Investigation of the Association of Magnetopause Instability With Interplanetary Sector Structure

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The variation of the solar wind parameters (speed, magnetic field intensity, and proton density) and geomagnetic disturbance with location within the interplanetary sector structure is well established [Wilcox, 1968]. The Kelvin-Helmholtz instability of the magnetopause provides a mechanism for the initiation of worldwide geomagnetic disturbance [Boller and Stolov, 1970, 1973]. Since the Kelvin-Helmholtz mechanism depends on an integration of several of the solar wind parameters, it is interesting to see how it varies within the sector structure.

The magnetopause is assumed to be a tangential velocity and magnetic field discontinuity. A simplified version of the instability criterion is

\[ U^2 > \frac{p_1 + p_M}{4 \pi \rho} \left[ B_x^2 \cos^2 \Psi_x + B_y^2 \cos^2 \Psi_y \right] \]

where \( I \) stands for interplanetary values outside the magnetosphere (magnetosheath values) and \( M \) stands for magnetospheric values. The symbol \( U \) is the stream speed of the solar wind at the magnetopause, and \( \Psi \) is the angle between the local stream velocity \( U \) and the magnetic fields. The symbols \( B \) and \( \rho \) stand for magnetic field intensity and mass density, respectively. It has been assumed that the wave vector of the perturbation is in the \( U \) direction. The components of the magnetic field, which are parallel to the stream of the solar wind at the boundary, create a stabilizing influence. The probability of instability (or more correctly, instability parameter) may be taken to be a linear function of the difference between \( U^2 \) and the right-hand side of the instability criterion [Boller and Stolov, 1970]. This parameter is calculated for 42 Explorer 18 crossings of the magnetopause [Boller and Stolov, 1973]. The placement of each magnetopause crossing within the interplanetary sector structure was determined from Wilcox [1968]. A superposed epoch analysis of the 42 crossings displaying the probability of instability as a function of position within the sector structure is shown in Figure 1. The eight infinitely large values for the right-hand side in the method 1 calculations of Boller and Stolov [1973] were assumed in the averaging to be an order of magnitude greater than the highest finite value for that day of the superposed epoch analysis. On the day in which no other values existed (day 6, toward) an order of magnitude higher than the highest finite value on the previous day was taken.

The probability of instability is plotted with a plus sign in sectors with magnetic field away from the sun and with a minus sign in sectors toward the sun. The average of toward and away sectors is indicated by circles.

An inspection of the figure shows that the largest probability of instability occurs on day 3, whereas the smallest occurs on day 6 for all three cases. This variation of the probability of instability within the sector structure is almost identical to that for geomagnetic activity [Wilcox, 1968]. This gives further support to the idea that the integration of the solar wind parameters via Kelvin-Helmholtz instability is an important concept in understanding geomagnetic disturbance.

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REFERENCES


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