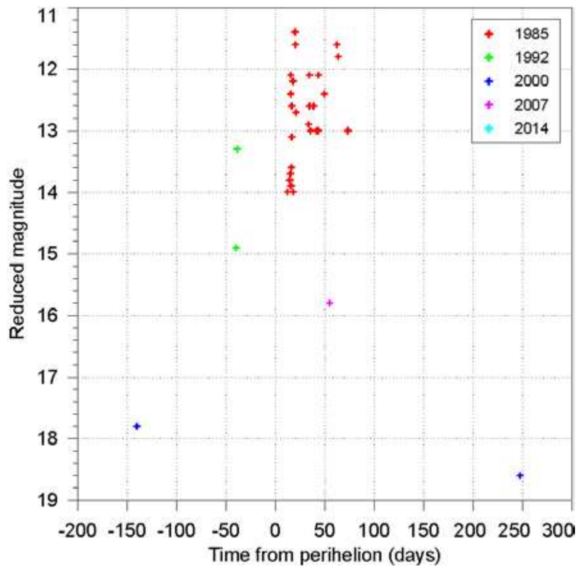

Figure 22. Composite plot showing the observations of 108P/Ciffreo, plotted against time from perihelion and corrected for the distance from the Earth.

Notes on Table 3

The magnitude of the comets can be calculated from the equation:

$$m = H_1 + 5.0 \log(\Delta) + K_1 \log(r)$$

For many comets there are insufficient observations to calculate K_1 accurately and so a value of 10 is assumed, which gives the constant H_{10}. CCD observations approximating to visual, which include a measure of the coma diameter, are used to augment the light curves of those comets with insufficient visual observations. A correction for aperture of 0.0033mm^{-1}, and the observer corrections derived in previous papers,[21,22] have been applied and the H values are reduced to zero aperture.

Some comets do not follow the standard equation and are better fitted with a linear equation:

$$m = H_1 + 5.0 \log(\Delta) + K_1 \text{abs}(t - T + \Delta t)$$

where t is the Julian Date, T the Julian Date of perihelion and Δt an offset. If Δt is positive the comet is intrinsically brighter prior to perihelion. Standard magnitude parameters are also given for these comets for use in planetarium programmes.

lination. Observation is difficult for around six weeks either side of conjunction. Probable major outbursts occurred in April, May & September, with additional minor outbursts.

The May outburst followed the usual pattern, with an initially high degree of condensation steadily becoming more diffuse, but the others were not so clear cut. At brightest, in May, it reached around 12th magnitude. Richard Miles continues to research the behaviour of the comet and has published a series of papers in *Icarus*.[17,18,19]

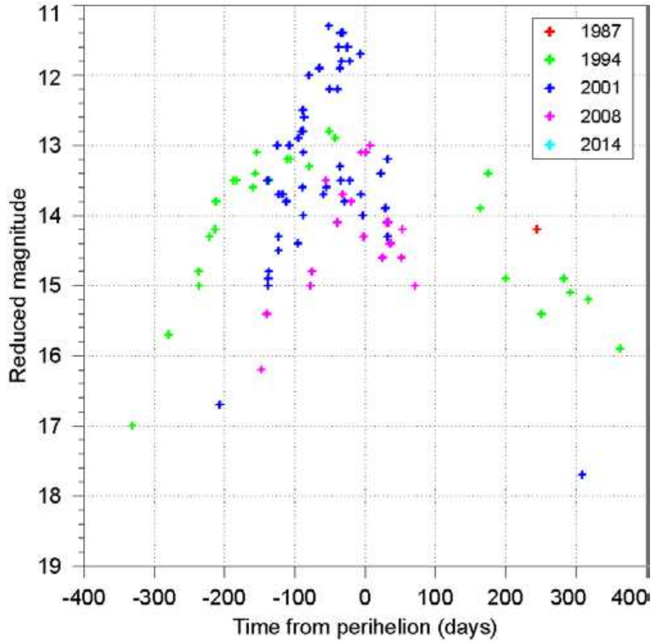

Figure 23. Composite plot showing the observations of 110P/Hartley, plotted against time from perihelion and corrected for the distance from the Earth.

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Figure 24. 29P/Schwassmann-Wachmann imaged by Damian Peach on Mar 12. 20″ CDK with FLI camera; 5×2min unfiltered.

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