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CALTECH AND THE IGY

COSMIC RAYS

by H. V. NEHER

MANY OF THE gross aspects of cosmic rays have now been ferreted out—not only of the primary radiation itself, but of its numerous progeny as they filter down through the atmosphere. Few other fields of investigation have proven to be so puzzling—or so fruitful—in yielding new and exciting information as the field of cosmic rays. But much remains to be done, particularly in regard to the disposition of cosmic rays over the earth and the nature of the changes that take place from time to time.

The International Geophysical Year promises to add significantly to our store of knowledge. The cosmic-ray group at Caltech plans to make several series of balloon flights during the IGY. In the summer of 1957 we want to make six to eight balloon flights with ion chambers from Thule, Greenland. In 1958 we plan to establish a base station at Bismarck, North Dakota, and make simultaneous flights with balloons launched from a roving station, going by ship from the east coast of the United

States to Greenland. In late 1958 we plan to set up a base station in New Zealand and make simultaneous flights with a shipboard station leaving the United States and proceeding to the Antarctic.

By these experiments we hope to gain further information (1) on the geomagnetic effects on the incoming, electrically-charged cosmic-ray particles, and (2) on the nature of the fluctuations that take place.

Cosmic rays would be much less interesting if they remained constant. Knowledge once gained would be the same, year in and year out. and once we knew what the properties of cosmic rays were at any one time we would know it would be the same at all times.

The impression that cosmic rays remain constant in time came about with some justification because early measurements were made at or near sea level, and over short periods of time. Recently, Dr. Scott Forbush of the Carnegie Institution of Washington has analyzed measurements extending over about 18 years, and has shown that, at sea level, cosmic rays change about four percent during a solar cycle. Surprisingly, the relationship is inverse, so that when the sun is most active the intensity of cosmic rays is least, and vice versa. There is thus some justification for the idea that cosmic rays are nearly constant since this solar-cycle change is fairly small.

High altitudes and latitudes

However, as everyone now knows, cosmic rays themselves do not reach down to sea level—only their progeny do. We have to go to high altitudes and to high latitudes if we really want to find out what cosmic rays are up to. People are becoming somewhat less mundane in their thinking than was the case before rockets and space travel were talked of—just as we in the United States are becoming less provincial-minded as we become more aware of what is happening in the rest of the world.

Since cosmic rays appear to be really cosmic (i.e., they appear to come from space itself) when we speak about them in meaningful terms, what we are actually talking about is cosmic rays as they would be observed at some distance from the earth. The reason for getting away from the earth is that its magnetic field interferes with the low-energy part of the cosmic ray spectrum.

There are two locations on the earth where conditions are such that we are as good as out in space, provided we can get to the top of the atmosphere—namely, near the two geomagnetic poles. Here, charged particles of all energies can come to the earth, because the magnetic lines of force of the earth are vertical—or nearly so—and even the lowest energy particle can come spiralling in.

The requirement of reaching to the top of the atmosphere we cannot meet completely, but we can get 99 percent through the atmosphere with present-day balloons. This corresponds to a height of about 100,000 feet. Protons with energies as low as 150 million electron volts can penetrate down to this altitude. Indeed, on one flight in 1955, made from Thule, Greenland, our balloon reached an altitude where the pressure was only 0.40 percent of one atmosphere, and the particles found here were presumably protons and had energies down to 100 million electron volts.

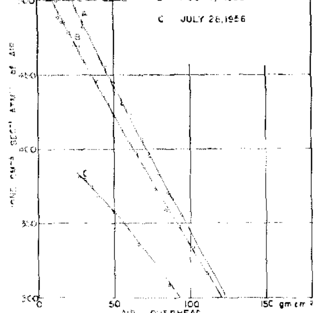
From work with various kinds of equipment sent to high altitudes with balloons, we know that a majority of cosmic-ray particles of higher energies are protons. In a series of balloon flights with ionization chambers at various latitudes in 1954 it was shown that the low-energy particles that can reach down to less than 10 percent through the atmosphere are also protons.

The curves at the left, below, show how large the changes at high altitudes can be with the passage of time. The abscissas are in terms of grams per cm^2 of air pressure (1033 $g/cm^2 = 1$ atm); the ordinates are the ionization produced in an ionization chamber in terms of ion pairs/cm^3/sec/atm of air. (To convert to milliroentgens per year multiply by 15. To get the intensity in space multiply the ordinates by 2.) To account for the large differences between curves A and C, the numbers of incoming particles must have changed by a factor of 2.5 at least from 1954 to 1956.

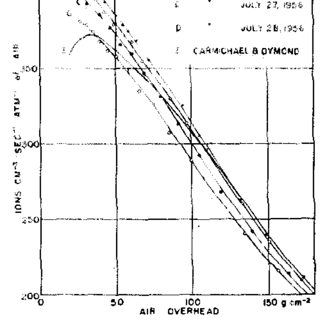
Since the low minimum of 1954, the sun has been increasing in activity and will presumably reach a maximum near the end of the IGY.

What 1957 and 1958 will bring, we, of course, dare not predict. We plan to return to Thule, Greenland, in both these years to learn what we can. In 1956 the ionization in the middle part of the atmosphere was less even than in 1937, when the sun was at a maximum of activity—although, at the lowest pressures, the intensity was higher in 1956 than in 1937, as shown at the right, below. The maximum of the curve of Carmichael and Dymond is due to the paucity of low-energy particles which do not multiply, compared with those of higher energy which create a number of secondaries as they strike the atmosphere.

It is hoped that the data taken during the International Geophysical Year, by the several institutions planning balloon flights with various kinds of equipment at different latitudes, will add appreciably to our fund of knowledge concerning cosmic rays.



Intensity changes in cosmic rays from 1954 to 1956.



Cosmic ray intensity on different days in 1956 compared to 1937 (E).