SH 5.I- I2

INFLUENCE OF MAGNETIC CLOUDS ON COSMIC RAY INTENSITY VARIATIONS

Badruddin, R.S.Yadav and N.R.Yadav
Space Science Group, Dept. of Phys., A.M.U. Aligarh (India).

S.P.Agrawal
Dept. of Phys., A.P.S. Univ., Rewa (M.P.).

ABSTRACT

Neutron monitor data has been analysed to study the nature of galactic cosmic ray transient modulation associated with three types of interplanetary magnetic clouds -clouds associated with shocks, stream interfaces and cold magnetic enhancements.

I. Introduction. It is well known that interplanetary magnetic field is of basic importance in the modulation of galactic cosmic rays. Most of the earlier studies of transient cosmic ray intensity modulations in relation to IMF are confined to the field strength, irrespective of the origin of change in it and other associated properties (Barouch & Burlaga, I975; Duggal et al., I983). Recently 46 magnetic clouds were identified in the interplanetary data obtained near the earth between I967-78 and classified into three classes - shock associated clouds, a stream interface and a cold magnetic enhancement. The Max. field strength is found to be approximately the same and the temperatures are low in all the three types of clouds. The physical characteristics of the magnetic clouds and their role of occurrence suggest that many or all the clouds might be related to coronal mass ejections(Klein and Burlaga, I982).

Newkirk et al. (I98I) have suggested that the interplametary manifestation of coronal mass transients(ejection) may play an important role in galactic cosmic ray modulation and Burlaga (I983) has observed that the detailed studies of the relations between magnetic clouds and cosmic rays have mot been made, but they are worth taking.

In view of the known characteristics of magnetic clouds in relation to magnetic and plasma properties for different classes of clouds and their association with CMEs, it seems important to investigate, in detail, the cosmic ray intensity variations in relation to these clouds of different classes.

2. Analysis. Three types of clouds mentioned above are observed to be moving high magnetic field structures in the interplanetary space. In earlier studies of transient cosmic ray modulations related to interplanetary magnetic field intensity enhancements, most of them are confined to their relationships irrespective of the origin of their enhancement and their other physical properties. We have performed the superposed epoch analysis, using Deep River super neutron monitor data and the date of the cloud observation at the earth as the epoch day, for three classes of clouds seperately. Some individual events have also been studied for more

specific investigations. The various interplanetary parameters associated with these clouds are then used to study the time profile and other characteristics of large amplitude transient decreases(Fd-type) in cosmic ray intensity, which are generally associated with shock associated clouds.

3. Magnetic clouds and Cosmic ray intensity Variations. In Fig. I, We have shown the superposed epoch plots of cosmic ray intensity data from Deep River for three classes of clouds. It is found that the decrease in cosmic ray intensity, with the clouds preceded by a shock, is higher in comparision to the decreases observed inassociation with other two types of clouds and the decrease starts earlier than the arrival of the clouds. The recovery is complete nearly ina week time. The decrease in cosmic ray intensity associated with the cloud followed by a stream interface is much smaller than the one mentioned above. The decrease time is also elevated and the onset of the decrease takes place on the arrival of the cloud. The decrease observed in association with the clouds associated with cold magnetic enhancement is still smaller in amplitude and duration, but the decrease in cosmic ray intensity starts when the clouds arrives at the earth.

4. Magnetic clouds following shocks and cosmic ray intensity variation. We have plotted the cosmic ray intensity data in relation to some individual shock associated clouds(Fig.2). Whenever the shock arrival time is not available we have used the sudden commencement of geomanetic storms(SSC) data, since SSC can be regarded as the geomagnetic signature of the arrival time of the interplanetary shocks. We can see from Fig.2 that, in general, the Forbush-type decrease starts at time of arrival of the shock wave at the earth. However, there are a few cases when no appreciable decrease in cosmic ray intensity is observed, with the shock associated clouds. suggestions have been made in the past that the Forbush-type decrease is caused by the entry of the earth into a loop or tongue of IMF field lines that are fresly ejected from the sun. Cosmic ray density in such loops was considered to be depressed because these field lines do not reach boundary regions of the the heliosphere and also because particles are cooled as the loop expands. We found(Fig.I&2) that in case of shock associated clouds decrease in cosmic ray intensity starts, at the earth, not at the arrival of the cloud, but at the arrival of the shock that precedes the cloud by few hours. It is difficult to follow the exact time history of the events in detail, because cosmic ray profiles vary significantly with the longitude and latitude of the observing stations. However, it is likely, that the magnetic regime that contaimed the lowest density of galactic cosmic rays was a portion of the magnetic cloud. These results are in agreement with the view expressed by Palmer et al.(I978).

5. Physical Properties of shock associated magnetic clouds and associated cosmic ray variations.

We have seen that the transient modulation of cosmic ray intensity is related,ingeneral,to the clouds of all the three classes.However,the time profile and amplitude of cosmic ray modulation for three types of clouds is different.Forbush-type transient modulation is related,generally,with the cloud preceded by a shock.We have thus used the cloud and shock parameters to further study the various features of associated modulation.

Fig.3 shows the relation between the duration of the cloud near the earth and the total time taken for a forbush decrease to recover to pre-decrease level from the start of the event.It seems that the total duration of the forbush decrease increases as the cloud duration increases.However, as shown in Fig.4,the time taken by the decrease from the onset time to reach the minimum value of intensity does not depend on the duration of the cloud.But the recovery time of these decreases seems dependent on the duration of the clouds (Fig.5),it is larger for larger duration clouds.Though our results show the above mentioned behaviour,still there is needto have more data to varify this result conclusively.The observed duration of the cloud will depend upon the size and/ or speed of the cloud.Since the clouds are observed to be expanding to distances of at least 4AU,they are more likely to be important at larger distances as far as the recovery time is concerned.From the study of cosmic ray intensity at IAU,6.97AU,& I5.9IAU and the findings that a magnetised plasma cloud moved outward and that the recovery time at these distances were,respectively- 6, 22,and I50 days,it may be possible that some of the cloud move to such large distances;they might also be expanding while moving to such distances.It has beenmentioned by Lockwood and Webber(I977) that the modulation regions associated with Forbush decreases were propagating several astronomical units beyond earth.

6. <u>Amplitude of decrease and its relation to the speed of shock associated clouds.</u> We have also studied the amplitude of decrease in relation to maximum solar wind velocity increase observed in association with these shock associated clouds(Fig.6).In general the increase in amplitude is larger when the cloud speed is larger.

References.

Barouch,E.and Burlaga,L.F.(I975),J.Geophys.Res.,80,449.
Burlaga,L.F.,(I983),Proc. I8th ICRC,I2,2I.
Duggal,S.P.,Pomerantz,M.A.,Schaefer,R.K.and Tsao,C.H.,(I983), J.Geophys.Res.,88, 2973 .
Klein,L.W.and Burlaga,L.F.,(I982),J.Geophys.Res.,87,6I3.
Lockwood,J.A.and Webber,W.R.,(I977),J.Geophys.Res.,82,I906.
Newkirk,G.Jr.,Hundhausen,A.J.and Pizzo,V.,(I98I),J.Geophys. Res.,86,5387.
Nishida,A.,(I982),J.Geophys.Res.,87,6003.
Palmer,I.D.,Allum,F.R.and Singer,S.,(I978),J.Geophys.Res; 83, 75.

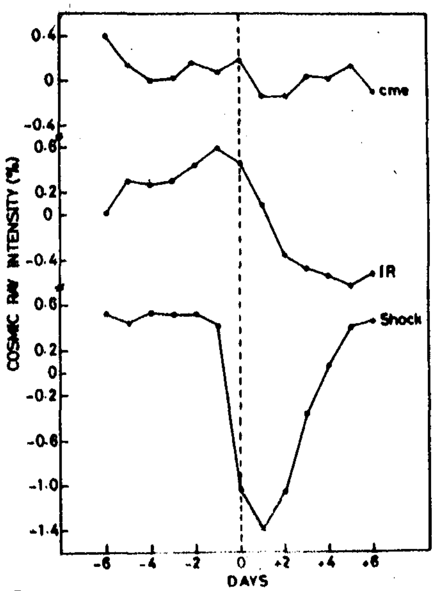

Fig.-1

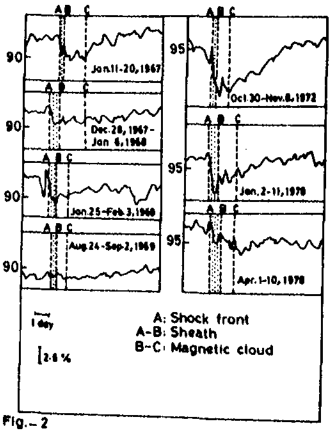

Fig.-2

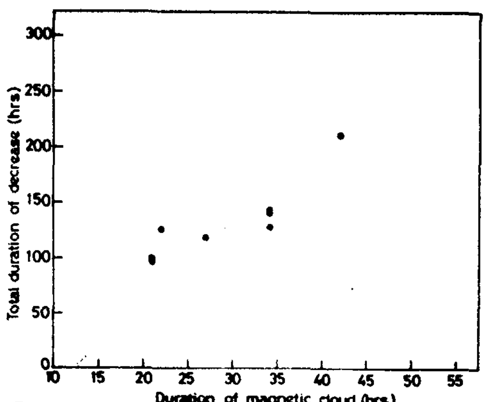

Fig.-3

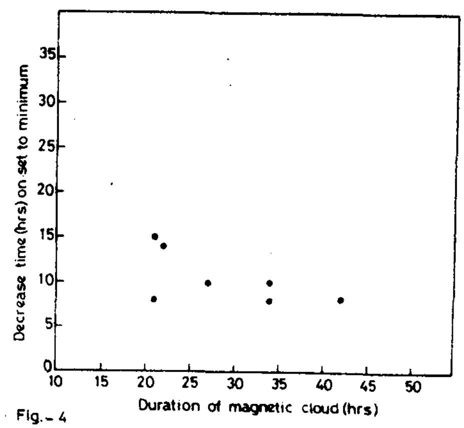

Fig.-4

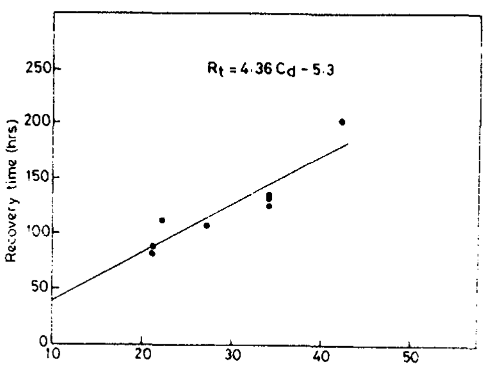

Fig.-5

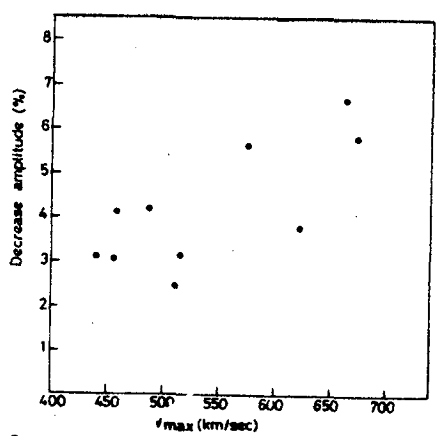

Fig.-6