also be due to a lowering of density, in a region of dimensions of about 1/3 A.U. and with a time scale of the order of hours or days. The diurnal variation can be explained by the addition of the small outward component to the velocity of particles coming from the direction of the sun, and the subtraction of the same small component from the velocity of particles moving toward the sun. Rough computations indicate that this effect will explain quantitatively these three manifestations of solar modulation. If the radial dimension of an irregularity is of the order of 10^{11} cm, cosmic-rays with energies of the order of 100 Bev will be affected considerably less by an encounter with an irregularity than will comic-ray particles of lower energy, so that energy dependence of the solar modulation is to be expected.

Discussion

Hines, C. O.: A great deal of information is given us here, which will require some time for assimilation. For the moment, though, I would like to point out that the conclusion "there is no statistically significant asymmetry in the position of those solar flares that produce PCA's" is quite different from the conclusion "it is statistically highly probable that no asymmetry exist." The available data are concerning too few to permit the second conclusion to be drawn, even though this same paucity of data may justify the first. But unless and until the second conclusion can be drawn, it seems to be too early to accept further conclusions based on it. Specially, I see no compelling reason for believing that the PCA particles are free from the control of a previously exciting solar magnetic field.

Knecht, R. W.: It would seem to me that the burden of proof should rest with those trying to show that an asymmetry exists rather than vice-versa.

Gold, T.: The propagation "as a cloud" of the PCA particles cannot be contemplated as for too much energy and momentum would be implied if the magnetic field and the interplanetary gas locked in it were all accepted to the speed appropriate to the transit times.

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II-5-13. Propagation of Solar Particles through Interplanetary Magnetic Fields*

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A model of interplanetary magnetic fields, which is formed by the outward streaming of solar plasma clouds, can account for various characteristics of solar particles observed on the earth. All available information of solar flares including radio emissions, polar cap absorptions, geomagnetic and cosmic ray storms during the period from July 1957 to December 1960 has been examined. Summarizing the results obtained, following experimental facts have been found:

1. There is an intimate relation between major solar radio outbursts of continuum radiation (type IV) and solar cosmic ray events. Large cosmic ray storms are also associated with this type of solar outbursts.

2. The time variation of polar cap absorptions caused by the flares originating from

* No manuscript has been received and the preprint is reprinted.

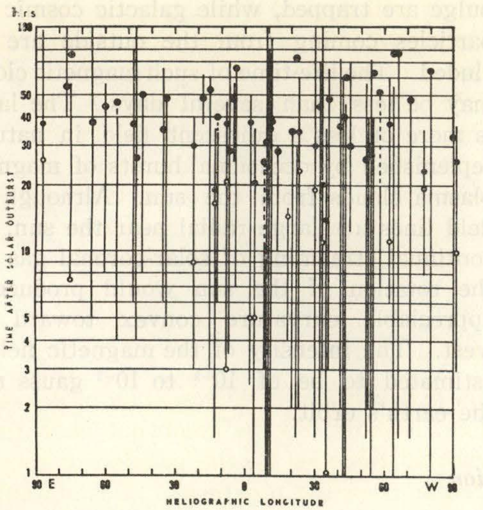

Fig. 1. Heliographic distribution of time delays of polar cap absorptions and of geomagnetic storms. (lines–PCA and circles–sc's of geomagnetic storms).

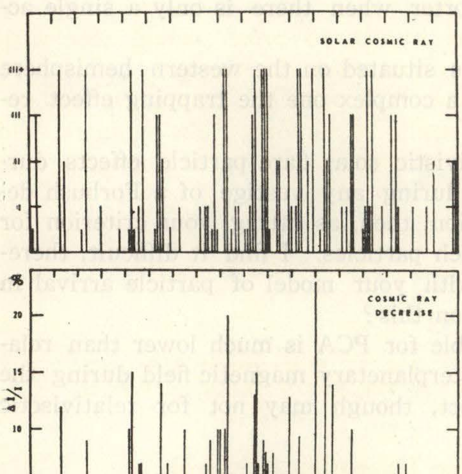

Fig. 2. Distribution of magnitude of polar cap absorptions, cosmic ray storms and geomagnetic storms with respect to the heliographic position of their source flares.

the western side of the solar disk has a shorter time-scale than from the eastern side. Solar cosmic ray particles arrive within a few hours after the flares originating in the west, and more than several hours for those from the west. (Fig. 1)

3. When solar cosmic rays are injected while a solar plasma cloud is in transit between the sun and the earth, the time variation of polar cap absorption reveals a complex feature, very slow rise until the time of the onset of a geomagnetic storm and, being followed by enormous rise of intensity afterwards. Also, at some particular occasions, polar cap absorptions disappear suddenly after the successive arrival of geomagnetic storms.

4. Polar cap absorption events are well distributed from the flares all over the solar disk, though smaller events tend to show some western excess. The source flares are well identified within the visible solar disk with the exception of a few events.

5. Geomagnetic storms show a strong dependence on the position of source flares. Most severe ones originate near the central part of the solar disk. Cosmic ray storms, on the other hand, show no significant such tendency. (Fig. 2)

6. The delay time of geomagnetic storms is nearly independent with respect to the position of the source flares. However, when geomagnetic storms occur one after another,

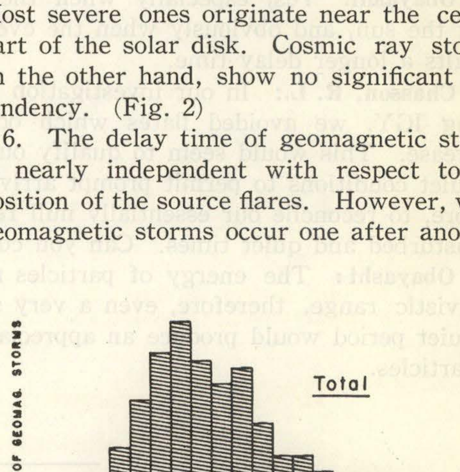

Fig. 3. The occurrence frequency distributions of the delay time of geomagnetic storms.

the storm following after the leading one has a shorter time delay. The average time delay of the storms of this type is 26 hours, while that of isolated or leading storms is 47 hours. (Fig. 3)

The model of interplanetary magnetic fields emerging from these facts is as follows: The interplanetary field consists of two parts, viz., magnetic plasma clouds ejected from the solar flares and their remnants. The former may be called an expanding magnetic bulge forming huge loops of field lines connected with the sun. The solar cosmic ray particles injected inside of this magnetic bulge are trapped, while galactic cosmic ray particles coming from the outside are excluded. The life-time of such magnetic clouds may be less than several days. The latter is more or less a quiescent field in nature; replenished by occasional bursts of magnetic plasma clouds from the sun. Although the field lines are large radial near the sun, the continual streaming of solar-coronal gas and the rotation of the sun would produce an appreciable curvature convex toward the west. The intensity of the magnetic field is estimated to be of 10^{-3} to 10^{-5} gauss near the earth's orbit.

Discussion

Chernavsky, D. S.: Were any events considered with delays over the 100 hours shown in your graph showing PCA's SC of geomagnetic storms and flares.

Obayashi, T.: No, because if we assume the possibility of a time delay more than 100 hours, it would introduce much ambiguities for the identification of the flare responsible to geomagnetic storm.

Gold, T.: Is the PCA delay time usually shorter when there is only a single active region on the sun?

Obayashi: Yes, especially when the flare is situated on the western hemisphere of the sun, and obviously when the event was a complex one the trapping effect results a longer delay time.

Chasson, R. L.: In our investigation of relativistic solar flare particle effects during IGY, we avoided flares which occurred during any vestige of a Forbush decrease. This would seem to qualify our selection, then, as fitting your criterion for quiet conditions to permit prompt arrival of such particles. I find it difficult, therefore, to reconcile our essentially null results with your model of particle arrival in disturbed and quiet times. Can you comment on this?

Obayashi: The energy of particles responsible for PCA is much lower than relativistic range, therefore, even a very small interplanetary magnetic field during the quiet period would produce an appreciable effect, though may not for relativisctic particles.