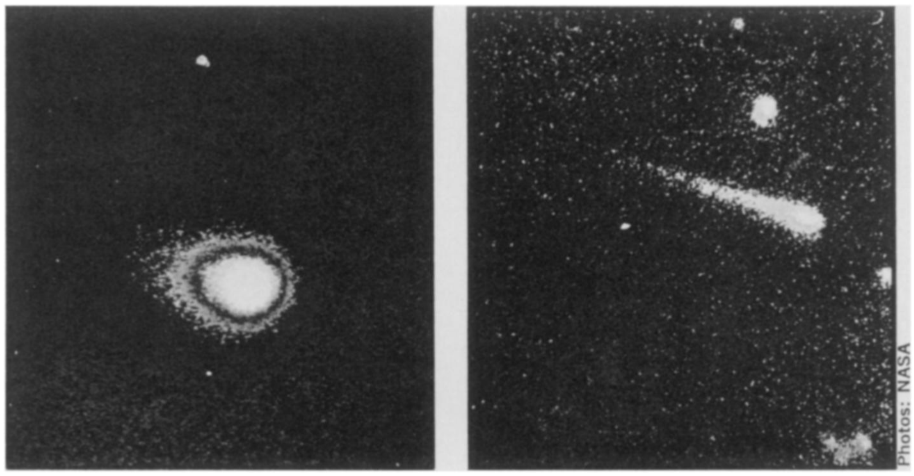
EYES ON THE COMET

If Kohoutek was a flop, numerous scientists didn't get the message

by Jonathan Eberhart



Special processing shows Kohoutek's UV brightness without, and with, hydrogen.

Months before Christmas, an astronomer spotted a tiny blur on a photographic plate: a comet, still hundreds of millions of miles away and inconceivably dim but destined to come much closer. Within weeks of its discovery it had brightened from thirteenth to eighth magnitude, leading to the prediction that by perihelion in January it could be as bright as minus 2.6, competing even with brilliant Venus. The world waited. The press waxed rhapsodic. Cecil B. DeMille made plans to photograph the spectacle for a movie about Mary of Nazareth.

The Christmas Comet barely made it at all. In mid-November its growing gleam suddenly slowed. By Chistmas it was no brighter than a dim, fourth-magnitude star, and even at its nearest to the sun it never got past magnitude three.

It was the Christmas of 1940. The comet: Cunningham.

"Looking at Comet Kohoutek," says Luigi Jacchia of Harvard Observatory, "many an old-timer must have had a sense of déjà vu. The unpredictability of comets is an old story, and compared to what some of them did, Kohoutek was not such a bad performer after all."

Comet Westphal, for example, which had been observed in 1852, was rediscovered in 1913, two months out from the sun and a little brighter than magnitude eight. Yet instead of brightening, it got dimmer, finally disappearing all together four days short of perihelion. Biela's Comet, a dependable performer discovered in 1772, came around repeatedly in 6.7-year cycles until 1846 when it split in two. The two fragments appeared once more in 1852, then vanished, leaving nothing but some debris which produced a meteor shower 20 years later.

Nor do all comets simply get brighter or dimmer on a smooth curve. Comet Holmes in 1892 oscillated up and down over nine magnitudes, and a 1973 comet, Tuttle-Giacobini-Kresak, spanned ten, a difference in brightness of 10,000 times. "If you must bet," says Harvard's Fred Whipple, "bet on a horse, not on a comet."

Millions of people bet on Kohoutek, and by sheer numbers most of them were disappointed. The happy few were scientists, who, thanks to almost 10 months between the comet's discovery and perihelion, were able to amass unprecedented armies of experiments and even design new instruments to look at it. So much data was gathered that Stephen P. Maran, presumably in the ideal position as head of NASA's massive Operation Kohoutek, is still hearing about new results.

So why were all those other people left out in the cold? What happened to the anticipated Comet of the Century?

The villain's name, says Armand Delsemme of the University of Toledo, is n. It is an exponent in an equation that says in part that a comet gets brighter as the nth power of its distance from the sun gets smaller. The larger n is, the faster a comet brightens as it approaches.

In the first few weeks following Kohoutek's discovery, the magnitude in which astronomers were trying to measure changes was extremely small, making the task of measurement proportionately difficult. In the earliest published estimates, Kohoutek was given a range of possible n from 6.0 to 4.0. It soon became apparent that the real n was more like 4.0, and by early November—a month and a half before the comet was supposed to be conspicuous in the sky—it was down to 3.0. Maran tried in press conferences first to minimize and later to rule out the initial optimism, but for the public the die, ably abetted by the media, had long since been cast: the brightest estimate got the most attention. Another factor, says Maran, was the lack of emphasis in pointing out that at its brightest the comet would be too near the sun for anyone but possibly the Skylab astronauts to see.

Astronomers, Delsemme maintains, should have been more skeptical even from the first. Only one comet in 10, he says, has an n as high as 6.0, and a study of 30 particularly bright, first-time comets gives them an average n of only 3.7. The average of all comets, according to a compilation by Nicholas Bobrovnikoff, is a mere 3.3. This means that by the time Kohoutek had traveled halfway to the sun from where it was discovered, its brightness would have been growing more than six and a half times faster than that of the average comet. Such a prediction, several astronomers have ruefully suggested, ought at least to have warranted more forceful publicity for later, revised calculations.

Fortunately, no lack of brightness could erase the benefit of Kohoutek's long advance warning, as dozens, perhaps hundreds, of researchers will attest. Two recent scientific meetings only four days apart, for example, together offered 19 presentations of results on the comet, representing the work of more than 50 scientists.

One of the biggest outstanding questions is where comets are born. All the new comets that have been seen, says Whipple, have been coming in from a region outside the solar system, extending out to perhaps half the distance to the nearest star. But this doesn't mean they were born there.

One school of thought has it that they were formed within the solar system, in the region of the orbits of Uranus and Neptune, then tossed outward by the gravity of the planets. As far as earth-based measurements can tell, Whipple says, "Uranus and Neptune are fundamentally just a collection of comets." On the other hand, he points out, the probabilities are small that many comets could be thrown out of the solar system while remaining in orbits that would bring them back in again. As few as one percent of the comets that have been seen could reasonably be explained this way, he says.

The other side of the coin is that they may indeed have formed out beyond the sun's most distant planets, and been captured into sun-circling orbits. Earth-based radio studies of Kohoutek have provided some evidence that favors this idea: the detection of a pair of complex molecules, methyl cyanide (CH_3CN) and hydrogen cyanide (HCN) in the comet itself. If comets were formed within the solar system, says Whipple, these "more exotic molecules" would probably not have been present. The heat of the primordial sun would almost surely have broken them down into simpler ones before the comets congealed into being. One of the few other places in which methyl cyanide and hydrogen cyanide have been seen, in fact, is in interstellar nebulas.

A major motivation in NASA's plans to send unmanned probes in the 1980's to study comets from close range (SN: 3/9/74, p. 162) is the chance of being able to detect some of the scarce "parent molecules" whose dissociation into simpler forms produces the bulk of the molecules in a comet. Observations of Kohoutek have indicated that one of these by-products, the hydroxyl (OH) radical, seems to have been born within about 9,000 miles of the comet's nucleus, suggesting that this may be the size of the parent molecules' domain.

There are also indications that some of the parents may be more abundant than had been believed. Paul Feldman of Johns Hopkins University found surprisingly large amounts of carbon, in atomic rather than molecular form, indicated in data from a sounding rocket launched Jan. 4, when Kohoutek was near perihelion. Atomic carbon had been predicted, but not in such amounts. Its parent molecule, possibly CO, was found to be evaporating in the comet at the same rate as water, a common constituent. This could mean that the source of the carbon was an outer layer deposited after the comet was formed, but it could also mean that the parents are present in far larger amounts than comet theorists had foreseen.

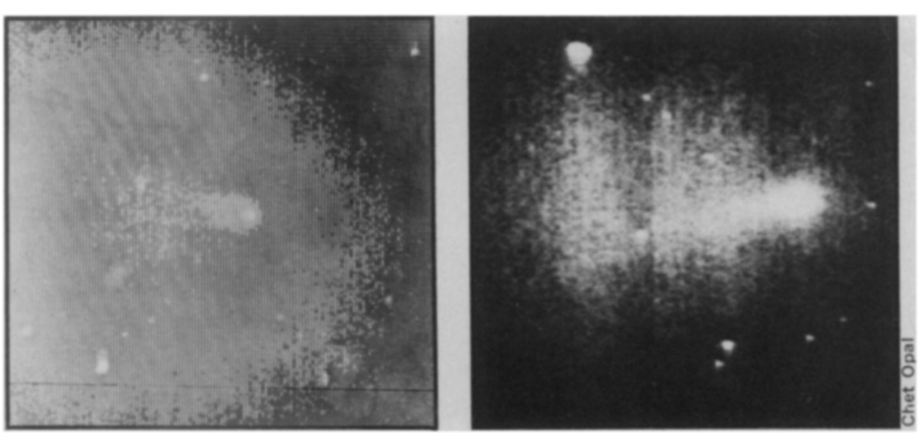
Questions about Kohoutek will be a long time in the answering—there are "several hundred" yet-unidentified spectral lines, for example, according to Maran—but the long-watched object nonetheless provided astronomers with an unprecedented chance for detailed structural studies and for charting the changes in a comet as it approaches and recedes from the sun.

The fortuitous presence of Skylab enabled the astronauts to take ultraviolet photo sequences of Kohoutek's hydrogen halo as it grew nearer. Chet Opal of the Naval Research Laboratory helped to produce a detailed map of the hydrogen using "isophots"—contour lines showing regions of equal brightness. George Rieke of the University of Arizona, after looking unsuccessfully for a 10-micron "bump" in the spectrum that would have indicated silicate dust in the comet's head, finally saw it appear, says Maran, when Kohoutek was about 150 million to 160 million miles from the sun. This suggests that perhaps the dust was released from entrapping ice grains as the comet neared the sun. On Jan. 16, with the comet heading outward, adds Rieke, an abrupt and peculiar change in the polarization pattern further suggested (although the polarization measurements are not fully conclusive) that dust picked up by the comet at different times ends up in different parts of the nucleus.

With so much time available for preparation, a number of astronomers ventured predictions of what they might see. Zdenek Sekanina of the Smithsonian Astrophysical Observatory correctly foresaw the formation of an anti-tail, made up of particles cast off by the comet, lagging behind the regular tail because of their greater individual masses and pointing in a direction much closer to the sun. An apparently rare feature, observed for the first time on Kohoutek, was a halo of icy grains, which appeared as predicted by Delsemme.

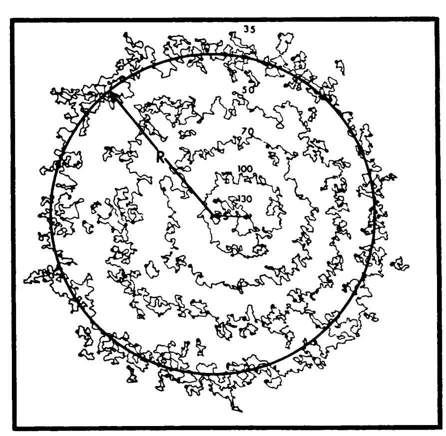
The possibility of sending unmanned spacecraft to visit comets has been a topic of discussion and study for many years, and Kohoutek has added to the interest. NASA is considering a "slow" mission to Comet Encke, to be launched in 1979, so-called because it would use a weak but steady electric propulsion system to bring the speed of the spacecraft to within five kilometers per second of the comet's velocity, giving several hours of observation time. A less expensive option would use a conventionally powered craft that would hurry past the comet, possibly jettisoning an unpowered probe to swoop in near the comet's nucleus. This could be a "kamikaze" mission, one NASA official says, since particles up to a yard across may be breaking free from the nucleus, and might collide with the probe. Another Encke flight, launched in 1981 to arrive three years later, would match speeds exactly, enabling the vehicle to tour slowly through the comet's halo. The closest proposal to a certainty, even though it's the farthest in the future, is of course a shot to Halley's Comet, due in 1986.

"I only hope," says one astronomer, "that the public isn't so unhappy about Kohoutek that it squelches all the comet probes." Kohoutek was not the Christmas spectacular that it somehow got cracked up to be; but for the scientists, it was at least a goldmine. □



Chet Opal

Missile tracker images a month apart aided brightness and size-growth profiles.



Opal's hydrogen brightness contours.