Cosmic-Ray Changes from 1954 to 1957*

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ONE of the chief characteristics of cosmic rays that is often given is that they remain essentially constant from one time to another. It is the purpose of this Letter to point out that one of the important characteristics of cosmic rays is that they do change very much with time.

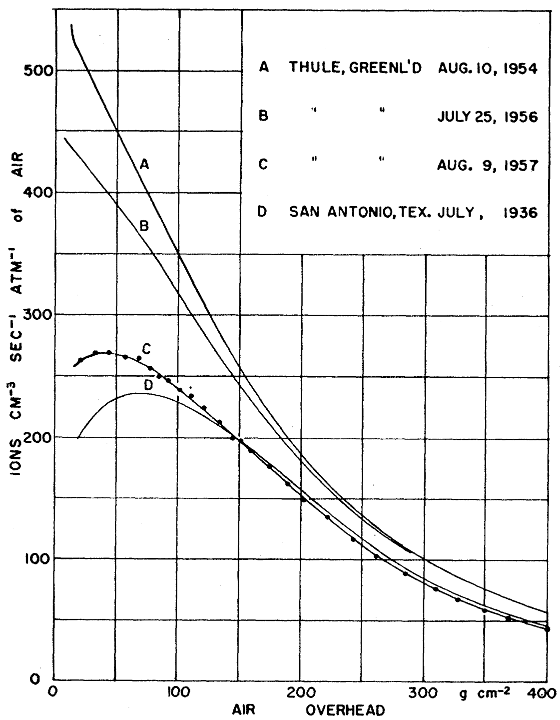

FIG. 1. The ionization at high altitudes near the north geomagnetic pole in 1957 was less than half its value in 1954, the area under the ionization-depth curve was down 34%, and the numbers of primary particles was down by a factor of four.

By cosmic rays we mean, not the radiation we receive under the blanket of atmosphere, but the primary particles before they have been influenced either by the earth's atmosphere or by its magnetic field. To say that there are only small changes in cosmic rays because no large variations are measured near sea level is like saying that the seasonal change of temperature in Canada is only a few degrees because that is all that is measured in a fifty-foot deep mine.

That large changes (exclusive of solar flare effects) do occur in cosmic rays has been pointed out previously.[1,2] By comparing the data obtained with balloons in the Arctic in 1954 and in 1937, it was possible to say that the numbers of primary particles near the north geomagnetic pole had increased from the solar maximum of 1937 to the solar minimum of 1954 by a factor of 2.5. It was shown that most of this change was in protons whose energies were below 10^9 ev.

The balloon flights with ionization chambers in northwest Greenland in 1957 were made when solar activity was near a maximum. Figure 1 illustrates the large change that has taken place here in the primaries as the sun has gone from very low to quite high activity. The flight of August 9, 1957, is typical of the six made at Thule during the period August 9 to 20. It is of interest that during the present solar maximum the ionization due to cosmic rays at Thule is nearly 30% lower than in 1937 when the sun was also at a maximum of activity. This is consistent with the higher level of solar activity during this cycle compared with that 20 years ago.

In comparing this flight with those made in San Antonio, Texas,[3] in 1936, it is, of course, necessary to be sure that the instruments now used give the same answers as those used at that time. We have gone to some pains to make certain that such a tie-in can be made.[1,4] It is believed that a direct comparison is possible, with an error of less than 1%.

In comparing curves *C* and *D* of Fig. 1 we may regard the bulk of the primaries as close to the same at these times since the absorption in the lower part of the atmosphere is nearly identical. Curve *C* at the low pressures shows the presence of more low-energy particles than *D*, causing it to rise above *D* and to shift its maximum to lower pressures. We estimate that these additional particles (assumed to be primarily protons) have a mean energy of 3 Bev. To account for the additional area of *C* compared with *D*, we then need 0.02 particle cm^{-2} sec^{-1} $sterad^{-1}$ at the top of the atmosphere.

Using previous results[3,5] at San Antonio, Texas, we find that there were at Thule in August, 1957 a total of 0.056 particle cm^{-2} sec^{-1} $sterad^{-1}$. This figure is to be compared with 0.24 found for Thule[2] in August, 1954. We infer that cosmic-ray particles in space near the orbit of the earth also changed by a factor of 4 between the solar minimum of 1954 and August, 1957 when the sun was near a maximum of activity.

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