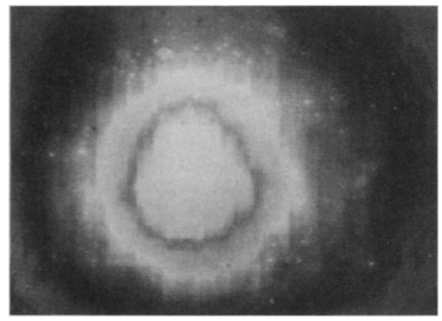
SCIENCE NEWS of the week

Comet Halley Encounters Earth's Space Age

After visiting the earth every three-quarters of a century or so for millennia, Comet Halley has at last been met by a reception committee. First came the Soviet Union's Vega 1 spacecraft on March 6, followed three days later by Vega 2, as Japan's Suisei and Sakigake looked on from a distance. On March 13 came the most daring attendee of all, Europe's Giotto, which passed only 605 kilometers from the comet's dusty nucleus. And as the unprecedented spacecraft assemblage reported in detail to its earth-bound mentors, the guest of honor more than lived up to its reputation.

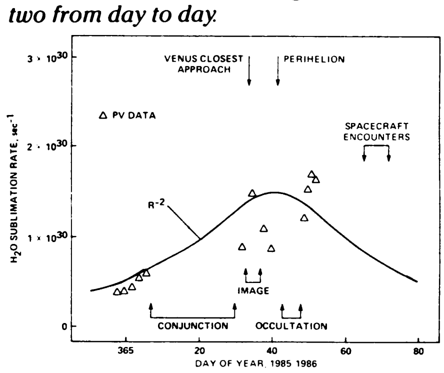
Scientists had long been aware that the reception might turn out to be more of a confrontation. Besides the general dust hazard, earth-based observations had already shown a number of extended "jets" spurting forth from the nucleus, as the sun's heat freed concentrations of ice, dust and gas.

Furthermore, the Venus-orbiting Pioneer spacecraft, which in January had experienced the closest view of the comet's closest approach to the sun, had revealed that the amount of water vapor coming off of the nucleus did not vary smoothly with the changing heat input. Instead, it would double or drop by half from one day to the next, with hints that the variations could be even more rapid. "It turns on so suddenly," said Jeffrey Cuzzi of the NASA Ames Research Center at Moffett Field, Calif. "Like popcorn." Commented principal investigator Ian Stewart of the University of Colorado in Boulder (who is now refining his data to see how big the changes were from hour to hour), "There's a tremendous amount riding on that Giotto camera."



Illustrations: NASA

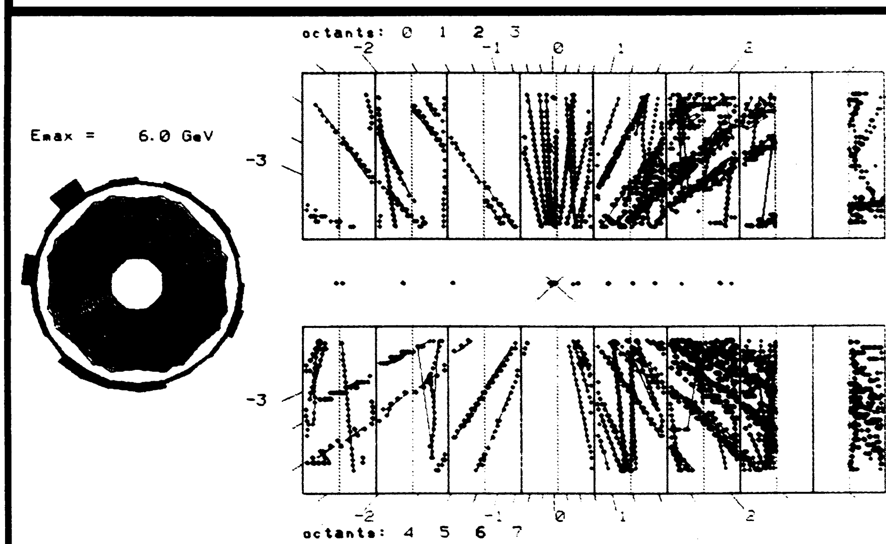
The orbiting Pioneer Venus (PV) spacecraft in January got the best view of Comet Halley's closest approach to the sun. Water-vapor brightness measurements yielded the image above (ring shapes are result of processing) and showed (triangles below) that the amount of water vapor coming from the comet's nucleus was varying by factors of two from day to day.



But even the Vegas, aimed to miss the nucleus by larger, safer distances and intended in part to provide targeting information for Giotto, turned out to have a couple of rough rides. Vega 1 passed 8,889 km away, yet particle impacts reduced the power output from its solar panels by 45 percent. Fortunately, the panels were there merely to charge the craft's batteries, which saved the day — by design — when the going got heavy.

Vega 2 went closer, flying by at 8,030 km from the nucleus and suffering an *80 percent* power loss. Yet officials gathered at the Space Research Institute in Moscow were puzzled. Although Vega 2 had gone closer, data from dust detectors aboard the two craft (particularly a pair of instruments designed by John Simpson and colleagues from the University of Chicago and included at Soviet invitation) seemed to indicate that Vega 1 had flown through one of the comet's jets, while Vega 2 had not. Early looks at the data, in fact, suggested that Vega 2 had been struck by three to four times *fewer* dust particles than its predecessor. Aided by photos from the two craft, scientists concluded that by the time Vega 2 went by, the comet's nucleus had rotated

Protons meet antiprotons at 1,600 GeV



Fermilab

X marks the spot (between top and bottom octants) where a proton with 800 billion electron-volts (800 GeV) energy collided head-on with an antiproton of equal energy in the Tevatron (SN: 9/28/85, p. 202) at the Fermi National Accelerator Laboratory in Batavia, Ill. This is one of the first collisions at that energy, the highest in the world and nearly three times that of the nearest competitor.

The very high multiplicity of things produced in the collision is immediately apparent on the plot. Each line of dots represents the track of some kind of particle made in the collision. As the detector is three-dimensional, the tracks are color-coded according to the octant of the third dimension in which they appear. The circle at left divides the third dimension into octants and indicates the color assigned to each.

This is a test run, and its importance, according to Roy Schwitters of Fermilab, is to show that "the apparatus really works." Right now the apparatus is down while the detector is being completed and adjustments are made to permit actual experimental runs, which Schwitters expects to start in November. When the Tevatron is working at its design capacity, about 50,000 of these collisions will occur every second. At that time, ironically, a trigger on the detector will throw out the ones that look like this, which is quite ordinary. The physicists are interested in rare particles like Ws and Zs that appear only once in many thousands of collisions. In three months of running they anticipate recording about 100 Ws. — D.E. Thomsen so that the jet was no longer crossing the flyby trajectory. Yet there was *more* damage to Vega 2's solar panels, perhaps underscoring that a few well-placed impacts can sometimes do more damage than a whole dust storm. After all, the Pioneer and Voyager spacecraft that went to Jupiter, Saturn and Uranus passed through the asteroid belt, planetary rings and radiation belts with little or no damage.

A number of the scientific instruments on the Vegas suffered in the dust bombardment, but none was destroyed on both craft. Similarly, though Vega 2's infrared spectrometer never worked at all, apparently because of a leak in its cooling system, Vega 1's reported evidence of water, carbon dioxide and hydrocarbon molecules among its early findings. It also indicated temperatures within the comet's dusty coma to be about 330K ± 20K. This was higher than had been anticipated by some researchers, suggesting at least the possibility that the excess might be due to heat retained by the enveloping dust, which Space Research Institute Director Roald Sagdeev termed a "dust cocoon."

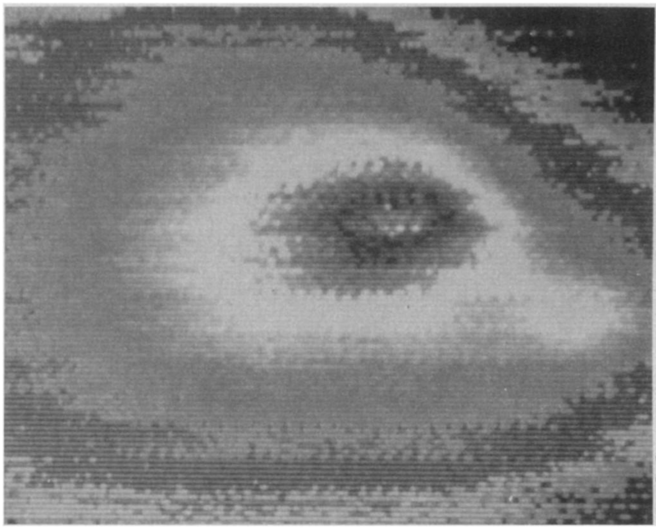
Neither the Vegas nor Giotto detected any sharp magnetic shock wave, or "bow shock," where the solar wind was "blowing" at and around the comet. This appeared to confirm expectations that Halley, and perhaps any comet, lacks an intrinsic magnetic field. Vega 1's data, in fact, seemed to show at least a rough similarity to the findings from the ICE spacecraft that last Sept. 11 flew through the tail of Comet Giacobini-Zinner, according to Frederick L. Scarf of TRW Inc. in Redondo Beach, Calif. ICE had not been designed to go to a comet, so it lacked cameras and many other instruments of the sort carried by the Halley fleet. It did, however, enable scientists to compare another comet in some ways with Halley, and next week ICE will pass Halley about 28 million km from its sunlit side, allowing the same set of instruments to be applied to both objects.

The Giotto encounter was indeed the spectacular that scientists had hoped for. Limited by battery capacity, it was not turned on until 4 hours 19 minutes before its 605-km closest approach to the nucleus, and 71 minutes later it took the first of about 2,000 pictures of the huge coma. The real prizes, however, were its pictures of the nucleus, taken from as close as 1,530 km.

The nucleus appeared to measure about 15 by 8 km, making it not only more irregular than expected but also considerably larger than the roughly 3- to 6-km estimates of the past. From earth-based observations, the earlier estimates had been built on an assumed reflectivity for the nucleus — if it was shinier, a given measured brightness would mean it was smaller. But as Giotto camera-team leader Horst Keller of the Max Planck Institute in West Germany described it, "There's no question that the true color of the nucleus is black, absolutely black, blacker than coal, almost like velvet." This did not mean that cometary nuclei no longer seemed to be "dirty snowballs," a term coined in 1954 by astronomer Fred Whipple (who was present for the encounter at the Darmstadt, Germany, control center). Far more likely is that near the sun, the "lighter," outer areas of exposed ice are vaporized more readily by heat than are those covered by dust — leaving a more uniform blackness.

Comet Halley's nucleus is the dark object at upper left in this image taken by the Giotto spacecraft from 18,000 km away. Two bright jets of dust emanate from the cigar-shaped region. Arrow indicates the direction of the sun.

ESA



What appears to be two objects in this Vega 1 image is actually the result of computer processing that divides the scene into discrete regions of increasing brightness. The nucleus is approximately centered, with a possible bright jet at lower right.

VEGA Imaging Team

But though they still seem to be made of ice/snow, "ball" may be a less appropriate term than just "icy conglomerates," composed perhaps of various fragments that may even come apart occasionally and then regroup as nondescript lumps. Or, as Paul Weissman of Jet Propulsion Laboratory in Pasadena, Calif., suggested even before the spacecraft flybys, loosely bound "rubble piles."

Giotto seemed to be surviving the dust onslaught unscathed until about 2 seconds before its point of closest approach, when it was suddenly dealt a blow — whether by dust or chunk-sized rubble was initially unclear. Scientists at first thought Giotto's mission was over, as all their data disappeared. Was Giotto crippled? Destroyed? Neither. Some 34 minutes later, its data were being picked up again, as the spacecraft's "nutation dampers" succeeded in stabilizing what had only been an abruptly induced wobble and restored continuous communication with earth.

Besides taking pictures, instruments aboard the craft measured the comet's composition (reporting carbon, oxygen, hydroxyl and other constituents) and other characteristics, and sent the researchers back to their home institutions with a treasure trove of data like none they had ever had before.

Another result was the international cooperation that the event produced among Soviet, European, American, Japanese and other scientists — which just might be one of Comet Halley's major legacies. — *J. Eberhart*