8. COSMIC RAY FLARES

M. A. Ellison

This work has been carried out in collaboration with Susan M. P. McKenna and J. H. Reid.

The characteristics of the ten solar flares, which have generated cosmic ray increases recorded at ground level in the years 1942–60, are summarized and reviewed along with their geophysical effects.

The flares observed on the disk were notable for the flash of radiation in Hα, occurring in a time of the order of 2-3 minutes, large area of about 2000 millionths of the hemisphere, twin bright filaments crossing the spot group and running parallel to the 'magnetic axis,' and obscuration of the umbrae with highest field strengths. Type IV continuum radiation of high intensity and long duration was recorded during the last five events and outstanding S.I.D.s were recorded in all cases.

The disk co-ordinates of these flares show remarkable asymmetries in contrast to normal class 3 and 3+ flares. There is a strong preponderance west of the central meridian and five cases occurred close to the west limb. Easier and more direct paths to the Earth evidently exist for high-energy particles from western flares. The implications, in terms of radial magnetic fields in the Sun-Earth space, bent westwards by the Sun's rotation, are discussed.

All the flares except one occurred north of the solar equator (the exception was 2° S). It is suggested that the radial fields are deflected southwards by the Sun's motion towards the solar apex. High-energy particles do not appear to reach the Earth at the times of solar maximum activity.

Some of these flares were among the greatest ever recorded: others were not optically of great importance. It is concluded that the arrival of high-energy particles capable of producing cosmic ray effects at ground level is mainly determined by factors other than flare importance, such as the variable magnetic fields in the Sun-Earth space, the disk position of the flare and the magnetic field conditions in the sunspot region.

DISCUSSION

B. Bell. A comment with reference to the north-south asymmetry in the location of cosmic ray flares: the northern solar hemisphere produced a majority of great geomagnetic storms in the cycles 9, 15, 16, 17, 18 and 19; the southern hemisphere produced a majority in cycles 10-14.

H. Dodson-Prince. I wish to make a constructive suggestion that information regarding the magnetic field in the regions in which flares break out might be obtained by studying magnetic fields of filaments, both quiescent and active, since many flares occur very close to the borders of filaments which cross plages.

M. A. Ellison. There are also cases of flares occurring over umbrae without filaments.

H. Dodson-Prince. Yes, the cosmic ray flares and the polar cap absorption flares do occur over the umbrae of major spots, but the flares do not often start over the umbrae.

W. O. Roberts. Is the bending of the radial fields due to solar rotation sufficient?

M. A. Ellison. The convexity towards the west will increase with time, but we do not know the duration of these ordered radial fields. They probably may last a few days or at most a week. With regard to magnetic fields in the Sun-Earth space, I could not refer to all the evidences produced by the cosmic ray experts. Briefly, in the initial stages of these events high-energy particles arrive from the direction of the Sun or from a point west of the Sun.

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At about the time of the maximum cosmic ray effect particles of lower energy begin to arrive isotropically from all directions. These latter are believed to reach us by diffusion and reflection from disordered plasma fields which are present as well as the ordered radial fields in the Sun-Earth space.

R. Lüst. I would like to say that the observed east-west asymmetry of the flares producing cosmic rays could also be explained by a twisted magnetic field which does not extend to the Earth.

9. THE SOLAR MAGNETIC FIELD IN PLAGE REGIONS

R. B. Leighton

The study of solar magnetic fields in plage regions using a photographic technique (Leighton, R. B., *Ap. J.* **130,** 366, 1959) reveals a close geometrical relationship between the bright emission of Ca^+ and magnetic fields. All regions showing magnetic fields of greater strength than the 20-gauss limiting sensitivity of the apparatus also show Ca^+ emission. The bipolar nature of spot groups is clearly revealed, even when no spots of one polarity are present. The field outside spots has a filamentary, patchy appearance. The widely scattered remnants of old spot groups can be seen as patches of magnetic field, each polarity covering a large area.

The fine structure of the magnetic field has been studied, and small tubes of force have especially been looked for. There is no evidence that the magnetic field passes between the granules in small disconnected tubes of force. Tubes as small as 2″ should have been visible if they were present, and if their field strength were as large as perhaps 50 gauss.

DISCUSSION

M. K. V. Bappu. I should like to ask whether the correlation between Ca^+ plage structure and the spatial magnetic field is of a type in which one can assume that actual changes in plage structure denote actual changes in the magnetic field spatial distribution. If it is so, Ca^+ spectroheliograms of the Kodaikanal series of several flares do not show any changes in the calcium plage structure before, during and after flares and, hence, may be considered to indicate that perhaps flares do not actually upset the magnetic field distribution pattern.

R. B. Leighton. Yes, there is a correlation between intensity and magnetic fields in the plages.

R. Michard. What is the magnetic difference between Ca^+ and $H\alpha$ plages? Do the $H\alpha$ plages represent regions of transverse and the Ca^+ plages regions of longitudinal fields?

R. B. Leighton. This we do not know.

A. B. Severny. According to W. E. Stepanov there should be a relation of that kind.

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