Variations of Cosmic-Ray Intensity with Variation of Barometric Pressure and Temperature at Sea Level

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Some results are given from the records of three different ionization-chambers, two under 110 cm Fe, one under 12 cm Fe. A daily influence generally parallel to temperature is found in the thin shielded instrument, not in the thick shielded one, and only in winter. It is found that the short periodic variations are not followed by the thick shielded instruments. The *long periodic* variation with temperature is generally antiparallel and moreover temperature and pressure variation is the same in all three instruments. A barometric coefficient of -6.4 percent per cm Hg is found and a temperature coefficient of -0.21 percent per degree C. The high value found for barometric variation is not explained, but seems not improbably to be related to the high values sometimes found at large angles from the vertical.

SINCE December, 1936 we have recorded the ionization by cosmic rays in three vessels of 40 l of argon of 40 atmos. Two vessels were shielded by 110 cm Fe and one vessel by 12 cm Fe. The accuracy of one single measurement was 0.1 percent and when no especial disturbing influences were working, the mean variation was about 1 percent.

In the course of our recording, we could calculate the correlation of the variation with pressure and temperature. This has now become of present interest on account of the decay of the mesotrons in the atmosphere. Formerly we mentioned[1] that the short periodic barometer influence was only felt in the thin shielded vessel and was not felt by the thick shielded vessels. On the other hand we found that the variations over a large period were observed to be about equal in both vessels.

Also for magnetic variations we[2] found formerly a difference of influence in the vessels, which means that the lower limit of energy in the two cases is not the same. (See Fig. 1.)

If we calculate the mean value for every hour for the period of a month, we obtain the result that the mean value of the barometer is nearly the same. When we next compare the variation of the cosmic radiation with temperature of the atmosphere at the earth's surface, we see that the value reduced from the thickly shielded vessels is perfectly insensible to the variation of the temperature, but that for the thinly shielded vessel there is a parallism with the temperature, but this is true only in the winter months and not in summer.

Especially in summer, although at the bottom of the atmosphere the temperature variation is larger, we found no influence at all. In Fig. 2 some special examples are shown. On comparing the mean values for different months, we found the same variation for the three instruments. In Fig. 3 the values for long periods are given.

From these we find the barometric coefficient $BE=-6.4$ percent per cm Hg and the temperature coefficient $TE=-0.21$ percent per degree C. This second value is not very different from the value -0.18 ± 0.011 which was given by Blackett[3] from the variations measured by Compton and Turner.[4]

This temperature variation is antiparallel and may be explained by the fact that increase of

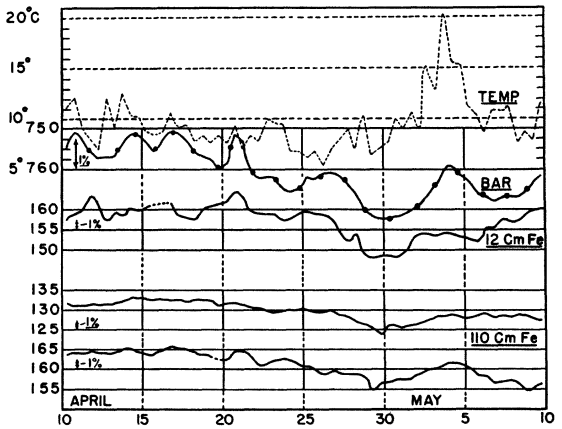

FIG. 1. Variations of cosmic radiation with barometric pressure under different shields.

[1] J. Clay, E. M. Bruins, C. G.'t Hooft, Congrès de Palais de la Découverte, 135 (1937).
[2] J. Clay, E. M. Bruins, Physica **5**, 111 (1938).
[3] P. M. S. Blackett, Phys. Rev. **54**, 973 (1938).
[4] A. H. Compton, R. Turner, Phys. Rev. **52**, 799 (1937).

temperature increases the path of the mesotrons in the atmosphere. It is remarkable that this increase is just in a direction opposite to that by the daily temperature variation. But we must be very cautious here, because we know but very little about the relation between the temperature of the lowest part of the atmosphere and the temperature of the stratosphere. Haurwitz[5] concludes that in many cases the variation in temperatures of the troposphere and the stratosphere are opposite.

It was known that the *TE* was found sometimes positive and negative in other cases. It was explained by Messerschmidt[6] by variation of the amount of emanation of the atmosphere; but in our case the emanation could not have any influence, neither for the thin shielded nor for the thick shielded instrument. Hess, Graziadei and Steinmaurer[7] found a negative *TE* for thick shield and no effect for thin shield, which agrees with our measurements in summer. Barnóthy and Forró[8] found a negative temperature coefficient in most cases, but perhaps a little more than we found in the ionization chamber. Similarly there are many uncertainties about the significance of the barometric variations at sea level. From our records it is apparent that there are two different changes of pressure, the short periodic cyclonic variation and the long periodic one.

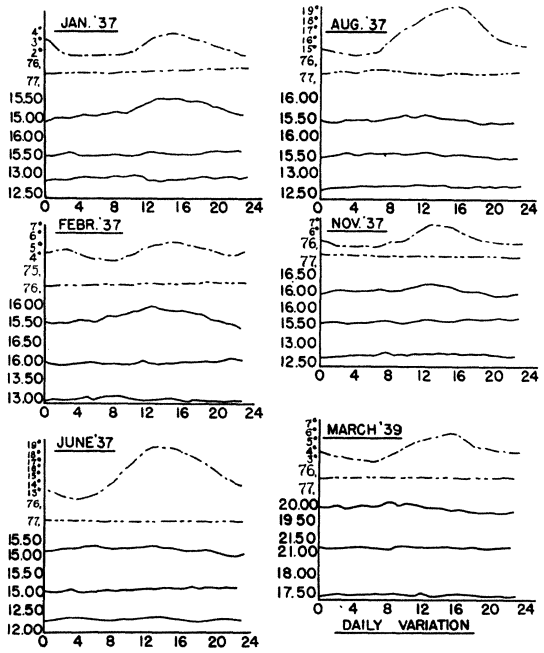

FIG. 2. Daily variation in cosmic radiation with temperature under different shields.

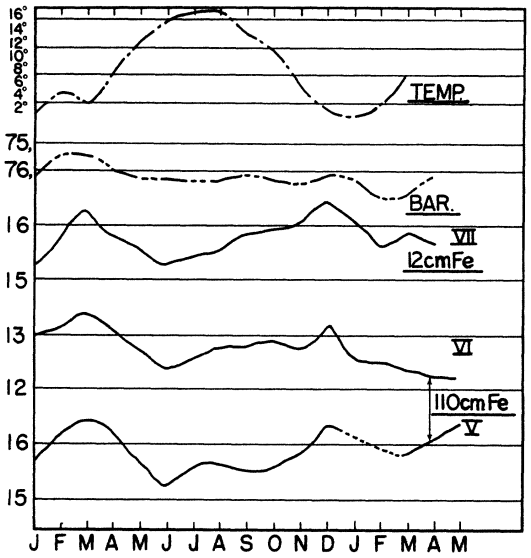

FIG. 3. Long periodic variations of cosmic radiation with temperature and pressure under different shields.

When we found the very high value for the barometer effect of 6.4 percent per cm Hg some time ago, we thought at first that this could not be right, but since we have measured the barometric influences with counters in small cones, we know that the variation is sometimes different for different directions and that the value in directions with a large angle from the vertical, has also been found to be about 6 percent. An indication of this effect may perhaps be found in the results of Barnóthy and Forró, who found an increase for the barometric effect with an increasing angle from the vertical. (-3.12 percent per cm Hg for the vertical direction, -3.4 percent for 50° and -3.8 percent for 64°.) Therefore, we think now that it may still be right, but the origin of this difference remains inconceivable at the moment.

But we may remark on this point, that we are not at all sure what is the significance of the variation of pressure at the bottom of the structure of the whole atmosphere.

[5] B. Haurwitz, Geophys. Inst. Leipzig III, [2] 333 (1924–1927).
[6] W. Messerschmidt, Zeits. f. Physik **87**, 800 (1934).
[7] V. Hess, H. Graziadei and R. Steinmaurer, Wien. Ber. **143**, 313 (1934); **144**, 53 (1935).
[8] J. Barnóthy and M. Forró, Zeits. f. Physik **100**, 742 (1936); **104**, 535 (1936).