THE SOLAR WIND VELOCITY AND ITS CORRELATION WITH GEOMAGNETIC, SOLAR AND COSMIC RAY ACTIVITY

by

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1. INTRODUCTION

In this report we discuss the correlation of plasma velocity measured by Mariner II with various indices of solar and terrestrial activity during more than 4.5 solar rotations covering the period 28 August through 31 December 1962 (day 240 to 365). The daily mean and the six-hourly mean plasma bulk velocities have been derived from approximately 40,000 spectra received from the plasma probe which consisted of a single electrostatic spectrometer pointing within 0.1 degrees of the center of the sun.

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2. EXPERIMENTAL RESULTS

Figures 1a and 1b show the plot of the daily mean plasma velocity, the planetary indices K_p and the sunspot and C. R. activity. The plasma velocity does not show any correlation either with the cosmic ray diurnal amplitude and time of maximum or with the overall solar activity as measured by the sunspot

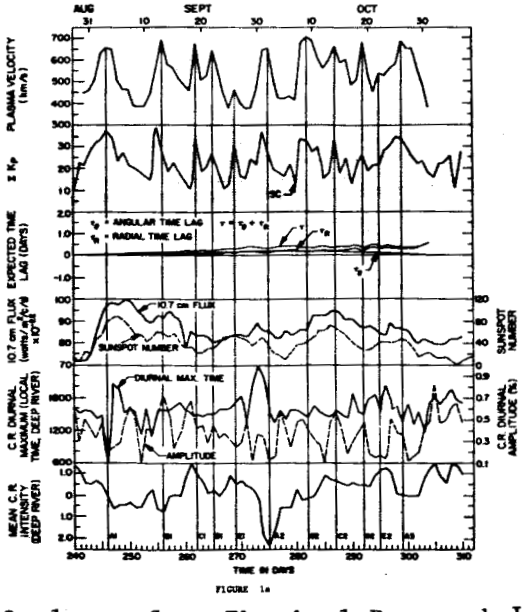

FIGURE 1a

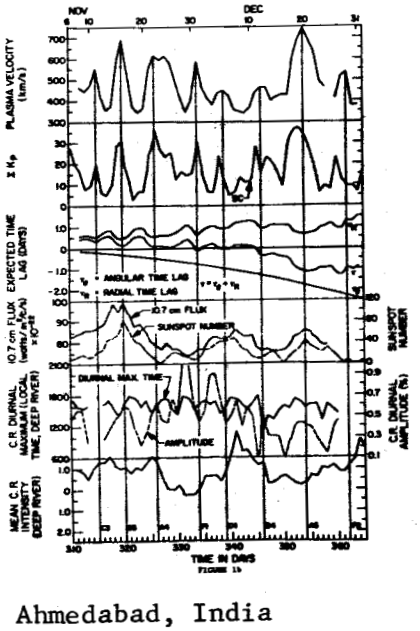

FIGURE 1b

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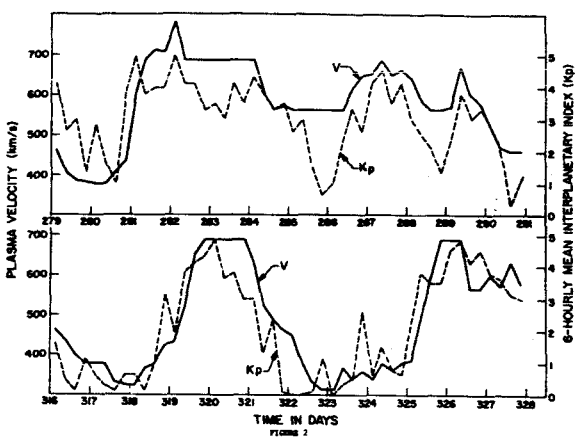
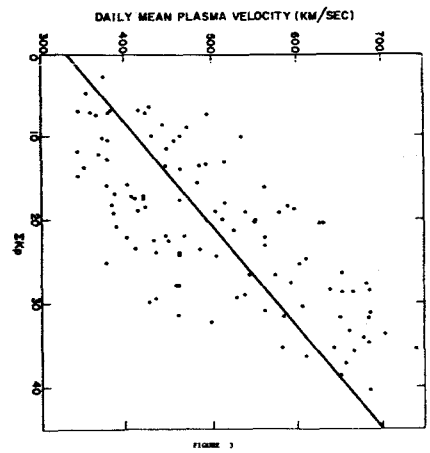
number and 10.7 cm flux. However, a remarkable correlation exists between daily $\sum K_p$ and daily mean plasma velocity with no time lag, except after day 352 when both the "expected" and the observed time lags were approximately one day. Every major peak and trough in plasma velocity (indicated in Figure by vertical lines) was associated with a corresponding peak or trough in $\sum K_p$, the correlation coefficient between the two for the entire period being $0.73 \pm .04$.

Figure 2 shows the six-hourly mean plasma velocity and K_p for three selected periods. Even when the plasma velocity was continuously high for a few days, K_p did not become small. The correlation between six-hourly mean plasma velocity and K_p was 0.65 ± 0.04 . Preliminary analysis shows no correlation between K_p and dv/dt, the flux or the kinetic pressure. Our results





conclusively prove that K_p is a measure of the plasma velocity and not of the time rate of change of plasma velocity.

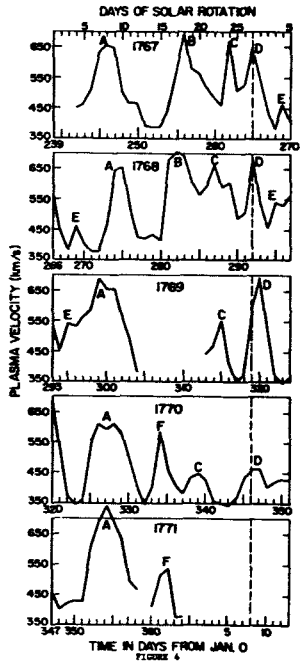
The relationship between K_p and the daily mean plasma velocity is illustrated in Figure 3. The best fit for the data is given by the straight line

$$V \text{ (km/sec)} = (8.44 \pm 0.74) \sum K_p + (330 \pm 17)$$

V = 330 km/sec, corresponding to $\sum K_p = 0$ represents the minimum plasma velocity which can excite disturbances in the geomagnetic field. Applying this relation we find that the mean plasma velocity during 1957 was 510 km/sec. Comparing the extrapolated velocity of 475 km/sec with that measured by Explorer X just at the boundary of the magnetosphere on 26 March 1961, we conclude that the velocity gets attenuated by a factor of 1.6 across the shock front ahead of the cavity.

Each of the peaks shown in Figure 1 exhibits a very strong 27-day

recurrence tendency (see Figure 4). The peaks are divided into five groups, A to E, where each member of a group represents an encounter with the same long-lived plasma stream. Only two of these were associated with Sc storms, the rest being associated with M-region storms. Particularly interesting are A series peaks which were associated with a region of the photosphere which, time after time contained from one to three calcium plages. Beginning in rotation number 1766 with McMath plage number 6504, this active region was still visible in rotation 1777. The complete solar and terrestrial relationships of these peaks are summarized in Table I.



3. CONCLUSIONS

1. There was always a measurably large plasma flow from the directionof the sun. Plasma velocity varied from day to day.

2. Plasma velocity is not correlated with the cosmic-ray diurnal amplitude or time of maximum or with the overall solar activity.

3. Plasma velocity is very strongly correlated with K_p. The relationship between K_p and velocity can be represented by the equation

$$V \text{ (km/sec)} = 8.44 \sum K_p + 330$$

where V and $\sum K_p$ are both daily values. Using this empirical relation, we find that (a) the daily mean plasma velocity averaged over a year varies from $\sim$ 510 km/sec to $\sim$330 km/sec from sunspot maximum to sunspot minimum, and (b) the plasma velocity measured near the earth by Explorer X was a factor of $\sim$ 1.6 lower than the velocity of the interplanetary plasma on the day of observation.

4. The plasma velocity showed a very strong 27-day recurrence tendency and a close association with M-region storms, which indicates that M-regions are emitters of high velocity plasma.

A full account of these results will appear in the December issue of J.G.R.

TABLE I

	Solar Relationships								Terrestrial Relationships			
			Optical Region (Calcium Plage)				Radio Region		Geomagnetic Storms			
Classification	Date of Observed Maximum Plasma Velocity	Date of CMP	McMath Plage Number	Return of Region	Latitude	Decimetric 9.1 cm Period of Activity	Metric 169 MC/S	Decametric 7.6-41 MC/S Date on which Continuum or Type IV Observed	Begin Date	Begin Time	End Date	End Time
A1	246	245.0	6536	6504	N10	244-245		244.9	244	06xx	247	24xx
A2	274	272.6	6562	6504	N12	-	Moderate	271.8	274	0100	275	19xx
A3	300	298.3	6586	6504	N09	299	Strong	296.7	297	12xx	301	18xx
A4	326	324.5	6618	6504	N11	-	Moderate	-	325	06xx	327	0500
A5	354	351.7	6646	6504	N11	352-353	Strong	352.8	351	1500	356	1100
B1	256	255.6	6554	new	S09	-	Moderate	255.6	255	0520	257	09xx
B2	282	279.4	6567	6548	S12	277	Moderate	-	280	2025	284	15xx
B4	334	332.5	6635	new	N00	Moderate	Moderate	-	334	0100	334	1800
B5	362	360.5	6653	6635	N04	361	Little	358.8				
C1	265	263.6	6563	new	N00		Little	260.6 263.7				
C2	292	291.4	6581	6563	N03	Moderate	Strong	288.8	292	07xx	296	23xx
C3	320	318.0	6614	6563	N04	315-318	Moderate	318.6				
C4	347	344.6	6644	6563	N04	342-345	Moderate					
287	287	285.4	6585	new	S14	286	Moderate		286	0800	288	09xx
315	315	312.3	6606		S11		Strong	311.9				