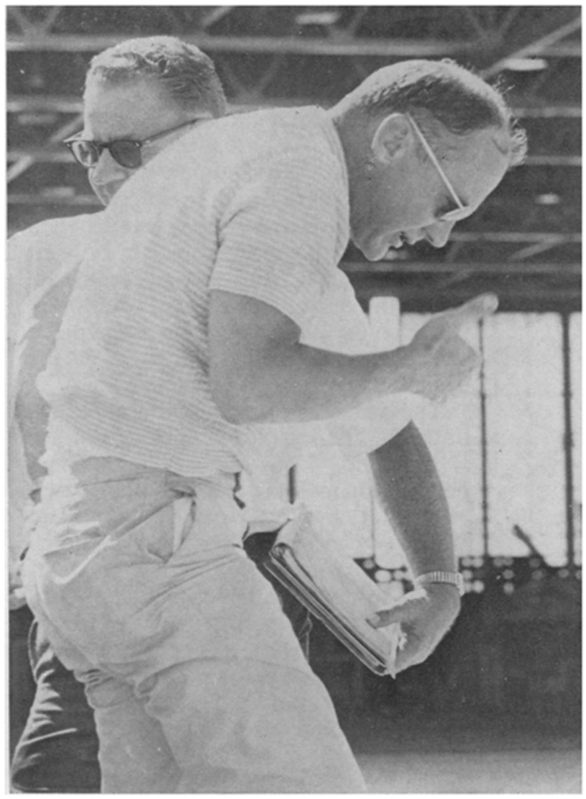
science news
OF THE WEEK

A light in an astronaut's eye

Three space crews have seen light flashes that could be cosmic-ray effects



NASA

Aldrin: First to see flashes.

Astronauts and scientists have long known and accepted the hazards of radiation in space, beyond the protective envelopes of earth's atmosphere and magnetic field. They can estimate radiation doses for short-term Apollo flights, and they are confident these are not harmful. They are less confident, however, about the effects of long-term exposure. Little but estimates of incidence-rates, for instance, is known about heavier, high-energy particles in space. And until Apollo 11 it was difficult for the radiation biologists to generate much concern about invisible particles that, even if they were as heavy as iron nuclei, are relatively rare.

Concern was generated following that July trip to the moon during which Astronaut Edwin E. Aldrin of Apollo 11 saw brief but intense flashes of light, apparently inside the spacecraft. Puzzled, he mentioned the flashes to crew members Neil A. Armstrong and Col. Michael Collins during their last night in space. Armstrong, who had been unaware of the phenomenon, then counted at least 100 flashes before the night ended.

Since that time, all crew members of Apollos 12 and 13 have reported the flashes, which vary in description from the intense, darting lights that Col. Aldrin thought were entering and leaving the capsule, to pencil-line-like flashes, and Roman-candle-track flashes. They have seen the flashes whether their eyes were opened or closed, often at the rate of one per minute. Aldrin reported the flashes at his Apollo 11 debriefing sessions in August. He asked the Apollo 12 crew to watch for them, and by the time the Apollo 12 crew had been debriefed, radiation had become the prime suspect.

The radiation that an astronaut gets on a lunar trip is equivalent to four or five chest X-rays. Most of it is from light particles, such as the nuclei of hydrogen and helium atoms, and gamma rays.

But in the total radiation dose are the effects of an array of heavier particles, such as iron, which has an estimated incidence rate of about six per hour per square centimeter. The incidence of the heavier particles is rarer, but the dose per particle is proportional to the square of the charge of the particle, and climbs rapidly with the increase in particle mass. Iron has a charge of 26, hydrogen a charge of one.

Several theories about the flashes have emerged from meetings of the National Aeronautics and Space Administration's medical team with the National Academy of Sciences' Space Science Board's Radiobiological Panel.

One is that the flashes are stimulations from direct impact of heavy cosmic-ray particles on the optic nerve, on the retina or in the brain. In tests with frogs, Drs. Leo Lipetz of Ohio State University and Cornelius Tobias of the Donner Laboratory at the University of California at Berkeley showed that light sensations could occur from the ionizing effects of radiation in the retina. When a particle hits a cell, it strips electrons out of an atom with which it collides; when the atom returns to balance by recapturing an electron, energy is released in the form of light.

A second possible explanation of the flashes is particle contact within the eye itself, with the light emitted as Cerenkov radiation. Cerenkov predicted that when a particle moves through a medium at a velocity faster than the velocity of light in that medium, its shock wave would release light energy. This could be happening in the vitreous of the eye, says astronaut Dr. Philip Chapman. The vitreous is the clear, colorless transparent jelly in the back of the eyeball. Upon entry into this medium, the particle would set up a shock wave and the Cerenkov effect.

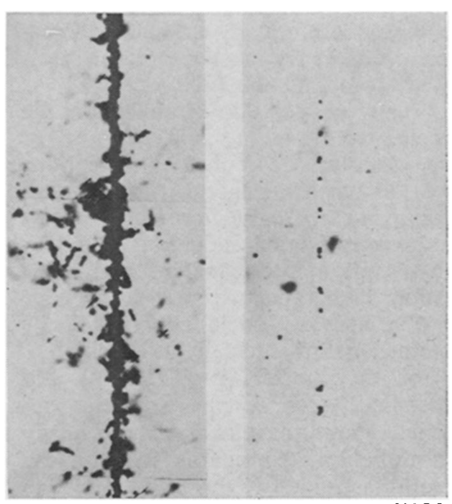
The problem with the Cerenkov effect as an explanation, says Dr. Charles Barnes, member of the NASA radiological team, is that in order to form the sharp image the crews are seeing, the particle would have to be focused on the retina itself or the light would be diffused.

It may very well be that both the Cerenkov and heavy particle effects are occurring, says Dr. Don Hagge, formerly of NASA's space-physics department, now of Mark Systems, Inc., in California. "I am sure the scintillation from high-energy particles is part of the light that they see, in addition to direct stimulation," he says.

Dr. G. G. Fazio of the Smithsonian Astrophysical Observatory in Cambridge, Mass., hopes to duplicate the light-flash effect, with Dr. J. V. Jelley of the United Kingdom's Atomic Energy Authority at Harwell, England. He agrees with Dr. Hagge. "At this point, we cannot distinguish between the two effects; both seem reasonable," he says.

To distinguish between Cerenkov radiation and particle impact, several experiments are planned for Apollo 14 in December.

The Cerenkov radiation could be tested by looking for it while looking at the moon. Cosmic rays would not be



NASA

Cosmic rays: Calcium (l.), protons.

coming from that direction, and if the crew still saw flashes, it probably could not be from the highly directional Cerenkov effect. Another experiment is designed to narrow the search. The astronauts will put pressure on the eye, keeping signals from passing from the eye to the brain. If the flashes continue, the stimulus is coming from some place other than the retina: impact on the optic nerve itself, for instance.

The value of astronaut observations of these flashes, explains Dr. Barnes, is manifold. "One big problem is that people do not take radiation seriously. Now that its effects can be seen, and the crew can count them, we can correlate the frequency with the incident-rate recorded on the dosimeters."

What is known to date about astronaut exposure comes largely from several dosimeters, or radiation measurement devices that fly on each trip to the moon. One such device is the film badges that the men wear on their ankles, thighs and chests. Dr. Herman Schaefer of the School of Aerospace Medicine at Pensacola, Fla., has examined the microscopic pictures, which show tracks made by light radiation particles, and the huge swaths cut by the heavy, high-energy particles. From this, NASA officials report the incidence of high-energy particles is about five to six times as high as was expected, but still within what they say is a safe dosage.

Impelled by the now dramatic evidence of astronaut exposure, NASA is also pressing toward a broader, earth-bound experimental program in an effort to anticipate and forfend trouble.

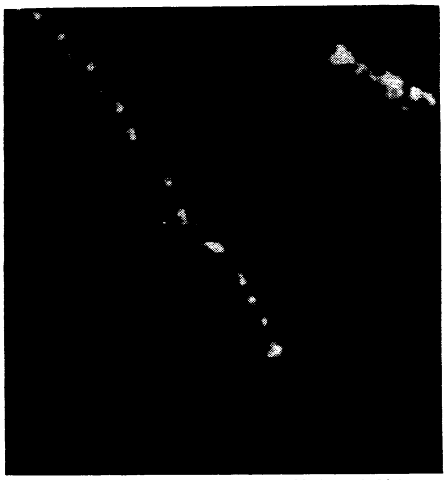
Since the particles are unique to the space environment outside of the earth's magnetic field, they can be studied only with accelerators on earth. "What we really need is one such accelerator," says Dr. Barnes. NASA and the Atomic Energy Commission are currently exploring the possibility of redesigning or modifying an existing accelerator for this purpose. The University of California at Berkeley currently has a proposal before the AEC for modifications to its heavy ion linear accelerator, which could fill the bill.

When the decision is made on the accelerator, it would still take up to five years to accomplish modifications and the particle experiments with human tissue. Space officials who are now studying estimated radiation doses for long-duration interplanetary and space station flights believe that knowledge of the heavy particle effects will be obtained before such flights occur.

For the shorter Apollo flights still scheduled, NASA officials are less concerned about the effects of the heavy ion radiation. Continuing tests on the Apollo astronauts who have gone to the moon have turned up no ill effects of the radiation. □

ELECTRON MICROSCOPY

Individual atoms photographed



Univ. of Chicago

Thorium atoms: A microscopic first.

"There is," said Dr. Albert Crewe in 1964, "no law of nature that says you cannot look at an atom."

Last week, the University of Chicago physicist reported that he has done just that. Using an electron microscope designed and built in his own laboratory, Dr. Crewe, with graduate students Joseph Wall and John Langmore, took pictures of single uranium and thorium atoms that had been hooked to a standard laboratory chemical called benzene-tetracarboxylic acid. Their unique technique, which enabled them to take what are considered to be the first verifiable photographs of individual atoms, paves the way for new studies of the structure of biological molecules, including chromosomes and aberrant cells.

At present, X-ray crystallography is the preferred method of determining the molecular architecture of biological materials. It has been employed successfully in deciphering the three-dimensional structure of some dozen proteins, but it has limitations. A major handicap lies not with the technique itself, but with the fact that it requires crystallization of the sample; scientists have thus far been unable to grow crystals of a number of biological substances, including DNA.

Says Dr. Crewe, "DNA is such a long sloppy molecule it is extremely difficult to crystallize. We can, and are, examining it with our microscopes without having to worry about crystallization." He speculates that in one or two years he and his colleagues will determine the sequence of the component bases in DNA. This will reveal the precise order of bases in an entire molecule much the way scientists now sequence the amino acid order of proteins. According to Wall, base sequence up to now has been determined only for very small portions of DNA molecules. "We hope to expand on a technique originated by Dr. Michael Beer at Johns Hopkins for tagging each of the four bases with specific heavy atoms," he says. Some of the necessary chemistry is in hand.

Already, Dr. Beer has shown that a compound of osmium, with atomic number 76, reacts preferentially with thymine, one of the four DNA bases. When the chemistry of attaching other specific heavy atoms to the remaining three bases is worked out, the researchers will be able to identify the sequence of those bases by detecting the appropriate heavy atom under the electron microscope.

The Crewe microscope, which can be reproduced for an estimated cost of $150,000, has several distinguishing features. Its electron source is a tiny tungsten point 30 angstroms across that operates in an extremely high vacuum. "This electron source," says Dr. Crewe, "is the smallest which is known and enables us to produce a very small focused spot of electrons on the specimen."

The specimen is supported on a thin carbon film approximately 20 angstroms thick. A beam of electrons sweeps back and forth across the specimen. As focused electrons pass through the specimen, the scientists are able to measure simultaneously two types of scattering, elastic and inelastic. The former refers to large angle bending that occurs when electrons from the tungsten source collide with the nucleus of the atom; the latter to patterns obtained from their collisions with electrons surrounding the atom's nucleus.

"We collect all the electrons that pass through the specimen," Dr. Crewe explains. "With conventional electron microscopes you can collect only a few of the electrons—perhaps only one percent." On an oscilloscope attached to the microscope, the revealed atoms appear as bright spots on a dark background.

The Crewe microscope is a comparatively small, 25,000-volt machine that can resolve separations of about five angstroms. For this reason, the specimen was constructed with heavy atoms (uranium has an atomic number of 92, thorium of 90) whose spacing is greater than five angstroms. A 100,000-volt machine now under construction and expected to be ready for use within six months in Dr. Crewe's laboratory will enable the researchers to single out smaller atoms. The larger instrument will have a resolving power of about three angstroms.

Dr. Crewe will publish his findings in SCIENCE within the next month. □