A Bunch of Little Comets — But Just a Little Bunch

The Voyager 2 spacecraft has provided such spectacular close-up photos and other information about Jupiter, Saturn and Uranus that it is little wonder that small attention has been paid to what it did when it was still near earth. Yet measurements made by one of its instruments shortly after its 1977 launching, scarcely studied during the intervening decade, have now been cited as evidence for the possibility that the moon has been bombarded by enough small comets (as opposed to meteorites) to account for every lunar crater less than about 1,500 meters across formed in the last 3.2 billion years.

With so many comets hurtling at and around the moon over its history, it would be a virtual certainty that an even larger fusillade has come at the earth, and the Voyager data leave room for that possibility too. Yet the number evoked by those data is dwarfed by the implications of a scientific controversy about one researcher's dramatic proposal that enough tiny, otherwise unsuspected comets have been striking the earth over the eons for their ice to have provided the water-equivalent of earth's entire atmosphere every 5 million years (SN: 12/6/86, p.361).

The basis for that suggestion has been dark spots visible in nearly all of the thousands of ultraviolet images of the earth's atmosphere recorded by NASA's Dynamics Explorer 1 satellite. The spots, according to the University of Iowa's Louis A. Frank, represent a dimming of the ultraviolet emissions due to concentrations of water vapor, such as might be deposited there by incoming comets. But his view is far from widely accepted.

No fewer than 10 issues of GEOPHYSICAL RESEARCH LETTERS, the scientific journal that first published his hypothesis, have carried articles by researchers who disagree, accompanied in each case by Frank's rebuttal. One of the dissenters is Thomas M. Donahue of the University of Michigan in Ann Arbor, who speaks of Frank with great respect but who still thinks the proposal is vastly overstated. He has noted, for example, that the amount of hydrogen presumably dissociated by sunlight from water in the atmosphere and escaping into space can explain only about one one-thousandth of the water that Frank's proposed comets would be bringing in.

Yet it is Donahue, together with Michigan colleague Tomas I. Gombosi and Bill R. Sandel of the University of Arizona in Tucson, who has found new reason — in Voyager 2's old data — to invoke a long-running comet onslaught himself. Their data depict a far less dramatic history, however, with an overall "flux" of little comets, or "cometesimals," that Donahue says is about 100 million times smaller than that required by Frank's idea.

The measurements are from Voyager's ultraviolet spectrometer, or UVS, and include readings of what are called Lyman alpha emissions, given off by hydrogen atoms such as those released from water. When Donahue started reexamining the data, he originally expected to see signs of virtually nothing brighter than the general background emissions of the interstellar medium. But although the difference between Voyager 2's measurements and the expected brightness of the interstellar medium was indeed small, it was not zero. At earth's distance from the sun, for example, Donahue says, the overall ultraviolet brightness recorded by the spacecraft was about 650 Rayleighs, of which about 500 is the interstellar background. The other 150 or so is due to "something else."

There were fewer than two dozen observations to go on: They had to be made with the UVS always pointing in the same direction, normal to the imaginary line between the sun and the spacecraft and facing away from the oncoming interstellar wind. The data, says Donahue, cover a span from the earth out to a distance of about 380 million kilometers (minus a gap from 155 million to 200 million km, while other tasks made the UVS unavailable for these particular observations). As the spacecraft receded from earth, the measured brightness of the emissions decreased rapidly enough to suggest essentially a hydrogen "bulge" at the beginning of the trip — the part nearest the earth and moon.

Furthermore, notes Donahue, who described the idea at the recent meeting of the International Union of Geodesy and Geophysics in Vancouver, British Columbia, data from the U.S. Mariner 5 and 10 spacecraft and the Soviet Veneras, all of which made their voyages in toward Venus, indicate that the effect does not continue any closer to the sun than earth's mean distance — further suggesting that the phenomenon is primarily associated with the earth-moon region.

The source of the water that Donahue and his colleagues suggest to be capable of producing the observed hydrogen would be a large number of cometesimals, each ranging from about 8 to 100 meters across. Rather than being balls of ice, he says, they would be more like loosely packed snowballs, porous and with densities possibly as low as 0.1 gram per cubic centimeter — a tenth the density of liquid water.

Yet as light as they are presumed to be — which is not inconsistent with some calculations based on measurements made during last year's appearance of Comet Halley — Donahue's group estimates that they would be swinging through the solar system in parabolic orbits, such that they could hit the surface of the moon at speeds on the order of 60 kilometers per second, or about 25,000 miles per hour.

Meanwhile, there is far more to be learned about the effects of incoming comets. Frank, for example, notes that an "artificial comet" produced earlier this month by jettisoning a container of water and other materials from a NASA sounding rocket, was carefully timed to be visible to two artificial satellites: the Dynamics Explorer, whose data triggered the original controversy, and another known as Polar BEAR. (Timing the rocket's liftoff to be in view of both satellites required such precision, says Michael Mendillo of Boston University, that the available "launch window" was less than two seconds long.) The results are still being analyzed, says Frank, but extremely preliminary looks at the data hint that each craft may have seen signs of an ultraviolet reduction.

Donahue is careful to note that there are a variety of uncertainties yet to be resolved in his group's hypothesis, but neither is Frank's model anything like home free. For the small amount of water implied by Voyager 2's Lyman alpha readings to have come from the huge number of little comets in Frank's proposal, Donahue says, each comet of about 12 meters in diameter would have to be blanketed beneath some 12 kilometers of dust. — *J. Eberhart*

Shrinking silicon chips down to size

The tinier the semiconductor transistor, the faster and less power-consuming it becomes. Some researchers, however, have wondered if there is a limit to the advantages of chip miniaturization, and have suggested that when transistor features get thinner than about 0.25 micron, unwanted "parasitic effects," such as high resistance in the wrong places, would emerge.

Researchers at IBM Corp. in Yorktown Heights, N.Y., say they have allayed such worries by making some of the smallest silicon transistors ever fabricated and operating them at liquid-nitrogen temperatures (77 kelvins). While other scientists have made devices with individual parts in the 0.1-micron range, IBM's