LETTERS TO THE EDITORS

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Cosmic Rays and the Great Sunspot Group of January 29–February 12, 1946

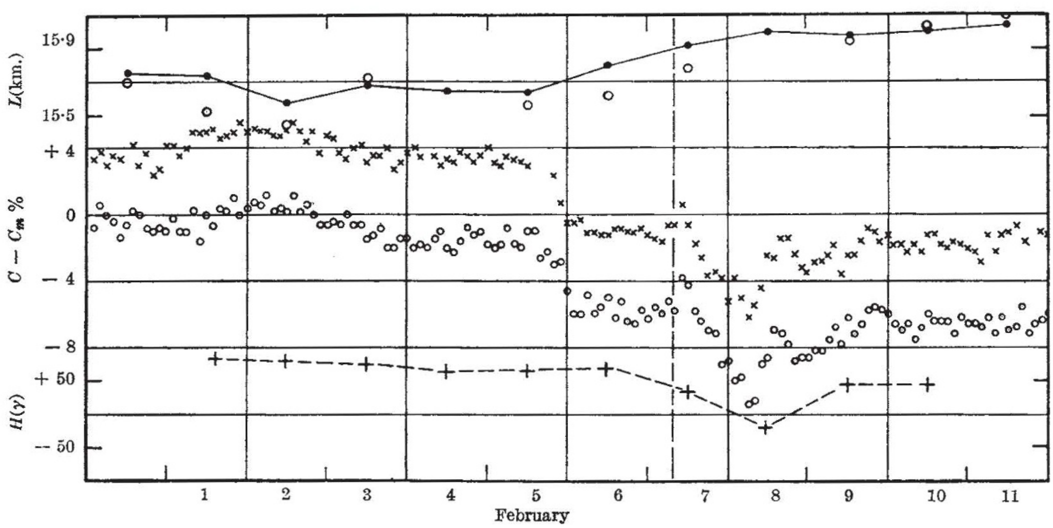
LARGE variations in the intensity of cosmic rays have been observed during the period of the recent great sunspot group, January 29–February 12, 1946. According to information kindly given by the Royal Observatory, a magnetic storm, a considerable number of solar flares, and radio fade-outs were also observed during this period. The intensity of cosmic rays has been recorded in London and Manchester; the apparatus used in London has been previously described by one of us[1], and that used in Manchester was similar in principle, although differing in some details. The most important difference was the use of two instead of three trays of Geiger–Müller counters, which meant that rather more particles approaching from an inclined direction were recorded.

The accompanying figure shows the percentage variation in the number of cosmic rays for intervals of two hours, commencing with the period 00·30–02·30 on January 31, and finishing with the period 22·30–24·30 on February 11. For clarity the points relating to Manchester have been displaced 4 per cent upwards. One of us[2] has shown that the intensity of cosmic rays, C, is related to the barometric pressure, B, and the height, L, of the layer at which the atmospheric pressure is 7·5 cm. of mercury by the formula

$$C - C_m = \mu(B - B_m) + \mu'(L - L_m),$$

where $\mu = -2{\cdot}28$ per cent per cm. of mercury, $\mu' = -5{\cdot}4$ per cent per km., and the suffix m refers to mean values. The intensities shown on the figure have been corrected for atmospheric absorption, which is represented by the first term in the above equation, but not for the second term, which is due to the decay of mesons. The mean daily height, L, over London has been kindly supplied by the Meteorological Office and is indicated by the line and filled circles at the top of the figure; corresponding values for Liverpool are shown by open circles. The broken line at the bottom of the diagram represents the mean daily value of the horizontal force H in γ as recorded by the Geomagnetic Station at Abinger. (The values shown on the graph should be added to 18,500 γ.)

Allowing for meteorological influences, a small decrease of cosmic ray intensity appears to have occurred on February 3, the intensity remaining at this slightly lower level until a much greater decrease took place on February 5 and 6. During these days there was only a short period of minor geomagnetic activity beginning suddenly at 13·00 on February 3 and ending about midnight the same day. The major sunspot crossed the central meridian early on February 6. The terrestrial field remained more or less undisturbed until a magnetic storm commenced at 07.30 on February 7, as indicated by the broken vertical line. The development of this storm appeared to be delayed until there was a sudden large decrease in the horizontal force at 10.20, about which time there was a small but sharp peak in the cosmic ray intensity. From this time until 12.00 on February 8 there were many violent fluctuations in the horizontal force (the extreme range being 525 γ) coinciding with a further large drop in cosmic-ray intensity. After a comparatively rapid recovery of this intensity to the pre-storm value, the return to the normal value prevailing at the time of the appearance of the sunspot group has been very slow, and a month later was not yet complete. During this month there were several further small fluctuations, but the results have not yet been fully analysed. The magnitude of the total change, allowing for variations in the pressure-level (7·5 cm. mercury), can be taken as 10·5 ± 0·4 per cent in London. The decrease in Manchester appears to be rather less, but it is difficult to say whether this difference is significant, as only one balloon sent up from Liverpool reached the necessary height on February 8, and consequently the correction cannot be made accurately. In general, the cosmic ray intensities at the two stations follow one another very closely.



It may be of interest to note that this decrease, the greatest since that of March 1, 1942[2,3], has been accompanied by the recurrence of radio noise from sunspots discovered by Appleton and Hey. The decrease in cosmic ray intensity on that occasion was slightly greater than on this. The area of the sunspot in 1942 was less than half that of the one this year.

The fact that no appreciable decrease in the horizontal force was observed on February 5 and 6, whereas the decrease in cosmic ray intensity on these days was comparable to that which occurred during the magnetic storm, is very remarkable. Such a phenomenon has, however, been observed previously by one of us, and may be regarded as a counterpart of the fact that some magnetic storms are not accompanied by appreciable disturbance in cosmic rays. Thus once more it would appear that the relation between the geomagnetic field and cosmic rays must be complex, or that other influences must affect the cosmic ray intensity.

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[1] Duperier, *Terr. Mag. and Atmos. Elect.*, **49**, 1 (1944).
[2] Duperier, *Proc. Phys. Soc.*, **57**, 472 (1945).
[3] Duperier, *Nature*, **149**, 579 (1942).

Ionosphere Storm Effects in the *E* Layer

DURING the course of an ionosphere storm, and more particularly near its beginning, I have frequently observed that the signals from short-wave stations which are situated within the skip-zone are subject to a form of distortion which is peculiar to them alone. This is quite different from the 'flutter' and other types of fading to which signals from more distant stations often become subject during an ionosphere storm, and it takes the form of a partially rhythmic note of low audio-frequency, producing the effect of a distinct and pronounced 'rumble' upon the received signal. The intensity of the 'rumble' varies directly with the wave-length of the received station, and also, apparently, directly with its power and the directivity of its aerial system. It is particularly noticeable in Britain upon the signals from the B.B.C.'s high-powered short-wave stations. I have observed this effect to begin very early in an ionosphere storm, the signals from stations within the skip-zone often being affected in this way *before* those from more distant stations begin to show any signs of deterioration due to the storm.

Mr. T. L. Eckersley has investigated the mechanism of the reception of signals from stations within the skip-zone[1,2], and his original findings have since been confirmed[3]. These are, briefly, that reception of signals from a transmitter working on a frequency above the critical frequency can be of a permanent character, and is provided by energy 'scattered' from within or just above the *E* layer of the ionosphere, the most important type of scattered signal being received as follows. The wave on leaving the transmitter follows an obliquely upward path, passes through the *E* layer and, after reflexion at the *F* layer, again reaches the *E* on its downward path where 'scattering' takes place; and part of the scattered energy coming back along the original path, it may be received at locations near the transmitter. The scattering agent is the irregular ionic clouds which always exist in the *E* layer—or just above it—but which do not exist in the *F* layer.

The object of the present communication is to suggest that the 'rumble' mentioned above—characteristic as it is of reception under disturbed conditions from stations within the skip-zone only—is due to the effect of an ionosphere storm upon the ionic clouds in the *E* layer and not to its effect upon the *F* layer. The fact that it increases in