

The Night of the Comet

It was a historic event for researchers and a spectacle for the media: On the eve of March 14, 1986, the *Giotto* space probe hurtled past Halley's Comet at a distance of 600 kilometers and sent back measurement data and close-ups of the nucleus. More than 220 European scientists were involved in the project, including 22 from Max Planck institutes.

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The control center of the European Space Agency ESA has spruced itself up: Rugs cover the polished floors, flowers decorate the corridors. Several hundred journalists and a large number of celebrities including Her Royal Highness Princess Margaret of Hesse have come to Darmstadt on the evening of March 13, 1986. They want to experience "the most important event in space travel since the moon landing," as Research Minister Heinz Riesenhuber puts it.

For the first time in history, an unmanned probe will execute a fly-by very near to the nucleus of a comet and photograph it close up. It's not a rendezvous with just any comet, though: this is the legendary Halley's Comet, which approaches Earth once every 76 years, and which inspired people the world over during its last guest appearance in 1910. Back then, the comet not only had to serve as an advertising medium for a range of products, such as typewriters and vanilla pudding, but it was also considered to be a harbinger of bad luck. It was said that its tail brought poisonous gases to Earth, against which allegedly only expensive comet pills could offer any protection.

And Darmstadt isn't the only city where comet fever is holding sway on March 13, 1986. More than 50 TV stations want to broadcast *Giotto*'s cosmic encounter into the nation's living rooms. Germany's two public broadcasting companies, ARD and ZDF, both bring a "night of the comet," with ZDF airing the show until the early hours of the morning. Later, critics would have nothing good to say about the show broadcast from Mainz, presented by Joachim Bublath and Bernd Heller. Celebrity astrologer Madame Teissier ("The stars are tense this evening") is given on-air time, as is a woman who claims she observed a swarm of UFOs over Düsseldorf. Also featured are comet hairstyles and drinks, as well as a Halley's breakdance. In short: a lot of silly jokes and very little science flicker across the screen for hours.

And this despite the fact that researchers pronounce the mission – which cost around 350 million Deutschmarks – outstanding, even before the first results are in. *Giotto*, stresses the then ESA Director General Reimar Lüst, is ESA's first interplanetary

probe and the first scientific payload aboard an *Ariane* rocket. And never before has a vehicle built by humans come so close to a comet. *Giotto* is viewed as the flagship in an armada of five space probes – American, Russian and Japanese – that are flying toward Halley's Comet.

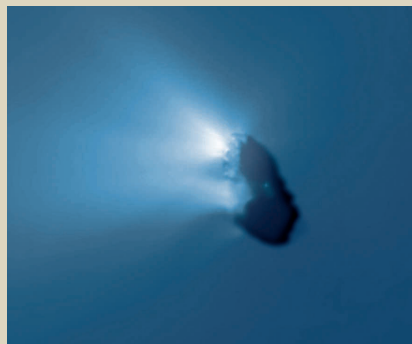
The vehicle, named after the Italian Renaissance painter *Giotto* di Bondone, who immortalized Halley's Comet as the Star of Bethlehem in a fresco, carries ten instruments: mass spectrometers, plasma devices, a magnetometer and a camera. The probe was launched on July 2, 1985. The rendezvous with Halley's Comet is a remarkable feat by the trajectory engineers, as the comet doesn't fly in the ecliptic plane in which the planets orbit the Sun like coins on a gaming table. A further complication is that it moves "the wrong way around," namely in the opposite direction to Earth, and thus to the paths of space probes, as well.

On March 13, 1986, Halley's Comet crosses the ecliptic from above – precisely the point where *Giotto* is to intercept it. The researchers have calculated that the encounter will be fleeting, at the inconceivably high speed of 250,000 kilometers per hour, or 68.4 kilometers per second. The separation from Earth is then around 150 million kilometers; signals that race through space at the speed of light require around eight minutes to cover this distance.

The scientists feel reasonably prepared for the rendezvous itself. Even if they don't

know precisely what *Giotto* can expect, they have an idea what comets are: dirty snowballs measuring a few kilometers in diameter. At least that's how American astrophysicist Fred Whipple described them in his model back in the 1950s. Whipple has also come to Darmstadt, as has the father of cometology, Jan Hendrik Oort, and US media astronomer Carl Sagan.

Most of the time, comets remain far out in the planetary system, but periodic comets like Halley regularly leave their cosmic fridge. On an orbit that is usually elongated and oval, the huge chunks then set off on their journey toward the Sun, and their surface heats up.



Nucleus of Halley's Comet: This image was assembled using several images taken at different distances. The peanut-shaped rock measures around 15 by 7 kilometers. Strong dust fountains are clearly perceptible.

Impromptu science: At an improvised press conference at two o'clock in the morning, Horst Uwe Keller presents images taken by his Halley Multicolor Camera. *Giotto* project manager David Dale acts as the "sound engineer."



When the comet comes within a certain distance of the Sun, the volatile components – mainly water and frozen gases – vaporize and carry away the embedded dust particles. The evaporated particles spread out uniformly to all sides and eventually form a cloud measuring several hundred thousand kilometers in diameter – the coma – around the nucleus.

High-energy UV light from the Sun penetrates this coma, breaking up molecules or snatching electrons from them. This creates a plasma, which ultimately flutters like a flag in the solar wind. It is this tail that gives the comet its characteristic appearance; it usually also contains a "dusty" component, which is generated by the pressure of the sunlight. The solar wind – an ever-blowing stream of electrically charged particles – had been predicted by Ludwig Biermann of the Max Planck Institute for Astro-

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The "Giotto" mission was one of the most successful space missions. The European Space Agency ESA, in particular, has proven that, when it comes to technology, the Old World no longer needs to hide in the shadows (...) Unreserved recognition also goes to the "camera people" of the Max Planck Society.«

physics. On March 13, 1986, the day of the *Giotto* rendezvous, he would have been 79; however, the comet researcher had died two months prior.

Biermann thus didn't live to experience the memorable night of the comet, which kicks off in Darmstadt at 2 p.m. with an initial press conference. The speeches and interviews follow at around 7 p.m. The VIP lounge fills up slowly, while the engineers and scientists sit in the darkened control room, staring ahead of them as the screens fill with numbers and letters. At around 9 p.m., at a distance of one million kilometers, *Giotto* passes the comet's bow shock wave – the shock front that Halley pushes ahead of it and that is invisible in visible light.

"We are measuring the compression of the magnetic field, the heating up of the protons, and the first plasma particles of the comet," says Arne Richter from the Max Planck Institute for Aeronomy (today: Solar System Research). On his lapel he wears a red ribbon – as do Reimar Lüst and Jochen Kessel from the Max Planck Institute for Nuclear Physics – representing the Gagarin Medal, which had been awarded to the researchers a short time before in Moscow.

In Darmstadt, while twenty cleaning ladies are busy emptying wastepaper baskets and cleaning windows, the hand of the clock jumps to 10:03 p.m. Horst Uwe Keller becomes restless. The Halley Multicolor Camera (HMC), whose project leader is the researcher from the Max Planck Institute for Aeronomy, transmits the first image. *Giotto* is now still 767,000 kilometers away from the nucleus. From now on, HMC provides images at a rate of one every four seconds.

As the scientists' excitement increases, so does the confusion for the invited guests in Darmstadt. A computer converts the gray shades on the images into different, arbitrarily chosen colors in order to emphasize contrasts and highlight details. "It looks like a fried egg," says one female visitor, disenchanted. "Or like the Galapagos Islands," adds the person sitting next to her, with disappointment.

Horst Uwe Keller, however, is delighted. He can make out Halley's nucleus on the photos! It is 15 kilometers long, twice as large as first thought, and looks like a peanut. It contrasts clearly as a silhouette against the bright background of the coma. On the side of the comet facing the Sun, at least two broad jets of dust shoot up into space. The raw data already contains a sensation: Some researchers had assumed that there was no solid nucleus under the coma, but a rather loose accumulation of dust and smaller rocks. In fact, the nucleus of Halley's Comet is extremely dark and resembles more an "icy ball of dirt" than a dirty snowball.

Midnight in Darmstadt: In front of the control center, the special post office that has been selling *Giotto* stamps and postmarks has closed its doors. Inside, science carries on. The probe continues to send back new images. Just after 1 a.m.: 14 seconds before *Giotto* is to reach its closest point to Halley's Comet, around 600 kilometers, the last image is produced. It shows only a bright fountain of dust. "Probably the one that hit the camera and knocked out the whole space probe," says Klaus Wilhelm from the Max Planck Institute for Aeronomy.

At least 120 dust particles per second hit the vehicle – having, at those high speeds, the same effect as bullets. Even the two protective shields – an aluminum sheet 1 millimeter thick, and a second sheet made of Kevlar and rigid foam and measuring around 1.5 centimeters thick – are no longer a match for this. The probe starts to tumble, the temperature aboard and inside the camera rises by 12 degrees. The plan was actually for *Giotto* to observe the comet's nucleus from the other side after the fly-by, but the screens in the control center remain dark. The Halley Multicolor Camera is out of action for the rest of the mission.

Nevertheless: The scientists are euphoric. At two o'clock in the morning on March 14, they again appear before the media. At an improvised press conference, Horst Uwe Keller explains the final images. *Giotto* had continued to operate almost up to the point of closest approach. "The probe has achieved the task for which it was built," says ESA Director General Lüst with pride. The British Prime Minister, Margaret Thatcher, sends a congratulatory telegram. And in the Darmstadt media center, the lights are finally switched off.