Interplanetary Magnetic Field Effects in the E-region Drifts at Low Latitudes

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Interplanetary magnetic field (IMF) effects in the horizontal drift velocities of the ionization irregularities in ionospheric E- and F-regions are presented. The drift measurements were made at an equatorial station, Tiruchirapalli (dip 4.8°N) since Oct. 1972 and an extensive series of E- and F-region drift measurements was conducted during the period 1973-75. IMF data obtained from Explorer 50 and HEOS-2 satellites and published by National Space Science Data Center are used in the present study. Midday drift velocities in the E- as well as in F-region are examined with the corresponding northward ($B_z$) and eastward ($B_y$) components of IMF. Linear relations are noted for E- and F-region drift velocities with both $B_z$ and $B_y$. These results support the view that the solar plasma interacting with the IMF would impose an electric field in the equatorial ionosphere and cause changes in the resultant electric field.

Interplanetary magnetic field (IMF) effects on the geomagnetic and ionospheric phenomena in the equatorial region have been reported by some workers in recent years. A review of these works has been published by Matsushita. Correlations between the southward component of IMF ($B_z$), geomagnetic field variations at different latitudes, the disappearance of Esq at Huancayo and the E-W drifts at Jicamarca were found by Matsushita and Balsley. Rastogi and Chandra reported the decrease in the daytime westward drift or in the nighttime eastward drift in F-region over Thumba (dip 0.6°S) with increases of southward $B_z$ which were interpreted as caused by a decrease in the equatorial east-west electrostatic field. Rastogi and Patel pointed out that rapid turning of IMF to northward value is associated with the disappearance of Esq or reversal of the E- or F-region drifts. The association of the $B_z$ component of the IMF with the equatorial drifts has not been investigated so far and this is the primary aim of the present study.

IMF effects in the E-W drift velocities of the ionization irregularities in ionospheric E- and F-regions are presented here. The drift measurements were made at an equatorial station, Tiruchirapalli (dip 4.8°N) since Oct. 1972 and an extensive series of measurements were conducted during the period 1973-75. IMF data obtained from Explorer-50 and HEOS-2 satellites, published by National Space Science Data Center are used for the study.

In Fig. 1 are shown the variations of the $B_y$ and $B_z$ components of the IMF for 18 Sep. 1974, a day when large changes were noted in IMF. Also shown in Fig. 1 are the E-W drift on 18 Sep. 1974 and the mean drift for the month of Sep. 1974. The westward drift is higher on 18 Sep. 1974 than the average in the forenoon hours while in the afternoon the opposite is the case, the decrease leading even to a counter electrojet. The $B_z$ component appears to be correlated here with its value going northwards in the forenoon hours and becoming southward again in the afternoon hours. Since the changes in IMF are simultaneously reflected in the drifts the correlations between the midday drift velocities have been examined with the corresponding $B_z$ and $B_y$ values in this study. Fig. 2(a) shows the variation of the midday E-W drift velocities in E- and F-regions with $B_z$. Good correlations are seen with a linear dependence of drift on $B_z$ both for E- and F-regions. Westward drift increases with increasing northward $B_z$ value, the changes being 3.0 m/sec and 2.9 m/sec, respectively, for E- and F-regions for a $\gamma$ change in $B_z$ value. Similar dependence of E-W drifts on $B_y$ is shown in Fig. 2(b). Both E- and F-region drifts show dependence on $B_y$, the westward drift velocities increasing with increasing values of $B_y$ or with increasing eastward component of IMF. These changes are 1.7 m/sec and 1.5 m/sec, respectively, for E- and F-regions for a $\gamma$ change in $B_y$ value.

Since the drift measurements of the irregularities in the equatorial region are an index of the electric fields, these results support the view that the solar plasma interacting with the IMF would impose an electric field in the equatorial region. To further examine this dependence on a day-to-day basis we have plotted the midday values of the drifts and the $B_y$ and $B_z$
Fig. 1.—Variations of the $B_y$ and $B_z$ components of IMF and of E-W drift at Tiruchirapalli on 18 Sep. 1974

Fig. 2.—Variations of the mean midday E-W drifts for E- and F-regions over Tiruchirapalli with: (a) $B_y$ and (b) $B_z$

Components for each day. Day-to-day changes are thus illustrated in Figs. 3(a) to 3(d) for a period Feb. 1974 to June 1974. On 14, 15 and 17 February and later on 21 and 22 February [Fig. 3(a)] there are drops in $B_y$ which are associated with the decrease, or sometimes even a reversal in $B_y$ is seen again on 18-19 April [Fig. 3(b)] which is again associated with the decrease or even a reversal of drift. The large decrease in $B_y$ on 16th May [Fig. 3(c)] is associated with drift reversal. However, the decrease in $B_y$ on 24 May does not seem to have any effect on drifts. The reversal on 22 May, preceding this could be due to some other reason like changes in the local wind system, associated with a counter electrojet. Similarly large increase of $B_y$ on 3 May does not have any effect on drifts. Decreased values of $B_y$ from 15 to 19 May seen to have a role in decreasing drifts in that period. Finally the example in Fig. 3(d) shows large increase (positive values) of $B_z$ and $B_y$ around 2 June which is associated with increased westward velocity.

Low values of $B_y$ on 10 and 11 June are associated with reversals of drift. Again from 15 to 20 June $B_y$ values are low and this period shows drift reversals. Increases in $B_z$ on 12 June and in $B_y$ on 13 and 14 June seem to have caused increase in the drift velocities. Thus there is ample evidence of changes in drifts with changes in $B_y$ or $B_z$ in spite of the fact that there are some days when the changes in IMF do not seem to have effects in drift velocities. There are reversals caused by changes in $B_y$ alone or by changes in $B_z$ alone as also caused by simultaneous changes in $B_z$ and $B_y$.

In a recent paper Fejer et al. have examined the drift measurements at Jicamarca with IMF changes and noted that while the $B_y$ component appears unimportant the $B_z$ component has some effects. They noted reversals in drifts associated with rapid reversal in $B_z$ from south to north with instances when IMF may reverse without any apparent effect in drifts. They also reported perturbations in electric fields when $B_z$ is large and southward but not changing drastically.
They concluded that the IMF does not affect the equatorial electric field directly, but it causes changes in magnetospheric electric fields, auroral zone electric field and conductivity distribution, which alter the worldwide ionospheric current flow and electric field pattern. Investigations are needed to examine IMF effects at different latitudes.

Regarding the changes associated with $B_y$ component of the IMF, Galperin et al. have studied the dependence of the ion convection velocity and the total ion concentration measurements from Cosmos 184 satellite with the reversals of the sign of $B_y$. Systematic decreases of the near equatorial ion density were observed after reversals from $B_y$ negative to $B_y$ positive. These decreases were accompanied by relative enhancements of the upward and eastward components of the plasma drift velocity. These observations also support the effects of the $B_y$ component of IMF in the equatorial electric fields.

References