LETTERS TO THE EDITORS

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Solar and Sidereal Diurnal Variations of Cosmic Rays

The study of the solar diurnal variations of cosmic rays, which has been described elsewhere[1], has now been extended, in respect of the first harmonic, by arranging in six groups the data for 860 complete days during the period May 1941–April 1944. The first group consists of the data for January and February of all three years, the second group of data for March and April of all three years, and so on, the material for each day consisting of 12 bi-hourly numbers of triple coincidences.

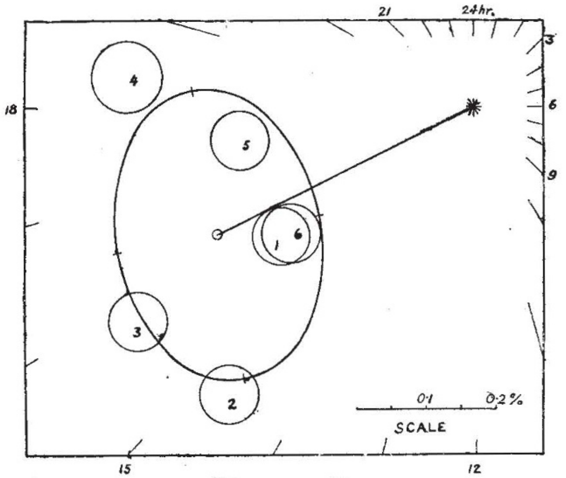
The second and third columns of the accompanying table give respectively the average amplitude in percentage of the mean intensity and time of maximum of the apparent 24-hour wave in cosmic rays for each of the six groups, and the mean after correcting for non-cyclic variation and pressure.

As our observations have shown that the daily mean numbers of particles after correcting for air-mass absorption are generally well correlated with the heights of the 75 mm. pressure-level, it was necessary to ascertain whether the daily change of temperature had any appreciable effect on the height of that layer, so affecting the apparent diurnal variation of cosmic rays. For this the upper-air data obtained in England during the period November 1943–October 1945 by sending up sounding balloons every six hours have been used. Monthly averages of the departure from daily mean height for each hour have been correlated with similar departures of ground temperature, and it has been found that the correlation coefficient, by using 48 pairs of departures, has the very high value of 0·92. For the regression coefficient, we obtained, contrary to what had been generally supposed, the quite appreciable value of 18 metres per degree C., about 0·4 times the seasonal change. There can be no doubt that such a correlation is chiefly due to the heating of the stratosphere by radiation, the difference between the average temperatures at noon and midnight being about 3° C. at 16 km., in contrast with a corresponding difference of only 1° C. or rather less at 7 km. It is therefore to be expected that at levels a few kilometres higher than 16 km. the effect of daily change of ground temperature will be even more appreciable.

As the mean rate of decay of mesons previously found is 0·0054 per cent per metre, a temperature change of 1° C. during the day would imply a variation in cosmic ray intensity of 0·1 per cent as measured by our apparatus. By correcting for this effect we have the values given in the last two columns of the following table :

Group	Ampl.	$t_{max.}$	Ampl.	$t_{max.}$
1 (Jan.–Feb.)	0·23%	16·3h.	(0·33±0·04)%	15·7h.
2 (Mar.–Apl.)	0·26	14·9	0·54±0·04	14·7
3 (May–June)	0·30	17·7	0·59±0·04	15·8
4 (July–Aug.)	0·45	20·7	0·50±0·05	18·3
5 (Sept.–Oct.)	0·28	20·4	0·34±0·04	17·5
6 (Nov.–Dec.)	0·22	16·5	0·32±0·04	15·7
Mean	0·244	18·1	0·414±0·018	16·3

Ignoring the very small possibility of an effect due to thunderstorms, we conclude that the seasonal change in time of maximum as well as in amplitude shown by the last two columns of the table could be taken as evidence of the existence of a variation with sidereal time. Thompson[2] has shown that if a sidereal variation is present, alone or together with a seasonal change in the solar amplitude only, a shift in phase is always introduced, and the points representing the apparent solar variation when plotted and taken in chronological order will always have a cyclic arrangement. The harmonic dial of the accompanying figure, in which points representing the values given in the last two columns of the table have been plotted, clearly shows the cyclic arrangement. The existence of a sidereal variation is therefore proved under the hypothesis that the seasonal change in the real solar variation affects only the amplitude, not the phase. In our ignorance of the nature of the agent responsible for the solar variation, it is obvious that this hypothesis is entirely arbitrary, but it appears to be the only means of separating a sidereal variation from a solar one from data obtained at one station only.



Solar time dial

The radius of each large circle represents the probable error.

On the basis of this hypothesis we obtain for the sidereal variation an amplitude of 0·21 per cent, with the maximum at about 21 hours sidereal time. This amplitude is of the same order of magnitude as that predicted originally by Compton and Getting[3] assuming the extra-galactic origin for the rays.

As for the solar amplitude, it is found that the minimum occurs probably in December and the maximum in June, with the values of 0·06 and 0·77 per cent respectively. Such a seasonal change suggests that the solar variation is closely controlled by the sun, though it is difficult to see through what agency the sun exerts its influence. However, the fact that the ratio of the amplitudes for June and December, 0·77/0·06 = 13, has roughly the same value as the ratio $\cos^2 \theta_j / \cos^2 \theta_d$, where θ is the zenith distance of the sun, seems to indicate that the solar variation might be due to penetrating particles coming from the sun. For if some of the cosmic rays are derived from that origin, we may expect their intensity to vary, taking into account the absorption by the atmosphere, approximately as $\cos^2 \theta$. It is therefore possible that a solar component of cosmic rays exists. The intensity in June at the time of maximum should represent 1·5 per cent of the total cosmic ray intensity as measured by our apparatus. The fact that the maximum is attained at about 4 p.m. might be due to deflecting action by the geomagnetic field.

If the sun emits cosmic rays, there is no reason, of course, why other stars should not do the same. It is noteworthy that the maximum of the sidereal variation appears to take place some hours after the transit across the meridian of the galactic centre, just as the maximum of the solar component occurs after noon ; so one might be led to conclude that a part at least of the cosmic radiation originates within the galaxy.

A more detailed account of this investigation will be published elsewhere.

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[1] Duperier, *Proc. Phys. Soc.*, **57**, 468 (1945).

[2] Thompson, *Phys. Rev.*, **55**, 11 (1939).

[3] Compton and Getting, *Phys. Rev.*, **47**, 817 (1935). For comparison, see also Vallarta, Graef and Kusaka, *Phys. Rev.*, **55**, 1 (1939).

Infra-Red Recording with the Cathode Ray Oscilloscope

In a recent communication in these columns, Daly and Sutherland[1] have described a new instrument in which an infra-red spectrum is traced upon a cathode ray screen having a long persistence of glow, so that the spectrum can be measured rapidly, and, effectively, is seen over a definite range continuously.

We also have recently built such a cathode ray tube infra-red spectrometer, but using a somewhat different form of presentation of the spectrum which seems to us more convenient for practical purposes. In many salient features our instrument is analogous to that of Daly and Sutherland. The radiation entering the spectrometer is interrupted at approximately 18 cycles per second, and after emerging is focused upon a Bell Telephone thermistor bolometer having a time constant of about 8 milliseconds. The bolometer, which has a resistance of 2·2 megohms, is arranged in a balanced bridge circuit, the output from which is fed into a resistance-capacity coupled amplifier of high gain tuned to give a flat response between about 5 and 25 cycles per second. The output from this amplifier is amplified further, rectified, and again amplified before being fed to the vertical deflexion plates of a large cathode ray tube with long afterglow. The rotation of the prism is geared to the contact moving on a circular potentiometer slide wire, thus providing a time-base horizontally on the cathode ray screen. The spectrometer so far used employs a 60° prism of rock salt or quartz with about 2½ in. length of refracting face in Wadsworth mounting, the whole being enclosed in a 'Perspex' box ; the amplifier includes numerous filters to remove undesirable noise and pick-up.

The essentially new feature of the present instrument is that the output voltage, after half-wave rectification, is smoothed, so that the trace obtained is the smooth emission curve of the source, against which are troughs due to any absorption bands. This form of record is just the same as that obtained in single-beam recording spectrometers, and seems to us to show the absorption bands—particularly the feeble ones—more clearly than the record produced by a succession of half-wave pulses.

Fig. 1 is a photograph of the spectrometer and oscilloscope taken during the tracing of the absorption of 2.2.4 trimethylpentane between 6·5 μ and 9 μ. The trace is formed within a rectangle 8½ in. × 5½ in. in size. Various cams are available by means of which different widths of spectrum can be projected on the screen, and movement from one range to another is obtained by a screw attached to the rotational mechanism. While still retaining the full resolving power of the spectrometer, it is possible to project a spectral width of about 3 μ for a time of traverse of about 15 seconds. We also show a record of the emission of the Nernst glower between 1 μ and 4 μ, with bands of water at 2·7 μ and of a hydrocarbon at 3·3 μ (Fig. 2).

The full details of this instrument, with several suggestions for further improvement, will shortly be described elsewhere.