THE COMET'S TALE

Journal of the Comet Section of the British Astronomical Association

Number 33, 2014 January

Not the Comet of the Century

2013 R1 (Lovejoy) *imaged by Damian Peach on 2013 December 24 using 106mm F5. STL-11k. LRGB. L: 7x2mins. RGB: 1x2mins. Today's images of bright binocular comets rival drawings of Great Comets of the nineteenth century.*

Rather predictably the expected comet of the century failed to materialise, however several of the other comets mentioned in the last issue, together with the additional surprise shown above, put on good appearances. 2011 L4 (PanSTARRS), 2012 F6 (Lemmon), 2012 S1 (ISON) and 2013 R1 (Lovejoy) all became brighter than 6th magnitude and 2P/Encke, 2012 K5 (LINEAR), 2012 L2 (LINEAR), 2012 T5 (Bressi), 2012 V2 (LINEAR), 2012 X1 (LINEAR), and 2013 V3 (Nevski) were all binocular objects. Whether 2014 will bring such riches remains to be seen, but three comets are predicted to come within binocular range and we can hope for some new discoveries. We should get some spectacular close-up images of 67P/Churyumov-Gerasimenko from the Rosetta spacecraft.

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Section News from the Director

Dear Section member,

Once again it has been a busy year for me. In addition to comets I am President of my local Natural History Society (but only for this year) and have been appointed the botanical co-recorder for the old county of Cambridgeshire. In many ways a botanical recorder is similar to a Section Director, in that I have to collate observations and carry out quality control. There is however much better central software support with staff employed in the role by an organisation that has roughly the same membership as the BAA or SPA, and a lower subscription than the BAA. True, the organisation does get grant money to carry out work, but perhaps the BAA could seek grant money from professional organisations to make observations that the professionals need but do not have the resources to make. Outsourcing to amateurs is very effective for many government funded bodies as there are no staff costs to cover.

On the comet side 2012 S1 (ISON) has been the main topic of mostly inane conversation on the internet and in the media. It brings home the fact that in most cases when the media experts are talking about a subject that you have knowledge, they get their facts wrong. This strongly suggests that when they are talking about subjects about which you have no knowledge they will also get the facts wrong. The problem with this is that whilst with 2012 S1 it didn't really matter, when it comes to matters of public policy it makes a great deal of difference.

Although 2012 S1 was a disappointment, 2013 R1 (Lovejoy) was a very nice comet, but received surprisingly little coverage. My best view was on the morning of December 28, when I was observing from Dodleston, near Chester. Here the skies were much darker than from my home in Cambridge and the comet showed a fine tail in 20x80B.

I had hoped to organise a follow-up to the Section meeting in the spring of 2014, where we would have a computer workshop to demonstrate imaging techniques. Unfortunately one of the potential venues, the Institute of Astronomy in Cambridge, has recently stripped out its "common terminal area" to turn it into offices, on the grounds that these days everyone has their own laptop or desktop. An aim of the meeting was to give potential imagers the opportunity to work through techniques with mentors on hand, all using similar PCs. It looks as if we should instead have a workshop where you bring your own laptop – perhaps at the RAS, although the IoA has a suitable seminar room for a small meeting.

There has been an improvement in the formatting of submitted observations over the year, though there are still some mistakes. Do check the format controlled files of observations that I make available on the web page to see if I have had to edit your observations. With the development of the COBS database an obvious solution is for all observations to be submitted to it. They can then be extracted by national co-ordinators for immediate analysis online or in publications such as this and for more detailed analysis later in publications such as the BAA Journal. When I worked on Antarctic data, the Antarctic Treaty placed an obligation on me to make it publicly available. The British Antarctic Survey therefore places all its meteorological and ozone data on the internet as soon as it is received. It is not always convenient to trawl round several sites looking for data, so there are also specialised international data centres which collate the data from specific fields. The ICQ originally met this requirement for comet observations, but for a variety of reasons does not currently meet the needs of the community. It looks as if COBS is going to take over this mantle, and I propose to let them have all of our ICQ format data.

There have been a few additions to the web pages over the last year. I have started a blog, mostly criticising some of the comments that appear on the internet and the media. Increasingly people seem to want to comment without knowing any facts, and even those who do have facts make selective use of them. I have also prepared tables of comets reaching small phase angles and a version is included in this edition. I would encourage daily electronic, and in a few cases visual, observations of these objects during the indicated period. There is likely to be anomalous brightening, which provides information about the make-up of material in the coma.

You may have spotted that I've changed the sub-title of The Comet's Tale to Journal of the Comet Section of the British Astronomical Association. Over the years the newsletter has expanded, and with nearly 50 pages it seems more appropriate to describe it as a Journal.

Albert Jones with the telescope used for his discovery of comet 2000 W1 (Utsonomiya-Jones).

We lost one of our senior members in September with the death of Albert Jones. The earliest observations that we have from him in the digital archive are from 1951 when he observed 2P/Encke and 1957 when comets 1956 R1 and 1957 P1 were on view, and the most recent are from 2008. His earlier observations were digitised and are in the ICQ archive. My last contact with him was in 2011 January, when he was pleased to have downloaded The Comet's Tale. Altogether he contributed over 1000 comet observations and discovered two. Both were found whilst observing variable stars, the first in 1946 and the second in 2000.

In 2015 I will have been the BAA Comet Section Director for 25 years. I think this is enough (perhaps too much), and it is time to start considering a successor, to take up the post at the start of the new BAA year in 2015 October. There is a lot for a Section Director to do, though a new one may choose to delegate many of the tasks, which include: often daily updates to the web pages, correspondence with observers, non-observers and the media, quality control and archiving of observations, writing notes and papers for the Journal, writing and collating The Comets Tale, analysing observations, maintaining orbital and magnitude data files, attending meetings and of course making your own observations. Although the BAA has triennial reviews of its Section Directors, there is no policy on the length of time that they or BAA Officers should serve. I suggest that it is best practice to have a time limit of no more than three successive three-year terms or ten years without a break. This would create opportunities for change, which are often lost when one person stays in post for a long time.

Because of the many things that I do, I rarely acknowledge receipt of observations, unless there is a need for clarification. This does not mean that your observations are not valued, far from it, without them there would be no data to analyse and no scientific results to present. Everyone's observations are important, as each individual observer has systematic biases, and these are difficult to detect unless there are enough observations from other observers. Although it is invidious to mention some without mentioning all I would particularly like to mention Kevin Hills who is contributing a large number of electronic visual equivalent magnitudes, Damian Peach who is producing beautiful images and Juan Jose Gonzalez who manages to make visual estimates of many low contrast comets from his mountain location. They set a standard which we should all strive towards if we can.

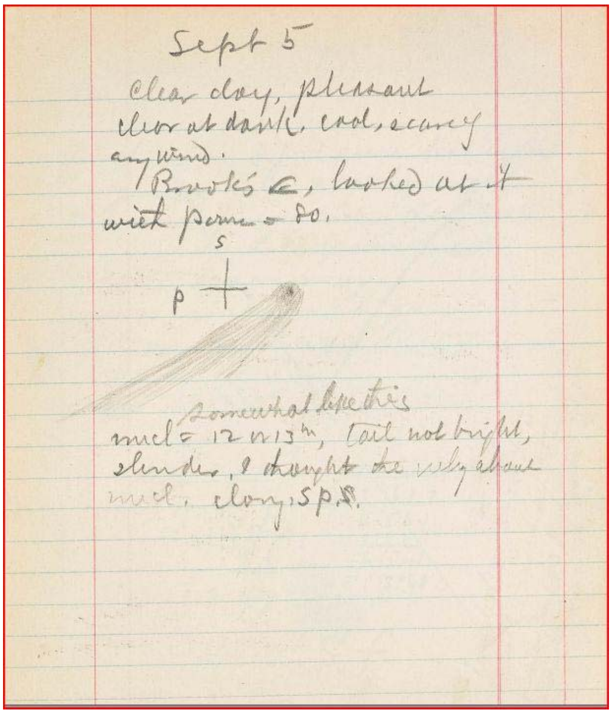
Best wishes, *Jonathan Shanklin*

Section News from the Secretary

My main task as Section Secretary is to upload comet images onto the BAA Comet Gallery, and to respond to observer queries. I hope I have replied to all emails sent to me and that observers have seen their comet images promptly placed on the Gallery.

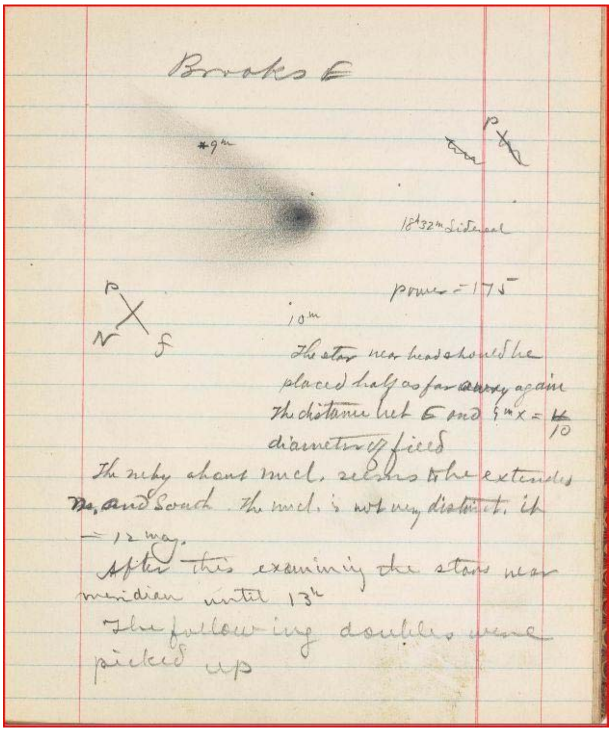
2013 has been a very busy year with at least 4 bright comets under observation by members. This has resulted in a huge increase in the number of images placed on the Gallery compared to last year. The bare facts are these: 72 section members have observed 82 individual comets and submitted 1200 images. The 4 brightest comets and the number of images are as follows: 2011 L4 (PanStarrs) (330), 2012 S1 (ISON) (215), 2013 R1 (Lovejoy) (159), 2012 F6 (Lemmon) (60).

Individual observers and the number of comet images submitted are as follows: Angel+Harlingten (25), Adam (1), Arditti (1), Baransky (228), Buczynski (192), Bryssinck (61), Baddiley (5), Bell (2), Bullen (2), Carson (18), CARA (14), Campsas (1), Cooper (3), Curtis (1), Colombo (1), Dymock (43), Evans (3), Eagle (4), Evetts (2), Fraser (4), Gonzalez (1), Glenny (1), Giambersio (4), Gavin (4), Herald (1), Holt (1), Haymes (1), Hudson (1), Holmes (1), James (62), Jaeger (13), Jennings (2), Jackson (2), Lawrence (12), Leadbetter (1), Ligustri (3), Lancashire (1), Loughney (2), Leith (1), Marsh (6), Mobberley (90), Mackie (8), Martignoni (40), Moreles (6), Miles (28), Mills (2), Milani (1), Morrison (1), Peach (105), Paul (1), Pappa (6), Poyner (1), Privett (4), Platt (2), Pratt (1), Put (2), Relf (6), Robertson (6), Sharp (21), Storey (44), Strange (15), Stone (1), Simpson (1), Scarmarto (2), Tipping (1), Tough (6), Teerasak (7), Vetterlein (5), Warell (48), Ward (1), Winter (2) and Weightman (2).



Sketch of 1888 P1 (Brooks)on 1888 September 5 by E E Barnard, taken from his observing book

The images received were obtained using a variety of instruments including CCD's, DSLR's and some visual drawings. The most active observers used Remote/Robotic telescopes mainly in the USA (at New Mexico) due to the better conditions experienced at these sites. Images of superb quality were obtained from these facilities. Many other observers battle against the ever changing UK weather and use their own telescopes in back gardens, continuing a long tradition. All these observers make a good contribution to the Section. We have seen an increasing use of DSLR's because the bright comets we have seen this year are very conveniently imaged using these cameras. To sum up I recommend members to have a good long look through the BAA Comet Gallery (1700 images) and enjoy the contributions made by members.



Sketch of 1888 P1 (Brooks) by E E Barnard taken from his observing book

One last point I would like to make is related to visual drawings of comets. I brought this subject up at the Section meeting at Northampton and tried to encourage observers to submit drawings and sketches. There is a long tradition, which goes back centuries, of observers recording their views of comets, seen though telescopes, binoculars and with the naked eye. It is still a very valid observing method and we would like to see more observers submitting drawings and sketches. I suspect that many observers do not submit drawings and sketches because they may feel that the quality of their drawings is not good enough. Some may feel that any drawings that they make are not realistic enough or look somewhat childlike in their execution. This is not the case. To try and make this point I show the observing notebook of one of history's greatest comet observers, Edward Emerson Barnard. These pages show the comet sketches of Comet Brooks he made at the telescope at Lick in 1888. If they were good enough for Barnard then we should be able to make drawings that are of equal value. Any observation of a comet is unique and can never be repeated exactly. So a drawing is a valid record of that comet at that moment in time, especially if accompanied by extensive written notes made at the time. Give it try and you will be pleased with the outcome. Send the observation into the Section and we will be very pleased to receive them.

Denis Buczynski

Tales from the Past

This section gives a few excerpts from early RAS Monthly Notices and BAA Journals. The BAA was formed in 1890.

150 Years Ago: Some reports of astrometric observations and orbits were published in Monthly Notices, but unusually there are no noteworthy items on comets from 150 years ago. The only piece that caught my attention was a note in the obituaries at the forty-fourth Annual General Meeting that "The King of Siam, an Honorary Member, reported as dead, is still alive".

100 Years Ago: The January Journal has a note from James Skjellerup on his observation made in September of a new comet. This had actually been discovered by Gale (1912 R1) three days earlier, but he was unaware of this. There is a slightly carping review of the second edition of Chambers *The Story of Comets*. The first edition had sold nearly 2000 copies in nine months, showing the demand for the book, and the reviewer says "We think it was unfortunate that the author set about satisfying this demand so quickly." This was all on account that it included no update on the recent return of 1P/Halley, though it did feature an illustration of the great Daylight Comet of 1910, as seen at Biskra, North Africa. Elements for the return of 20D/Westphal were given, but noting that the time of perihelion was up to 7½ months in error.

Artist's impression of the Daylight Comet taken from http://www.phenomena.org.uk/page77/page84/page84.html

At the February meeting Dr Crommelin read a letter on the discovery by Mr B Lowe, of Laura, South Australia, of a comet [There are digital records online, eg http://trove.nla.gov.au/ndp/del/article/59728145]. He had received some notes by post from the Adelaide Observatory a few days earlier, and they gave a lesson for beginners. Mr Lowe was an enthusiastic beginner and had been hunting comets for several months. He had made a pre-discovery of Gale, and did not only observe in the evening, but "he continued long after midnight". He had discovered a new comet in the small hours of the morning and had observed it on December 31, January 3, 5, 6 and 9; but had failed in two respects. He had not immediately communicated the observation to an observatory, and he had not made a careful sketch showing the field stars and the position of the comet. No other observations of the comet had been received. Later the discovery was discussed at the September meeting of the New South Wales (NSW) Branch [Australia] and Messrs Thow, Gale and Beattie all concurred in the opinion that the object could be none other than the nebula Messier 56 [but see for example http://meteorshowersonline.com/showers/coma_berenicids.html]. There also appears to have been a good deal of discussion at this meeting on whether or not the Earth passed through the tail of 1P/Halley on 1910 May 19.

The death of Dr David Smart was announced at the March meeting. He was notable in the field of comet orbit computation, particularly that of 1P/Halley, but professionally was a medical Doctor. Professor Fowler gave a lecture on the spectra of comets at the April meeting. The abstract covers six pages, so you will need to get a copy of the BAA Journal DVD in order to read it in full, but there were a few points of interest. The Swan bands were also known as the candle-flame spectrum of carbon, which can be seen in the blue base of a candle flame. The first spectroscopic observation of a comet was made in 1864 by Donati. Sir William Huggins had observed the spectra of comets in 1866, 67 and 68, particularly noting the resemblance of the 1868 spectra to that of the candle-flame spectrum. During the talk he demonstrated this by showing a spectrum of 1911 O1 (Brooks) with the Swan spectrum below it. He also showed a spectrum of the comet with a low pressure spectrum of CO below it, demonstrating that CO was present in the tail. He inclined towards the meteoritic theory of comets, but did not know how the gases in the tail of the comet were repelled from the head, or how they were made luminous. A talk given at the New South Wales Branch meeting in October by E H Beattie argued that comets with parabolic orbits are not interspacial, but must be members of our own solar system. If they had been interspacial, their axes would be aligned towards the solar apex. He also gave the useful formula for the velocity of a parabolic comet of v = $(2/r)^{1/2}$ earth's mean velocity [29.78 km s^{-1}] [so putting in the figures for 2012 S1 gives 378 km s^{-1}].

The NSW April meeting also had a comet talk, this time on the nebular origin of comets. The author suggests the possibility of a solid nucleus, then concludes “I venture also to suggest that the loss of material which a comet must experience in its long history might be recuperated from the ‘trail’ of material along the course of its orbit, of which we had decisive evidence in the case of many comets, and which might be the case with all. The meteor showers illustrate this in the case of some short-period comets. The ‘family’ of comets in the case of the great comet of 1882 and its *compagnons de voyage* illustrates this over a wider field.”

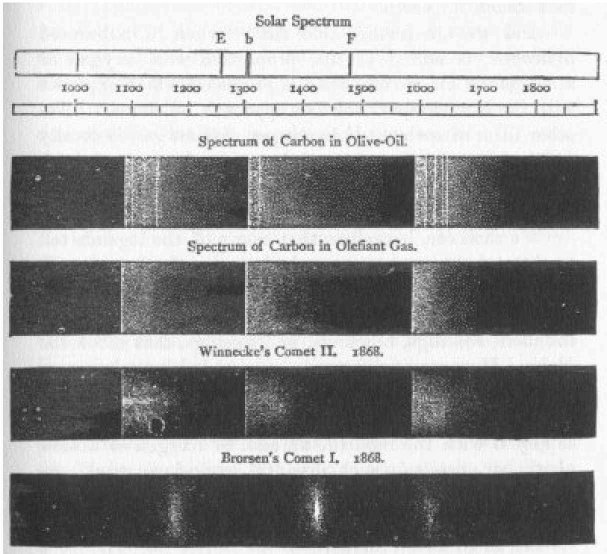


Image from http://levigilant.com/Bulfinch_Mythology/bulfinch.englishatheist.org/atl/Ragnarok.html

Observations of 1913 J1 (Schaumasse) were reported at the May meeting, which was relatively easy visually, but difficult to photograph, requiring an exposure of 75 minutes. The Annual Report in the September Journal notes observations of Gale (who was a member of the Association). Dr Crommelin notes that 20D/Westphal had been searched for without success, but in the next paragraph notes that it was found on September 26 by Delavan at La Plata. The issue concludes with an Appendix of Memoranda for Observers in the Various Sections. The work of the Comet Section covered Sweeping the Sky for New Comets; Observation of Comets, where photography was regarded as the primary medium for studying the physical appearance and the changes of comets. Visual observation of bright comets was thought to supplement the photographs. Other work covered Calculation of Orbits and Calculation of Ephemerides. The November Journal lists the member of the Section, with 14 names given. The Presidential Address of the NSW Branch by Rev T Roseby notes that Cyanogen was found in the spectrum of 1912 R1 (Gale). The President goes on to say “These ‘*angel ministers*,’ after all, bring with them ‘*airs from heaven*,’ to use Shakespeare’s phrase, very different from what we might expect. Cyanogen is one of the deadliest of mineral poisons.” The comet notes mention the remarkable collapse of Westphal’s comet. It began in October with plenty of promise of an interesting display, but faded rapidly at the end of the month. Dr Crommelin likens the behaviour to that of 17P/Holmes, and suggests that it should be watched in view of the possibility of another outburst. He also mentioned Neujmin’s comet which had a period of 18 years and passed near the orbit of Mars (28P/Neujmin) and 21P/Giacobini-Zinner whose orbit practically intercepted ours, so we might hope to have a meteor shower from it. Donohoe Medals went to Rev J H Metcalf and Messrs Schaumasse and Neujmin.

50 Years Ago: At the April meeting Michael Hendrie showed some photographs of 1963 F1 (Alcock) and 1963 A1 (Ikeya) taken by Alan McLure from Los Angeles and Dr Elizabeth Roemer from Flagstaff. The Annual Report notes the third comet discovery of George Alcock and his award of the Jackson-Gwilt Medal and Award from the Royal Astronomical Society. Four comets had been observed during the session by 43 observers. The Goodacre Medal and Gift was awarded to Dr G Merton for his work on comets at the AGM in October. Amongst other work he had proved the identity of 1902 O1 with 1922 K1 and predicted its return in 1927 (26P/Grigg-Skjellerup). The December Journal gives a synopsis on new theories on the origin of comet tails. The theory that they are created by solar radiation pressure fails by many orders of magnitude. A newer theory by Biermann and Treffitz suggested that they form due to collision with particles in the solar wind, but this again fails. Finally the latest theory linked in the discovery of the interplanetary magnetic field by Mariner II, so suggests that it was the magnetic field that carried the charged ions of the comet tail with it. In much the same way that Roger Dymock is now producing an A-Z of comets for beginners, so too did Michael Hendrie in the February Journal in part one Comet Terminology, which also gave some suggested further reading.

RAS Specialist Discussion Meeting

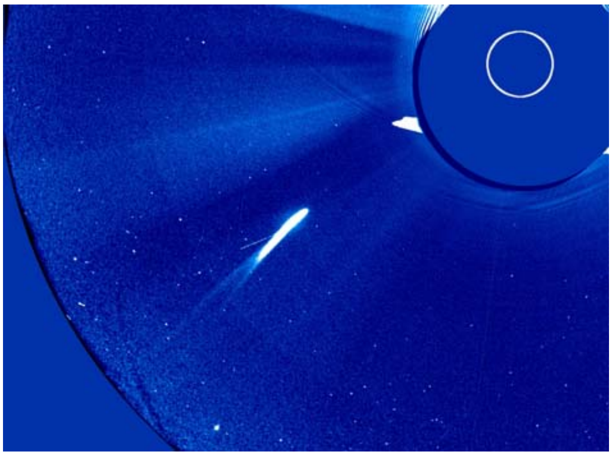
Comets’ Interactions with other Solar System Bodies

Geraint Jones, John Brown and Stephen Lowrie organised the meeting to discuss the important role that comets have played in the formation and evolution of the planets, through bombardment of their surfaces and consequent delivery of volatiles species to those bodies. Approximately 40 people attended the meeting, held at Burlington House on 2013 March 8. These notes are my own interpretation of what was said at the meeting.

Karl Battams (Naval Research Laboratory): Near-Sun comets observed by LASCO and SECCHI. Karl had been a student at University College London, and got a job at NRL in 2003. He got into the SOHO program when his supervisor asked him to take a role in the project. He described the LASCO coronagraphs. He gave a resume of the first years of the project, with the first amateur discovery in 1999 and it quickly grew into what is now called citizen science. In 2002, three other comet groups were recognised. SOHO observations have lead to better understanding of comet tails, eg 2002 V1 (NEAT). The Marsden, Kracht and Machholz complex demonstrates a process of continuous fragmentation and orbit evolution and leads to an end state of a cometary body. STEREO was launched in 2006, with the pair of satellites slowly separating to give perspective views of the Sun, though they will cross again in 2015. Their coronagraphs are better resolution though SOHO, but have a different bandpass. Their are two heliospheric imagers, HI-2 having an 70° field and HI-1 having a 20° field, both offset from the Sun. Shortly after the spacecraft became operational 2006 P1 (McNaught) passed through the field. 2P/Encke showed a spectacular tail disconnection event. In COR2 Kreutz comets are all tail and no head, but in LASCO the same comets show head and no tail. This is possibly because the COR bandpass omits the Sodium 589.2 line, or because of polarisation. 2010 saw an excess of bright Kreutz comets. The first example of a Kreutz tail interacting with the solar wind was seen. An ion tail was seen in one from LASCO. In 2011, 2011 N3 (SOHO) was seen to vaporise in EUV as it penetrated to 0.15 solar radii. It lost around 107 kg, implying a body 10-50m in diameter. 2011 W3 (Lovejoy) was discovered from the ground by Terry Lovejoy, but was not expected to survive past perihelion. As it went through perihelion it lost its tail, but grew another. Sekanina and Chodas extensively modelled what happened in their 2012 paper [Comet C/2011 W3 (Lovejoy): Orbit Determination, Outbursts, Disintegration of Nucleus, Dust-Tail Morphology, and Relationship to New Cluster of Bright Sungrazers. ApJ 757 127 http://m.iopscience.iop.org/0004-637X/757/2/127?recenthistorytab=viewed]. It was about 100m across and travelled at 0.002c at perihelion. The observations may show evidence for rotation, but this has not yet been analysed. SOHO is in year 18 of a 2 year mission. New solar observing spacecraft are scheduled for launch in 2017 and 2018. Solar Orbiter will have a wide-field heliospheric imager. 2011 W3 remains the only comet where tail material has come out on the opposite side of the Sun.

NASA was organising an observing campaign for 2012 S1 (ISON) as a community initiative. There is no possibility that it is a periodic comet. It comes from the Oort Cloud. It passes less than 3 Ro from the Sun. Fragmentation is possible [The Roche limit for a solid comet would be 1.78 R_o, and for a fluid one 3.42 R_o according to Wikipedia.] Sodium tails might be possible to detect using a simple filter [would subtracting a Light Pollution Rejection filter image from a clear image work? Ed]

John Brown (Glasgow): Destruction regimes of Sun-skimming and Sun-plunging Comets. He was a solar physicist, but had become interested in comets. He was looking at how mass is lost. Close to the Sun, frictional heating becomes important. It grows to be 10^4 times greater than sunlight, leading to a potential flash spectrum. The 2 MK coronal temperature is not an issue as the heat content is minimal and is roughly equivalent to sunlight on a beach. It would take 100 years to vaporise a 10^{12} kg comet. Sun-grazers and Sun-skimmers (where $q/R_o > 1.01$) “fizzle”, but Sun-plungers enter the solar photosphere and are much more explosive (similar to the recent Russian meteor). None have yet been observed, and to see effects the comet would need a mass greater than 10^9 kg. The kinetic energy associated with a Sun-grazer is not negligible, eg 2011 W3 had 10^{20} kJ, which is greater than the thermal energy of the entire corona above the comet. A “fizzle” takes about 1000 seconds, compared to the pancake splat of a Sun-plunger, which is over in a second. He would expect effects similar to a solar flare, so it could generate ripples. A spinning comet could lead to a “bouncing bomb”.



The brightest of the 2010 Kreutz comets, which was discovered in STEREO images

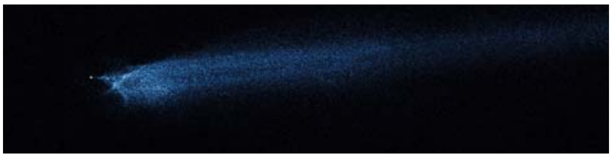
Geraint Jones (Mullard Space Sciences Laboratory/UCL): Ion and dust tail observations of near-Sun comets. He was looking at Sun-skirter dust tails. The insolation for 2011 W3 at perihelion was 32,000x that at 1 au. 2006 P1 had a highly structured dust tail. Dust was accelerated by solar radiation pressure, but in proportion to its cross-section. All near Sun comets show striae and these are not aligned on the nucleus. β is the ratio of radiation to gravitational force. When β is less than 1, gravity dominates. When β equals 1 then the particle moves in a straight line. If β is greater than 1 the particle is lost to the solar system. There were two theories for the formation of striae. They could form from parent particles, which subsequently fragmented, creating the striae. An alternative theory linked them to an active area on a rotating nucleus with a continuous cascade of fragmentation. The dust grains last a shorter time before they break-up the closer their release is to the Sun. The striae of 2006 P1 were modified by the solar wind, creating a ripple like effect. Modelling of the solar magnetic field suggested that the comet encountered a change in field direction on January 13, which is when the striae changed, and this best fits the rotational model with a fragment cascade.

Yudish Ramanjooloo (MSSL/UCL/Isaac Newton Group of Telescopes): Solar wind flow information from comet tail orientations. 2011 W3 showed an ion tail. He reviewed the theory of magneto-tail interaction. The ion tail lags the actual solar radial direction by a few degrees, depending on the magnetic field. His project was to analyse solar wind velocities. He projected the images onto the orbit plane, mapped them to get the tail position, then analysis gave the velocity. He got rather different values for LASCO and STEREO data, which still needs explaining.

Kimberley Birkett (MSSL/UCL): Modelling the sodium tails of near-Sun comets. A neutral sodium tail was first seen in 1957 P1 (Mrkos), but their possibility was then forgotten until re-found in 1995 O1 (Hale-Bopp). It has since been seen in several other comets. The source of the sodium is not known. It is possible to get acceleration of sodium if the solar sodium line is doppler shifted either due to Sun/Comet motion (Swings effect) or Sun/sodium motion (Greenstein effect). She predicted the possibility of a separated sodium tail for 2012 S1.

Leigh Fletcher (Oxford): Impacts on Giant Planets. There is a family of impacts on Jupiter ranging from 1993 F2 (D/Shoemaker-Levy) [a comet], the Wesley 2009 July 19 object [an asteroid] and flashes seen in amateur images post 2010 [meteoroids]. The Wesley impactor came in at around 70°, compared to the much steeper 1993 F2 at about 45°. The meteoroids don't get very far down into the atmosphere. D/1993 F2 heated the higher stratosphere, but the Wesley impactor did not due to the much shallower angle of the impact plume along the incoming track. The impacts drive extraction of material, eg ammonia, and there is also shock chemistry. The observations of the Wesley impactor plume are consistent with a generic silicate. Although it was thought that only Jupiter Family Comets were likely to hit Jupiter, the latest studies show that asteroidal impact is just as likely. Again monitoring the planets is something for citizen science.

Colin Snodgrass (Max-Planck-Institut für Sonnensystemforschung): False comets: Collisions between asteroids. Main-belt comets have a coma and tail due to ice, but a near circular orbit and are clearly comets. What about objects such as 2010 A2 (P/LINEAR)? HST images showed an odd morphology. They used the model normally applied to comet tails to track the motions of dust grains, using Rosetta images to help 3-D reconstruction. They deduced that a collision with the object had occurred on 2009 February 10±5days. β was of order 10^{-4} to 10^{-5} implying mm to cm sized grains. The smaller grains had already been lost by the time of discovery, and it was not found earlier because of a small solar elongation. It would have been too faint to be seen in STEREO. They also deduced that $3x10^5$ m^3 or $4x10^8$ kg of the mass had been ejected, or around 16%. The collision would have created an 80m crater on a 120m body, with the impactor 6-9m across. Such a collision would happen every 1.1Gy for a body in the orbit of 2010 A2, however there are sufficient numbers in orbit that an event would happen about once a decade. Dust production from asteroids is 3 or 4 magnitudes less than produced by comets. The X-shape is consistent with an impact cone, but a new paper suggests rotational break-up. The train is still there and its material is redder than the nucleus. (596) Scheila showed a plume in 2010 that is consistent with a 30m impactor. 2012 F5 (P/Gibbs) probably underwent an impact in 2011 July. The ejected mass was 10^8 kg and the nucleus is small. Although small asteroids are rarely hit there are a lot of them. We should expect to see about one a year, mostly of objects unknown at that point. 2013 A1 (Siding Spring) passes close to Mars in 2014 October. This will give the opportunity to study an Oort Cloud comet close up with a suite of scientific instruments.



Hubble WFC3 Image of P/2010 A2 (January 29, 2010). ***Credit:*** *NASA, ESA, and D. Jewitt (UCLA)*

Sam Duddy (Kent): Main belt comets. Comets undergo outgassing and were probably formed beyond the snow line near Jupiter. They are often visible to the naked eye. Asteroids are rarely ever visible to the naked eye and are stellar. They have not much in the way of volatiles and formed between Mars and Jupiter. The orbits are usually quite different, with comet orbits being highly elliptic and inclined. A dedicated survey by Hsieh & Jewitt found three comets in the asteroid belt with results published in 2006. Since then several more have been found. MBC orbits are stable, so they probably formed where they are, which implies that at least some asteroids have volatiles, which in turn implies that the position of the snow line must have varied inwards from Jupiter. Observations show that (24) Themis has water ice, and modelling of (1) Ceres suggests a water-ice mantle. Asteroids must have a protective layer or activity wouldn't persist for more than a few thousand years. A collision is needed to excavate an area, then after some time activity will resume at each perihelion passage, as in 133P/Elst-Pizarro. MBCs are important as they may be the main vector for delivery of earth ocean water. For confirmation we need in situ measurement of D/H at two or more MBC.

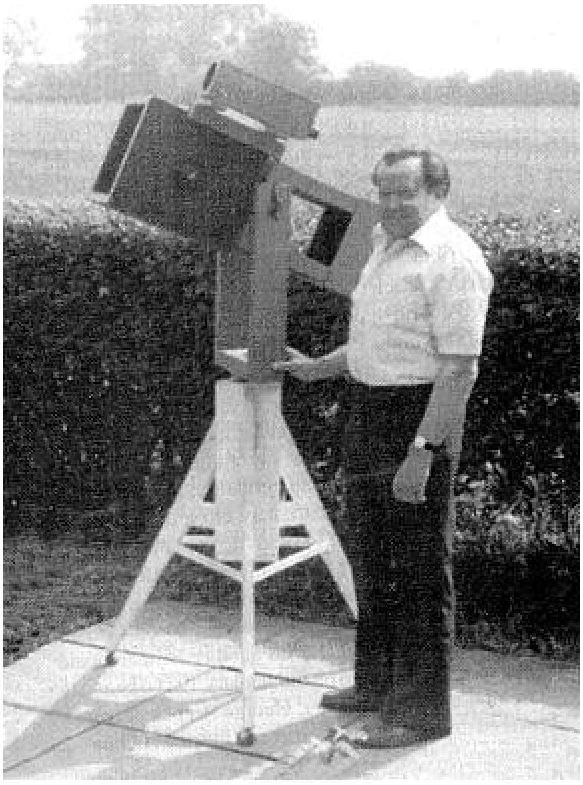
Mark Price (Kent): Impacts on Terrestrial Planets. Impacts are ubiquitous in the solar system. There is a light gas gun at Kent to investigate the physics of impacts. They have demonstrated that organisms can survive impacts. Recent impacts have been observed on Mars which clearly reveal volatiles, and there is a question of whether these could include methane. They tested an impact on local terrestrial basalt, but there was no methane release. Experiments on pre-biotic material suggest that amino acids can form in impacts.

Ian Wright (OU) [Given by Andrew Morse]: Rosetta-Philae: a cometary impact of a different sort. Rosetta was launched in 2004. It is currently in hibernation and will wake up in 2014 January for its rendezvous with 67P/Churyumov-Gerasimenko in May and landing in 2014 November. It is a long chain. They tried sampling during the (21) Lutetia flyby, but there was no significant detection of volatiles. The lander has an autonomous sequence after arrival, followed by long term science for six months. They are looking to reprogram the lander to allow measurement of oxygen isotope ratios, and are currently testing in the laboratory.

Stephen Lowry (Kent): Comet 67P/Churyumov-Gerasimenko. He spoke about the shape model and thermal properties of 67P. The initial light-curves didn't have enough information to constrain the fit, and prograde and retrograde rotation was possible. The dataset was extended to 2007 and linked with previous observations. The best model was a faceted pebble, rotating in 12.76 hours. There was a general agreement between different modelling teams on the pole position, however the Kent group actually consider their alternate position the better fit. The new thermal model allows fitting of thermal inertia, surface roughness and geometric albedo, as well as the effective radius. They derive a radius of 1.95km and albedo of 0.062. The thermal inertia is close to 0, implying thermal equilibrium, with very fine grained material (finer than the lunar regolith). One advantage of 67P over the original target of 46P/Wirtanen, is that it is larger so that they have a much better dataset on the "inactive" nucleus prior to the encounter than would have been the case. The model assumes convex facets and no albedo variation, so the fact that the light curve is not fitted perfectly implies that there are probably craters and albedo variations.

Jonathan Shanklin

Comet Section Meeting



Roy Panther with his 8-inch 'old discoverer' (Northamptonshire Natural History Society)

The Section held its first solo meeting for several years at the Humfrey Rooms of the Northampton Natural History Society on 2013 May 18. Denis Buczynski and Nick James organised the programme and Nick Hewitt oversaw the local arrangements. 42 participants signed the attendance register. A full recording of the meeting, together with the presentations is available via the Section web page.

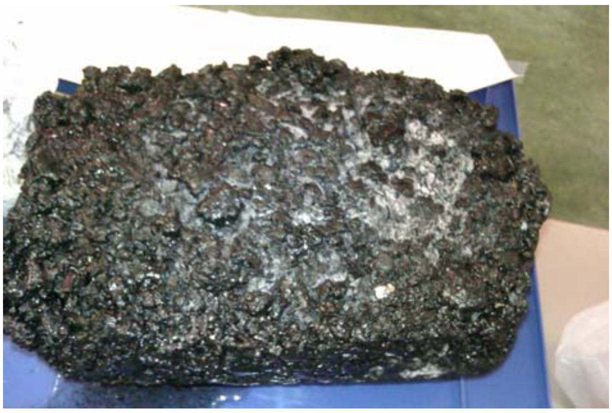
Denis introduced the meeting and said that it was going to run to time. He paid tribute to Roy Panther, discoverer of 1980 Y2, who was present.

Denis asked who had observed comet PanSTARRS whilst showing an image of 2011 L4 on the screen. Most of those present said that they had, but he then said that he meant 2012 B1, showing the need to be precise. He showed several unusual observing scenarios, including observing from Times Square. He then introduced Jonathan Shanklin to start the program of talks.

Jonathan Shanklin introduced the Section, and explained that one remit is to produce scientifically useful observations. Although the Section was formed in 1891, most of the extant original observations date back to the 1940s. There are around 40,000 visual and electronic observations of 500 different comets, including returns of over 100 periodic comets. Publications include the WWW pages, this newsletter, papers in the Journal and the Observing Guide. Amateurs have the capacity to make visual observations, astrometry, imaging, and perhaps occultations. All have their scientific uses. Visual observations, combined with comparable electronic observations allow determination of light curves, with the magnitude parameters giving physical information about the comet. We can compare the parameters of periodic comets from return to return to monitor changes – something that our long term archive provides a solid foundation. Astrometry is vital to professionals who may want to target spacecraft or radio telescopes. Discovery is still possible, though opportunities are becoming increasingly limited, albeit not zero. Images provide another vital dimension. It is however up to the observer to reduce their own observations, and if these are to be of use for later analysis they must be submitted in the correct format. Some comets show well defined outbursts, but often such reports reflect changes in observing conditions, or expectations based on an assumed magnitude. Comet 2P/Encke appears not to have changed in absolute brightness since the first well-recorded Section observations in the early 1950s. Comet 9P/Tempel appears to have been brighter in 1994 than it was in 2005, although the shape of the light curve is similar at the two returns. A paper on the observations of 67P/Churyumov-Gerasimenko has recently been published in the Journal. Observations of cometary brightness allow predictions to be made, but often the behaviour of a comet changes as it approaches perihelion. Something happened to 2011 L4 during solar conjunction that reduced its absolute magnitude by about two magnitudes. Whether 2012 S1 will be spectacular will be clear by the time you read this, but at the meeting I suggested maybe -6 at perihelion.

The next speaker was Denis Buczynski who spoke about wide field imaging. Some comets are beautiful. The scale needed depended on the angular dimensions of the comet. Old astrograph images had fields of 10 – 20 degrees. New technology includes cooled CCD and DSLR cameras, which can give 1-2° fields. Coma correction is needed over the entire field. Michael Jaeger produces excellent images using a 10cm astrograph with a secondary of 5cm. Images may be for beauty, for measurement (tail, magnitude, coma diameter, tail orientation or streamer development). You may need to mosaic to get full details of a long tail. Tail disconnection events can be used to measure solar wind velocity. Colour imaging allows separation of dust and gas tails. Detection of synchronic banding allows measurement of dust events on the nucleus. Denis had picked up 2012 S1 at 16th magnitude with a 300mm telephoto lens and DSLR. Richard Miles has been imaging 2011 L4 for photometry, where the key is to use short exposures to avoid saturation. In answer to a question Denis said that all images are potentially useful; they may show the start of an event, or something nearby, eg a GRB. When you submit an image using the correct name format is essential as the archiving is automated. You don't need to submit raw images, but you do need to submit the analysed products (eg photometry in ICQ format).

Guy Hurst spoke about observing comets visually. The BAA has a long history and needs continuity of observation. He still gets reports of discoveries, though most are false reports. The ephemeris magnitudes on MPECs are often widely different to visual magnitudes. Guy started observing with 1969 Y1 (Bennett). The discovery message about 1980 Y2 was conveyed from Roy Panther at Walgrave to Guy at Wellingborough by taxi, as he had just moved there and the phone company hadn't managed to install a phone line. Most amazing was George Alock's discovery of 1983 H1 (IRAS-Araki-Alcock) which was 6th magnitude. Reinder Bouma's charts are excellent for finding and magnitudes. The Sidgwick method of magnitude estimation is recommended. Descriptive detail is less often noted, so description is welcome, and indeed can be of use to professionals, eg colour, inner coma detail. Comets can outburst, eg 17P/Holmes. Comet 1975 V1 (West) was a stunning sight. John Bortle made drawings of its nuclear fragmentation. Some people don't observe in moonlight, however many comets remain visible and an outburst may have occurred. Drawing has been the traditional way of recording comets and Guy showed an illustration of 1402 D1. Tycho worked out that comets were above the atmosphere. Tail position angle in measured with respect to celestial co-ordinates, not geographic ones (ie not with respect to the horizon). A good quality eyepiece can make a big difference to what you can see in the inner coma – most electronic images over-expose this area. 1973 E1 (Kohoutek) was actually quite a nice comet, and George Alcock drew considerable tail detail. Some comets turn out to be returns eg 153P/Ikeya-Zhang. There had been quite a few interesting comets in recent years. In response to a question Guy said that yes, drawings are used and that they often appear in formal reports. The BAA Computing Section also produces finder charts, and these were updated immediately after the meeting to include comparison magnitudes.



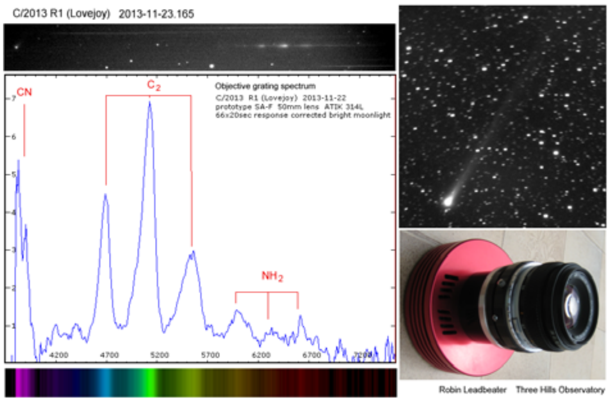
Glyn's "Do it yourself" Comet

Glyn Marsh concluded the morning session with a Do-It-Yourself comet. Glyn was a research chemist with the former British Nuclear Fuels and the present UK National Nuclear Laboratory. Glyn had brought a freezer with him on his trip over from the Isle of Man, along with several props. First off was a simple model comet nucleus wrapped in a cotton wool coma. This was followed by a more authentic example made from freezer ice crystals and soot from a chimney and he particularly noted that the mixture stank but that it was too dense. Next were various coal samples. Anthracite sieved to <1mm gave a density of 0.74, 1-5mm gave 0.7. Wood charcoal gave 0.067 which is much closer to what is needed. Although the chemistry of comets is reasonably well understood, much of a comet's structure is a materials science issue and is less well-understood. For ices he showed some snow (i.e. vapour-phase sublimated water) that had fallen in April, though it had annealed during storage. He simulated accretion by spraying the charcoal sample with water from a mister and then freezing it in layers. He likened the product to a lightweight and friable Hobnob biscuit. Comets also have silicates, so talc powder (hydrated magnesium silicate, density 0.6 $g.cm^{-3}$) was added. Soot clearly has more than just carbon as it stinks. Vermiculite is another low density silicate (magnesium iron aluminium silicate), so this was added too. He decided not to add CO or CN on Health & Safety grounds! Carbon Dioxide in the form of dry ice came from a CO_2 fire-extinguisher, which was discharged into a porous cotton bag. He then produced from the freezer "one I made earlier" – a model comet nucleus of frozen soot, talc, vermiculite and a central hollow that he filled with dry ice. Sprays of water onto the dry ice led to jets and out-gassing through the porous structure. He concluded that comets need to be cold to hold together, they are filthy and they stink. He named his comet 2013 K1, or strictly D/2013 K1 as it wasn't going to survive! In response to a question he said that the structure of a comet will play a part in its brightness evolution. The composition also varies between different comets, and probably within a comet. Alan Fitzsimmons said that modelling shows that surface flows take place from active areas across a comet's surface. [If you only follow one recording from the meeting, this is the one!]

Denis read a message from Amar Sharma of the Nikaya Observatory, Bangalore, India, who is creating an encyclopaedia of comet hunters and discoverers. He is compulsively obsessed by comets. As his local conditions are poor for observing or discovering comets he intends to produce a biography of comet hunters and discoverers instead.

The meeting then broke for lunch, with many sampling the sandwiches from the delicatessen round the corner, supplemented by copious tea and biscuits supplied by our hosts, or samples of the local beer. Informal discussion continued throughout.

Robin Leadbeater began the afternoon session with a talk on amateur spectroscopy of comets. His first spectrum taken 9 years ago used a 100 line per mm (lpm) school grating in front of a 30mm lens and a long exposure webcam. Plotting the intensity against wavelength showed the emission bands. A better alternative today is the Star Analyser, which is basically the same as the school grating, but is better quality and mounted in a 1.25" fitting. He showed contrasting spectra of 2011 L4 and 2012 F6 taken by Rob Kaufman using a Star Analyser mounted in front of a Digital SLR camera. 2012 F6 shows Swan bands, whilst 2011 L4 has a continuous spectrum with prominent Na_D lines. A slit spectrograph can be put on a telescope and allows setting on different parts of the coma and tail. The spectrum is also easier to process, so you can remove light pollution background and then divide by the solar (lunar) spectrum to clearly see the comet contribution. This can then be digitised. Darks, flats, sky background subtraction are always done for all spectra. Spectra from Paolo Beradi of 2011 L4 shows C_2 bands in the inner coma, but not in the tail, whilst both show Na_D, however part of this may be from our atmosphere. There is a bit of absorption red-ward of the line, perhaps implying that material is moving towards us at a few hundred kilometres per second. A recent spectrum taken by Robin around the Na_D region at higher resolution (April 6) showed C_2, NH_2 and weaker Na_D, but with the line clearly split. In future he plans to use a more sensitive 10 Angstrom resolution (Alpy600) long slit spectrograph. Responding to a question he said that it would be possible to remove telluric lines by taking spectra of a star at similar altitude. A questioner asked if it might be possible to use pre-perihelion spectra to help predict future behaviour. The general view was that whilst it would be possible to classify comets (eg gassy, dusty etc), this wouldn't necessarily help predict what they might do. You can purchase decorative lamps with Ne, Kr, Ar etc which provide ideal calibration sources. The Star Analyser costs £90, the Alpy is £500 – 1000, and then the sky is your limit!



A low resolution spectrum of 2013 R1 (Lovejoy) by Robin taken on 2013 November 23 using a grating in front of a 50mm lens

Nick James followed, speaking about photometry of comets: why, what and how. Why – to avoid some of the speculative headlines such as "15 times brighter than the full moon", and "will it hit the Earth". In the later case you could vote (25% for, 75% against!). Comets are now being discovered so far out that standard light curves may not give a good extrapolation. How bright an object is depends on distance, surface properties, and for an asteroid, the phase. H_o tells us about the diameter and albedo, and $R(\alpha)$ tells us the surface type. Distant comets should behave similarly to asteroids. Comet activity increases as the comet approaches the Sun so $1/r^2$ becomes $1/r^n$, but n may vary, and $R(\alpha)$ is assumed to be 1, but this is not necessarily true for a distant comet. A magnitude estimate for a distant comet is relatively straightforward. He showed a graph for 2012 S1, where at the moment the comet is very distant, so there is a long lever to predicting what will happen at perihelion. In fact the comet is essentially behaving as an asteroid at the moment. 2011 L4 showed the difficulty of prediction – prior to conjunction the best estimate was that it might reach -5, but in the event it reached 0. We need an electronic estimate to use a similar function to the eye. 17P/Holmes was relatively straightforward to measure at the start of its outburst, but very hard at maximum size. It might be impossible for some comets, eg 1996 B2 (Hyakutake) or those in twilight, or those with a broad tail. Afρ is a method of measuring dust production, and is independent of aperture (ie box on the sky). Plotting magnitude against aperture gives information about the physical process in the comet. For 2011 L4 this implies dust production at 10 tonnes/s, compared to gas at 100 kg/s. In response to a question he said that for Afρ you need to use red sensitive (eg red channel DSLR) or unfiltered images for distant comets. You can subtract the star field to get an accurate comet magnitude, but it is fiddly. You should also exclude the tail.

He handed over to Roger Dymock to explain the route to visual equivalent magnitudes. The aim is to generate merged electronic and visual light curves to cover a greater part of a comets orbit. The process starts with Astrometrica, which is a standard for measurement. It needs two runs, first with UCAC4, then CMC4. Sometimes Astrometrica doesn't centre the image correctly the first time round. Once this is OK it generates output. FoCas gets the Astrometrica data and processes it to give position and magnitude tracks which should be straight, and gives a multibox report which is saved. It doesn't use stacked images. If you happen to catch something else in the image the Spanish refer to it as sinning. Kphot tries to calculate a total magnitude on the basis of a growth curve. It is relatively simple, although the interface is a bit clunky. You can measure the coma diameter using AIP4Win. You can use Astrometrica to measure the length and position angle of the tail, or use the Aladin sky atlas. The information is then put into COBS, which also gives a graphical view of all the observations. In answer to a question he said that we need to have a slightly better integration of the various packages to make life easier. The BAA is developing a new web interface that will allow better submission of observations. Roger's Project Alcock web page has a complete menu for how to do things. We need a workshop to train people in how to do the job in practice [In the pipeline]. Kevin Hills [who submits a lot of measurements] said that the first time is daunting, but it gets relatively easy with practice. Astrometrica is €25, and the others are free. AIP4Win does cost. Aladin is free. Dave Spooner has produced an English version of the Focas manual. All observations should go to Jonathan Shanklin for analysis and conversion to TA format.

After a tea break during which Nick Hewitt dished up star spangled cookies, Professor Alan Fitzsimmons told us why professionals need amateurs in the context of comets. Although he is a professional astronomer he has taken amateur images and showed us his picture of 2011 L4 and the Moon taken in March.

The definition of amateur is blurred – many do professional quality work. There is a range of amateur ability, all of whom can contribute to research. Terry Lovejoy discovered 2011 W3 though a sky survey with a relatively small telescope. This compares to PanSTARRS with a 1.8m telescope and a 3.2° field of view. It has a huge CCD detector with a 1.8 Gigapixel raw exposure, with a 1 minute cycle time and a total of 12GB per image. It sees known comets all the time and so far has discovered five this year, most of around 21st magnitude. They avoid the Milky Way and low down in the sky. They don't yet cover all the sky every week, and are affected by the weather as they loose about one third of nights. PanSTARRS had detected 2012 S1 on 2012 January 28, but only in two images as a stellar object. The Catalina Sky Survey had recorded it in 2011 December, so a good orbit was quickly available. Around 2400 comets have been discovered by SOHO, they initially brighten rapidly, but then fade as grains vaporise faster than they are produced, before brightening again as silicates vaporise. SOHO comets are virtually all small and are brighter in Orange (ie sodium), although this implies that they are larger than 100m. Almost all active light curves are from amateur observations as professional observations rarely see brighter than 12th magnitude as the detector saturates. 29P/Schwassmann-Wachmann is in continuous outburst, but is still not understood. Richard Miles uses the Foulkes Telescope and shows structure in the inner coma. 17P/Holmes observations allowed modelling of the outburst – gas was ionised and pushed away from the comet as seen in the sequence of images from November 6 – 16. Amateur images allow study of disconnection events.

Measurements need to be on a firmer and more extensive footing. We are getting there. There is good software (Astrometrica, Focas etc). Unfiltered images are better than none, but filters are good for science. For distant comets unfiltered is OK, but you need to be careful about catalogues. There are accurate catalogues such as Tycho, CMC, APASS, SDSS & PS1. Afρ is a useful measure for professionals, though it makes some assumptions (Q constant, no radiation pressure, constant dust properties) which may not be true, so whilst not accurate it is at least consistent and allows comparison of comets. Comets are colourful – dust, tail and coma are all different. Spectra show the range of emissions, but the reduction is more complex as the equations are harder. Again there are several unrealistic assumptions (no dissociation, radial motion and constant production).

Amateurs can help with promotion of comets. We need to correct misconceptions. Star parties are one type of outreach and he showed a rather similar portrait to the one shown on the cover of the last issue of The Comet's

Tale, except that in the case of 2011 L4, no comet was visible.

PS1 at dawn. The mountain in the distance is Mauna Kea, about 130 kilometers southeast. Photos by Rob Ratkowski. Copyright © by PS1SC.

Looking to the future, PanSTARRS 2 is now in its dome and should start early next year. PS1 only devoted 6% of time to solar system survey, but in November it went up to 11%, and will go up to 40% at the end of this year, followed by 40% for both telescopes. ATLAS (Asteroid Terrestrial impact Last Alert System) is under construction at Mauna Loa and is designed for detecting moving asteroids. This will have two 0.5m telescopes with a 40° field of view that will cover the entire sky (excluding low down, Milky Way etc) to 20th magnitude three or four times each night. There are a lot of robotic telescopes available to amateurs, so backyard telescopes become unnecessary. Las Cumbres Observatory Global Telescope Network (LCOGT) will have two 2m, seven 1m (increasing to 14) and twenty 0.4m telescopes in a network.

Long exposure of a LCOGT 1m as the dome rotated, showing site services container with weather tower.

Over the next four years seven comets are predicted to become brighter than 10m, with 52 brighter than 15m and 211 brighter than 20m. These are only the known periodic comets, so are mostly near the ecliptic, as they are Jupiter family comets. Some of the more interesting comets are discovered by amateurs. Quantitative measurements underpin professional research. Promotion of comets to the media is increasing.

In response to a question he said that the PS catalogue, covering 15 – 22 magnitude, will go down to about -30° in five PanSTARRS bands, all of which have standard transforms and is more internally consistent than Sloan. Terry Lovejoy had initially picked up his comet simply because of its green colour in the DSLR images. You could perhaps derive separate R, G, B magnitudes from DSLR images. PanSTARRS can't detect Kreutz group comets; in principle you could target Machholz group comets, but this would probably be in post-processing. SkyMapper will be a 1.35m telescope survey at Siding Spring and is a southern equivalent of PanSTARRS. 2021 sees the LSST come on line, which will be able to detect comets of 17th magnitude and fainter.

Jonathan Shanklin

Rob McNaught

Rob McNaught gave a talk at the Society for Popular Astronomy meeting in London on 2013 October 26. These are some notes from his talk.

Rob was a former SPA Meteor Section Director. During his career he discovered 82 comets, all but one as a professional. He has now retired from the Australian National University. His first comet observation was of 1969 Y1 (Bennett) on 1970 April 4, which was reported in JAS Circular 32 [The Junior Astronomical Society later became the SPA]. As an amateur he started with nova searching and meteor watching. He became involved with astrometric observation of comets thanks to a suggestion from Guy Hurst and his first measurements were of 81P/Wild. [As with many astronomers Rob was not very precise with comet names, giving for example PanSTARRS, 2013 as a name. There are 14 that match this description to date in 2013. To avoid confusion I give the full designations.]

He discussed the criteria for what makes a comet great. A long period of visibility doesn't necessarily make a comet great – it could be mediocre. He went through his top seven comets in reverse order:

1P/Halley was best seen in 1986 March. He had recorded a bright jet that had been visible in binoculars for a few hours in late February. This had also been seen by Gordon Garradd, but sadly the originals of both their sketches had been lost, Rob's in the major bush fire last year. For some reason the observations had never been lodged in the Halley archive.

1975 V1 (West) was visible in the dawn sky of early March 1976.

1995 O1 (Hale-Bopp) was bright for a long time.
1996 B2 (Hyakutake) passed close to the Earth and had a long tail.
1969 Y1 (Bennett) was the first comet he saw, and so may be placed higher than it deserved.
2011 W3 (Lovejoy) ended up as a ghost tail with no head.
2006 P1 (McNaught) had a spectacular tail.

Rob McNaught with the Uppsala telescope he used to scan for NEOs
[From http://www.astropodcast.com/podcasts/001-astropodcast-rob-mcnaught/]

For Rob it wasn't just awesome comets. Astrometry was a big thing. The MPC/CBAT often asked for follow-up and discovers asked for confirmation. He had started to search UK Schmidt Telescope plates for fun, but it developed into a job. He was supported by Brian Marsden, Gareth Williams and Dan Green. Other influences were Minoru Honda, Jack Bennett, George Alcock and discoverers world-wide both amateur and professional. Some professional discoverers eg Michelle Olmstead were volunteers.

He had joined the TA Nova Search Patrol using pairs of 35 mm slides and nearly discovered SN 1987A. He had discovered 1987 U3 (McNaught) using this technique. As he then also found the comet on archive images he was able to compute a provisional orbit within an hour of discovery. With the UKST plates he just scanned for trails using a binocular microscope. The convention was that the discoverer's name was first in the designation, with the photographer second, eg McNaught-Russell. A suspect found on 1993 April 27 should have been McNaught-Cass, but it wasn't followed up at the time as there were a lot of other trails to measure on the plate. It was eventually discovered as 1995 O1 (Hale-Bopp).

The Catalina Sky Survey used three telescopes of which the Siding Spring Survey was one component. All had the same detectors, but the northern telescope had a wider field and was much more effective at finding near-earth asteroids. This was one reason for stopping the SSS. One of the comets, 2008 J4 (McNaught) was only observed for a short time and was essentially a headless comet. He finished with a sequence of images of 2006 P1 (McNaught) which he saw in the daylight (just) on a specially arranged flight to Hong Kong and back!

In answer to questions he remarked that the Australian astronomical community had actively discouraged funding for NEA survey. 65 of his discoveries were made using automated software on the Uppsala Schmidt which reported moving objects, but which he then identified as "fuzzy". Some search programs (eg LINEAR) don't make this check, so there are potentially main belt comets hiding in the archive data.

Jonathan Shanklin

Professional Tales

Many of the scientific magazines have articles about comets in them and this regular feature is intended to help you find some that you've missed.

The Size-distribution of Scattered Disk TNOs from that of JFCs between 0.2 and 15 km Effective Radius
Michael J. S. Belton Icarus. Preprint at http://arXiv.org/abs/1312.1424

We investigate the differential size-frequency distribution (SFD) of Jupiter Family comets (JFCs) in order to determine whether they are primordial accreted objects or collisional fragments as suggested by current models of the evolution of Trans-Neptunian Objects (TNOs). We develop a list of effective radii and their uncertainties for 161 active JFCs from published sources and compute the observed differential size-frequency distribution using a Probability Index technique. The radii range from 0.2 to 15.4 km and average 1.9 km. The peak of the distribution is near 1.0 km. This is then corrected for the effects of observational selection using a model published earlier by Meech et al. (Icarus 170, 463-491, 2004). We estimate that the total number of active JFCs between 0.2 and 15.4 km is approximately 2300 indicating that our current sample of the of active JFC population is far from complete. The active JFC size-frequency distribution, over the range from 0.6 to 10 km where it is best defined, is found to be closer to an exponential distribution in character than a power-law. We then develop a statistical model, based on the assumption of a steady state, for converting the distribution of active JFCs to the SFD of the source population among the TNOs. The model includes the effects of devolatization (that produces a large sub-class of defunct nuclei) and surficial mass-loss. Comparison with available TNO observations shows that to simultaneously attain continuity with the data on objects in the hot TNO population (Fuentes et al. (Astrophys.J 722,1290-1304; 2010), satisfy constraints on the number of TNOs set by the occultation detections of Schlichting et al. (Ap.J. 761:150; 2012), and to remain within upper limits set by the Taiwanese-American Occultation Survey (TAOS; Zhang et al, Astron. J. 146, Id 14, 10pp) the total JFC population must contain a large fraction of small defunct nuclei. The effective power-law index of the inferred TNO differential SFD between 1 and 10 km is -4.5±0.5 indicating a population in this range that is not in fully relaxed collisional equilibrium. We conclude that the cometary nuclei so far visited by spacecraft and many JFCs are primordial accreted objects relatively unaffected by collisional evolution. We find a turndown in the slope of the predicted TNO cumulative distribution near 1 km radius rather than near 10 km that is seen in many TNO evolutionary calculations. This may or may not represent the onset of a collisional cascade.

Rosetta

There is a European ground based campaign to provide support for the Rosetta spacecraft and amateurs are expected to provide a significant imaging contribution, particularly when the comet is closer to the Sun in the sky than professional telescopes are allowed to point. The latest ESA press-release was issued on October 11, with 100 days to go before the space-craft woke up, though it appears that it was recycled at the American Geophysical Union meeting a month or so later:

In July 2011 the spacecraft was put into deep-space hibernation for the coldest, most distant leg of the journey as it travelled some 800 million kilometres from the Sun, close to the orbit of Jupiter. The spacecraft was oriented so that its solar wings were facing the Sun to receive as much sunlight as possible, and it was placed into a slow spin to maintain stability. Now, as both the comet and the spacecraft are on the return journey back into the inner Solar System, the Rosetta team is preparing for the spacecraft to wake up. Rosetta's internal alarm clock is set for 10:00 GMT on 20 January 2014.

Once Rosetta wakes up, it will first warm up its navigation instruments and then it must spin down to point its main antenna at Earth, to let the ground team know it is still alive.

"*We don't know exactly at what time Rosetta will make first contact with Earth, but we don't expect it to be before about 17:45 GMT on the same day,*" says Fred Jansen, ESA's Rosetta mission manager. "*We are very excited to have this important milestone in sight, but we will be anxious to assess the health of the spacecraft after Rosetta has spent nearly 10 years in space.*"

After wake-up, Rosetta will still be about 9 million km from the comet. As it moves closer, the 11 instruments on the orbiter and 10 on the lander will be recommissioned. In early May, Rosetta will be 2 million km from its target, and towards the end of May it will execute a major manoeuvre to line up for rendezvous with the comet in August. The first images of a distant 67P/Churyumov-Gerasimenko are expected in May, which will dramatically improve calculations of the comet's position and orbit. Closer in, Rosetta will take thousands of images that will provide further details of the comet's major landmarks, its rotation speed and spin axis orientation. Rosetta will also make important measurements of the comet's gravity, mass and shape, and will make an initial assessment of its gaseous, dust-laden atmosphere, or coma. The spacecraft will also probe the plasma environment and analyse how it interacts with the Sun's outer atmosphere, the solar wind.

After extensive mapping of the comet's surface during August and September, a landing site for the mission's 100 kg Philae probe will be chosen. It will be the first time that landing on a comet has ever been attempted. Given the almost negligible gravity of the comet's 4 km-wide nucleus, Philae will 'dock' with it using ice screws and harpoons to stop it from rebounding back into space. It will send back a panorama of its surroundings and very high-resolution pictures of the surface and will perform on-the-spot analysis of the composition of the ices and organic material. A drill will take samples from 20–30 cm below the surface, feeding them to Philae's laboratory for analysis. "*The focus of the mission then moves towards what we call the 'escort' phase, whereby Rosetta will stay alongside the comet as it moves closer to the Sun,*" notes Fred.

The comet will reach its closest distance to the Sun on 13 August 2015 at about 185 million km, roughly between the orbits of Earth and Mars. As the comet hurtles through the inner Solar System at around 100 000 km/h, the relative speed between orbiter and comet will remain equivalent to walking pace. During this 'escort' phase the orbiter will continue to analyse dust and gas samples while monitoring the ever-changing conditions on the surface as the comet warms up and its ices sublimate. "*This unique science period will reveal the dynamic evolution of the nucleus as never seen before, allowing us to build up a thorough description of all aspects of the comet, its local environment and* *revealing how it changes even on a daily basis,*" says Matt Taylor, ESA's Rosetta project scientist.

Rosetta will follow the comet throughout the remainder of 2015, as it heads away from the Sun and activity begins to subside. "*For the first time we will be able to analyse a comet over an extended period of time – it is not just a flyby. This will give us a unique insight into how a comet 'works' and ultimately help us to decipher the role of comets in the formation of the Solar System,*" adds Matt.

The Legacy of Comet Hunters & Discoverers

Amar A. Sharma
Nikaya Observatory, Bangalore, India

Amar A. Sharma has long possessed his own eternal, unquenched aspiration to discover comets from the land of India, and envisions someday narrating his own discovery stories. This article was prepared using prime excerpts from his upcoming large compilation – a biography on worldwide comet hunters and discoverers.

As the curtain of the day with all its life dissolves in with the dark night creeping out, a thimbleful of souls in the world's mighty burgeoning population head out each possible dusk and dawn. The fading of twilight which for the civilized world marks retirement from the day's business, for especially this sect called “Comet Hunters” enshrines another night flooded with renewed energy, encouragement and hope. They are earnestly getting ready for a duty of peering and hunting with telescopes and binoculars, with an entrenched aspiration, a desire to catch a new incoming celestial interloper – a comet – before anyone else in the world does.

Comet hunters epitomize faith, patience, determination and stamina at an unsurpassed level; these kinds of phenomenal attributes which are quintessential in the art of comet hunting surpass several other rigorous walks of astronomy. Thousands of hours over hundreds of lonely nights are spent in winning but an unpredictable member of the sky – a passing comet. Who would think of, or want to get up at midnight, drive out all the way to their observing site for pre-dawn hunting, return home and still attend office? Comet hunters! And the rewards are well worth taking the chances.

For them the destination always does not matter, because the journey is as beautiful as the destination! The legendary Japanese comet hunter Minoru Honda in the decades past had advised another young aspiring and later-successful Japanese comet hunter Kaoru Ikeya, in the latter's earlier days, “If you are going to hunt for comets in aim of discovering one, do not hunt at all”. Such sublime is the essence of a true comet hunter’s life. For an enlightened comet hunter like Honda, we can understand comet hunting must have been about the harmony of experiencing countless moments under the night sky and seeking glimpses of the celestial wonders like clusters, nebulae, stars and galaxies as he simply traversed the sky in pursuit of his new comet. And the fun was the suspense factor in the act was reserved as suspense.

Every comet hunter and discoverer has their reasons what lured them towards comets and the determination to hunt for new ones. It could be awe-striking sights of some wondrous Great Comets, or inspiration derived from senior comet hunters and their hard-earned discoveries, or even no real reasoning but an instinctive bond towards comets. It is rightly said about this rare, esteemed sport that to succeed, the only formula is as Leslie Peltier had advised: “To find a comet, keep looking”. And for Lewis Swift it was the motto: “One cannot discover comets lying in bed”.

What is the incentive for comet hunters to discover their own comets? By convention, the nomenclature includes the surname of the discoverer, which then is attached within the name of a comet riding in the heavens. If it turns out to be periodic in nature, every time it re-visits the Earth, the forthcoming generations get to witness the same flying icy-mudballs what their predecessors saw, possibly, those named after even one of their own ascendants’!

Be it intended discoveries or accidental ones made by comet hunters, general amateur astronomers or even laypersons, the salutations always go up when you discover a comet – a famed entity by itself, having had the richest record of striking fear, as much as awe, from time immemorial over plenty a world’s civilizations. And if your comet discovered happens to be of the "Great Comet" category (like Hale-Bopp or Ikeya-Seki), those which rarely arrive in our skies once in a decade or more – which grip attention of even common public and non-astronomers with baited breath – that is an instant etch down history books, for posterity to remember. This is what Comet ISON is “expected” to do. We all are waiting for a great show from it – that of once-in-a-decade if not practically once-in-a-lifetime. Isn’t it? But how much do we know about its discoverers – those who have brought ISON to us?!

A comet discovery is a thorough reward of a comet hunter’s unparalleled pursuit of the heavenly felines; felines because that’s how David Levy puts them: “Comets are like cats, they both have tails and precisely do what they want”. Comet ISON, too, functions to be part of a systematic comet hunting program by some comet hunters, who might not have actually expected to see their comet, one day, predicted to shine in the sky. They are none other than the duo: Artyom Novochinok from Russia and Vitali Nevaski from Belarus.

What is amazing is after the time this article was completed and before it's editing began, Australia's Terry Lovejoy discovered his 4th comet! That is how fickle-active comet hunters can get. It is also worth adding that, tragically, just 4 days after Lovejoy's new find, the community witnessed the demise of legendary Albert Jones at 93.

Terry Lovejoy with his Celestron 8-inch Hyperstar photographic comet hunting setup. Terry is the first person to discover a comet with a DSLR, the first to find SOHO comets outside of SOHO itself using their internet images, and the first person to have found a Kreutz Sungrazer comet from the ground as well as the first to have found a Kreutz Sungrazer comet from space!
The photograph is provided by Terry Lovejoy and the credit and copyright lies with him.

In this essay, we look at as many instances – actually the most explosive insight presented – of the diversity of comet hunters and their splendid finds, and we learn about the unexampled stars that they have shone to be. [I write with sincerity here that it was obviously not possible to include names of *every* possible comet hunter, and some could be found missed out].

The history of the sport began with Charles Messier, the father of comet hunting, when he avenged for losing out on spotting the predicted return of Halley's Comet. The later part of 1700s and whole of 1800s was dominated with many early members of the comet hunting fraternity competing with each other like William Brooks, Edward Emerson Barnard and Lewis Swift from the US, even Joel Hastings Metcalf, Robert van Arsdale, John Mellish and Charles Perrine did discover comets. From France hailed the rivals Charles Messier and Jean Louis Pons, and Europe also produced Ernst Tempel, Friedrich Winnecke, Michel Giacobini and Alphonse Borrelly who discovered no less than a dozen comets each. The lady Caroline Herschel from the UK also dominated comet discoveries with 8 new finds.

The southern hemisphere, too, was making a mark in discoveries from the Australian and New Zealand hemispheres, with John Tebbutt, John Grigg, William Gale and David Ross serving to be the prominent comet discoverers from this region.

Then there were still others who exhibited their presence in the overall 19th century comet hunting sport. As time moved on, there was immense continued activity in the century that came next – 20th – with literally dozens of discoverers carving their names on comets.

A rare photograph from April 1962 (after discovery of Comet Seki-Lines), showing the young and very successful Tsutomu Seki (on the right) with his comet-hunter friend Koichi Ike (on the left).
The photograph is provided courtesy of Eiji Kato with permission granted by Tsutomu Seki. Credit and copyright lies with Seki.

We start with this. There is something frenzy about the psyche of the Japanese when it comes to comet hunting. It can be said the number of Japanese who were hunting for comets in the 20th century is equivalent to the number of hunters collectively over other countries; there were at least 50 Japanese individuals who have discovered atleast one comet in the last century! Of course, this national tradition of comet hunting was inspired due to Minoru Honda, the father of Japanese comet hunting, followed by the likes of the very successful Tsutomu Seki and Kaoru Ikeya, who themselves followed in Honda's footsteps, ruling the mid-century. It was a generation-to-generation heritage passed on; several later Japanese comet hunters were in turn directly influenced by Seki and Ikeya. You will find only Japanese comet discoveries with single, double and triple barrelled all-Japanese comet names! Names like Comet Takamizawa or Comet Terasako with one Japanese discoverer, Comet Okabayashi-Honda or Comet Kudo-Fujikawa with two Japanese discoverers, and Comet Mori-Sato-Fujikawa or Comet Tago-Honda-Yamamoto are representations of the all-Japanese comet discoveries. Of course, apart such only-all-Japanese discoveries, they still made their attendance in comets simultaneously with co-discoverers non-Japanese. Examples are Comet Okazaki-Levy-Rudenko or Comet Honda-Mrkos-Pajdušáková.

It is worth a mention of the Japanese comet hunters on the dawn of May 1, 1968. Five of them discovered upon the same comet – 1968 H1 (Tago-Honda-Yamamoto) – near Andromeda Galaxy (M31) even though Koichi Itagaki, another Japanese, had discovered this comet first in Japan on April 25, but could not report it immediately.

The pre-dawn of 5th October, 1975 is a mirror-image day. Eight only-Japanese comet hunters individually discovered two new comets - 1975 T1 (Mori-Sato-Fujikawa) and 1975 T2 (Suzuki-Saigusa-Mori) – in a span of 1 hour 20 minutes between 17:50 UT and 19:10 UT! What's more bizarre is Hiroaki Mori was the common discoverer of these 2 comets timing himself just 70 minutes apart – an unbeaten record!! Truly, like samurais of the sky, the Japanese stealthily raided the comet hunting battle-field, in big numbers.

The 20th century was conveniently filled with an equivalent dominance in comet discoveries from the southern hemisphere, as much from the northern. By astronomer Edgar Everhart's count, between 1840 and 1919, only 10 out of 213 telescopic finds of long period comets were made from south of the equator. After this is where South Africa emerged to play a substantial role in comet discoveries, as would not be known to the reader. Of the 57 discoveries of the 20th century from South Africa alone, 38 were made in the 30 year period from between 1920 and 1950 by South Africans (or its non-native immigrants). Noteworthy names of the 20th century are John Francis Skjellerup, William Reid, Jack Bennett, Michiel John Bester, Daniel du Toit, Alexander Forbes, Cyril Jackson and Hendrik van Gent, apart half a dozen more South African names that have discovered comets.

The 1970s, after the South African discoveries went on low ebb, saw emergence of another prodigy, who too hailed from the southern hemisphere. It was truly the time of comet discoveries from down south. After witnessing the splendour of Comet Bennett in 1970, Australia's William Bradfield (actually a New Zealander) started comet hunting only at the age of 43 armed with a 100-year old (!) 6-inch f/5.5 refractor (originally built by its previous owner for comet hunting), but Bradfield possessed a non-faded resolution, "OK, if Bennett, an amateur astronomer from South Africa could find a comet that eventually turned into a spectacular object, perhaps I can find a comet too. And this is supposed to be a comet hunting telescope. It may be rough and ready, but you don't need a chrome plated telescope to discover a comet". What came next was Bradfield snatching discoveries after discoveries in the 1970s and 1980s; we have him etch his name in history as the sole discoverer of *all* of his 18 comets – i.e. 18 only-Comet-Bradfields!

Rodney Austin with his 8-inch Meade Schmidt-Newtonian on a custom designed mounting. This was the telescope he used to discover C/1989 X1 (Austin), which was predicted to become an easy naked-eye object during spring of 1990, however, the comet did not live up to expectations.
The photograph is provided by Rodney Austin and its credit and copyright lies with him.

New Zealand's Rodney Austin nabbed three comets and Australia's David Seargent nabbed one as a result of their own long hours of visual comet hunting. In the past few years, Australia's Terry Lovejoy is emerging to having good success with his photographic comet hunting survey.

Competing with Bradfield's finds in the 1970s and 1980s was US' successful Donald Machholz, who summed up 11 comet finds under his crown. Don has spent over 7000 hours of comet hunting alone in a career spanning well over 3 decades! The US then saw emergence of David Levy with his discoveries in 1980s and 1990s who, today, stands at 23 comet discoveries; his comet hunting program having been initiated way back in December 1965. It was also the time of other American comet hunters like Howard Brewington with 5 comets and Michael Rudenko with 3 discoveries. Alan Hale did spend several hours hunting for comets, and hit one jackpot – and the best one at that – which everyone remembers: Comet Hale-Bopp. Canada had Rolf Meier who discovered 4 comets after spending many hours of hunting.

Comet hunters are outlandish when it comes to hunting for their passionate flying possessions, and there can be nothing to stop them. They do it from anywhere: from toilets to battlefields! We look at some of them.

By bad fate, the young Minoru Honda was drafted into the Japanese army in August 1941 and sent to northern China and Singapore in course of the Pacific War. He was eccentric enough to continue comet hunting there, after conjuring up a telescope from a discarded 3-inch lens while working to siphon gasoline from beat-up old cars. Honda had begun searching the southern sky for comets from Singapore, from the battlefield, while other soldiers were fast asleep! As he did not have any star map, he knew the only way to distinguish comets from nebulae was to observe them multiple times and look for their motion. He was duly rewarded for this when he actually discovered a 7th-magnitude comet and the word passed out from the middle of battlefield all the way to Tokyo Observatory – which turned out to be the return of the periodic Comet Grigg-Skjellerup, however, not a new comet. Yet it was a commendable act. The telegram from the south not only suggested Honda's well-being, but even brightened the mood of war-torn Japan.

In another instance, severely affected by World War II, the German Anton Weber's home in Steglitz located in Berlin, had no windows or window frames present, even in the toilet. While he was sitting there one clear night, he saw a diffuse object through one of the window openings which was later confirmed and announced as a comet, 1946 K1 (Pajdušáková-Rotbart-Weber).

There are numerous other incidences, many fancy, we find in 'Cometsville' – the world of comet hunters.

Comets gave the American Edward Barnard, literally, a roof to sleep under when he cashed in on the Warner Prize and its $200 prize five times and built a house from the funds! His "Comet House" is still known in Nashville, Tennessee.

There is something about the British connection of discovering comets on either Christmas nights, or from their home's windows!

On Christmas night of 1960, UK's Michael Philip Candy was checking out a new 125-mm aperture short-focus refractor (a comet-seeker made for him by Horace Dall) from an upstairs window of his home in Hailsham when he discovered Comet 1961 II. Impressively, precisely 20 years later on the same night, the Christmas night of 1980, Roy Panther felt it impossible to ignore an exceptionally clear sky, although it was Christmas Eve. It was the night he would finally discover a comet, 1980 II, sadly his only one, after having clocked up 600 comet hunting hours spread over 699 nights of 33 years. At that time he did not have a telephone, so to announce his discovery he sent a written message via taxi from his home at Walgrave to Guy Hurst at Wellingborough. George Alcock swept up 1983 H1 (IRAS-Araki-Alcock) in May 1983 after putting his wife to bed. This was from indoors through a double-glazed window at the top of the stairs, with Alcock kneeling on the floor using just 15x80 mm binoculars.

Equipment would never come in as an excuse to comet hunters. As mentioned right above this, Alcock's fifth and last comet discovery 1983 H1 came with 15x80 mm binoculars. Bradfield found his 11th comet 1980 Y1 (Bradfield) using just a pair of 7x35 mm binoculars, even though it was a 6th magnitude fuzz. As we saw earlier that he had purchased in 1970 (for just $60) a 100 year old, 6-inch f/5.5 portrait-lens, which served to be a rich-field refractor. Bradfield nailed 14 discoveries out of 18 with this antique piece. Later when he upgraded to a 10-inch reflector, he built its telescope body from wood found in a scrap pile (which included a couple of house-bricks to help with the counter-balance)! This retired rocket scientist carved his niche with no equipment involving rocket-science, but the simplest of them all.

It is interesting to know something about the determination of comet hunters even when not having success with their equipment. Before George Alcock even started comet hunting, he made his New Year's resolution in 1953 to embark on a 5-year comet search with his 4-inch refractor, which had a 1 degree field. In 1958, without a comet discovery, he would resolve to carry on for another 5 years. There can be little doubt that Alcock had the wrong equipment for comet hunting in the early years, because a few other comet hunters were stealing comets from him. As soon as his brother John Alcock gifted him a 25x105 mm binocular-telescope, after only 7 months sweeping with the new binoculars, Alcock discovered his first comet just 3 days prior to his 47th birthday in August 1959. What is intriguing is the second Comet Alcock was discovered just 2 days after his 47th birthday; that is 5 days between 2 comet discoveries after a 65 year dearth (since 1894) of any British comet discoveries was, and still is, a fairy-tale event! After totally more than 560 nights of hunting spread over 6.5 years, Alcock was significantly paid off.

Czechoslovakia played a pivotal role during the perilous World-War II decade to sponsor, in all likelihood, the first professional visual comet search program in history, and probably the only one then. As part of the Skalnaté Pleso, 5 observers found 18 comets between 1946 and 1959. They were Antonín Bečvář (the founder), Antonín Mrkos, Lubor Kresák, and Ľudmila Pajdušáková with Margita Vozárová (lady observers). And their equipment was nothing more than 25x100 mm giant binoculars called Somet-Binnars. It was just their determination to host a systematic comet hunt program and the procedure called for nightly searches using multiple observers; each member spending time in shifts! Ľudmila Pajdušáková alone notched up 5 new comets as part of the team effort.

On the other hand, clouds – an integral part of any amateur's life especially in the most crucial of times – have also inhibited times of comet discoveries. Vance Petriew, who accidentally discovered a comet – pointing at the wrong star in the horn of Taurus to find the Crab Nebula – at the 2001 Saskatchewan Summer Star Party, Canada, had to confirm the comet suspect the second night. He had to face everything weather could offer in form of a storm: major winds started blowing, some very dark and menacing thunderclouds came overhead, lightning lit up their observing site like daylight, the first raindrops started falling, and even a telescope blew over!

Comet hunters are time-tested, and age acts no impediment in their pursuit. While the late Albert Jones stands to be the oldest comet discoverer with his last discovery in 2000 coming in at age 80 (born 1920), Lewis Swift discovered his last comet in 1899 at age 79 (born 1820). Albert Jones, the world respected variable star observer – the only one who has made over 500,000 estimates! – has earned the distinction of standing at the longest time span between 2 comet discoveries. His first comet discovery came in 1946 (aged 26), and the second one only in 2000 – these discoveries were made while carrying on routine variable star observations. A whooping 54 years between 2 comet discoveries is just one of the feats of the great soul whose invaluable contribution to the community in form of an astronomy career itself spanned a whole 7 decades!

William Bradfield's last comet discovery in 2004 came in at the age of 77. Two renowned comet hunters as well as nova hunters, who were very successful as discoverers of both comets and novae, were George Alcock and Minoru Honda. Alcock's last nova discovery came in at age 79, while Honda's last nova discovery came in at age 74; they were competitors during their eras.

The determination of comet hunters, in various contexts, is apparent from several circumstances. It could be the gruesome cold conditions in which they have to hunt, as is evident from Tsutomu Seki's quote, "Cold winters bothered me in investigating comets. When the temperature was -5°C, the lens of the telescope froze. After continuing my observation for over 3 hours in that temperature, my heart and body also became as cold as ice", which is such sobering. Another one of his reveals, "I persevered from the evening to 4 o'clock in the morning in 0°C".

On the other hand, the perseverance of comet hunters could be tested in the many comets they might miss spiced with the oddities of their observing conditions. A classic example is Lithuania's Kazimieras Cernis. Any faint-hearted comet hunter could even think of stopping comet hunting after missing out discovering one or two comets and getting dismayed, but Cernis set himself as an example apart. It was on around 9 occasions that he had near misses in claiming comets for himself – either he made an independent discovery or had followed up unknowingly on a previously discovered comet. However, it was as the culmination of these nine occasions of failure spread over 806 hours of visual comet hunting spanning 8 long years that Cernis was finally rewarded his first comet discovery; his total comet discovery count going on to 3. His challenges were many; his remote observing site at Mt. Maidanak in Uzbekistan – 3000 km from home – had no good telephone connection, on the other hand he had no circulars, no telegrams, and no other information about existence of certain comets. Getting the word out from Mt. Maidanak to Moscow and from Moscow to Cambridge, USA, we can only leave it to imagination how he achieved it!

Kazimieras Cernis of Lithuania observing through his 48-cm reflector at Maidanak Observatory, Uzbekistan. Now he is an amateur-turned-professional astronomer, now with the Vilnius University. He has also discovered many SOHO comets using online images from the spacecraft.
The photograph is provided by Dr Kazimieras Cernis and its credit and copyright lies with him.

The successful Japanese comet hunter Shigeki Murakami, too, experienced discouragement when he happened to be 3 hours 43 minutes late in getting his discovery announced by the IAU's CBAT. The visual find was finally claimed by David Levy, on October 2, 2006. Levy was comet hunting that dawn and happened to nail it adjacent to Saturn in Leo. There have been many such misses in their heavenly pursuits, which have only added to the determination of true comet hunters.

Few amateurs working in professional capacity – and there has been a significant role of women astronomers too – have had a stint of comet discoveries; who better than the historic team of Eugene Shoemaker and Carolyn Shoemaker, teamed with David Levy and Wendee Levy. The Levy collaboration with the Shoemakers resulted in 13 discoveries titled "Shoemaker-Levy"; manifestation of a successful professional comet survey using the 18-inch Schmidt telescope at Mt Palomar in the 1990s. In turn, Carolyn Shoemaker has 32 comet discoveries to her credit, more than anyone alive at that time. We all will remember the historic Comet Shoemaker-Levy 9 which slammed into Jupiter and gave us an unprecedented insight into the fragility of our life here on Earth.

It was also Jean Mueller, a librarian by profession, who had her breakthrough and got to work at Palomar Observatory and use the 48-inch Oschin telescope. She discovered 15 comets (of which 7 are periodic) apart atleast 49 supernovae and 9 unusual asteroids as part of her routine sky patrols.

Today, as since we have had in history, comet hunting is the only sport wherein a consistent affair of rewarding the discoverer has been carried on as a tradition. We have had the following awards – and a near complete list in order of time from 1800’s to present – to commemorate the spirit of a comet hunter: Joseph de Lalande's prize money; Frederick VI the King of Denmark's Gold Medal; Imperial Academy of Sciences at Vienna's Gold Medal; Warner Safe Remedy Prizes' cash prize; the Donohoe Bronze Medal (serving for 60 years); Astronomical Society of Japan’s Medals (only for its country's discoverers); US' Tuthill Comet Award (for American discoverers, later extended for Canadians); and finally the Edgar Wilson Award, which is still continuing today. All these reward only the amateur comet discoverer, keeping their spirit and dedication in mind.

Reward or not, comet hunters hunt comets because their instincts, their passion drives them to do so, and will continue to do so, eternally. This is the immovable fact about these esoteric souls.

Then, there are the untold stories of comet hunters like the Japanese Koichi Ike, a close friend and guide for Tsutomu Seki, of whom Seki has fond memories, a friend who searched comets for nearly 50 years but was never fortunate to ever embrace and etch his possession in the sky.

Comet hunters’ modesty and responsibility places them away from civilization, in complete solitude. We know the folks and their allies, who once discovered comets, are out there chasing them even now, while the world heads on to their night's comforting slumber. Well, the curtain of twilight has just dropped.

The Donohoe Comet Medal. Photograph from the January 25, 1890, Publications of the A.S.P. Credit and copyright: Astronomical Society of the Pacific

Project Alcock Update

Roger Dymock

Outreach

George Alcock, Brian Marsden and John Alcock at the IWCA held in Cambridge in 1999.

This project is a comet search programme promoted by the BAA Comet Section. Its aim is to encourage members of amateur astronomical societies to develop their observational skills by hunting for comets visually, using binoculars and telescopes, by imaging and by searching images returned by spacecraft such as SOHO and STEREO. It should appeal to all skill levels many of which may well be present among members of any given society. Hopefully this will become a two-way street with ideas being passed around between societies. It would seem appropriate to name this programme ‘Project Alcock’ after the UK’s foremost comet discoverer – George Alcock.

Activities under this banner have included;
- talks to a number of societies
- writing articles for ‘Popular Astronomy’ and several society newsletters
- starting a Comet Observing Group in my own society – Hampshire Astronomical Group

At the present time I am developing a Comets A-Z which can be found on the Project Alcock website at http://www.britastro.org/projectalcock/Comets%20A%

20to%20Z.htm It is very much a work in progress but I thought it better to upload what I have done and update it as and when I complete the various entries. The objective of this A to Z is to assist those who have a basic grounding in matters astronomical, but are new to comets, to better understand the terminology used, for example, in:

- papers appearing in the Journal of the British Astronomical Association
- the BAA Comet Section's Observing Guide
- The comet’s Tale
- the Comet Section and Project Alcock websites
- articles in Popular Astronomy

Please let me know of any additional entries you feel should be included.

Example entries;

Disintegration

The words disintegration and fragmentation seem to be interchangeable when it comes to comets.

Comets, being composed of a mixture of rock and various ices, are quite fragile objects. They are therefore quite susceptible to being broken up by the gravitational influence of Jupiter or the Sun for example or by outgassing when close to perihelion.

In this A-Z I will classify a disintegrated comet as one that has literally turned to dust as was the case with 2010 X1 (Elenin) - before, Figure D2, and after, Figure D3.

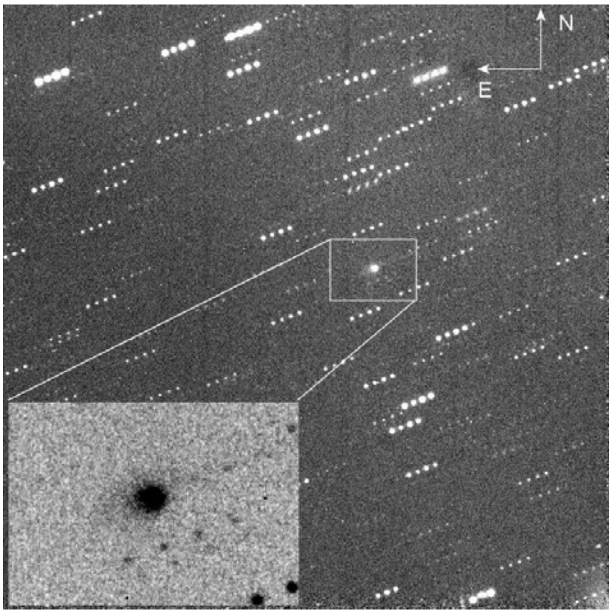


Figure D2. Comet 2010 X1 (Elenin), 2011 Apr 27, 0507UT, 20x20 arc mins, 4x60 sec exp, SSON OMI 0.61m f/10 Cassegrain, FLI Proline PLO9000 CCD, unfiltered, R Dymock, MPC G6

Figure D3. 2010 X1 (Elenin), 2011 October 22, 116x87 arc mins, 6x300 sec exp, GRAS Takashashi FSQ 106ED refractor, SBIG STL-8300-C CCD, Rolando Ligustri.

Fragmentation

The words disintegration and fragmentation seem to be interchangeable when it comes to comets.

Comets, being composed of a mixture of rock and various ices, are quite fragile objects. They are therefore quite susceptible to being broken up by the gravitational influence of Jupiter or the Sun for example or by outgassing when close to perihelion.

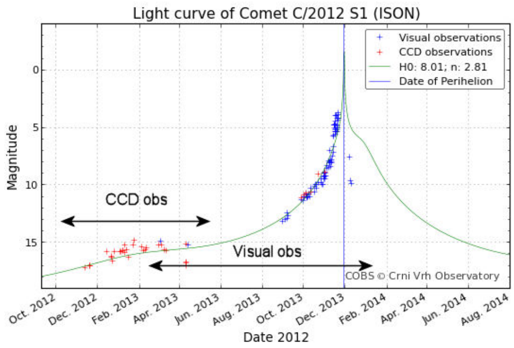
In this A-Z I will classify a fragmented comet as one that has broken up but still exists as several discrete parts, for example D/1993 F2 (Shoemaker-Levy) before its various parts impacted Jupiter.

Fragments of D/1993 F2 (Shoemaker-Levy). Credit STSci

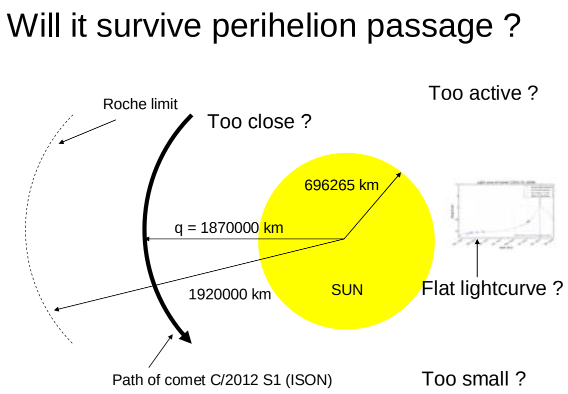
Mentoring

The CCD Astrometry and Photometry procedure (http://www.britastro.org/projectalcock/CCD%20Astrometry%20and%20Photometry.htm) has enabled total or visual equivalent magnitudes to be calculated from CCD images. It works well for comets mag 10 or fainter but is not accurate for brighter, larger comets. Possibly DSLR images analysed using Iris will provide an answer and a procedure should be in place in the New Year.

Several Comet Section members are now using the procedure and submitting their results to the Comet Observations (COBS) database (http://www.observatorij.org/cobs/) database as well as to the Comet Section Director. Section members are encouraged to use this procedure as it provides data on the fainter comets and extends the lightcurves of the brighter ones by several months. This is well illustrated by the lightcurve of 2012 S1 (ISON) which is now D/2012 S1 (ISON).



Unfortunately the comet of the century blazing brighter than the full moon was not to be. One might say 'I came, ISON, I was'. I did my best to warn of this in this slide from my presentation to local astronomical societies;

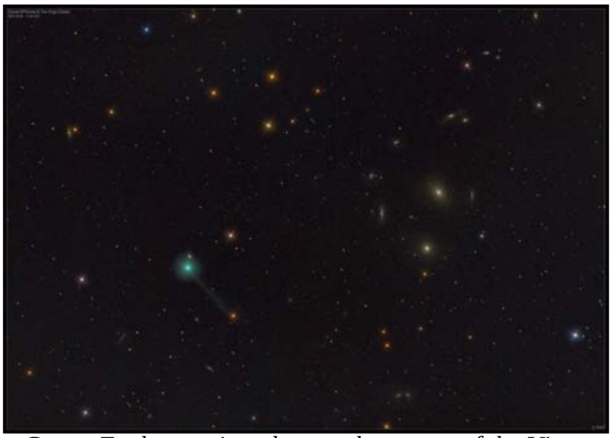


Review of comet observations for 2013 January - 2013 December

The information in this report is a synopsis of material gleaned from MPECs, The Astronomer (2012 December – 2013 November) and the Internet. It covers comets designated during 2013, and those with electronic or visual observations made during the year. Note that the figures quoted here are rounded off from their original published accuracy. Light-curves for the brighter comets are from observations submitted to the Director and TA. A report of the brighter comets seen during the year, including observations published in The Astronomer will be produced for the Journal in due course. I have used the convention of designating interesting asteroids by A/Designation [Discoverer] to clearly differentiate them from comets, though this is not the IAU convention.

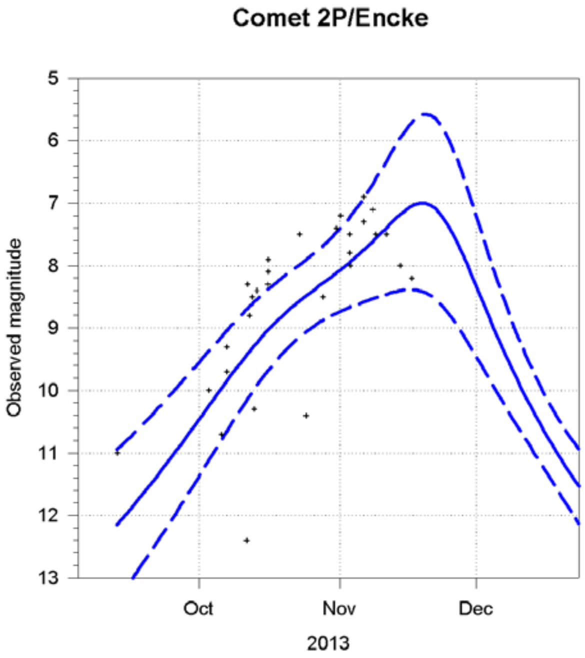
Further information can be found on the Section web pages, in previous editions of *The Comet Tale* and in the BAA Guide to Observing Comets. Images of comets can be found in the Section Comet Gallery, and a photogenic selection are shown here as those taken for astrometric purposes do not reproduce very well. Magnitude estimates are in the year files which are on the Section web page; these include some electronic observations of comets which are not mentioned here.

Observers contributing magnitude estimates used in the analyses include: James Abbott, Alexandre Amorim, Margarete Amorim, Gianluigi Adamoli, Sandro Baroni, Alexandr R. Baransky, Nicolas Biver, Eric Bryssinck, Denis Buczynski, Paul Camilleri, Matyas Csukas, Chris Clayton, Emilio Colombo, Haakon Dahle, Jose Guilherme de Souza Aguiar, Roger Dymock, Michael J. Gainsford, Massimo Giuntoli, Marco Goiato, J J Gonzalez, Stephen Getliffe, Werner Hasubick, Tim Haymes, Kevin Hills, Nick James, Heinz Kerner, Carlos Labordena, Martin Lehky, Glyn D. Marsh, Jose Carvajal Martinez, Michael Mattiazzo, Richard McKim, Giannantonio Milani, Peter Morris, Artyom Novichonok, J P Navarro Pina, Mieczyslaw L. Paradowski, Jan Qvam, John Sabia, Toni Scarmato, Jonathan D. Shanklin, SOHO Satellite, William C de Souza, David Spooner, Enrico Stomeo, David Storey, Johan Warell, Graham W. Wolf, Colin Watling and Seiichi Yoshida.

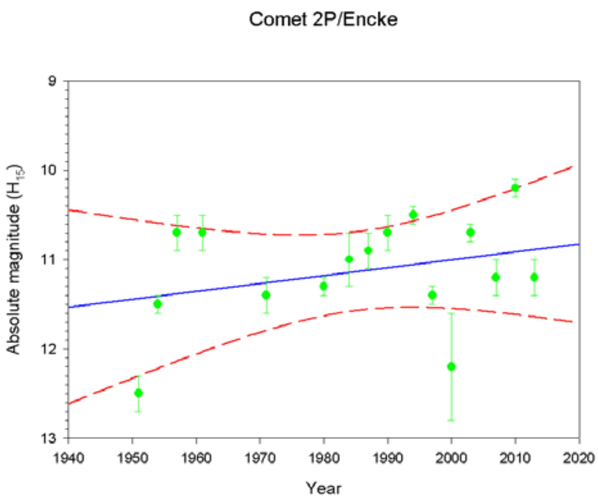


Comet Encke passing close to the centre of the Virgo cluster of galaxies. M84/86 are off to the right while Encke is at left contrasting starkly in colour with the distant elliptical galaxies. Damian Peach: 0.11m F5.6 with STL-11k camera. LRGB. L: 4x3mins. RGB: 1x3mins. Taken with the comet at 16° altitude during morning twilight.

This year saw comet **2P/Encke's** 62nd observed return to perihelion since its discovery by Mechain in 1786. The comet brightened rapidly during October rising from about 11th magnitude at the beginning of the month to 7th at the end. Its brightness didn't change much during the first half of November, though it became more condensed. 31 electronic and visual observations received to date give an uncorrected preliminary light curve of $m = 11.0 + 5 \log d + 8.7 \log r$



The provisional H_{10} absolute magnitude is very similar to those determined in recent years and there is no evidence for a secular fading in the archive of BAA observations of the comet. Although the mean curve shows a brightening, this is not statistically significant and the comet essentially has been constant in absolute magnitude.



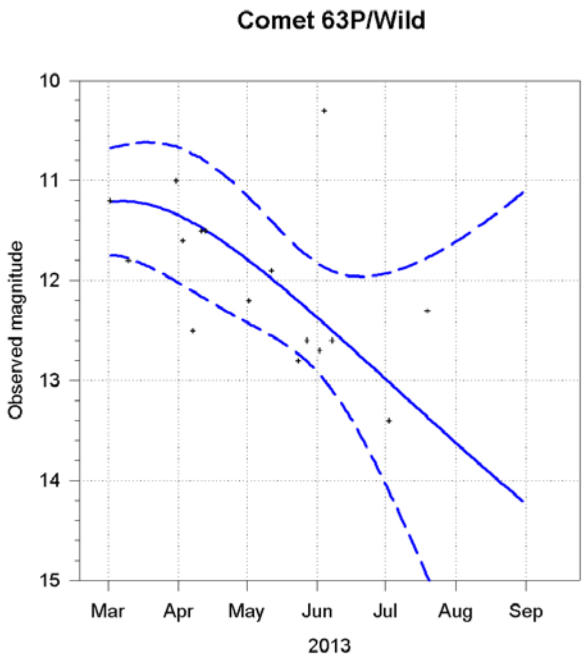
Richard Miles has produced an explanation for the outburst of **17P/Holmes** involving the catalytic decomposition of H_2O_2. Richard continues to follow the comet with the Faulkes Telescope. Kevin Hills also made a couple of visual equivalent magnitude measurements.

26P/Grigg-Skjellerup was observed once visually and once electronically as it faded from 12.6 on August 10 to 15.4 on September 2.

Outburst of 29P - 2013 June/July Damian Peach. All 20"CDK@F4.5. FLI-PL6303E camera. 4x3mins unfiltered.

29P/Schwassmann-Wachmann underwent several outbursts, reaching 10.4 at the brightest in late June. Other outbursts took place in March, May, early June and August.

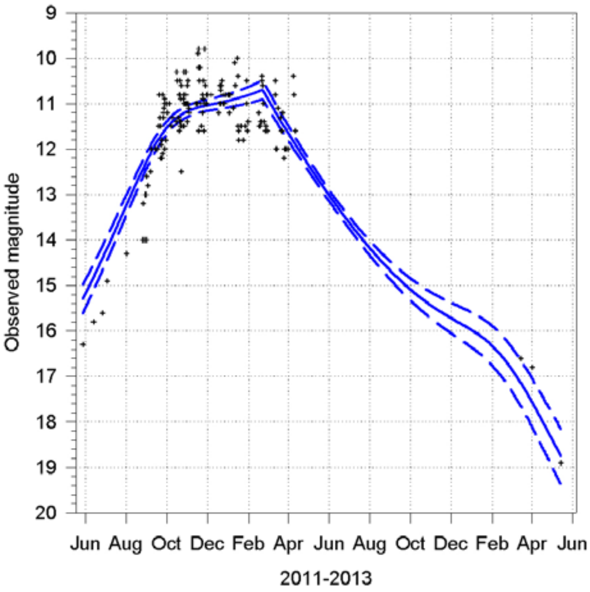
63P/Wild Juan Jose Gonzalez observed the comet at 11th magnitude in his 20cm Schmidt-Cassegrain at his Spanish mountain location on 2013 March 1.8. Visual observations continued until early June, though Gonzalez gave a much brighter magnitude than Carlos Labordena. Kevin Hills electronic observations have some overlap with the visual observations and confirm the general picture of a fading comet in June and July.



16 observations reported to the BAA give a preliminary light curve of 8.1 + 5 log d + [10] log r. The log r range is too small for a reliable determination of the parameter.

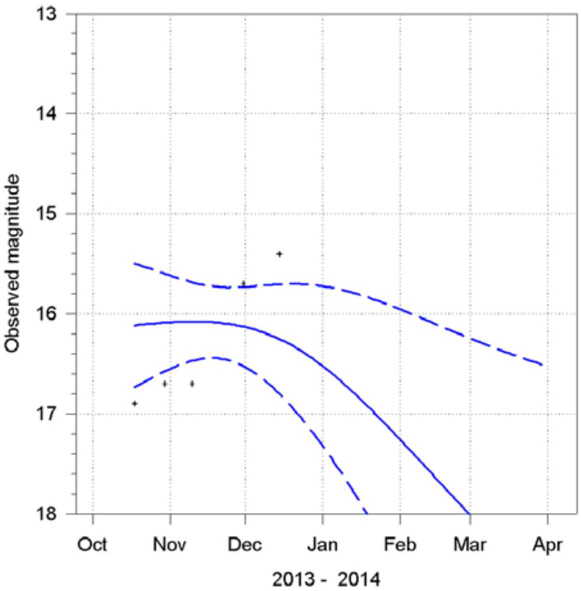
78P/Gehrels was imaged by Kevin Hills in the spring. His equivalent visual magnitudes confirm the general conclusion of a linear light curve, with the comet brightest at about 40 days after perihelion.

Comet 78P/Gehrels



6 electronic observations of **84P/Giclas** received at the 2013 return give a preliminary light curve of 12.3 + 5 log d + [10] log r, although the majority of these observations were made when the comet was at small phase angle and showing an enhanced brightness. I hope that the electronic observers will continue following the comet as it fades to help determine the nature of the brightening.

Comet 84P/Giclas

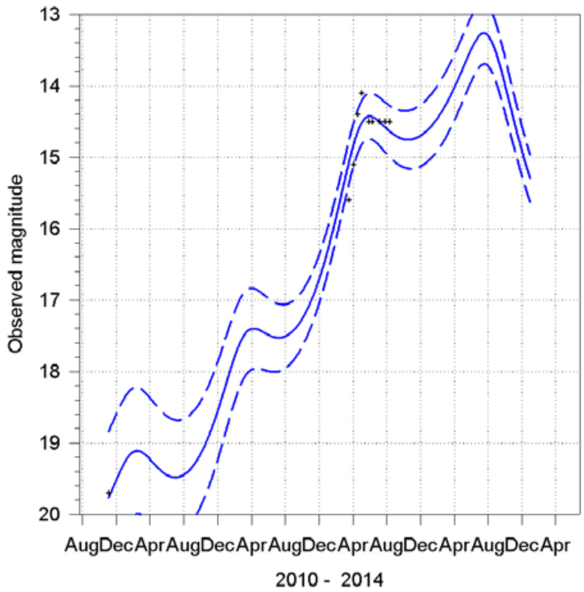


98P/Takamizawa was followed by Kevin Hills from April to November. His observations suggest that the comet peaked at around 14th magnitude in August.

102P/Shoemaker Four electronic observations received at the 2013 return give a preliminary light curve of 11.9 + 5 log d + [10] log r however there are some indications that the light curve may be asymmetric, with the comet brighter after perihelion.

117P/Helin-Roman-Alu was followed by Kevin Hills from March to August. His observations confirm the magnitude equation in use and suggest that the comet will come into visual range during 2014.

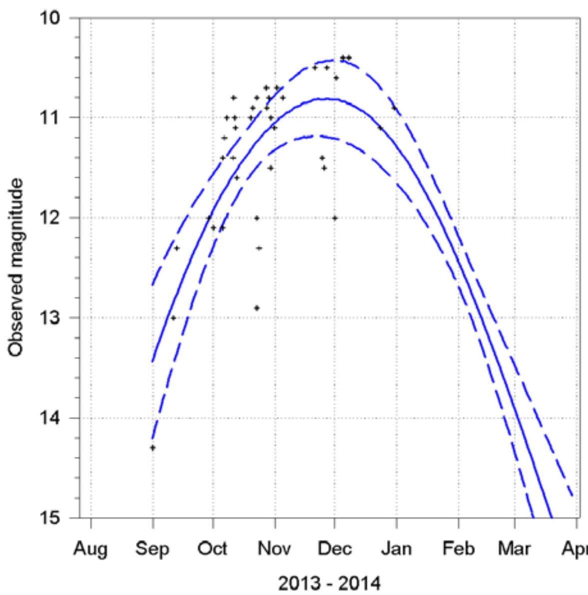
Comet 117P/Helin-Roman-Alu



119P/Parker-Hartley was followed by Roger Dymock and Kevin Hills from August to December when it brightened from about 18th to 16th magnitude.

125P/Spacewatch was followed by Kevin Hills in March and April when it was 16th magnitude.

Comet 154P/Brewington



154P/Brewington The comet was recovered at the 2013 apparition on 2013 August 2.02 by F Fratev with the 0.35m reflector at the Zvezdno Obshtestvo Observatory, Plano. It will return to perihelion 0.25 days later than expected. The recovery magnitude was about 4^m fainter than expected.

39 electronic and visual observations received so far suggest a preliminary uncorrected light curve of :

$$m = 2.6 + 5 \log d + 37.7 \log r$$

The error bars remain quite large.

158P/Kowal-LINEAR was followed by Kevin Hills from August to December when it was around 18^{th} magnitude.

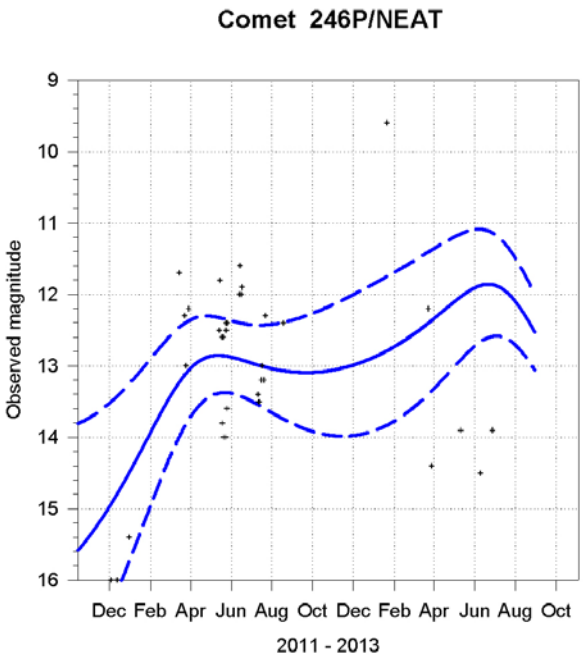
175P/Hergenrother was followed by Kevin Hills and John Sabia from March to May when it was around 16^{th} magnitude.

178P/Hug-Bell was followed by Kevin Hills from October to December when it was around 17^{th} magnitude.

184P/Lovas was followed by Kevin Hills and David Spooner from August to November when it was around 16^{th} magnitude.

244P/Scotti was observed by Kevin Hills in April when it was around 16^{th} magnitude.

246P/NEAT

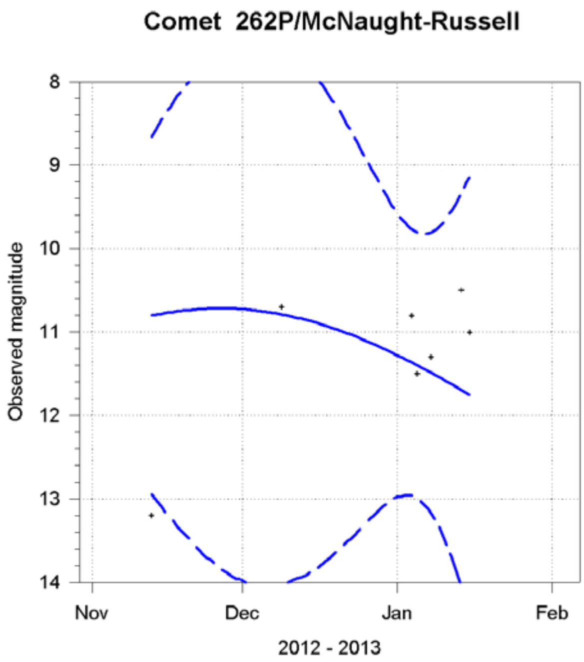


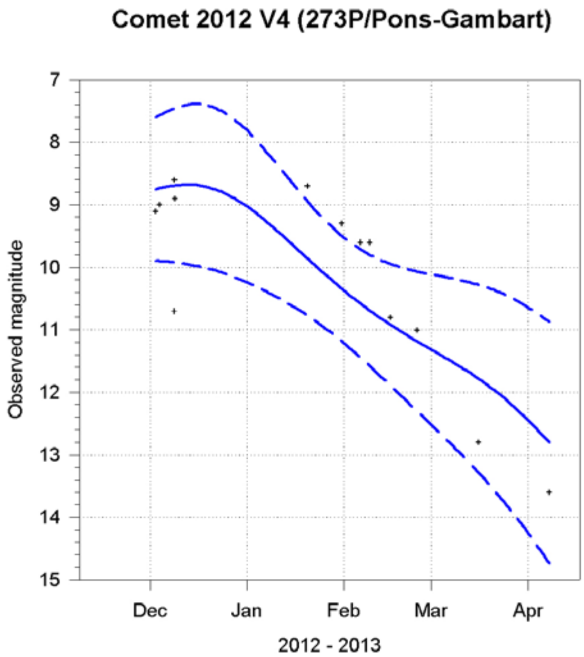
Following its outburst in 2012 March the comet very slowly faded. The light curve shows how the comet would have behaved if it followed m = 8.1 + 5 log d + 5 log r

256P/LINEAR was followed by Kevin Hills from March to May when it was around 18^{th} magnitude.

257P/Catalina was followed by Roger Dymock and Kevin Hills from August to December as it faded from around 16^{th} to 18^{th} magnitude.

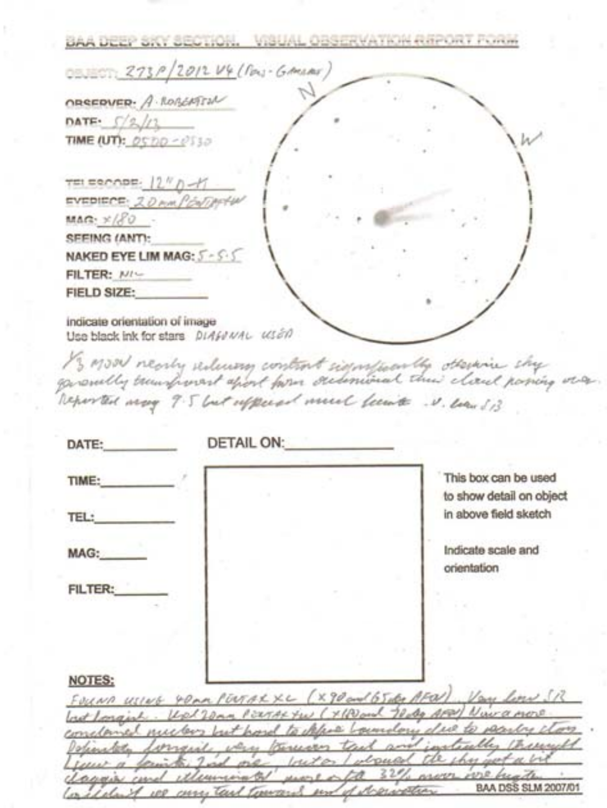
262P/McNaught-Russell
A few additional observations were received in January, but the magnitude parameters remain poorly determined. It seems likely that the comet faded more rapidly than shown in the light curve, which assumes a decline at 10 log r.





273P/Pons-Gambart
The comet emerged from conjunction towards the end of January as a 9th magnitude object, a little brighter

than expected, but in line with suggestions of a linear light curve, with the comet brightest about 22 days after perihelion.



273P drawn by Andrew Robertson on February 5

Surprisingly few observations have been received after January, although the comet became well placed in the evening sky.

Four comets have been numbered, either following recovery, or location of pre-discovery images.

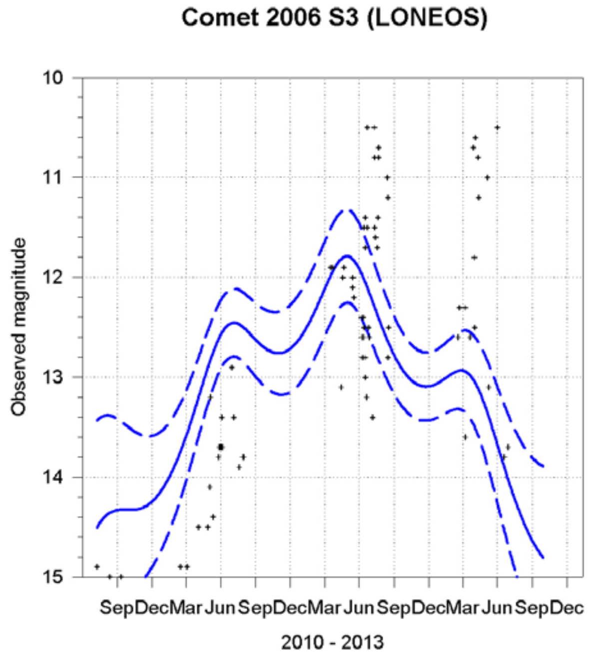
279P/La Sagra = 2009 QG$_{31}$ In early 2013 Rob Matson found the comet in NEAT images taken with the Palomar 1.2m Schmidt in 2002 July, and other images were found in frames from the Apache Point 2.5m telescope. It was therefore assigned a number, having been observed at two returns.

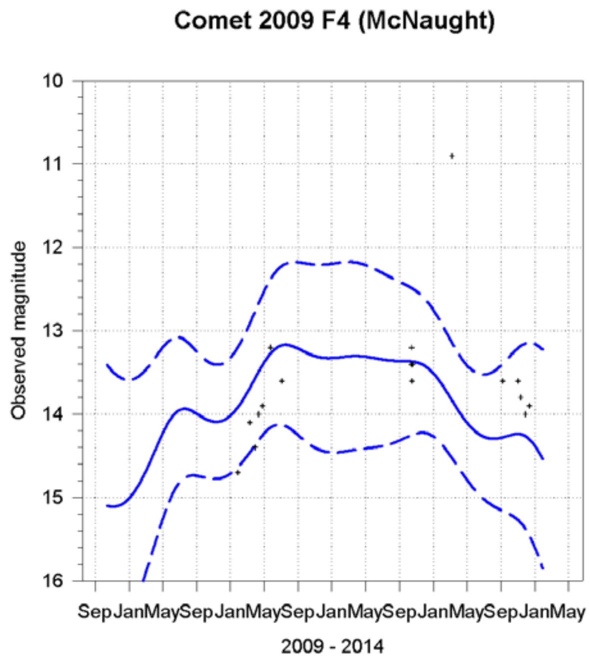
282P/PanSTARRS = 2012 T1 On 2013 January 26 Rob Matson found images of the comet in frames taken by NEAT with the Palomar 1.2m Schmidt on 2001 December 9. Although the comet has been numbered, the MPC does not give it a name.

288P/Spacewatch = 2006 VW$_{139}$ = (300163) Spacewatch This main belt asteroid, discovered by Spacewatch on 2006 November 15, was shown to have cometary features in PanSTARRS images taken in 2011 November. It was at perihelion in 2011 July and has a period of 5.3 years, with a perihelion distance of 2.4 AU. It has been observed at returns in 2000, 2006 and 2011, and at six oppositions and was therefore given a periodic comet number.

289P/Blanpain = 1819 W1 = 2003 WY$_{25}$ The comet was recovered by PanSTARRS on 2013 July 4.46, when it was found in outburst at 20th magnitude, some five magnitudes brighter than expected. [MPEC 2013-N20, 2013 July 6]. A new linked orbit was published in MPEC 2013-N21 [2013 July 7] and it was then numbered. Although expected to be renamed Blanpain-Catalina, the name has reverted to simply 289P/Blanpain. It will make close approaches to the Earth in 2020 (0.09 AU in January) and 2035 (0.09 AU in November).

2006 S3 (LONEOS) has had a long period of observation, but has now dropped below the visual threshold. I suspect that the imagers will continue coverage into 2014.



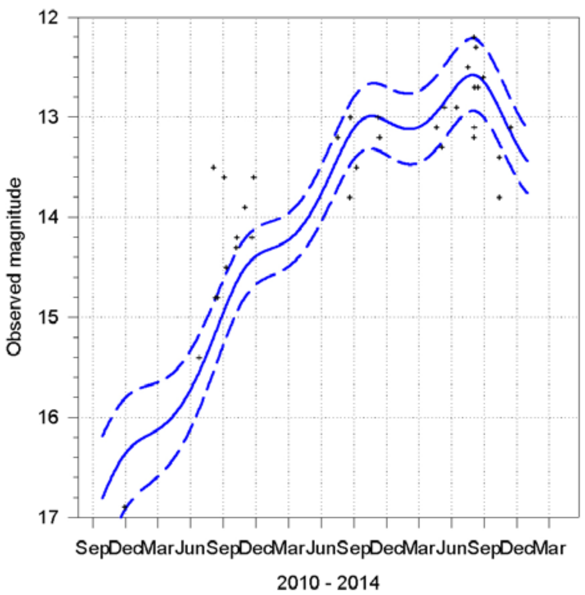


2009 F4 (McNaught) Kevin Hills continued imaging the comet and computed equivalent visual magnitudes, so the light curve now extends for five years. It is a distant object, which was at perihelion in 2011 at 5.5 au.

2010 S1 (LINEAR) is another distant comet that is likely to have a long period of visibility. It was at perihelion at 5.9 au in May 2013. For such a distant comet it has brightened quite rapidly, with a provisional uncorrected light curve of :

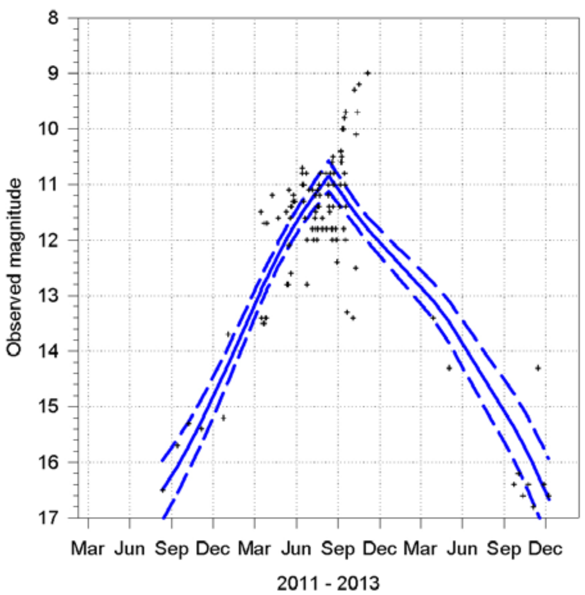
m = -5.2 + 5 log d + 18.3 log r

Comet 2010 S1 (LINEAR)



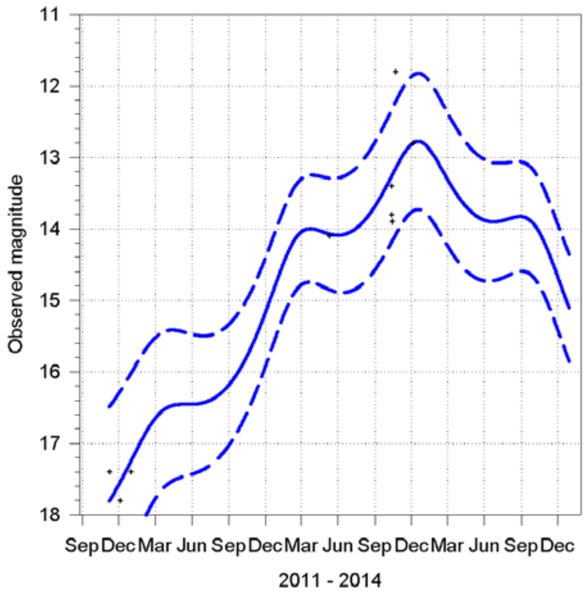
2011 F1 (LINEAR) was imaged during 2013, and the resulting visual equivalent magnitudes suggest a linear style light curve with the comet intrinsically brightest about 150 days before its perihelion in 2013 January.

Comet 2011 F1 (LINEAR)



2011 J2 (LINEAR) is another distant comet, which was at perihelion in December at 3.4 au.

Comet 2011 J2 (LINEAR)



2011 L4 (PanSTARRS) was recovered after solar conjunction on 2012 December 24.3 by Alexander Amorim, when it was 8.1 in his 0.18m reflector. It soon became clear that the rate of brightening had slowed compared to that prior to conjunction. By 2013 February it had reached 5th magnitude. It continued brightening and by the end of the first week of March had reached 0^{th} magnitude according to observations by Marco Goiato. The comet was first observed from southern England on March 12. I observed it from central Cambridge on March 13, when it was around 0^{th} magnitude, with a 15' tail in 8x42B. Clouds and cold temperatures prevailed over Cambridge for much of March, but on the 28th they parted for a short while at just the right time permitting a view of the comet from a nearby Common. In 8x42B it was 4.3, with a 1° tail in pa 020.

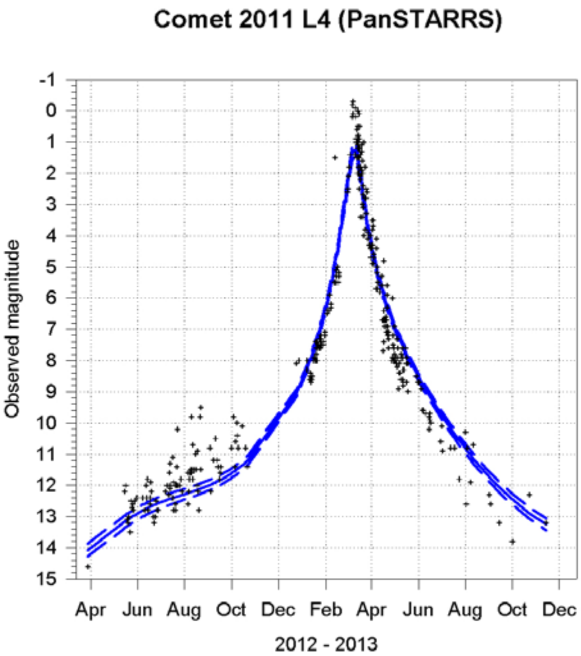
2011 L4 on 2013March 13 at 19:06 UT Nick James

It was still visible to the naked eye in April, with Carlos Labordena estimating it at 5.6 on the 21st. It continued to fade rapidly in May, but Gonzalez, Labordena and Shanklin all made observations with large binoculars in June, perhaps aided by its high northern declination. Although it remained in the evening sky the last visual observations were made in August, with electronic imaging continuing until November.

Image of 24 x 90 secs with Canon 1000d at ISO 800 with an 180mm f2.8 lens. Mid exposure 21.58UT Taken from Dalry, North Ayrshire 2013 April 05 Bill Ward

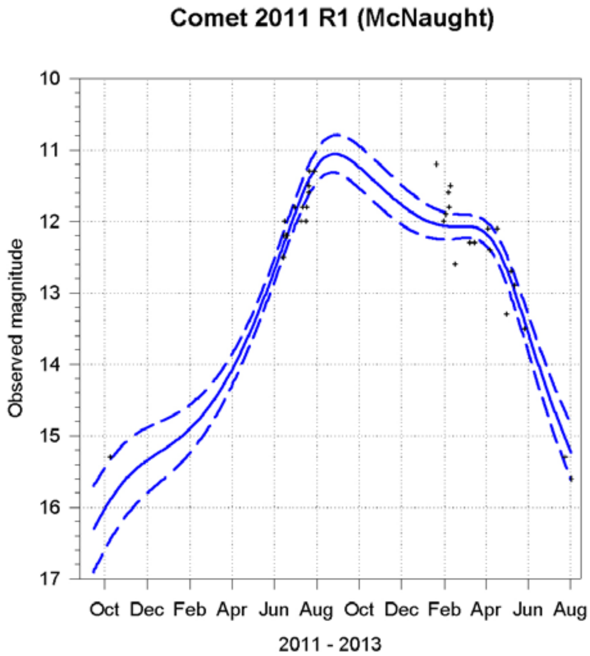
Visual observations suggest that tail development was greatest around March 19, when it was two or three degrees long. The coma was highly condensed for much of the apparition, only becoming more diffuse from mid April onwards.

Nicolas Biver comments that it is one of the dustiest comets observed, with disproportionately high dust compared to its water vapour sublimation rate.

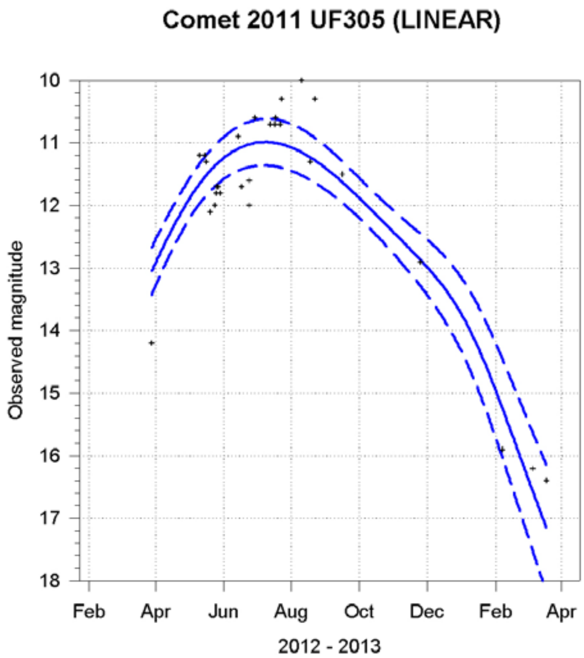


Although a single curve is shown here, there is some evidence for a change in photometric behaviour when the comet was in solar conjunction between 2012 October 22 and 2012 December 24. This will be explored further in the final analysis.

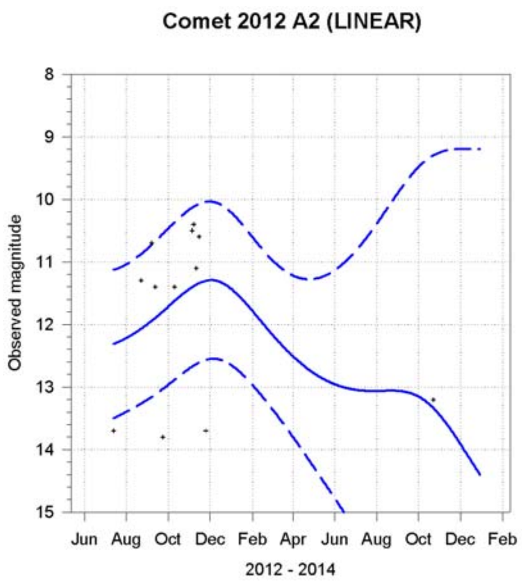
2011 R1 (McNaught) was at perihelion at 2.1 au in 2012 October. It was in conjunction for much of the second half of 2012, but was recovered by Juan Jose Gonzalez and Alexandre Amorim in 2013 January. It was fading, but there is a good overlap between visual and electronic observations from March to May.



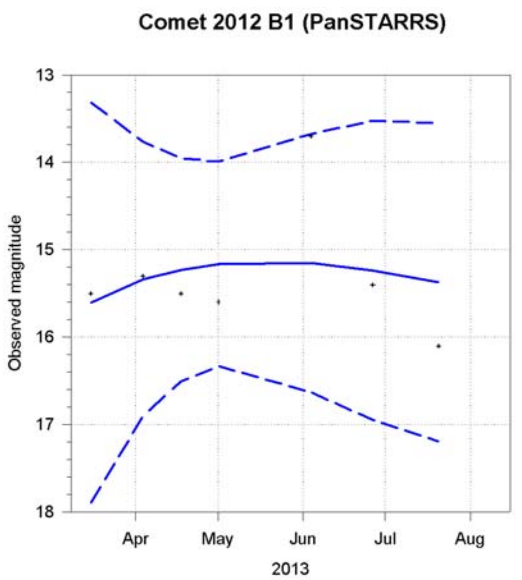
2011 UF_{305} (LINEAR) continued to be observed electronically during February and March by Kevin Hills and John Sabia, making a significant extension to the light curve.



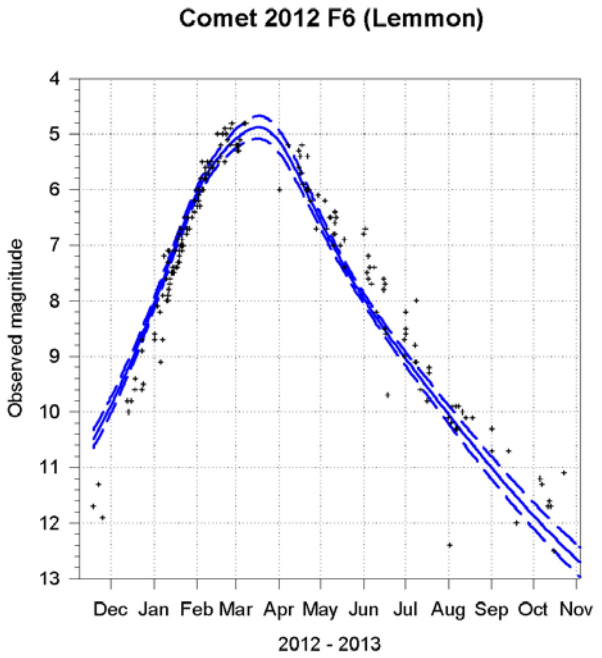
2012 A2 (LINEAR) was at perihelion at 3.5 au in 2012 November. Denis Buczynski made an electronic observation in October, greatly extending the light curve.

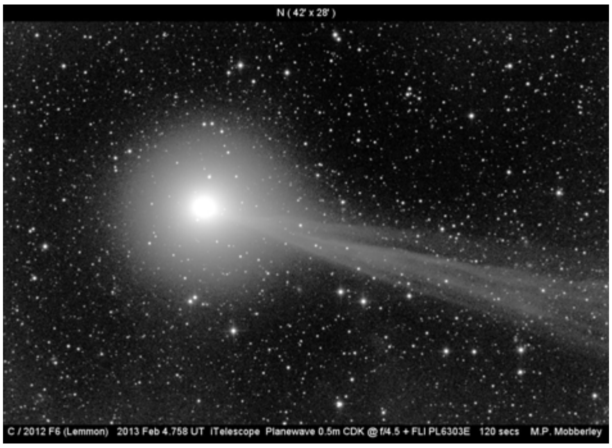


2012 B1 (P/PanSTARRS) was at perihelion at 3.8 au in 2013 July. Images of the comet were found from the previous return in 1997 but it has not yet been numbered. Roger Dymock, Kevin Hills (electronic) and Juan Jose Gonzalez (visual) contributed observations. For this comet the visual observation was nearly two magnitudes brighter than the electronic ones.

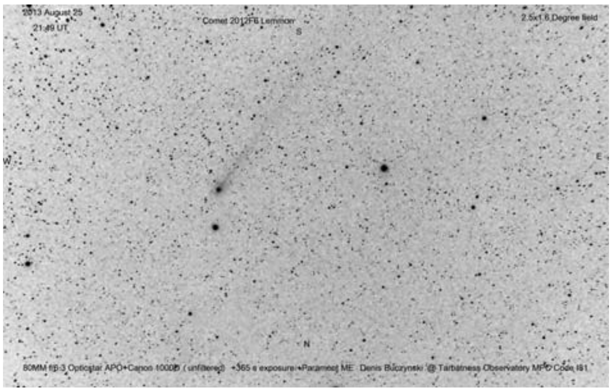


2012 F6 (Lemmon) was followed by Southern Hemisphere observers as it brightened during January. Michael Mattiazzo estimated it at 8.1 in 25x100B on the 3rd, and by the end of the month Alexandre Amorim estimated it at 6.3 in 10x50B. It was brightest in early March, and tail extent was greatest then with Marco Gioato reporting around 2° in 7x50B. Northern observers didn't pick it up until May when it was long past its best. My first view was not until June 30, when it was 8.5 in 25x100B from central Cambridge, though James Abbott saw it half a magnitude brighter on July 8 using 15x70B. Observations continued until October, though it was well placed and should have remained within visual range until November.





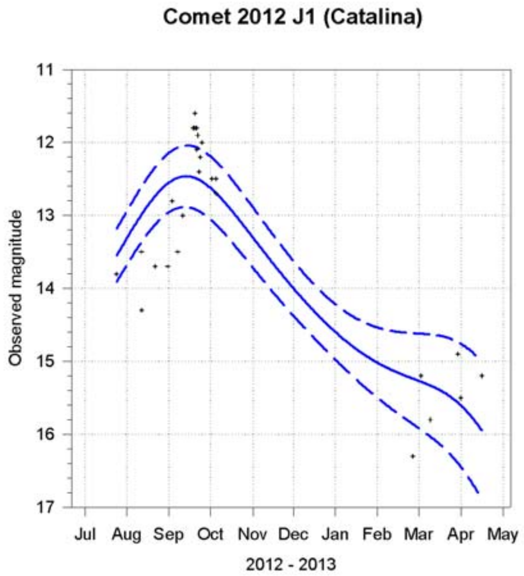
Martin Mobberley imaged 2012 F6 on February 5, when it showed a large coma (visual observations gave up to 15') and a short tail.

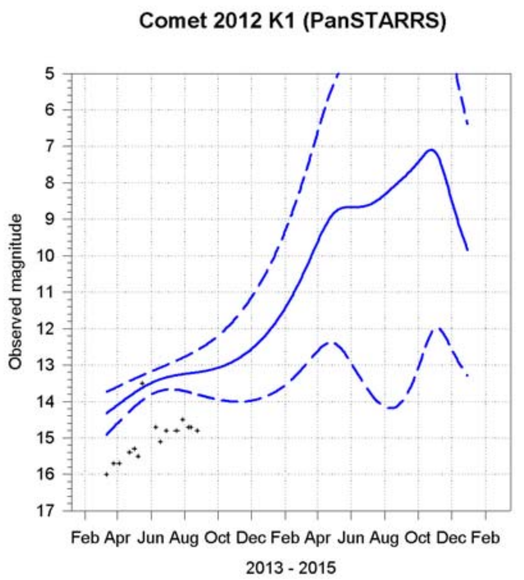


Denis Buczynski's widefield image of 2012 F6 on August 25 showed a proportionately more prominent tail (30') that was considerably longer than seen by visual observers (10').

172 visual observations received so far suggest a preliminary light curve of m = 5.3 + 5 log d + 9.0 log r however there are clear systematic deviations from the mean curve both before and after perihelion.

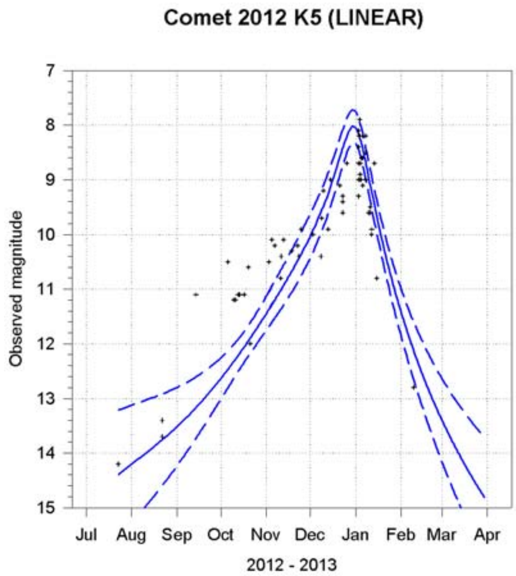
2012 J1 (Catalina) is another fairly distant comet, with perihelion at 3.2 au in 2012 December. Kevin Hills and David Spooner continued the light curve in 2013 with electronic observations between September to December.





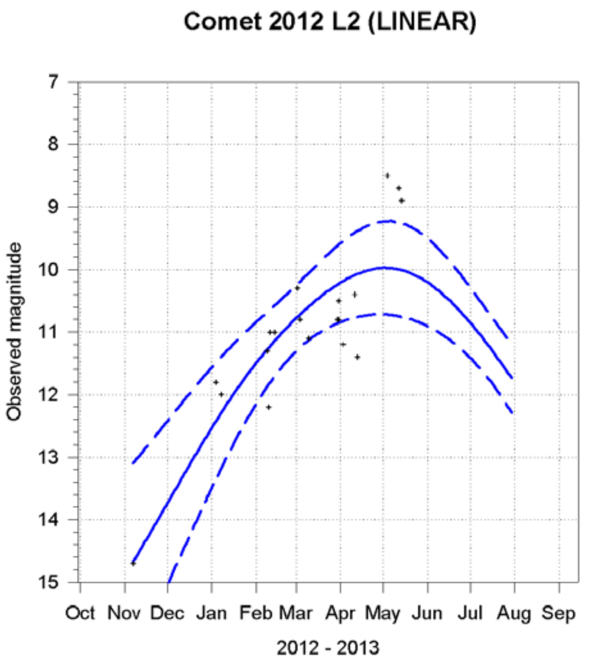
2012 K1 (PanSTARRS) has perihelion at 1.05 au in 2014 August. The light curve has huge error bars, but the comet could a binocular or even naked eye object in the morning sky in October and November 2014. The same expert who for several months predicted the imminent demise of 2012 S1 (ISON) is predicting that this comet too will self destruct. The 17 mostly electronic observations received so far, all made with the comet over 4.8 au from the Sun, suggest a preliminary light curve of m = 6.4±1.8 + 5 log d + 4.9±2.4 log r, though the H_{10} absolute magnitude is much brighter. The Bortle formula (which in any case applies to comets with perihelia smaller than 0.5 au) gives 7.0 + 6*1.05 = 13.3, so this is another instance where anything could happen. Observations once the comet is within the orbit of Mars will give better indications of the comet's future prospects.

2012 K5 (LINEAR) faded rapidly in January and only two observations (one visual and one electronic) were made after mid month. A best fit standard light curve is shown here, but further data may show that a different fit is necessary.



2012 K5 imaged on January 8 by Efrain Morales Rivera from Puerto Rico

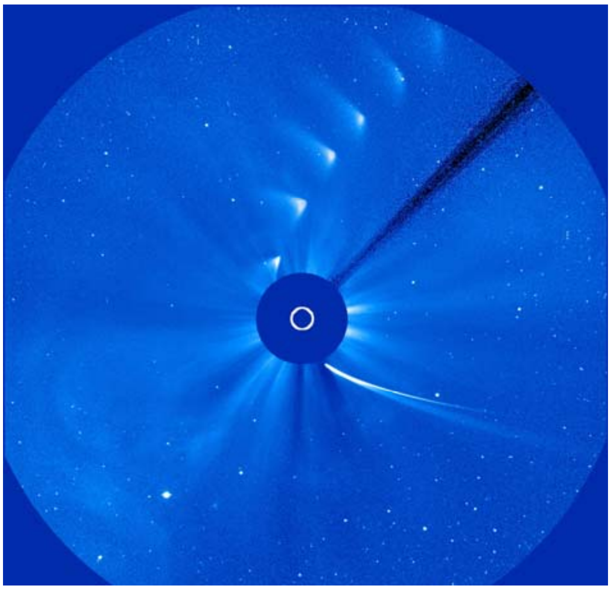
2012 L2 (LINEAR) Observations are rather sparse as the comet was at a poor solar elongation, but perhaps hint at a perihelion outburst, with the comet two magnitudes brighter than expected.



2012 S1 imaged by Michel Jaeger on November 10

2012 S1 (ISON) The comet emerged from solar conjunction in 2013 September as an 11th magnitude object in the morning sky, as seen by Juan Jose Gonzalez on September 1. By early October it had brightened to 10th magnitude, but it was clear that the comet was not brightening very quickly. I glimpsed it in late October in 25x100B at about magnitude 9.5. Reports on November 6 suggested a possible increase in brightness and change in appearance, however nothing further developed. Tail rays did form, but this was a solar effect. A tail disconnection event occurred on November 13. Professional observers suggested a rapid increase in gaseous output between November 12 and 13. The comet became more active on November 14, developing a near stellar appearance and reaching magnitude 6. It brightened further to 5th magnitude by November 15, but then remained near this brightness according to ground based observers. German scientists suggested that the November 12 to 14 sequence was caused by a minor fragmentation event, which also created coma wings. General tail activity also increased, with a disconnection event seen on November 13. I observed it on November 19.25 when it was 5.3 in 20x80B. Its absolute magnitude was close to or fainter than the Bortle survival limit, and the comet did not survive long after perihelion.

The comet entered the SOHO C3 field on November 27 and continued brightening until some 12 hours prior to perihelion, when it was around -2. It then faded. It showed two tails, the longest over 4° long. It was also visible in the STEREO H1A field. The brightest portion of the comet became elongated. A tail feature survived perihelion in the C2 field, and then the comet reappeared as a bright, well condensed object in the C3 field on November 29. On November 30 the comet appeared very diffuse and significantly fainter in the C3 field and this progressed further as the comet left the field. A possible explanation is that the intense solar wind and radiation when very near the Sun stripped all material from the nucleus, causing the fade. As the thermal wave penetrated the bare nucleus it disintegrated, leaving a ghostly remnant.

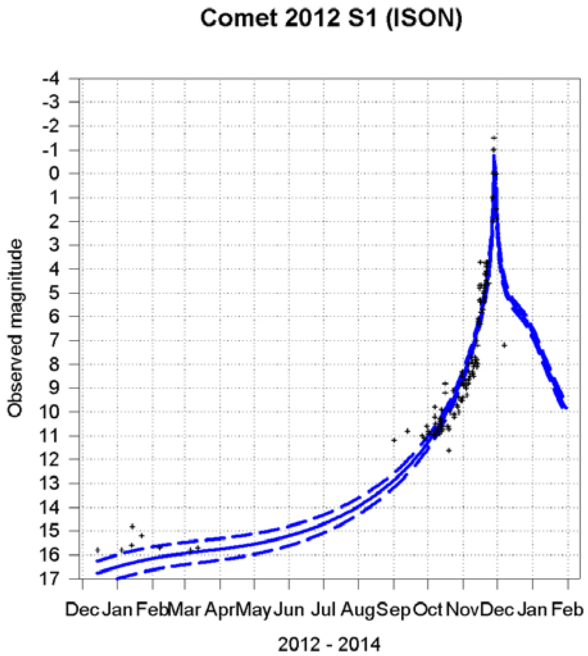


SOHO C3 montage of 2012 S1 at perihelion

The remnant was detected from the ground by Juan Jose Gonzalez on December 7.26, when it was 7.2 in his 200mm SCT. He also noted faint tails. The tails seen in C3 did not lie along the radius vector and the tails seen by Juan Jose were only 0.3° long.

Speculation and hysteria about the comet thrived throughout the apparition. Shortly after discovery some in the media suggested that the comet would be 12 times brighter than the full moon and therefore visible in daylight. One analyst suggested for several weeks that the light curve had flattened to such an extent that the comet's complete disintegration was imminent, but the comet continued to slowly brighten. Image flaws were interpreted as effects in the comet. There was also speculation (NASA Science News) that the comet could cause a meteor shower, or as the dust would be exceedingly fine, a display of noctilucent clouds around 2014 January 12. BBC Radio 4 News on November 20 had a short item at 06:50 which had at least three errors: Contrary to what their science correspondent said, 2012 S1 did not get higher in the sky over the next week, Mars was not in Virgo and comets did not form in the Oort Cloud. The BBC TV lunchtime news on November 28 presented several misleading simulations without identifying them as such.

126 electronic and visual observations received until December 20 suggest a preliminary aperture corrected light curve of m = 7.3±0.1 + 5 log d + 6.3±0.3 log r In general the comet did not deviate much from the mean light curve until the final fade began.



2012 T5 (Bressi) The comet reached perihelion at 0.3 AU in late February 2013. It brightened from 12th magnitude at the beginning of January to 9th magnitude and became well condensed in early February, but then faded to 10th magnitude and was lost in solar conjunction. No observations were made following perihelion and it seems likely that it disintegrated.

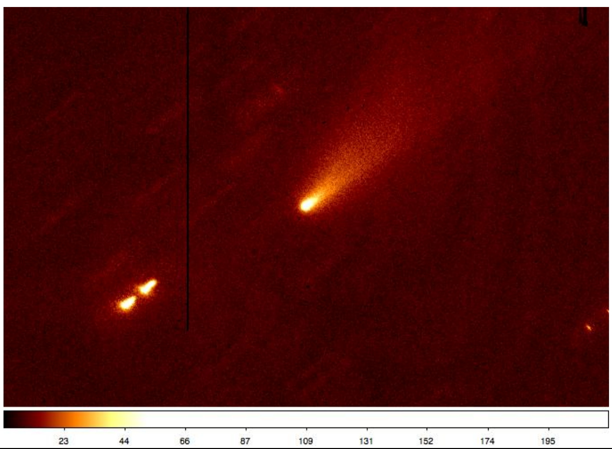
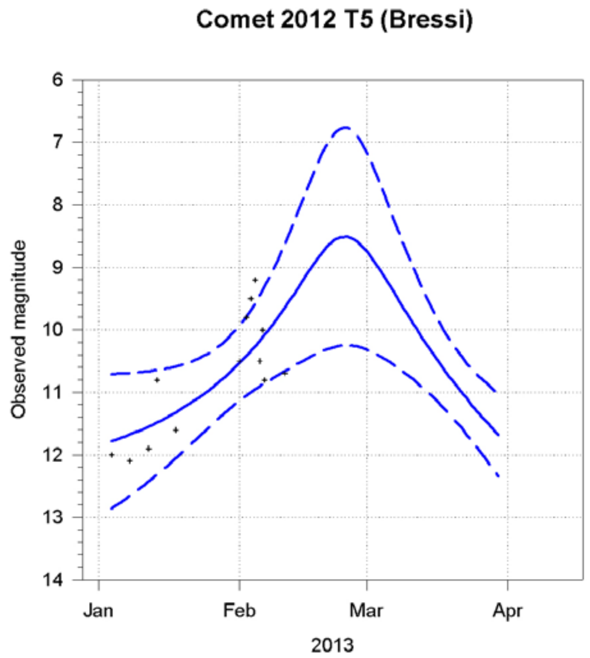
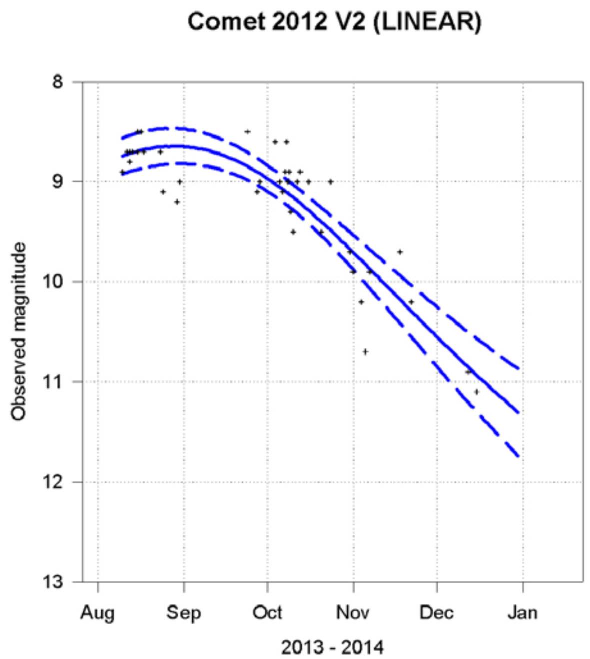


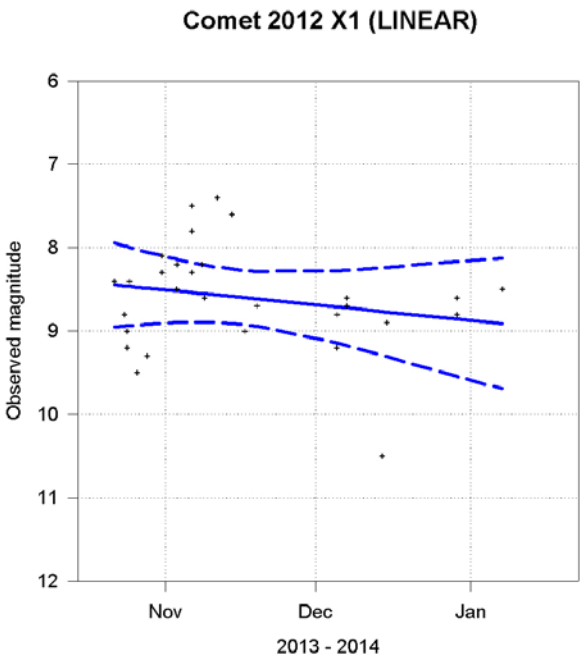
Image of 2012 T5 taken around 01:30 UT on the 16th of December with the 3.6m NTT at La Silla by Colin Snodgrass. There was no sign of any secondary nuclei in a stack of 3 x 120s exposures in R band, in sub-arcsecond seeing.

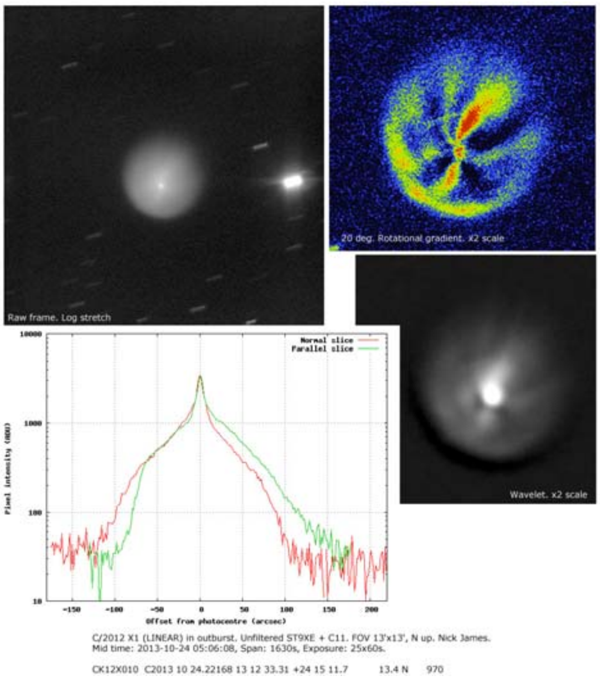


2012 V2 (LINEAR) The comet was spotted by Vladimir Bezugly in SWAN imagery in 2013 July, suggesting that it was at least two magnitudes brighter than expected. It become visible to southern hemisphere observers in mid August, when it was about 9th magnitude and was still this bright in early October. It was fading by the time it became visible in northern skies.

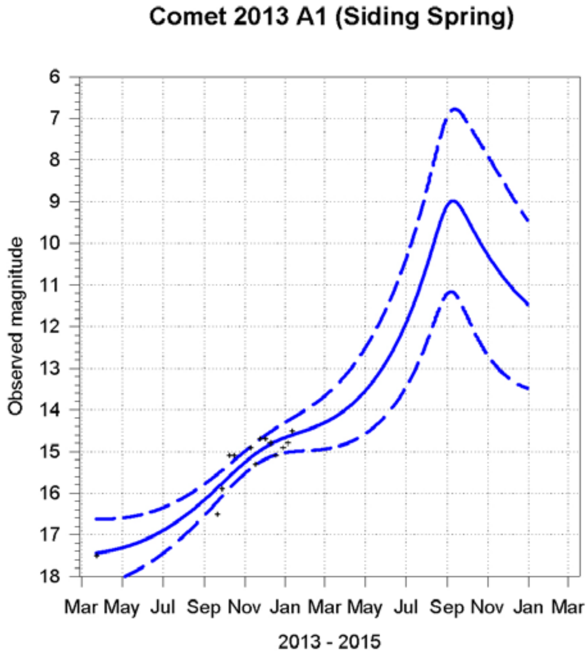


2012 X1 (LINEAR) On October 20 Hidetaka Sato imaged the comet in outburst at 8.5, some 5 magnitudes brighter than expected. It is not clear what its future brightness evolution will be. Richard Miles suggests that the outburst is similar to those seen in 29P/Schwassmann-Wachmann, in which case we can expect an expanding coma becoming more diffuse, with a slow decline in brightness as the outer coma is lost to the background, and a possible decline is seen in the observations. It will reach perihelion at 1.6 AU in 2014 February.





2012 X1 imaged by Nick James on October 24, with log stretch, 20° rotational gradient, wavelet and density slice processing



2013 A1 (Siding Spring) An 18th magnitude comet was discovered at Siding Spring on January 3.54. Follow-up observations led to pre-discovery observations from the Catalina Sky Survey made on 2012 December 8. It was discovered when still 7.2 au from the Sun, and does not reach its 1.4 au perihelion until 2014 October. [MPEC 2013-A14, 2013 January 5] It will be a southern hemisphere object when at its brightest of perhaps 7th magnitude, and will have faded to around 10th magnitude when it enters UK skies in 2015 January. The comet will pass very close to Mars on 2014 October 19 at 18:25, becoming a Great Comet for any Martians, as it misses by a nominal 0.00096 au and may create a spectacular meteor shower in the thin Martian atmosphere. The orbit has an Earth Minimum Orbit Intersection Distance (MOID) of 0.38 au.

14 electronic observations received so far suggest a preliminary aperture corrected light curve of $m = 6.7 \pm 1.0 + 5 \log d + 6.3 \pm 1.6 \log r$ The error bars are two magnitudes at perihelion.

2013 A2 (P/Scotti) Jim Scotti discovered a 20th magnitude comet in Spacewatch images taken with the 0.9-m f/3 reflector at Kitt Peak on January 6.29. The preliminary orbit was based on a two day arc, yet gave values to five significant figures. [MPEC 2013-A45, 2013 January 8] The comet has a period of 8 years and was at perihelion at 2.2 au in February. It approaches within 0.6 au of Jupiter, but these encounters have made only minor changes to the orbit.

2013 A3 (277P/LINEAR) Jim Scotti recovered 2005 YQ_{127} in Spacewatch II images taken with the 1.8-m f/2.7 reflector at Kitt Peak on January 7.10. It has a period of 7.6 years and is at perihelion at 1.9 au in June, 0.12 days later than predicted from the discovery apparition. [MPEC 2013-B18, 2013 January 18] It will approach within 0.5 au of Jupiter in 2185.

2013 AL_{76} (P/Catalina) A 20th magnitude asteroid discovered by the Catalina Sky Survey on January 14.21, was found to be cometary during follow-up observations by professional and amateur astrometrists, including Peter Birtwhistle, Gary Hug and Hidetaka Sato. The comet was at perihelion at 2.0 au in 2012 December and has a period of around 16 years. [MPEC 2013-B77, 2013 January 23]

A/2013 AS_{105} [ESAOGS] This unusual asteroid was discovered by the ESA Optical Ground Station at Tenerife with the 1.0m reflector on January 15.07. The initial orbit gave a period of around 160 years with perihelion at 5.4 au in 2011 May. [MPEC 2013-B21, 2013 January 18, 11-day orbit]. Aphelion was at around 55 au. In this orbit it could approach to within 0.5 au of Jupiter. The Tisserand parameter of the orbit with respect to Jupiter was 2.84. Such an orbit is typical of a potential Jupiter family comet.
The object was subsequently linked to 2010 AO_{137} with other observations back to 2007. The more definitive orbit is less interesting, with no Jupiter encounters, and a period of 65 years. Tj is 2.93. [MPEC 2013-B21, 2013 January 19]

2013 B1 (278P/McNaught) Jim Scotti recovered 2006 K2 in Spacewatch II images taken with the 1.8-m f/2.7 reflector at Kitt Peak on January 19.53. It has a period of 7.1 years and was at perihelion at 2.1 au in August, 0.17 days earlier than predicted from the discovery apparition. [MPEC 2013-B58, 2013 January 21]

2013 B2 (Catalina) The Catalina Sky Survey discovered a 19th magnitude comet on January 16.23. [MPEC 2013-B84, 2013 January 23] It is at perihelion in July at 3.7 au.

A/2013 BN_{27} [Catalina] This unusual asteroid was discovered by the Catalina Sky Survey with the 0.68m Schmidt on January 17.33. [MPEC 2013-B64, 2013 January 21, 4-day orbit]. The retrograde orbit has a period of around 500 years with perihelion at 1.6 au in 2012 October. Aphelion is at around 125 au. The Tisserand parameter of the orbit with respect to Jupiter is -0.23.

A/2013 BL_{76} (Lemmon) Elements for a 21st magnitude object discovered by the Mt Lemmon Survey on January 20.08 were initially listed amongst those of comets. [MPEC 2013-C12, 2013 February 3] It is now classed as a Trans-Neptunian Object (TNO). The object was at perihelion at 8.4 au in 2012 October and has a slightly retrograde orbit with a period of over 40,000 years.

2013 C1 (280P/Larsen) Jim Scotti recovered 2004 H2 in Spacewatch II images taken with the 1.8-m f/2.7 reflector at Kitt Peak on February 5.50. It has a period of 9.6 years and was at perihelion at 2.6 au in December, 0.58 days earlier than predicted from the discovery apparition. [MPEC 2013-C25, 2013 February 6]

2013 C2 (Tenagra) Michael Schwartz and Paulo Holvorcem discovered a very distant comet on 2013 February 14.24 at the Tenagra II Observatory in Arizona. At discovery the comet was around 19th magnitude and over 9 au from the Earth. [MPEC 2013-D22, 2013 February 17] Perihelion is at 9.1 au in 2015 August. It has a period of around 60 years.

2013 CE_{31} (281P/MOSS) Claudine Rinner at the Morocco Oukaimeden Sky Survey (MOSS) discovered an object on February 5.11, that was initially flagged as an asteroid. Pre-discovery images were found in Spacewatch data from January. Cometary features were found. It reached perihelion at 4.0 au in 2012 May and has a period of around 11 years. With further astrometry leading to an improved orbit, Maik Meyer found and measured the comet in NEAT images from February and March 2002, and the comet was also found in Spacewatch images from 2000 November. The comet made an approach to 0.4 au of Jupiter in1999 which reduced the perihelion distance from 4.6 au to its present value.

2013 CU_{129} (P/Pan-STARRS) An asteroid was discovered by Pan-STARRS 1 with the 1.8m R-C telescope on February 13.32. Subsequent observations in 2013 June showed cometary features. [MPEC 2013-L64, 2013 June 13]. The comet has a period of 4.9 years with perihelion at 0.80 au in 2013 August. It makes relatively frequent approaches to both Jupiter and the Earth, with approaches to our planet in 2018 (0.45 au) and 2023 (0.12 au).

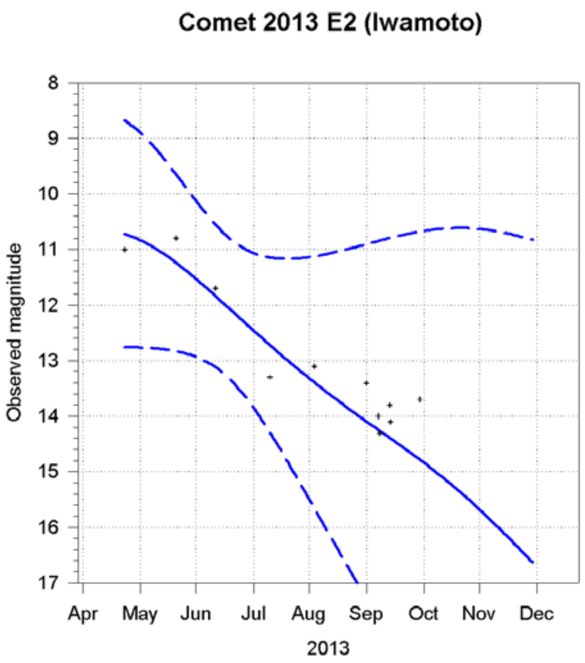
2 CCD and visual observations received so far suggest a preliminary aperture corrected light curve of m = 15.2 + 5 log d + [10] log r

A/2013 CY_{133} [Pan-STARRS] This Centaur asteroid was discovered by Pan-STARRS 1 with the 1.8m R-C telescope on February 14.40. [MPEC 2013-D25, 2013 February 18, 4-day orbit]. The asteroid has a period of around 22 years with perihelion at 5.8 au in 2014 December. Aphelion is at around 10 au. The Tisserand parameter of the orbit with respect to Jupiter was 2.92.

2013 D1 (Holvorcem) Paulo Holvorcem discovered a comet on 2013 February 16.31 with the 0.41m astrograph at the Tenagra II Observatory in Arizona. At discovery the comet was around 19th magnitude. [MPEC 2013-D41, 2013 February 20] It has perihelion at 2.5 au in 2013 April. It has a period of around 40 years.

2013 E1 (McNaught) Rob McNaught discovered a 19th magnitude comet on March 4.74 during the Siding Spring Survey with the 0.5m Uppsala Schmidt. The comet reached perihelion at 7.8 au in 2013 June. The latest orbit is strongly hyperbolic.

2013 E2 (Iwamoto) Masayuki Iwamoto discovered a 14th magnitude comet on images taken with his 10cm refractor at Tokushima on March 10.83. The comet was near perihelion at 1.4 au and was just over 40 degrees elongation from the Sun in the dawn sky. Calculations by Hirohisa Sato show that the comet is in a long period orbit. Marco Antônio Coelho Goiato estimated the comet at about 11.0 in his 0.22-m reflector on March 23.35.



11 observations received so far suggest a preliminary light curve of m = 7.4±0.4 + 5 log d + 12.6±1.3 log r

2013 EV$_9$ (283P/Spacewatch) A 19th magnitude asteroid was discovered by Spacewatch on March 2.28 with the 0.9m reflector. Cometary characteristics were noted in images taken by Hidetaka Sato in 2013 April using the remote 0.51m telescope at the iTelescope Observatory at Siding Spring, and confirmed by other observers, and earlier observations were found from 2013 February. The comet was at perihelion at 2.1 au in 2013 April and has a period of around 8 years. [MPEC 2013-J07, 2013 May 2] This was another confirmation of cometary features by the T3 project. Andrew Lowe quickly reported that he found astrometry from 1996 and 2005 and that the comet had made a number of approaches to within 0.5 au of Jupiter between 1600 and 2400.

2013 EW$_{90}$ (P/Tenagra) Michael Schwartz and Paulo Holvorcem discovered an asteroid like object of 19th magnitude on 2013 March 3.19 at the Tenagra II Observatory in Arizona. Later observations then showed cometary features. [MPEC 2013-J52, 2013 May 13] Perihelion was at 3.3 au in 2012 October. It has a period of around 8 years.

2013 F1 (Boattini) Andrea Boattini discovered an 18th magnitude comet on March 23.34 during the course of the Catalina Sky Survey with the 0.68-m Schmidt. The comet was at perihelion at 1.9 au in 2012 December.

2013 F2 (Catalina) An 18th magnitude comet was discovered on March 24.18 during the course of the Catalina Sky Survey with the 0.68-m Schmidt. Pre-discovery images from 2012 December, 2013 January, and March were found in Pan-STARRS data. The comet was at perihelion at 6.2 au in 2013 April.

2013 F3 (McNaught) Rob McNaught discovered a 17th magnitude comet on March 29.76 during the Siding Spring Survey with the 0.5m Uppsala Schmidt. The comet reached perihelion at 2.3 au in 2013 May. It has a period of around 80 years.

2013 G1 (P/Kowalski) Richard Kowalski discovered an 18th magnitude comet on April 2.43 on images taken during the Mt Lemmon Survey with the 1.5m reflector. This was the 150th comet discovered by the Catalina /Mt Lemmon Sky Survey. The orbital inclination is low, and an orbit computation by Hirohisa Sato suggests an elliptical orbit with a period of 17 years and perihelion at 3.4 au in 2013 November is fitted by the astrometry. The latest orbit has a period of 18 years and perihelion at 3.3 au in 2013 December. The comet made an approach to Jupiter in 1927, and then had a very close approach to within 0.003 au of Saturn in 2001 April. This encounter increased the perihelion distance from around 2 au to its present 3.3 au.

2013 G2 (McNaught) Rob McNaught discovered a 17th magnitude comet on April 8.72 during the Siding Spring Survey with the 0.5m Uppsala Schmidt. The comet was at perihelion at 2.2 au in 2012 December. This was Rob McNaught's 75th discovery.

2013 G3 (PanSTARRS) Pan-STARRS discovered a 20th magnitude comet on April 10.42. The discovery MPEC reported that it reaches perihelion at 4.3 au in 2015 January and has a period of 33.2 years. The MPEC orbit was based on only a four day arc and seemed unduly precise for this limited amount of data. As a contrast the JPL orbit viewed on April 16 was hyperbolic! This indicates that not too much credence should be given to preliminary orbits - they are an aid to predicting the position over the next few days, but not much more. The latest orbit [MPEC 2013-K38, 2013 May 24] gives perihelion at 3.9 au in 2014 November.

2013 G4 (P/PanSTARRS) Pan-STARRS discovered a 21st magnitude comet on April 12.49. It was at perihelion at 2.6 au in 2013 February and has a period of around 9 years.

2013 G5 (Catalina) An 18th magnitude comet was discovered on April 13.46 during the course of the Catalina Sky Survey with the 0.68-m Schmidt. The comet was at perihelion at 0.9 au in 2013 September. JPL give a MOID of 0.07 au, so a meteor shower is a possibility.

2013 G6 (Lemmon) A 19th magnitude comet was discovered on April 13.48 on images taken during the

Mt Lemmon Survey with the 1.5m reflector. It was at perihelion in 2013 July at 2.0 au.

2013 G7 (McNaught) Rob McNaught discovered an 18th magnitude comet on April 13.65 during the Siding Spring Survey with the 0.5m Uppsala Schmidt. The comet will reach perihelion at 4.7 au in 2014 March.

2013 G8 (PanSTARRS) Pan-STARRS discovered a 20th magnitude comet on April 14.60. [MPEC 2013-H22, 2013 April 19]. It reaches perihelion at 5.1 au in 2013 November.

2013 G9 (Tenagra) Michael Schwartz and Paulo Holvorcem discovered a distant comet on 2013 April 15.39 at the Tenagra II Observatory in Arizona. At discovery the comet was around 20th magnitude and over 6 au from the Earth. [MPEC 2013-H23, 2013 April 19] Perihelion is at 5.3 au in 2015 January.

A/2013 GY54 [Pan-STARRS] This unusual asteroid was discovered by Pan-STARRS 1 with the 1.8m R-C telescope on April 4.38. The asteroid has a period of around 50 years with perihelion at 4.6 au in 2014 October. [MPEC 2013-G47, 2013 April, 34-day orbit]. Aphelion is at around 22 au. The Tisserand parameter of the orbit with respect to Jupiter was 2.78.

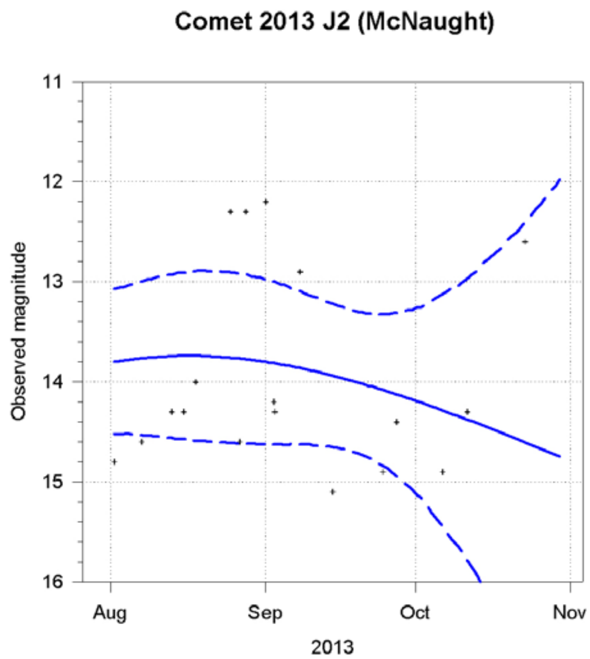
2013 H1 (La Sagra) The La Sagra team at the OAM Observatory discovered an 18th magnitude comet on April 19.11 with the 0.45m reflector. The comet was at perihelion at 2.6 au in 2013 May. [MPEC 2013-H27, 2013 April 22]

2013 H2 (Boattini) Andrea Boattini discovered an 18th magnitude comet on April 22.45 during the course of the Catalina Sky Survey with the 0.68-m Schmidt. [MPEC 2013-H45, 2013 April 25] The preliminary MPEC orbit suggested that the comet was at perihelion at 2.5 au in 2011 March and had a period of 36.5 years. This was based on a three day arc. Not surprisingly the latest orbit gives something completely different - a hyperbolic orbit with perihelion at 7.5 au in 2014 January.

A/2013 HA [Mt Lemmon] This unusual asteroid was discovered during the Mt Lemmon survey with the 1.5m telescope on April 16.24. The orbit has a period of around 10 years with perihelion at 1.7 au in 2013 May. [MPEC 2013-H14, 2013 April 17, 3-month orbit]. The Tisserand parameter of the orbit with respect to Jupiter is 2.55 and the object can approach within 0.5 au of the planet. It can also approach within 0.1 au of Mars, and will do so in 2098. It is an outer Main Belt Asteroid.

A/2013 HS$_{150}$ [Cerro Tololo] This Centaur asteroid was discovered with the Cerro Tololo Dark Energy Camera on the 4.0m CTIO reflector on April 16.30. [MPEC 2013-Q30, 2013 August 25, 3-day orbit]. The asteroid has a retrograde orbit with a period of around 130 years and perihelion at 2.8 au in 2013 January. Aphelion is at around 50 au. The Tisserand parameter of the orbit with respect to Jupiter was -0.03.

2013 J1 (284P/McNaught) Jim Scotti recovered 2007 H1 with the Spacewatch 1.8m reflector on May 1.41. The comet will return 0.22 days earlier than predicted.



2013 J2 (P/McNaught) Rob McNaught discovered an 18th magnitude comet on May 8.75 during the Siding Spring Survey with the 0.5m Uppsala Schmidt. [MPEC 2013-J38, 2013 May 10]. The comet reached perihelion at 2.1 au in 2013 August. Although the discovery MPEC gave a periodic orbit of about nine years (based on an arc of 1.7 days) subsequent circulars gave a parabolic orbit whilst retaining the P/ designation. This was a good move, as the latest orbit gives a period of around 16 years.

18 electronic and visual observations received so far suggest a preliminary aperture corrected light curve of m = 10.1 + 5 log d + [10] log r

2013 J3 (McNaught) Rob McNaught discovered a 17th magnitude comet on May 8.55 during the Siding Spring Survey with the 0.5m Uppsala Schmidt. [MPEC 2013-J40, 2013 May 11] The comet was at perihelion at 4.0 au in 2013 February.

2013 J4 (P/PanSTARRS) Pan-STARRS discovered a 21st magnitude comet on May 5.26. It will reach perihelion at 2.3 au in 2013 July and has a period of around 16 years. [MPEC 2013-J51, 2013 May 13]. There are only observations over a seven day arc.

2013 J5 (Boattini) Andrea Boattini discovered a 20th magnitude comet on May 13.32 during the course of the Catalina Sky Survey with the 0.68-m Schmidt. [MPEC 2013-K25, 2013 May 20] The comet was at perihelion at 4.9 au in 2012 December.

2013 J6 (Catalina) An 18th magnitude comet was discovered on May 9.37 during the course of the Catalina Sky Survey with the 0.68-m Schmidt. [MPEC 2013-K31, 2013 May 21] The comet was at perihelion at 2.4 au in 2013 April.

A/2013 JD_4 [Mt Lemmon] This Centaur asteroid was discovered during the Mt Lemmon survey with the 1.5m telescope on May 3.32. [MPEC 2013-J19, 2013 May 5, 2-day orbit]. The orbit has a high inclination with a period of around 40 years and perihelion at 1.6 au in 2013 January. The Tisserand parameter of the orbit with respect to Jupiter is 0.88 and the object can approach within 0.4 au of the planet.

2013 K1 (Christensen) Eric Christensen discovered a 17th magnitude comet on May 18.46 on images taken during the Mt Lemmon Survey with the 1.5m reflector. [MPEC 2013-K26, 2013 May 20]. The comet was near perihelion at 0.9 au, but is intrinsically faint and 0.8 au from the Earth. This is the 50th comet discovered from Mt Lemmon.
Cedric Bemer notes that the orbit has an Earth MOID of 0.06 au, so a meteor shower is possible with the Earth reaching this point 54 days after the comet. He suggests looking around 05:30 UT on 2013 July 29.

2013 K2 (285P/LINEAR) Hidetaka Sato recovered 2003 U2 with the remote iTelescope 0.51m astrograph at Mayhill Observatory on May 8.45. Perihelion is 0.18 days earlier than predicted. [MPEC 2013-K37, 2013 May 24]

2013 K3 (286P/Christensen) Hidetaka Sato recovered 2005 L4 with the remote iTelescope 0.51m astrograph at Siding Spring on May 19.70. Perihelion is 0.18 days earlier than predicted. [MPEC 2013-K47, 2013 May 31]

2013 L1 (287P/Christensen) Jim Scotti recovered 2006 R2 with the Spacewatch 1.8m reflector on June 1.29. The comet will return 0.75 days earlier than predicted.

2013 L2 (Catalina) A 19th magnitude comet was discovered on June 2.30 during the course of the Catalina Sky Survey with the 0.68-m Schmidt. [MPEC 2013-L41, 2013 June 9] The comet was at perihelion at 4.9 au in 2012 May.

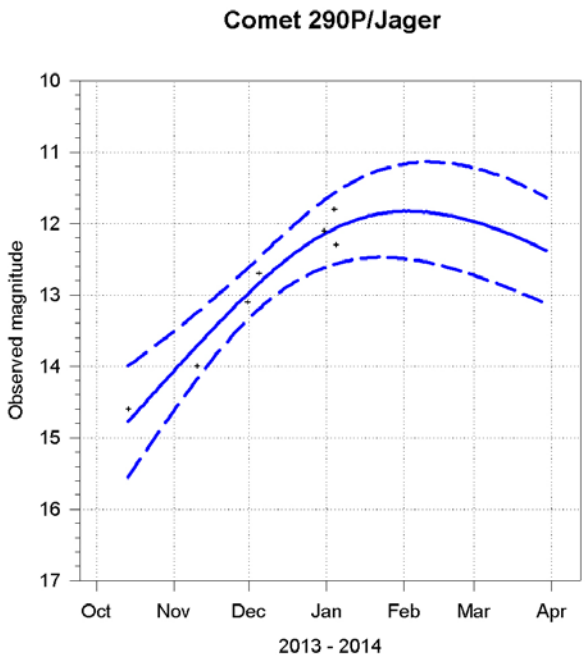
A/2013 LA_2 [Pan-STARRS] This Centaur asteroid was discovered by Pan-STARRS 1 with the 1.8m R-C telescope on June 1.37. [MPEC 2013-L23, 2013 June 5, 4-day orbit]. The asteroid has a retrograde orbit with a period of around 20 years and perihelion at 3.0 au in 2013 January. Aphelion is at around 12 au. The Tisserand parameter of the orbit with respect to Jupiter was -1.23. The object can approach Jupiter within 0.5 au and Saturn within 1 au.

A/2013 LD_{16} [Mt Lemmon] This Trans-Neptunian asteroid was discovered during the Mt Lemmon survey with the 1.5m telescope on June 6.28. [MPEC 2013-L47, 2013 June 10, 4-day orbit]. The orbit is retrograde with a period of around 600 years and perihelion at 2.5 au in 2013 October. The Tisserand parameter of the orbit with respect to Jupiter is -1.70.

A/2013 LH_{16} [Pan-STARRS] This unusual asteroid, classified as an Apollo, was discovered by Pan-STARRS 1 with the 1.8m R-C telescope on June 7.47. [MPEC 2013-L51, 2013 June 10, 3-day orbit]. The asteroid has a period of around 5 years with perihelion at 0.7 au in 2013 September. The Tisserand parameter of the orbit with respect to Jupiter was 2.68.

A/2013 LG_{29} [Pan-STARRS] This Centaur asteroid was discovered by Pan-STARRS 1 with the 1.8m R-C telescope on June 12.37. [MPEC 2013-M02, 2013 June 16, 4-day orbit]. The asteroid has a period of around 70 years with perihelion at 3.6 au in 2013 August. The Tisserand parameter of the orbit with respect to Jupiter was 2.44. The object can approach within 1 au of Saturn and 1.2 au of Uranus.

2013 N1 (290P/Jager) K Sarneczky and G Marschalko recovered 1998 U3 with the 0.6m Schmidt at Konkoly Observatory on July 8.04. Perihelion is 1.96 days earlier than predicted. [MPEC 2013-N46, 2013 July 13] To date there is no clear evidence of whether or not the comet is following the linear form of light curve that it showed at the last apparition. The light curve shown is a standard one, with 7 visual and electronic observations received to date suggesting a preliminary light curve of $m = 1.5 \pm 1.6 + 5 \log d + 28.5 \pm 4.4 \log r$



2013 N2 (291P/NEAT) Gary Hug recovered 2003 S1 with the 0.56m reflector at Sandlot Observatory, Scranton, on July 11.39. Perihelion is 0.67 days earlier than predicted. [MPEC 2013-N48, 2013 July 13]

2013 N3 (P/PanSTARRS) Pan-STARRS discovered a 21st magnitude comet on July 4.44. [MPEC 2013-N50, 2013 July 13] It will reach perihelion at 3.0 au in 2014 February and has a period of around 20 years.

2013 N4 (Borisov) Gennady Borisov discovered a 17th magnitude comet with a 0.2m astrograph, 0.25m reflector and 0.32m reflector at the Crimea-Nauchnij observatory in collaboration with I Ionov, O Bryzgalov and Ayrtom Novichonok on July 8.99. [MPEC 2013-N51, 2013 July 13] The comet perhaps reached 9th magnitude at perihelion, however it was at a small solar elongation. It was at perihelion at 1.2 au in 2013 August and has a period of around 90 years, so might have been seen previously at a favourable return. The elongation, although still poor, is increasing and Seichi Yoshida observed the comet at 11th magnitude in early October.

3 visual observations received so far suggest a preliminary light curve of m = 7.4 + 5 log d + [10] log r

2013 N5 (P/PanSTARRS) Pan-STARRS discovered a 21st magnitude comet on July 14.58. [MPEC 2013-P17, 2013 August 4] It was at perihelion at 1.8 au in 2013 July and has a period of around 18 years.

A/2013 NS$_{11}$ [Pan-STARRS] This Centaur asteroid was discovered by Pan-STARRS 1 with the 1.8m R-C telescope on July 5.27. [MPEC 2013-N43, 2013 July 12, 7-day orbit]. The asteroid has a retrograde orbit with a period of around 45 years and perihelion at 2.7 au in 2014 September. The Tisserand parameter of the orbit with respect to Jupiter is -0.83.

A/2013 NF$_{15}$ [Pan-STARRS] This unusual asteroid was discovered by Pan-STARRS 1 with the 1.8m R-C telescope on July 14.49. [MPEC 2013-O06, 2013 July 16, 1-day orbit]. The asteroid has an orbit with a period of around 11 years and perihelion at 1.4 au in 2013 June. The Tisserand parameter of the orbit with respect to Jupiter is 2.38 and it can approach within 0.2 au of the planet.

A/2013 NZ$_{23}$ [Pan-STARRS] This potentially hazardous asteroid, classified as an Amor, was discovered by Pan-STARRS 1 with the 1.8m R-C telescope on July 14.58. [MPEC 2013-O41, 2013 July 27, 1-day orbit]. The asteroid has an orbit with a period of around 5.7 years and perihelion at 1.0 au in 2013 July. The Earth MOID is 0.02 au. The Tisserand parameter of the orbit with respect to Jupiter is 2.74 and it can approach within 0.1 au of the planet.

2013 O1 (292P/Li) Hidetaka Sato imaged comet 1998 Y2 (P/Li) on May 9.80 with the 0.51m astrograph of the iTelescope at Siding Spring, but confirmation of the recovery was not made until July 16.39 when it was imaged by M Masek with the 0.3m reflector at the Pierre Auger Observatory, Malargue. [MPEC 2013-O52, 2013 July 27] Perihelion is 0.85 days later than predicted.

2013 O2 (P/PanSTARRS) Pan-STARRS discovered a 21st magnitude comet on July 16.60 [MPEC 2013-O53, 2013 July 27] It will reach perihelion at 2.1 au in 2013 December and has a period of around 7.5 years. It makes occasional approaches to Jupiter, most recently to within 0.3 au in 1994. This reduced the perihelion distance from 2.6 au to its present value.

2013 O3 (McNaught) Rob McNaught discovered an 18th magnitude comet on July 24.65 during the Siding Spring Survey with the 0.5m Uppsala Schmidt. [MPEC 2013-O54, 2013 July 27] The comet reached perihelion at 3.2 au in 2013 September.

A/2013 OP$_3$ [Pan-STARRS] This unusual asteroid, classified as an Amor, was discovered by Pan-STARRS 1 with the 1.8m R-C telescope on July 16.52. The asteroid has an orbit with a period of around 8 years and perihelion at 1.2 au in 2013 September. The Earth MOID is 0.2 au. [MPEC 2013-O45, 2013 July 27, 0.8-day orbit]. The Tisserand parameter of the orbit with respect to Jupiter is 2.57 and it can approach within 0.3 au of the planet.

A/2013 OP$_5$ [Siding Spring] This unusual asteroid was discovered during the Siding Spring Survey with the 0.5-m Uppsala Schmidt on July 29.67. The asteroid has an orbit with a period of around 5.8 years and perihelion at 1.3 au in 2013 August. [MPEC 2013-P06, 2013 August 1, 3-day orbit]. The Tisserand parameter of the orbit with respect to Jupiter is 2.87 and it can approach within 0.3 au of the planet.

2013 P1 (P/PanSTARRS) Pan-STARRS discovered a 20th magnitude comet on August 1.54. [MPEC 2013-P18, 2013 August 4] It was at perihelion at 3.4 au in 2013 February and has a period of around 25 years. There were pre-discovery images from Spacewatch taken on July 28.28.

2013 P2 (PanSTARRS) Pan-STARRS discovered a 20th magnitude comet on August 4.37, with prediscovery images from July 26.52. [MPEC 2013-P42, 2013 August 7] It will reach perihelion at 2.8 au in 2014 February.

2013 P3 (Palomar) The Palomar Transient Factory discovered a 19th magnitude comet on August 8.37 with the 1.2m Schmidt. [MPEC 2013-Q02, 2013 August 16]. It will be at perihelion at 8.6 in 2014 November.

2013 P4 (PanSTARRS) Pan-STARRS discovered a 20th magnitude comet on August 15.49. [MPEC 2013-Q34, 2013 August 26] It will reach perihelion at 6.0 au in 2014 August and has a period of around 60 years.

2013 P5 (P/PanSTARRS) Pan-STARRS discovered a 21st magnitude comet on August 15.50. [MPEC 2013-Q37, 2013 August 27] It will reach perihelion at 1.9 au in 2014 April and has a low eccentricity and a very short period of around 3.2 years. There are some similarities between its orbit and that of Flora group asteroids and it is probably another example of a Main Belt Comet. The HST took images of it on September 10 and 23, showing a complex tail structure that might be linked to rotation rate.

A/2013 PE_{67} [Catalina] This Trans-Neptunian asteroid was discovered by the Catalina Sky Survey with the 0.68m Schmidt on August 9.27. [MPEC 2013-Q15, 2013 August 18, 15-day orbit]. The retrograde orbit has a period of around 400 years with perihelion at 1.8 au in 2013 December. Aphelion is at over 100 au. The Tisserand parameter of the orbit with respect to Jupiter is -0.66. The orbit is cometary, so this may be a "dead" comet and could show activity when it gets closer to perihelion.

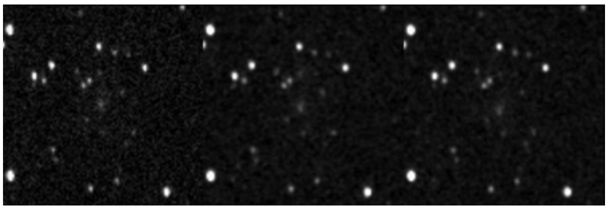
A/2013 QH_{10} [Pan-STARRS] This unusual asteroid, classified as an Amor, was discovered by Pan-STARRS 1 with the 1.8m R-C telescope on August 24.45. [MPEC 2013-Q38, 2013 August 28, 4-day orbit]. The asteroid has an orbit with a period of around 5.2 years and perihelion at 1.2 au in 2013 April. The Earth MOID is 0.2 au. The Tisserand parameter of the orbit with respect to Jupiter is 2.93 and it can approach within 0.4 au of the planet, the most recent close approach being in 1953.

2013 R1 (Lovejoy) Terry Lovejoy discovered a 14th magnitude comet on September 7.69 with his 0.20-m Schmidt-Cassegrain and CCD camera. [MPEC 2013-R72, 2013 September 9]. Terry has provided an account of the discovery:

In recent months I have been putting a considerable amount of effort into improving my automatic comet detection software. It's now at the point I am saving a considerable amount of time compared to the old method of blinking frames by eye. So it's really pleasing to have the software find a new comet, C/2013 R1.

On the morning of September 7 (UT) I did an imaging run consisting of 225 individual fields, with 3 separate exposures on each field. By taking 3 separate exposures of the same field, spaced by a time interval of, in this case 8.5 minutes, allows detection of minor planets and asteroids much easier. In practice objects moving as slowly as 0.2 degrees per day show a small but noticeable shift between the images.

Returning to September 7, all of the fields were processed through the detection software which identified a number of suspects. Although mostly false positives are were found in the form of poorly registered stars, reflections and asteroids but one the suspects located in field number 76, centred on RA 6h 00m Dec -7d 9m, looked very much like a comet. At first I thought this would be one of the existing periodic comet's, but a quick check in guide showed nothing as well as a check using the online Comet NEO Checker tool on the Minor Planet Center website. A further check against the Digital Sky Survey showed nothing either (sometimes a row of faint stars can give the impression of a moving object if one or more of the stars is not visible in one of the image triplets). Below is the actual image triplet with the suspect in it.



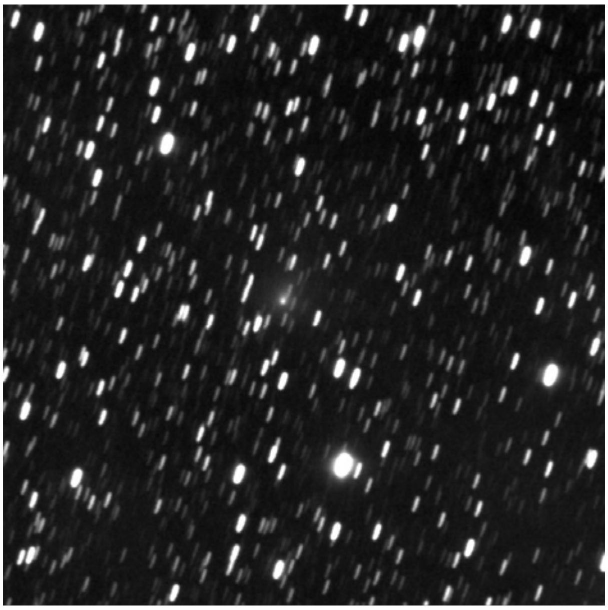
Discovery image: The "suspect" as imaged at 2:30am, 2:38am and 2:47am local time. Each exposure is 14 seconds

Once it was established there was no existing object was there, it was necessary to rule out reflections from bright stars. I have been fooled by this a couple of times before, luckily never reporting it to CBAT until follow-up observations were performed. Furthermore it was surprising this could be a new comet, since the area was readily accessible to northern hemisphere surveys and amateur comet hunters.

So I extrapolated the position for the following morning at RA 05 59 40 and Dec -06 33 00 and waiting anxiously for that area of sky to get high enough to image. At 1:15 am I fired off a single 30 second exposure and as the image displayed I immediately saw a diffuse object very close to the predicted position. I felt positive I had a new comet, but to be sure I began a sequence of 30 second exposures, and as the images display slowly but surely I could see the object move against the star field. There was now no question about this being a comet, but to be certain it was time for other people to confirm the sighting and an orbit to be determined prior to an official announcement. The orbit is important in determining whether the comet is new, or a lost periodic one being rediscovered. Furthermore CBAT have a strict process to prevent embarrassing mishaps (in the past a number of non-existent comets actually got designations).

After obtaining 3 additional astrometric positions from September 8, I submitted a report to CBAT and soon the NEO Confirmation page was updated to reflect the new object. Thanks to the prompt action of the following stations A79, H36, H47, I39, I47, Sato at I89 and Guido, Howes, Sato, Novichonok, Urbanik, Ligustri at Q62 the comet was quickly confirmed as C/2013 R1 in CBET 3649 issued on September 9.

The prospects for C/2013 R1 are quite favourable as it approaches the earth to 0.4 AU in late November when it will most likely be visible in binoculars from dark skies. Images seem to indicate a larger external coma and that the true brightness is around 2 magnitudes higher than current predictions, so it will be interesting to watch total magnitude estimates as it gets closer to the sun. Perihelion occurs on Christmas day when it *will be between the orbit of earth and Venus, but it will have receded to 0.9 AU from the earth which should result in a net fading (but it should also be more condensed then). During this time it will pass close to Comet ISON and it may be possible to photograph both of them together with a short telephoto lens.*



Confirmation image of 2013 R1 : 80 x 30 second exposures, FOV is 33 x 33', North at left. Taken September 10.7, 2013 UT.

The comet had perihelion at 0.8 au near the December Solstice and approached the Earth to 0.4 au on November 20.

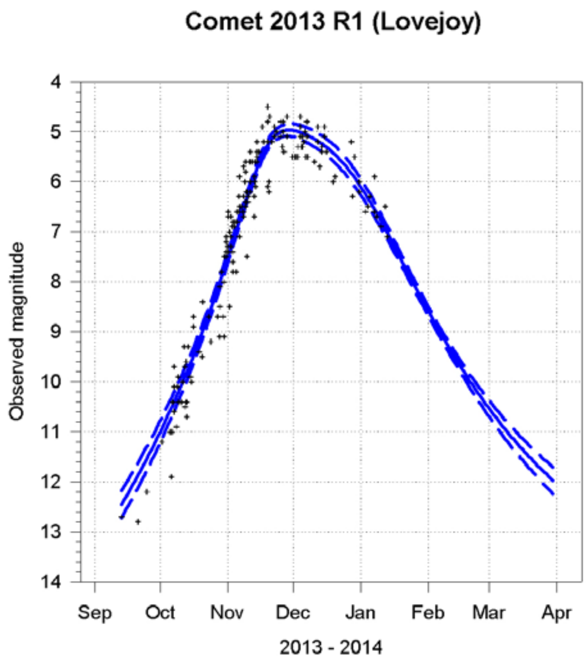
2013 R1 imaged by Eryk Bryssinck on November 11

The comet brightened relatively rapidly after discovery and was soon within binocular range. Juan Jose Gonzalez observed it in 25x100B on October 7, estimating it at 9.7. A month later he was able to see it with the naked eye and observers were beginning to pick out a tail. The coma was largest around the time of the approach to Earth, reaching at least 15' and steadily became more condensed as the comet approached perihelion. Tail development was best around this time, with lengths up to 5° being reported. The observations suggest that there was a faint outer coma that was not picked up by observers in more light polluted areas.

By mid January it was fading quite rapidly, but still showing a faint tail. It had also ceased to be visible in the evening sky, so the number of observations dropped substantially.

2013 R1 imaged by Mike Glenny on December 6

132 visual observations received so far suggest a preliminary aperture corrected light curve of m = 6.9±0.1 + 5 log d + 12.8±0.7 log r



2013 R2 (293P/Spacewatch) Jim Scotti recovered 2006 XG16 with the 1.8-m Spacewatch II reflector on September 14.48 when it was 22nd magnitude. [MPEC 2013-S01, 2013 September 16] The comet's orbit approaches within 0.18 au of the Earth.

2013 R3 (P/Catalina-PanSTARRS) The Catalina Sky Survey discovered a 19th magnitude comet on

September 15.38 and it was independently found by Pan-STARRS on September 15.54. [MPEC 2013-S53, 2013 September 27] It was at perihelion at 2.2 au in 2013 August and has a period of around 5.3 years.

2013 S1 (Catalina) A 19th magnitude comet was discovered on September 28.39 during the course of the Catalina Sky Survey with the 0.68-m Schmidt. [MPEC 2013-T27, 2013 October 4] The comet was at perihelion at about 2.8 au in 2013 August.

2013 T1 (P/PanSTARRS) Pan-STARRS discovered a 20th magnitude comet on October 5.37. [MPEC 2013-T76, 2013 October 8] It was at perihelion at 2.2 au in 2013 July and has a period of around 14 years. There were pre-discovery images from Mt Lemmon taken on September 13.4.

2013 T2 (P/Schwartz) Michael Schwartz discovered a 19th magnitude comet in images taken with the Tenagra II 0.41-m f3.75 astrograph on October 15.36. Prediscovery images were found in Catalina Sky Survey data from September 14. [MPEC 2013-U18, 2013 October 22] The comet has a period of around 6.3 years with perihelion at 1.6 au in 2013 June. It will fade.

2013 TW_5 (Spacewatch) Tim Bressi discovered this object at the Steward Observatory, Kitt Peak with the 0.9m Spacewatch reflector on October 3.49. It was first reported as an unusual asteroid, which had a period of around 16 years with perihelion at 3.1 AU in 2015 September. [MPEC 2013-T47, 2013 October 6, 3-day orbit]. Six days later a further MPEC [2013-T92, 2013 October 12] reported the object to be a comet, following further observations by Spacewatch and H Sato. The MPEC stated "Very preliminary elements" yet still gave them to five or more places of decimals. Later circulars give a parabolic orbit with perihelion at 5.9 au in 2014 July.

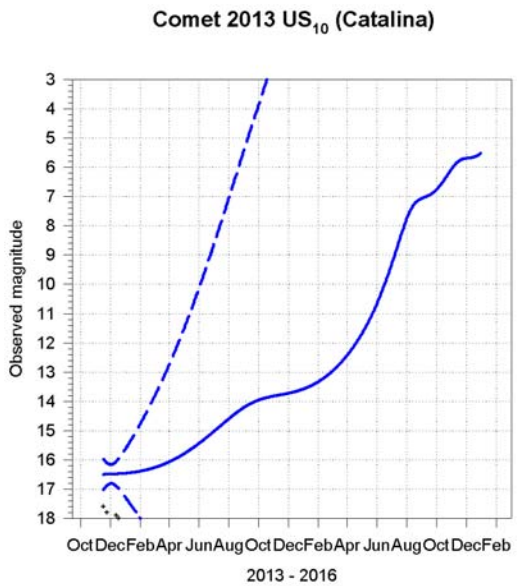
2013 TL_{117} (P/Lemmon)
An unusual asteroid, classified as an Amor, was discovered during the Mt Lemmon survey with the 1.5m telescope on October 4.25 and was also designated as 2013 UT_2. [MPEC 2013-U68, 2013 October 28, 24-day orbit]. Further observations showed cometary characteristics, and the object was given a cometary designation on MPEC 2013-X59 [2013 December 12]. The object has a period of around 6.8 years and perihelion at 1.1 au in 2014 February. The Tisserand parameter of the orbit with respect to Jupiter is 2.64 and the object can approach within 0.5 au of the planet and to 0.2 au from the Earth, which it did in 1980.

A/2013 TT_4 [Mt Lemmon] This unusual asteroid was discovered during the Mt Lemmon survey with the 1.5m telescope on October 3.40. [MPEC 2013-T36, 2013 October 4, 1-day orbit]. The object has a period of around 12 years and perihelion at 1.4 au in 2013 August. No further observations have been reported. The Tisserand parameter of the orbit with respect to Jupiter is 2.36 and the object can approach within 0.3 au of the planet.

2013 U1 (Catalina) An 18th magnitude comet was discovered on October 22.11 during the course of the Catalina Sky Survey with the 0.68-m Schmidt. [MPEC 2013-U83, 2013 October 30] The comet was near perihelion at about 2.4 au and has a period of around 40 years.

2013 U2 (Holvorcem) Brazilian amateur Paulo Holvorcem disovered a 19th magnitude comet on October 23.42 with the 0.41-m f3.75 astrograph at the Tenagra II Observatory. [MPEC 2013-U84, 2013 October 30] The comet will reach perihelion at about 5.1 au in 2014 October.

2013 US_{10} (Catalina) Not surprisingly, a 19th magnitude object discovered during the course of the Catalina Sky Survey with the 0.68-m Schmidt on October 31.16 [MPEC 2013-V05, 2013 November 2] has turned out to be a comet. The asteroidal orbit seemed very odd, with period of 6.1 years and perihelion at 0.4 au, although it made no nearby passes to Jupiter, and the asteroid had a fairly bright absolute magnitude. The orbit had a MOID with respect to Earth of 0.54 au. The cometary orbit [MPEC 2013-V31, 2013 November 6, 3-months observations] gives perihelion at about 0.8 au in 2015 November, a scenario suggested by Reinder Bouma soon after the asteroidal orbit was published. The comet is still very distant from the Sun, being 8.3 au away at discovery. With a November perihelion date it will not be optimally placed for viewing, but may reach at least 9th magnitude.



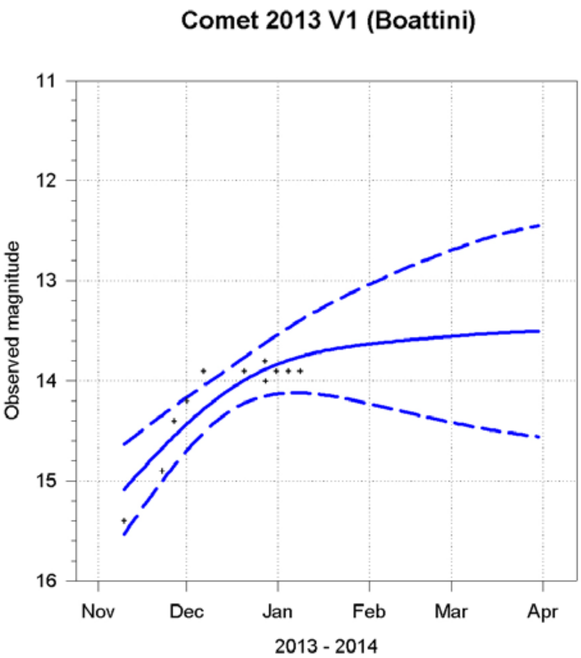
4 electronic and visual observations received so far suggest a preliminary aperture corrected light curve of m = 5.2 + 5 log d + [7.5] log r As you can see there are really no constraints on the light curve.

A/2013 UR_3 [Catalina] This unusual asteroid, classified as an Amor, was discovered by the Catalina

Sky Survey with the 0.68m Schmidt on October 23.30. [MPEC 2013-U45, 2013 October 26]. The asteroid has an orbit with a period of 5.7 years and perihelion at 1.3 au in 2013 December. The Earth MOID is 0.3 au. The Tisserand parameter of the orbit with respect to Jupiter is 2.77 and it can approach within 0.5 au of the planet.

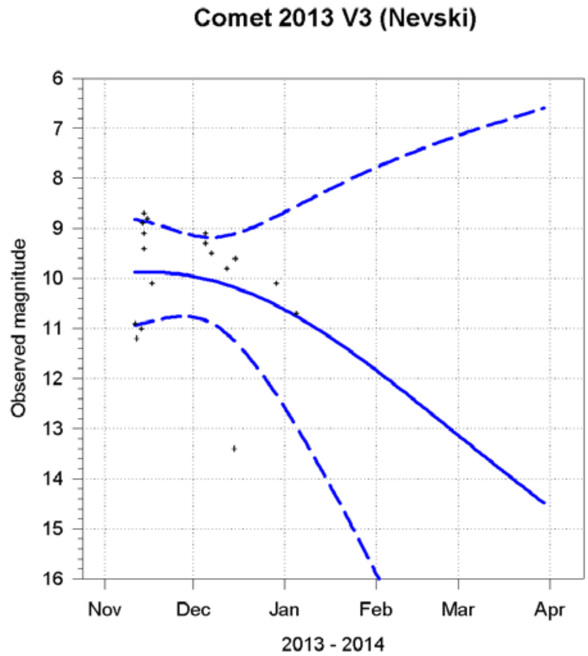
A/2013 UQ_4 [Catalina] This very unusual asteroid, classified as an Amor, was discovered by the Catalina Sky Survey with the 0.68m Schmidt on October 23.37. [MPEC 2013-U54, 2013 October 27, 3-day orbit]. The asteroid has a retrograde orbit with a period of over 400 years and perihelion at 1.1 au in 2014 July. The Earth MOID is 0.11 au. The Tisserand parameter of the orbit with respect to Jupiter is -0.97. It will approach the Earth within 0.3 au in 2014 July. It is well placed in northern skies at perihelion and could reach 10th magnitude. If cometary activity commences it could get brighter.

2013 V1 (Boattini) Andrea Boattini discovered an 16th magnitude comet on November 4.38 during the course of the Catalina Sky Survey with the 0.68-m Schmidt. [MPEC 2013-V32, 2013 November 6]. The comet will reach perihelion at 1.7 au in 2014 April, when it may be 14th magnitude.

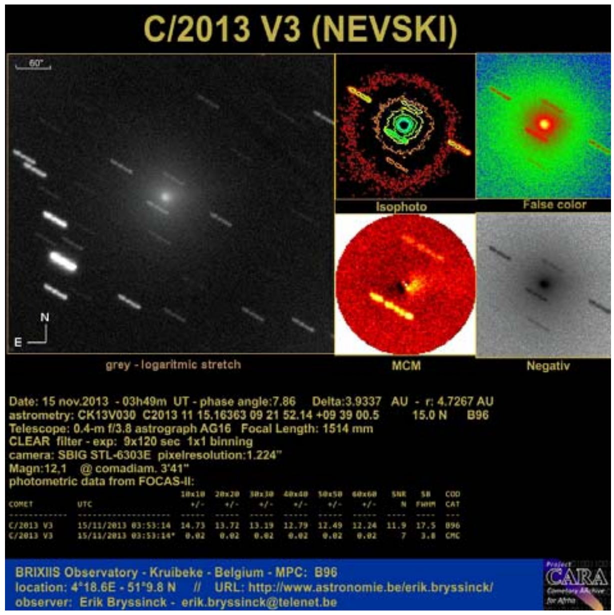


2013 V2 (Borisov) Gennady Borisov discovered a 17th magnitude comet with the 0.2m astrograph at the Crimea-Nauchnij observatory on November 6.01. [MPEC 2013-V43, 2013 November 8] The comet will reach perihelion at 3.5 au in 2014 October. Visual reports suggest that it may be as bright as 11th magnitude.

2013 V3 (Nevski) Vitali Nevski discovered a 15th magnitude comet with the 0.2-m f/3 reflector of the International Scientific Optical Network (ISON) at Kislovodsk Observatory, Russia on November 6.99. [MPEC 2013-V45, 2013 November 8] The comet was just past perihelion at 1.4 au and near its brightest. It has a period of around 45 years.



18 electronic and visual observations received so far suggest a preliminary aperture corrected light curve of m = 7.8 + 5 log d + 14.6 log r , however the error bars are considerable.



2013 V3 imaged by Erik Bryssinck on November 15

2013 V4 (Catalina) An 18th magnitude comet was discovered on November 9.28 during the course of the Catalina Sky Survey with the 0.68-m Schmidt. [MPEC 2013-V94, 2013 November 15] The comet will reach perihelion at about 5.2 au in 2015 October.

2013 V5 (Oukaimeden) An 18th magnitude comet was discovered on November 12.15 by Michel Ory using the 0.5-m reflector at the Oukaimeden Observatory, Marrakech. [MPEC 2013-V95, 2013

November 15] The comet will reach perihelion at about 0.6 au in 2014 September. The comet could reach 6th magnitude, when it will be best seen from the Southern Hemisphere.

A/2013 VF_2 = 2011 OD_{39} = 2010 HS_{10} This unusual asteroid, classified as a Jupiter Trojan, has an orbit with a period of 12.0 years and perihelion at 5.0 au in 2008 October. [MPEC 2013-V44, 2013 November 8]. The Tisserand parameter of the orbit with respect to Jupiter is 2.96 and it can approach within 0.2 au of the planet. The orbit shows some similarity to that of 29P/Schwassmann-Wachmann.

A/2013 VX_9 [Catalina] This unusual asteroid was discovered by the Catalina Sky Survey with the 0.68m Schmidt on November 4.38. [MPEC 2013-V50, 2013 November 9, 5-day orbit]. The asteroid has an orbit with a period of around 10 years and perihelion at 2.0 au in 2013 October. It is classed as an Outer Main Belt Asteroid. The Tisserand parameter of the orbit with respect to Jupiter is 2.40 and it can approach within 0.5 au of the planet.

2013 W1 (P/PanSTARRS) Pan-STARRS discovered a 21st magnitude comet on November 24.31. [MPEC 2013-W23, 2013 November 27] It will reach perihelion at 1.4 au in 2014 March and has a period of around 6.5 years. There were pre-discovery images from the Catalina Sky Survey taken on November 9.3.

2013 W2 (PanSTARRS) Pan-STARRS discovered a 21st magnitude comet on November 27.37. [MPEC 2013-X26, 2013 December 5] It will reach perihelion at 4.4 au in 2015 January and has a period of around 30 years.

2013 X1 (PanSTARRS) Pan-STARRS discovered a 20th magnitude comet on December 4.43. There were pre-discovery images from the Mt Lemmon Survey taken on November 29.5. [MPEC 2013-X29, 2013 December 6] It will reach perihelion at 1.3 au in 2016 April according to the discovery elements, however as these were based on an arc of 6 days with the comet over 8 au from the Earth they seemed likely to change, despite being given to a precision of five decimal places. Rather more realistically the JPL Horizons small-body browser gave the 1-sigma uncertainty in q as 2.2 au, and the perihelion date as 365 days. Surprisingly further orbits, most recently that published on December 25, gave similar elements with a reduction in the uncertainty, currently to 0.1 au and 7 days. The comet will be a telescopic object for Northern Hemisphere observers in the winter of 2015/16. At perihelion it is visible from the Southern Hemosphere, when it may be a binocular object.

2013 X2 (294P/LINEAR) Hidetaka Sato recovered 2008 A2 with the remote iTelescope 0.43m astrograph at Mayhill, New Mexico on December 11.51. Perihelion is 0.24 days earlier than predicted. [MPEC 2013-X72, 2013 December 14]

2013 Y1 (P/LINEAR) Jim Scotti recovered 2002 AR_2 with the 0.9m Spacewatch telescope at Kitt Peak on September 14.2, and it was also imaged by the Mount Lemmon Survey during September and October, but it wasn't finally confirmed until Scotti imaged it with the 1.8-m Spacewatch II reflector on December 25.15 when it was 21st magnitude. [MPEC 2013-Y30, 2013 December 25] The comet returns to perihelion 0.7 days earlier than predicted.

2013 Y2 (PanSTARRS) Pan-STARRS discovered an 18^{th} magnitude comet on December 30.51. Observations accumulated over the next ten days before an orbit was published. [MPEC 2014-A59, 2014 January 10] It will reach perihelion at 1.9 au in 2014 June.

A/2013 YF_{48} [Mt Lemmon] This unusual asteroid was discovered during the Mt Lemmon survey with the 1.5m telescope on December 28.11. [MPEC 2013-Y73, 2013 December 31, 2-month orbit]. The object has a period of around 30 years and perihelion at 4.4 au in 2014 September. Aphelion is at around 14 au. It is classed as a Centaur asteroid. The Tisserand parameter of the orbit with respect to Jupiter is 1.05 and the object can approach within 0.4 au of the planet.

A/2013 YG_{48} [Catalina] This unusual asteroid was discovered by the Catalina Sky Survey with the 0.68m Schmidt on December 28.36. [MPEC 2013-Y74, 2013 December 31, 3-day orbit]. The asteroid has an orbit with a period of around 25 years and perihelion at 2.0 au in 2014 March. Aphelion is at around 14 au. It is classed as a Centaur Asteroid. The Tisserand parameter of the orbit with respect to Jupiter is 1.44. It can approach within 1.4 au of Saturn.

2014 A1 (P/Garradd) 2007 H3 (P/Garradd) was recovered by an observing team at the Pierre Auger Observatory, Malargue using the 0.3m f/10 reflector on January 6.31. Following recovery, prediscovery NEAT images from 2001 June were identified. The comet was close to the predicted time of return.

Three Kreutz group comets discovered in STEREO images during the year have received designations (2013 E3, 2013 F4 and 2013 F5), but two other STEREO objects have not yet had orbits computed. None of the 223 SOHO comets reported have had orbits computed. Provisionally there were 7 non-group comets, 13 Meyer group, one returning Marsden group and one Kracht group.

In total PanSTARRS discovered 18 comets during the year, the combined Catalina and Mt Lemmon Survey discovered 17, 9 were discovered at Siding Spring before the Survey closed and Spacewatch discovered 3. Amateurs had an astonishing year with 14 discoveries (depending a little on where you draw the line between professional and amateur).

Comet Prospects for 2014

One comet that was at perihelion in 2013 may still be a naked eye object at the beginning of 2014. 2012 K1 (PanSTARRS) may reach 6th magnitude after its August perihelion, but is unfortunately a morning object. 2013 V5 (Oukaimeden) may reach a similar magnitude in September, but is then a Southern Hemisphere object. The returning periodic comets are not particularly bright, with the most interesting one being 209P/LINEAR, which could reach 11th magnitude when it passes 0.06 AU from the Earth in May. Martians will have the spectacle of a Great Comet in October.

These predictions focus on comets that are likely to be within range of visual observers. Members are encouraged to make visual magnitude estimates, particularly of periodic comets, as long term monitoring over many returns helps understand their evolution. Guidance on visual observation and how to submit estimates is given in the BAA Observing Guide to Comets. Drawings are also useful, as the human eye can sometimes discern features that initially elude electronic devices.

Theories on the structure of comets suggest that any comet could fragment at any time, so it is worth keeping an eye on some of the fainter comets, which are often ignored. Specific targets that have been suggested by Richard Miles include 17P/Holmes, 29P/Schwassmann-Wachmann, 41P/Tuttle-Giacobini-Kresak, 52P/Harrington-Abell, 63P/Wild, 174P/Echeclus (60558), 255P/Levy, 289P/Blanpain, 2010 H2 (P/Vales), 2010 V1 (P/Ikeya-Murakami) and 2012 X1 (LINEAR). They would make useful targets for CCD observers, especially those with time on instruments such as the Faulkes telescope. CCD observers are encouraged to report total magnitude estimates, using the format given in the BAA Guide and using the methodology developed by Roger Dymock. When possible use a waveband approximating to Visual or V magnitudes. Such estimates can be used to extend the visual light curves, and hence derive more accurate absolute magnitudes, and to derive equivalent parameters for fainter comets.

In addition to those in the BAA Handbook, ephemerides for new and currently observable comets are published in the *Circulars*, and on the Section, CBAT and Seiichi Yoshida's web pages. Complete ephemerides and magnitude parameters for all comets predicted to be brighter than about 21^{m} are given in the International Comet Quarterly Handbook; details of subscription to the ICQ are available on the Internet. The BAA Observing Guide to Comets is available from the BAA Office; a new edition is planned for 2014.

The selection of a project comet for 2014 is quite difficult, as none of the periodic comets that have a long observing history has an extended period of view. Instead there are a couple of suggestions. Visual observers may like to follow 290P/Jager to monitor the exact form of the light curve. Electronic observers may like to observe some of the comets that approach small phase angles. All observers should try and follow 2012 K1 (PanSTARRS) which may be the best comet of the year.

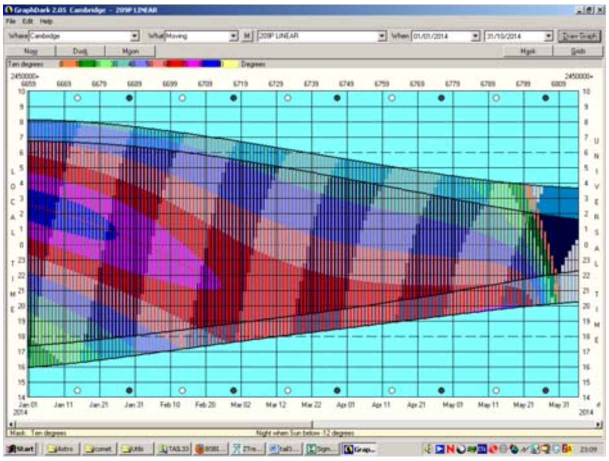
The wooden dome that used to house the Mertz refractor used by Finlay. http://friends.saao.ac.za

William Henry Finlay discovered **15P/Finlay** from the Cape Observatory on 1886 September 26, with an 18cm refractor. It was around 11th magnitude at this and the following return. In 1906 it passed 0.3 AU from the Earth and reached 6th magnitude. Jupiter perturbations in 1910 gave an unfavourable return in 1913, but a good one in 1919, though they were unfavourable after that until 1953, when it was recovered. It has been observed at every return since 1953. 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 year the comet is at a southern declination, but might be picked up by well placed observers in October. Observing circumstances for UK observers improve in December, when it could be visible in large binoculars.

29P/Schwassmann-Wachmann is an annual comet that has outbursts, which over the last decade seem to have become more frequent. The comet had one of its strongest outbursts yet recorded in early 2010. The comet is an ideal target for those equipped with CCDs and it should be observed at every opportunity. The comet is at a southern declination, reaching opposition in Lupus in May and passing through solar conjunction in December.

154P/Brewington remains well placed in the evening sky for the first quarter of the year as it fades from around 11th magnitude, following its perihelion in 2013 December.

209P/LINEAR was discovered as an apparently asteroidal object of 18th magnitude on 2004 February 3.40. It is intrinsically faint, but on May 29.33 it passes only 0.055 AU from the Earth; the 8th closest approach by a comet. 252P/LINEAR will pass even closer at a distance of 0.036 AU on 2016 March 21.52. As might be expected, the observing window is quite short. The comet comes into visual range in early May when it is at high northern declination and rushes south so fast that UK observers will lose it by the end of the month. Southern Hemisphere observers then get a brief chance to see it as it heads towards high southern declinations. There is also a strong possibility of a meteor outburst with a ZHR of perhaps 100 from the comet on May 23/24 at 07:21 UT. The expected radiant is around RA 8h 11m Dec +79°, with the USA and southern Canada the most favoured location.

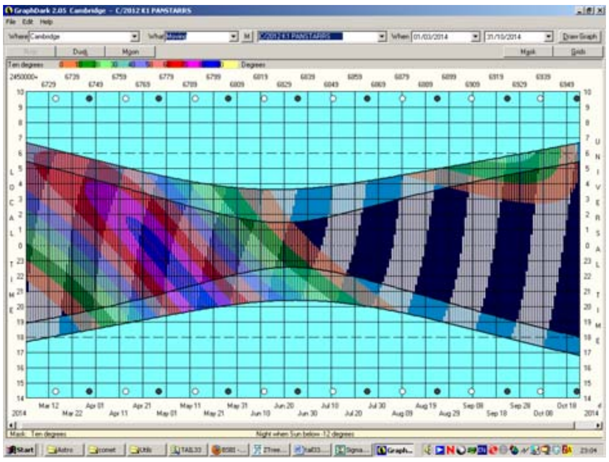


Visibility chart (Cambridge) for 209P [January 1 – June 5]. To create your own diagrams, download Richard Fleet's software via the Section web page.

289P/Blanpain made a close approach to the Earth (0.11 AU) at the end of October at its discovery return and was discovered around a month later, when it was near perihelion. It was perhaps around 5th magnitude. There is an identity with Apollo asteroid 2003 WY_{25}, which was noted to have a faint coma by David Jewitt in 2004. The comet is the source of the Phoenicid meteor shower, which outburst in 1956, and this could be active again in early December 2014. The comet's brightness at the discovery return may have been due to a fragmentation event, as the absolute magnitude of the asteroid is very much fainter. If a similar outburst occurred at this return the comet could reach 11th magnitude, however it is more likely that it will only be a target for CCD imagers with access to large telescopes.

Bill Liller and Michael Jager at the IWCA in 1999

290P/Jager was discovered by Michael Jager on 16- and 9-min Technical Pan film exposures with a 0.25-m f/2.8 Schmidt camera. It was quite widely observed visually. The observations are best fitted by a linear type light curve, with the comet becoming brightest some six weeks after perihelion. The observing circumstances in 2014 are almost identical to the discovery return, as perihelion is only four days later in the year. The comet is well placed for observation during the first third of the year, and could reach 10th magnitude, depending on whether or not it shows a linear type light curve at this apparition.

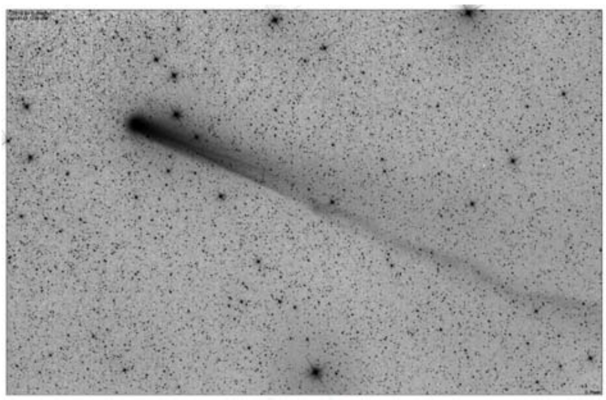


Visibility chart (Cambridge) for 2012 K1 [March 3 – October 23]

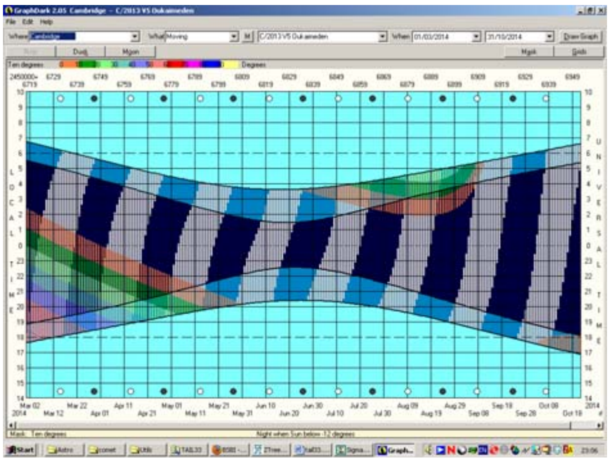
2012 K1 (PanSTARRS) could be visible from the start of the year, but it doesn't get into the evening sky until March. By April it should be visible in large binoculars and it remains well placed for viewing into June. It passes through solar conjunction and reappears in the morning sky in September, when it might be just visible to the naked eye from favourable locations. It moves south, so that UK observers lose it in October, but it remains a binocular object for Southern Hemisphere observers until the end of the year. It passes a degree from 8m NGC 55 around December 18.

2013 A1 (Siding Spring) could reach 7th magnitude in September and is essentially a Southern Hemisphere object. It comes into visual range in May and then should be followed until November when it drops into the twilight. It is a southern circumpolar object when it comes closest to Earth at the beginning of September. The comet makes a very close approach to Mars six days prior to perihelion, when it will be a spectacular object in Martian skies, being only 0.0010 au from the planet at its closest and perhaps magnitude -9.

2013 R1 (Lovejoy) reached perihelion on 2013 December 22 and will be fading from its brightest, though it will still be a binocular object at the start of January. It is really a morning object, beginning the year in Hercules. In early February it passes close to planetary nebula NGC 6572. It fades quickly and will be a telescopic object by March.



2013 R1 imaged by Damian Peach on January 3. A tail disconnection event is visible. This a long exposure B filter image to help enhance the ion tail contrast. 106mm F5. STL-11k. Blue filter. 7x 3mins



Visibility chart (Cambridge) for 2013 V5 [March 5 – October 25]

2013 V5 (Oukaimeden) has a brief period of visibility at the end of August for UK observers, when it may be around 8th magnitude in the morning sky. Southern Hemisphere observers will get a better view, with the comet coming into view in the morning sky in early August. By the time it reaches its brightest just after mid September, it also becomes visible in the evening sky and should show a short tail. As the comet fades, it becomes exclusively an evening object, but sinks lower in the sky and will be lost in the second half of October. It passes close to open cluster NGC 2244 on August 23, five degrees from open cluster M47 on September 7 and a couple of degrees from galaxy M83 on September 25.

The other periodic and parabolic comets that are at perihelion during 2014 are unlikely to become brighter than 12th magnitude or are poorly placed. Ephemerides for these can be found on the CBAT WWW pages. Several D/ comets have predictions for a return, though searches at favourable returns in the intervening period have failed to reveal the comets and their orbits have been perturbed by Jupiter to give larger perihelion distances. There is however always a chance that they will be rediscovered accidentally by one of the Sky Survey patrols. Several SOHO comets are predicted to return, however these will only be visible from the SOHO or STEREO satellites.

Looking ahead to 2015, there are currently no bright comets predicted. What excitement there is comes from 67P/Churyumov-Gerasimenko, which reaches perihelion in August. It creeps into the morning sky shortly after perihelion and visual observations will be important to put the Rosetta observations into the context of previous apparitions.

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Jonathan Shanklin

RAS Meeting 2014 April 11: Bridging the Gap: Comets after Stardust and Before Rosetta

Studies of comets have been dramatically changed by space missions to several comets. In the last decade the NASA Stardust spacecraft returned samples from comet 81P/Wild and flew past 9P/Tempel which had also been visited by the NASA Deep Impact Mission. This year the European Space Agency spacecraft Rosetta will rendezvous with comet 67P/Churyumov-Gerasimenko and will then place a lander on its surface – the first soft landing on a comet.

This discussion meeting aims to bring together all those interested in cometary science; bridging the gap between those working on different space missions, as well as between those working on missions, modellers and observational astronomers. Talks are expected to include latest results from 81P/Wild, the status of, and expectations for, Rosetta as well as analysis of 2012 S1 (ISON).

Tea and coffee will be available from 10:00 and again after the meeting at 15:30. A report will appear in the next issue of The Comet's Tale.

Comets reaching perihelion in 2014

Comet	T	q	P	N	H_1	K_1	Peak mag
286P/Christensen	Jan 6.2	2.38	8.37	2	14.0	10.0	20
293P/Spacewatch	Jan 10.4	2.11	6.94	1	14.5	10.0	18
2007 R2 (P/Gibbs)	Jan 15.6	1.47	6.38	1	17.0	10.0	20
292P/Li	Feb 4.8	2.52	15.1	1	5.9	15.0	14
107P/Wilson-Harrington	Feb 5.3	0.99	4.29	9	15.0	5.0	16
129P/Shoemaker-Levy	Feb 11.6	3.91	8.89	3	11.0	10.0	19
2013 N3 (PanSTARRS)	Feb 12.0	3.03	20.2	1	13.0	10.0	21
169P/NEAT	Feb 15.3	0.61	4.21	2	16.0	5.0	15
2013 P2 (PanSTARRS)	Feb 17.1	2.83			11.5	10.0	18
2012 X1 (LINEAR)	Feb 21.6	1.60			8.0	10.0	12
296P/Garradd	Mar 1.3	1.83	6.55	2	14.0	10.0	18
294P/LINEAR	Mar 3.2	1.30	5.74	2	15.5	10.0	16
52P/Harrington-Abell	Mar 7.5	1.77	7.58	8	6.6	20.3	12
2013 W1 (P/PanSTARRS)	Mar 8.1	1.42	6.50	1	17.5	10.0	19
290P/Jager	Mar 12.5	2.16	15.2	2	8.6	5.0	11
25D/Neujmin	Mar 13.1	1.29	5.43	2	10.5	10.0	9?
2002 R5 (P/SOHO)	Mar 15.0	0.05	5.75	2			
2013 G7 (McNaught)	Mar 16.8	4.69			7.5	10.0	17
2003 Q1 (P/SOHO)	Mar 22.6	0.05	5.28	2			
117P/Helin-Roman-Alu	Mar 27.2	3.06	8.29	3	1.9	20.0	13
17P/Holmes	Mar 27.5	2.06	6.89	10	10.0	15.0	17
119P/Parker-Hartley	Apr 2.6	3.03	8.85	3	9.0	8.0	15
124P/Mrkos	Apr 9.6	1.65	6.04	3	13.1	15.0	15
1996 X5 (P/SOHO)	Apr 9.8	0.05	5.77	2			
2003 Q6 (P/SOHO)	Apr 14.3	0.04	5.30	2			
1996 X3 (P/SOHO)	Apr 15.7	0.05	5.77	3			
2013 P5 (P/PanSTARRS)	Apr 15.8	1.94	3.24	1	17.0	10.0	21
156P/Russell-LINEAR	Apr 16.6	1.58	6.81	4	13.0	15.0	18
2013 V1 (Boattini)	Apr 21.2	1.66			10.5	10.0	14
2001 Q11 (P/NEAT)	Apr 23.1	1.95	6.41	1	14.5	10.0	19
191P/McNaught	May 6.2	2.04	6.63	2	13.0	10.0	18
209P/LINEAR	May 6.3	0.97	5.09	2	17.0	5.0	11
295P/LINEAR	May 14.7	2.05	12.3	2	12.0	10.0	17
134P/Kowal-Vavrova	May 21.5	2.57	15.6	2	7.1	10.0	12
132P/Helin-Roman-Alu	May 21.7	1.91	8.23	3	10.1	10.0	15
4P/Faye	May 29.6	1.66	7.51	21	8.0	13.1	13
2005 JQ_5 (P/Catalina)	May 30.0	0.83	4.42	1	17.5	10.0	17
16P/Brooks	Jun 7.7	1.47	6.14	16	11.9	8.2	15
181P/Shoemaker-Levy	Jun 10.4	1.12	7.52	3	10.5	10.0	12
2013 Y2 (PanSTARRS)	Jun 14.0	1.94			12.0	10.0	16
222P/LINEAR	Jul 4.5	0.78	4.84	2	16.5	15.0	15
2012 U1 (PanSTARRS)	Jul 5.0	5.27			7.5	10.0	18
75D/Kohoutek	Jul 9.4	1.78	6.67	3	10.5	10.0	15?
72D/Denning-Fujikawa	Jul 11.4	0.78	9.02	2	15.5	25.0	13?
106P/Schuster	Jul 20.1	1.55	7.28	4	10.0	15.0	14
2003 O3 (P/LINEAR)	Jul 24.7	1.25	5.48	1	18.0	10.0	19

2013 TW5 (Spacewatch)	Jul 25.6	5.90			7.5	10.0	19
2013 P4 (PanSTARRS)	Aug 12.1	5.97	56	1	7.5	10.0	19
210P/Christensen	Aug 17.2	0.53	5.65	2	13.5	10.0	11
2012 K8 (Lemmon)	Aug 19.2	6.46			6.0	10.0	18
2002 S4 (P/SOHO)	Aug 23.4	0.05	5.95	2			
2008 Q2 (P/Ory)	Aug 24.6	1.38	5.84	1	16.5	10.0	18
2011 S1 (P/Gibbs)	Aug 26.6	6.89	25.4	1	9.5	10.0	22
11P/Tempel-Swift-LINEAR	Aug 26.8	1.55	6.30	6	15.0	10.0	18
2012 K1 (PanSTARRS)	Aug 27.6	1.05			4.5	10.0	6
206P/Barnard-Boattini	Aug 27.9	1.15	5.83	2	19.0	10.0	19
289P/Blanpain	Aug 28.2	0.96	5.32	2	10.5	10.0	11
2008 J2 (P/Beshore)	Aug 30.3	2.35	6.39	1	9.0	10.0	14
2013 J1 (McNaught)	Sep 2.5	2.29			13.0	10.0	17
2007 H1 (P/McNaught)	Sep 2.7	2.29	7.04	1	10.0	10.0	14
2001 BB_{50} (P/LINEAR-NEAT)	Sep 3.7	2.36	13.7	1	13.0	10.0	19
170P/Christensen	Sep 18.3	2.92	8.61	2	12.0	10.0	18
2013 V5 (Oukaimeden)	Sep 27.6	0.64			9.0	10.0	6
2013 V2 (Borisov)	Oct 14.5	3.51			7.0	10.0	15
2003 U3 (P/NEAT)	Oct 15.4	2.49	11.4	1	12.0	10.0	17
32P/Comas Sola	Oct 17.6	2.00	9.58	10	5.9	19.5	13
108P/Ciffreo	Oct 18.4	1.71	7.23	4	9.2	15.0	12
70P/Kojima	Oct 20.8	2.01	7.05	6	11.0	15.0	17
2013 A1 (Siding Spring)	Oct 25.3	1.40			5.6	8.0	7
2013 U2 (Holvorcem)	Oct 25.6	5.11			7.5	10.0	18
135P/Shoemaker-Levy	Nov 1.6	2.68	7.41	3	6.5	20.0	17
80P/Peters-Hartley	Nov 10.1	1.61	8.07	5	8.5	15.0	14
2013 G3 (PanSTARRS)	Nov 10.5	3.80			9.0	10.0	18
269P/Jedicke	Nov 14.6	4.08	19.8	2	8.0	10.0	17
40P/Vaisala	Nov 15.8	1.82	10.98	7	8.9	15.0	15
2004 V1 (P/Skiff)	Nov 20.3	1.40	9.91	1	16.0	10.0	17
2013 P3 (Palomar)	Nov 23.8	8.65			5.5	10.0	19
193P/LINEAR-NEAT	Nov 24.8	2.17	6.76	2	11.4	10.0	16
110P/Hartley	Dec 17.8	2.48	6.86	4	6.9	10.0	12
2000 QJ_{46} (P/LINEAR)	Dec 20.5	1.89	14.0	1	14.0	5.0	16
15P/Finlay	Dec 27.1	0.98	6.51	14	8.5	22.6	9
287P/Christensen	Dec 28.4	3.05	8.55	1	11.0	10.0	18

The date of perihelion (T), perihelion distance (q), period (P), the number of previously observed returns (N), the magnitude parameters H_1 and K_1 and the brightest magnitude (which must be regarded as uncertain) are given for each comet. The magnitudes, orbits, and in particular the time of perihelion of the D/ comets, are uncertain. 25D was last seen in 1927, 72D in 1978 and 75D in 1988. 17P/Holmes outburst after its last return and a return to quiescence is assumed. Magnitude information is not given for the SOHO comets; these have not been numbered by the IAU despite having been observed over several returns.

Note: $m_1 = H_1 + 5.0 * \log(d) + K_1 * \log(r)$

Comets reaching within 3 degrees of zero phase angle or 180° opposition

Comet name	Designation	Approximate period							mag
Spacewatch	C/2013 TW5	2014	1	17	to	2014	2	18	18.8
Neujmin	25D/	2014	1	22	to	2014	2	1	9 ?
Shoemaker-Levy	129P/	2014	1	23	to	2014	2	12	19.3
LINEAR	P/2004 FYE0	2014	2	2	to	2014	2	24	18.4
Helin-Roman-Crockett	111P/	2014	2	7	to	2014	2	25	19.1
Echeclus (60558)	174P/	2014	2	11	to	2014	2	13	17.7
McNaught	C/2013 E1	2014	2	15	to	2014	3	23	18.8
Christensen	266P/2012 P1	2014	2	20	to	2014	3	4	17.2
Palomar	C/2013 P3	2014	2	21	to	2014	4	14	19.9

Shoemaker-Levy	135P/	2014	3	17	to	2014	3	29	17.3
Catalina	C/2013 US10	2014	3	28	to	2014	3	32	16.1
PANSTARRS	C/2012 F3	2014	4	6	to	2014	4	26	16.0
Christensen	P/2007 C1	2014	4	11	to	2014	4	15	19.7
Kowal-Vavrova	134P/	2014	4	16	to	2014	4	30	12.2
Tenagra	C/2013 G9	2014	4	16	to	2014	5	12	17.9
Catalina	C/2013 V4	2014	4	21	to	2014	4	23	18.5
Harrington	51P/	2014	4	27	to	2014	5	15	18.1
PANSTARRS	P/2012 B1	2014	5	13	to	2014	6	4	15.5
Finlay	15P/	2014	5	17	to	2014	5	21	19.5
Lovejoy	C/2013 R1	2014	5	28	to	2014	6	7	13.9
PANSTARRS	C/2012 A1	2014	5	29	to	2014	6	30	19.6
Catalina	C/2013 V4	2014	5	31	to	2014	6	2	18.3
Reinmuth	44P/	2014	6	3	to	2014	6	17	16.8
Shajn-Schaldach	61P/	2014	6	15	to	2014	6	27	17.7
Bus	87P/	2014	6	16	to	2014	6	26	16.8
Churyumov-Gerasimenko	67P/	2014	7	3	to	2014	7	15	17.4
Larsen	280P/2013 C1	2014	7	7	to	2014	7	19	18.8
Echeclus (60558)	174P/	2014	7	23	to	2014	8	24	16.8
McNaught	C/2013 E1	2014	7	31	to	2014	8	8	19.5
Kowalski	P/2013 G1	2014	8	2	to	2014	8	18	18.9
Zhao	P/2007 S1	2014	8	3	to	2014	8	19	19.2
Encke	2P/	2014	8	9	to	2014	8	23	17.2
Catalina	C/2013 F2	2014	8	10	to	2014	8	14	20.0
LINEAR	P/2000 QJ46	2014	8	14	to	2014	8	26	16.1
NEAT	P 2003 U3	2014	8	16	to	2014	8	28	16.9
McNaught	P/2005 L1	2014	8	26	to	2014	9	11	16.7
Palomar	C/2013 P3	2014	8	28	to	2014	10	15	19.3
LINEAR-NEAT	204P/	2014	8	31	to	2014	9	14	17.7
Catalina	C/2013 US10	2014	8	31	to	2014	9	12	14.1
Spitaler	113P/	2014	9	10	to	2014	9	22	15.7
McNaught	C/2013 E1	2014	9	15	to	2014	9	23	19.5
PANSTARRS	C/2013 P4	2014	9	21	to	2014	10	25	18.8
Ikeya-Murakami	P/2010 V1	2014	9	27	to	2014	10	17	16.0
LONEOS-Christensen	P/2005 RV25	2014	10	10	to	2014	10	22	17.6
Catalina	C/2013 V4	2014	11	5	to	2014	12	3	16.9
McNaught	P/2013 J2	2014	12	2	to	2014	12	14	19.4
LINEAR	C/2010 S1	2014	12	9	to	2014	12	15	15.0
PANSTARRS	C/2013 X1	2014	12	13	to	2014	12	31	17.6
NEAT	180P/	2014	12	20	to	2015	1	3	17.9
Palomar	C/2012 LP26	2014	12	22	to	2014	12	32	19.2
Hartley	110P/	2014	12	26	to	2015	1	7	11.7
McNaught	191P/	2014	12	26	to	2015	1	7	18.6
van Houten-Lemmon	271P/2012 TB36	2014	12	30	to	2015	1	23	19.2
Hartley	110P/	2014	12	30	to	2015	1	3	11.7
Spacewatch	C/2011 KP36	2015	1	5	to	2015	1	7	16.5
Ory	P/2008 Q2	2015	1	10	to	2015	1	16	19.7
Palomar	C/2012 LP26	2015	1	11	to	2015	1	19	19.2
Jedicke	269P/2012 R2	2015	1	14	to	2015	1	32	16.6
NEAT	P/2001 H5	2015	1	15	to	2015	1	29	18.9
Brooks	16P/	2015	1	16	to	2015	1	26	16.4
Parker-Hartley	119P/	2015	1	18	to	2015	1	32	15.2
PANSTARRS	C/2013 W2	2015	1	19	to	2015	2	10	19.4
Helin-Roman-Alu	132P/	2015	1	23	to	2015	1	31	16.0

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