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Effect of the Interplanetary Magnetic Field Upon the Cosmic Ray Modulation

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Abstract

Cosmic ray data observed with neutron monitors as well as underground muon telescope located at Mawson have been used to study the effect of interplanetary magnetic field (IMF) upon the cosmic ray solar diurnal variation. This data coves almost three solar cycles during the period 1965-1992. The median primary rigidity of response for these detectors covers the rang 23-164 GV. The solar diurnal variation has been calculated for days with high, intermediate and low IMF magnitude. This analysis reveals that days characterized by high IMF magnitude are associated with higher diurnal variation amplitudes as well as higher solar plasma parameters.

1 Introduction:

The interaction of galactic cosmic rays with the interplanetary medium leads to a small cosmic ray anisotropy (~0.5%) known as diurnal variation. These cosmic ray particles suffered sufficient scattering in the interplanetary medium to remove the density gradient which is otherwise set up to cancel the effect of the overall, conservative electric field (Parker, 1964, Axford, 1965, Stern, 1964). The cosmic ray intensity decreases as the interplanetary magnetic field (IMF) magnitude increases (Sabbah and El-Borie, 1997). The upper cut-off rigidity (R_c) of the diurnal variation (at which the anisotropy disappears) is correlated with the IMF magnitude (Ahluwalia, 1992; Sabbah 1999a). The values of R_c show ~20-year magnetic cycle (Sabbah, 1999a). As the IMF strength increases, the upper limit to the efficient cosmic ray scattering increases and consequentially R_c increases. Sabbah, 1999b, correlate R_c to the geomagnetic activity. Hence it is essential for the theoreticians to involve R_c in their drift model.

In this paper we have investigated the effect of IMF upon cosmic ray diurnal variation during the period 1965-1992.

2 Analysis of Data:

Neutron monitor (NM) data observed at Rome and Tokyo together with underground muon telescope at Mawson (31 m.w.e) have been used in this analysis. The median primary rigidity R_m for these detectors lies in the range 23 GV $\leq R_m \leq$ 146 GV. Days with Furbish decreases with magnitude $\geq$ 4% as seen by Deep River neutron monitor have been eliminated from the data. The influence of large ground-level enhancements caused by solar flares has been eliminated as well. A linear trend has been removed from each day of the data by subtracting the best fit linear regression of the hourly counts. Finally we calculate the diurnal variation of each day by calculating the Fourier coefficients.

The yearly average values of the IMF magnitude (B) have been calculated from the Omnitape during the period 1965-1994. Days with IMF magnitude above (B+σ)are classified as high IMF magnitude. Where (σ) is the standard deviation. While days with IMF magnitude below (B+σ) are classified as low IMF magnitude. Otherwise, are considered as intermediate.

In order to examine the yearly average characteristics of the diurnal variation modulated by the IMF, the Fourier coefficients for each day have been separated according to the above three divisions of the IMF magnitudes. Finally, the yearly average daily variation vectors are then calculated for each division during the period 1965-1992.

3 Results and Discussion:

Figure 1 displays the yearly average values of the high (H), represented with dashed lines, intermediate (M) and low (L) magnetic field magnitude. Note that the IMF magnitude reaches the highest value during years of declining phase of solar activity. It shows 11-year cycle (Sabbah, 1996) The corresponding solar wind speed, temperature and ion density are shown in Figure 2. We notice that high IMF magnitudes are associated with high plasma parameters as well. Years of sunspot maxima (M) and sunspot minima (m)are indicated with upward pointing arrows at the bottom panel. Figure 3 displays the yearly average values of the amplitude of the diurnal variation for each IMF deviation at each station. The time of the solar polarity reversal is shown by crosshatched areas in the bottom panel of the Figure 3. The polarities of the solar field in the southern solar hemisphere away (A) and toward (T) are also shown at the bottom panel. We see that the amplitude of the diurnal variation during high IMF (represented with dashed lines) is the highest. It is also enhanced during declining phase of solar activity. Note also that he IMF magnitude and the other plasma parameters are enhanced as well. Galactic cosmic rays suffere more scattering as the IMF strength increases.

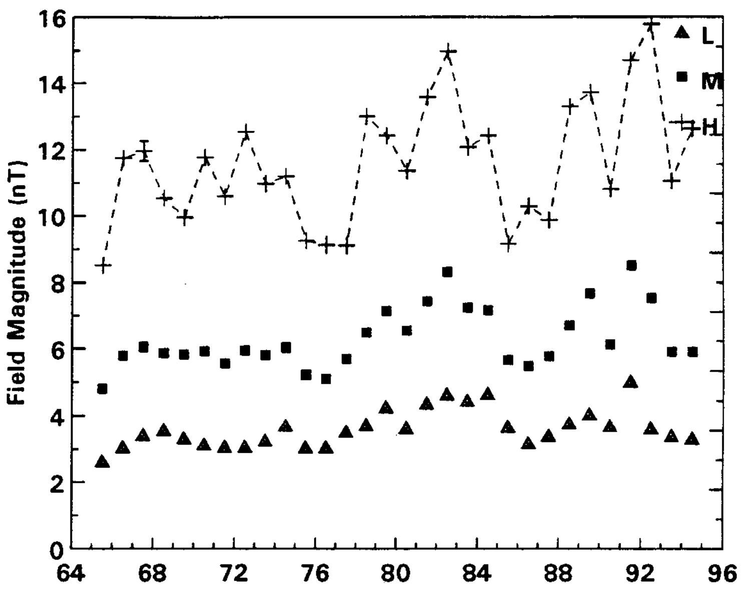

Figure 1: The yearly average values of the IMF magnitude for high, intermediate and low field.

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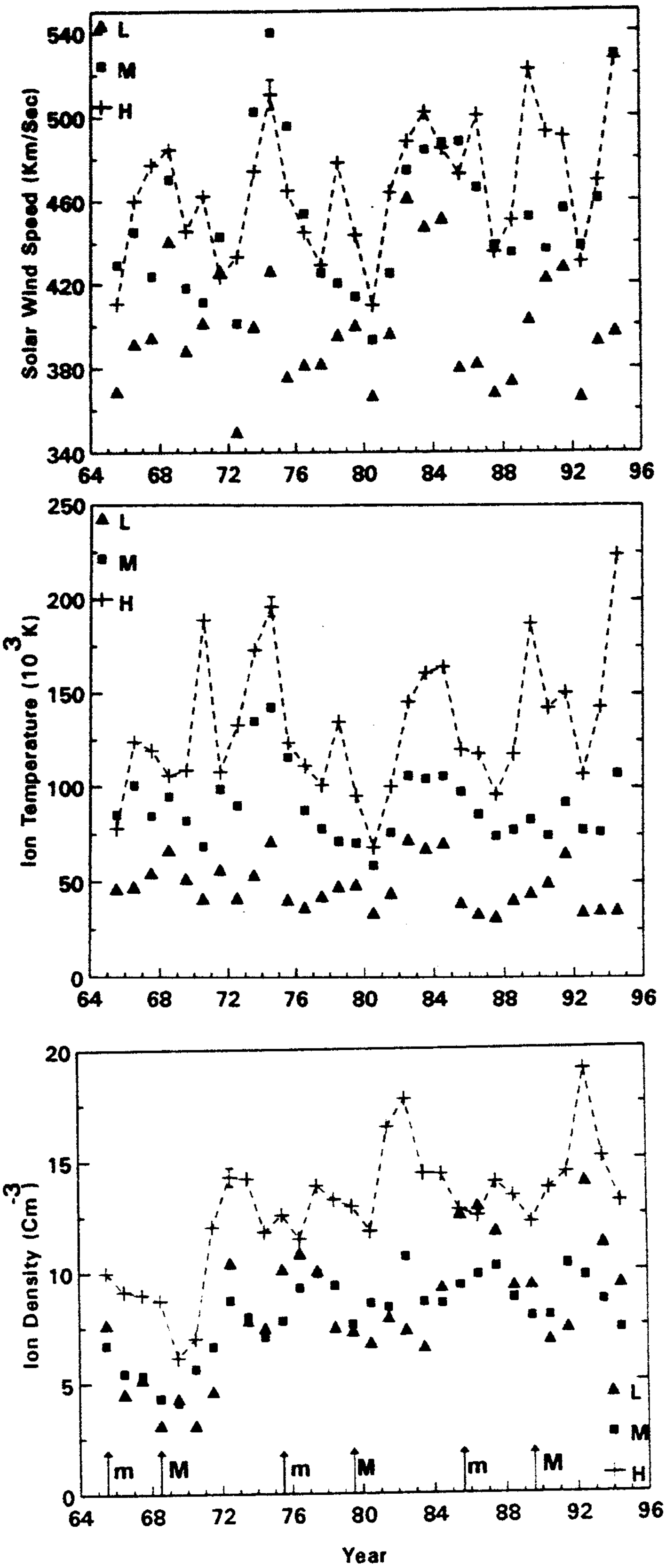

Figure 2: Yearly average values of solar wind speed, temperature and ion density. Vertical arrows in the bottom of the horizontal scale mark the positions of solar activity cycle maxima (M) and minima (m).

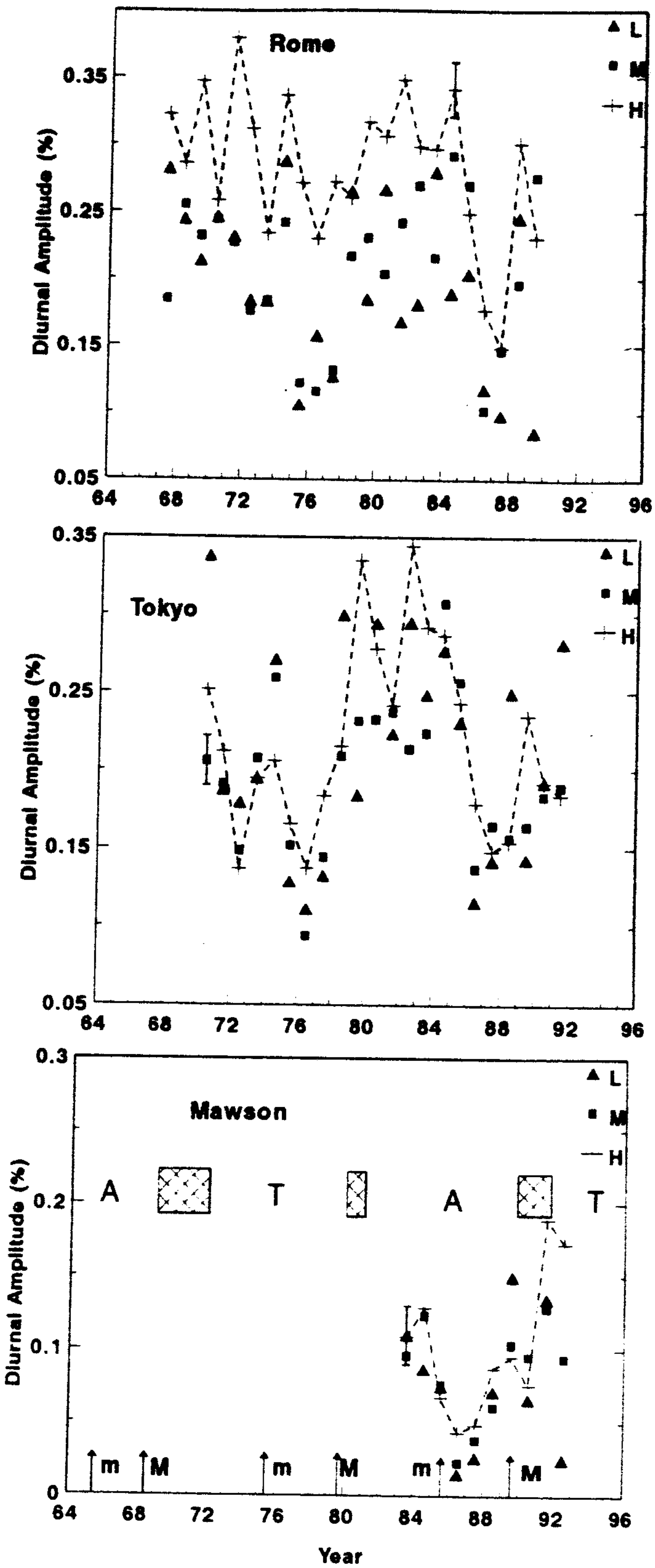

Figure 3: Variation of the yearly average amplitudes of the diurnal variation obtained with NMs at Rome and Tokyo and under ground muon telescope at Mawson for high, intermediate and low IMF magnitude.