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Interplanetary magnetic field and equatorial ionosphere

by

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ABSTRACT. – *Simultaneous data on the interplanetary magnetic field (IMF) and h'F at the equatorial station, Kodaikanal (Geo Mag. Lat. 0.6° N) has been examined for 15 occasions to infer the possible effect of the sudden northward transitions of IMF on the electric fields in the equatorial ionosphere during night time. The results do not indicate a definite influence of the interplanetary magnetic field on the nocturnal equatorial ionosphere*

RESUME – *Les données simultanées du champ magnétique interplanétaire (I M F) et h'F à la station équatoriale de Kodaikanal (latitude géomagnétique 0.6° N) ont été examinées en 15 occasions pour déduire l'effet possible des passages soudains au nord du champ magnétique interplanétaire sur les champs électriques dans l'ionosphère équatoriale pendant la nuit Les résultats n'indiquent pas une influence bien nette du champ magnétique interplanétaire sur l'ionosphère équatoriale nocturne.*

1. Introduction

The equatorial ionosphere is well known to exhibit several characteristic features associated with the intense electrojet currents at *E*-region altitudes during day time due to the greatly enhanced electrical conductivity at the dip equator and the east-west electric field. The currents are very small during night time due to the greatly reduced *E*-region electron density, but the electric field is of the same magnitude though reversed in direction (Satya Prakash *et al*, 1970). Extensive evidence has been reported over the past several years to indicate a prominent effect of the interplanetary magnetic field (IMF) on the electric fields in the high latitude ionosphere (Heppner, 1972 , Mozer *et al*, 1974 ; Maynard and Johnstone, 1974 ; Wolf, 1975). Some evidence to suggest a possible effect of IMF on the equatorial ionosphere also exists in literature. Matsushita and Balsley (1972) showed that, during geomagnetically disturbed periods, there exist good correlations between the changes in interplanetary southward magnetic field and *H*-component of geomagnetic field, *E*-region east-west electron drifts and disappearance of *q*-type of sporadic-*E* (*Esq*) on ionograms, in the equatorial region. Rastogi and Chandra (1974) noticed the *F*-region east-west drift speed at Thumba, close to the dip equator, during midday or midnight hours to decrease with increasing magnitude of the southward component of IMF, B_z. Rastogi and Patel (1975) presented data for a few events to show that large changes in B_z from southward to northward are associated with depressions in the *H*-component of geomagnetic field (counter-electrojet), disappearance of *Esq* on ionograms and reversals in the *E*-region horizontal drift and *F*-region vertical drift in the equatorial region, during day time. They also noticed similar reversals in the *E* and *F*-region drifts during night time (post midnight period) in close association with a northward transition of IMF, for one particular event (3 July 1968). For this same event, it was shown later by Rastogi (1977) that the northward transition of IMF is associated not only with reversals in *E* and *F*-region drifts but also increase in *F*-region height (*h'F*) and onset of intense range spread-*F* on ionograms in the equatorial region. These changes in the equatorial ionosphere (during day and night times) have been explained by them as due to the imposition of a reverse (westward) electric field in the equatorial region due to the interaction of the solar wind with the interplanetary field. The mechanisms of the coupling between the interplanetary magnetic field and the equatorial ionosphere are however not clear. In a recent review article, Matsushita (1977) expressed the opinion that the above mentioned evidence of a possible effect of IMF on the equatorial ionosphere represents common ionospheric disturbances due to geomagnetic storms or magnetospheric substorms, probably triggered by-B_z, rather than direct effects caused by changes in IMF, as the data presented by the various workers pertains mostly to disturbed periods. Very recently, Kane (1978) studied about a dozen clear cut counter-electrojet events in relation to changes in IMF and found the absence of a definite relationship between the occurrence of counter-electrojet and flipping of B_z from southward to northward. A similar inference was also drawn by Patel (1978) from a examination of the relationship for 20 events, between the disappearance of *Esq* on ionograms, reversal or decrease in the equatorial electrojet and northward transition of B_z.

Observation and conclusion

As the existing evidence indicative of a possible effect of IMF on the electric fields in the equatorial ionosphere during night time is limited just to a single event (3 July 1968), it is felt worthwhile to examine the relationship for a considerable number of events to infer whether the reported influence is a systematic one or not. In this brief communication, we present the results of such an attempt where in we have studied the effect of changes in IMF on the minimum virtual height of *F*-region, $h'F$, at the equatorial station, Kodaikanal (10° 14'N, 77° 28'*E*, *Dip* 3.5°N). The choice of $h'F$ to infer the IMF effects on the electric fields in the nocturnal equatorial ionosphere is quite appropriate, as changes in $h'F$ during night time in the equatorial region are mainly attributed to the changes in electrodynamic drift caused by an east-west electric field. The published IMF data (hourly averages) for the period 1963-74 (UAG rep No. 46-WDC-A for STP, NOAA, U.S.A) is initially searched to select days with sudden inversions of the latitude (θ) of IMF from negative to positive values i.e. sudden northward inversions of B_z, corresponding to night time conditions for the longitude sector under consideration. In doing so, only those events where in the value of 'θ' is consistently of the same sign for at least 3 hours on either side of the transition and the change in 'θ' is at least from $-40°$ to $+40°$, have been taken into consideration. This selection procedure is adopted in view of the nature of the IMF data used (hourly averages) and also because of the intention to limit the present analysis to clear cut cases. A final sample of 15 events became available for study for which simultaneous ionospheric data at Kodaikanal was available.

At equatorial latitudes, the *F*-region height ($h'F$) under quiet conditions typically shows a post sunset rise reaching a maximum around 19-20 hrs L.T followed by a decrease. The postsunset height rise shows a positive correlation with solar activity and is considered to be due to an enhanced eastward electric field in the equatorial ionosphere as the incoherent scatter observations at Jicamarca (Woodman, 1970) have shown strong upward plasma drifts in the *F*-region around sunset time during high sunspot years. In figure 1 are shown, in comparison, the changes in the latitude (θ) of IMF, $h'F$ and $\Delta h'F$ (deviation from the monthly median) at Kodaikanal for the 15 selected events. The format of presentation is the same for all the events. The daily planetary geomagnetic index, A_p is also shown in Figure 1 for the various events to indicate the level of geomagnetic activity As may be seen from Figure 1 in a majority of the events the northward inversions of B_z occurred far away from the sunset period. However, in some cases the transitions in B_z occurred rather close to sunset period and to enable a separate sunset effects from possible IMF effects, the time of local sunset is indicated in Figure 1 for these events.

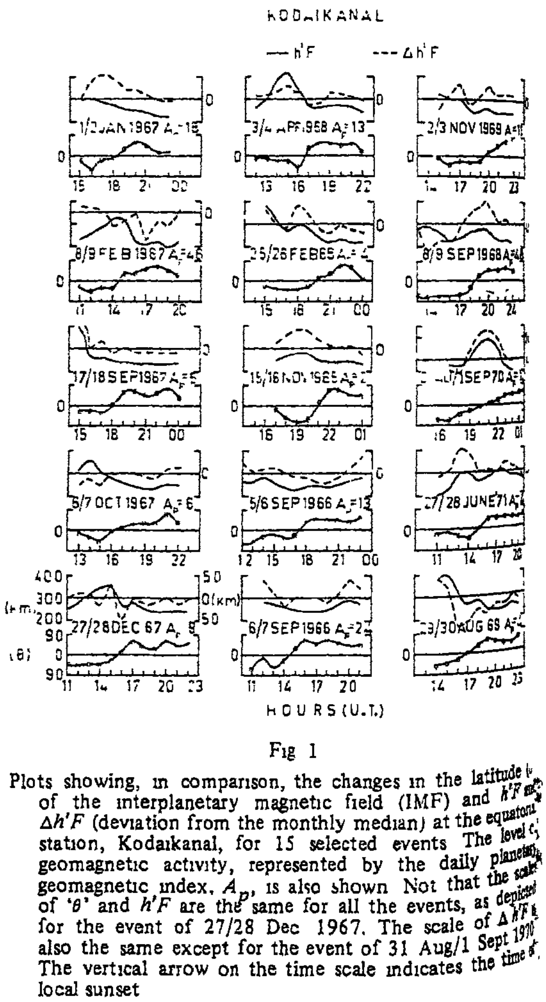

Fig 1

Plots showing, in comparison, the changes in the latitude (θ) of the interplanetary magnetic field (IMF) and $h'F$ and $\Delta h'F$ (deviation from the monthly median) at the equatorial station, Kodaikanal, for 15 selected events The level of geomagnetic activity, represented by the daily planetary geomagnetic index, A_p, is also shown Not that the scale of 'θ' and $h'F$ are the same for all the events, as depicted for the event of 27/28 Dec 1967. The scale of $\Delta h'F$ is also the same except for the event of 31 Aug/1 Sept 1970. The vertical arrow on the time scale indicates the time of local sunset

It is clearly evident from the results presented in Figure 1 that, except for the two events of 8/9 Sept 1968 and 31 Aug/1 Sept 1970, in the rest there is no trend whatsoever of a significant increase in the *F*-region height (indicative of reversal in the *F*-region vertical drift) at Kodaikanal in response to the sudden northward transitions of IMF. Even for the events of 8/9 Sept 1969 and 31 Aug/1 Sept 1970, the significant increases in the *F*-region height appear to start well ahead of the changes in IMF direction, suggesting that they may not be related to IMF variations. Besides, on some occasions (3/4 Aprl 1968, 8/9 Feb 1967, 25/26 Feb 1968, 27/28 Dec 1967) the northward transition of B_z seems to cause a decrease rather than the increase in $h'F$ as can be seen from Figure 1. However, the decrease in layer height in these cases is either not significant or seems to have started well ahead of the changes in IMF direction. A further study of the *F*-region behaviour at Kodaikanal (not shown here) using M(3000) values and the formula of Shimazaki (1959) showed that the behaviour of the height of maximum ionization, *hmF2* and Δ *hmF2* (deviation from the monthly median) is essentially similar to that of $h'F$ and Δ $h'F$ respectively for all the events. The present study thus indicates that there is no systematic and significant effect of the northward transitions of IMF on the equatorial ionosphere during night time.

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Références

Heppner J.P., "Electric fields in the magnetosphere", in *'Critical problems of magnetospheric physics'*, (ed) E R Dyer, P 107, National Academy of Sciences, Washington D C, 1972

Kane R.P., "Counterelectrojet and interplanetary magnetic field", *J. Geophys. Res*, 83, 2671-1674, 1978.

Matsushita S., and B.B. Balsley, "A question of DP-2", *Planet space Sci.*, 20 1259-1267, 1972.

Matsushita S., "IMFP effects on the equatorial geomagnetic field and ionosphere-A review", *J. Atmos Terr. Phys*, 39, 1207-1215, 1977.

Maynard N.C., and A.D. Johnstone, "High-latitude day side electric field and particle measurements", *J. Geophys. Res*, 79, 3111-3123, 1974.

Mozer F.S., and W.D. Gonsalez, F., Bogott, M.C. Kelley, and S. Schutz, "High latitude electric fields and the three dimensional interaction between the interplanetary and terrestrial magnetic fields", *J. Geophys. Res*, 79, 56-63, 1974.

Patel V.L., "Interplanetary magnetic field variations and the electromagnetic state of the equatorial ionosphere", *J. Geophys. Res*, 83, 2137-2144, 1978.

Rastogi R.G., and H. Chandra, "Interplanetary magnetic field and the equatorial ionosphere", *J Atmos Terr. Phys.* 36, 377-379, 1974.

Rastogi R.G., and V.L. Patel, "Effect of interplanetary magnetic field on ionosphere over the magnetic equator", *Proc. Indian Acad. Sci.*, 82A, 121-141, 1978.

Rastogi R.G., "Equatorial spread-*F* and interplanetary magnetic field", *J Geomag. Geoelecter*, 29, 557-561, 1977.

Satya Prakash Gupta S.P., and B.H. Subbaraya, "A study of the irregularities in the night time equatorial *E*-region using a Langmuir probe and plasma noise prob", *Planet space Sci*, 18, 1307-1318, 1970.

Shimazaki T., "A theoretical study of the dynamical structure of the ionosphere", *J. Radio. Res Lab*, 6, 109-140, 1959

Wolf R.A., "Ionosphere-magnetosphere coupling", *Space, Scie, Rev*, 17, 537, 1975.

Woodman R.F., "Vertical drift velocities and eastwest electric fields at the magnetic equator, *J. Geophys Res*, 75, 6249-6259, 1970