tween 0.4% and 1.5%. The result of the present experiment is therefore consistent with other experiments.

Alikhanian *et al.*, on the other hand, report a value of 8% for $K/\pi^{\pm}$. This value is still uncorrected[8] both for the difference in the lifetimes of the π and K mesons and the difference in the time of flight. The corrected value of Alikhanian should be 14% which is too large by at least a factor of five.

V. CONCLUSION

If the mass 540 existed in an abundance of one in every 200 muons, as claimed by Alikhanian, this experiment should have yielded five or six. The probability of finding none in that case is 0.4%. We thus conclude that the existence of the mass-500 in the abundance reported is not consistent with the present experiment

[8] This has been kindly pointed out to us by Dr. J. Hornbostel.

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Further Evidence for a Variation in the Rate of Dense Extensive Air Showers with Solar Time*

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The variation in the rate of dense extensive air showers with solar time previously found in Dublin, Ireland has been confirmed using a similar apparatus situated in Mona, Jamaica. It is suggested that this and other variations in rate with solar time may possibly be due to a periodic change in the structure function of the showers.

In 1956 a variation in the rate of dense extensive air showers with solar time was reported.[1] It appeared to be correlated with the semidiurnal oscillations of the atmosphere. In order to corroborate the effect and to study it further, a similar (but completely new) apparatus was setup on the campus of the University College of the West Indies at Mona, Jamaica. A site on a tropical island was chosen because of the well known increase of the amplitude of the semidiurnal wave in the atmosphere near the equator. As in the previous experiment the apparatus consisted of 6 M units, each M unit being 3 small Geiger-Müller counters each of sensitive area 14 sq cm placed at the corners of a horizontal equilateral triangle of side 20 cm. A coincidence of the three counters provided a master pulse. The event was classed as an extensive shower if an unshielded tray of Geiger counters of area 2100 cm^2. placed some meters from the M unit was discharged, and as a local shower if not. Events in which two or more M units were discharged simultaneously were called multiple events. Considerable care was taken to exclude spurious variations in rate. All voltages (even heater voltages) were stabilized using a Servomex A.C.7 stabilizer which does not distort the wave form. The more critical voltages were then subjected to a further stabilization. Many precautions to avoid pickup were taken and the many tests applied failed to reveal its occurrence. The apparatus was tested at least twice a week. Finally the "local" events provided a monitor rate which showed no variation with time.

Figure 1 shows the rates averaged over two-hour periods of the "extensive" events plotted against solar time for the Dublin station for the period March, 1955 to March, 1956 and for the Jamaican station for the period August, 1957 to August, 1958. The average daily pressure variation at Mona is also shown. For the Dublin station the probability that the results could be due to chance assessed using a χ^2 test applied to 4-hourly averages is 0.003, or for the "multiple events," 0.002. The amplitude of the semidiurnal wave for the extensive events (calculated by the method of Chapman and Bartels[2]) is 13% with a probability that it could be due to chance of 0.0008.

For the Jamaican station the corresponding values

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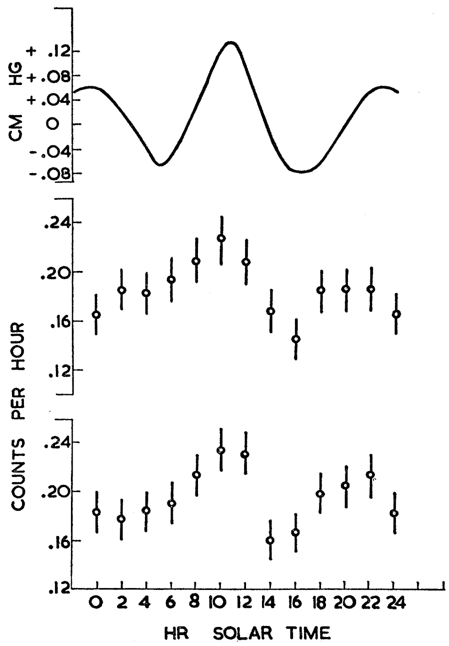

FIG. 1. The top curve shows the average daily pressure variation at Jamaica in cm of mercury. The two lower curves show, respectively, the rates in counts per hour of extensive air showers detected by 6 M units (a) for Jamaica, August, 1957 to August, 1958 and (b) for Dublin, March, 1955 to March, 1956.

are 10% and 0.03. The measurements are independent but the variation similar. The probability therefore that both could be due to chance is 0.00003. Since the publication of the first paper mentioned, various other authors[3–5] have reported variations of large amplitude in the rate of extensive air showers, with solar time. Previously a variation similar to that reported by McCusker and Wilson had been noticed by Cranshaw[6] and a variation in the rate of extensive air showers of high electron density with sidereal time during the course of a short run had been seen by Fornaca and Martelli.[7] The simplest hypothesis is that all these variations are in some way connected. It seems unlikely that there is change in the flux of the primary particles with solar time. The correlation with the atmospheric oscillations suggests that the cause lies in the upper atmosphere. If for instance the height of the first interaction varied periodically, one might obtain a periodic variation of the structure of the shower at sea level. The electron distribution at sea level can be approximated by[8]

$$\rho_i = \frac{N}{2\pi r_0} \frac{e^{-r_i/r_0}}{(r_i+1)},$$

where ρ_i is the number of electrons per sq meter at r_i meters from the core; N is the total number of electrons in the shower; r_0 is a parameter which is experimentally found to be 80 m. If we suppose that r_0 varies from 75 to 85 m, then for a shower of 10^6 electrons the area of the region with $\rho_i > 700$ particles/m^2 changes from 12 to 7.6 sq m. At the same time the density 200 m from the core changes from 0.73 to 0.87 particles/m^2. From 5 to 100 m from the core there is little change. Thus if such a change in r_0 occurred, one would find (a) a large change in counting rate from a device detecting >700 particles/m^2, (b) a change in rate 180° out of phase with this from a device detecting showers spread over a large distance, and (c) little change in any device detecting at distances from 5 to 100 m from the core. Experimentally the first of these has been seen by ourselves in Dublin and Jamaica, by Cranshaw at Cambridge, Wilson at Ottawa and, possibly, Fornaca and Martelli. The second has been reported by Cranshaw and Galbraith and the results of Crawshaw and Elliot are not inconsistent with it.

If the variation is indeed connected with the behavior of the upper atmosphere, then one may expect variations in phase and amplitude with both time and place. While the theory[9,10] of the 12-hour pressure wave has been, in many ways, successful, the approximations involved make it useless for predicting the day to day variation of a given millibar level. Nevertheless the theory does predict a change of phase of 180° at about 30 km and large changes in amplitude and phase above that height.

Experimentally, it is very difficult to follow the movement of particular millibar levels above 30 km. Indeed it seems possible that the recording of rates of extensive air showers detected by suitable apparatus may prove to be the best method of doing this.

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