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EDMOND HALLEY M.A. (OXON), D.C.L.(OXON), FRS
(1656 – 1742)

by

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Halley, like Newton, Darwin, Einstein and many others, is one of the few scientists whose names are familiar to us all. Like these other scholars the facts for which we remember him represent just part of a life rich in experience and recognition and it is often interesting to reflect on the way in which the identified work is wrapped within an entire career of creative endeavour.

Halley was the son of a wealthy city merchant, born in late 1656 (variously reported as October 29 and November 8 depending on the calendar used) during the Cromwellian rule and at the age of 10 in 1666 saw the Great Fire of London.

His early education was in St. Pauls Cathedral School where he became School Captain in 1672 at the age of 15. Always fond of practical science Halley carried out measurements on the earth's magnetic field in London during the following year and subsequently astronomical observations using instruments which he had either purchased or constructed. Entering Queens College, Oxford, in 1673 he was involved in studies of both geometry and astronomy and two years later derived the first conclusive geometrical proof of the location of the sun at the focus of elliptical planetary orbits.

In an attempt to improve on the results of Tycho Brahe for the prediction of planetary positions, Halley set out to establish a catalogue of the positions of southern stars which would complement similar measurements being made by Hevelius (in Danzig) and Flamsteed, the first Astronomer Royal (in Greenwich) to provide a reference system of stars over the entire sky.

Supported by his father, he chose the island of St. Helena in the Southern Atlantic 1500 miles west of Africa and left England in the company of the Secretary of State and Sir Jonas Moore on the three month journey.

In two years of observation, with enormous problems caused by the weather, he managed to accurately position 341 stars. In this time he also observed the change in the rate of his clock pendulum in the vicinity of the equator caused by the increase in the local gravitational attraction, various solar and wind eclipses and the first complete transit of Mercury across the solar disc.

On his return in 1678 King Charles instructed the University of Oxford to confer on Halley a Master of Arts degree for the achievements he had made. In similar recognition the Royal Society elected him as a Fellow in November 1675.

In an effort to replace open sights on astronomical instruments with telescope sights Halley visited many of the recognized observational astronomers of his time. During these visits the great comet of 1680 was visible and Cassini (after whom the major division in the rings of Saturn is named) suggested a relation of the 1680 comet to that of 1577 (recorded by Brahe) and another of 1665. A lasting interest in comets resulted from this chance meeting.

After returning to England, Halley married Mary Tooke in late 1684 (again an event with various recorded dates). They had three children who survived to adulthood, the only son Edmond becoming a naval surgeon. The daughters Catherine and Margaret outlived their father.

In attempting to show that Kepler's third law for elliptical orbits required an inverse central force based on the sun at one focus, he, along with Robert Hooke, were challenged by Christopher Wren to provide a proof. In their efforts, Halley learned from Newton in August 1684 that he (Newton) had solved the problem some considerable time previously. During the relationship which followed Halley was instrumental in persuading Newton to publish his Principia, which finally appeared in 1687, one year after Halley had been appointed as Clerk to the Royal Society.

His work as Clerk led him to considerable experimental studies and formal lectures. This work covered a wide range of topics from the global circulation of air and water, to the thermal properties of liquids and gases and on the development of new methods of artillery. He was also involved in a number of mathematical problems at this time, publishing papers on cubic and quadratic equation solutions.

The association with Newton resulted in the latter appointing Halley as his deputy when he himself became Warden of the Mint in 1696. It also led to an awareness of the new calculus, which was used by Halley to simplify optical calculations. In turn, Lagrange who was one of the great mathematicians, was influenced by the publications describing this work in optics and moved away from the classical geometry towards the modern mathematics and analysis, subsequently developing all the Newtonian concepts in the form which we now know them.

The year 1698 saw Halley appointed as Captain of the naval ship HMS Paramour and responsible for establishing a detailed map of the earth's magnetic field and a more restricted study of the tides in the English Channel.

Eventually, Halley was appointed to the Savilian Chair of Geometry at Oxford on January 8, 1704. From this position, among many other things, he published his work on comets. This work, entitled "Astronomiae Cometicae Synopsis" listed the orbits of 24 different comets and suggested a connection between the comets which were observed in 1456, 1531, by Kepler in 1607 and by Halley in 1682. It was also predicted that this periodic comet would appear in 1758, having a period of approximately 76 years.

As we know it did, but only just in time, being observed on Christmas Day 1758, sixteen years after Halley's death on January 25th 1742.

It is probably as a result of this successful prediction that we recognize his name. However, it is almost certain that his influence on astronomy and geophysics would have been recognized more strongly had it not been for the comet. His final work as Astronomer Royal following Flamsteed was an end to a remarkable career.

HALLEY'S COMET

Now that *that* comet has passed the sun, and we are about to see it at its closest approach to the earth before leaving us for the most distant parts of the solar system, what was it all about? What have we learned, was it unexpected or is it just more information to add to the growing pool of astronomical data on comets?

Halley's comet is not the only comet to visit the central regions of the solar system where it can be conveniently viewed without the assistance of a telescope. It isn't even the most frequent visitor as several comets have periods of just a few years. It can however be one of the brightest and the enormous extent of the tail which was visible during its last visit in 1910 left an image in the public eye which has lasted over the decades. The persistence of this image has been lengthened by the photographic records which came from various observatories and appear in most of the textbooks of astronomy. Unfortunately, as we know, this visit did not provide a comparable spectacle.

Remarkably however, because of the developments of both camera equipment and photographic materials it has been well within the capabilities of anyone who possesses an intermediate priced camera to produce pictures during this visit which are very similar to those of the professionals in 1910.

Historically, Halley's Comet is the name given belatedly to the comet which was identified by Edmond Halley as possibly being a regular visitor to the vicinity of the earth, in other words, a *Periodic Comet*. His evidence was based on a tentative identification of the comet of 1682 with comets which were observed in 1456, 1531 and by Kepler in 1607. Given the interval between these dates, Halley predicted its return in 1758 after a period of approximately 76 years. Unfortunately, Halley died at the age of 86 in 1742 and consequently remained unaware of the fate of his prediction. In the end it was very close, and the confirmatory observation was made only one week from the end of the year. An amateur astronomer reported the sighting on Christmas day and in so doing provided the much needed experimental evidence that at least one group of comets existed in orbits bound to the sun.

Once a periodicity has been established it was a matter for historians to trace the previous appearances of the comet back into the early records of nations which had traditionally noted the comings and goings of objects in the sky. This search still continues today and Table 1 gives a list of the cometary appearances which seem to fit the periodicity which Halley had determined.

<u>The Previous Visits</u>

Year	Perihelion Date	Nearest Approach to Earth	Time Since Last Visit
239 BC	May	0.46	?
163 BC	October	0.95	77.4 +
86 BC	August	0.44	77.8
11 BC	October	0.17	74.2
66 AD	January	0.25	76.2
141 AD	March	0.17	75.2
218 AD	May	0.44	77.2
295 AD	April	0.32	76.9
374 AD	February	0.10	78.8
451 AD	June	0.49	77.3
530 AD	September	0.28	79.3
607 AD	March	0.10	76.5
684 AD	October	0.26	77.6
760 AD	May	0.43	75.6
837 AD	February	0.04	76.8 *
912 AD	July	0.49	75.3
989 AD	September	0.40	77.2
1066 AD	March	0.11	76.5
1145 AD	April	0.29	79.1
1222 AD	September	0.36	77.4
1301 AD	November	0.19	79.2
1378 AD	December	0.12	77.1
1456 AD	June	0.45	77.5
1531 AD	August	0.49	75.2
1607 AD	October	0.25	76.2
1682 AD	September	0.42	75.0
1759 AD	March	0.13	76.5
1835 AD	November	0.20	76.7
1910 AD	April	0.15	75.5
1986 AD	February	0.42	75.8

The perihelion date is given to the nearest month where possible. The closest approach to the earth for the early visits is obtained from orbital calcualtions and is given in terms of the earth-sun distance (= 150 million km).

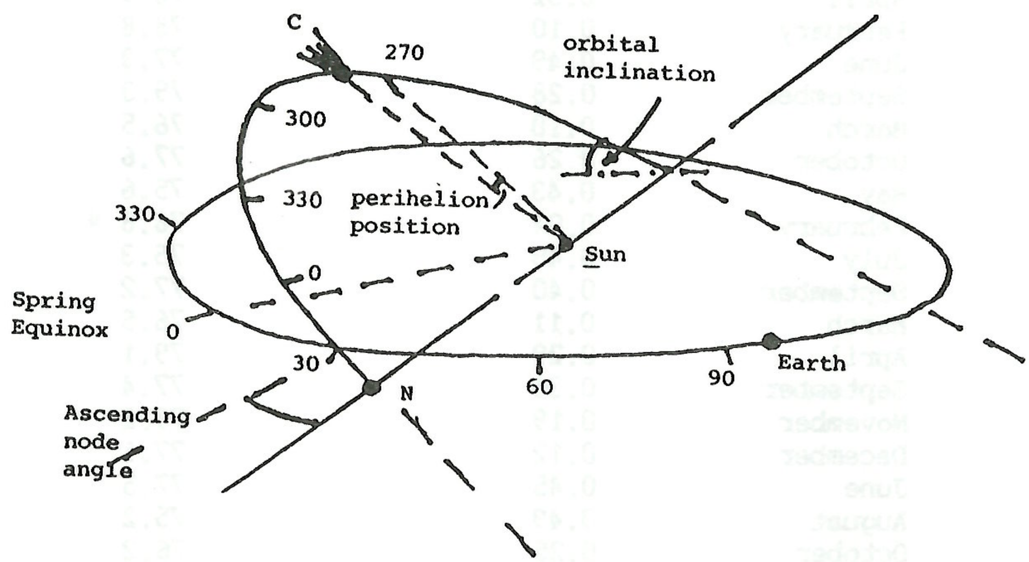
+ identity uncertain;
* this distance corresponds to approximately 6 million kms just 16 times as far away as the moon.

The details of the orbit of the 1682 comet were published by Halley in a paper entitled *'Astronomiae Cometicae Synopsis'* (A Synopsis Cometary Astronomy) submitted to the Transactions of the Royal Society - (in Latin) but also published separated by Oxford University Press (1705, again in Latin) and in English in 1705 by John Senex, publishers in London. This paper listed a series of numbers for each of 24 comets which described their orbits relative to the solar system.

The entry in the table corresponding to Halley is shown below

1682|21°16'30"|17°56'0"|2°52'45"|58328|9.765877|Sept 4.07 39|108.23.45|

In order, these columns relate to the year, the ascending node, the orbital inclination, the perihelion position, perihelion distance, (in 150,000 kilometers), the logarithm of the perihelion distance, the time of perihelion passage and the argument of the perihelion (the angle NSC). These parameters are shown in the diagram below.

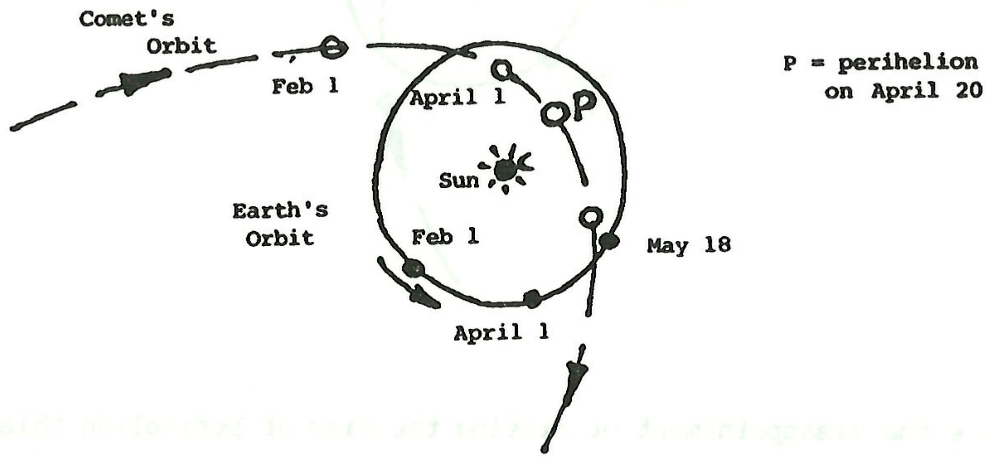


The fine details of this orbit will change due to close encounters between the comet and the planets as it passes through the solar system on its 76 year round trip. As a consequence of these changes, the observed time between visits varies slightly, as is clearly seen from the Table. Of course with the power of modern computers, it is possible to predict the changes that will occur in the future provided that we have a good knowledge of the path which the comet is following during this present visit. Consequently much of the professional photographic activity using large Schmidt telescopes will be used to determine this current orbit.

<u>The Appearance of a Comet</u>

Do we know in advance how spectacular Halley's comet will be? The answer to this is that we have some idea. Astronomers need to consider the orbit of the comet, the orbit of Earth and the position of the Sun in relation to these. Since the most active time for a comet occurs when it is closest to the Sun (the perihelion position) we on the earth need to be on the same side of the sun as

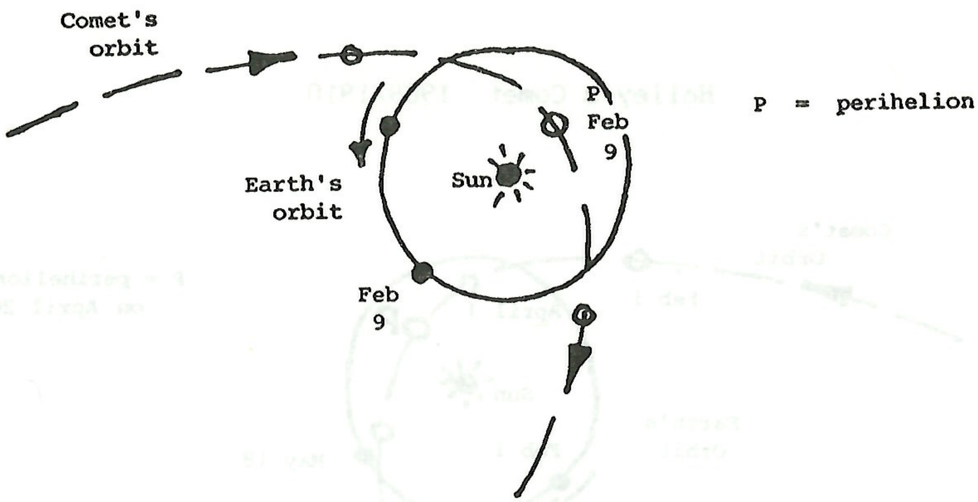
Halley's Comet 1909/1910



the comet at perihelion to see this phase of the comet's activity. This is what happened in 1910 on the last return of Halley's comet. The two orbits are shown in the diagram. Although the Sun was between the Earth and the comet briefly in March, by early April the Earth and the comet were heading toward one another on their respective orbits. On May 18, 1910, the dust tail of Halley's comet is thought to have passed only 400,000 km from the earth, leading to a popular superstition at the time that all manner of "poison gases" would invade the Earth. The head of the comet was closest to the Earth on May 20, 1910, at a distance of 31 million km. This is not the closest encounter that the Earth has had with Halley's comet however, as may be seen from the Table.

In the 1985-1986 return, the perihelion of Halley's comet occurred on February 9 1986, when the sun was between the Earth and the comet. The figure below shows the two orbits for the 1986 return and as may be seen, the earth and comet are on opposite sides of the Sun at the time of perihelion. This results in a total lack of observations at what could have been the most active time of the development of the tail structure.

Halley's Comet 1985/1986

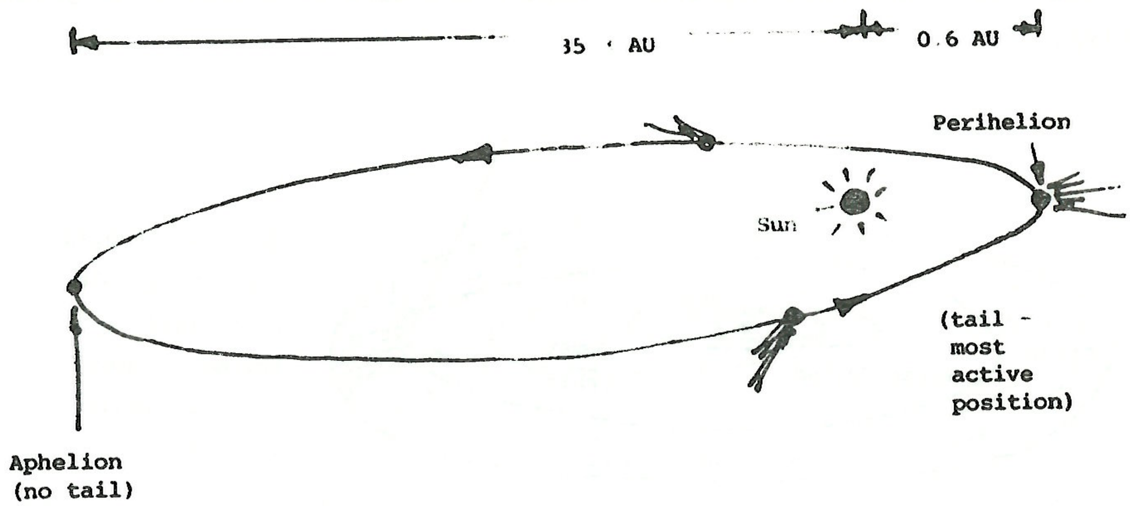


Despite the disappointment of missing the view of perihelion this time round, we have had, without a doubt, the most widespread publicity on Halley's comet of any previous generation. You must remember that even in 1835, the return was only recorded by drawings or writings of the comet. Black and white photography was largely restricted to the professionals in 1910.

Now, many people own televisions, radios, cameras and the like. Satellites can transmit exotic colour stills, films and computer-generated and enhanced images around the Earth almost as soon as they are obtained. Our Earth-bound pictures of Halley's comet have been joined for the first time by images from space craft sent to rendezvous at various distances with comet. The scientists who are collecting the vast amounts of data which these space probes have generated are likely to be years in completing their analysis.

The Comet

What about Halley's comet? In the years while the scientists are trying to analyse their data and the public once again loses sight of this astronomical object, Halley's comet will continue in its orbit, to return in 2061. The orbit of Halley's comet is a very large ellipse. At aphelion, the farthest distance form the Sun, the comet will be some 35.3 astronomical distance units (AU) from the Sun. This is 35.3 times as far from the Sun as the Earth is. When it is as far away as this, Halley's comet will be cold and dark, with no trace of the tails which we traditionally associate with any comet It is only when a comet is 'warmed' by the sun's radiation that a tail is produced.

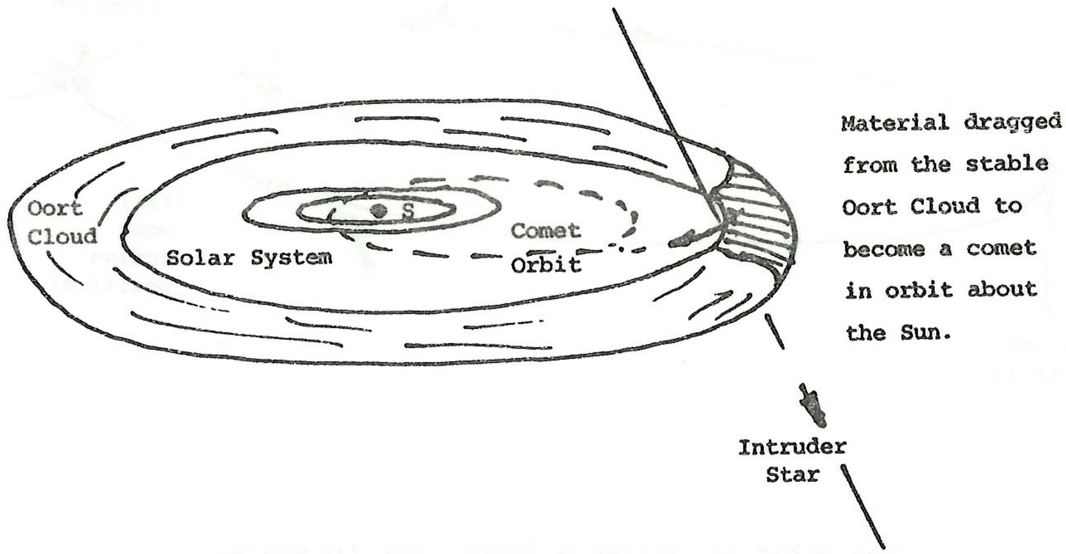


The orbit of Halley's Comet (not to scale)

Why should comets appear at all? This question has intrigued scientists for centuries. Comets used to be regarded as harbingers of disasters, omens sent to us by the gods, before it was realized by Halley that some comets keep returning and will continue to do so.

Current astronomical thinking is that comets come from an enormous swarm of material, the Oort comet cloud, which exists at about 50,000 - 100,000 AU from the Sun - the very edges of our solar system. Jan Oort is a remarkable Dutch astronomer who calculated that such a cloud was probably formed some four thousand million years ago, at about the same time as the solar system itself. The matter in this cloud is generally believed to be the remnants of the processes which formed the planets, although there is a theory (not widely accepted) that the Oort cloud comets are the debris of an exploded planet.

How is the material in the Oort cloud, 50,000 AU from the sun converted into a comet like Halley that only travels as far as 35 AU? Theories again differ. It is commonly agreed that some type of collision had to occur to 'bump' material in the Oort cloud out of its normal very large and possibly circular orbit into a much smaller, highly elliptical orbit. What caused the perturbation? Our best guess is that a local star in its motion through the galaxy moved close to our solar system in the distant past and that the resulting gravitational influence was enough to change the orbits of some of the objects in the Oort cloud. However, we do not know which star it was, or when this happened, despite the work of a number of scientists on this problem.



In its journey around more than 100,000 million kilometres of this orbit around the sun, during which time it threads its way through the almost circular orbits of the planets, comet Halley is trapped by the gravitational field of the Sun. It is also subjected to the gravitational attraction of the planets themselves, which although much smaller, lead to the changes in both predicted position and period.

If this was the whole story, comets would have remained insignificant objects and with the exception of direct collisions with the earth, could have gone unnoticed. However, the mass of gas and planetary debris which has been consolidated into the 'dirty snowball' of Whipple's theory is in full view of the Sun as it falls through the solar system towards the Sun.

Over much of the orbit, the distance to the Sun is so great that the intensity of the light, heat and particle radiation reaching the comet surface is very small and has little effect. Once the comet approaches to within a distance of a few astronomical units from the Sun, say within the orbit of Mars, the continuous irradiation of the surface from the Sun leads to the temperature rising sufficiently to cause vapourisation of the frozen gases. We know from spectroscopic evidence that much of this material is water ice and at 5AU the Suns radiation can release about 10^{22} (10,000 million, million, million) molecules of water from a 1 km square surface each second. At 1AU the rate approaches 10^{30} molecules per second.

The gas molecules escaping from the surface form an atmospheric mantle around the central nuclear core. However, the gravitational attraction is too small to retain the gas molecules as a permanent atmosphere. Their velocities are quite high and well in excess of the escape velocity from the comet mass. As a result of this the particles in the molecular gas are essentially free to move in the space of the solar system. Consequently the mantle continuously expands, reducing the density near to the surface, exposing the surface to more solar radiation and hence leading to more vapour release. In other words, the effect of the solar radiation on the cold comet, is to cause a continuous mass loss. This loss deposits vapourised molecules into an extended atmosphere called the *coma* from which they escape into the inter-planetary medium.

Such an evaporation rate corresponds to mass losses of several tonnes per second and eventually must place a limit to the number of times which any comet can pass close to the sun in its orbit. One should at this time note, that while it would seem to be a simple matter to calculate the total mass loss per orbit and hence to calculate the maximum number of orbits form the present mass of the comet, this is not so. Why? We do not accurately know the mass of Halley's Comet, or any other comet circling within the solar system. Although the comet is held in its stable orbit by the gravitational attraction between its mass and that of the sun, in the final calculation only the solar mass remains in the expressions describing the orbit. Consequently only 'guesstimates' of the mass can be made using evidence which is sometimes very indirect.

Mixed with the frozen gases are solid particles whose diameters can range from a few tens of nanometers to several centimetres. These appear to be made from silicate materials, although recent evidence would suggest that carbon based solids are also present. Particles of this type, lying on the surface or embedded in the vapourising ices, are blown along with the expanding gas flow, away from the surface and into the coma. Large particles can not be accelerated significantly by this molecular wind but grains of up to 30 microns diameter appear to be capable of being carried by the wind and becoming an integral part of the coma. The particles which can not escape into the coma fall back onto the surface of the solid nucleus to join the other grains and pebbles of matter still embedded in the ices yet to be evaporated. The result is a protective layer of fine material which must give the outer surface of the comet an appearance which is very similar to the moraine of some glaciers (particularly those near Mt. Cook in New Zealand). This blackened surface of course, is precisely the cause of the remarks made by the Giotto scientists that the comet nucleus is the blackest object in the Universe.

Life in the coma of expanding gas is still affected by the Sun. Each dust particle and molecule interacts eventually with the radiation from the Sun. This happens more frequently with the bigger dust particles than with the minute molecular species. Acting like mirrors, the dust scatters the light incident on it, and in so doing, experiences a force due to the change in momentum. This force acting over the area of the particle, is the *radiation pressure*. This force acts in a direction radially away from the sun while there is also a gravitational force towards the sun on each particle. The ultimate direction of the motion of the particles depends upon the ratio of these forces which is given by

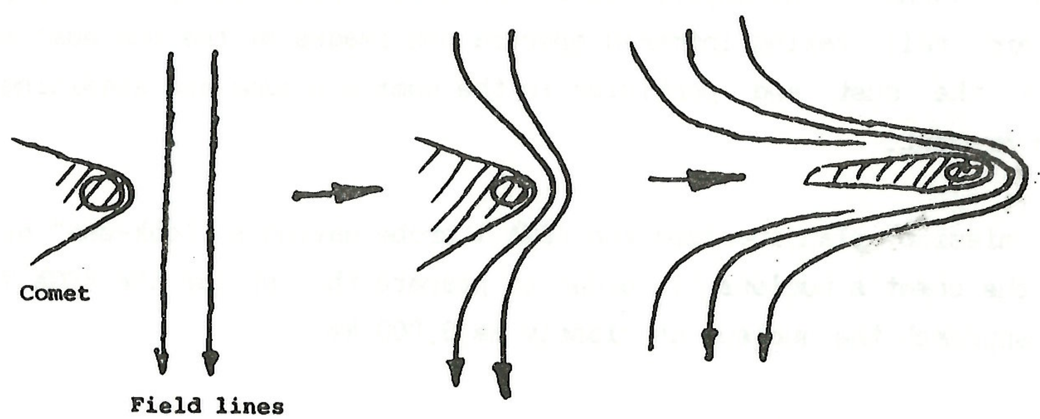
$$\frac{F_{radiation}}{F_{gravity}} = \frac{1}{\rho s} = \frac{1}{\text{(Dust particle density)} \times \text{(dust particle radius)}} \cdot$$

Consequently, for big, dense particles gravity wins, while for small, less dense materials the radiation pressure force dominates. The tails of comets which scatter sunlight, and therefore consist dominantly of dust particles, usually point in a general direction away from the sun. However since the particles in the tail (the *Dust Tail*) are still in orbits around the sun, their motion must also satisfy Kepler's laws. As a result, while the direction of the tail in the sky is away from the sun it can deviate from the line joining the comet to the sun by as much as 50^{o}.

The molecular gas of the coma is also exposed to the solar radiation; however for these particles it is the intense untraviolet radiation and the particles of the solar wind which make the most contribution to what we can detect. The energy of some components of this radiation is sufficient to break the molecular bonds of, for example, the water molecule, forming H and an OH species in the coma region. At their ambient temperatures and in the gas pressure gradients these species expand to form a giant envelope of neutral gas. This envelope was only discovered in 1970 through observations made by the Orbiting Astrophysical Observatory (OAO-2) which detected a roughly sperical cloud of neutral hydrogen atoms out to a distance of several million kilometers in the comets Tago-Sato-Kosaka 1969 IX and Bennett 1970 II. This was also later shown to be accompanied by a comparable envelope of OH as could be predicted from the model described above. It has also been detected around comet Halley during this visit by the space probes which are discussed in the following sections.

A second tail the *Plasma Tail* is also observed with most comets. This points directly away from the sun and is remarkably narrow compared with the dust tail. It has been shown to consist almost entirely of ions for example CO^+, H_2O^+ etc. whose neutral parent molecules have lost an electron in interacting with the ultraviolet light from the sun. The features of this tail, which usually appear as rays coming from the nucleus, can change rapidly and it is believed that it originates from the motion of the ionized gas surrounding the comet relative to the magnetic field of the sun.

The particles of the plasma become trapped by the magnetic field, and spiral around the field direction. Consequently for further relative motion the field must take this trapped material with it. However the increase in inertia leads to a deceleration of the relative motion in this region compared with areas where the magnetic field does not interact with the comet. As a result the magnetic field lines wrap around the comet and compress the ionized material into a narrow plasma tail which is readily seen.



The complex interactions between the magnetic field and the plasma can result in the plasma tail breaking away from the comet head, as a *disconnection* and provides rapidly varying structures in the visible comet. Such a disconnection is readily visible in some of the photographs of the 1910 comet, and again this year our own research group have photographic records of what is probably a similar event in March.

Space probes to Halley

The space capabilities of international science have provided the basis of a much more detailed inspection of Halley than has ever been achieved before. This took the form of a fleet of space craft, instrumented for a wide range of observational material, being launched for a close encounter with the comet in early March. Some notes on this fleet, along with a few other space probes which made observations of the comet are given in the following.

VEGA 1 and 2.

The VEGA 1 and 2 probes were launched by the USSR on 15 and 21 December 1985 respectively. They were the largest probes sent to rendezvous with Halley's comet, each carrying 14 experiments on board.

Both Vegas have narrow and wide-field cameras, a spectrometer and a camera-spectrograph in an instrument package which weighs 50 kg. The total weight of each probe is 1 tonne. The objectives of the mission included photography of the coma, nucleus and tail; taking infrared spectra and images of the nucleus; a study of the nature of the dust and particles in the coma's plasma and examining the magnetic phenomena present.

The mission plan involved the VEGA 1 probe having a "look-see" at about 10,000 km from the comet's nucleus, in order to prepare the way for the VEGA 2 probe, which may then approach the nucleus as closely as 3,000 km.

Suisei (originally Planet A).

Suisei ("comet" in Japanese) is part of a 2-probe Japanese mission to study Halley's comet. The Japanese Institute of Space and Astronautical Sciences (ISAS) launched Suisei on 15 August 1985 and its virtually identical sister probe Sakigake on 8 January 1986.

The primary objective of Suisei was to observe the growth and behaviour of the coma of Halley's comet. The weight of Suisei is 120 kg, including a 10 kg instrument package with an ultraviolet telescope and camera a solar wind analyser and a magnetometer

Suisei came to within a distance of 150 000 km from Halley s comet on March 8

The Suisei/Sakigake mission was the first Japanese inter-planetary mission to be attempted

GIOTTO

GIOTTO is the probe sent by the European Space Agency (ESA) and was launched on 2 July 1985. It passed within about 500 km of the comet's nucleus on 13 March 1986 and provided the first ever close-up pictures of the nucleus.

Several experiments were carried by GIOTTO The scientific objectives included taking 4-colour images of the actual nucleus sampling the material in the comet's coma, analysing the material with several dust detectors and 3 mass spectrometers, studying the light distribution in the comet with a photometer and determining the magnetic conditions with a magnetometer.

GIOTTO weighs 960 kg, of which the scientific package is only 53 kg. A specially designed 'bumper' shield made of foam and Kevlar a material used in bullet-proof vests, weighs 60 kg but provided some vital protection against the inevitable damage caused by the 70 km/sec "sandstorm" which the probe met at such close range. At these speeds a 1 mm grain of dust can penetrate several centimeters of steel. The GIOTTO instruments are powered by a solar cell, which is backed up by batteries just in case the bumper shield does not adequately protect the solar cell.

Initially scientists were only able to maneouvre GIOTTO to within about 1000 km of the comet's nucleus, but the results of the Russian VEGA 1 mission allowed GIOTTO control to trim this figure down to 500 km.

The data from Giotto was relayed back to Earth in real time (that is, as it was collected), rather than being stored, since there was considerable doubt that GIOTTO would survive its mission. The prime receiving station for the GIOTTO data was the Parkes Radio Telescope in NSW Australia, which relayed the data to Carnavon in Western Australia and thence to Darmstadt, West Germany to the ESA Headquarters.

As we know, GIOTTO was struck by a small dust grain within seconds of its nearest approach. While this collision misaligned the satellite and communication was lost, the automatic control systems recovered the system and within 60 minutes a battle-scarred GIOTTO was functioning again as is left the nucleus behind.

The live coverage of the event by television revealed a bright triangle showing some structure which was thought to be the detailed nuclear structure of crevasses and fragmented ice. *This interpretation was rapidly realised to be wrong*, and the bright comet-like patch of light turned out to be jet of evaporating material being blown out from the nucleus. The nucleus itself was just visible away to the left hand side of the pictures shortly before the end of transmission, but unfortunately the false-colour rendering of the presented image which had been chosen by the computer experts made this detail totally non obvious. Retrospectively, examination of the image in monochrome where bright is bright and faint is faint showed the correct details unambiguously.

<u>INTERNATIONAL COMET EXPLORER (ICE)</u>.

The first probe-comet encounter took place on 11 September 1985, when ICE passed about 8000 km from the nucleus of Comet Giacobini-Zinner. ICE is a joint NASA/ESA project and was launched in August 1978.

It is designed to study solar wind conditions and will pass between the Sun and Halley's comet, at a distance of about 30,000,000 km from the comet's nucleus.

ICE has the distinction of already having survived a passage through the tail of a comet: it passed through over 60,000 km of the tail of Comet Giacobini-Zinner and yet was fit to observe Halley's Comet!

Other space probes have been specially diverted from their normal mission to observe Halley's comet. These are described below.

<u>SOLAR MAXIMUM MISSION (SMM)</u>.

The SMM is a NASA Deep Space probe which is normally used to study the Sun. It was temporarily diverted from this task in order to observe Halley's comet at a high spectral resolution, with an instrument which combines an ultraviolet spectrometer and a polarimeter.

<u>INTERNATIONAL ULTRAVIOLET EXPLORER (IUE)</u>.

Like the SMM, IUE is a NASA Deep Space probe. It was temporarily reprogrammed from December 1985 until March 1986 to observe Halley's comet, specifically when the angle between the Sun and the comet was more than about 45°.

PIONEER.

NASA's Pioneer Venus Orbiter (PVO), usually studying Venus, turned its attention towards Halley's comet in February 1986. On 4 February Halley's comet passed within 45,000,000 km (0.3 AU) of Venus and the PVO ultraviolet spectrometer was used to obtain images of the comet.

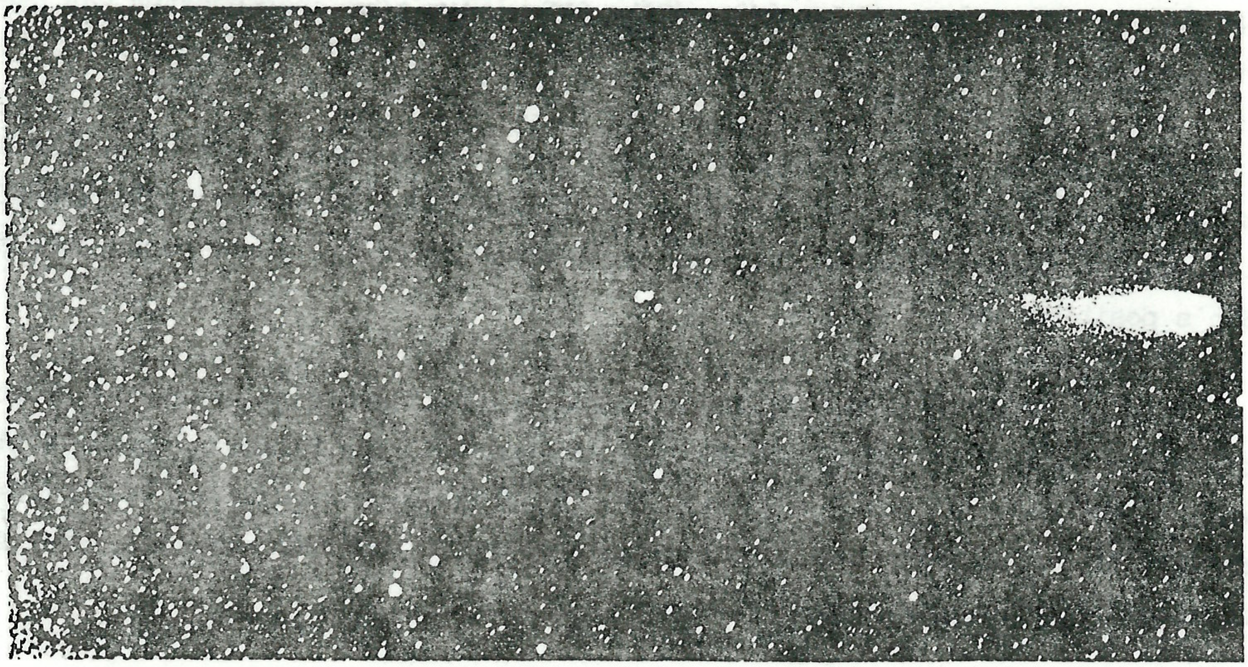
The period in early February before and after the comet's perihelion (9 February: the comet is then closest to the Sun) was the most active part of the comet's orbit, but was hidden from our Earth-bound and space probe views because of the Sun's position then.

Pioneer 7 also observed Halley's comet in late March 1986, when the comet and the probe were less than 30,000,000 km (0.2 AU) apart. The Pioneer 7 probe's plasma analyser performed in situ analysis of the solar wind conditions in the comet's environment at around about the same time as the GIOTTO and VEGA missions intercepted the comet at a much closer range.

IN RETROSPECT.

There can be no doubt that the 1986 visit of Comet Halley was a disappointment for many of the public who had been led by tour operators, airlines and sections of the media to expect a repeat of the 1910 sightings. Astronomically, the comet was right on time and apart from an increase in brightness in March which led to reasonably good viewing for those willing to abandon the comfort of their beds, the visibility was essentially that predicted by the astronomical community. It is a pity that the commercial pressures, which are capable of doing so much to involve the public in the excitement and beauty of astronomy, on this occasion left a large number of people with a feeling of disappointment.

For the astronomers, the visit provided a series of new and exciting results. Many of these came from the space probe contacts which by their very nature led to detailed insights of various phenomena within the coma which could not have been obtained from the earth. Possibly the major finding from earth bound telescopes was the discovery of spectroscopic evidence for the CH bond with the subsequent speculation that very complex organic materials may exist associated with this and other comets. If this were so, it would lend the much needed support for the speculations of Hoyle and Wickramsinghe concerning the role of comets on the origin of terrestrial life.



A photograph* of Halley's Comet taken from the Blue Mountains in March 1986. The picture was taken using the very fast and successful Fuji 1600 colour print film, with an exposure of 10 minutes using a 135mm f2. lens. The camera was attached to a rotating mount which could track the comet and avoid the star streaks in untracked photographs.

* Mounted copies of this colour photograph are available for $1.00 from Mrs. B. Ellis, The School of Physics, University of New South Wales, Kensington, 2033. Phone (02) 697-4560. All proceeds go to the funds for the La Mancha Telescope construction project which will be available for public and secondary school use once it is completed.

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