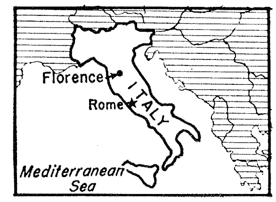

International Space Science Symposium

Florence. The 5th International Space Science Symposium, held here from 12 to 16 May by the Committee on Space Research (COSPAR) of the International Council of Scientific Unions, was considered a successful meeting by many of those in attendance. In general the quality of the papers was high, and delegates from the Soviet Union made a considerable contribution. Others attending the session considered the symposium disappointing. These observers felt that delegates were flooded with papers of too specialized interest and that, even though the symposium program was rigidly preselected, there were still so many papers that there was little time for comment during the sessions.

There were many answers to these complaints. Many who attend the sessions consider the purpose of COSPAR gatherings—of which the symposia are merely a part—to be less intellectual than political. They think it natural that debate should sometimes be less lively at the symposium than it is in COSPAR working groups concerned with an international reference atmosphere or the program for the International Years of the Quiet Sun. According to this view, countries seeking to become more active in space research or technology can get an annual briefing and stimulus from the symposia and working group meetings. American and Russian scientists can exchange views in an atmosphere that is not governmental, but also is not wholly unofficial.

Many were grateful that Soviet contributions were, for the first time, submitted for advance screening. There were many Soviet papers, and they were detailed. Some onlookers said they heard Soviet space scientists disagreeing with each other in open sessions for the first time—V. I. Krassovsky denying, and C. S. Ivanov-Kholodny maintaining, that a strong particle flux helps maintain the ionosphere at night.

Delegates thinking in these terms were distressed that the Soviet physical theorist I. R. Shklovsky was unable to come to Florence to give a scheduled lecture honoring Galileo on the 400th anniversary of his birth. Introducing Bruno Rossi of the Massachusetts Institute of Technology, who discussed recent studies of gamma-ray and x-ray sources in the heavens in a commemorative lecture, Italian solar astronomer Guglielmo Righini expressed regret at Shklovsky's absence.

The wealth of data and the lack of dramatic announcements of broad significance were taken by some scientists as signs that space research is settling down to a normal scientific life. They felt that researchers using balloons, rockets, and satellites are now producing scientifically interesting work in quantity.

To complaints about the technical emphasis on equipment and the narrowness of the announced results, participants replied that information from space is not comparable to the more readily generated data from, say, a biochemical laboratory. Elaborate technology is required to put instruments into space, and to acquire and reduce the data.

Despite the persistence of unanswered questions about the generation of auroral displays, the maintenance of the ionosphere at night, and the large expansions of the upper atmosphere, these delegates were heartened by the continuing flow of information about the ionosphere, the neutral atmosphere, the magnetosphere, and the solar wind, and about the interrelationships of these phenomena.

The conference heard early results from the first of an American series of Interplanetary Monitoring Probes or IMP's, Explorer XVIII (IMP-1), launched last November. Describing an orbit fixed in space, with an apogee of 200,000 kilometers, IMP-1 has confirmed the existence of a magnetohydrodynamic shock wave on the sunward side of the earth, separated from the outer edge of the magnetosphere by a region of turbulence. The finding had been expected, as were data showing that the interplanetary magnetic field had a spiral structure, probably caused by superposition of solar rotation on the solar wind—the radial streaming of particles from the sun.

D. G. King-Hele of the Royal Aircraft Establishment in Farnborough, England, reported several calculations of the earth's gravitational field and of atmospheric density that were based on perturbations of the orbits of satellites. In one report, he said that values obtained from nine satellites orbiting between 200 and 300 kilometers above the earth indicated that the atmosphere at that height was rotating 1.1 to 1.9 times as fast as the earth. He said the phenomenon needs explaining.

R. A. Helliwell of Stanford University reviewed studies of the continuous radio "hiss" and the discrete emissions, such as "whistlers," which occur either occasionally or periodically at very low frequencies. He said: "It has been shown that the existing particle streams carry adequate amounts of kinetic energy to provide a source for the observed emissions. Mechanisms are available to account, at least qualitatively, for all the observed noises.

"Cerenkov radiation from secondary electrons in the ionosphere may be able to account for the particular kind of noise known as polar chorus. Traveling-wave-tube amplification as well as the transverse gyroresonance instability could account for hiss. The transverse gyroresonance instability operating near the top of the path provides the easiest explanation for discrete emissions."

Instead of serving as a reservoir of particles dumped into the auroral zone by the impact of a flux of particles from the sun, the outer Van Allen radiation belt seems to be generated by the same acceleration processes which produce auroras, according to Bengt Hultqvist of the Geophysical Observatory in Kiruna, Sweden (on a year's leave in the United States at the Goddard Space

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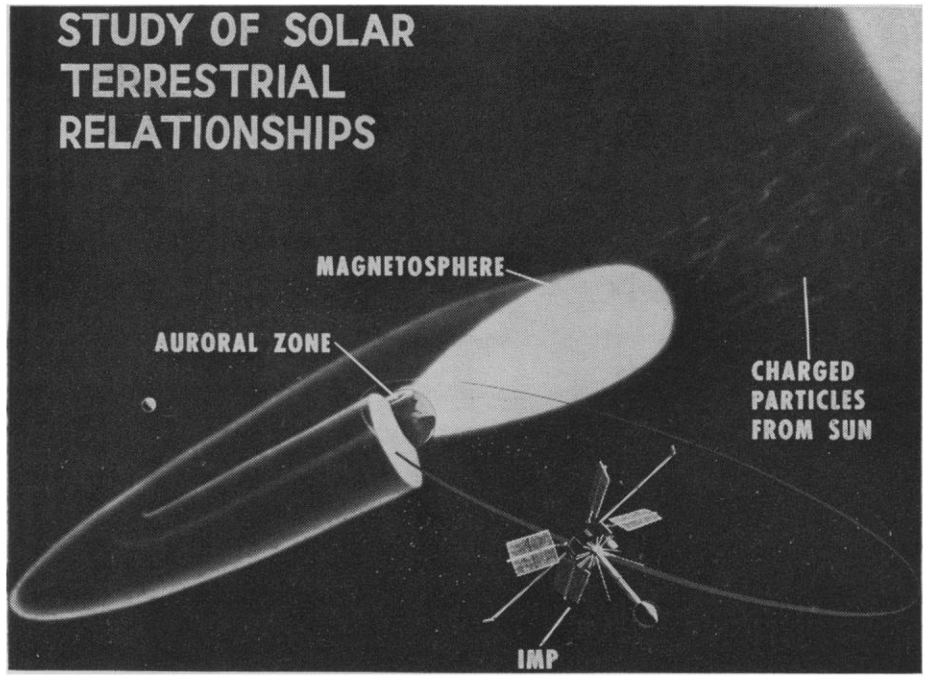
Flight Center). Hultqvist was discussing findings of B. J. O'Brien from the Injun I and Injun III satellites and of K. A. Anderson and J. R. Winckler from balloon measurements of x-rays in the lower ionosphere.

There were conference reports that analysis of results from the British Ariel I and the Canadian Alouette satellites, launched in 1962 from the United States, continues in America, Britain, Canada, and France. Ariel measured temperatures and distribution of particles and ions in the ionosphere. Alouette sounds the ionosphere from above. Ionosphere studies from the two satellites were reported by J. Sayers and P. Rothwell of the University of Birmingham; A. P. Willmore, C. L. Henderson, R. L. F. Boyd, and J. Raitt of University College, London; J. W. King, D. Eccles, P. A. Smith, and A. J. Legg of the Radio Research Station at Slough, England; F. du Castel, J. M. Faynot, and P. Vila of the Ionospheric Research Group of the French National Center for Telecommunications Studies (CNET); and G. L. Nelms and E. S. Warren of the Canadian Defence Research Telecommunications Establishment, Ottawa.

Preliminary analysis of data from micrometeorite detectors flown aboard the British Ariel II satellite, launched from the United States in late March, seems to show that even very thin foils exposed to cosmic dust are not being penetrated, although microphones are detecting dust. R. C. Jennison and J. A. McDonnell of the Jodrell Bank radio astronomy observatory speculated that a large proportion of cosmic dust may be a very-low-density "fluff."

Herbert Friedman of the U.S. Naval Research Laboratory and Riccardo Giacconi of American Science and Engineering Corporation both reported further on the 1962 and 1963 rocket experiments which have detected fairly well defined x-ray sources in the constellation Scorpius and the Crab Nebula and a much more diffuse source in the general direction of the Cygnus loop. Although the two groups of experiments, launched by the Navy and the Air Force, differ in observing technique, they overlap in findings, the Friedman group having observed the sources in Scorpius and the Crab Nebula, the Giacconi group, those in Scorpius and the source near the Cygnus loop.

Friedman pointed out that his proposal that the two discrete sources may be "neutron stars" is based on the original suggestion of H. Y. Chiu [*Ann. Phys. N.Y.* **26**, 364 (1964)] and subsequent calculations by Donald Morton of Princeton University. Such stars, which might be the ultimate result of a supernova explosion, would have about 1.3 times the mass of the sun in a volume of 16-kilometer diameter. (*Sci. Am.*, June 1964).



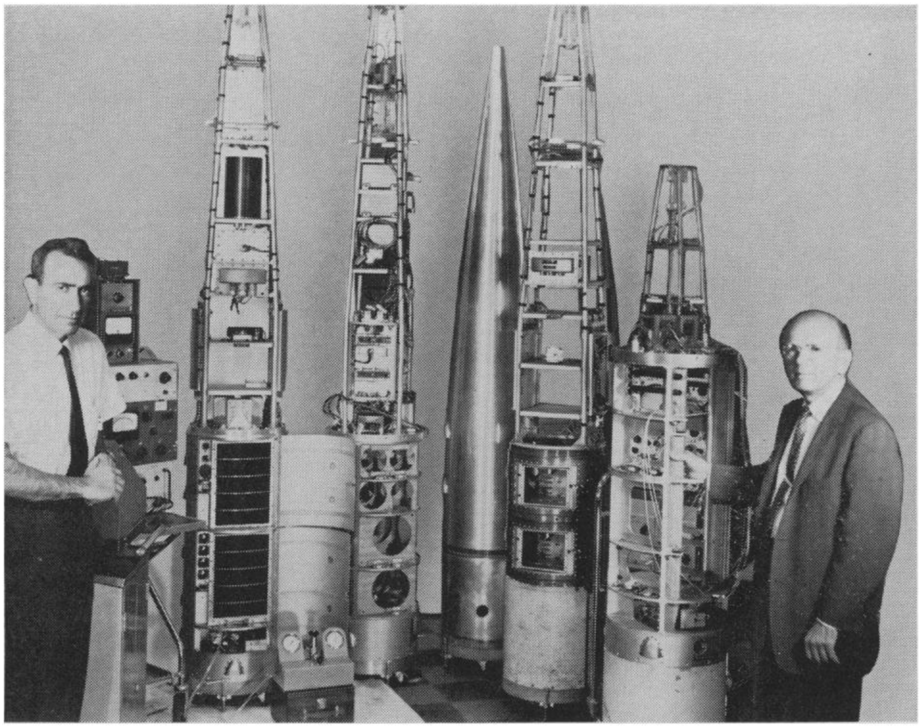
Artist's conception of course taken by the Interplanetary monitoring probe. [NASA]

The current observations, at a wavelength of 1 to 8 angstroms, seem to be disclosing "neutron stars" rather near the earth, Friedman said. Future observations will carry the search to wavelengths of 10 to 50 angstroms in an effort to detect x-radiation from the other side of the Milky Way and perhaps from other galaxies. He mentioned plans for a rocket firing on 7 July, by which it is hoped to observe from above the atmosphere the occultation of the Crab Nebula by the moon. If the observation is successful the moon should either cut off the x-radiation abruptly, if the source is a tiny point like a neutron star, or gradually, if the x-radiation emanates from a large gas cloud.

Giacconi, Friedman, and D. W. Sciama of Great Britain all discussed another kind of x-radiation being detected in rocket experiments: a diffuse background radiation that is not coming from the sun and is perhaps not even coming from within the Galaxy. Friedman noted that the general background showed no "horizon brightening" due to bremsstrahlung in the atmosphere. Sciama proposed that, when more sensitive instruments for measuring cosmic x-radiation are developed, they might be used to test theories about the density of gas between galaxies and the temperature of that gas. It might be possible he said, to learn whether the radiations are the result of integrated emissions from the centers of many galaxies or the result of photon-electron collisions in intergalactic space.

As usual, the emphasis of the COSPAR sessions was heavily on the physical sciences. But biological experiments moved into a spotlight of their own. Attracting much attention were reports of early experiments sent aloft with the Soviet's four most recent manned Vostok satellites, in 1962 and 1963. The Russian cosmonauts and other living systems functioned well, but there were enough hints of trouble to reinforce worries about space flights lasting more than a week, and to focus attention on a forthcoming series of American biological satellites, the first of which is scheduled to be launched in late 1965.

Soviet scientist Vasili V. Parin reported that cosmonauts Andrian Nikolayev and Pavel Popovich showed some "transient functional reactions" in their cardiovascular systems, which disappeared 7 to 10 days after their flights. Even as long as 2 days after their flights, Valeri Bykovsky and Valentina Tereshkova showed a loss of elasticity of blood vessels, or orthostatic hypotension; American doctors noted the



Herbert Friedman (left), superintendent of the Atmosphere and Astrophysics Division, NRL, and Edward T. Byran (right), head of the Astronomy Section, NRL, with rocketry hardware. The second unit from the right will fly in the 7 July experiment. The nose cone that covers it is located at its left; the remainder of the rocket (not shown) includes tankage and fins. Two x-ray detectors contained in the lower rectangular slots will be stabilized so that they point to Crab Nebula during the occultation. [Official U.S. Navy Photograph]

same condition in Walter Schirra and Gordon Cooper after their much shorter flights.

V. V. Antipov cautiously observed that acceleration of rocket payloads into or out of orbit, vibration, prolonged weightlessness, or slight doses of radiation experienced over several days seem, by themselves or in combination, to cause measurable changes in chromosome arrangement and in division or growth of living cells.

Some of these results of biological experiments aboard Vostoks 3, 4, 5, and 6—experiments in which, at times, the cosmonauts had a part—had been disclosed earlier in Soviet journals and review volumes rapidly translated into English. But the findings had not been discussed so fully before Antipov reviewed them.

The Vostok flights lasted up to 120 hours. Each of the flights carried some or all of the following organisms: cultures of lysogenic K-12 *Escherichia coli* bacteria which had incorporated the lambda prophage; human cells of the HeLa strain; mouse marrow cells; various strains of the alga *Chlorella* (a possible candidate for a closed ecological system on long space flights); the mold *Neurospora*; microspores of the plant *Tradescantia paludosa*; colonies of young male and female *Drosophila melanogaster*—fruit flies mated for the first time in space; and dry seeds of carrot, onion, lettuce, tomato, cucumber, mustard, tobacco, bean, pine, wheat, and *Evonymus europea* L.

According to N. M. Sisakyan, O. G. Gazenko, and Antipov, lysogenic bacteria were aboard all four of the flights. Such bacteria, studied intensively in Paris by André Lwoff, Elie Woolman, and François Jacob, are of great interest to geneticists. When a phage invades a normal bacterium, the genetic material of the phage takes over the protein-manufacturing system of the bacterium so that up to about 100 copies of the bacteriophage can be manufactered. When the new phage particles are complete, the bacterium bursts and dies. The particles are released. In lysogenic bacteria, by contrast, the genetic material of the invading phage becomes incorporated into the genetic material of the bacterium. Only rarely do such "prophages" take over in the usual way and become "vegetative" and hence "virulent." Thus, the output of phage particles in a culture of lysogenic bacteria is rather low.

Soviet scientist N. W. Zhukov-Verezhnikov and his colleagues compared the output of phage particles in cultures which had never left the ground and in those which had spent several days in space. They first used a direct comparison but later, for Vostoks 5 and 6, changed to an indirect method of "preliminary incubation and suppression of phage particles by an anti-phage serum." In all four cases the production of phage was higher in the cultures exposed to conditions of space flight.

The effect had been expected because lysogenic bacteria are affected by low doses of radiation. But the results of the actual space flights seemed to implicate a combination of factors.

"It is well known," said Antipov, "that being a radiosensitive object, lysogenic bacteria respond to the action of comparatively low doses of ionizing radiation (200 to 400 millirads) by induced phage production. This effect is observed under the action of various kinds of ionizing radiation—x-rays, gamma rays, fast neutrons and high energy protons."

But the total dose of radiation received inside the capsule of Vostok 5, which spent 120 hours in orbit, was only about 60 millirads, and the dose in Vostok 6, which was aloft 72 hours, about 40 millirads.

The increased production of phage particles showed "no clearly expressed dependence . . . on time of flight." Phage production in Vostok 3's culture was 4.6 times that of control cultures; in Vostok 4's culture, 1.86 times; in Vostok 5's culture, 3.7 times; and in Vostok 6's culture, 1.7 times.

The role of radiation in inducing phage production on the long space flights became even more ambiguous in a test of an antiradiation chemical, mercaptopropylamine. This agent was administered to lysogenic cultures aboard Vostoks 5 and 6. The drug lowered production of phage in both experimental and control cultures.

And so Sisakyan, Gazenko, and Antipov speculate that cosmic radiation alone, even if it contained an unexpectedly high proportion of heavy nuclei, did not cause the increase of phage production in the orbited samples: "There are more grounds to suppose that this effect is caused by the complex action of vibrations, accelerations, weightlessness and ionizing radiation. The possibility is not excluded that dynamic factors of flight sensitize lysogenic cultures . . . to . . . cosmic radiation . . . So far as vibration is concerned, this fact has been proved experimentally" (by Zhukov-Verezhnikov and others).

Fruit flies were sent aloft with Vostoks 3, 4, and 5. Cosmonauts Nikolayev, Popovich, and Bykosky joined together previously separated capsules containing unmated males and females. From fruit flies aboard the first two flights, a total of 482 offspring were obtained. In these, four different anomalies were observed, all invovling only one half of the body and apparently all nonheriditary. The anomalies were loss of one half of the thorax, absence of macrochetes on one side, small size and roughening of one eye, and a subnormal nerve endowment in one wing. Delays in egg-laying and the finding that 312 of the offspring were females were explained by the fact that the eggs had spent a time at 20°C (had not been maintained at a constant 25°C, like the controls), by the unusually dense feeding medium, and by the crowding of the mating flies. The flies and eggs aboard Bykovsky's capsule all died, apparently because of overheating on reentry.

N. L. Delone and his colleagues have been the chief students of the *Tradescantia* spores which have been sent aloft on all four flights. Those aboard the Popovich and Bykovsky flights have been studied intensively. Popovich "fixed" a sample once on his flight, at 57 hours after launch; Bykovsky "fixed" samples three times, at 1.5, 76, and 120 hours after launch.

Anomalies of growth, such as gigantic cells or outgrowths, appeared in samples aboard all four flights. The Soviet scientists said they could not determine which of the space-flight factors caused these anomalies, but their analyses indicated that detailed violations of normal cell division seemed to increase with length of time in the weightless state, and that chromosomal anomalies were due to the vibration and acceleration of the ascent and descent of the space capsules.

Although no changes were noted in the viability of HeLa cells, there were some "immunological changes." The space flights had little effect on strains of *Chlorella* algae varying in shape, size, oxygen-producing ability, and resistance to radiation. There may have been some changes in the less resistant strains, but the results are inconclusive.

There was little change in the frequency of germination, amino acid content, or starch content of the seeds of higher plants sent aloft, but there were some anomalies of cell division. The degree of change was the same for a 3-day or a 5-day flight. In carrot and tomato seeds there was some increase in the rearrangement of chromosomes; in wheat and cucumber seeds, some change in the ratio of root and stalk sprouting; in wheat, some stimulation of growth; and in onions, some repression of growth.

There was questioning of conference participants about why the Americans had not launched similar experiments. Reporter John Hillaby received the following answers, among others (*New Scientist,* 21 May 1964, p. 472):

"The Americans . . . said that it was a waste of time to experiment beyond the baseline of known facts, especially those in which the effects of vibration, acceleration, de-celeration, radiation and weightlessness were entangled . . .

"As one American put it: 'The Russians fired their material into space and are now busily engaged on their homework. As almost everything except weightlessness can be carried out more cheaply on the ground, we are trying to do our homework first.' "

Some of this homework was described in the extensive American review of space research in the United States (a National Academy of Sciences document) submitted to COSPAR. The biological work has included a large number of attempts to simulate a Martian environment; continued development and testing of small instruments that might detect life forms on Mars; studies of fossils and meteorites; development of more rigorous methods of sterilizing a capsule and components intended for a Mars landing; studies by Brookhaven and Oak Ridge national laboratories of the effects of various types of radiation on living systems; studies of reactions to weightlessness and sensory deprivation; and studies of packages (shielded by material of densities 0.4 and 4.5 g/cm^2) exposed, aboard a series of Air Force satellites, to radiation from the high-altitude thermonuclear explosions of 9 July 1962 (American) and 28 October 1962 (Russian).

Colin S. Pittendrigh of the department of biology at Princeton reviewed the scientific aims of the American biological satellite series (New York *Times,* 10 Mar. 1964).

Scientists concerned with these studies, Pittendrigh said, consider of first importance questions about the origin of life which might be elucidated by landing a completely sterilized vehicle on Mars. But technological difficulties limit them to much less ambitious experiments in the near future.

Pittendrigh divided the experiments of the series into three main categories.

1) Biological engineering, or the well-being of primates in long flights. Nello Pace, physiologist of the University of California, Berkeley, will conduct an experiment to see whether the cardiovascular system of monkeys in such flights undergoes a steady deterioration ending in death or whether it reaches a new equilibrium which may be unequal to the stresses of reentry into the earth's atmosphere. Monitors like these that will be placed inside the aorta and vena cava of the monkeys have already been tolerated up to 6 months in preflight tests. W. Ross Adey of the Brain Research Institute, Los Angeles, will study the ability of monkeys to perform a task requiring acute vision. Performance of the task will be reinforced by food.

2) *Ad hoc* work on radiation hazards. More knowledge of the absolute dose levels to be faced, the mix of energies, and the effect of the various doses, will be sought. It would be cheaper to make these studies on the ground, but a possible synergistic effect of weightlessness requires that they be made in flight.

3) Endogenous rhythms. Organisms aboard prolonged flights will be removed from most of the earth's gravitational field and also from the effects of the earth's 24-hour rotation. Such experiments may provide crucial evidence in the continuing controversy over diurnal physiological responses that persist in darkness.

Pittendrigh also said that a "gravity receptor" in plants has long been postulated but never isolated. Biologists are interested to know whether such a receptor is capable of detecting very low gravitational fields of $10^{-4}g$, say, and whether, in the absence of a gravitational field, the organization of cells might be affected in some basic way.

The experiments will be launched for periods of 3 to 30 days in modified Air Force Discoverer satellites and recovered by the methods used for recovering Discoverers.

It was felt that the discussion of the Soviet biological results at this COSPAR space science symposium had heightened the interest of the United States' proposed biological satellites.

—VICTOR K. MCELHENY