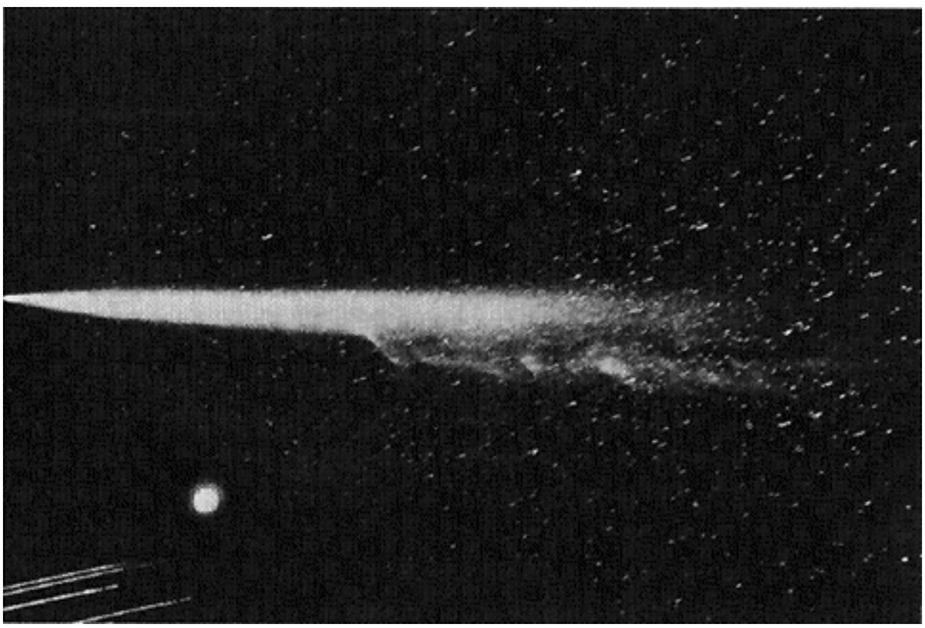
Halley's Comet

The most famous of comets, associated with many important events in history. Records of Halley's Comet appear at least as far back as 240 b.c., and they are found in the Bayeux Tapestry (the apparition of the comet in 1066) and in the *Nuremberg Chronicle* (the apparition of 1456 and probably those of 684 and 1301). The comet's size, activity, and favorably placed orbit, with the perihelion roughly halfway between the Sun and the Earth's orbit, ensure its visibility to the naked eye at each apparition.

Illustration Halley's comet on May 13, 1910. The planet Venus is in the lower part of the photograph. The tail stretched approximately 45 degrees on this date.



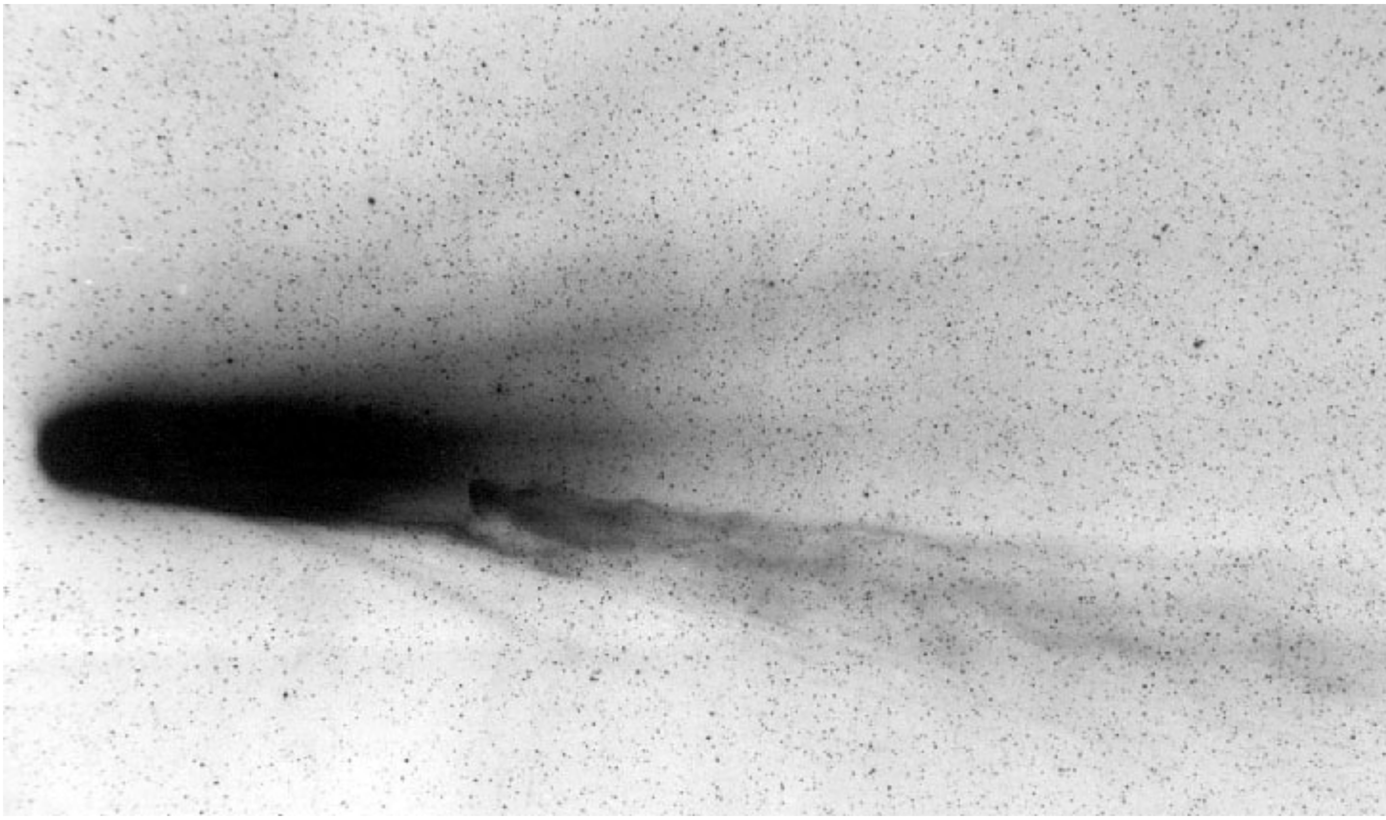
Despite major observing campaigns on recent bright comets, specifically comets Hyakutake and Hale−Bopp, Halley's Comet is the basis for many ideas about comets in general. No other comet has had so organized a campaign as that of Halley's in 1985−1986, during which several space missions were launched that made on−site measurements and produced several images of the nucleus. Although detailed knowledge of one comet is invaluable, comets are likely to be highly individualistic, and it should not be assumed that they are all similar to Halley's Comet.

History

This comet was the first to have its return predicted, a feat accomplished by Edmond Halley in 1705. He computed the orbits of several comets with Isaac Newton's new gravitational theory. The orbits of comets observed in 1531, 1607, and 1682 were remarkably similar. Halley assumed that the sightings were of a single comet and predicted its return in 1758−1759. The prediction was verified, and the comet was named in his honor. Halley's Comet was observed in 1835 by F. W. Bessel and by numerous astronomers in 1910 and 1986. Halley's Comet displays the gamut of known cometary phenomena, including a long tail when sufficiently close to the Sun (Fig. 1). Because of its predictable orbit, brightness, and extensive activity, it was the prime target of the six spacecraft making up the Halley Armada in March 1986. See also: Comet

Fig. 1 Halley's Comet as photographed by the United Kingdom Schmidt telescope in Australia on March 9, 1986. Dust−tail structures are visible (above), and the plasma tail (below) also shows a completely detached portion called a disconnection event. (*Copyright © by Photolabs*, *Royal*

Observatory, Edinburgh)



Orbital properties

The comet's orbit is a very elongated ellipse, with an eccentricity of 0.967, which has a perihelion of 0.59 astronomical unit (1 AU = the average Earth−Sun distance = 9.30×10^7 mi = 1.496×10^8 km) and an aphelion of 35 AU, between the orbits of Neptune and Pluto. Halley's Comet was farthest from the Sun in 1948, and has been moving away from the Sun since its perihelion on February 9, 1986. Halley's Comet will return to perihelion in 2061. The average period of revolution is 76 years, and the comet's motion is retrograde, that is, opposite the planets' motion. The present relative positions of the comet's orbit and the Earth's orbit mean that the comet can approach Earth as close as 0.15 AU at the descending node. See also: Celestial mechanics

1986 apparition

Halley's Comet was detected for the first time on its most recent approach to the Sun by D. C. Jewitt and G. E. Danielson of the California Institute of Technology. The comet was recovered on October 16, 1982, by using the 200−in. (5−m) telescope on Palomar Mountain and an advanced electronic detector originally designed for the Hubble Space Telescope.

Casual viewers, if they were far enough south and well away from city lights, saw the comet in March and April 1986. However, Halley's Comet was not the spectacular object for public viewing that it was in 1910. The excitement for the 1985−1986 apparition lay primarily in the massive cooperative effort that scientists launched to observe the comet.

In March 1986, six uncrewed spacecraft successfully encountered Halley's Comet on the sunward side and made measurements in its vicinity (see table). These missions produced data that have greatly enhanced the understanding of comets. Observations of Halley's Comet were also made by spacecraft in orbit around the Earth and the planet Venus, and by ground−based instruments. The ground−based observations were coordinated by the International Halley Watch, composed of networks of astronomers and institutions worldwide formed to coordinate the total observing effort and to archive results.

Spacecraft	Sponsor	Approx. closest approach	Date
*Vega 1**	Soviet Union	8890 km or 5520 mi	March 6, 1986
Suisei	Japan	151,000 km or 94,000 mi	March 8, 1986
*Vega 2**	Soviet Union	8030 km or 4990 mi	March 9, 1986
Sakigake	Japan	7,000,000 km or 4,350,000 mi	March 11, 1986
Giotto	European Space Agency	605 km or 375 mi	March 14, 1986
International Cometary Explorer	NASA, United States	28,000,000 km or 17,400,000 mi	March 25, 1986
*Produced imaging of comet nucleus.			

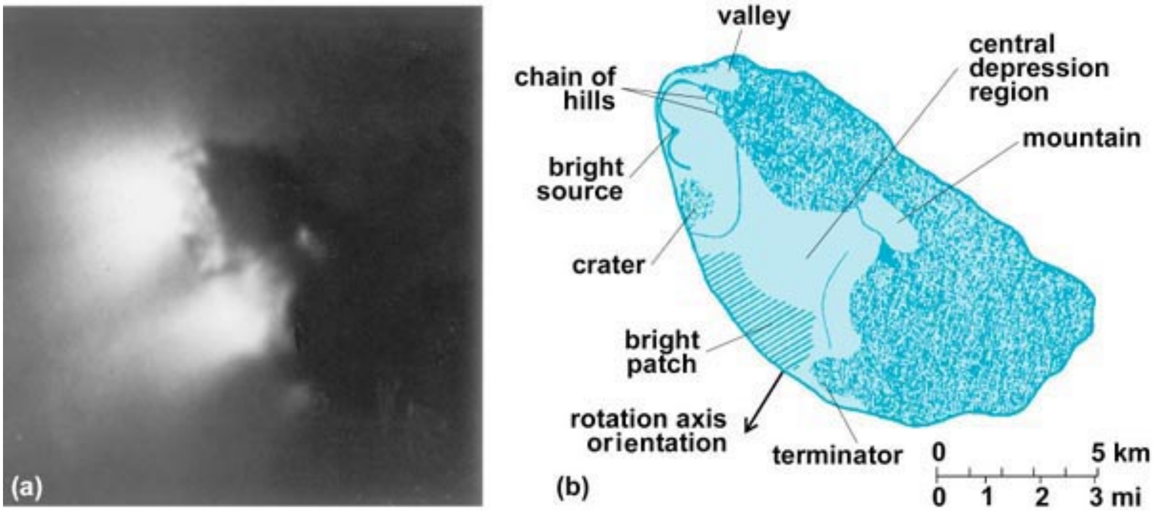
Results from both space and ground−based observations focus on three general areas. The first concerns the interaction of the comet with the solar wind. H. Alfvén's basic picture has been confirmed: the comet's plasma tail is indeed formed by the comet−solar wind interaction. Molecular ions from the comet are trapped onto solar−wind magnetic field lines, causing the magnetic field lines to drape around the comet to form the plasma tail. This process has been confirmed in detail by the spacecraft observations. Somewhat surprising is the immense distance over which the interaction takes place, up to approximately $1\ \ 10^{7}$ km ($6\ \ 10^{6}$ mi) or more from the comet, as measured by the spacecraft. Plasma processes in comets can produce spectacular results, such as disconnection events (Fig. 1).

The second area is chemical composition. The composition of the gas as measured in the inner coma is approximately 80% water (H_2O), roughly 10% carbon monoxide (CO) as determined from a rocket observation, approximately 3.5% carbon dioxide (CO_2), a few percent in complex organic compounds such as polymerized formaldehyde $(H_2CO)_n$, and the remainder in trace elements. The deuterium−to−hydrogen ratio (D/H) was initially found to be close to the value for terrestrial ocean water, although the uncertainty in the initial value was high. These results supported the view that comets may have supplied an important fraction of the volatile elements to the terrestrial planets, possibly including prebiotic molecules to Earth. However, a refined analysis gives a D/H value well above the value for ocean water. Thus, if the D/H value for Halley's Comet is typical, comets cannot have been the sole source of ocean water. Note that the composition values refer to a comet that has passed through the inner solar system many times. The values for the deep interior of Halley's Comet or for other comets may be different and would probably have a higher value of carbon dioxide.

The dust composition was found to be as follows. Some particles are composed primarily of the light atoms hydrogen (H), carbon (C), nitrogen (N), and oxygen (O), and are called CHON particles. Another kind has a silicate composition similar to the rocks that make up the crusts of Earth, Moon, and Mars, and of most meteorites. Most dust particles resemble a mixture of these two types, that is, they resemble carbonaceous chrondrites enriched in the light elements (hydrogen, carbon, nitrogen, and oxygen). These should resemble the Brownlee particles collected in the Earth's upper atmosphere.

The third general area on which the results focus is the cometary nucleus. Researchers have long based their understanding of the nucleus on F. Whipple's dirty, water−ice snowball model. According to this model, the Sun's heating of the nuclear surface produces sublimation of the ices, causing gas and dust to be released to form the cometary atmosphere and tails. All available evidence from the Halley observations, including images of the nucleus obtained by *Giotto* and the *Vega*s, confirms Whipple's model. The spacecraft observations also show that the nuclear body, shaped like a potato or peanut, is roughly 15 km (9 mi) long and 8 km (5 mi) across, somewhat larger than expected (Fig. 2). The surface of the comet, found to be darker than expected, is comparable to black velvet or coal. The nuclear surface is likely a crust of dust covering the sublimating ices. Solar energy heats the surface, and energy is conducted downward to the ices, where sublimation occurs. Some of the gases produced by the sublimation escape through thin areas or openings in the crust, forming the jets that were observed originating from the surface of Halley's nucleus.

Fig. 2 Nucleus of Halley's Comet from *Giotto* spacecraft. (*a*) Composite image formed from 60 individual images. The resolution varies from about 800 m (2600 ft) at the lower right to about 80 m (260 ft) at the upper left. The material in the bright jets streams toward the Sun, leftward. (*b*) Matching drawing labeling the features on the nucleus. (*Harold Reitsema*, *Ball Aerospace*; *copyright © 1986 by Max Planck Institut für Aeronomie*)



A major area of controversy concerning Halley's Comet persists. Evidence for the rotation period of the nucleus has been presented to support values of 2.2 days and 7.4 days. In retrospect, the rotation of the highly asymmetrical nucleus is likely to be complex. Indeed, the final answer to this important question involves a model with five dominant active regions and a nucleus that rotates and spins and also precesses. This model satisfies the constraints placed on the motion by the images from the *Vega* and *Giotto* spacecraft, the observations of jets and shells, and the observed variations in brightness. The model implies an approximately constant density throughout the interior of the nucleus.

Some insight into the active comet's dusty environment can be inferred from the dust's effect on the spacecraft. The three spacecraft that passed closest to Halley*Giotto* and the two *Vega*survived but were seriously damaged because of the density of the dust and the high speed of the spacecraft. The *Giotto* spacecraft was retargeted to intercept Comet Grigg−Skjellerup in July 1992.

1991 outburst

On February 12, 1991, when it was 14.4 AU from the Sun, Halley's Comet displayed a major outburst which lasted for months. The dust cloud was about 300,000 km (185,000 mi) across. Major activity this far from the Sun is unprecedented and nicely illustrates the challenges of cometary science.

Associated meteors

Halley's Comet is associated with two meteor showers, the −Aquarids and the Orionids. The origin of these showers undoubtedly involves meteoroids from the comet's nucleus that were gravitationally perturbed into their current orbits, which intersect the Earth's orbit. See also: Meteor

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For Further Study

Topic Page: » **Astronomy &Space Science:** » **Solar system, sun and planets**

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