Advertisements

Do you have anything for sale, or do you want anything (preferably, but not necessarily astronomical)? Advertise here - no charge.

Apollo 13 film

On the 3rd November there will be a gala showing of the new film ***Apollo 13***. This will be held at Beau Sejour in aid of Maison St Pierre. Tickets cost £12.50, and are available from David Le Conte. The price includes drinks and a super buffet during the interval. Dress is formal. Book by 30 September for good seats.

The film, which has had good reviews, is about the 1970 flight to the Moon. The spacecraft suffered severe damage when a liquid oxygen tank exploded, endangering the lives of the three astronauts on board: James Lovell, Fred Haise and Jack Swigert. The spacecraft was at that time over 200,000 miles from the Earth, and had to carry on around the Moon before returning safely to Earth several days later.

It is a fascinating story, which could have gone tragically wrong, and the film, starring Tom Hanks, is said to be well worth seeing. ¤

Scouts galore

On Tuesday, the 8th August, a whole scout troop, 22 in all, turned up at the Observatory, unannounced! They were visiting the Island, and had seen that the Observatory was open to the public on Tuesday evenings. They enjoyed good observing conditions. ¤

This issue has kindly been sponsored by

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The next newsletter will be published early in November. The deadline for publication materials is 15th October.

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Sagittarius

The Newsletter of the Astronomy Section of La Société Guernesiaise

September/October 1995

Forthcoming events

Terraforming
by Christopher Le Conte
Tuesday, 5th September
8.00 pm at the Observatory

Video Evening and Star Night
Tuesday, 17th October
7.30 pm
at La Houguette School
8.30 pm at the Observatory

and, of course:
Every Tuesday evening
from 7.30 pm at the Observatory
and observing on Fridays if clear

In this issue

Analemmatic sundial for Guernsey

CCD Mosaicing

A lunar mosaic of 41 images

Comets

Inside

Major articles in **bold**

Centre insert

September/October star chart

Terraforming

What on Earth does that mean? Nothing, but it might mean something on Mars! Find out **at 8.00 pm on Tuesday, the 5th September, at the Observatory,** when Christopher Le Conte will describe this space-age process.

Christopher has long been interested in science fiction based on sound science fact. Terraforming may be currently in the realm of science fiction, but, just as space travel, once purely the subject of science fiction, has become a reality, terraforming could be fact in a few decades.

It is the name given to the proposal that a planet currently inhospitable to man could be made habitable by altering its climate. Sounds far-fetched? It is a serious suggestion, and much theoretical work has been done on evaluating the techniques which would be needed to allow man to inhabit Mars, for example.

Christopher's talk will be illustrated.

Video Evening and Star Night

Once again it is time for our annual public showing of videos, followed by observing (weather permitting). The videos start **at 7.30 pm at La Houguette School**, and about an hour later we will head up to the Observatory. Saturn will be well-placed, in Aquarius, its rings barely visible as they are still almost edge-on.

Again, help is needed with this event, which has proved quite popular in previous years. Usually we show several short astronomical videos, or extracts, and anyone who has one they think would be suitable should contact Geoff Falla.

Observatory Day success

Much was accomplished on the Observatory Day held on Saturday, the 22nd July. The six members who came managed to give the main building a thorough clean, and completely painted the main room. The painting of the outside of the C14 building, which was started last year, was also completed. The toilet was cleaned, weeds were cleared, and quite a bit of reorganisation was carried out.

There still remain some jobs to be done, so any member who feels the urge is welcome. In the meantime, many thanks to those who came on Observatory Day: Roger Chandler, Geoff Falla, Heather Froome (and her daughter), Sean Harvey, David Le Conte, and Bert Ozanne

Barbecue observed, but not shooting stars!

The annual barbecue was held on the 11th August in the best weather conditions for some years. About 15 people enjoyed a beautiful evening at the Observatory, and, for the first time, Section members must have been out-numbered by guests, including several from other Sections, and visitors Richard Gledhill and his wife. Richard is a member of the Ewell Astronomical Society.

We were especially pleased to welcome Griff and Betty Caldwell, La Société President and Treasurer, respectively, and Hugh Lenfesty (our landlord). Thanks go to Hugh for again providing the barbecues.

The bright Moon and late hazy conditions meant that the count of Perseid meteors had to be abandoned, but good telescopic views of the Moon, Jupiter and other objects thrilled our guests.

Sundials explained

On the 25th July a small, but appreciative audience, including Eric Snell, designer of the Liberation Monument, heard Richard Mallett talk about sundials.

Richard was a founder member of the British Sundial Society. He described how the Society has grown in just a few years to a membership of about 500. It has so far catalogued some 2500 sundials in the British Isles – an impressive number, until you realise that this is estimated to be just 10% of the total.

Richard showed many colour slides of sundials all over Britain, and some elsewhere, illustrating the various types of dial. These included the hollow, hemispherical dial invented by the Greeks, scratch dials, equatorial dials and armillary spheres, modern dials, and some very complicated ones (such as the Queen's College dial in Cambridge, which tries to show solar time, the time from noon, sunrise, sunset, the length of the day, the zodiac sign, and the month, as well as being a Moon dial!).

Above all, the illustrations showed how beautiful and ornamental sundials can be, as well as being functional.

One of the oldest dials in England is the 670 AD Bewcastle Cross in Northumbria, a plaster-cast of which is in the British Museum. Richard showed many old dials on English churches (we have a few in Guernsey, too), which divided the time between sunrise and sunset by 8 (before the Norman Conquest) or 12 "hours". Their purpose was simply to indicate the times at which services were held. The period of the "hours" therefore varied with the season and place.

This was a fascinating talk, well presented.

Congratulations

. . . to Daniel Cave, who, once again, has had a picture accepted for publication in the national *Astronomy Now* magazine. The September issue includes his 15-minute CCD image of the Sombrero Galaxy, M104, taken with the 14-inch telescope. The Astronomy Section and La Société were acknowledged. This is the third time that Daniel has had an image published in the magazine – he is getting to be a regular contributor!

Open evenings continue to attract visitors

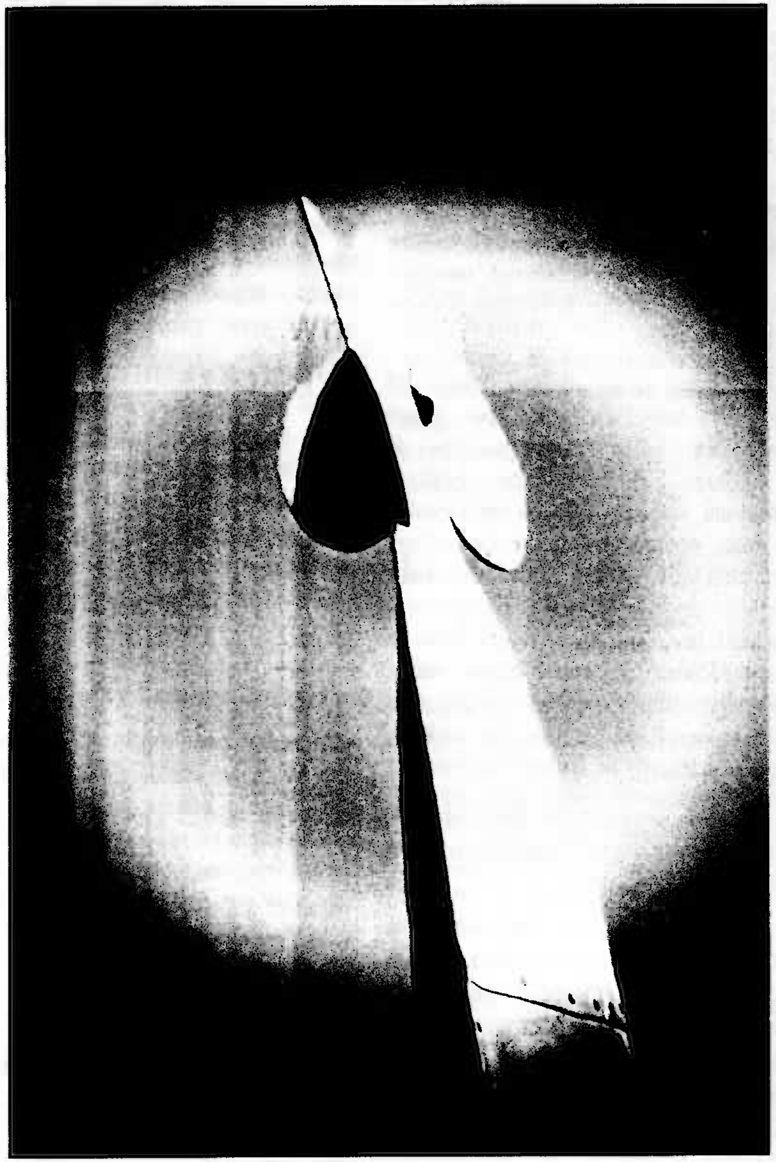
The opening of the Observatory to the public from 9.30 pm on Tuesday evenings has continued to be a success, with steady numbers, typically 12 to 15, coming on most weeks when the sky is clear. Most have never seen through a large telescope before, and they therefore appreciate the opportunity given by the Section.

There has been a mix of locals and visitors, many with children. Some have come more than once. They have gone away knowing a bit more about the night sky and what the universe contains, and with a greater awareness of it. The Section has also been provided with a small but steady flow of much needed funds.

Observatory on video

The Education Development Centre is making a video about the Liberation Monument. In July, David Le Conte was interviewed at the Observatory, against the background of the C14 telescope, about the Section's role in the design and construction of the Monument. ¤

What is it?



It's obviously not astronomical, so what's it doing here? And why was the Astronomy Section asked to take a picture of it? Find out on page 7.

Famous Lives - 10 Edwin P Hubble (1889 - 1953)

You will recall that Herschel called what today we term galaxies "*island universes*", as far back as the mid-18th century. However, it was not until the early 20th century that conclusive proof was found to acknowledge that Herschel's island universes were in fact separate and distinct galaxies, many millions of light years away from our own.

The man credited with this remarkable discovery, and others, is Edwin Powell Hubble, the American astronomer. He was born on the 20th November 1889, and conducted the majority of his work using the 100-inch Mount Wilson telescope (then the largest in the world) in California. He was a graduate of Chicago University, and also spent some time studying at Oxford.

Today Hubble is remembered for giving his name to the "*Hubble Constant*", and its value plays a critical role in all discussions relating to cosmology [1]. He also derived a system of classifying galaxies which is still in use today, and he supplied supportive proof for the theory of an expanding universe, by showing that galaxies are moving away from us at enormous speeds (with the exception of the Local Group of galaxies). In many ways his work laid the foundations of modern cosmological thinking. All this is pretty impressive for a man who practised law in Kentucky before becoming a professional astronomer by joining the staff of the Yerkes Observatory in 1914.

Between 1922 and 1924 Hubble provided the first proof that galaxies were independent, separate bodies outside our own galaxy. He obtained this by studying Cepheid variables in the Andromeda Galaxy, M31. In doing this he was pursuing an old theory, which could be traced back to Kant and Herschel in the 18th century.

Hubble set about measuring the periods of the Cepheid variables, using the 100-inch Mount Wilson instrument, and, basing his calculations on the then figures for the Cepheid Scale, he found that the distance of the Galaxy was 900,000 light years, which placed it well outside our own. Today, of course, we know that the Andromeda Galaxy is 2,200,000 light years distant. This was a startling piece of research, and the accumulation of many years of painstaking work.

He also devised a system of classifying galaxies. Using his system, galaxies are placed in two main groups, *elliptical* and *spiral*, with the spiral form evolving from the elliptical, and subsequently sub-dividing into two types, those named *normal* and *barred*. (see figure 1). »»

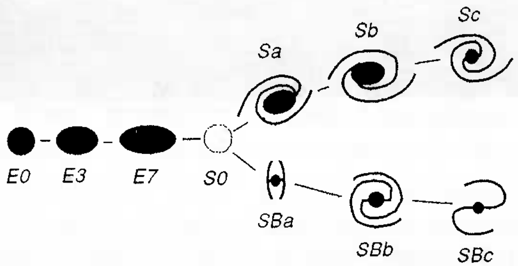


Figure 1. Hubble's classification of galaxies

Present calculations suggest that 60% of galaxies are elliptical, 30% spiral, and 10% irregular. Using this classification our galaxy is an *Sb* type.

His early research led him on to new discoveries which culminated in 1929 with his theory of an expanding universe. By using red shift he demonstrated that the distant galaxies were receding from our own.

Others, notably Slipher (between 1912 and 1925), had already shown this, but it was Hubble who was to go on and formulate a relationship between the distance of the galaxy and its recessional velocity. He found that the greater the distance the greater the recessional velocity.

This relationship is known as *"Hubble's Constant"*, expressed as 55 km per second per megaparsec (1 megaparsec = 1 million parsecs, or 3.26 million light years) [2]. The original figure given by Hubble was 526 km per second per megaparsec.

He once wrote, after his discoveries:-

> *"If the Universe is expanding, it may finally be possible to determine the nature of the expansion and the time at which the expansion began – that is to say, the age of the Universe."* [3]

Hubble's name will forever be associated with the greats of astronomy. His work was epoch making, and paved the way for others, such as Graham Smith and Walter Baade, and the 20th century Isaac Newton: Stephen Hawking. It is interesting to note that Hubble's work compliments Einstein's predictions of an expanding universe.

His name is now truly with the stars, as the telescope which bears his name continues to reveal to us the wonders of the Universe.

This great man of science died on the 28th September 1953, aged 63. ¤

David Williams

References:

1. *Guinness Book of Astronomy,* Patrick Moore, 1988, page 154.
2. *Ibid.*, page 154.
3. *Pioneers in Astronomy*, Navin Sullivan, 1964, page 123.

Figure 1: *Penguin Dictionary of Astronomy*, Ake Wallenquist, 1967.

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The Encyclopædia Britannica

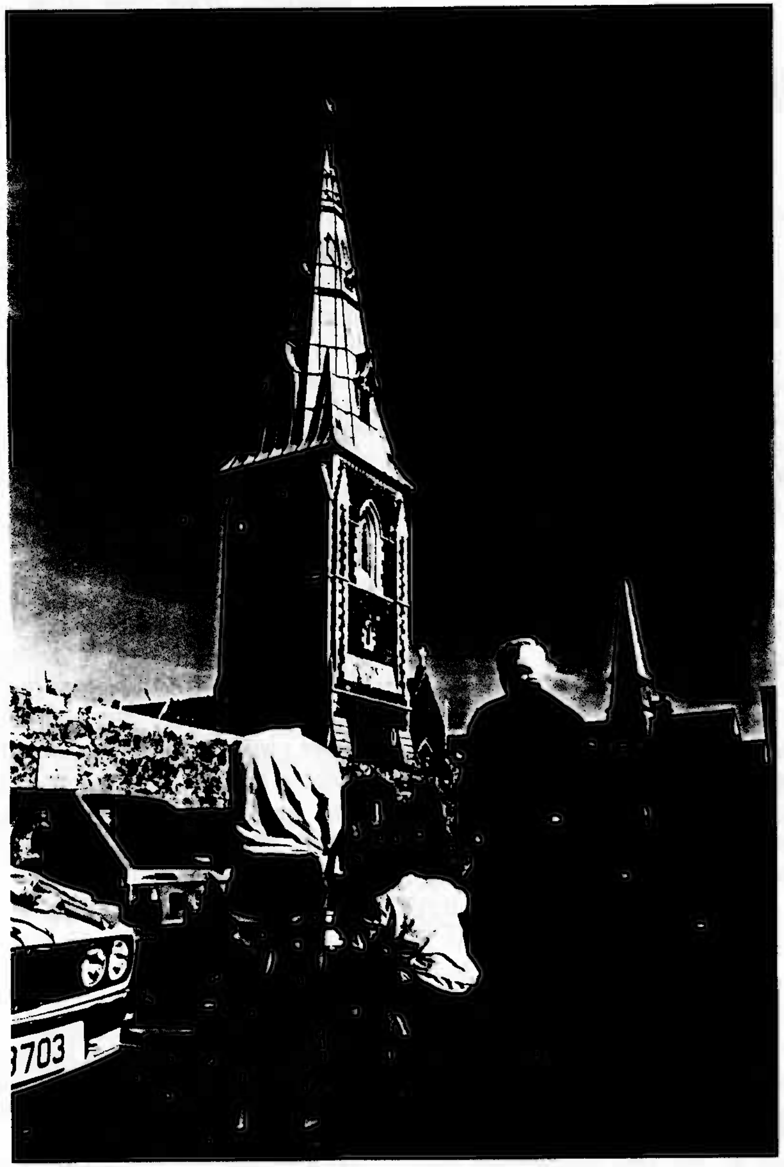
Postscript:

You may recall that, back in the March/April 1994 issue of Sagittarius, I introduced my series of *Famous Lives* with a list containing ten great astronomers, and two 20th century scientists who, strictly speaking, while being great scientists, were not astronomers. However, their work was of such significance to astronomy and the development of modern astronomical and cosmological knowledge and theory, that I felt they deserved inclusion.

Robert Goddard and Wernher von Braun stand out as two of the giants of early rocket research and development in the 20th century. Without their pioneering work the Space Age would still be the domain of the science fiction writers, and the advances we have achieved using the Hubble Space Telescope and other instruments would not have occurred. Astronomy owed them a great debt. ***DW***

David Williams's articles on Goddard and von Braun will appear in the next two issues of Sagittarius.

It's the weathercock on St Joseph's Church steeple



(See page 4.) The Astronomy Section was asked to set up a powerful telescope for architect Andrew Dyke to look at possible corrosion in the support of the weathercock, and to examine the state of the copper sheeting on the steeple. This was done by Geoff Falla and David Le Conte in July. Photographs were taken for record purposes. The photograph above shows Andrew looking through the 11-inch Celestron telescope, while Canon Hetherington and Geoff look on. Powers of 100 to 400 gave superb close-up views, and the method saved the unnecessary erection of a lot of scaffolding! (Photographs by DLC.)

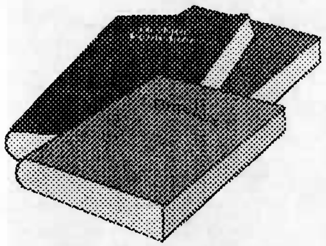
Book Review

Here I AM!

by Russell Stannard

published by Faber & Faber

Price £3.99



This delightful book is written by the author of the *Uncle Albert* series, and is equally as witty, absorbing and interesting as that wonderful series. The final title in that series is *Uncle Albert and the Quantum Quest* – a review will follow at a later date.

Back to *Here I AM!* This book is an attempt to show that science and religion are compatible and not at odds. The title derives from the Old Testament, and is also used by Jesus in the New Testament. When Moses asks God what he should tell the people, God replies: "Tell them that I AM that I AM." *cf Jesus: " I AM the bread of life, I AM the light of the world, etc."* However, enough of the RS lesson.

Stannard has written another winner for children, as he introduces them to the wonders of the universe and the possibility that all is not just chance, but the result of a Supreme Creator and Sustainer. All this is accomplished by the relationship that is forged between teenager Sam and his computer – as God uses the computer as a 20th century means of communication.

The games and conversations that follow reveal the universe, and address difficult questions: "*What about all the suffering in the world – I thought you were a loving God?*" asks Sam – he gets his reply.

As with all his children's books, he finishes by posing a question – he makes his readers think about his book and what they've been reading.

This is a splendid book for children and adults alike, and, yes, I am a fan. ¤

David Williams

Have you bought a new astronomy book lately? Or borrowed one from the library? If so, why not write a review for Sagittarius?

Did you know?

Outer planets visible (ie near opposition) in the summer tend to be low in the sky, as seen from the northern hemisphere, while those visible in the winter tend to be high. This is because they are near the ecliptic (the apparent path of the Sun amongst the stars), the night side of which is low in summer and high in winter. The Sun, which is on the opposite (day) side of the ecliptic, is high in summer and low in winter.

You can see this effect by using a planisphere. Watch how the height of the night-time side of the ecliptic changes during the year.

Over the last few months we have enjoyed watching Jupiter, especially its moons circling the planet and sometimes passing in front of and behind it. In the next few months it will be the turn of Saturn – getting higher in the sky. ¤ ***DLC***

Be a gnomon! by David Le Conte

The ***analemmatic sundial*** – it's quite a mouthful! Perhaps "fundial" would be a better term, as it's a sundial for audience participation. If you want to use it you have to put yourself into it, because the time is indicated by your own shadow.

Usually, sundials have a *gnomon* – a stylus whose shadow indicates the time. And usually the gnomon is designed to be parallel to the Earth's axis (hence the fixed, sloping gnomons of garden type sundials).

The gnomon of the analemmatic dial, however, is *vertical* and *movable*. Its position depends upon the month. Depending on the size of the dial, the gnomon can therefore be a movable vertical pin, or it could be anything that can be moved, such as a person!

I have calculated the dimensions for a life-size analemmatic sundial, and these are shown on the centre pages of this issue. Note that it can be proportionately scaled up or down.

The actual construction can be done in several ways. For example, it can simply be painted on the ground, or the hour marks could be small wooden posts with the numbers painted or carved on them. It can be as decorative or as simple as you like. In testing my calculations I laid it out with (empty) peanut butter jars!

Note, however, that it must be orientated accurately towards the true north direction, so if you use a compass you must make a correction for magnetic variation. The best way to determine true north is to use the Pole Star, making allowance for its offset in azimuth from true north at the time of observation.

I would be happy to help anyone thinking of making an analemmatic sundial – both in its construction and in finding true north.

There are signs that an analemmatic sundial will be painted in the playground of one of Guernsey's schools in the near future. If so, I hope to be able to publish a photograph in a future issue of Sagittarius.

Where does the name *analemmatic* come from? Obviously, it must be associated with *analemma*, which we know as a figure eight pattern of the Sun's position at noon over the course of the year (and which is often depicted on old terrestrial globes).

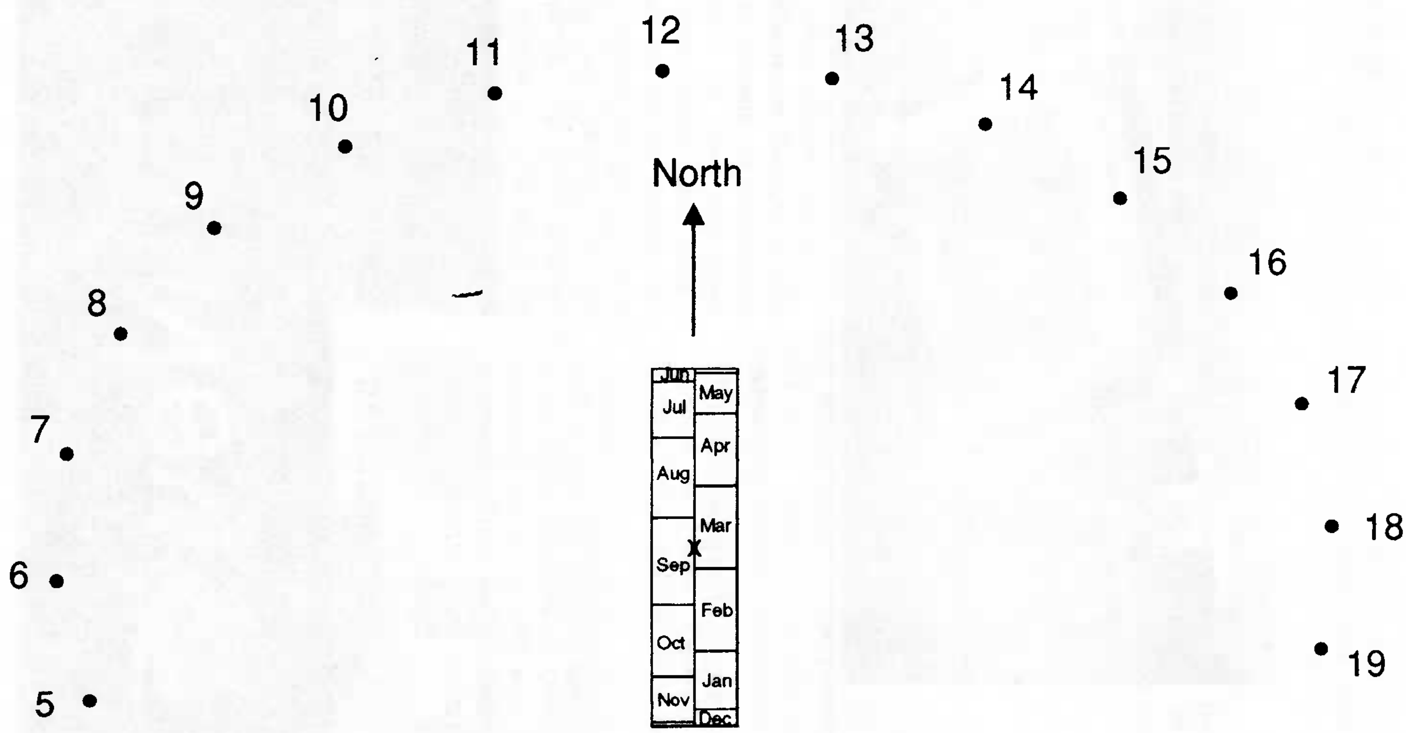
However, in their book *Sundials*, Mayall and Mayall say that to the Romans the analemma was an instrument and method of projection used for demonstrating and solving some of the common astronomical problems. They point out that the Roman architect Vitruvius wrote a *Treatise on Architecture*, in which he said that anyone could construct sundials "provided only he understands the figure of the analemma".

The *analemmic curve* is dependent upon the Equation of Time, which has been the subject of a previous article in Sagittarius. It is a plot of the apparent Sun relative to the mean Sun. Perhaps the curve will be the subject of a future article.

Mayall and Mayall say that the chief use of the analemmatic dial was in conjunction with a portable horizontal dial, to enable it to be set properly without the use of a meridian line. A life-size dial, however, can be equally functional, and fun as well.

David Le Conte

AN ANALEMMATIC SUNDIAL FOR GUERNSEY



Dimensions of time marks

GMT (hr)	E-W distance (mm)	N-S distance (mm)
5	1906 W	460 S
6	1998 W	70 S
7	1954 W	325 N
8	1776 W	698 N
9	1478 W	1024 N
10	1079 W	1280 N
11	606 W	1448 N
12	92 W	1518 N
13	428 E	1484 N
14	919 E	1350 N
15	1348 E	1123 N
16	1684 E	820 N
17	1906 E	460 N
18	1998 E	70 N
19	1954 E	325 S

Dimensions of date scale

Date	N-S distance (mm)
1 Jan	555 S
1 Feb	405 S
1 Mar	183 S
1 Apr	97 N
1 May	348 N
1 Jun	525 N
21 Jun	564 N
1 Jul	552 N
1 Aug	422 N
1 Sep	194 N
1 Oct	66 S
1 Nov	324 S
1 Dec	517 S
21 Dec	564 S

All distances are measured from the position marked x

The analemmatic sundial can be painted on a flat surface, such as a school playground. The shadow is cast by a person (acting as the sundial's gnomon) standing on the centre north-south line at the position corresponding to the month. His or her shadow indicates the time, as shown by the time marks (remember to add one hour for summer time).

The dimensions shown above are suitable for a child about 1.5 metres (5 feet) high. The whole sundial can be scaled up or down in proportion.

Time marks after 12 o'clock can, of course, be shown as pm times.

For further information or assistance contact David Le Conte (telephone 64847).

CCD News

CCD mosaicing by Daniel Cave

INTRODUCTION

The charged coupled device (CCD) is generally the astronomer's detector of choice when it comes to observing in the optical wavelengths. A linear response, combined with a very high efficiency (up to about 80%) means that the CCD is as near to being the perfect detector for astronomy as we are likely to see. Today's CCD's, however, do have one major drawback. They are difficult and therefore extremely expensive to produce in large sizes. Currently the world's largest production CCD has a sensitive area measuring 62 by 62 mm with 5,120 by 5,120 pixels (see figure 1). One such CCD chip would cost around $50,000 (about £29,000).

Smaller CCD chips are much cheaper to produce per square millimetre and so mosaicing CCDs together can save large amounts of money. »»

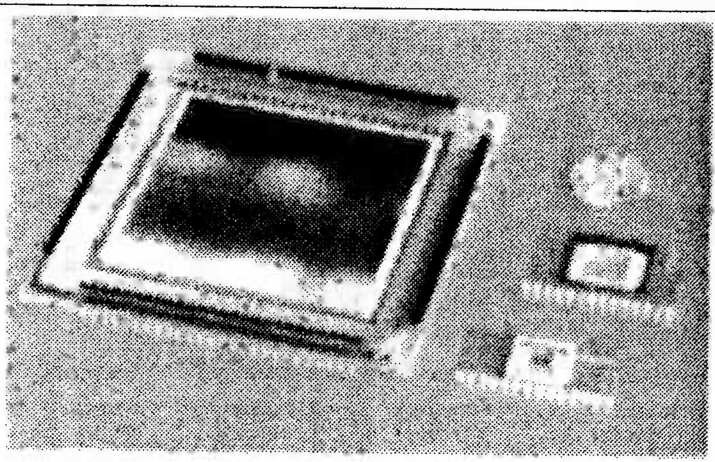
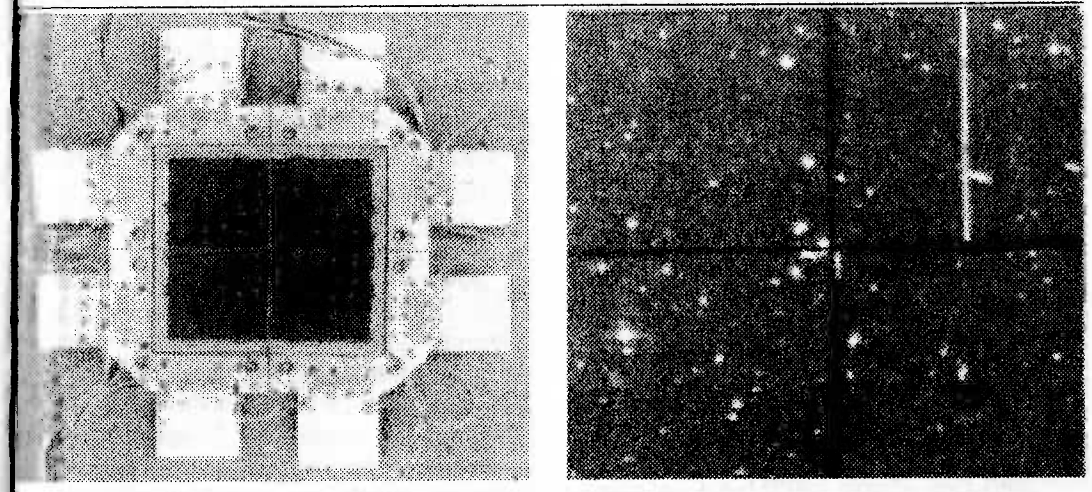


Figure 1
The Dalsa Megasensor (left), the worlds largest CCD has a sensitive area of 5,120 by 5,120 pixels. Whilst such a chip would provide a much larger field of view than conventionally sized CCDs (right), the Megasensor has not ye been tested for astronomical applications.



igure 2a & 2b
n example of a physical mosaic constructed from four 2048-by-2048 CCDs. At right is an image produced using it, t egions of missing data can be clearly seen.

METHODS FOR FORMING MOSAICS

There are several ways in which mosaic images can be produced. A brief discussion of some possible methods for producing images with wide fields of view follows.

Physical Mosaicing of the CCD chips

By manufacturing CCD detectors with the electrical connections limited to only one or two sides, it is possible to place CCDs in very close proximity to each other. In this way large sensitive surfaces can be built up (see figure 2a). There are obviously gaps left between the CCDs causing unrecorded areas in the final image, but these are relatively small in comparison to the whole image array. The dead area is typically around 20-40 pixels in width, and an example image is shown in figure 2b.

This approach is able to make big images as quickly as if one large detector was used, since all the images for the mosaic can be taken at the same time, not sequentially. There are, however, technical problems with the accurate alignment of the CCDs in a mosaic needed to produce high quality images.

Optical Mosaicing of the CCD chips

This method uses mirrors and re-imaging optics to feed sections of an image to physically separate CCDs (see figure 3a). An image is brought to focus on a pyramid of mirrors, each face of this pyramid has a portion of the complete image in focus on it and has a slightly concave surface. The light is redirected by this pyramid into a series of re-imaging optics which form an image of each of the pyramid faces. »»

The complete image has been effectively split into four smaller images which can be recombined electronically later.

The technique produces a camera that is able to record the individual mosaic images at the same time, and so allows a large image to be created quickly. This approach does have some drawbacks, however, most notably the high cost of the additional optics. Also the region of the join is often visible in the final image (see figure 3b).

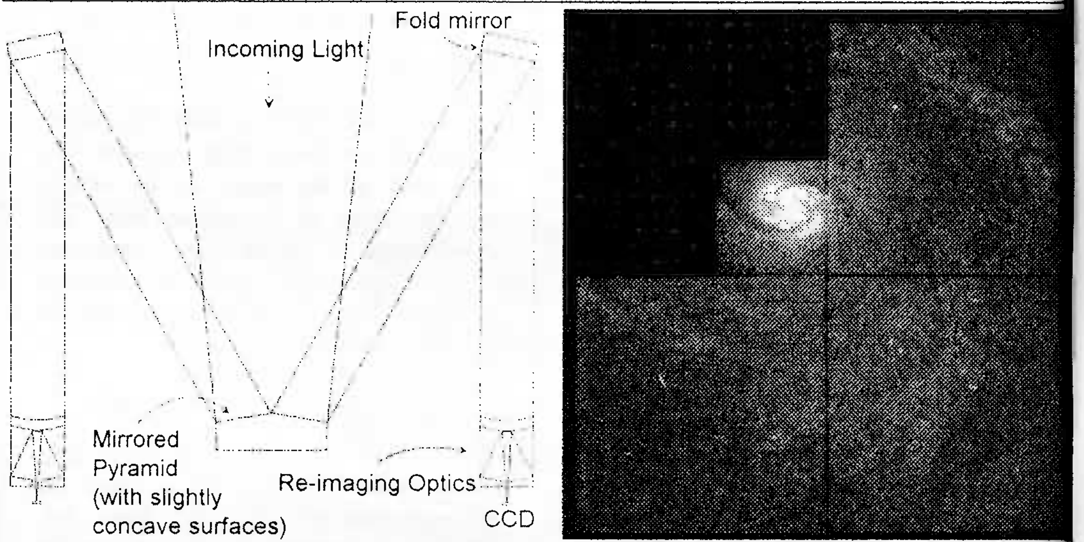
Examples of this design include the Hubble Space Telescope's Wide Field Planetary Camera and the Palomar 200 inch 'Four Shooter' camera.

Scanning Images

Of all the possible methods discussed, this is the cheapest one to implement. By using a low cost linear array, which does not contain a large number of pixels, the amount of ancillary electronics is reduced.

To produce an image, the desired scene is scanned by the array, with the direction of motion perpendicular to the orientation of the CCD.

The CCD is read out at appropriate intervals to give the required resolution, and the strips are reassembled in the computer to create the image. The scanning of the observed object can be achieved simply by switching off the



igure 3a & 3b
. diagram of a camera designed to produce mosaics using 'optical' methods and an image produced using it. In t
ase the Hubble Space Telescope's Wide Field Planetary Camera recorded an image of M100, a spiral galaxy in t
irgo cluster. Joins at the boundary of each image can be seen.

telescope's right ascension drive, or if longer exposures are needed to record faint objects it can be driven at slower than sidereal rate.

This method is able to cover very large areas of sky; in principle a limitless region can be covered (storage space allowing). The major problem with this approach is that it is exceedingly slow, especially if long exposures of faint objects are wanted. Also since each strip of the image is taken at a slightly different time the observer has to be aware of this when interpreting the results.

Software Mosaicing

Software mosaicing involves using one camera to record a series of images, each with a slightly overlapping field of view. After the exposures have been taken, they are stitched together in a computer to produce one large image of the target region.

This method has several advantages over some of the other methods. Firstly the cost is very low in comparison as no new hardware is required. Software mosaicing can be carried out on existing CCD camera systems by simply adding the software to perform the joining. The method also allows for better joining of the images, with less artefacts from the combination process than any other technique. The technique is also highly flexible, allowing images of different exposures, different image scales and different relative rotations to be joined.

Problems encountered when using this technique include it being much slower to produce a mosaic than some of the other methods discussed. This is because each area of sky has to be imaged sequentially. Redundant data is also produced by this technique in order to provide a region of overlap. Finally, as the images are taken at different times (conceivably from seconds up to many months apart) the user must bear this in mind when interpreting the results.

THE LUNAR MOSAIC

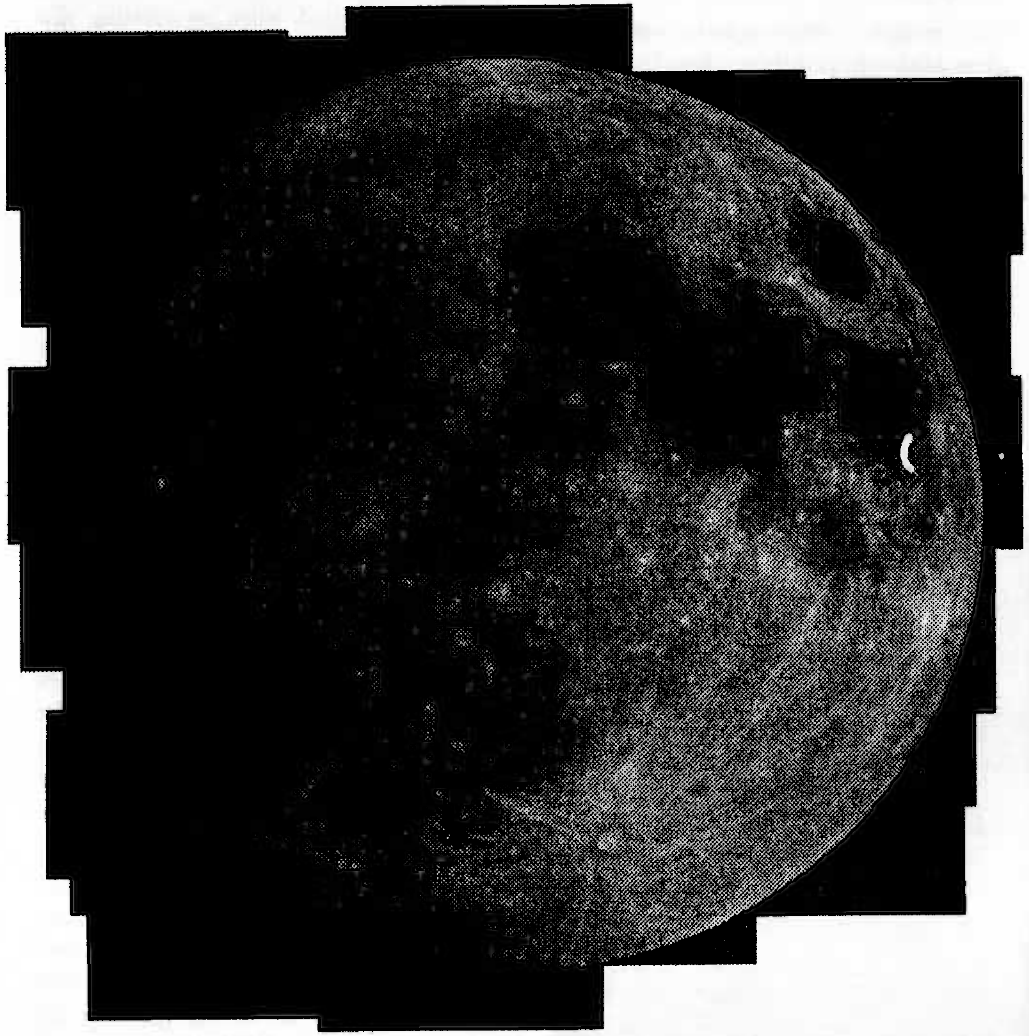
The 41 images used in this mosaic (*see next page*) were taken on the night of 13/14 April 1995. The images were composited using computer software. A Celestron C-14 telescope, working with a focal length of approximately 1950 mm and a focal ratio of about f/30 was used to collect the 0.02 second exposures used in the mosaic. The exposure time was carefully selected so that the brightest feature on the Moon did not quite saturate the CCD.

The individual images were taken with a Starlight Xpress SX camera. Flat fielding did not successfully remove the effects of dust spots on the CCD window, and dark spots are still apparent in some of the images. Due to the shortness of the exposures no dark frame subtraction was required.

The images were joined using bright features on the lunar surface as alignment points. There were a few cases where common features were difficult to find, but eventually all the images were incorporated into the mosaic. Due to the large amount of computer processing required, the mosaic took over three days of work to put together even while using a fast computer.

The final composite image has an image resolution of 1817 by 1476 pixels. When stored as an uncompressed image file it occupies 2.7 megabytes of disk space. »»

The Lunar Mosaic



This image of the Moon was made by Daniel Cave by mosaicing 41 separate images taken with the Astronomy Section's Starlight Xpress CCD camera and the 14-inch Celestron telescope. When shown on a computer screen the image shows a lot of detail and good contrast. The photocopying process used in the production of *Sagittarius*, of course, does not do it justice, especially as the photocopier tends to darken the image and lose contrast. A large-scale printout can be seen at the Observatory.

Comets by Geoff Falla

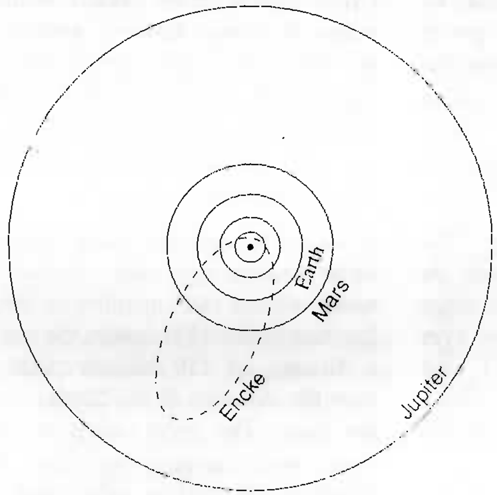
Comets used to be called "hairy stars" before their real nature was better understood. The description was a result of the thin streaks of light seen emanating from the head of the comet as the tail formed on its progress around the Sun and out again into deep space.

The most ancient observations of comets known to science were documented in Chinese annals as far back as the year 2369 BC. Since these early times around two thousand comets have been recorded, including the returns of periodic comets. Most discoveries have been in comparatively recent times. The invention of the telescope has allowed many faint comets to be observed which would previously have gone unnoticed and unrecognized.

As a rule comets only become observable when they are at less than twice the Earth's distance from the Sun, or two Astronomical Units. Comets describe orbits around the Sun in the same way as planets, except that for most comets the orbits are highly elliptical. *Encke's Comet* has an orbital period of only around 3.3 years, the aphelion point being well within the orbit of Jupiter.

In the case of the famous *Halley's Comet*, which returns regularly every 76 years, the aphelion distance at its furthermost point is beyond the orbit of Neptune (*see page 19*).

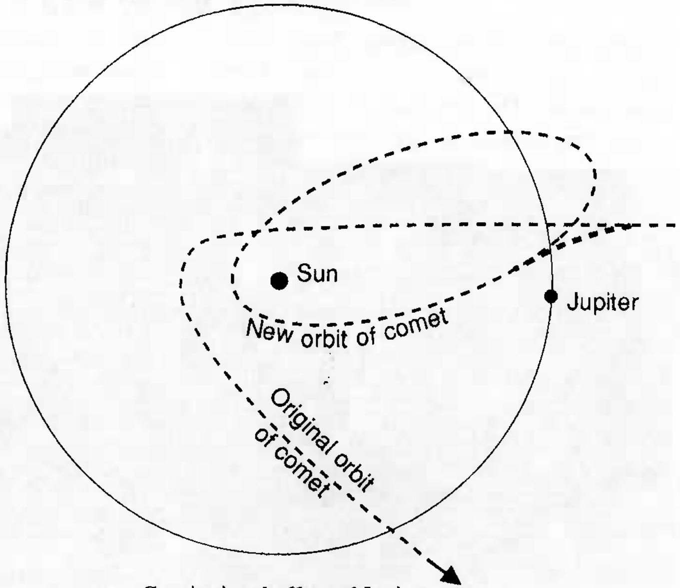
There is a large family of comets which appear to be closely associated with the orbit of Jupiter, and there seems to be a good reason for this. If a comet coming in from the furthest reaches of the Solar System passes too close to Jupiter, which is the most massive planet, the comet will be affected by Jupiter's gravitational field and may be pulled out of its orbit. The comet may either be ejected from the Solar System altogether by a 'sling shot' effect, as used by recent planetary space probes, or the comet may be deflected into an orbit which will thereafter only take it out to the orbit of Jupiter. This appears to have happened many times in the past, giving rise to the Jupiter family of comets.



The orbit of Encke's Comet

The most recent example was *Comet Shoemaker-Levy 9*, which had a different end result. In 1993 the Comet evidently passed too close to Jupiter, was pulled out of its orbit, and broke into fragments. The remains of the Comet then collided with Jupiter in 1994, producing dramatic effects in its atmosphere which could be observed with even relatively small telescopes. »»

Comets are very varied, both in size and shape. They all present a nebulous appearance, a typical comet consisting of a bright *nucleus* surrounded by a luminous cloud, the *coma*. This makes up the head of the comet. Some comets, particularly small ones, may indeed remain as just a nebulous luminous patch in the sky, while others will form the characteristic *tail* which we all wish to see as the comet approaches the Sun.



Gravitational effect of Jupiter

The actual appearance of the tail will vary, depending on the size of the comet and its position in the sky in relation to the Earth. Some comet tails may appear as just a faint streak in the sky, while occasionally a comet tail has stretched up into the sky like the beam of a searchlight. The tail may be curved, and there may be subsidiary jets or tails at different angles. The apparent length of a comet's tail will also depend on perspective as seen from the Earth, while, if the tail extends fairly close to the Earth it will appear wide and fan shaped.

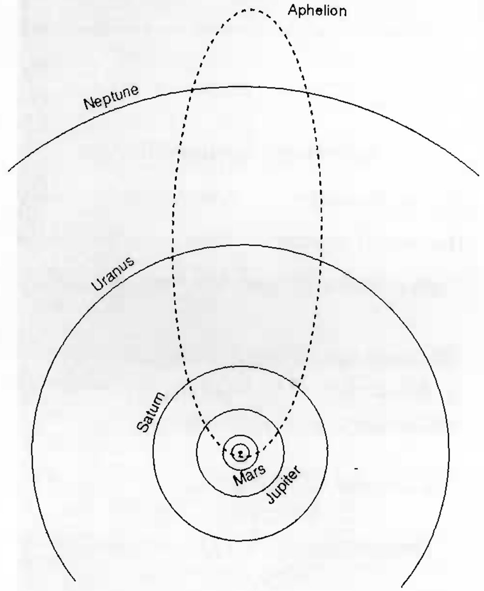
The size of comets can vary greatly. The head of a comet, the nucleus with its surrounding coma, may be on average around 100,000 miles. The largest ever recorded was the great comet of 1811, with an enormous diameter of around one and a quarter million miles – greater than the diameter of the Sun itself.

In contrast, the actual nucleus or core of a comet is considered to be relatively minute, perhaps less than a mile across, and rather fragile in structure since it can be broken up by gravitational attraction, as has happened on several occasions.

In 1986 the European Space Agency's *Giotto* Space Probe passed within a few miles of Comet Halley's nucleus, giving the first ever opportunity for a close-up photograph. Instead of an irregular 'dirty snowball' of astronomical theory, at least one photograph revealed a rather well-defined cylindrical shape.

In transit through the inner regions of the Solar System, the tails of comets often reach several million miles in length. In the case of the 1811 comet the tail reached a distance of 110 million miles, greater than the distance of the Earth's orbit from the Sun. The great comet of 1843 was even more impressive, with the tail reaching 200 million miles, and covering an angular distance of 68° in the sky. »»

In approaching the Sun the tail of a comet is formed by the pressure of solar radiation acting on the gas and dust particles making up the comet, so that the tail points away from the Sun. As the comet reaches perihelion and passes around the Sun, the tail changes direction rapidly so that in leaving the vicinity of the Sun the tail is in front of the comet. In its passage near the Sun, the temperature of the comet's nucleus increases, emitting sodium vapour with a characteristic yellow radiation. Sometimes this is bright enough to be seen in daylight, as in the case of *Comet Skjellerup* in 1927 even when just a few degrees away from the Sun.



The orbit of Halley's Comet

A comet is always to some extent unpredictable, so the appearance and behaviour of any new comet, particularly a potentially bright one, is a rare celestial event awaited with great interest. ¤

Geoff Falla

New comets discovered

There is excitement about the discovery of a comet, named Hale-Bopp after its discoverers, beyond the orbit of Jupiter, at a magnitude of 10½ – bright for such a distance. The International Astronomical Union's Central Bureau for Astronomical Telegrams, at the Smithsonian Astrophysical Observatory, says that its orbital characteristics are similar to those of the great comet of 1811, and it could therefore become a spectacular object. It is due to reach perihelion in the Spring of 1997, when it might be as bright as magnitude -1½!

It is currently very low in our southern sky – almost on our horizon – and attempts to see it from the Observatory have so far been unsuccessful. It is moving slowly northwards, and we hope to glimpse it soon.

William Bradfield discovered his 17th comet on the 17th August. At 6th magnitude it is quite bright (on the limit of naked eye visibility), but cannot be seen from the northern hemisphere. ¤ ***DLC***

Did you know?

In the 19th century an award of $200 was made in the United States for each new comet found. E E Barnard (of Barnard's star fame) had a comet hunting programme, and managed to meet his mortgage commitments on a new house by discovering new comets just as payments became due. So much of his home was financed through comet money that it became known as the 'comet house'. ***DLC***

– from *Observing Comets, Asteroids, Meteors, and the Zodiacal Light* by Stephen J Edberg and David H Levy