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TITLE The Relation of Solar Wind Structure to Hydromagnetic Discontinuities

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The Relation of Solar Wind Structure to Hydromagnetic Discontinuities

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ostract

High resolution ISEE-3 data have been used to examine the relative abundances : tangential (TD) vs. rotational (RD) discontinuities in different types of solar ind flow. Three types of flow were examined; flow from coronal holes, sector undary flow and transient flow. It has been found that coronal hole flow has ıbstantially more discontinuities and a greater ratio of RD's to TD's than do ıe other types of flow. Discontinuities are least frequent in transient flows ıaracterized by bidirectional streaming of electrons. This leads us to the onclusion that meaningful studies of the velocity dependence of the rates of :currence of different types of discontinuties must take the type of flow (coro- ıl hole versus transient) into account.

itroduction

The relative abundance of different types of hydromagnetic discontinuities y yield insight into the acceleration and propagation of the soler wind in fferent types of solar wind flow. High numbers of tangential discontinuitues D's) in a flow might indicate highly structured, perhaps filamentary coronal asma. High numbers of rotational discontinuities (RD's) might imply strong D wave acceleration of the solar wind.

For this study three types of flow associated with different source regions the sun were identified; they are flow from coronal holes, flow in a (boundary) yer about the current sheet associated with coronal streamers, and transient ow associated with coronal mass ejections. Coronal hole flow can be classified typically high speed (>400 km/sec), low density, low temperature flow, see gure 1. Sector boundary flow can be classified as typically slow (<400 km/sec), nse, and cool flow, see Figure 2. Transient flows can be high or low speed d are often associated with enhanced abundances of helium. ISEE-3 magnetometer d plasma data from Aug. 1978 to Feb, 1980 were used to study the properties of e discontinuities within these three types of flow.

tablishment of the Data Sets

First it was necessary to select sets of ISEE data that could confidently be signed to a particular type of flow. For coronal hole flow the data were llected by identifying coronal holes in the spectroheliograms of NOAA's Solar

Geophysical Data, see Figure 1. Only those coronal holes within +- 10° of the subspacecraft heliographic latitude were used. Chromosphere observations in the helium D3 wavelengths were also inspected for coronal holes passing the solar limb. Start/stop times for the data were arrived at in the following way: the solar wind profile at 1 AU was mapped back to the sun assuming a constant radial velocity, and the approximate leading and trailing edges of the coronal holes were compared to those seen on the map. The start/stop times were corrected at .3 AU by examining the velocity, temperature, number density and magnetic field profiles mapped back to .3 AU using the mapping method of Barouch [1977], whose 1-dimensional model removes the effects of interplanetary compression due to the build up of fast streams overtaking slower ones. The 0.3 AU profiles were searched for distinct plasma streams occuring at approximately the right times. In all, data from 10 coronal holes in the correct latitude range were collected, of which 3 seem to be repeated apparitions of one hole, 2 repeated apparitions of another hole and one coincides with a possible transient and was discarded. A total of 279 hours of coronal hole data were collected.

For coronal streamer flow we chose to study flow about the current sheet crossing since it is an event that is easily identifiable in the data. Gosling et al. [1981] identified such regions as coronal streamer flow, a region of generally high proton density, low temperature, but principally low speed with uncharacteristically low alpha abundance, separating areas of different magnetic polarity on the sun, see Figure 2. Since the streamer flow is primarily a low velocity phenomenon where the boundaries of the low temperatures and high densities do not necessarily correspond with those of the low speed region, we identified as sector boundary flow that within the low speed region. As a verification process the data were mapped to 0.3 AU to where with the compression removed the boundaries of the stream interface in the velocity data are sharper and better defined. In all, 711 hours of boundary flow were collected.

Transients are the most difficult to identify in the solar wind because here are no clear-cut solar-wind parameters unique to the flow. They can be any peed and any density. They often have high magnetic field strength and low lasma beta. They are sometimes associated with high alpha abundances (>8 %) and idirectional streaming of electrons, with magnetic clou : and coronal mass jections. Because of the lack of definitive identifying parameters, we chose two eparate sets of transient data. The first set was exclusively associated with idirectional streaming from a list compiled by Gosling et al., [1987]. Twenty of he longest of the Gosling events were chosen for this study, of which, two were iscarded because they had time intervals in common with a coronal hole or with ector flows. In all 18 events were used, comprising 342 hours of data. A econd set of possible transient flow was compiled by visual inspection of 5 inute averaged ISEE data for high alpha abundances (HAE's) (>8 %). This sample onsisted of 10 intervals, totalling 222 hours of data. Some of the transients orresponded with those identified by Zwickl et al. [1983], some did not.

ta Analysis

Once the data were assembled, an analysis was performed using a computer de developed by Tsurutani and Smith [1979], which identifies discontinuities in e interplanetary magnetic field. The criteria for choosing the discontinuities re a) that the magnetic field change across the discontinuity be at least half great as the largest of the field magnitudes adjacent to the discontinuity, d b) that the vector change be larger than the statistical average of fluctua-

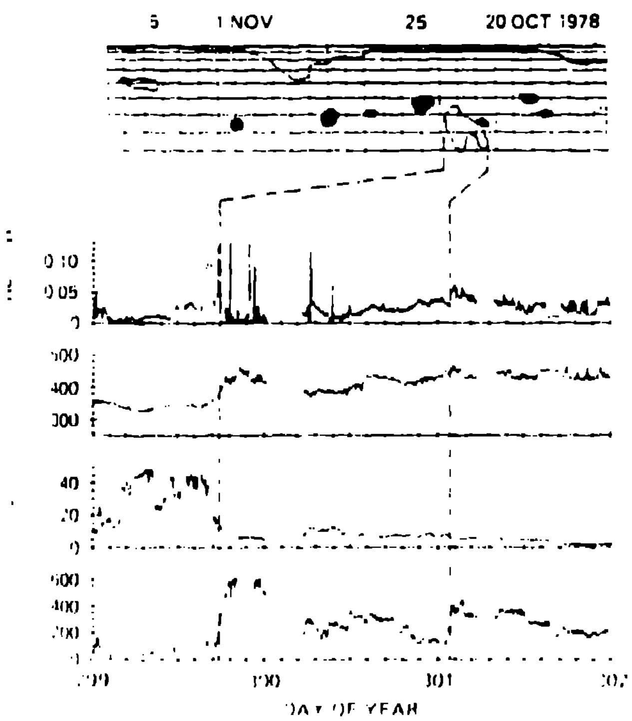

Figure 1. Ratio of number density times velocity of alphas to that of hydrogen, velocity, proton density and proton temperature profiles for the 1978 coronal hole pictured above and indicated by the dashed lines. The picture is from Solar Geophysical Data.

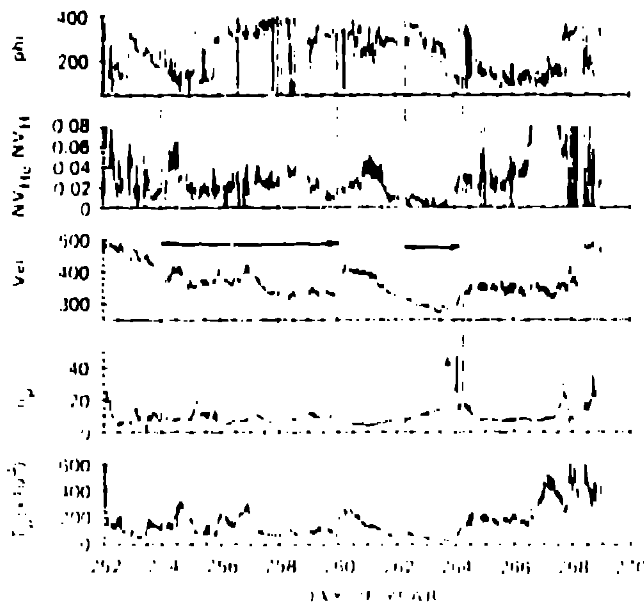

Figure 2. Magnetic longitude (in degrees), ratio of number density times velocity of alphas to that of hydrogen, velocity, proton density, and proton temperature profiles for two 1978 sector boundary crossings shown between the dashed lines.

ns in a 3 minute interval preceeding and following the discontinuity. The
continuities thus chosen were hand edited to remove thick, wavelike changes,
ving only those discontinuities that are sharp and well defined. A minimum
ance analysis [Sonnerup and Cahill, 1967] was used determine the normals to
discontinuities, which were then classified using the following criteria:

Rotational	Bn/IBI >= 0.2	[IBI]/IBI < 0.2
Tangential	Bn/IBI < 0.2	[IBI]/IBI >= 0.2
Either	Bn/IBI > 0.2	[IBI]/IBI < 0.2
Neither	Bn/IBI > 0.2	[IBI]/IBI >= 0.2

e Bn is the normal component of the magnetic field vector, B, in the minimum ance coordinate system, and the square brackets denote changes across the ontinuity. For a more detailed discussion of these criteria see Neugebauer et [1984]. The results of this analysis are listed in table 1. The columns of table show 1) the number of hours of data examined, 2) the number of discon- ities found, 3) the number of discontinuities per hour, 4) the average speed ach data sample, 5) the number of discontinuities per unit distance in the r wind frame, obtained by dividing the number of discontinuities per hour by speed, and 6) the ratio of RD's to TD's.

Table 1

	obs. hrs	#D's	#D's per hr	avg vel	#D's per AU	ratio RD/TD
Coronal Hole Flow:	279	349	1.25	554	94	8.4
Boundary Flow:	711	247	.35	324	45	3.0
Transient Flow						
BDS events:	342	65	.19	465	17	1.8
HAE events:	222	104	.47	425	48	2.0

ssion

The results of the analysis show that coronal holes have both the highest ency of occurrence and the highest ratio of RD's to TD's, by nearly a factor ree from the next highest value. Transient flows have the lowest ratio of to TD's. The transient flows associated with bidirectional streaming (BDS) it nearly a factor of three fewer discontinuities than do those associated HAE's but a nearly identical ratio of RD's to TD's.

Our conclusions are that coronal hole flow seems to stand out as a distinct of flow as best illustrated in Figure 3. The number of RD's per AU has been ed vs. the number of TD's per AU. All types of flow exhibit more RD's than but coronal hole flow is distinguished from the rest by the high number of per AU. If RD's in the solar wind are created by the steepening of MHD in the inner corona, then our results are consistent with a much greater acceleration field in coronal holes than in other types of flow. Of the two ient data sets both lack the large numbers of RD's per AU seen in coronal , thus wave acceleration may not be important even for high speed transient lows. The large percentage of TD's in the HAE data set indicate that the helium nriched part of a coronal mass ejection may be more filamentary than the mater-al originating higher in the corona. The difference between the HAE and BDS data ets emphasises the difficulties in identifying transient flow. The coincidence f events associated with bidirectional streaming and other types of flow suggest hat bidirectional streaming and the inferred magnetic reconnection may not be estricted to transient events.

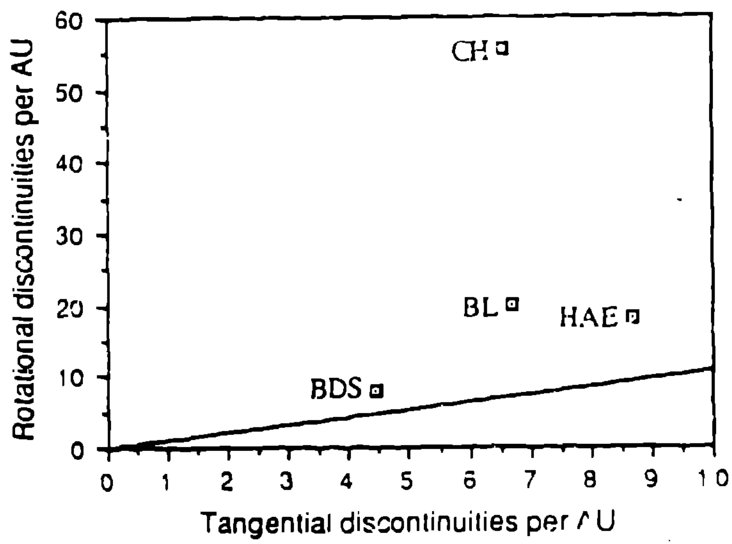

Figure 3. The number of TD's per AU versus the number of RD's per AU. The solid line indicates equal numbers of TD's and RD's.

erences

rouch, E., Properties of the Solar Wind at 0.3 AU Inferred from Measurements at . AU, J. Geophys. Res., 82, 1493, 1977.

sling, J.T., D.N. Baker, S.J. Bame, W.C. Feldman, R.D. Zwickl, and E.J. Smith idirectional Solar Wind Electron Heat Flux Events, J. Geophys. Res., 92, 8519, 987.

gebauer, M., Alignment of Velocity and Field Changes Across Tangential Discontinuities in the Solar Wind, J. Geophys. Res., 90, 6627, 1985.

gebuaer, M., D.R. Clay, B.E. Goldstein, B.T. Tsurutani, and R.D. Zwickl, A eexamination of Rotational and Tangential Discontinuities in the Solar Wind, . Geophys. Res., 89, 5395, 1984.

nerup, B.U.O., and L.J. Cahill, Magnetopause Structure and Attitude from xplorer 12 Observations, J. Geophys. Res., 72, 171, 1987.

rutani, B.T., and E. J. Smith, Interplanetary Discontinuities; Temporal Variations and the Radial Gradient from 1 to 8.5 AU, J. Geophys. Res., 84, 2773, 979.

ckl, R.D., J.R. Asbridge, S.J. Bame, W.C. Feldman, J.T. Gosling and E.J. Smith, lasma Properties of Driver Gas following Interplanetary Shocks Observed by SEE-3, Solar Wind Five, NASA CP-2280, 711, 1983.