Mesotron Variation with Upper Air Temperatures

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(Received September 3, 1941)

A TWIN, large area cosmic-ray telescope, after the design of W. F. G. Swann and to be described in a later article, is in operation at Fordham University and is being used in connection with studies of the time variation of the mesotron component and of the temperature coefficient of the mesotron.

Duperier[1] has made a careful investigation of seasonal temperature and cosmic-ray variations. Our investigation has so far been concerned with variations of daily 12-hr. means (6 P.M.–6 A.M.) of mesotron intensity at ground level with upper air temperature data as reported by sounding balloons at Lakehurst, New Jersey, daily from 4–6 A.M. Correlations were made for ground mesotron intensity, reduced for barometer changes,[2] and "spacial average" temperatures up to 16 km. Correlations between ground mesotron intensity and temperatures *at* given levels of 3, 6, 9, and 12 km were also made and are given by the dashed portion of Fig. 1.

Average temperatures up to other levels were not computed because from the trend of our correlation data for temperatures prevailing *at* given levels, Fig. 1, we were led to a new method of taking mean temperatures. The former method, a spacial average, was to integrate the temperature *vs.* height curve and divide by height. The new method we have adopted is to integrate the pressure *vs.* temperature curve and divide by pressure. This is in keeping with the air mass effect noted by Loughridge and Gast.[3] Accordingly, we have indicated by the solid portion of Fig. 1 the temperature coefficient as calculated by our revised method for taking mean temperatures of different air masses.

As is seen from the figure, there is a continually decreasing temperature coefficient as one correlates ground mesotron intensity with temperature values *at* the indicated heights. This itself seems to indicate that air mass is more fundamental in these investigations and hence by taking average temperatures by the spacial average method the temperature at the higher atmospheric levels plays undue influence. On the other hand, if one follows the newer method proposed above, elements of equal mass play equal roles in obtaining mean temperatures. We designate these latter as *mean mass temperatures* or *mass temperatures*.

A comparison between the two methods shows that during the period from March 23 until August 21 the mean spacial temperatures from 0–16 km varied between $-36.5°C$ and $-18.4°C$ whereas the mean mass temperatures for the same air column varied between $-28.3°C$ and $+4.0°C$. Since the latter range is greater one obtains a smaller temperature coefficient $(1/I)\times(dI/dT)$ by this method than by the former. With the former method the coefficient may be made to increase continually if one takes tem-

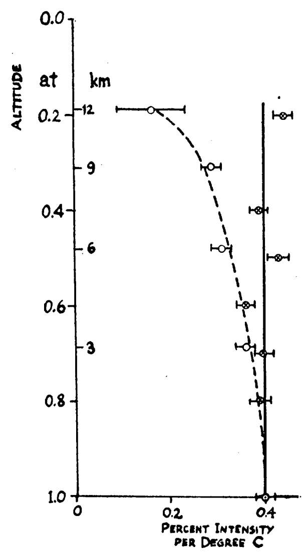

FIG. 1. Dashed curve: temperature coefficient as function of mesotron intensity at ground and temperatures prevailing *at* the level indicated by position of circle. Solid curve: temperature coefficient as function of mesotron intensity at ground and *mean mass temperature* between ground and levels corresponding to indicated fractions of *standard* atmosphere.

[1] A. Duperier, Proc. Roy. Soc. **A177**, 204 (1941).
[2] A. H. Compton and R. N. Turner, Phys. Rev. **52**, 799 (1937).
[3] D. H. Loughridge and P. F. Gast, Phys. Rev. **56**, 1169 (1939).

perature averages progressively higher into the stratosphere.

The seeming constancy of the temperature coefficient for mass temperatures taken for various fractions of the atmospheric mass seems to indicate a fundamental significance of the new method. Data for solid portion of Fig. 1 are taken for given fractions of a *standard* atmosphere. The original data are now being correlated with mass temperatures of given fractions of the actually prevailing *daily* atmosphere, and also with the change in height of the center of gravity of the daily atmosphere, to attempt to determine whether deviations from the straight line occur and whether possibly a peak occurs for some particular fraction of atmospheric mass. For these determinations 24-hr. mean values for mesotron intensity, 6 P.M.–6 P.M., are now being used as closer correlation is obtained thereby. Analysis of data showed that one telescope (upper) ceased to give reliable counts around the beginning of June. Data from lower telescope were accordingly used in our determinations.

The high value for the temperature coefficient of the mesotron component, -0.40 ± 0.02 (percent/°C), is interpreted on the basis that our measurements are essentially of only the mesotron component since vertical screening of 22 cm Pb is used between the counter trays, and side showers are screened by 4 in. Fe. Previous values for the temperature coefficient, obtained with ionization chambers, range between -0.1 percent and -0.25 percent. Hess[4] and collaborators reported at greater altitudes in the Tyrol values of α for shielded chambers 0.09 percent, and for unshielded chambers even much smaller values were found due to the increased number of electrons measured.

According to Blackett[5] the temperature coefficient is

$$\alpha=(1/L)(dz/dT)=(1/N)(dN/dT).$$

If we resolve the cosmic-ray intensity N into mesotron (M) and soft (S) components we may write

$$\alpha_1=[1/(M+S)][d(M+S)/dT]$$

and

$$\alpha_2=(1/M)(dM/dT).$$

Since it may be safely assumed that $dS/dT=0$ it is obvious that $\alpha_1<\alpha_2$, namely, $\alpha_1=\alpha_2 M/(M+S)$. Considering that at sea level about 80 percent of observed cosmic-ray intensity is due to the mesotron component this would account for an actual ratio $\alpha_1/\alpha_2=3/4$ which is almost the ratio actually obtained if one assumes with Gill that the correct value of α obtained with the Model C meter above the geomagnetic knee is $\backsimeq 0.25$ percent. This seems to indicate that in broad outlines the above interpretation is correct. Inserting our value for $\alpha=-0.4$ percent and taking Blackett's $dz/dT=0.05$ km/°C we obtain for the "life range" L of the mesotron $L=0.05/0.004=12.5$ km. Using Blackett's estimate of the total mass (40 times the mesotron rest mass) we obtain the lifetime of the mesotron at rest $\tau_0\backsimeq 1\times10^{-6}$ sec. for the more energetic part of the mesotron spectrum (3.7 Bev). The value $\alpha=-0.4$ percent at present is taken as tentative only and will be checked over a period of at least six more months.

We wish to make acknowledgment of financial aid for this research to the American Philosophical Society and to the Carnegie Institution of Washington. We are especially indebted to Professor W. F. G. Swann for his interest in this project and for allowing the construction of the counters in the shops of the Bartol Foundation. We wish also to thank Mr. Holzman of the La Guardia Airport Weather Bureau and Mr. J. H. Kimball and Mr. D. R. Morris of the Weather Bureaus in New York for furnishing necessary meteorological data.

[4] V. F. Hess, Phys. Rev. **57**, 781 (1940).
[5] P. M. S. Blackett, Phys. Rev. **54**, 973 (1938).