Getting out from under

Balloons, rockets and satellites help astronomers get above the atmosphere's blackout blanket

by Dietrick E. Thomsen

• A spacecraft with two 750-foot, V-shaped antennas is orbiting the earth gathering radio signals from the galaxy and the solar system. Radio Astronomy Explorer A rocketed July 4 to record signals that cannot be received through the earth's atmosphere.

• Three weeks earlier, on June 12, a British Skylark rocket carried an X-ray telescope to a height of 115 miles over Woomera, Australia, to search for X-ray stars—objects first seen in 1962. Their existence would never have been suspected on the basis of information available at the surface of the earth.

• In May an optical telescope—Stratoscope II—was lifted by balloon to a height of 80,000 feet in the hope of taking clearer pictures of stars and planets than could ever have been done from the earth.

• And, by 1970, the United States hopes to orbit another X-ray observer.

These activities begin the fulfillment of an age-old dream of astronomers, who might have remarked, as St. Paul did in another context: "Now I see through a glass, darkly, but then I shall see face to face." They will escape the clouding atmosphere.

The earth's atmosphere is a serious nuisance to astronomy. Over the whole range of radiation from the stars the atmosphere offers only two small windows: visible light and some radio waves.

For millenia astronomers were aware only of the optical window because it corresponds to what can be sensed by the human eye. In fact, until a century ago no one suspected that visible light was only a small part of a vast electromagnetic spectrum.

The discovery of radio—the same electromagnetic radiation as light, but at a lower frequency, longer wavelength, and lower energy level— finally led astronomers to look with other eyes than their own for radiation from the heavens. Radio stars were discovered, mostly with radar-type antennas developed during World War II. Equipment in rockets and balloons later found discrete sources of X-rays—radiation with higher energy and shorter wavelength than ordinary light.

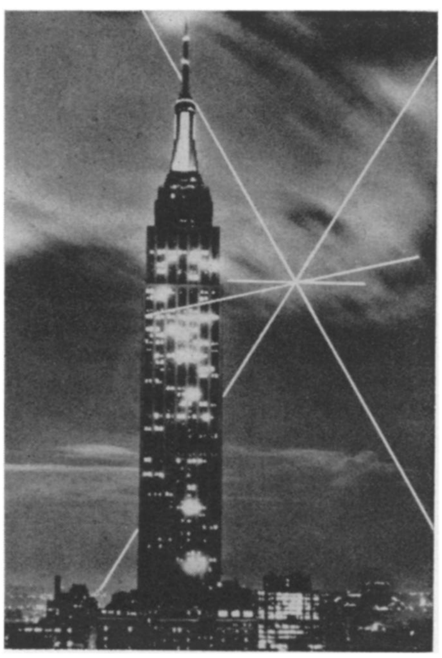
But the atmosphere is always there. Radiation is known to range from wavelengths of tens of kilometers at the radio end through infrared, visible and ultraviolet light to X-rays and finally gamma rays at about a ten-million-billionth (10^{-14}) of a meter. That spread offers vast opportunities to astronomers—if they can escape the atmosphere.

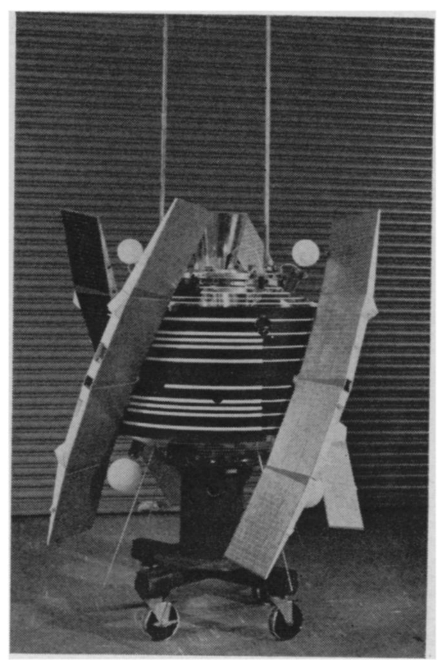
Two kinds of process affect the radiation that strikes this envelope of air.

When the wavelength of the radiation striking the surface of the atmosphere —or any other physical substance for that matter—is very much longer than the distance between electrons in the substance, the wave encounters these electrons as it would a connected mesh, which it sets into collective vibration.

The vibrating mesh reflects some of the radiation, transmits some, and absorbs some, turning it into heat.

Whether reflection, transmission, or absorption dominates depends on the composition of the material. It takes substances as dense as metal to provide total reflection of light and most radio, but the upper atmosphere will do it for the longest radio waves. At light and





NASA

Radio satellites' 1,500-foot antenna spread compared with the Empire State Building. At right, the satellite.

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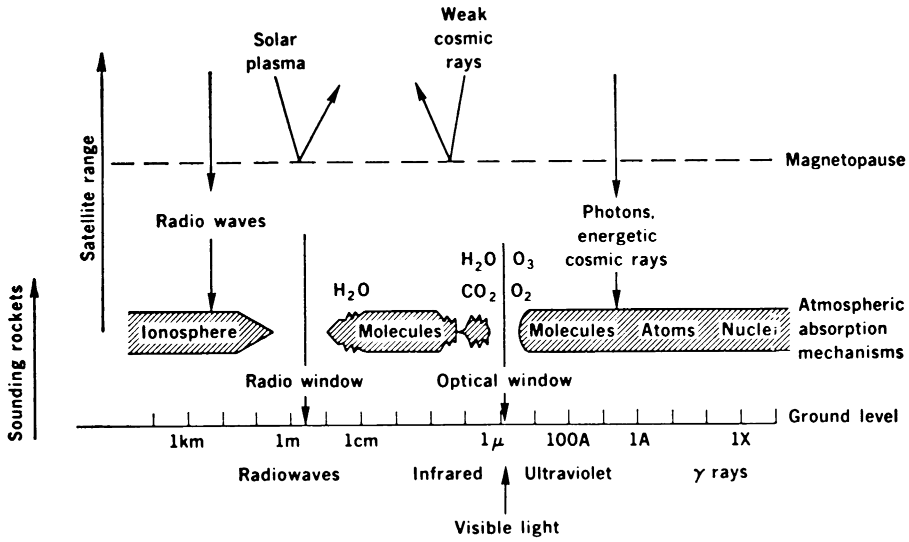

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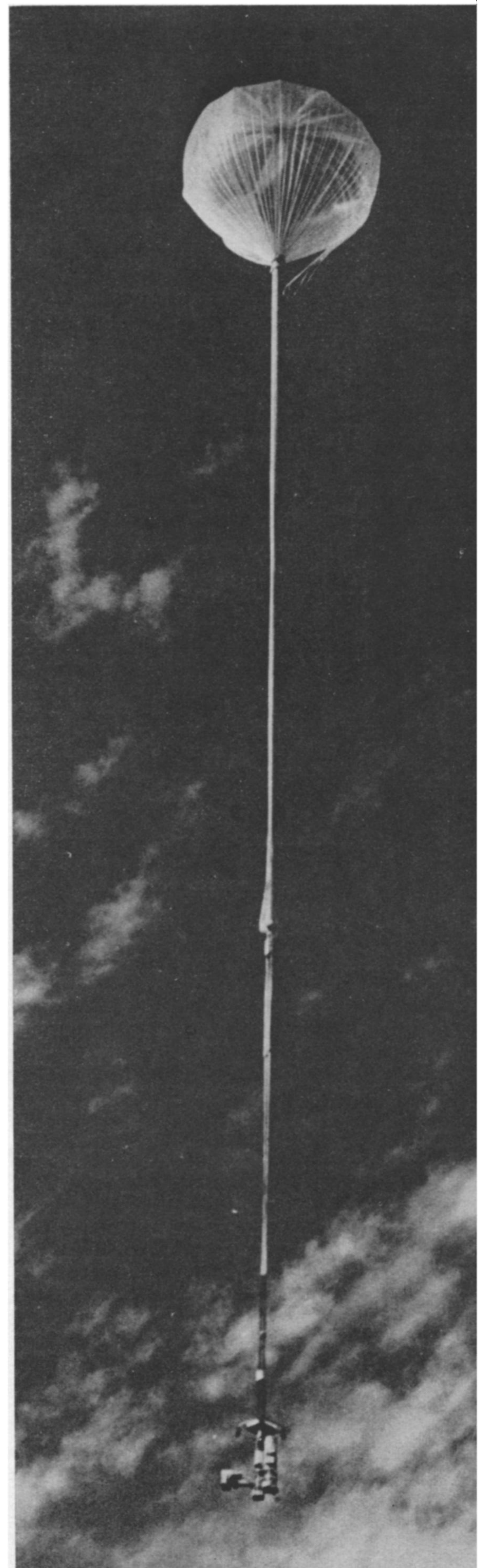

Spectrum shows portions blocked by the atmosphere. Stratoscope II (right) rides its balloon above most of the atmosphere's absorption and twinkling.

radio wavelengths some atmospheric absorption always weakens the signal. Each wavelength has its own problem:

- Longer X-ray wavelengths meet electrons individually and are totally absorbed.
- Shorter wavelength X-rays undergo Compton scattering: They bounce off electrons like billiard balls, losing some energy in the process and are weakened by repetition of this process until they can be totally absorbed.
- In the lowest wavelength region—gamma rays—the radiation decays spontaneously into particles that are useless to astronomers because they carry no clues to their astronomical sources.
- Ultraviolet radiation is blocked by the atmosphere when it knocks weakly bound electrons off atmospheric gas atoms and dissociates gas molecules, in interactions which produce the earth's ionosphere.
- In the infrared range, absorption takes place when molecules of water or oxygen are rotated by the impinging energy.

Astronomers, regardless of the wavelengths on which they rely, have always tried to get out from under the atmosphere. For the last 20 years balloons and rockets have been opening up new ranges, and ever since artificial satellites became big enough to carry their equipment, astronomers have been standing in line at the world's space agencies.

The biggest surprises so far have come in the X-ray region. Although the total observing time so far spent on X-ray astronomy is no more than a few hours, compared to the untold millions of hours that have been devoted to optical observations, the X-ray work is already credited with the discovery of a new class of object—the X-ray stars—which have provoked a loud and continuing flap among astrophysicists.

The Radio Astronomy Explorer is taking a first look at the other extreme of the spectrum. It will look for signals at wavelengths out to about 10 kilometers. Beyond this, says Dr. Robert Stone, National Aeronautics and Space Administration's project director for the radio astronomy explorers, ionized gas clouds in the galaxy absorb the radiation and prevent observation.

This first look at an unknown region will sketch a rough map of what the galaxy looks like at these wavelengths. If any interesting features such as new identifiable sources of radio energy appear, future satellites in the series will carry equipment designed to look at them in detail.

The space agency's first attempt to lift optical telescopes into orbit, OAO-1, suffered a battery failure, but the second one, with six telescopes aboard, is scheduled to go sometime this fall.

For small equipment, such as scintillation counters, photoelectric cells, bolometers, and even spark chambers, NASA has a Small Astronomical Satellites program. This, as its director Marjorie Townsend stresses, is an inexpensive method of investigation, since the satellites are carried by Scout rockets, the smallest launch vehicles that can put things into orbit. The first SAS, scheduled for mid-1970, will carry X-ray observing equipment. The second will carry a small spank chamber to look for gamma ray sources. Ultraviolet and infrared will come later. One SAS a year is the hope, if the budget holds.

The longterm goal of many astronomers is to set up shop on the moon. With no air, reception over the entire electromagnetic spectrum should be excellent, and a firm base will hold larger, heavier equipment than any satellite can handle.