The Making of a Comet

Early on Christmas morning, a group of scientists plans to generate the first artificial comet, more than 100,000 kilometers from earth—and you can watch

By JONATHAN EBERHART

It is to be a Christmas comet, appearing in the night skies early on December 25. There are no photos of its coming; no astronomers have spent months tracking it through powerful telescopes. In fact, no one has seen it at all. Because it does not exist. Rather, if all goes well, it will simply spring into being on Christmas morning, virtually from nothing — a bizarre, fuzzy, glowing, greenish disk that changes in mere minutes to a purplish hue as it begins to extend a comet's characteristic tail. And in less than half an hour, except perhaps to those for whom technology is augmenting or replacing their eyes, it will be gone.

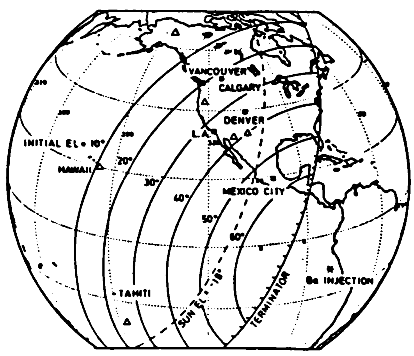
What kind of comet is this, eerily colored, fading in and out like some kind of cinematic special effect?

In fact, a special effect is just what it will be: Called the first artificial comet, it will be triggered by a radioed command from earth to an orbiting satellite about 116,000 kilometers away, where a container of barium-laced copper oxide crystals will be released into the firmament. At first glowing a sort of yellowish-greenish blue by reflected sunlight, the expanding cloud of barium atoms will be rapidly transformed by solar ultraviolet radiation into barium *ions*, which instead reflect a pale, purplish cast.

Its purpose? To provide answers, as three satellites, together with hosts of earth-based and airborne observers, study it in ways some of which have never been applied to any natural comet that ever existed.

The satellite that jettisons the barium, a second probe positioned about 200 km away from it and a third one at a much lower altitude, together are known as AMPTE, the Active Magnetospheric Particle Tracer Explorers. In September, AMPTE generated and studied a pair of lithium clouds on the sunward side of the shock wave that exists where the solar wind collides with earth's magnetic field (SN: 9/29/84, p. 197). There, the goal was to see how the solar wind — "tagged" with a lithium "tracer" — actually gets into earth's radiation belts, trapped in the magnetic field. The thing that will get AMPTE researchers from several nations up so early on Christmas morning, however, is the chance to see how a "calibrated" comet (it was designed for the purpose, after all) is affected by the solar wind, including observations made *within the "comet" itself.*

As a comet approaches the sun, the growing warmth frees increasing amounts of material — water, dust, etc. — from the comet's outer layers. Much of it streams out behind the comet in its orbit and reflects sunlight to form the visible dust tail so familiar in scenes from photographs to ancient tapestries to the sky itself. In addition, however, there is the much subtler "ion tail" (sometimes completely invisible to the naked eye), which is drawn out by the passage of the solar wind (whose magnetic field guides the ions), follows it, and thus always points away from the sun.



G. Haerendel/Max Planck Institute

To observe AMPTE's comet (assuming that you are on the nightside —west —of the terminator), find your location on the map, turn in the direction of the point labeled on the map as "Ba INJECTION," and look up at the angle indicated for your location by the curved, concentric lines. (From Denver, for example, you would face approximately south-southwest and look up at an angle of about 35° from the local horizontal.)

Numerous photos of cometary ion tails have been taken, often through filters sensitive to the wavelengths of light emitted by particular ions. But just how efficient is the solar wind at stripping a comet of its evolving "atmosphere"? No two comets are alike, and no spacecraft has ever visited one, so there has been essentially no way to tell how much material is released from a given comet or how much of that is ionized and swept away. AMPTE will produce a known amount of barium vapor (2.5 kilograms), and at a known rate. Furthermore, the barium is eminently visible, and although it is released as neutral atoms, it obligingly changes color as it is ionized.

Many such clouds of barium, lithium and other elements have been produced in past experiments (usually from sounding rockets), but they have been formed at lower altitudes that are within earth's magnetic field so that the solar wind never reaches them to stretch them out into a tail. Instead, the ions become aligned with *earth's* field lines, and in fact are commonly used as tracers in geophysical studies. AMPTE's high-altitude release, however, should take place right *in* the solar wind, with the color-changing glow giving scientists a direct indication both of how readily the barium is ionized and of how rapidly the ions are swept into a tail.

Another advantage of the artificial comet over any natural one in such a study results from the fact that it will be essentially a "cometless comet," with no solid nucleus. Instead of a kilometers-wide ball of dirty ice occupying the center of the action, there will be AMPTE's Ion Release Module (IRM) satellite, heavily instrumented and stationed — by definition — right at the source. As long as the comet is visible, it will accompany the IRM around in its orbit, though shortly after that the solar wind will have carried off all of the ionized barium, and the fragments of the barium canister (destroyed by the thermite detonation that triggers the cloud) will be driven out and away by the blast.

About 200 km downstream from the West German IRM in the solar wind's flow will be the United Kingdom Subsatellite (UKS), equipped to study the speed, density and structure of the ion tail as it forms. At a much lower altitude, the U.S. Charge Composition Explorer will monitor naturally occurring ions as well as any of the injected barium ions that may show up in the geomagnetic field.

Not all of the observations, however, will be made from space. Scientists will be watching the growth and other changes in the "comet" from such observatories as Kitt Peak in Arizona, Mauna Kea in Hawaii and El Leoncito in Argentina. In addition, the National Aeronautics and Space Administration's Galileo airborne observatory (a Convair 990 jet) will be flying out over the Pacific Ocean from Alaska, while a Boeing 707 belonging to the Argentine Space Research Organization takes off from Tahiti to observe in the southern hemisphere.

Still other professionally staffed facilities are scheduled to take part, but there could be a role even for amateur observers. Clouds, for example, could block the view from certain key sites, and accurately tracking the barium cloud's growth requires observations from a variety of widespread locations. The "comet" will probably appear too close to daylight to show clearly in the easternmost part of the United States, but in California, for example, it is tentatively targeted to be generated at 4:18 a.m. PST. Viewing opportunities should be best from the Midwest out as far as Hawaii and throughout the eastern Pacific (see map).

Even a pair of 7x50 binoculars should show the "comet" to good effect for casual viewing, but photographic observations that might turn out to be useful to the AMPTE team will need to include accurate times and other data.

If weather or other conditions pose too much of a problem, the experiment may be delayed until early on Dec. 27, but that is the only other presently listed option. Christmas morning was not selected for reasons of sentiment or publicity, AMPTE researchers say, but was the result of several test requirements—the presence of a new moon, a low sun angle, the proper relative positioning of the IRM and UKS, and the location of the satellites in view of observing sites in the western United States and eastern Pacific.

AMPTE's scientists, meanwhile, envision the possibility of learning more from the experiment than just the behavior of its one comet. Researchers around the world, for example, are preparing for the coming of famed Comet Halley, notes Mario Acuña of the NASA Goddard Space Flight Center in Greenbelt, Md. Few natural comets before Halley will be visible from the southern hemisphere, he says, but many instruments are being set up there for that event, and "Comet AMPTE" could provide a chance to calibrate some of the equipment. Also, says Stamatios Krimigis of the Johns Hopkins Applied Physics Laboratory in Laurel, Md., results from the AMPTE satellites may prove useful in optimizing instrument settings aboard another space probe, known as ICE (the International Cometary Explorer), which is on its way to fly through the tail of Comet Giacobini-Zinner on Sept. 11, 1985. For example, following AMPTE's first lithium release in September, he says, it was determined that the density of the ionized lithium "plasma" varied more rapidly than expected; it was thus possible to set certain of AMPTE's instruments to sample the density at a faster rate, in time for the second release nine days later.

The disk of Comet AMPTE, as seen from earth, may be only about one-sixth the diameter of a full moon, calculates the experiment's chief scientist, Gerhard Haerendel of the Max Planck Institute for Extraterrestrial Physics in Munich, Germany, and its brightness may be a relatively modest magnitude 2.5. (Morris B. Pongratz of Los Alamos National Laboratory in New Mexico thinks it could be considerably brighter, if the barium ions are picked up rapidly enough by the solar wind for the resulting doppler shift to move their spectral wavelength away from the absorption of the unshifted wavelength due to barium ions in the sun.)

Even so, and though the comet may be visible for well under an hour to an observer with binoculars ... Merry Christmas. □

Join the AMPTE 'comet watch'

A tape recording of information about observing the AMPTE "artificial comet" can be heard by calling NASA's Goddard Space Flight Center in Greenbelt, Md., at *301-344-0470.*

Those who would like to contribute documented photographs of their observations of the "comet" for possible assistance with AMPTE's studies can send them to: *John T. Lynch, AMPTE Program Scientist, Code EES, NASA Headquarters, Washington, D.C. 20546.* Supporting data should include: the observer's precise latitude and longitude, accurate pointing information (less necessary if the background star field is visible in the photos), precise times of each observation, wavelengths and bandwidths of any filters used, photographic data (film types, exposure times, apertures, use of low-light image intensifiers, etc.) and absolute brightness estimates if possible.