leagues at the Geophysical Institute, University of Alaska for their kind hospitality and assistance. Dr. V. P. Hessler generously provided an earth-current detector to assist us in following magnetic activity during the disturbed period. We are also indebted to Mr. Harold Leinbach for the invaluable information that solar storms were in progress and to Mr. Wayne Hughes for his able assistance in preparing and launching the balloon flights. In addition, we wish to express our appreciation for the splendid cooperation and assistance of Mr. Richard Inman and associates of the Federal Aviation Agency (Fairbanks Station).

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UNUSUAL COSMIC-RAY FLUCTUATIONS ON JULY 17 AND 18, 1959

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Between July 11 and July 18, 1959, a remarkable succession of three large Forbush decreases of cosmic-ray intensity occurred. The third of these decreases, which coincided with a magnetic storm beginning at 1638, Universal Time, on July 17,[1] about 19 hours after a class 3+ solar flare observed from 2115 to 2230 on July 16, exhibited unusual features which should be pointed out.

The intensity as given by the hourly totals of the standard neutron monitor at Deep River, Ontario, Canada (IGY station B211, lat. 46° 06′ N; long. 77° 30′ W; altitude 475 feet), from July 9 to July 24, is shown in Fig. 1(a). The 100% level is arbitrarily chosen. The decrease between July 11 and July 18 amounts to some 26%, and the intensity on July 18 is the lowest that has ever been observed. The times[1] of sudden commencement of magnetic storms and the times of occurrence of class 3+ flares are marked on Fig. 1(a). The decreases on July 11 and July 15 have a normal appearance; the one on July 17-18 has abnormal features.

One unusual feature is the occurrence of three very rapid[2] changes in intensity, to be seen in Fig. 2 which displays 10-minute totals for July 17, 18, and 19. Beginning at about 2340 on July 17, the intensity decreased some 7% in about 20 minutes. It remained low for some 30 minutes and then at 0030 it recovered in only 10 minutes. About 40 minutes later, beginning at 0110, a

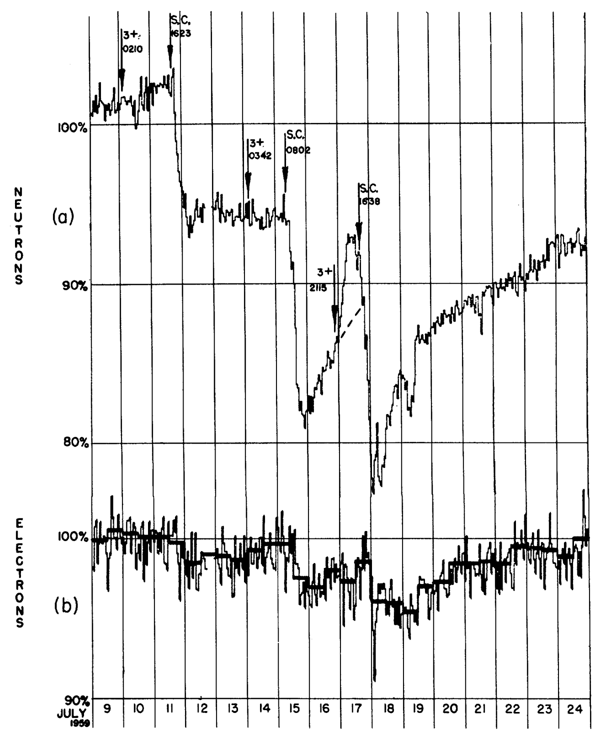

FIG. 1. The upper graph (a) shows the hourly totals of the Deep River standard neutron monitor from July 9 to July 24, 1959. The times of flares of importance 3+ and of the commencement of s.c. magnetic storms are shown. The lower graph (b) shows the hourly totals of an ion-chamber detecting pulses arising from photons and electrons of the soft component of energies greater than 400 Mev. Times and dates are in U.T.

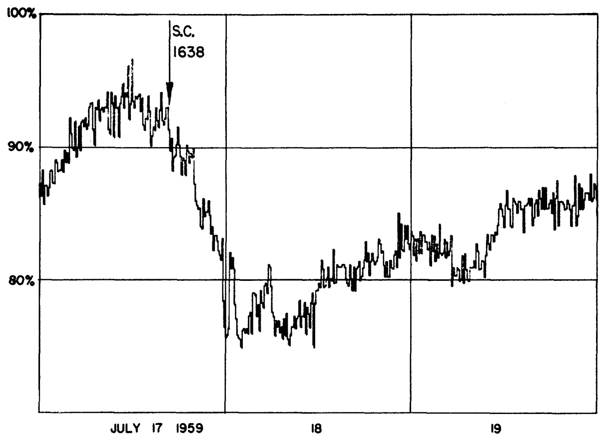

FIG. 2. Ten-minute totals of the neutron intensity, obtained by adding the results of the standard neutron monitor and the boron trifluoride ion-chamber, showing very rapid rates of change in the neutron intensity near midnight on July 17-18.

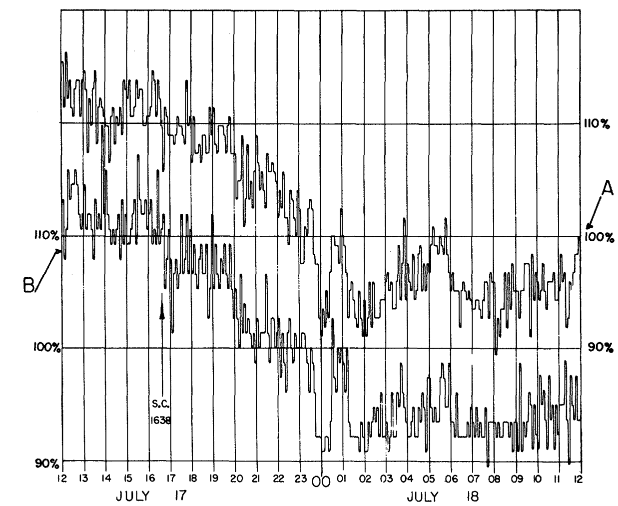

FIG. 3. Five-minute totals of the standard neutron monitor (channel A) and of the independent boron trifluoride ion-chamber (channel B) showing satisfactory correlation of the very rapid rates of change in neutron intensity near midnight on July 17-18. Channel A is scaled by a factor of 30 and channel B by 40, and the results are plotted in the form of a histogram. Fractional parts of a scaling factor are not printed out by the apparatus but are carried into the succeeding 5-minute totals. This gives the graphs a quantized appearance.

second sharp decrease of 7% in about 25 minutes occurred. No comparable sea level neutron monitor increases or decreases approaching 7% in less than 20 minutes have been noted in our observations during the past two years. The most rapid previous decrease was that on February 11, 1958,[3] in which the rate was 4% in 40 minutes. Figure 2 is plotted from the sum of the 10-minute totals of the two independent sides of the standard neutron monitor and the 10-minute totals of another neutron monitor in the same laboratory. This other monitor is a 30-inch diameter pulse-counting ion-chamber filled with enriched boron trifluoride and enclosed in an 8-foot cube of graphite. The counting rate from the ion-chamber is about equal to that of the standard neutron monitor; the combined counting rate is about 15 000 in 10 minutes. Five-minute totals from the neutron monitor and from the completely independent ion-chamber apparatus are plotted separately in Fig. 3. The rapid rates of change of intensity near midnight on July 17-18 are similar in each plot within the statistical uncertainty of the numbers of neutrons counted.

This event is undoubtedly one of exceptional importance. It is difficult to account for such rapid changes of neutron intensity on the basis of existing theories of the modulation of cosmic radiation.

Another unusual effect is the marked increase of intensity which began early on July 17 and continued all day until the time of the Forbush decrease which must be presumed to have begun two to three hours after the sudden commencement of the magnetic storm. This increase may be seen above the dashed line on Fig. 1(a), which is an extrapolation of the recovery from the previous Forbush decrease. It is known from the balloon observations of Winckler and his group[4] at Minnesota, and from the riometer observations of Leinbach and Reid,[4] University of Alaska, that copious numbers of protons of solar origin were present at high altitudes on July 17 and also early on July 18. The possibility therefore exists that this increase is a sea level effect of cosmic rays from the sun. On the other hand, it appears to be more probable that the effect is merely an unusual modulation of galactic cosmic radiation, because the five previous known occurrences of cosmic radiation from the sun at sea level[5] had a characteristic shape, with a sharp maximum reached within a small fraction of an hour of the onset, quite different from the shape of this increase.

It is of interest to examine the behavior of a detector in the same laboratory sensitive to primary cosmic radiation of much higher energy.

The hourly readings of a 30-inch diameter pulse-counting ion-chamber filled with 12 atmos of argon and surrounded by 1.5 cm of lead are shown in Fig. 1(b). This ion-chamber records pulses of at least 4 electrons produced in the lead shield by photons and electrons of the soft component. These photons and electrons originate from primary cosmic rays of very much higher energies than those from which the sea level neutrons mainly arise. The rate unfortunately is comparatively low—only 10 000 per hour—and so 12-hourly as well as hourly totals have been plotted in Fig. 1(b).

The three Forbush decreases are seen clearly; they are about one-sixth of the size of the neutron decreases; the increase on July 17 may be absent; there is a decrease seen as a downward spike between 0100 and 0400 on July 18, which is probably significant statistically and may indicate that primary cosmic radiation of rather high energy was affected at this time when the neutron intensity was pushed down to such a low value.

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[2]These features do not show in the plot of hourly totals in Fig. 1(a) and they will not be seen in the standard bi-hourly listings of the International Geophysical Cooperation.

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CHARGE INDEPENDENCE IN HYPERON PRODUCTION*

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If the reactions

$$\pi^+ + p \to \Sigma^+ + K^+ \text{ (amplitude } f^+), \tag{1}$$

$$\pi^- + p \to \Sigma^0 + K^0 \text{ (amplitude } f^0), \tag{2}$$

and

$$\pi^- + p \to \Sigma^- + K^+ \text{ (amplitude } f^-), \tag{3}$$

satisfy charge independence, then the three amplitudes involved are not independent. If one makes the usual isotopic spin assignments of a $(\Sigma^+, \Sigma^0, \Sigma^-)$ triplet and a $(K^+\ K^0)$ doublet, then the complex amplitudes f^+, f^0, and f^- are related to the two independent amplitudes $f_{3/2}$ and $f_{1/2}$ that correspond to total isotopic spin 3/2 and 1/2. The relations are

$$f^+ = f_{3/2}, \tag{4}$$

$$f^0 = (\sqrt{2}/3)f_{3/2} - (\sqrt{2}/3)f_{1/2}, \tag{5}$$

$$f^- = (1/3)f_{3/2} + (2/3)f_{1/2}. \tag{6}$$

The linear dependence which then follows,

$$\sqrt{2}f^0 = f^+ - f^-, \tag{7}$$

corresponds to a triangle in the complex plane, and therefore the "triangle inequality"[1]

$$[2\sigma(\Sigma^0)]^{1/2} \leq [\sigma(\Sigma^+)]^{1/2} + [\sigma(\Sigma^-)]^{1/2} \tag{8}$$

must hold for the differential cross sections $\sigma(\Sigma)$ at each production angle and for the integrated cross sections. [The two additional inequalities obtained by permutation of Eq. (8) must also hold, but do not concern us. They are not contradicted by any experiments.]

Previous experimental results of Brown et al.[2] for 1.1-Bev pions incident on a 12-in. propane bubble chamber without magnetic field have indicated a sharp contradiction with Eq. (8) for backwards-produced Σ's. If substantiated, this observation would imply either that charge independence does not hold for Reactions (1), (2), and (3), or, alternatively, that the usual isotopic spin assignments are wrong.[3]

We have measured absolute differential cross sections for Reactions (2) and (3), using 1.09 $\pm$ 0.01 Bev (i.e., 1.22-Bev/c) π^- incident on the Alvarez 10-in. liquid hydrogen bubble chamber, with an 11-kilogauss magnetic field. Our results differ substantially from those of Brown et al.,