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**Symposium on Geomagnetic Activity and Solar
and Terrestrial Relationships**

(Held at Colaba Observatory, Bombay on 13 December 1954)

The Alibag Magnetic Observatory which was started in 1904 completed 50 years of service in the cause of Geomagnetism. Its Golden Jubilee was celebrated at Alibag on 12 December 1954. As a part of the celebrations, a symposium on "Geomagnetic Activity and Solar and Terrestrial Relationships" was held in the Colaba Observatory, Bombay, on 13 December 1954 at 10-30 A.M. The Director General of Observatories, Mr. S. Basu, proposed Prof. K. R. Ramanathan, Director, Physical Research Laboratory, Ahmedabad, and President, International Union of Geodesy and Geophysics, to the chair. After introductory remarks, the Chairman called upon Prof. P. S. Gill to open the discussions.

1. Prof. P. S. GILL, Head of the Department of Physics, Aligarh University and Director, Gulmarg Research Laboratory reviewed the work on the intensity variations of cosmic rays at sea level and at mountain heights. He discussed the asymmetry in the incoming cosmic radiation from easterly and westerly directions as a function of the height of the station. He also stated that part of the intensity variations is connected with geophysical phenomena.

2. Prof. V. A. SARABHAI of the Physical Research Laboratory, Ahmedabad, gave an

account of the studies of cosmic ray intensity—both hard and soft component—carried out at Kodaikanal and at Ahmedabad, and their correlation with (1) meteorological factors and (2) solar activity. He gave a detailed account of the analysis of cosmic ray intensity according to lunar and solar time following the method outlined by Chapman and Tschu. He also dealt with the variations of cosmic ray intensity with barometric pressure. There is a world-wide variation in the phase of the 24-hourly variation of cosmic rays with solar activity.

3. Prof. S. K. CHAKRABARTY, Head of the Department of Mathematics and Geophysics, Bengal Engineering College, Howrah, presented another aspect of the short period variation in cosmic ray intensity associated with the 'solar flares' and compared the magnitude of the simultaneous changes in the cosmic ray intensity and that in the geomagnetic field. It was suggested that both the phenomena can be explained on the basis of the dynamo theory by introducing a transient change in the earth's dipole field and in the ionospheric conductivity. Reasons for the absence of cosmic ray changes associated with some solar flares and geomagnetic field changes were suggested based on the work of Firor (*Phys. Rev.*, May 15, 1954). The effect

of the choice of instruments, ionization chambers or counters, on the interpretation of the observed results on cosmic ray intensity was discussed.

Discussion

Dr. A. P. Mitra of the Radio Research Committee, New Delhi remarked that ionospheric absorption measurements using cosmic radio noise at 18.3 mc/s during the time of solar flare (made in Australia by Shain and Mitra) showed two principal effects. One was the ultraviolet effect, showing an increase in absorption simultaneously with the flare; the other was a corpuscular effect (noticeable particularly for class 3 flares) which appeared also as an increase in the absorption about 30 hrs after the flare and lasting for periods of the order of 10 hrs. Magnetic storms did not follow until sometime later. It was not possible to reconcile this corpuscular absorption with the idea of increased absorption in the F_2 layer. As regards the ultraviolet effect it appears that the fadeout enhancement is only an overall enhancement in the ionisation of the normal D -region.

Prof. Sarabhai said that the sign of sudden commencements in a magnetic storm is sometimes positive and sometimes negative and wanted to know what is the physical explanation for this?

Dr. A. K. Das stated that perhaps this is connected with the charge of the incoming particles—positive or negative.

Dr. A. M. Naqvi remarked that there are two types of magnetic storms—one with gradual commencement and the other with a sudden commencement. Sudden commencement type is associated with cosmic ray increase.

Prof. P. S. Gill said that the increase in the electronic ring current system flowing at distances of several earth radii strengthens in magnetic dipole moment of the earth for regions outside these ring currents, while inside, near the earth's surface, the magnetic horizontal force is reduced. The cosmic ray particles are deflected out in greater proportion, hence the decrease in cosmic ray intensity during a magnetic storm.

Dr. L. A. Ramdas, Deputy Director General of Observatories, asked if there were any

other hills around the place where Prof. Gill took his cosmic ray observations, which would have affected the directional effect of cosmic ray intensity. Prof. Gill replied in the negative.

Mr. K. S. Rajarao of the Colaba Observatory asked Dr. Chakrabarty (i) why the cosmic ray increase associated with the solar flare was noticed only in higher latitudes and not in the equatorial region although the magnetic storms which were caused by much slower particles affected the equatorial region and (ii) how the cosmic ray particles are ejected out of the sun from a flare; for if betatron action due to sunspot magnetic field as put forth by Forbush and Swan were true, flares which have been observed in spotfree regions should also be able to eject out particles.

Prof. Chakrabarty replied that the mechanism of the ejection is not as yet very clear but it should be kept in view that even if the particles are ejected from the sun they may not always reach the earth.

Mr. S. L. Malurkar remarked that the ring currents that affect both cosmic rays and magnetic storms are different from the ring currents that affect only one of them. A systematic analysis of every magnetic storm and cosmic ray increase would be very useful.

4. Mr. S. L. MALURKAR, Director, Colaba and Alibag Observatories, spoke "On the Relation of First Impulses in Horizontal Force and Vertical Force Magnetograms at Alibag." In most sudden commencement magnetic storms at Alibag the horizontal intensity increases and the vertical intensity drops. The magnitude of the first impulse would, one expects, bear some relationship. It is only when the first impulses are much beyond the scatter of this relationship that one can describe the S.C. storm as unusual and try to find out the cause. The dot diagram connecting the first impulses in H. F. and V. F. records suggests, apart, from a first approximate linear relation, a relation of the form:

$$\Delta V = A \left\{ 1 - \epsilon^{-B(\Delta H - \Delta H_0)} \right\}$$

where A and B are constants.

Discussion

In reply to a question from Prof. K. R. Ramanathan, Mr. Malurkar replied that the equation was empirical.

Dr. A. P. Mitra described the ionospheric effects of a sudden commencement of a magnetic storm and gave evidence to show that a flare current system is the same as the normal S_q current system.

Prof. K. R. Ramanathan remarked that the polarisation field is unidirectional and the incoming stream of particles causing the magnetic storm, is as a whole electrically neutral.

5. Dr. P. K. SEN GUPTA, Meteorologist, New Delhi, summarised some of the ideas of magnetic storms—(1) of the intense types with sudden commencement due to solar flares and (2) of the moderate types with 27-day recurrence tendency supposed to be due to particles coming from the solar M -regions, with the help of Bartels' diagram. He recalled Chapman's ideas of the presence of *neutral* particles in the solar stream as established by ionospheric records during a solar eclipse. He then spoke about the corpuscular eclipse in the F_2 layer preceding the optical eclipse as a result of the relative velocities of the solar particles on the one hand and the velocities of the earth and the moon on the other, as described by Chapman. His calculation for the particular velocities coming from the sun gave a time-difference of 2 to 5 hours between the corpuscular and optical eclipses. He showed some recent ionospheric records indicating the presence of two corpuscular eclipses corresponding to a fast group of particles having velocities of the order of 1600 km/sec and a slower group having velocities of the order of 450-640 km/sec.

6. Dr. A. K. DAS, Director, Astrophysical Observatory, Kodaikanal, spoke of the solar M -regions and their geomagnetic effects. According to Waldmeier and Kiepenheuer the M -regions on the Sun emit slow particles with velocity of the order of 300 to 600 km/sec possibly through long-lived filaments and cause geomagnetic disturbances. Corpuscles due to prominences on the limb cannot ordinarily cause

magnetic storms; but corpuscles emitted by filaments close to the central meridian can give rise to geomagnetic disturbances. Recent studies carried out at Kodaikanal reveal that there are M -regions (unconnected with filaments or calcium and hydrogen flocculi) which emit bursts of ultraviolet light and of radio waves in addition to corpuscular radiation; at least on three occasions, namely on 24, 25 and 29 August 1953 when an M -region was traversing the Sun's disk, Kodaikanal records of solar noise and of the horizontal component of the earth's magnetic field showed synchronous and identical-looking pulsations. The exact similarity between the magnetic pulsations and the solar noise bursts in the three cases cited seems moreover to indicate that the bursts of ultraviolet light were intimately connected with the acceleration of charged particles or plasma oscillations which gave rise to the radio-frequency emission.

7. Dr. ALI M. NAQVI of the Department of Physics, Delhi University, referred to certain long sequences of geomagnetic activity noticed in the plot of the 3-day running means of the International Magnetic Character figures for the period 1931-34. The work reported was carried out by Dr. Naqvi and Mr. J. N. Tandon. Bartels and others, using the monthly mean of geomagnetic activity, found two maxima in March and September. Bartels by his harmonic analysis concluded that the six-monthly periodicity, rather than twelve-monthly periodicity, was physically significant. The studies of Dr. Naqvi and his co-workers indicate that the long sequences of geomagnetic activity show a twelve-monthly periodicity. For the period 1931-34, three such long sequences have been found.

Dr. Naqvi favoured the axial hypothesis for the annual variation of geomagnetic activity, according to which the tilt of $7^\circ.2$ of the solar axis of rotation to the ecliptic and the annual motion of the earth around the sun are responsible for the annual variation of geomagnetic activity. From geometrical consideration he showed how the position of the annual

maxima and minima for the long sequences are dependent upon the heliographic latitude of the M -region responsible for the geomagnetic sequence.

Discussion

Prof. Sarabhai said that the superposed epoch method was the best way of working out problems of the type presented by Dr. Naqvi and the latter's figure gave only a profile. Chapman has shown that there is an equinoctial maximum in all magnetic activity. The biennial curve obtained by Dr. Naqvi may be due to the fact that activity over the solar surface is not balanced in both hemispheres.

Prof. K. R. Ramanathan asked whether the amplitude of the annual geomagnetic variation was greater during sunspot maximum or minimum.

Dr. A. K. Das replied that it commences 2 years before the sunspot minimum.

8. Mr. M. K. GANGULI of the Central Water and Power Research Station, Poona, spoke about long trends noticed in the annual values of geomagnetic elements. Study of long series of geomagnetic data of Alibag, Cheltenham, Abinger, etc revealed that about 70 per cent of the secular variation was made up of simple linear trend, with a possibility of reversal in the secular trend. No parallelism was noticed with the sunspot cycle of 11 years; however an overall association with the solar cycle was present.

9. Mr. K. S. RAJARAO of the Colaba Observatory traced the history of the concept of the M -regions and the futile attempts to identify them with visible features on the Sun. The correlation between the coronal streamers coming from the bright regions of λ 5303 and the minor recurrent type of magnetic storms, was sought to be established. It was proposed that M -regions may be the bright coronal regions themselves, by virtue of the fact that the solar noise may also be emitted from the coronal region as put forth by the Australian School and the association

of the solar noise, geomagnetic storms and ionospheric disturbances.

10. Prof. K. R. RAMANATHAN gave an account of the recent studies of the F_2 layer at Delhi, Bombay, Ahmedabad and Madras—the critical frequencies being higher at Bombay and Ahmedabad than at Delhi or Madras. The height of maximum electron density in the F_2 layer indicates an enormous difference in pressure at that height between Madras and Bombay or Ahmedabad for a narrow latitude difference. But the noon maximum critical frequencies at Delhi, Bombay, Madras and Trichinopoly show a gradual increase towards lower latitude indicating a regular sequence.

At Delhi the afternoon values of maximum electron density are higher in winter than in summer during the sunspot maximum period.

Prof. Ramanathan also referred to the abnormally large diurnal variation in the horizontal force of the earth's magnetic field noticed in the magnetic equatorial region. He mentioned the work of the Japanese geomagnetics who had tried to explain this abnormality as due to the sporadic E -layer ionisation. The other theory put forth by Martyn and Baker explains the phenomenon as due to an electrojet, a current, flowing in the ionospheric level over the magnetic equatorial region. Following Cowling, one may think of different values of conductivity in the ionosphere, (1) when there is no magnetic field and (2) when there is a magnetic field. When the magnetic field is horizontal, and the Hall effect is suppressed by a polarisation field there will be an additional conductivity. This Hall conductivity at a height of 100 km may be responsible for the abnormal diurnal variation in horizontal force in the magnetic equatorial region.

The meeting ended with a vote of thanks to all those who had taken part in the symposium and also to the Chairman by Mr. S. Basu, the Director General of Observatories.