THE COMET'S TALE

Newsletter of the Comet Section of the British Astronomical Association

Volume 13, No 1 (Issue 25), 2006 April

Comets: from Antiquity to the Present Day

An RAS Specialist Discussion Meeting

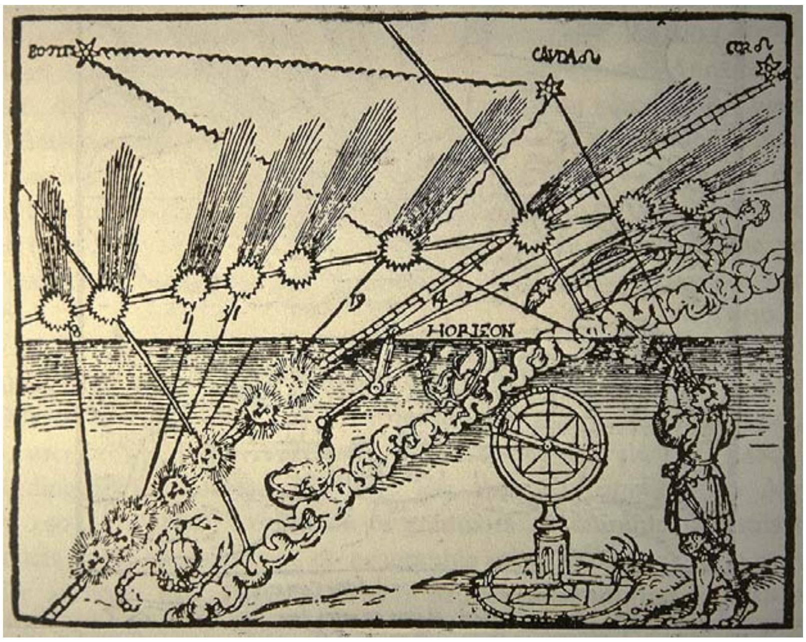
2005 December 9

Professor Iwan Williams and Dr Stephen Lowry organised the meeting to commemorate the tercentenary year of the publication of Halley's 'Synopsis of the Astronomy of Comets'. The science programme included various aspects of cometary science including their history, links with other solar system minor body populations such as Kuiper Belt Objects and near-Earth asteroids, and some recent developments from spacecraft missions. The following notes are my account of the meeting, and may not accurately reflect the speaker's original presentation. Notes in square brackets are my comments. An account of the meeting also appears in the April issue of the RAS Journal A&G.

The meeting was held in the lecture theatre of the Geological Society, with an audience of around 60. Iwan Williams began the meeting by noting that it was 300 years since Halley had published his paper predicting the return of comets, and three months since the start of real cometary science [Deep Impact]. The RAS copy of the paper, along with Peter Apian's Astronomicum Caesareum, published in 1540 was on display in the Geological Society library.

The first speaker was Don Yeomans (NASA/JPL) who spoke on "The Views of Comets before Newton and Halley". Early observations were for astrology. In mediaeval times it was a question of what they portended. Tycho established that comets lay beyond the Moon. Newton and Halley gave us orbits, and there was an association between comets and meteor streams in the 19th century.

The Chinese used lunar mansions to record comet positions to at least a degree accuracy. Their appearance and form were used to make predictions of events. Aristotle said that comets moved in straight lines and were earthly exhalations. The death of Julius Caesar was marked by a comet in 44 BC, which appeared after he had been murdered. When Charlemagne died in 814 there wasn't a real comet on view, so one was invented and recorded. Broadsides became very popular in the mediaeval period and publicised disasters. In 1456 Halley's comet was associated with the plague. Some comets were associated with good events, for example the comet wine of 1811.



The comet of 1532 drawn by Peter Apian

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The Section newsletter is now free to all BAA Members who make contributions to the work of the Section. The cost for other postal subscribers is £5 for two years, extended to three years for those who contribute to the work of the Section in any way, for example by submitting observations or articles. **Renewals should be sent to the Director and cheques made payable to the BAA.** Those due to renew should receive a reminder with this mailing. You can also download the newsletter (in colour) from the Section web page.

Section News from the Director

Dear Section member,

I had an interesting visit to the Southern Hemisphere, staying in the Falkland Islands, Bird Island, King Edward Point and Ascension Island. I managed some astronomy, observing comet Pojmanski from on board the Fishery Protection Vessel *Sigma* whilst on route between the Falklands and Bird Island. We also had one clear night at Bird Island and I observed the comet again in the early hours, in company with two others from the station and a congregation of the local fur seal pups, with petrels calling in the background.

The Milky Way at Bird Island

I arranged a stop-over at Ascension Island on the way north and spent four enjoyable days exploring this volcanic island. I was able to observe comet 73P/Schwassmann-Wachmann with my 90mm short focus refractor that I took on my travels, but observations were hampered by clouds. I can sympathise with Gill who stayed on the island for six months in 1882 and had to move from Georgetown to the inhospitable Mars Bay to get decent conditions. I walked to the bay (having gained permission to visit from the US Air Force, who were very helpful) across a barren cinder waste in scorching temperatures, which seemed far worse than the Egyptian desert that we visited to view the Leonids. I've written some notes on my visit and these are available on the web at http://www.antarctica.ac.uk/met/jds/notes_from_south_2006.htm.

Mars Bay, Ascension Island

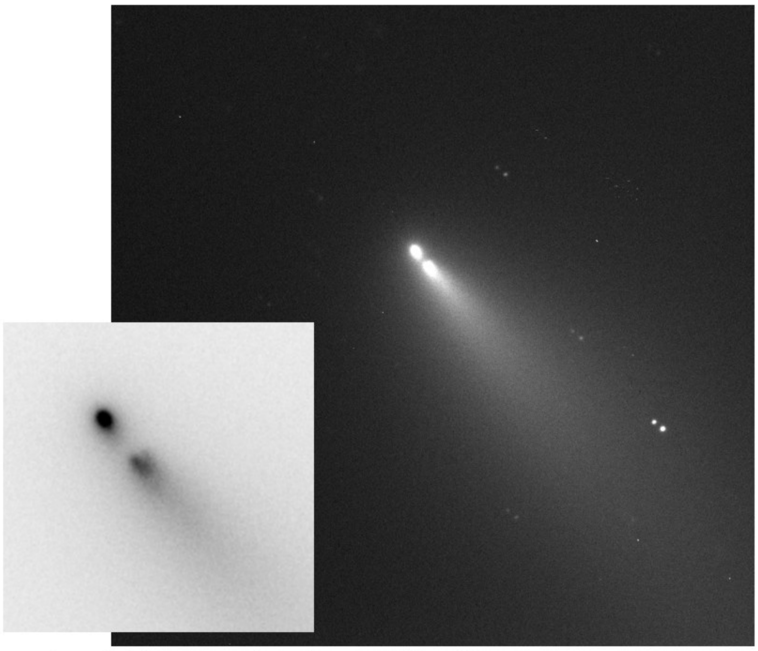
73P/Schwassmann-Wachmann is proving to be a very interesting object, or objects, with over sixty fragments having been reported as I write. The main component should become visible to the naked eye when it passes close to the Earth in May, however exactly how many of the fragments will survive remains to be seen. The numerous fragments do present a naming problem and those submitting visual observations should check the observations posted on the Section web page to make sure that they get the ICQ format correct. I'm afraid that the majority of reports do need some editing before they can be imported into the archives. In part this is a problem with some mail systems which insist on splitting what to them seems long lines, but in other cases is simply a matter of not quite getting the format correct. I had not considered the issue of components when we devised the image naming system, but the IAU system can be used. This just adds the component with a hyphen, for so use for example 73P-B_20060411_shanklin.jpg or 2009F2-C_20100923_shanklin.jpg. It is best to follow the standard BAA practice and include all relevant information (eg telescope, camera etc) with the image, rather than as a separate file. Visual observers also need to double check that they are getting the format exactly right – compare what you sent me by email with what appears in the observation file on the Section web page. Failing to get the format exactly right adds considerably to the amount of work I have to do to process the observations.

The boundary between comets and asteroids has been further eroded with the numbering of 174P/Echeclus, and the distinction is becoming blurred with other solar system bodies. I'm sure that Pluto would be better assigned a cometary designation than a planetary one, but the arguments about whether it is a planet or not (it clearly isn't!) will rumble on. There are perhaps reasonable grounds for even calling the Saturnian satellite Enceladus a comet – certainly the images showing water jets look remarkably similar to those of spacecraft images of comets.

Perhaps unsurprisingly no-one rose to my challenges in Astronomy Now and the SPA news circular of identifying exactly what comets were P/LINEAR 42 and P/NEAT 18 respectively. This clearly demonstrates how impossible the old naming scheme would have become, and why all astronomers should stick to the simple IAU convention.

We saw a very impressive demonstration of the power of a 2-m telescope at the April BAA Meeting, held in Liverpool. We had a live session on the Faulkes telescope in Hawaii and took a x-second exposure of component B of 73P. The BAA has further sessions on the telescope and I intend to ask for selected comets to be observed on a regular basis. My thoughts that these should be a mix of speculative and routine observations, with perhaps searches for some of the sunskirting comets, and observations of some of the brighter comets on their way in and out of perihelion. The initial targets might be comets 4P/Faye and 8P/Tuttle, which are the brightest periodic comets of the next couple of years, and 2002 R5, which Sebastian Hoenig predicts to return in August. It is possible that the Section might be granted regular observing time, so if you have suggestions for suitable targets let me know.

Apart from the last month or so it has been a very quiet period for comet observing, but I would like to thank BAA observers: James Abbott, Peter Birtwhistle, Roger Dymock, John Fletcher, Massimo Giuntoli, Werner Hasubick, Guy Hurst, Nick James, Geoffrey Johnstone, Albert Jones, Martin McKenna, Cliff Meredith, Richard Miles, Martin Mobberley, Gabriel Oksa, Roy Panther, Malcolm Park, John Punnett, Derek Rowley, Jonathan Shanklin, Jeremy Shears, Giovanni Sostero, David Strange, Cliff Turk, Alex Vincent, Eric Walker and also: Jose Aguiar, Alexandre Amorim, Alexander Baransky, Nicolas Biver, Jean-Gabriel Bosch, Reinder Bouma, Jose Carvajal, Edwin van Dijk, Stephen Getliffe, Vergil Gonano, JJ Gonzalez, Bjorn Granslo, Ernesto Guido, Michael Jager, Andreas Kammerer, Heinz Kerner, Mark Kidger, Carlos Labordena, Martin Lehky, A Lepardo, Rolando Ligustri, Michael Mattiazzo, Sensi Pastor, Maciej Reszelski, Jose Reyes, Juan San Juan, Pepe Manteca, Jose Martinez, Andrew Pearce, Stuart Rae, Walter Robledo, V Santini, Tony Scarmato, Ralf Vandebergh, Tony Ward and Seiichi Yoshida (apologies for any errors or omissions) for submitting observations or contributions since the last newsletter. Without these contributions it would be impossible to produce the comprehensive light curves that appear in each issue of *The Comet's Tale*. Observations from groups that currently do not send observations to the BAA would be much appreciated as they make a valuable addition to the analyses.



Comet 73P Schwassmann-Wachmann, fragment B. 2006 April 22.
20s + 40s exposures at 10:36:25 and 10:38:11 UTC. Bessell-V filter. Faulkes Telescope North (F65).
Main FOV 4.6 arcmin square, inset FOV 45 arcsec square. N up.

Obtained during the BAA/LAS Liverpool meeting. Processed by Nick James.

Comets under observation included: 29P/Schwassmann-Wachmann, 41P/Tuttle-Giacobini-Kresak, 73P/Schwassmann-Wachmann, 174P/Echeclus, 2005 E2 (McNaught) and 2006 A1 (Pojmanski).

I have been finding it increasingly difficult to produce two issues of the newsletter each year, so I plan to move to an annual report giving a preliminary review of the comets of the year. This will be published in early January and will also include many of the regular features that appear in the newsletter. Subscribers will have their subscription extended pro-rata. As always the latest news will be available on the Section web page.

Jonathan Shanklin

Tales from the Past

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

150 Years Ago: Dr Donati contributed a note giving an elliptical orbit for comet 1855 L1 (Donati) and suggesting an identity with a comet seen in 1362 (1362 E1), which had a poorly defined retrograde orbit. [*The orbit given in the 2005 Catalogue of Cometary Orbits gives a period of 252 years*]. The annual report of the Council, presented at the February RAS meeting, records that three comets were discovered during the year. A report is given of Struve's paper in the Memoirs of the Imperial Academy of Sciences in St Petersburg on observations of Biela's comet with the great Pulkova refractor at its 1852 return. This included detailed notes on its two components.

100 Years Ago: An extract from Astronomische Nachrichten (AN) notes that perturbation by a ring of planetoids might explain the anomalous motion of 2P/Encke, as this couldn't be explained by a resisting medium. The Presidential address also referred to the motion of Encke's comet and he suggested that future returns might throw some light on the mystery. [*We now think that it is related to the rotation of the nucleus and asymmetric outgassing]*. The West of Scotland Branch (Glasgow) had a lecture on comets at its November meeting, where the three types of comet tails were ascribed to metallic elements, hydrocarbons and hydrogen. At the December meeting Dr Smart read a paper on "The Orbit of Halley's Comet". He noted that the comet spends less than six months north of the ecliptic, and travels at 1.7 kms^{-1} between aphelion and the orbit of Neptune, but at 50 kms^{-1} at perihelion. An increase of only 0.5 kms^{-1} would make the orbit parabolic. Discussion of the paper raised the point that Pentecoulant was probably wrong in his calculation of the eccentricity at the last return. It was also commented that there had been no decent comets since 1882 and that at least Halley would be good in 1910. During the past month, five comets had been visible. Mr Longbottom had taken a 90 minute exposure of comet 1905 W1 (Schaer), though there was a break in the middle. Two comets were under observation at the January meeting. One had been discovered only a couple of days earlier by a former Member of the Association, Prof. W R Brooks of Geneva, New York. A new book "Remarkable Comets: A brief Survey of the most interesting fact in the History of Cometary Astronomy" by W T Lynn was reviewed. The reviewer noted that it would be suitable for the "man in the street" who wishes not to appear to his associates quite ignorant of matters connected with comets. In AN, Dr Cohn discusses whether one or three comets had been visible in 1742. [*Kronk notes that a second comet is likely, with a third possible]*. In March the President said that it was curious that there was an epidemic of comets of great perihelion distance. It might be that many had passed unobserved since 1729 [*Comet 1729 P1 had a perihelion distance of 4.1 AU]*. It was probable that we should see only a large comet that had such a great perihelion distance. There might be many small ones that passed through perihelion unobserved by us. Mr Maunder noted that the *Daily Mail* had brought up Halley's comet as an omen in connection with a scare-mongering story of a future German invasion in 1910. Comet 1906 F1 was discovered by Mr David Ross of Melbourne on March 18. Mr Ross was a Member of the Association and Vice-President of the Victoria Branch. This was his second discovery. Other Southern Hemisphere Members who had discovered comets were Tebbutt (5), Gale (1), Davidson (1) and Grigg (3). In March Lynn presented a paper on Halley's Comet and "Zadkiel". Zadkiel was Richard Morrison, an astrologer who associated all sorts of calamities with comet Halley over the ages.

50 Years Ago: The October meeting included a report on recent comets, particularly comet 1955 O1 (Honda). Dr Merton reminded observers of the rule which Dr Steavenson had told him of many years ago [*at least a decade, as a note had been published in the Journal in 1942*] that in **order to obtain reliable magnitudes of comets you should use the smallest telescope that will show the comet clearly**. In this case some observers had used 20cm reflectors when they should have used binoculars. Michael Hendrie showed some slides of the comet, including one with a 60 minute exposure. Roy Panther exhibited some drawings, and two drawings by George Alcock appear in the report. Two papers in the March Journal relate to predictions for early (ie pre 239 BC) appearances of comet Halley. [*None have been confirmed*]. At the March meeting Dr Merton opened a discussion on the observation of comets, which was followed by contributions from Steavenson, Alcock and M B B Heath.

RAS Meeting

Continued from Page 1.

Tycho showed that comets lay beyond the moon. Kepler however observed that comets were ephemeral and said that therefore they must move in straight lines. Galileo thought similarly. Hevelius thought that they formed in the atmosphere of Jupiter or Saturn, but travelled in curved paths. Halley determined orbits using Newton's theory and predicted the return of several. Applying planetary perturbations led to some uncertainty and he became increasingly less confident on his famous prediction. Clairaut refined the calculations with Lalande and Madame Le Paute, finishing them just six weeks before the comet was recovered by Palitzsch in 1758, although at the time Palitzsch did not realise it was the long awaited comet.

Encke linked several previously observed comets and showed that they were all the same. He also noted that it returned 2.5 hours early, supporting the idea of an interplanetary medium. Bessel made the first suggestion of what is now know as the "jet effect" caused by a rotating nucleus. Schiaperelli linked Swift-Tuttle with the Perseid meteors, however this led to the sandbank theory of comets. In 1950 Oort computed "original" values of the aphelion distance of a number of comets and postulated a cloud at the edge of the Solar System, and Whipple postulated a solid icy nucleus.

Giotto encountered Halley in 1986 with 100m resolution, Deep Space 1 visited Borrelly in 2001 with 50m, Stardust went to 81P/Wild in 2004 achieving 30m and noted vaporisation craters, but no impact craters. Deep Impact saw impact craters on 9P/Tempel, which was a very fragile icy dirt ball.

In answer to a question from Ian Ridpath, Don said that there were some similarities between Borrelly and asteroid Itokawa, but the latter had cm sized pebbles. Simon Mitton pointed out Lyttleton's work on the passage of another star near the Sun and had postulated the formation of comets by accretion. Lyttleton disliked Whipple. David Hughes suggested that the Americans had not been keen to send a spacecraft to Halley because they believed in the sandbank theory. Peter Hingley (RAS Librarian) remarked that there was still a lot of superstition associated with comets – he had been rung up by some stockbrokers at the return of Halley's comet, asking if it would cause a warm winter, and if so should they sell gas shares!

David Hughes (Sheffield University) addressed the question of "Edmond Halley: Why he became interested in comets". Halley was born in north London in 1656 and died in 1742. He was the second greatest British scientist. The Halley picture by Thomas Murray was a "cheap job" by an up and coming 20 year old painter, who later became famous. Why did Halley become interested in comets? 1) The form of a comet orbit was a big unknown, 2) Kepler's laws were known, 3) He was an excellent mathematician, 4) Great comets were frequent, 5) All his mates were interested in comets.

Halley's first paper was on planetary orbits. The discovery rate of comets increased during his lifetime, and even more so after his death. There were a lot of bright comets during his lifetime. All his chums were older than he was. Hevelius' idea was that comets were made of something else, so didn't have to obey the same law as planets. Most mid 17th century books showed comets moving in straight lines. Hooke made a comet model from wax and iron filings, suspended in sulphuric acid, which grew a tail. He also measured coma diameters and tail lengths using a telescope. Dorffel drew a diagram of the orbit of the comet of 1680. Halley tried to compute an orbit and failed, so he asked his chums for ideas. Flamstead suggested that the comet was magnetic and was repelled by the Sun. Newton drew the path and calculated the orbit, assuming that the orbit was a parabola. Halley first announced that 1P/ would return on 3rd January 1696, linking the returns of 1606 and 1682. Part of the reason for thinking that comets might return was that some comets showed very similar tracks across the sky. Halley also thought that comets had hit the Earth in the past, causing Noah's flood.

In answer to a question on how a comet could get as bright as -7, David said that this was easy if they passed very close to the Sun.

Mark Bailey (Armagh, in conjunction with David Asher and V Emel'yanenko) spoke about "Lessons from the Dynamical Evolution of Halley's Comet". In the early 19th century comets were thought to be interstellar and those few periodic ones had been captured by Jupiter. By the early 20th century comets had to be members of the Solar System, however there was a problem with their death rate compared to the age of the Solar System, and a growing number of periodic comets. Several bright comets gave a boost to theories, eg Donati, the Great Comet of 1882, the Great Comet of 1910. By 1980 the Oort Cloud theory had developed, with the capture by Jupiter of comets with period less than 200 years, however the excess of Jupiter Family comets (JFC) led to the idea of a trans-Neptunian disc. Computer development allowed the investigation of the orbital evolution of Halley's comet. Resonant perturbations can change the perihelion distance from 8 AU to 0 AU over 1 My, with rapid changes in inclination. Secular resonances can have enormous effects on comet orbits, despite many orbits being planet crossing, and many end up hitting the Sun. The observed Halley Type (HT) comets are mostly evolving towards smaller perihelion distances, eg Pons-Gambart. The same applies to 2P/ and 96P/. Kosai oscillations (where $q \cos^2 i$ is conserved) produce significant variation in resonant cases. Mark predicts a new class of NEO/comet orbit, where a direct orbit is flipped into a retrograde one.

Short period comets (SPC) can originate by capture from a direct orbit. Predictions suggest around 3000 HT comets, but we don't see them, so they must either fade or disappear. Vice-versa the predictions give too few JFC, so we need an additional source, eg the Kuiper Belt, but probably then still need fading. Resonances in mean motion and secular resonances are important and sun-grazing is a common end state. The high relative capture probability implies a large number of dead comets.

In answer to a question Mark said that secular changes normally operated over 100,000 years, so there is time for meteor streams to form. Planetary encounters can then "snip" the streams [possibly leading to orphan outbursts such as that seen in early October 2005 from Camelopardalus].

The next speaker was Stephen Lowry (Queen's University Belfast) on "Probing the Properties of Cometary Nuclei". We can image the nucleus directly. HST, Spitzer and ISO use a model and subtract the inner coma. There has been direct radar imaging of 2P/, 2004 Q2 and 2005 JQ5. It is possible to infer properties of the nucleus from rare events, eg 1993 F2 (D/Shoemaker-Levy), 1999 S4 etc. They have been imaging comets at large solar distances using ground based CCD, eg comet 2P/Encke over 4 nights to get a light curve. With sufficient observations it is possible to find alpha in the relation $N(>r) = cr^{-\alpha}$, and from what they have alpha is 1.6. There is evolution from Kuiper Belt Object (KBO) to Centaur to JFC. 2001 OG108 was originally classed as Damacloid, but it had an outburst which made it a comet. It has a rotation period of 57 hours, 4% albedo and a diameter of around 10km. No spectral features were seen.

Dead comet candidates are generally very blue [I may have got this the wrong way round]. There appears to be a rotational period cut off for comets, implying a density of around 0.6 $g.cm^{-3}$, but a few objects imply a density of 3. More work is needed to populate the statistics. 67P rotates in 12.7 hours. They used the VLT to image comet Halley in 2003, when it was at 28 AU, with a magnitude of 28.2, which implies that it can now be imaged through aphelion. They are starting to observe Long Period Comets (LPC) beyond 10 AU. 2001 G1 at 10 AU showed a starlike nucleus with a detached tail.

Alan Fitzsimmons (Queen's University Belfast) was searching for "Comet Candidates Amongst the NEO Population". Why is this important – predictions suggest that JFC should evolve into NEO orbits and we need to test theories of end states. It also helps to measure the overall impact risk. There is opportunity for remote and in-situ sensing.

Dynamical evolution alone can produce JFC from Trans-Neptunian Objects (TNO) with a ≥ 2.5 AU. There is a problem with Encke type objects, and to get such small aphelia needs perturbations from the terrestrial planets and strong non-gravitational forces. Observationally 2% of NEOs are active comets, but 6% of NEOs could come from JFC. Where are they? It may be a question of poor discovery due to their inert nature or low albedos, or lack of identification due to low inactivity. Comets generally occupy a different space of the e/q diagram compared to NEOs, but some high eccentricity objects may be comets. Objects with the Tisserand invariant T_j more than 3 are asteroidal, but what of those less than 3? Images of 2003 KV2, which has $T_j = 2.86$, showed a tail. They had found a few more objects, eg 2005 JQ5 ($T_j = 2.96$). In May when they observed 169P ≡ 2002 EX12 ($T_j = 2.89$) it was nearly stellar, although when observed a few days later with larger aperture and better seeing it was completely stellar, so they had thought it was just the poor seeing. However in July when it was closer to the Sun it showed a clear tail. This demonstrates that you have to observe them when close to the Earth and Sun, and with good seeing.

Cometary nuclei are often red and dark. There are 500 NEOs with known colours and 80 with albedos. There is an abundance of D types and low albedos in those with $T_j < 3$. This implies that 15% of NEOs could be JFC, which is more than the 6% that dynamicists want, but 8% could be outer belt asteroids, although the dynamicists need to do more work on this class of object. Overall there is a 50/50 chance of a D-type, low albedo asteroid with $T_j < 3$ being a comet.

In answer to a question from Mark Bailey, Alan said that the size distribution of NEOs and comets followed the same power law. David Hughes said that surface activity often varied from apparition to apparition, and we don't know why.

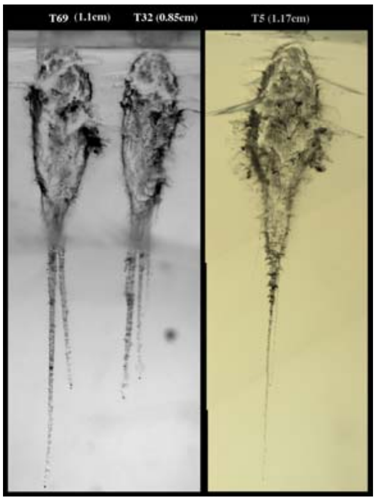
The final speaker before lunch was Neil McBride (Open University) speaking on "Comets in the Kuiper Belt". The first KBO was discovered in 1992. The discovery rate had peaked a few years ago. There were several classes: Plutinos, which had a 3:2 mean motion resonance with Neptune, Classical which orbited between about 42 and 47 AU, and a tail of Scattered Disk Objects (SDO), which ranged from 44 to 100 AU. Centaurs had semi-major axes less than that of Neptune. There are now over 1000 objects with semi-major axes greater than that of Neptune. There are a few with very large aphelia, but there is a problem in observing these as they spend most of their time at great distances from the Sun. Some are bigger than Pluto, and there are some with large light curves, for example 2004 EL61 is 1500km in size and rotates in 4 hours. Many are binaries with similar sizes and a large separation, and are probably remnants of three-body captures. Their spectra are similar to Pluto or Triton. There is a range form neutral to very red colours, but there may be four broad types. The classical objects are all red. The Centaurs are either neutral or red. The scattered disc is more or less primordial, and was originally much more massive. JFC came from Centaurs, some of which come from the SDO and others from the Oort cloud. The SD has 10^5 objects larger than 100km, and 10^{10} larger than 1km. Medium sized objects probably look like Phoebe, and the smallest objects look like comets.

After lunch Mike A'Hearn (University of Maryland, USA) told us about "Deep Impact: The Experiment". The impactor came in obliquely at an angle of 20 – 36°. The glitches in the encounter animation were due to dust hits; there were four, with the largest having a mass of 0.5g, spot on the predicted size distribution. Imaging was down to boulder sized objects. There was plenty of geology: large smooth surfaces, craters, old striped terrain, scarps, evidence of layers with rough terrain above and below smooth terrain. The effective radius was 3.0km, with maximum and minimum diameters of 7.6 and 4.9km. The jets haven't yet been associated with surface features. The camera was 6mm out of focus on a long focal length instrument, however unlike the HST it was possible to recover good images through deconvolution. The colour image showed the comet was reddish, with the brightest areas having an albedo of 4% and a factor of two variation. Outbursts happen all the time [and are very small], but are short lived, decaying in typically an hour, they recur on particular parts of the nucleus, which has a rotation period of 40 hours. Outbursts go to the NE quadrant as the 'top' surface rotates into sunlight. It has a temperature of 365 – 240 K, and is locally in solar equilibrium, implying that there is no thermal inertia below about 1cm. This means that the surface is hottest at noon, when the Sun is highest in the sky.

A gravity controlled crater was created. The ejecta were optically thick and cast shadows. A ray structure appeared. A small puff of material at 3500K was emitted very quickly in about 0.5 seconds, before the main ejecta came out. This was about 10 tons of liquid silicate. The rest of the material was cold – room temperature or less, and amounted to about 10,000 tons. The ejecta were bluish, as were some of the surface patches, implying ice on the surface and ice crystals in the ejecta. There were large particles, which consisted of weakly bonded smaller particles. The overall density of the nucleus was 0.4 $g.cm^{-3}$ and it was as strong as talcum powder, with a 75% porosity. Spectra show water, carbon dioxide, CH-X and organics after the impact. The crater was about 100m across and 20m deep. There is lots of water ice below the surface. There is much work still to be done on the data.

A comment was made that ice isn't expected on the surface, so where do the patches come from. A suggestion was overnight frost. In answer to a question Mike said that an overhang had been seen on 81P/Wild despite the talcum like consistency. Mark Bailey commented that accretion must have occurred at low relative velocity.

Neither David Bowdley or Paul Roche (Cardiff University) were able to give their presentation on "Deep Impact on Maui: Scientific and Educational Collaboration with the Faulkes Telescope", so Simon Green (OU) spoke on cometary dust measurements near 81P/Wild from Stardust. The primary mission of the spacecraft was the sample return and it had an imaging camera. There was also a dust flux monitor, which could detect particles down to 3 microns, but only over a small area. A UK sensor had a larger area and could detect particles down to 50 microns. There was a maximum detection rate at closest approach to the comet, followed by a second peak 700 seconds later at a distance of around 4000km from the nucleus. There was a surprising distribution at closest approach, with clear swarms of particles giving jumps in the rate from 0 to 1000 s^{-1} in a few seconds. At higher resolutions the rate jumped from 0 to 500 in bursts in as little as 1/10 second, equivalent to a distance of 600m. The jets have an angular width of around 5° corresponding to a distance of 600m and clearly give rise to the swarms. The jets have been mapped back to the nucleus. Not all swarms are correlated directly to the jets, and jumps in density from 400 m^{-3} to 0 in 1/10 second imply the fragmentation of large grains. Anti-correlated swarms are from fragmentation events close to the nucleus, whilst correlated swarms are from fragmentation outside the acceleration zone.



Comet particle tracks in Stardust aerogel

The more distant material seen at 700 seconds can't be a jet and may be a 40cm sized boulder fragmenting, several hundred days after ejection from the nucleus. The mass distribution is similar to that seen in Halley, ie most of the mass in a few large particles. He estimates that about 3000 15 micron particles will have been trapped in the aerogel, with 500 from the second event. Similar evidence for small fragmentation events has been seen in many comets, eg Halley, Grigg-Skjellerup, Borrelly (Deep Space 1), West, Hale-Bopp. We should be able to get an estimate for the density of the grains from the sample return.

Andrew Coates (Mullard Space Sciences Laboratory, University College London) followed on with "Cometary Plasma Tails". Comets show some similarities to Venus, Mars and Pluto. The bow shock position depends on the volatile production rate, with a factor of 100 variation between Halley and Grigg-Skjellerup. Neutrals ionise in sunlight or by charge exchange. The solar wind slows down due to cometary output – heavy cometary ions are added to the flow causing deceleration by mass loading. The magnetic field is frozen into the flow. Once ionised, ions move in a cycloidal path and can be accelerated to 70 keV. Most of the acceleration happens near the bow shock. The Ulysses spacecraft detected the tail of comet 1996 B2 (Hyakutake) at 3.8 AU. At comet Borrelly the pickup was asymmetric, reflecting asymmetric emissions. X-rays come from charge exchange between cometary ions downwind. We don't know what role tail rays [frequently seen in images] play. Rosetta will investigate these aspects, and also the distant 'inert' nucleus. There is no evidence for a plasma tail in Deep Impact data.

Max Wallis pointed out that comets have a large hydrogen coma, so not all cometary ions are heavy.

The final speaker was Gerhard Schwehm (ESA/ESTEC, The Netherlands) who presented "ESA's Rosetta Mission to Comet Churyumov-Gerasimenko". We study comets to understand the history of the solar system. The lander is named Philae after an Egyptian obelisk, now in the garden of the Kingston Lacy estate in Dorset, which helped to decipher hieroglyphs. There are 11 instruments on board Rosetta, covering imagery (down to 4cm), spectroscopy, mass spectrometer, radio, dust, plasma and tomography. The lander, which has a mass of 100kg, will anchor itself with harpoons. The target, 67P/Churyumov-Gerasimenko is about 4km diameter, has a density of between 0.2 and 1.5 $g.cm^{-3}$, an albedo of 4% and a rotation period of 12.3 hours. The rendezvous is due in May 2014 and the mission will run till 2015 after perihelion. The spacecraft is derived from a telecommunications satellite as they are designed for a long life. The solar panels are 32m from tip to tip. Rosetta observed 2002 T7 in April after commissioning, and 9P/Tempel in July. All the instruments are working well.

Gerhard was asked given the low density and tensile strength, what happens in a 1 $m.s^{-1}$ impact? He thought that the lander would go in to about 30cm, but that more studies were needed. I asked how the microgravity field would affect the lander and orbitter. Gerhard said that the field would be mapped from the initial orbit and the safest trajectory to the most interesting site would be chose. The orbit prior to release would be at 2km, so the transit time for the lander would be short. It was suggested that the small asteroid, (2867) Steins, due to be encountered en route might be an interesting object itself.

Professional Tales

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

First some abstracts from the 37th Lunar and Planetary Science meeting; the full papers are available on the web.

Paper 1092 - References to historical comets from 497 A.D. to 1402 A.D. in English manuscripts. E. G. Mardon & A. A. Mardon

Paper 1527 - Representations of halley's comet in April 1066 A.D. found in the Bayeaux Tapestry and other contemporary written accounts. J. A. Greenspon (StarGate Research), A. A. Mardon, E. G. Mardon (Antarctic Institute of Canada)

Introduction: This Medieval embroidery - incorrectly called tapestry is a band of linen - 231 feet long and more than 19 inches wide. A portion of it is missing including the final portion. It depicts the Norman Conquest of England leading up to the Battle of Hastings in 1066 A.D. in which Harold Godwin king of England was killed.

It is a remarkable work of art and important as a source of mid-11th Century history. Legend states that the Bayeaux Tapestry was made by Queen Matilda William of Normandy with the help of the ladies of his court. It contains 70 scenes and various Latin words. Scene 31 of the Bayeaux Tapestry states in Latin: "ISTIMIRANT STELLAE" - "Marveling at the star."

The six men are in the scene pointing to the comet in the sky with signs of fear. On the border above is a drawing of a comet moving from left to right. The comet appears as a round ball of red with white points and a burning rake like object tail being drawn from the ball. Scene 32 is of King Harold on his throne bending towards a man who appears a soothsayer or an interpreter of dreams.

On the lower border is a picture of ghostly empty vessels floating on a calm sea with only black thread. It is only a sketch that is why it is taken as a dream. It is worth noting that Odo Bishop of Bayeaux or later Earl of Kent was a half brother of William and took a leading part in the Hastings Campaign and conquest of England. Odo a warrior bishop was born c. 1033 A.D. and died in Sicily in 1097 A.D. He probably commissioned the famous Bayeaux Tapestry for the dedication of his new cathedral Notre Dame in the city of Bayeaux in 1077 A.D. It is said that the tapestry was hung around inside the church once a year on a special feast day for centuries.

In conclusion this is the first pictorial record of a comet. The first time that it is mentioned in literature outside of the Chronicles was in 1476 A.D. So we can date the comet because of the battle of Hastings. The comet appeared in April 1066 A.D. for almost two weeks. By day and by night. It was very bright. [...]

Conclusion: The breadth of separate references to the appearance of Halley's Comet in 1066 A.D. in England indicated that the comets appearance was an important historical event and indicates a serious contemporary interest in astronomy. It indicates that more effort should be directed in the research and recovery of historical references to astronomical events such as comets or as sometimes referred to as 'star.' Their could be more historical references to comets that have long periods that we have as yet to see appear again in the 21st Century or some time in the far future.

Paper 1597 - Some properties of secular variations of brightness of some periodic comets. V. S. Filonenko

Introduction: A secular fading of the integrated brightness of sort-period comets was found by S. K. Vsekhsvyatsky. He interpreted this as a result of the disintegration of cometary nuclei. This phenomenon confirms youth of short-period comets and their quick evolution. N. T. Bobrovnikoff, Z. Sekanina, F. L. Whipple, V. P. Konopljova, A. S. Guliev et al. studied the secular variations of cometary brightness. They confirmed the reality of the brightness fading of short-period comets, they determined the values of this fading for several comets and they shown an influence of 11-year solar cycle upon secular variations of cometary brightness.

A paper by *Zdenek Sekanina and Paul W. Chodas* dealing with the "**Origin of the Marsden and Kracht groups of sunskirting comets**", I. Association with Comet 96P/Machholz and its interplanetary complex" has been published in the Astrophysical Journal Supplement Series, 161, p.551-586, December 2005.

Maik Meyer provides this synopsis of the paper and highly recommends it (all 37 pages!) to everyone interested in the new sunskirting comet groups.

* The tidal stresses experienced by the sunskirting comets are only about 0.5% of the stress which is experienced by sungrazers (Kreutz comets).

* Of the several linkages presented in recent MPECs the ones for the Marsden group comets are the most reliable. The ones between several Kracht group comets are highly uncertain and possibly not correct.

* The link between C/1999 J6 and C/2004 V9 is regarded as virtually certain.

* The orbital period for the Marsden group is expected to be between 5.5 and 6.0 years. (This in turn means that it is possible that no further (new) members will be found, except ones that were missed in the early times when SOHO was not operating due to problems.) We obviously see the final apparitions of the members of both groups.

* Fragmentation of C/1999 J6 took place most likely about 100 days prior to perihelion. When visible in SOHO in 1999 the angular separation of the fragments was below the resolution of the coronagraph.

* The lifetime of the fragments is not expected to be longer than 2 to 5 revolutions, depending on the initial mass.

* The visual magnitude of C/1999 J6 at its presumed close approach to Earth in 1999, of maybe 0.009 AU is derived to be of 19 to 21 mag, explaining why it was not detected. The lightcurve can not be described by usual models.

* The minimum diameter of sungrazer which may survive a perihelion passage is estimated to be about 1 km, with typical sizes for observed ones 16m to 130m! For sunskirters the diamters are much smaller, for the bright one C/1999 J6 it was estimated to be of about 41m, at the next revolution as C/2004 V9 it was only about 35m. The diameters for the fainter ones are even smaller, especially after fragmentation and not only erosion.

* It was found that the sunskirting comet groups most likely separated from 96P around 1000 A.D. The numerous simulations showed that the Marsden group, the Daytime Arietids, the Kracht group and the Southern delta Aquarids are from 96P. It is possible that the Quadrantids are also connected to 96P, but there is the need of more research. All of these groups resemble different states of an evolution, i.e. 96P will later be in a Marsden group orbit (if it survives that long), the Marsden comets will later be in a Kracht orbit (but will obviously never reach it because of destruction), the Kracht comets will later be in a Southern Aquarids orbit and so on...

* There are gaps in the distribution of elements for which no objects have been observed but are expected from the simulation. (w,node,i): (15,90,50), (36,65,17), (75,25,10), (105,355,10), (134,325,14)

Part II will deal with open questions and the fragmenation details.

The **RAS Darwin Lecture** was given by Professor Michael Werner (JPL) on May 12, and in it he showed a spectrum taken by the Spitzer Space Telescope of 9P/Tempel. This showed surprising complexity with silicates, carbonates, ice etc, which implies that the early solar system was well mixed, as these species all come from different source regions.

The Cambridge-Conference Network (CCNet)

CCNet was an electronic network devoted to catastrophism, but which included occasional information on comets. Over the last year or so it has become increasingly devoted to greenhouse warming scepticism, however there have been a few comet related items. To subscribe, contact the moderator Benny J Peiser at <b.j.peiser@livjm.ac.uk>. The electronic archive of the CCNet can be found at http://abob.libs.uga.edu/bobk/cccmenu.html

Unexpected meteor shower reveals presense of potentially hazardous comet. *Peter Jenniskens, Jarmo Moilanen, Esko Lyytinen, Ilkka Yrjölä, Jeff Brower*. WGN: the Journal of the International Meteor Organization

SETI Institute scientist and meteor expert Peter Jenniskens reports in a telegram issued by the International Astronomical Union's Minor Planet Center that an unexpected burst of meteors on October 5, 2005 has occurred, which betrayed the presence of a thusfar unknown, potentially Earth-threatening, comet.

The burst of meteors radiated from a direction on the border of the constellations Draco and Camelopardalis, and the new shower is called the October Camelopardalids. The meteors were caused by dust ejected by an Intermediate Long-Period comet during its previous return to the Sun, and the detection of the comet's dust trail implies that the comet itself could wander into Earth's path, if so directed by the gravitational pull of the planets. The comet itself has not yet been discovered and is likely to return to Earth's vicinity only once every 200 - 10,000 years. Chances are very small that Earth will be at the intersection point at the time of the return, hence, there is no immediate concern. The dust, however, is forensic evidence that may provide more insight into the nature of this new comet when the meteor shower is seen again in the future.

"Jarmo Moilanen (Finland), detected twelve meteors from a compact geocentric radiant at R. A. 164.1 ± 2.0º, Decl. +78.9 ± 0.5º, on the border of Draco and Camelopardalis, in the evening of October 5, 2005. The differential mass distribution index was a low s 1.4 ± 0.2 (+0 to -6 magnitude). The new shower was confirmed by Esko Lyytinen (2 meteors, early period only, located at 25.00 E; +60.25 N) and Ilkka Yrjölä (4 meteors: 26.4 E, +60.9 N) at nearby locations, and by Sirko Molau in Germany (7 meteors). Esko Lyytinen calculated an apparent speed of Vg 47.3 ± 0.5 km/s from one two-station meteor, close to the parabolic limit. We conclude that the event was caused by the 1-revolution dust trail of a yet unidentified potentially Earth-threatening (Halley-type or) Intermediate Long-Period comet with orbital elements similar to those of the meteoroids: Epoch 2005 October 05, a Inf. (15 - Inf.) AU, q 0.993±0.001 AU, w 170.5±1º, W 192.59±0.04º , and i 79.3±0.5º (J2000.0)."

Royal Astronomical Society award goes to Brian Marsden

The 2005 prize for Service to Astronomy and Geophysics goes to Dr Brian Marsden. Dr Marsden was Director of the International Astronomical Union's Central Bureau for Astronomical Telegrams from 1968 to 2000, and is now director Emeritus. In this capacity he was responsible for disseminating information about transient objects and events in all areas of astronomy and astrophysics. Since 1978 Marsden has also directed the IAU's Minor Planet Center, which issues orbital and related information about comets and asteroids. From 1987 to 2002 he was Associate Director for Planetary Sciences at the Harvard-Smithsonian Center for Astrophysics.

Physical characteristics of Comet Nucleus C/2001 OG108 (LONEOS). *Paul A. Abell, et al.* Icarus, Volume 179, Issue 1, 1 December 2005, Pages 174-194

A detailed description of the Halley-type Comet 2001 OG108 (LONEOS) has been derived from visible, near-infrared, and mid-infrared observations obtained in October and November 2001. These data represent the first high-quality ground-based observations of a bare Halley-type comet nucleus and provide the best characterization of a Halley-type comet other than 1P/Halley itself. Analysis of time series photometry suggests that the nucleus has a rotation period of 57.2±0.5 h with a minimum nuclear axial ratio of 1.3, a phase-darkening slope parameter G of ?0.01 ± 0.10, and an estimated H 13.05 ± 0.10. The rotation period of C/2001 OG108 is one of the longest observed among comet nuclei. The V-R color index for this object is measured to be 0.46 ± 0.02, which is virtually identical to that of other cometary nuclei and other possible extinct comet candidates. Measurements of the comet's thermal emission constrain the projected elliptical nuclear radii to be 9.6 ± 1.0 km and 7.4 ± 1.0 km, which makes C/2001 OG108 one of the larger cometary nuclei known. The derived geometric albedo in V-band of 0.040 ± 0.010 is typical for comet nuclei. Visible-wavelength spectrophotometry and near-infrared spectroscopy were combined to derive the nucleus's reflectance spectrum over a 0.4 to 2.5 μm wavelength range. These measurements represent one of the few nuclear spectra ever observed and the only known spectrum of a Halley-type comet. The spectrum of this comet nucleus is very nearly linear and shows no discernable absorption features at a 5% detection limit. The lack of any features, especially in the 0.8 to 1.0 μm range such as are seen in the spectra of carbonaceous chondrite meteorites and many low-albedo asteroids, is consistent with the presence of anhydrous rather than hydrous silicates on the surface of this comet. None of the currently recognized meteorites in the terrestrial collections have reflectance spectra that match C/2001 OG108. The near-infrared spectrum, the geometric albedo, and the visible spectrophotometry all indicate that C/2001 OG108 has spectral properties analogous to the D-type, and possibly P-type asteroids. Comparison of the measured albedo and diameter of C/2001 OG108 with those of Damocloid asteroids reveals similarities between these asteroids and this comet nucleus, a finding which supports previous dynamical arguments that Damocloid asteroids could be composed of cometary-like materials. These observations are also consistent with findings that two Jupiter-family comets may have spectral signatures indicative of D-type asteroids. C/2001 OG108 probably represents the transition from a typical active comet to an extinct cometary nucleus, and, as a Halley-type comet, suggests that some comets originating in the Oort cloud can become extinct without disintegrating. As a near-Earth object, C/2001 OG108 supports the suggestion that some fraction of the near-Earth asteroid population consists of extinct cometary nuclei.

Comet collision 'armageddon' unlikely. The Australian National University

The chances of the Earth being hit by a comet from beyond Pluto - à la Armageddon - are much lower than previously thought, according to new research by an ANU astronomer.

Using computer simulations and data from an American military telescope, Dr Paul Francis, from the ANU Research School of Astronomy and Astrophysics at Mt Stromlo, has found there are seven times fewer comets in our solar system than previously thought.

"I calculate that small comets, capable of destroying a city, only hit the Earth once every 40 million years or so," Dr Francis said. "Big continent-busting comets, as shown in the movies Armageddon and Deep Impact, are rarer still, only hitting once every 150 million years or so. So I don't loose sleep over it, but you're still more likely to be killed by a comet than to win the jackpot at Lotto."

Previous estimates of the number of comets were based on the work of amateur astronomers, who for hundreds of years have been scanning the skies, looking for new comets.

Previously, it was believed that these amateur astronomers were only spotting three per cent of the comets passing close to the Earth: the rest were thought to be missed because they were in the wrong part of the sky or were too faint.

But Dr Francis found that the amateurs were doing better than anyone had realised - they were actually spotting 20 per cent of comets. There are therefore far fewer undiscovered comets.

"The new data allowed us to count the number of faint and far-away comets that the amateurs had missed. And we found that they were pretty rare," Dr Francis said.

These results apply to comets coming from beyond the orbit of Pluto, which is where most comets live. The Earth is still at risk of being hit by asteroids, and by so-called short-period comets - ones that come past repeatedly, like Halley's comet.

"But asteroids and short-period comets come past again and again, so if we're clever enough we can find them all and predict which, if any, will hit the Earth," said Dr Francis. "If we find one on a collision course with the Earth, we would normally have hundreds of years warning in which to do something about it, like deflecting the asteroid.

"The comets coming from beyond Pluto, so called long-period comets, are nastier, as they are totally unpredictable, and if we see one on a collision course we'd have at best one or two years warning - not long enough to do anything."

Dr Francis' research has been accepted for publication in the Astrophysical Journal. It was based on computer simulations, published data from the Lincoln Near Earth Asteroid Research Project at White Sands Missile Range in New Mexico, and on data from amateur astronomers around the world.

The demographics of long-period comets. *Paul J. Francis*

The absolute magnitude and perihelion distributions of long-period comets are derived, using data from the Lincoln Near-Earth Asteroid Research (LINEAR) survey. The results are surprising in three ways. Firstly, the flux of comets through the inner solar system is much lower than some previous estimates. Secondly, the expected rise in comet numbers to larger perihelia is not seen. Thirdly, the number of comets per unit absolute magnitude does not significantly rise to fainter magnitudes. These results imply that the Oort cloud contains many fewer comets than some previous estimates, that small long-period comets collide with the Earth too infrequently to be a plausible source of Tunguska-style impacts, and that some physical process must have prevented small icy planetesmals from reaching the Oort cloud, or have rendered them unobservable. A tight limit is placed on the space density of interstellar comets, but the predicted space density is lower still. The number of long-period comets that will be discovered by telescopes such as SkyMapper, Pan-Starrs and LSST is predicted, and the optimum observing strategy discussed.

On Some Comet Observations in Ancient India. *R.N. Iyengar*. Journal of the Geological Society of India, Vol.67, No.3, March 2006

A brief review of the ancient prose text of Para¯s´ara, referring to comets, as transmitted by later non-religious Sanskrit literature is presented. The information passed on appears to belong to 2nd millennium BC or earlier. A sequence of 26 comets with names and purported effects are given. The form of each comet sometimes with its position in the sky is presented vividly. A year number, mentioned as the time interval between each appearance, is also given. The total period covered adds to about 1300 years. The first comet is said to have appeared in the era of the Floods. This would date the Floods to about 2500-2700 BC. Whether this has any historical importance needs to be further investigated. The names of many comets correspond with names of Vedic deities. This raises the possibility of comet sightings being alluded to in the Rig Veda

NASA's stardust findings may alter view of comet formation. NASA News

Samples from comet Wild 2 have surprised scientists, indicating the formation of at least some comets may have included materials ejected by the early sun to the far reaches of the solar system.

Scientists have found minerals formed near the sun or other stars in the samples returned to Earth by NASA's Stardust spacecraft in January. The findings suggest materials from the center of the solar system could have travelled to the outer reaches where comets formed. This may alter the way scientists view the formation and composition of comets.

"The interesting thing is we are finding these high-temperature minerals in materials from the coldest place in the solar system," said Donald Brownlee, Stardust principal investigator from the University of Washington, Seattle.

Scientists have long thought of comets as cold, billowing clouds of ice, dust and gases formed on the edges of the solar system. But comets may not be so simple or similar. They may prove to be diverse bodies with complex histories. Comet Wild 2 seems to have had a more complex history than thought.

"We have found very high-temperature minerals, which supports a particular model where strong bipolar jets coming out of the early sun propelled material formed near to the sun outward to the outer reaches of the solar system," said Michael Zolensky, Stardust curator and co-investigator at NASA's Johnson Space Center, Houston. "It seems that comets are not composed entirely of volatile rich materials but rather are a mixture of materials formed at all temperature ranges, at places very near the early sun and at places very remote from it."

One mineral found in the material brought back by Stardust is olivine, a primary component of the green sand found on some Hawaiian beaches. It is among the most common minerals in the universe, but scientists were surprised to find it in cometary dust.

Olivine is a compound of iron, magnesium and other elements. The Stardust sample is primarily magnesium. Along with olivine, the dust from Wild 2 contains high-temperature minerals rich in calcium, aluminium and titanium.

Stardust passed within 149 miles of comet Wild 2 in January 2004, trapping particles from the comet in an exposed gel. Its return capsule parachuted to the Utah desert on Jan. 15. The science canister with the Wild 2 sample arrived at Johnson on Jan. 17. Samples have been distributed to approximately 150 scientists for study.

"The collection of cometary particles is greater than we ever expected," said Stardust Deputy Principal Investigator Peter Tsou of NASA's Jet Propulsion Laboratory, Pasadena, Calif. "The collection includes about two dozen large tracks visible to the unaided eye."

The grains are tiny, most smaller than a hair's width. Thousands of them appear to be embedded in the glass-like aerogel. A single grain of 10 microns, only one-hundredth of a millimeter (.0004 inches), can be sliced into hundreds of samples for scientists.

In addition to cometary particles, Stardust gathered interstellar dust samples during its seven-year journey. The team at Johnson's curatorial facility hopes to begin detailed scanning of the interstellar tray within a month. They will initiate the Stardust at Home project. It will enable volunteers from the public to help scientists locate particles.

After registering, Stardust at Home participants may download a virtual microscope. The microscope will connect to a server and download "focus movies." The movies are images of the Stardust Interstellar Dust Collector from an automated microscope at the Cosmic Dust Lab at Johnson. Participants will search each field for interstellar dust impacts.

Evidence for cometary bombardment episodes. *W. M. Napier* Monthly Notices of the Royal Astronomical Society 366, 977-982 (2006)

Evidence is found that large terrestrial impacts tend to cluster in discrete episodes, with characteristic separations 25-30 Myr and durations of about 1-2 Myr. The largest impactors are strongly concentrated within such events, and the Cretaceous-Tertiary extinctions occurred within one of them. The evidence also indicates the presence of a weak periodicity, which might be ~24, ~35 or ~42 Myr depending on which peaks are taken as harmonics. The periodicity is most easily explained as a result of the action of the Galactic tide on the Oort comet cloud. The two longer period solutions are consistent with Galactic density estimates and with the current passage of the Solar system through the plane of the Galaxy. Other episodes may be a result of sporadic encounters with spiral arms, nebulae or stars.

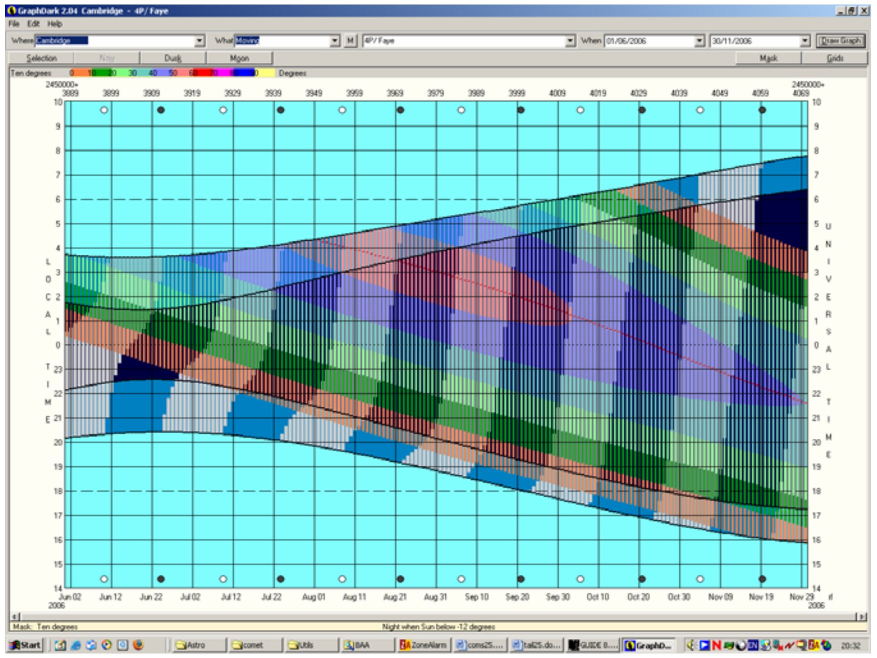
Review of comet observations for 2005 October - 2006 April

The information in this report is a synopsis of material gleaned from IAU circulars 8620 – 8711, The Astronomer (2005 October – 2006 April) and the Internet. Note that the figures quoted here are rounded off from their original published accuracy. Lightcurves for the brighter comets are from observations submitted to The Astronomer and the Director. A full report of the comets seen during the year will be published in the Journal in due course. 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.

Information that used to be published in the Observing Supplement can be found on the Section web pages and in the BAA Guide to Observing Comets. Reminders of the observing circumstances of forthcoming comets will however continue to appear in these pages.

Hervé A Faye discovered **4P/Faye** in 1843 during a visual search with a small telescope at the Paris Observatory. It reached 5^{m}, though this has never been reached at subsequent returns. It is possible that this was a one off caused by a slight reduction in perihelion distance from 1.8 to 1.7 AU following a close encounter with Jupiter in 1841. Several authors have suggested that the absolute magnitude of the comet is declining rapidly, but it reaches a similar magnitude at all favourable apparitions. This return is very similar to the 1991 return, when it reached 10^{th} magnitude. We should be able to pick it up in the morning sky in July, and it reaches opposition on the border of Cetus and Pisces in late October. It is at its brightest in early November and slowly fades.

29P/Schwassmann-Wachmann is an annual comet that has outbursts, which in recent years seem to have become more frequent and were more or less continuous in 2004. The pattern in the 2005/6 apparition was a little different, with most outbursts concentrated in the second half. At many recent outbursts it has reached 13^{m}. It spends the first half of the year in Aries, reaching opposition in late November as it retrogrades on the borders of Taurus and Perseus. The comet is an ideal target for those equipped with CCDs and it should be observed at every opportunity. It is well placed this year and UK based observers should be able to recover it again in July.



Observing circumstances for 4P/Faye

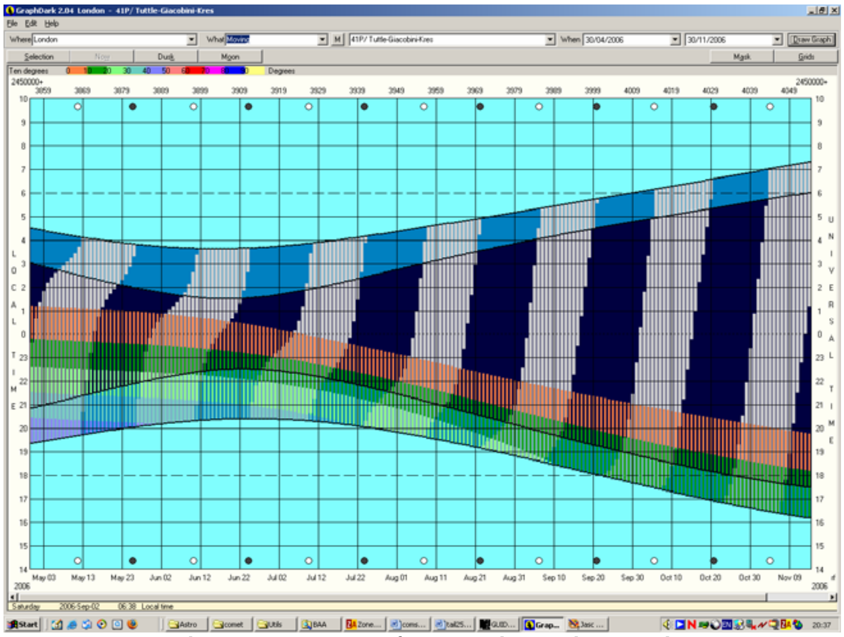
Horace Tuttle was the first discoverer of **41P/Tuttle-Giacobini-Kresak** in 1858, when he found a faint comet in Leo Minor. Nearly 50 years later, Professor M Giacobini discovered a 13m object whilst comet hunting, which was observed for a fortnight. A C D Crommelin linked the apparitions in 1928 and made predictions for future returns, but the comet wasn't recovered and it was given up as lost. In 1951, Lubor Kresak discovered a 10m comet in 25x100 binoculars whilst participating in the Skalnate Pleso Observatory's program of routine searches for comets. After further observations the comet was identified with the lost comet and a better orbit computed. The comet underwent a series of encounters with Jupiter in the sixteenth century, which reduced the perihelion distance from around 1.5 AU to 1.0 AU.

At the 1973 return, which was similar to the 1907 return, it underwent a major outburst and reached 4m, before fading and then undergoing a second outburst. Alternate returns are favourable and this, its 10^{th}, is one of them. At the last two returns the comet has reached around 8th magnitude and it could do a little better this time, although the CBAT ephemeris suggests that it will only reach 11th magnitude. The comet has not been observed visually at the time of writing, but is expected to be within range soon. It begins May in Gemini and continues through Cancer, Leo and Virgo, remaining relatively low in the western sky. It should be at its best in June, when it is in Leo.

52P/Harrington-Abell was discovered on a plate taken for the Palomar Sky Survey by Robert G Harrington and George O Abell. This is the eighth observed return of the comet since its discovery in 1955 and it never became brighter than 17th magnitude until 1998. It was not expected to get brighter than 15th magnitude at that return, however it was found in outburst at 12th magnitude in 1998 July, which was seven magnitudes brighter than expected. After the outburst it faded, and it is unclear how bright it will get this time around. In any case, it is not a favourable return and is poorly placed for observation from the UK.

Michael Clark of Mount John Observatory, New Zealand discovered **71P/Clark** on a variable star patrol plate in June 1973. At discovery the magnitude reached 13, but alternate returns are unfavourable and it is then 5 magnitudes fainter, though it hasn't been missed. An encounter with Jupiter in 1954 put it into its present orbit, which is such that it can approach quite closely to Mars, passing within 0.09 AU in 1978. This is the comet's 7th return since discovery and it could reach 10th magnitude during the northern summer. As might be expected from the discovery, it is best seen from the Southern Hemisphere and will not be visible from the UK.

The comet was recovered at the 2006 return by several observers, including Ernesto Guido, an Italian amateur astronomer. He provides the following details: *At the end of November I started the project to try to recover comet 71P. The first attempt was unsuccessful, probably because the comet was fainter than 19 magnitude, which was my limiting magnitude. On 29 December I tried again and this time I found 71P at 7' away from the nominal position roughly at 18.5 magnitude. On 30 December I was able to obtain a second night as requested from MPC.*

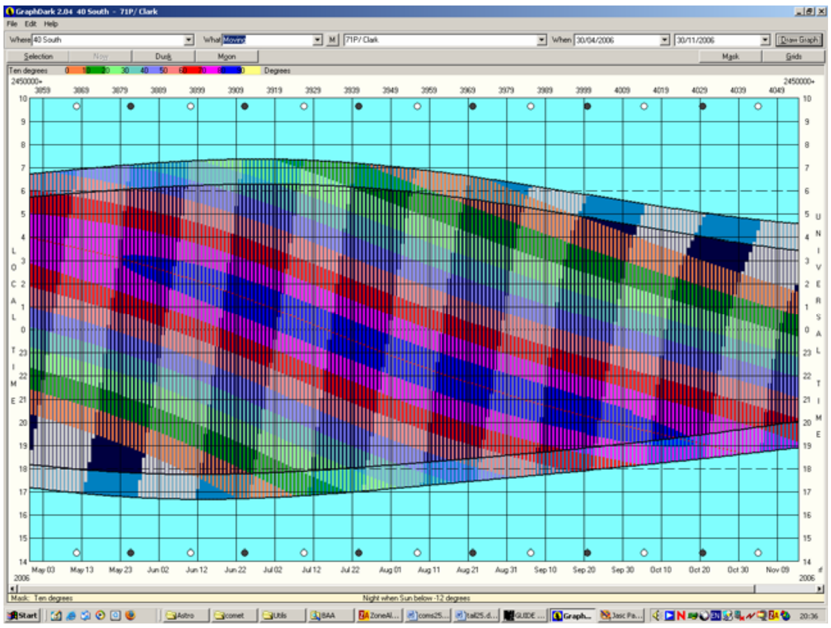


Observing circumstances for 41P/Tuttle-Giacobini-Kresak

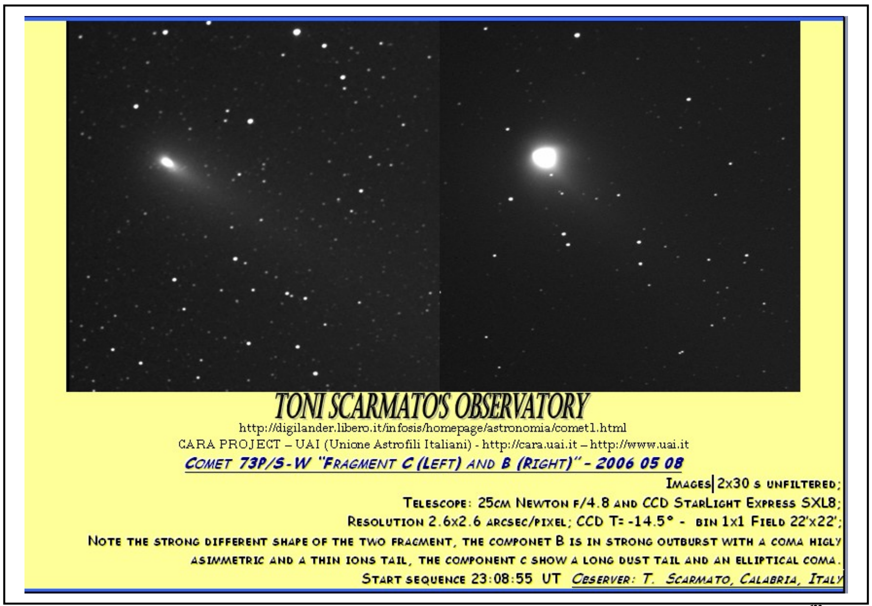
45P/Honda-Mrkos-Pajdusakova makes its 11th observed return since discovery in 1948 (it was missed in 1959). It has had several close encounters with Jupiter, the most recent in 1983 which made dramatic changes to ω and Ω. The perihelion distance has steadily decreased and is now the smallest it has been for the last 200 years. It can approach quite closely to the Earth and will do so in 2011 (0.06 AU) and 2017 (0.09 AU). At present the MPC only lists eight approaches closer than 0.06 AU out of 20 passes closer than 0.102 AU, and five of these are by periodic comets. It can also pass close to Venus and does so on June 4th, when it passes at 0.083 AU. It was well observed in 1995/96, when it reached 7th magnitude, but in 2001 it was fading from 9th magnitude. This is not a favourable return for UK observers, but it may be seen from further south during May and June when it is a morning object on its way in to perihelion.

Comet 73P/Schwassmann-Wachmann

Professor Arnold Schwassmann and Artur A Wachmann of

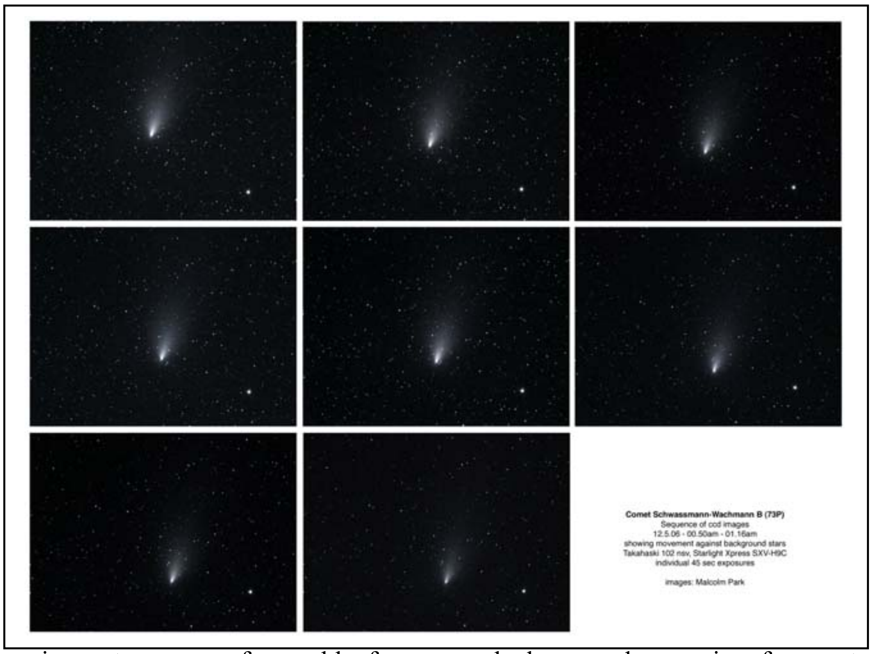


Observing circumstances for 71P/Clark for the Southern Hemisphere. These diagrams are made using Richard Fleet's Graphdark software.



Hamburg Observatory discovered their third periodic comet on minor planet patrol plates taken on 1930 May 2. Initially of magnitude 9.5 it brightened to nearly 6^m, thanks to a very close approach to Earth (0.062 AU) on June 1. The initial orbit was a little uncertain and the comet wasn't found at the next or succeeding apparitions until 1979. The comet passed within 0.9 AU of Jupiter in 1953, and 0.25 AU in 1965. In August 1979, Michael Candy reported the discovery of a comet on a plate taken by J Johnston and M Buhagiar while searching for minor planets; this had the motion expected for 73P/Schwassmann-Wachmann, but with perihelion 34 days later than in a prediction by Brian Marsden. Missed again at the next return, it has been seen at the last three returns. At the 1995 return the comet underwent a major outburst near perihelion, reaching 5^m when it was only expected to be 12^m. Subsequently four components were observed, though calculations by Sekanina suggested that the fragmentation occurred after the outburst. Three fragments were recovered in 2001, but only a few visual observations were reported as the comet was poorly placed and the absolute magnitude had clearly faded a little from the previous return. The components have now separated in the date of perihelion by roughly a day.

The comet's 1930 approach to Earth is currently ninth on the list of well-determined cometary approaches to our planet. In May the fragments will make another close approach, when the brightest one is likely to reach 5^m, thus becoming visible to the naked eye. The encounter circumstances are favourable for the UK. At closest approach the fragments will be racing across the sky at around 4.5° a day, strung along an arc of around 12°. The main fragment (C) is predicted to pass at 0.079 AU on May 12.38 when it is in Vulpecula. The other fragments will follow it, approaching closer and will be further north in the sky. After the encounter they rapidly head south and will be difficult to observe a week later.



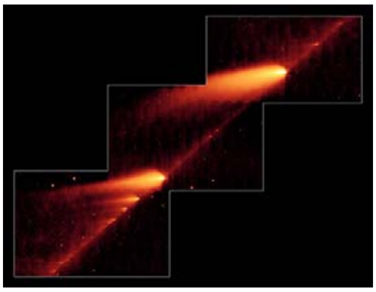
With the orbit approaching so closely to the Earth, an associated meteor shower might be expected, and the comet has been linked to the Tau Herculid shower, though the radiant now lies in the Bootes - Serpens region. Strong activity was reported in 1930 by a lone Japanese observer, but little has been seen since then. It is likely that any future activity would be in the form of a short-lived outburst, confined to years when the comet is at perihelion.

The comet was recovered on 2005 October 22.49 by Carl Hergenrother. The correction to the orbit published in the 2005 comet handbook was delta T -0.43 days. A paper on the 1995 splitting of the comet by Zdenek Sekanina, together with ephemerides for the components at this return was published in the ICQ. IAU circulars have regularly announced the discovery of further fragments, and there are at least 40 under observation. Many are short lived, and their brightness variation is highly erratic. Component (B), which had seemed a major fragment, began to disintegrate at the beginning of April, undergoing a brightness surge that briefly made it brighter than component A. The evolution was then remarkably similar to 1999 S4, forming an elongated coma without a centre of condensation.

Brian Marsden provided a list [MPEC 2006-G10, 2006 April 3] of perihelion times for the first identified fragments in chronological order:

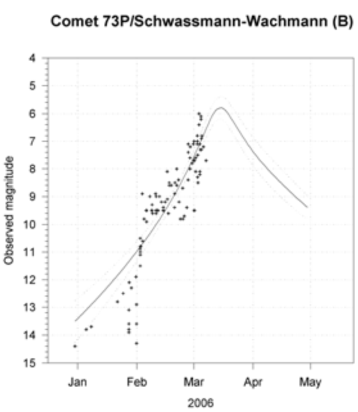
6.95	C
7.74	Q
7.88	P
7.93	B
8.11	G

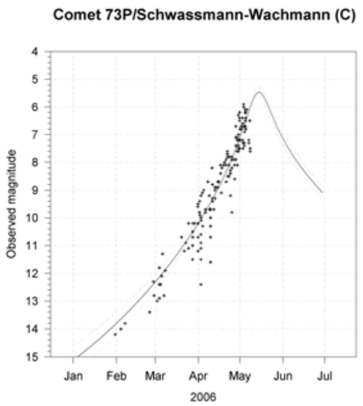
8.14	J
8.20	R
8.24	S
8.24	K
8.28	M
8.29	H
8.30	N
8.35	L
8.51	W
8.58	X
8.81	Y
8.83	T
9.02	U
9.08	V

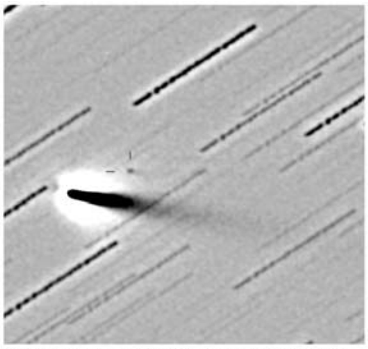


Spitzer image of 73P taken in early May. The image scale is not stated, but may be around 15' per frame.

Visual observations in early March put the main fragment of the comet ('C') at 12th magnitude, with the brightest of the others ('B') at 14th magnitude. It brightened rapidly, and by early April component C had reached 10th magnitude and was easily visible in large binoculars. 'B' was reported in outburst on April 2nd, and subsequent analysis of the photometry by Giovanni Sostero suggests that the outburst began a few days previously. On April 3.95 I observed both components in 20x80B and found that 'B' was noticeably brighter than 'C', with an estimate at around 9th magnitude. Despite a bright moon they were easily visible in large binoculars from sub-urban locations. A second outburst of B was reported in late April.







Comet 73P-b. 2006 May 16. 0212UTC. 30x20s, unfiltered ST9XE. 0.30m Newt Processed with 3 pixel radius Gaussian unsharp mask. 8.8 arcmin square, N at top.

Nick James.

Stop press news: a dramatic outburst in fragment 'B' put it up to 5th magnitude on May 9, with it easily visible in 20x80B from central Cambridge the following evening, despite light pollution, moonlight and mist turning to low cloud.

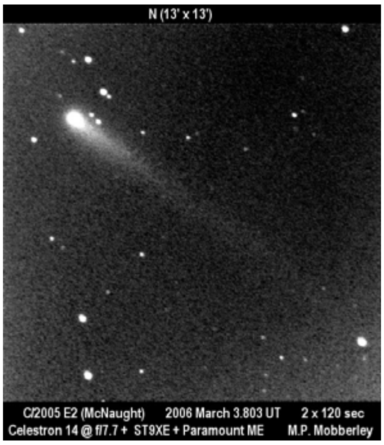
1997 V9 (SOHO) was a non-group comet found by Rainer Kracht whilst searching archival images for Meyer and Marsden group members in March.

2000 EC98 (174P/Echeclus = 60558)

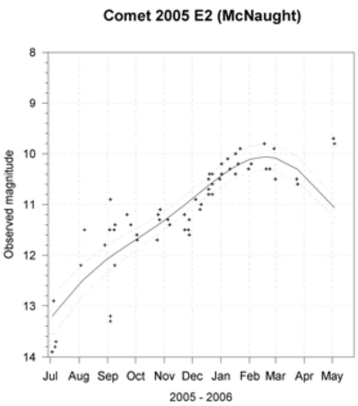
A cometary coma was detected around the centaur asteroid (60558) 2000 EC98 on 2005 December 30.50. At discovery by Spacewatch in 2000 the object was 21st magnitude, but the development of a coma has caused it to brighten by at least 3 magnitudes. Visual reports suggest it could be even brighter, and Seiichi Yoshida reports it at 14.4, with a 0.5' coma and DC3 in his 0.4m reflector on January 8.78. He suggests that this may be the most distant visual detection of a comet, as the object is 13 AU from the Sun. The object is in a 35 year orbit, and not due to reach perihelion until 2015, when it will be at 5.9 AU.

I suggested that the case seems similar to that of Chiron, which is (2060) 95P/Chiron, so the object should receive a cometary number. Roll on comet Pluto! The Committee on Small Bodies Nomenclature duly agreed to give the comet P/2000 EC_98 (cf. IAUC 8656, 8660) the same name as the centaur minor planet (60558), Echeclus (cf. MPC 55988), which has been assigned also the permanent comet number 174P (MPC 55911). [IAUC 8677, 2006 February 22]

2004 B1 (LINEAR) may get to 13th magnitude at its best in May. It is moving rapidly northwards and enters UK skies at the end of April. It moves through Aquila, Hercules, Corona Borealis, so becomes steadily better placed for viewing. A few observations from Southern Hemisphere last October suggest that it might even be as bright as 11th magnitude, so it will be worth trying to view it.



Comet **2005 E2 (McNaught)** was discovered by BAA Member Rob McNaught on March 12.75 with the 0.5m Uppsala Schmidt, during the course of the Siding Spring Survey. It reached perihelion at 1.52 AU in late February 2006, when it reached 10th magnitude. It was never very well placed and was fainter than expected. It is now in solar conjunction.



Sebastian Hoenig has predicted that **2002 R5 (SOHO)** may return in August. If his prediction holds, the object could become visible to Southern Hemisphere observers prior to perihelion, but is unlikely to be brighter than 12th magnitude.

Meyer Group SOHO comets 1996 N3, 1997 X7, 1998 G9, 2005 T9, 2005 W9, 2005 W11, 2005 Y8 and 2006 B4 were discovered with the SOHO LASCO coronographs and have not been observed elsewhere. They were sungrazing comets of the Meyer group.

Kracht Group SOHO comet 2005 W4 was discovered with the SOHO LASCO coronographs and has not been observed elsewhere. It was a sungrazing comet of the Kracht group. Brian Marsden comments on MPEC 2005-X14 [2005 December 3] that it seems likely that the Kracht-group comet C/2005 W4 is a return of C/2000 O3 (cf. MPEC 2000-Q09), a suggestion made by S. Hoenig. The orbital linkage utilizes just the C2 observations (those from July 30.89596 onward in the case of C/2000 O3); although only the first three C/2005 W4 observations were obtained with C2, the residuals of the C3 observations are not systematically displaced. This orbit gives the comet a period of 5.3 years and perihelion at 0.054 AU. Jonathan Shanklin discovered the comet in 2000, and Bo Zhou made the recovery.

Marsden Group SOHO comets 2005 G2, 2005 W1, 2005 W5, 2006 E2 and 2006 F3 were discovered with the SOHO LASCO coronographs and have not been observed elsewhere. They were sungrazing comets of the Marsden group.

Marsden group comet 2005 W1 has been linked to 2000 C4. Brian Marsden notes on MPEC 2005-W07 [2005 November 18] that it seems probable that this comet is identical with C/2000 C4 (MPEC 2000-C52; alternative direct orbit chosen on IAUC 7832 and MPC 44860), although it is conceivably identical with C/2000 C3 or C/2000 C7, which appeared around the same time (and, if they still exist, are also presumably about to return). The linked orbit has a period of 5.78 years, with aphelion beyond the orbit of Jupiter.

Brian Marsden notes on MPEC 2005-X14 [2005 December 3] that comet C/2005 W5 has not been satisfactorily linked to a Marsden-group candidate at its previous perihelion passage, although potential fits to the various 1999 members seem preferable to those involving the comets of Feb. 2000 (cf. MPEC 2005-W07). He further notes on MPEC 2005-Y27 [2005 December 23] Further to the note about C/2005 W5 at the end of MPEC 2005-X14 and its possible linkage to one of the Marsden-group comets of 1999, Z. Sekanina and P. Chodas, and also R. Kracht, have suggested that a fit to C/1999 U2 seems most likely. The linkage, giving a period of 6.10 years, is from the C2 observations. It should be noted that, although all the observations of C/2005 W5 are from least-squares cubic reductions (i.e., using 11 or more reference stars), in the case of C/1999 U2 this is true only for the observations shown with note 1 (rather than 2) in column 14. For the remainder it was necessary to make only quadratic reductions, and the observations from 1999 10 24.70145 onward are particularly unsatisfactory. Since the orbits below also reasonably represent the generally inferior C3 observations in both 1999 and 2005 (i.e., without systematic residuals above about 70 arcsec), it seems likely that the linkage is in fact correct.

SOHO Kreutz group comets 1996 R5, 1997 J6, 1997 O3, 1997 V8, 1998 L10, 1998 T2, 1998 U7, 1998 W8, 2005 S12, 2005 S13, 2005 T6, 2005 T7, 2005 T8, 2005 T10, 2005 T11, 2005 U2, 2005 U3, 2005 U4, 2005 U5, 2005 U6, 2005 U7, 2005 U8, 2005 V2, 2005 V3, 2005 V4, 2005 V5, 2005 V6, 2005 V7, 2005 V9, 2005 W6, 2005 W7, 2005 W8, 2005 W10, 2005 W12, 2005 W13, 2005 W14, 2005 W15, 2005 W16, 2005 W17, 2005 X2, 2005 X3, 2005 X4, 2005 X5, 2005 X6, 2005 X7, 2005 X9, 2005 Y3, 2005 Y4, 2005 Y5, 2005 Y6, 2005 Y7, 2005 Y9, 2005 Y10, 2006 A4, 2006 A5, 2006 A6, 2006 A7, 2006 B2, 2006 B3, 2006 B5, 2006 B6, 2006 C1, 2006 C2, 2006 C3, 2006 D2, 2006 D3 and 2006 D4 were discovered with the SOHO LASCO coronographs and have not been observed elsewhere. They were sungrazing comets of the Kreutz group and were not expected to survive perihelion. Some of these comets show no tail at all and it is possible that some supposed observations of Vulcan were actually tiny Kreutz group comets. There are now over 1140 SOHO comets, of which some 920 are members of the Kreutz group.

2005 V8 (SOHO) was a non-group comet discovered by Hua Su in C2 images on November 9. Brian Marsden notes on MPEC 2005-Y07 [2005 December 19] Alternate orbit solutions are possible for the non-group comets C/2005 V8 and C/2005 Y1. The orbit of C/2005 V8 is possibly similar to that of C/2005 H7.

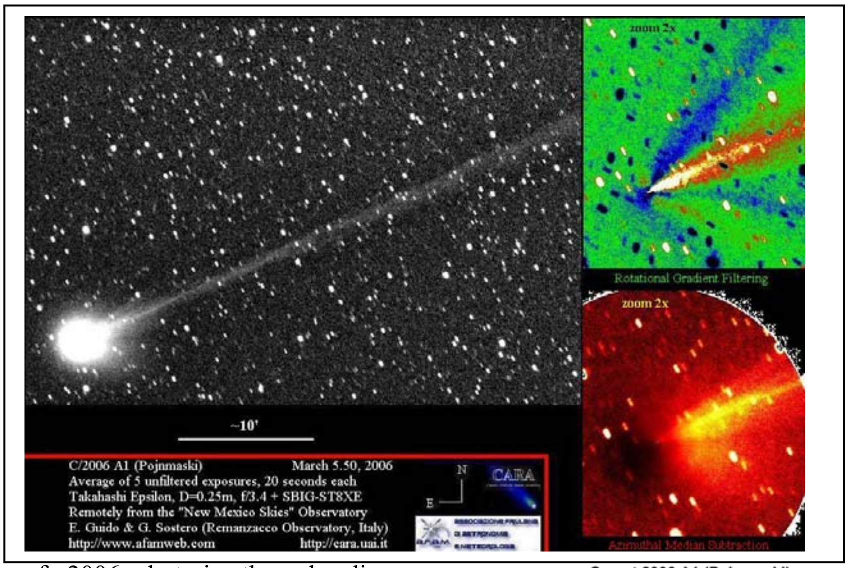
2005 X1 (Beshore) Edward Beshore discovered a 20th magnitude comet in the course of the Catalina Sky Survey on December 7.41. It has passed perihelion, which was at 2.9 AU in early July 2005. It will fade.

2005 XA54 (P/LONEOS-Hill) On January 6.41 BAA Member Rik Hill found an obvious comet on Catalina Sky Survey images. Tim Spahr has identified this with an asteroid discovered by LONEOS on December 4.38 and observed on two nights. The comet has a period of 15 years and reaches perihelion in early March at 1.8 AU. It could brighten to 16th magnitude in February and March, though it is an intrinsically faint object.

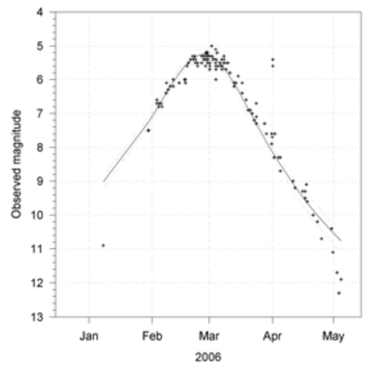
2005 Y1 (SOHO) was a non-group comet discovered by Steve Farmer in C2 images on December 17. Brian Marsden notes on MPEC 2005-Y07 [2005 December 19] Alternate orbit solutions are possible for the non-group comets C/2005 V8 and C/2005 Y1. The orbit for C/2005 Y1 is heavily weighted toward the C2 data, which for the most part are mutually unusually consistent, with the comet roughly of mag 7-8; the comet was much harder to detect in C3, and these reductions were unusually inconsistent. If this orbit is at all meaningful, a second entry into the C2 field should occur, although the phase angle would be very much larger and the magnitude obviously uncertain.

2005 Y2 (McNaught) Rob McNaught discovered another comet with the 0.5-m Uppsala Schmidt during the Siding Spring Survey. This one was found on December 30.46, and was 19th magnitude at discovery. The latest orbit confirms early suggestions that it is a periodic comet, with perihelion at 3.4 AU in late December 2004 and a period of 16 years.

2005 YW [LINEAR] This unusual asteroid, of 20th magnitude, was discovered by LINEAR with the 1.0-m reflector on December 21st. Currently 4 AU from the Sun, it reaches perihelion at 2 AU in December 2006 and has a period of over 1000 years. At aphelion it is 190 AU from the Sun. [MPEC 2005-Y43, 2005 December 27, 6-day orbit]. It is classed as a scattered disc object or cubewano and has a diameter of around 15 km. It will reach magnitude 17.5 at the end of 2006, but is then heading towards high southern declination.



Comet 2006 A1 (Pojmanski)



2005 YQ127 (P/LINEAR) was originally announced as an unusual asteroid, of 18th magnitude, discovered by LINEAR on December 28, which had an orbit typical of Jupiter family comets. It was at perihelion at 1.9 AU in early November 2005 and had a period of 8 years. [MPEC 2006-A07, 2006 January 2, 5-day orbit]. It can approach within 0.3 AU of Jupiter. As an asteroid it was estimated to be around 6km in diameter. Further observations showed cometary characteristics. The latest orbit shows that perihelion was at 1.9 AU in early November 2005, with a period of 7.6 years.

2006 A1 (Pojmanski) Grzegorz Pojmanski, of Warsaw University Astronomical Observatory, discovered a comet on All Sky Automated Survey images taken with a 180mm focal length f/2.8 telephoto lens (+ V filter) at Las Campanas. The object was placed on the NEOCP and has been confirmed as a comet. Kazimieras Cernis also reported an object in SWAN imagery, and this has the same motion as the new comet. The comet is at perihelion at 0.6 AU in late February. It will initially remain a southern hemisphere object, but should become visible from the UK in late February, as a binocular object in the morning sky, when it could be 6th magnitude. It will fade rapidly during March as the distance from Sun and Earth increases.

Michael Mattiazzo imaged the comet on January 7 and estimated the magnitude as 10.5 in his 20cm reflector. It seems to be brightening quite rapidly as Michael estimated it as 7.9 in 25x100B on January 23.5, with a 3' DC5 coma. I was able to observe the comet on Feb 8.05 from on board the Fishery Protection Vessel MV Sigma at 54S 39W with 10x50B and made it 6.1. For the next three weeks I was at Bird Island, a notoriously cloudy location, but on February 17/18 the skies remained clear and I estimated the comet at 5.6 in 10x50B, DC8 on February 18.21. Observations received in late February put the comet at around 5.5. Once in view from the UK, observers reported a 5 degree ion tail in early March. By early April it had faded to around 8.5.

Brian Marsden notes on MPEC 2006-E43 [2006 March 11] that the "original" and "future" barycentric values of 1/a are +0.000798 and +0.000800 (+/-0.000011) AU^-1, respectively. The "original" value suggests that this is not a "new" comet.

2006 A2 (Catalina) The Catalina Sky Survey discovered another faint comet, of 19th magnitude, on January 21.19. It is a distant object, past perihelion and will fade. Given the discovery date it should properly have been comet 2006 B1.

2006 A3 (175P/Hergenrother) Comet 2000 C1 (Hergenrother) was recovered by the Mt Lemon Survey. The comet will remain at around 20th magnitude for the next six months. The Committee on Small Bodies Nomenclature has announced that P/2000 C1 = P/2006 A3 (Hergenrother) has been assigned the number 175P (cf. IAUC 8664). [IAUC 8677, 2006 February 22]

A/2006 AQ [Mauna Kea] This Amor asteroid, of 20th magnitude, was discovered from Mauna Kea with the 2.24m reflector on January 2.23. It has a period of 6.3 years and perihelion is at 1.18 AU in early February 2006. [MPEC 2006-A16, 2006 January 5, 3-day orbit]. In the current orbit it can approach to around 0.4 AU of Jupiter. This type of orbit is typical of Jupiter family comets. The object is estimated at around 2km in diameter.

A/2006 AL8 [Siding Spring] This Apollo asteroid, of 20th magnitude, was discovered during the Siding Spring Survey with the 0.5m Uppsala Schmidt on January 8.70. It has a period of 6.7 years and perihelion was at 0.38 AU in mid November 2005, although the orbit is still rather uncertain. [MPEC 2006-A58, 2006 January 10, 2-day orbit]. The object is estimated at around 1km in diameter.

2006 B1 (McNaught) Rob McNaught has discovered another comet, during the course of the Siding Spring Survey. This one was found on January 27.62 and was 18th magnitude. It was at perihelion in November 2005 at 3.0 AU and will not brighten significantly.

A/2006 BO6 [Mt Lemon] This Apollo asteroid, of 20th magnitude, was discovered by the Mt Lemon Survey with the 1.5m reflector on January 22.11. It has a period of 5.6 years and perihelion was at 0.98 AU in late December 2005. [MPEC 2006-B55, 2006 January 24, 2-day orbit]. In the current orbit it can approach to around 0.4 AU of Jupiter. This type of orbit is typical of Jupiter family comets. The object is estimated at around 200m in diameter.

A/2006 BV7 [Steward] This unusual asteroid, of 21st magnitude, was discovered from the Steward Observatory with the 0.9m reflector on January 22.39. It has a period of 7.0 years and perihelion was at 1.69 AU in late December 2005. [MPEC 2006-B59, 2006 January 24, 3-day orbit]. In the current orbit it can approach to around 0.3 AU of Jupiter. This type of orbit is typical of Jupiter family comets. The object is estimated at around 800m in diameter.

A/2006 BZ8 [Catalina] This unusual asteroid, of 19th magnitude, was discovered by the Catalina Sky Survey with the 0.68m Schmidt on January 23.43. The orbit is retrograde and current solutions give a period of 30 years with perihelion at 1.90 AU in 2006 July. Gareth Williams notes: Observers with access to large telescopes are encouraged to search for cometary activity in this object. Parabolic and near-parabolic solutions are still possible. [MPEC 2006-B67, 2006 January 27, 4-day orbit]. The object is estimated at around 9km in diameter.

2006 CK10 (Catalina) Announced as an unusual asteroid, of 19th magnitude, it was discovered by the Catalina Sky Survey with the 0.68m Schmidt on February 4.43. The preliminary orbit was retrograde with an inclination of 144 degrees and a period of 150 years. [MPEC 2006-C44, 2006 February 8, 4-day orbit]. Rather as expected further observations showed the object to have cometary characteristics and it was given a cometary designation. The orbit is retrograde with an inclination of 144 degrees and current solutions give perihelion at 1.75 AU in 2006 July. The orbit is parabolic. It will be near solar conjunction when at perihelion.

2006 D1 (P/Hill) BAA Member Rik Hill has discovered another comet during the course of the Catalina Sky Survey. It is a faint 20th magnitude object in a periodic orbit of 13 years and will fade as it is past perihelion at 1.89 AU.

A/2006 DW62 [LONEOS] This Amor asteroid, of 19th magnitude, was discovered by LONEOS with the 0.59m Schmidt on February 26.28. [MPEC 2006-D59, 2006 February 27] It has a period of 5.9 years, with perihelion at 1.17 AU. Its orbit is typical of a Jupiter family comet, and it can pass within 0.1 AU of the giant planet. It is estimated at around 400m in diameter.

2006 E1 (McNaught) Rob McNaught discovered another comet during the course of the Siding Spring Survey on March 11.74. The object is 18th magnitude and reaches perihelion at 6.1 AU at the end of the year.

A/2006 ED1 [Catalina] This unusual asteroid, of 20th magnitude, was discovered by the Catalina Sky Survey with the 0.68m Schmidt on March 4.48. [MPEC 2006-E25, 2006 March 6] It has a period of 5.4 years, with perihelion at 1.41 AU. Its orbit is typical of a Jupiter family comet, and it can pass within 0.4 AU of the giant planet. It is estimated at around 1km in diameter.

A/2006 EX52 [Catalina] This unusual asteroid, of 20th magnitude, was discovered by the Catalina Sky Survey with the 0.68m Schmidt on March 5.26. The orbit is still rather uncertain, but it is retrograde and current solutions give a period of around 255 years with perihelion at 2.57 AU later this year. [MPEC 2006-E36, 2006 March 9, 18-day orbit]. Somewhat surprisingly it is being classed as a plutino, with a 3:2 resonance with Neptune. It is estimated at 9km in diameter.

2006 F1 (P/Kowalski) R Kowalski discovered an 18th magnitude comet on March 21.49 during the course of the Mt Lemon survey with the 1.5-m reflector. The initial orbit suggested that it would reach perihelion at 1.9 AU in 2007 May, when it might reach 13th magnitude. Further observations however show that it is in a periodic orbit [as first suggested by Hirohisa Sato], period 10 years, with perihelion at 4.1 AU in February 2008. The comet appears to have had a recent close encounter with Jupiter.

2006 F2 (Christensen) E Christensen discovered a 20th magnitude comet on March 23.33 during the course of the Mt Lemon survey with the 1.5-m reflector. It is near perihelion at 4.3 AU and has an orbital period of 45 years.

2006 F4 (P/Spacewatch) A 20th mag comet has been found on Spacewatch images taken on March 26.36 with the 0.9-m reflector by R S McMillan and M T Read. It is near perihelion at 2.36 AU and has a period of around 7 years.

2006 G1 (P/McNaught) Rob McNaught discovered another comet, during the course of the Siding Spring Survey, on April 5.70. The object is 18th magnitude and reaches perihelion at 2.6 AU in August. It has a period of around 11 years.

A/2006 GZ2 [Steward] This unusual asteroid, of 20th magnitude, was discovered from the Steward Observatory with the 0.9m reflector on April 7.18. It is in a retrograde orbit with a period of 60 years and perihelion is at 2.9 AU at the end of October. [MPEC 2006-G38, 2006 April 10, 2-day orbit]. It is estimated at around 7km in diameter.

2006 H1 (P/McNaught) Rob McNaught discovered another comet, during the course of the Siding Spring Survey, on April 29.79. The object is 18th magnitude and is near perihelion at 2.3 AU. It is in a short period orbit, with period of 6.6 years.

A/2006 HA6 [Siding Spring] This unusual asteroid, of 19th magnitude, was discovered during the Siding Spring Survey with the 0.5m Uppsala Schmidt on April 20.58. It has a period of 5.5 years and perihelion was at 1.20 AU in early March. [MPEC 2006-H24, 2006 April 21, 1-day orbit]. The object can approach to within 0.2 AU of Jupiter and 0.22 AU of the Earth. It is estimated at 600m diameter.

A/2006 HR30 [Siding Spring] This Amor asteroid, of 19th magnitude, was discovered during the Siding Spring Survey with the 0.5m Uppsala Schmidt on April 20.78. It has a period of 22 years and perihelion is at 1.23 AU in early January 2007. [MPEC 2006-H40, 2006 April 26, 9-month orbit]. The object could reach 14th magnitude when at perihelion. It can approach to within 0.6 AU of Jupiter and a similar distance from the Earth.

A/2006 HW51 [Siding Spring] This unusual asteroid, of 18th magnitude, was discovered during the Siding Spring Survey with the 0.5m Uppsala Schmidt on April 23.49. [MPEC 2006-H56, 2006 April 28] It has a period of 1000 years and perihelion is at 2.3 AU in late September. It has aphelion at 200 AU and can approach within 0.6 AU of Saturn. It is currently classed as a scattered disk object or cubewano and has an estimated diameter of 18km.

A/2006 HY51 [LINEAR] This Apollo asteroid, of 18th magnitude, was discovered by LINEAR on April 26.35. [MPEC 2006-H57, 2006 April 28] It has a period of 4 years and perihelion is at 0.08 AU in early July. It can approach within 0.09 AU of Earth, but with aphelion at 5.0 AU can only approach within 0.9 AU of Jupiter. It is estimated at 2km diameter.

A/2006 HZ51 [Catalina] This Amor asteroid, of 20th magnitude, was discovered by the Catalina Sky Survey on April 27.16. [MPEC 2006-H58, 2006 April 28] Further observations show that it is rather less interesting, with a period of 3 years, although it is a PHA approaching within 0.06 AU of Earth.

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

Comet Section CCD meeting (Part II)

2005 May 14

Part 1 appeared in the last issue, which is available as a pdf on the Section web page.

Nick James introduced Giovanni Sostero. He noted that Giovanni was one of the most active comet imagers in Europe and that he was also active in cometary photometry. Giovanni started by introducing some image processing algorithms that had been developed for the enhancement of faint cometary details. He said that the CARA group (Cometary Archive for Amateur Astronomers) included a team who were very skilled in developing tools for the popular Astroart package and that they had taken two algorithms used by professionals and made them more accessible to amateur observers.

The first algorithm was called azimuthal median subtraction. This creates a map of pixel intensity across the coma by using the median value of pixels in a series of concentric circles centred on the false nucleus. The median image is then subtracted from the real image to give a map of the coma which shows brightness differences. This map makes subtle photometric details apparent in the final image. The second algorithm was the radial weighted method. This works in a different way by making a synthetic coma using a 1/r law for the variation in brightness with distance from the coma centre. The 1/r law is what would be expected for an ideal coma made up of dust. The final image is the difference between the original image and this synthetic image and shows variations from the theoretical dust-only coma.

Giovanni also mentioned the Larson-Sekanina method which emphasizes radial detail. He said that it was interesting to compare these three methods. If a feature was visible using all three then it was likely to be real but if it was only visible in one it was probably an artifact. Giovanni illustrated this by showing some images of C/2004 Q1 (Tucker) processed in each of the three ways. These showed considerable detail which was not visible in the original images but which was consistent between methods. These methods really only work on bright comets and it is very difficult to enhance structure if the image SNR is small.

Giovanni now discussed the use of optical filters. He commented that the comet spectrum shown by Mark Kidger earlier in the meeting was one of a quiet comet where most of the light was reflected solar continuum. Frequently comets, particularly the brighter ones, were strongly contaminated by emission lines from ionised gasses. In these cases the light from the comet is made up of broadband scattered sunlight from dust and narrowband emission from various molecular species in the coma and tail. Depending on the comet these two contributors could be equal or one could dominate the other. Giovanni showed the spectrum of C/1996 B2 (Hyakutake) and Very strong emission lines could be seen, particularly the C_2 Swan bands around 513 nm and strong CN emission in the blue). These emission lines could lead to incorrect photometry if broadband unfiltered detectors were used.

The CARA group had considered whether it would be possible to use standard photometric filters (e.g. Johnson). They had concluded that they were better than nothing but that they were still too wide in many cases. For this reason professionals use narrowband interference filters but these are usually too expensive for amateurs. The CARA group has selected some filters which are very close to the professional ones but which are easily available from companies such as Edmund Optics. The cost is then much more reasonable (a 25 mm diameter filter costs around $90). CARA have used these filters to image CN (at 390 nm), C_3 (430 nm) and CO^+. They have also selected filters to isolate bands where there are no emission lines since this allows us to study the dust, unpolluted by gas emission. These filters have a very narrow bandpass of only 10 nm (FWHM) and so are only practical for bright comets. With fainter comets, such as 9P/Tempel, exposure times of an hour or more are necessary.

When put together the mathematical algorithms and the optical filters were a very powerful tool. Giovanni showed images of the inner part of the coma of C/2004 Q2 (Machholz) taken in January 2005. The CN emission line filter shows structure in the central condensation whilst the dust continuum filters show a fan opening towards the Sun.

The next part of the talk dealt with photometry. Giovanni described how he had seen a rapid evolution in this aspect of cometary astronomy and that what was needed for consistency was a procedure that amateur observers could follow. Giovanni said that he mostly agreed with Mark Kidger but that there were a few areas where they had differences, in particular he thought that optical filters were essential. He showed a spectrum of C/1995 O1 (Hale-Bopp) to illustrate this. He agreed that there were many instances where comets had no strong emission lines but that it was impossible to know for sure unless you had a spectrum and these were hard to come by. To have a general method that will work properly in all cases it is necessary to use filters. Giovanni also pointed out that the spectral sensitivity profile of CCDs varies considerably and so this would affect unfiltered estimates. As far as CARA are concerned there is no shortcut and so filters must be used.

The other problem is that there is no convincing definition of what defines a comet's magnitude! What do we measure given that the coma gradually merges with the sky? The Spanish group use a 10 arcsecond aperture and larger multiples of this. CARA does something similar but their aperture is defined in terms of physical size at the comet and they have decided to fix a reference window of 100,000 km or smaller. The first test was on C/2000 WM1 (LINEAR) in 2001 November. This was a comet with some gas contamination and this meant that the AFRho calculated using different colour filters showed different results. Unfiltered photometry would have definitely been affected by the gas emission in this case, without appropriate filters the measurements do not have a real physical meaning as far as AFRho is concerned. Giovanni said that only by using narrowband filters can you be sure to get consistent results.

Giovanni showed some examples of work with 9P/Tempel. This comet has a very low level of gas contamination and so the results measured with broadband filters, no filters and narrowband filters were similar. One of the problems with 9P was that it shows a very steep change in AFRho with aperture size which is unusual. In theory, assuming a canonical steady-state coma model, the coma should have the same AFRho no matter what photometric aperture was used. In the case of 9P the different results must mean that the model is wrong. Professionals think that there may be some seasonal effects at work here. Some parts of nucleus are more active at certain distances from sun and at certain phase angles.

In conclusion Giovanni said that the CARA photometry is comparable to professional results to within 10-15% and that they were good enough to have been published in some papers in the last few years.

After Giovanni's talk there was an open forum discussion of the various issues that had been raised. Denis Buczynski asked "Which method should the BAA Comet section adopt?" Giovanni described the selection of one method or other as a "lifestyle choice". The Spanish method may work 90% of the time but what about the 10% of comets where the observations were contaminated by gas? The Italian method was more complex but is did work on all comets.

Mark Kidger argued that that most comets did not suffer from significant gas contamination. Giovanni had shown the bright ones near to perihelion and Mark agreed that in these cases filters were necessary but for the vast majority of faint comets the Spanish method was effective and much simpler for the observer. Buczynski asked whether Giovanni observed faint comets far from perihelion with the same filters? In reply Giovanni said that CARA did not use narrowband filters below around magnitude 11.5 since exposure times would be too long. In these cases they used a broadband R or I filter. Mark commented that, for a periodic comet, 3AU out, it was a pretty safe bet that it would not have significant emission line activity. In conclusion Giovanni and Mark agreed that the Spanish method was appropriate for most faint comets which were far from Sun although Giovanni did question whether this was appropriate faint comets such as 9P/Tempel.

It was clear that 9P/Tempel was rather unusual and Giovanni wondered why the Spanish measurements of AFRho were 3-4 times bigger than the measurements made by other groups. Mark said that, since in this case AFRho was strongly aperture dependent, they were affected by the small aperture size. The Spanish AFRho values computed for larger apertures were more consistent with other data. Responding Giovanni said that he was not convinced since he had made measurements with the same 10 arcsec aperture and obtained an AFRho of 250 cm whereas the Spanish result was 750 cm. Something was wrong. After some discussion both agreed that 9P was a comet with unusual behaviour.

Nick James asked whether anyone using Spanish method used an R broadband filter. Mark said that some in the Spanish group were and he recommended this for the BAA since it did at least eliminate some observational variability.

Karen Holland asked Mark Kidger whether it would be possible to work out the transformation coefficients of various unfiltered CCDs in the way that Richard Miles had already done with some Starlight Express cameras. In most cases they had a response approximating R band in any case. Mark said you could do this if the spectrum was purely reflective but this method could not cope with narrowband gas emission. Since there is hardly any cometary spectroscopy now you wouldn't know how strong the gas contribution was. He was hoping to see more spectroscopy from amateurs in the future so that the applicability of various methods could be checked.

Mark pointed out some problems with the Italian method for comets observed over a large range of geocentric distances. He cited an example where the range of geocentric distance was a factor of 10. Since CARA were using a fixed physical aperture size this would change by factor of 10 between the furthest and closest observations, say from 20 to 200 arcsec. This would cause big problems if the sky background was bright. Usually a fixed angular aperture was better since, if the comet obeys the rules, the AFRho is independent of aperture. He acknowledged that 9P did not obey these rules! Giovanni said that he did not find problem with 3 arcmin aperture since their CCDs generally had a 10-15 arcmin field of view. Of course they needed a very accurate sky background correction in these cases. Mark responded by stating that he didn't think that it would be possible to get a good sky subtraction at this aperture. Giovanni said that, in these cases, they could reduce there aperture down to 25,000 km for instance. Giovanni further pointed out that the fixed angular aperture sampled different parts of the coma depending on geocentric distance whereas CARA were always observing the same volume at comet. To counter this Mark said that the Spanish observers now provide results in multiple apertures so that he can interpolate any aperture dimension that he wants.

To conclude Giovanni said that it was not important what he or Mark said about their respective methods. In the next few years it would become clear which method was most accepted by the number of third parties who used the data.

The next speaker was Jonathan Shanklin who was going to talk about his historical perspectives on comet observation. Jonathan said that some of the oldest comet observations were Chinese recordings made on silk. This medium was no longer popular but he had once received a record of a comet on a tapestry! The earliest Babylonian records are of Comet 1P/Halley and this comet is again recorded in woodcuts made at its return in AD66. The most famous Halley record is, of course, the Bayeux tapestry although it wasn't a particularly realistic portrayal.

In the middle ages comets were considered to be omens of doom but by the 15th century people were getting a better idea of what they were and had rediscovered what the ancient Chinese had known that comets tails point away from the Sun. The 17th and 18th centuries saw the production of magnificent star maps and the major advances of Halley and Newton allowed much more accurate predictions of comet's orbits. Hevelius recorded many comets and he would frequently record multiple nuclei. Today we know that most comets do not have multiple nuclei but Jonathan suggested that visual observers should use higher magnificiations to get early indications of any breakups that do occur.

The 18th and 19th centuries produced a number of particularly spectacular comets. One iconic image was made in 1744 and shows the multiple tails of Comet de Cheseaux rising above the horizon. These days we think that these may have been synchrones in the dust tail. Another spectacular comet was Comet Donati in 1858. Shanklin showed a picture of this comet with the old Northumberland dome in the foreground and compared it to a picture of Hale-Bopp with the modern dome. The Earth passed through the tail of Donati and perspective gave rise to great spreading rays in the sky which must have been particularly spectacular. Shanklin presented a series of woodcuts and copper plates which showing parabolic structure, rays and spines in the inner coma of Donati. These were very similar to the features visible in Hale-Bopp under high power.

Jonathan moved on to discuss the prospects for Deep Impact and speculated on the effect that the impact would have. The observational circumstances from the UK were poor for the July 4 impact. On the south coast the comet would be 15° up at the end of nautical twilight and so there was a chance of seeing it if it brightened dramatically. At the latitude of Cambridge it was only 10° up at end of nautical twilight and further north it was even worse. In 1983 the comet had reached 10th magnitude and in 1994 it behaved in a very similar way but since it came a little closer it reached 9th magnitude. Extrapolation of recent observations suggested that it wouldn't get brighter than 10th magnitude this year unless something dramatic happened. The impact was due when the comet was near perihelion and about 1 au from the Earth. Jonathan thought it unlikely that the impact would increase the active area by more than a factor of two so he expected that the best we could hope for was an increase to magnitude 9 or possibly 8. If this were the case it would be a very difficult observation from the UK given the low elevation.

The final talk was by Denis Buczynski on "discoveries, tools of the trade". Denis said this was to be a light talk since most of the meeting had been rather heavy! He was going to talk about various famous comet observers and the instruments they have used. Discoverers in the 18th and 19th centuries used instruments that would not be considered suitable today. Denis showed a picture of Pons' brass short-focus refractor on an alt-az mount. He had used this to discover 37 comets from France. William Tempel also used a refractor on a strange alt-az mount that allowed him to adjust the height of telescope. Other famous visual comet observers were Edward Emmerson Barnard, in his early days before he moved to the professional world, and John Mellish both of whom used 5-inch refractors. Another common feature, as Denis noted, was that comet discoverers needed to wear a substantial hat in those days.

Denis pointed out that these discoverers had to be hardy folk. Lewis Swift observed from a rooftop on top of a cider mill. He left the telescope tube on the roof but carried the lenses up and down a 100ft ladder! Other discoverers roped in assistants to help with the work. The Reverend Joe Metcalf involved other members of his family in his comet searching and his daughter once wrote that her "brother didn't look forward to the long winter nights when he had to guide father's telescope for hours". The son was never credited with any of the discoveries!

It is worth remembering that comets discovered around that time were usually brighter than magnitude 8-9 but they must have been very difficult to find given that the instruments had such narrow fields of view. Discovery became more efficient as photography was developed. Barnard used the 10-inch Bruce photographic telescope at Lick for Milky Way work and made the first photographic discovery of comet. Photography then became dominant and Max Wolf at Heidelburg found several comets during his photographic asteroid survey.

Nearer home, William Denning, the greatest English amateur discoverer before Alcock used a 10-inch, f/8 alt-azimuth Newtonian for his discoveries. One of Denis' favourite discovery groups was the one based at Skalnate Pleso where a programme had been set up during the 40s and 50s to visually discover comets using large binoculars. They had a team approach and each observer would spend a 90 minutes shift searching the sky. The team found 18 comets and the most successful individual observer was Ludmila Pajdusakova who later went on to a professional career and became president of the Czech astronomical society?

In modern times of course there was George Alcock. Denis showed a picture of a young Alcock using his 5-inch Zeiss binoculars. These binoculars were now in the safe possession of Glyn Marsh. One of George's contemporaries, Roy Panther, made his discovery on Christmas day, 1980 after many years of searching. Roy had built his own telescope and was a modest man so he didn't make much of a fuss about the discovery. He has carried on searching to the present day with no further discoveries.

Denis concluded the talk by showing pictures of Albert Jones and Bill Bradfield. Albert has made a remarkable number of variable star observations but he also discovered two comets, one at beginning of his observing career and one near the end. Bill Bradfield built his own reflecting comet seeker, designed specifically for his own height and made of bits found in scrap yards or bought in DIY stores. Despite appearances this was a comet discovery machine and his dedication has led to a large number of discoveries.

Nick James thanked Denis for his talk and brought the meeting to a close rather later than expected. He thanked all of the speakers and the audience for the lively open forum session and said that he hoped that BAA observers would start to make serious cometary photometry observations in the near future.

Nick James

[*Special thanks to Nick for transcribing the talks from his recording of the meeting*]

The Comet's Tale is produced by Jonathan Shanklin, with thanks to the British Antarctic Survey and the Institute of Astronomy, Cambridge for the use of computing facilities. E&OE.