In Search of Elusive Little Comets

The existence of mini-comets bombarding the solar system has reportedly been confirmed by two independent means; only their originator thinks the matter resolved

WHEN LOUIS FRANK of the University of Iowa, a prominent member of the space physics community, proposed 2 years ago that tiny, unseen comets are pummeling Earth 20 times a minute, the groans from the earth and planetary science community were all too audible. Hardly a specialty could escape the implications of the mini-comet hypothesis, and the implications were outrageous to all but Frank.

But at the recent spring meeting of the American Geophysical Union (AGU) in Baltimore, two different kinds of observations were reported that, it was claimed, confirm Frank's hypothesis. One was detection by a second satellite of the comets' effect on Earth's upper atmosphere, a claim that immediately kindled controversy. The other was an apparent telescopic detection of mini-comets swarming midway between Earth and the orbit of the moon. Astronomers have not seen these results yet, but the telescopic search still does not include the kind of evidence that would convince skeptics. The controversy will continue at least a while longer.

The controversy has been so heated not only because it touches so many fields, but also because these comets had remained invisible to all but Lou Frank and his ultraviolet camera on the Dynamics Explorer satellite. This elusiveness necessitated that mini-comets be the oddest objects in the solar system. According to Frank and his graduate students John Sigwarth and John Craven, mini-comets are made of pure water ice, so that there is no rock to flash into meteors on entering the atmosphere. No known comet is pure anything. Regular comets are about half dust, most of which is rock. The hypothesized mini-comets have the density of uncompacted snow—90% emptiness—so that they will fall apart at the merest tug from Earth's tidal forces and vaporize thousands of kilometers above the atmosphere. Otherwise they would slam into the deep atmosphere and be all too obvious.

To shield them from detection while still in outer space, mini-comets are cloaked with a thin layer of coal-black material that insulates the ice against the sun's heat. The blackness hinders telescopic detection, and the insulating mantle prevents the formation of an easily detectable coma of gas and the flooding of interplanetary space with water. Comet Halley has a black mantle of dust and organic matter, but Halley still began leaking water through weak spots as far out as the orbit of Jupiter.

The physical properties of mini-comets are disturbingly unrealistic to planetary scientists, but the most provoking aspect of the proposal is probably the flood of water involved. Peering down from its high orbit, Frank's ultraviolet camera has recorded momentary dark spots in Earth's dayglow, the sunlight-stimulated emission of the upper atmosphere. These "holes" in the atmosphere, as Frank calls them, appear at a rate of 20 per minute when extrapolated to the whole Earth. He concludes that the dark spots result from real objects below the satellite blocking out the dayglow. Each obstruction, according to Frank, is about 100 tons of water from a single disrupted comet that had been about 12 meters in diameter. If it is assumed that mini-comets have been arriving at the same rate for the age of the solar system, that is enough water to fill all the oceans.

Louis Frank. *Ten million house-size comets hit Earth's atmosphere each year.*

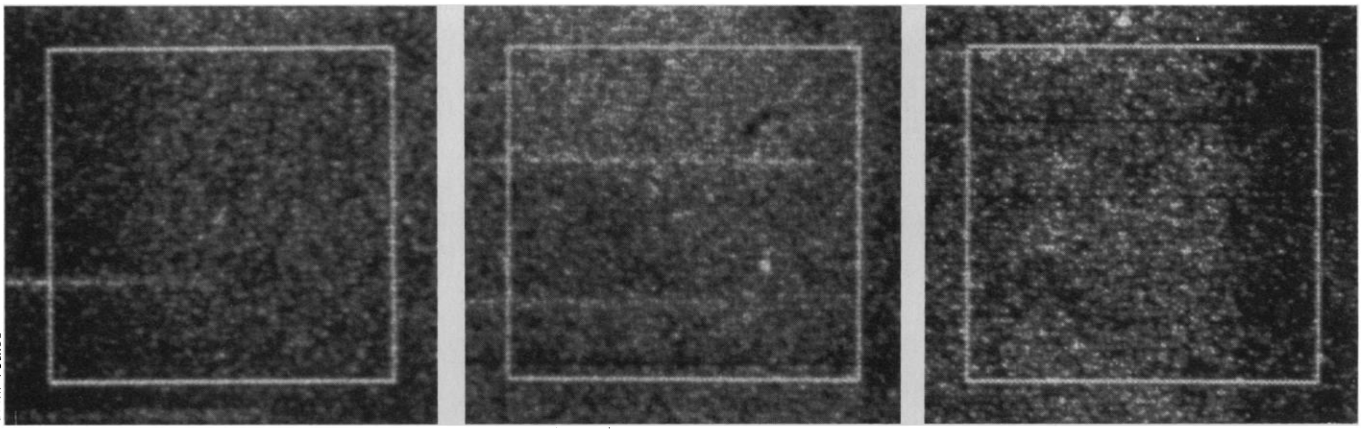
Other sources for the oceans, such as Earth itself, have been suggested, but the greatest conflicts with established thinking come elsewhere. Most places near the sun are strikingly dry. Closest to home, Earth's upper atmosphere is generally thought to be too dry for such a steady influx of water. The surface of the moon and the atmosphere of Venus are bone-dry, as is Mars despite its ancient history of surface running water.

While conceding that his proposal has been "unreasonable to every other person on the planet," Frank has concluded that it "is not in conflict with any solidly known fact about the solar system," including the death of the dinosaurs. A widespread feeling before the meeting was summed up by one critic who concluded, "This is the one theory I know of that has a thousand fatal flaws."

Flaws or no, there is nothing like direct, independent observation to bolster a seemingly dubious claim. Frank believes that his case is complete now with the two new studies presented at the AGU meeting. In the first, his Iowa group gave a joint paper with John Murphree and Leroy Cogger of the University of Calgary describing the observations of an ultraviolet camera aboard the Swedish satellite Viking. Murphree is the principal investigator for the camera.

The Iowa group had visited Calgary in January to agree on what could or could not be seen in the Viking images. "It took less than 3 minutes to identify a hole," said Frank, who gave the AGU talk in Murphree's absence. "You simply can't miss them. I don't see how these things were missed." The probability that a half dozen picture elements, called pixels, could come together in an image to form such dark spots is 1 in 100,000, according to Frank. A preprint circulated at the meeting by Frank concludes that the size, darkness, and frequency of occurrence of these atmospheric holes are similar to those of the holes seen by Frank's camera on Dynamics Explorer. The paper has Murphree's and Cogger's names on it as well as those of the Iowa group.

That will probably not last. Contacted in Calgary, Murphree cannot support Frank's conclusions. "I'm fairly convinced that these are just instrumental effects," he says. He expects to ask shortly that his and Cogger's names be dropped from the paper.


C. M. Yeates

Elusive mini-comets detected at last? *Clayne Yeates of JPL, who acquired these charge-coupled device images using the Space Watch Telescope, believes that these and other streaks were caused by dark objects about 3 to 4 meters in diameter passing roughly 150,000 kilometers from Earth. The short streak in the center of the left-hand box would have been caused by an object quite near that distance, and the longer ones at the centers of the middle and right-hand boxes would have been farther from it. Yeates has more work to do before he proves that these are real.*

Murphree sees one major problem with the Iowa interpretation of his data. The two groups cannot agree on how to calculate the probability of such dark spots occurring by chance, as part of the background of instrumental noise. At the moment their different approaches yield probabilities that differ by a factor of 10 billion, says Murphree.

This is the second time that two groups have disagreed on the interpretation of the same dark spots. Bruce Cragin and his colleagues at the University of Texas at Dallas analyzed 182 images from Frank's Dynamics Explorer camera. According to their work, dark spots consisted of a single pixel without significant darkening of adjacent pixels, which the group concluded was physically unrealistic. And the spots were the same size and occurred with the same frequency regardless of the satellite's altitude. "It fits noise," says William Hanson of the Texas group, "I'm sure of it."

The other claimed confirmation is not yet controversial, perhaps because no astronomers have seen the results. That may change shortly when Clayne Yeates of the Jet Propulsion Laboratory (JPL), himself a space physicist like Frank, submits his telescopic observations for publication.

To judge by the reactions garnered by *Science* from observational astronomers, Yeates, who had never used a telescope before, has done a respectable job of designing a search for Frank's mini-comets. Intrigued by astronomers' half-serious claims that a search with binoculars would have turned up such objects, Yeates investigated just how difficult a search would be. He found that only two telescopes would have a chance. He chose the Space Watch Telescope on Kitt Peak, which is equipped with a sensitive charge-coupled detector and is operated by Tom Gehrels of the University of Arizona. But even then, detection of mini-comets, if they existed, would be "barely possible, marginal," he found.

The key to Yeates's search was an innovative approach to pointing the telescope. Unable to track a specific object, which is the usual means of concentrating enough light on one spot on the detector, Yeates swung the telescope in such a way as to maximize the chances of tracking any object about midway between Earth and the moon that moved the way mini-comets are supposed to move. It was "sort of like a skeet shoot," said Yeates, only the targets were unseen. Frank had inferred mini-comet motions, like most of the rest of their properties, from their invisibility. To avoid lighting up on entering the atmosphere, their impact speeds must be less than 20 kilometers per second. In order to remain under that speed limit, they must orbit the sun in the same direction as Earth and near the same plane.

Given the proposed orbital characteristics, size, reflectivity, and frequency of appearance of mini-comets, Yeates calculated that, if they are real, he should see one streak up to 20 pixels long in every 2 to 20 exposures. The streaks would be caused by objects having a brightness of about 18th magnitude. That is about what he saw. "Everything agreed precisely with the predictions," he said. "I've never done an experiment that worked that way. That is rather remarkable. This is a class of objects that agrees exactly with those proposed by Frank."

For additional checks, Yeates varied the pointing of the telescope. When he switched from one side of Earth's shadow to the other, the proportion of short and long streaks changed as predicted by the change in viewing perspective. When he scanned opposite the direction of mini-comet motion, which should have stretched the short streaks, the short streaks disappeared.

Yeates also tried to eliminate all other possible causes for the streaks. He took the camera off the telescope and recorded only the streaks made by passing cosmic rays. Such streaks are too distinctive looking to be confused with the faint ones caused by dim objects, he says. He considered satellites or satellite debris; none could create enough streaks of the right length. Meteors and fireflies would not work either.

There is one thing Yeates has not done but must do in order to convince astronomers of the reality of his small objects. He must record the same object twice, the traditional requirement for confirmation of the discovery of a new member of the solar system. In this case, the detections must come on two quick, sequential exposures. Such exposures have been made, but Yeates has not yet analyzed them. That will take some months.

"No astronomer is going to be convinced until somebody goes out and confirms it," says Torrence Johnson of JPL. "The best you can say is that a pretty good experiment has been done, and preliminary study suggests that something is going on."

If the telescopic observations of tiny, dark objects hold up, everyone will simply have to adjust. Whether the atmospheric holes were ever real or not would become a moot question. They could be nothing but instrumental noise that pointed the way to real discovery. If, on the other hand, the telescopic detections turn out to be something else, it will be back to unproductive arguments about atmospheric holes until a new, more capable instrument comes along. ■

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ADDITIONAL READING

L. A. Frank, J. B. Sigwarth, J. D. Craven, "On the influx of small comets into the earth's upper atmosphere I. Observations," *Geophys. Res. Lett.* 13, 303 (1986); "II. Interpretation," *ibid.*, p. 307.