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.

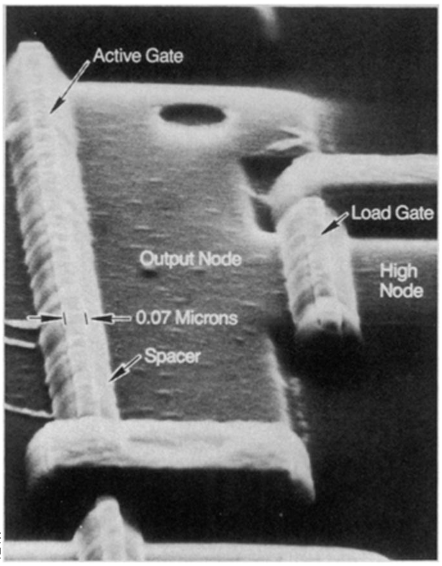
Meanwhile, there is far more to be learned about the effects of incoming comets. Frank, for example, notes that an "artificial comet" produced earlier this month by jettisoning a container of water and other materials from a NASA sounding rocket, was carefully timed to be visible to two artificial satellites: 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



IBM

With careful engineering, including the use of electron-beam lithography for delineating device features, IBM researchers have shown that high-performance, low-temperature silicon transistors with key parts smaller than 0.1 micron can be fabricated.

George A. Sai-Halasz and his colleagues are the first to scale down – in both the lateral and vertical dimensions – all the critical features to this size and smaller.

"At these dimensions we can pack 1 million of these things on a chip with no problem at all," says Sai-Halasz. "...You could put a whole computer on not more than two or three chips."

Operating the transistors at liquid-nitrogen temperatures also enables the researchers to scale down the voltage needed to switch them on and off; this in turn reduces the power dissipated by the transistors. The low temperature also improves the performance of the devices, as measured by the transconductance, or current flow out of the device per unit change in voltage. The researchers will report in the October IEEE ELECTRON DEVICE LETTERS that the transconductance of their devices is 40 percent higher than that reported for other silicon devices operating at room temperature and is comparable to that of gallium arsenide devices (which have been pursued largely because they promised greater performance and faster speeds than their silicon counterparts).

Sai-Halasz says he's convinced that the only worthwhile semiconductor devices of small proportions will have to be cooled to low temperatures. But he doesn't view this as a technological barrier because the computer industry "is moving in that direction anyway." By the time these kinds of tiny transistors can be put in mass production, he says, "liquid nitrogen will be no problem at all." The next problem to be solved, he notes, is how to get rid of all the heat generated by extraordinarily densely packed chips.

– *S. Weisburd*

RNA satellites confer viral resistance

For the past decade, researchers have been aware of the existence of tiny RNA "satellites" that reside within the cells of certain crops. Little is known about these enigmatic bits of genetic material; they seem to exist in a sort of dormant state in leaf cells, incapable of replicating without the assistance of a fully formed – and often disease-causing – "helper virus." The satellites are of interest to plant pathologists because they can influence the severity of the disease caused by their respective helper viruses.

Two reports in the Aug. 27 NATURE describe advances in the use of RNA satellites as natural inhibitors of crop-damaging viruses. The research points to a promising method of genetically engineering crops to better defend themselves against disease.

Bryan D. Harrison and his colleagues at the Scottish Crop Research Institute in Dundee, Scotland, genetically transformed tobacco plants so that the plants themselves, when attacked by a virus, produce a particular RNA satellite within their cells. The plant-produced satellite takes advantage of the disease-causing cucumber mosaic virus (CMV) in order to reproduce itself, but in doing so it suppresses CMV replication.

In similar research, Wayne L. Gerlach and others at CSIRO Division of Plant Industry in Canberra, Australia, successfully inserted the gene for a tobacco-plant RNA satellite that ameliorates the symptoms of infection by tobacco ringspot virus.

"What we've shown is that this satellite production attenuates the disease, and that it also greatly decreases the replication of the virus in the genetically engineered plants. And as a result of the lower virus concentration in these plants, they are much poorer sources of virus for insects to spread to other plants," Harrison told SCIENCE NEWS.

The beauty of this method of virus control, Harrison says, is that "the satellite precursors in the plant are only activated when the virus infects, so it doesn't matter how little satellite there is at the time of infection." When challenged by a virus, satellite levels "soon build up to very high concentrations." One disadvantage, he notes, is that similar RNA satellites actually *enhance* viral infectivity. Scientists need to understand how these differ, he says, lest a minor mutation in a virus-resisting satellite leave a plant more – rather than less – vulnerable to infection.

– *R. Weiss*

Taking a vacuum to extraterrestrial dust

While cleaning dust out of the corners of a room may be a loathsome part of everyday existence, scientists standing on Greenland's glacial ice cap are only too glad to do a little vacuuming. From the bottom of shallow lakes that form on the ice, they are collecting black dust that is helping to answer some cosmic questions, including how the early solar system developed.

Several years ago, researchers discovered that this black dust actually contains micrometeorites measuring about one-tenth of a millimeter across. In fact, the annual thawing cycle on the ice cap concentrates the extraterrestrial grains at the lake bottoms, making these the richest known deposits of micrometeorites on the earth's surface (SN: 8/30/86, p.133).

This year, Michel Maurette of the University of Paris and his colleagues finished a thorough analysis of the sizes and compositions of the micrometeorites – an analysis that is yielding unexpected results. "In addition to families of grains never reported before," write the researchers in the Aug. 20 NATURE, "we have found a suprisingly high abundance of unmelted chondritic fragments."

While chondritic fragments are the most abundant type of micrometeorite, scientists previously had thought that unmelted grains were extremely rare. However, the researchers found that about one-fourth of the total micrometeorites were unmelted and many were relatively large. They propose that a "very effective cooling mechanism" protected the grains from a fiery demise as they soared through earth's atmosphere.

Moreover, when Maurette's group compared the micrometeorites taken from Greenland with those collected from outside the earth's atmosphere by satellite, they found that each sample had a similar distribution of sizes. Such a correlation suggests that the grains found on earth come from a population of micrometeorites that inhabits the inner solar system.

Many believe that these micrometeorites come from comets, the so-called dirty snowballs that vaporize as they orbit the sun. Since comets are thought to have developed before the sun and planets, scientists study micrometeorite composition as a representative of the primordial matter that eventually coalesced into the solar system, says Ian Mackinnon, a cosmochemist at the University of New Mexico in Albuquerque. With Greenland yielding much larger grains than other sources – such as the deep sea – scientists will now be able to perform a wider range of physical and chemical tests on this cosmic dust.

– *R. Monastersky*