Dissertation

on

STUDIES IN COSMIC RAYS

I

"The Study of Time Variation of Cosmic Rays with Directional Telescopes at Ahmedabad"

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STATEMENT

The mean daily variation of meson intensity at Ahmedabad (Geomag. Lat. 13.9°N, sea level) measured with east and west pointing telescopes inclined to the zenith at 45°, has been studied by the author during the period 1957-1958. The data has been analysed and the conclusions arrived at are listed below. In the study of the average daily variation of meson intensities measured by east and west telescopes it is found appropriate to apply a correction not only for the daily variation of barometric pressure but for the daily variation of temperature of the atmosphere upto an altitude of 2 km from the ground.

1. The 12 month mean and 24 month mean daily variations in east and west directions have almost the same amplitude. The diurnal time of maximum in east, is found to occur 4 to 5 hours earlier to that in west, showing that on an average, the daily variation could be attributed to an anisotropy of primary radiation.

2. (a) The frequency distributions of parameters of diurnal and semidiurnal components of daily variation on individual days have been studied. West pointing telescopes are found to exhibit a larger variability in the diurnal time of maximum as compared to that in east both on individual days and on a monthly basis.

(b) The frequency distribution of large positive and

negative bihourly deviations, significant at the 2σ level confirm the larger variability found in west as compared to that in east.

3. (a) Picking the hours when large number of significant positive and negative deviations occur, at least twice as frequently as may be expected by chance alone, we find that they can be broadly grouped into three groups. Group A, corresponds to the days when large number of significant positive deviations occur in west around midnight local time. Group B, corresponds to the occurrence of large number of significant positive deviations near noon in either east or west. Group C, corresponds to the days when large number of significant negative deviations occur at 1600 or 1800 hours in either east or west. The mean daily variation for neutron intensity at different stations are determined for these groups separately.

(b) The daily variation for days of group A, involving a significant and large semidiurnal component on a world wide basis is associated with the occurrence of a sharp maximum of bihourly intensity near midnight local time at low latitudes, affecting mainly the low energy component of primary cosmic radiation. The occurrence is also associated with a relatively disturbed geomagnetic condition throughout the period and a Forbush type of decrease of mean intensity. For groups B and C, the time series of mean intensity do not show any significant changes.

(c) The frequency distributions of significant positive

and negative deviations at various stations, separately for days corresponding to groups A, B and C, are examined. It is found that the occurrence of maximum number of positive deviations at equatorial and southern stations on days corresponding to groups B and C, is much earlier (by about 4 hours) to that at northern stations. We believe that this indicates the existence under certain conditions of a hemispherical effect of the source of daily variation which is not symmetrical with respect to the equator.

(d) The diurnal time of maximum for the mean daily variation of neutron intensity at an equatorial station is found to be earliest for all the groups and it gradually becom later as we go either northward or southward towards the poles. This would normally be strongly suggestive of the source of daily variation being an anisotropy outside the influence of the geomagnetic field. However since, on other considerations we find that on geomagnetically disturbed days there is local non-meteorological source of daily variation of geocentric type, we are led to the view that the latter source must itself be produced by charged particle radiation from the sun which in its interaction with the geomagnetic field would be subject to similar effects as the charged primary cosmic rays.

4. (a) Since change in east-west asymmetry denotes either a change in primary spectrum or a change in cut off energy, the mean daily variation in east and west on days of low, normal and high asymmetry is investigated. It is found that

on days of high asymmetry the daily variations in east and west have a high amplitude and a 6 hours phase difference in the time of maximum of the diurnal component in east and west consistent with a source of anisotropy situated outside the influence of the geomagnetic field. Days of high asymmetry are further found to be associated with a low planetary index of geomagnetic disturbance (0.6).

(b) Mean daily variation of neutron intensities at various stations situated in northern, equatorial and southern belts is found on days of low and high asymmetry at Ahmedabad. On days of high asymmetry, the mean daily variation at all the stations exhibits a high amplitude of a predominently diurnal character. On days of low asymmetry, the mean daily variation at stations situated only in the northern hemisphere, show a high amplitude of daily variation. Thus the examination of mean daily variation of neutron intensity at various stations for epochs of low and high asymmetry gives again an indication of the existence of a hemispherical effect of the anisotropic radiation.

5. Mean daily variation of meson intensity in east and west for days of low, medium and high C_p is determined. It is found that on days of high C_p ($C_p \geqslant 1.0$), both east and west intensities show the same time of diurnal maximum. The frequency distributions of diurnal and semidiurnal times of maxima when the appropriate component is significant at the 2σ level on days of low, medium and high C_p are also examined. It is found that on days of high C_p the variability

of diurnal component in west is reduced giving rise to a peaked distribution of diurnal time of maximum, with the peak occuring at the same hour in both east and west. The absence of a phase difference ondays of high C_p in the occurrence of the diurnal time of maximum in east and west is interpreted as an indication of the existence of a geocentric non-meteorological source of modulation being responsible for the daily variation. Elliot et al and Parsons have also reported the need for looking into such a local source to explain the daily variation during some periods. The origin of such a geocentric source of modulation is discussed.

6. With a knowledge of the coupling coefficients and geomagnetic deflections in east and west the energy spectrum of variation has been determined under three different conditions, when the daily variation measured by east and west pointing telescopes shows significant and large amplitudes.

(a) The spectrum of variation consistent with the observed 12 month and 24 month mean daily variation in east and west, is found to be of the form aE^{-r} where $r = 0$ for $E > 20$ Bev and $r = 2$ for $E < 20$ Bev.

(b) On days of high asymmetry, when the daily variation can undoubtedly be related to an anisotropy outside the influence of the geomagnetic field, the spectrum of variation is found to be of the form $aE^{-0.8}$.

(c) On days of high C_p, the best fit for the spectrum of daily variation can be represented as $\delta D(E)/D(E) = aE^{0}$ where $E > 20$ Bev and $\delta D(E)/D(E) = 0$ where $E < 20$ Bev.

(d) Since the mean daily variation includes daily variation on days of high asymmetry as well as the daily variation on geomagnetically disturbed days, it is remarked that the conclusions derived from the study of mean daily variation over an extended period of time is not very meaningful. It is concluded that there are at least two types of daily variations, one caused by a geocentric source of modulation which is predominent on geomagnetically disturbed days and the other due to an anisotropy situated far outside the influence of the geomagnetic field and which is predominent on other days.

(e) An attempt is made to explain the increase in asymmetry, the spectrum of variation and the high amplitude of daily variation on days of high asymmetry, by invoking the presence of ionised streams of solar matter in the neighbourhood of the earth. It is found that in order to explain the observed results, the increment of energy suffered by particles crossing the beam of width 5×10^{12} cms, should be about 0.1×10^{8} eV. Assuming a frozen in magnetic field of the order of 5×10^{-6} gauss, the velocity of such beams is estimated to be of the order of 5×10^{7} cm/sec. The values obtained for various characteristics of the beams are found to be of the right order taking into account the various

astrophysical and geophysical evidences, which lends strong support to the beam theory.

7. Storm type decreases in east and west, for 6 storms which occurred during the years 1957-1958 and for which we have data for east and west pointing telescopes, are studied. The decreases of neutron intensities at Kodaikanal, Alma-ata and Hawaii, all of them situated at almost the same longitude as that of Ahmedabad, are also studied for these storms. It is found that the storms can be broadly classified into two groups.

(a) In group A type of storms, the time interval between SC storm and intensity minimum is found to be about 20 hours. These storms are accompanied by a sharp fall of nucleonic intensity and are found to have a same onset time at all the stations. The rate of decrease and the amplitude of decrease for low energy component is found to be more than that for high energy component. The low energy component as well as east-west asymmetry continued to be depressed in the later part of the storm, even two days after the minimum is reached.

(b) In storms of group B, the time interval between the commencement of the fall and the occurrence of minimum intensity is found to be about 30 - 35 hours. These storms are characterised by a gradual fall of nucleonic component intensity. The onset time at high latitude stations having a lower mean energy of response is found to be earlier than at low latitude stations. The rate of decrease is found to

be same for both low and high energy components. The amplitude of decrease, however, is found to be more for low energy component than for high energy component. These storms are found to be associated with weak or no Sc storms and changes of east-west asymmetry either during the main phase or in the later part of the storm are found to be very small.

It is believed that the storms of group A are caused by the envelopment of the earth by the lateral edge of the second type of streams, as proposed by Dorman. Streams of this type are probably very dense, have a high velocity and strong frozen in magnetic field (10^{-4} - 10^{-5} gauss) and probably originate within the sun's equatorial region.

Storms of group B are believed to be caused by the envelopment of the earth by the lateral edge of the streams of the first kind. Streams of the first kind are rarified streams having a weak frozen in magnetic field (10^{-6} gauss) and are probably connected with some high latitude formation on the sun.

8. A long term change in the diurnal time of maximum from 1955 to 1958 is observed in east, west as well as vertical intensities at Ahmedabad. The diurnal time of maximum in all the cases is found to shift to later hours by about 5 hours from 1955 to 1958. The form of the 12 month mean daily variation curve which was having two peaks in 1954-1955, one in the early morning and the other at noon,

changes into a curve having a single peak at about noon by 1957-1958. These long term changes are consistent with the results obtained by Elliot et al and Sarabhai et al.

These conclusions have been discussed in chapter VI and a list of references consulted by the author has been included at the end of the thesis.

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