GEOPHYSICAL RESEARCH LETTERS, VOL. 12, NO. 4, PAGES 187-190, APRIL 1985

NEW RESULTS ON THE PIONEER VENUS ORBITER FEBRUARY 10-11, 1982 EVENTS: A SOLAR WIND DISTURBANCE NOT A COMET

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Abstract. We study the characteristics of a series of disturbances observed on February 10-11, 1982 by the plasma analyzer and the magnetometer on the Pioneer Venus Orbiter (PVO) obtained in the solar wind upstream of Venus. We conclude that the events were associated with the propagation of a solar wind disturbance of coronal origin and not with an encounter with a comet or other local outgassing object (Russell et al., 1983). The plasma analyzer spectra clearly show the presence of increases in He^{++} and they argue strongly against Russell et al.'s interpretation. The peak in magnetic field magnitude on February 11 is identified as the magnetic signature of a thin, trailing "filament" at the end of a series of solar initiated events. Corresponding increases in He^{++} and magnetic field fluctuations were observed near earth by ISEE-3 about a day later, and this strongly supports the concept of a solar origin.

Introduction

On February 10 and 11, 1982, a series of disturbances was observed by the plasma analyzer and the magnetometer on PVO. Russell et al (1983) have associated the peak in magnetic field magnitude on February 11 with the passage of a comet, or an outgassing object. However, our study which emphasizes plasma and field correlations provides a context for the peak as being the magnetic signature of a thin, trailing "filament" at the end of a series of solar initiated events. Our analysis of the plasma ion distributions indicates that there were significant changes in the solar wind He^{++} abundance. The observed increase in He^{++} must be of coronal origin and this argues strongly against a cometary-type origin. It is important to note that corresponding increases in He^{++} and magnetic field fluctuations were observed near earth by ISEE-3 about a day later. This event is similar to that observed at PVO and Pioneer 11 in 1979 (Intriligator and Miller 1984) and at IMP and Helios 2 in 1978 (Burlaga et al., 1981). This event is also similar to others observed at PVO in February 1982. All of these end with "filaments" distinguished by corresponding signatures in the plasma ion and magnetic field observations although the magnetic field signatures are not as spectacular as that for the February 11 filament.

The observed increase in He^{++} is reasonably interpreted as the passage of a "helium driver" or "piston", since enhancements in He^{++} are known to be reliable signatures of a driver gas (Zwickl et al., 1983). Magnetic clouds are usually defined (Burlaga et al., 1981, Klein and Burlaga 1982) as regions where the magnetic field strength is high and the direction changes appreciably by means of rotation of one component nearly parallel to a plane. At times these clouds are followed by a filament (Burlaga et al., 1981).

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Paper number 5L6486.
0094-8276/85/005L-6486$03.00

Observations

Figure 1 shows the magnetic field magnitude from 0640 UT on February 10 to 0640 UT on February 11, 1982. The labels (e.g., sheath, main cloud) are based on analysis of the higher time resolution plasma and field data as discussed below. Figure 1 also shows ion distributions (ion energy per unit charge (E/q) spectra) obtained at two hour intervals from 1445 UT on February 10 to 0650 UT on February 11, 1982. The format of these spectra is similar to that employed in Intriligator and Scarf (1984). Figure 2 shows all of the ion spectra obtained during this time. We associate the spectrum at 1605 UT with the arrival of a magnetic cloud. The integrated flux levels and the shape of this spectrum and subsequent spectra are clearly different from those of the spectra obtained from 1445 to 1600 UT and, thus, are consistent with the arrival of a discontinuity which we associate with a magnetic cloud and then with an interval of enhanced He^{++}. This figure shows a development from a single peak to a double peak structure containing a H^+ peak and a He^{++} peak. The spectrum that begins at ~ 1645 UT has a prominent He^{++} peak indicating a substantial increase in He^{++} as compared, for example, with the spectrum obtained at 1445 UT. In the 1445 UT spectrum the He^{++} density is less than 2% of the H^+ density whereas in the ~ 1645 UT spectrum this ratio exceeds 10%. This He^{++} enriched plasma is the "piston" or "driver" of this cloud. As shown in Figure 2 there are a series of these changes in the spectra indicating intervals of enhanced He^{++} and the arrival of a series of magnetic clouds. The "main cloud" begins at 2153 UT on February 10 and lasts for almost 7 hours. After the "main cloud" there is a "trailing filament" of relatively brief duration. The difference in the spectra in the main cloud and in the filament is evident.

There is evidence in the ISEE-3 plasma data (Ogilvie, private communication) for substantially increased He^{++} abundances (with the He^{++}/H^+ ratio ~ 10%) at the end of February 11 and the beginning of February 12. These ISEE-3 data are consistent with the arrival of a helium driver at 1 AU. At this time the earth and Venus were nearly radially aligned.

Figure 3 shows the comparable magnetic field data at PVO and ISEE-3. The second cloud, sheath, main cloud, and trailing filament are evident in the data at PVO and ISEE-3. The increased duration of the main cloud at ISEE-3 is

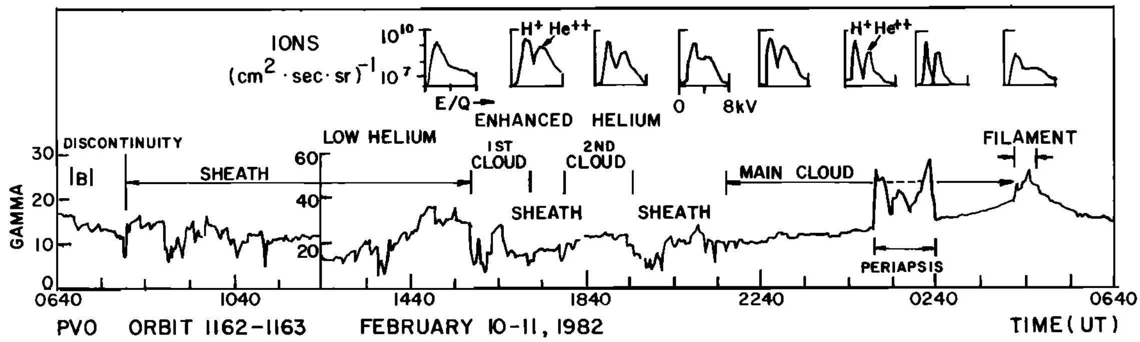

Fig. 1. PVO magnetic field magnitude from 0640 UT on February 10 to 0640 UT on February 11, 1982. Two hourly samples of PVO plasma ion distributions are also included (see Fig. 2 caption).

consistent with previous studies (Intriligator and Miller 1984; Burlaga et al., 1981) which indicate that these events expand as they propagate further from the sun.

Figure 4 shows higher resolution magnetic field data along with the ion spectra near the time of arrival of the main cloud at PVO. The sharp rotation in the magnetic field and the change in the shape of the plasma spectra are associated with the arrival of this event.

Figure 5 shows the observations associated with the trailing filament. The thin boundaries of the filament are evident. The increase in the field magnitude and the decrease in the plasma flux are consistent with a total solar wind pressure balance across the filament.

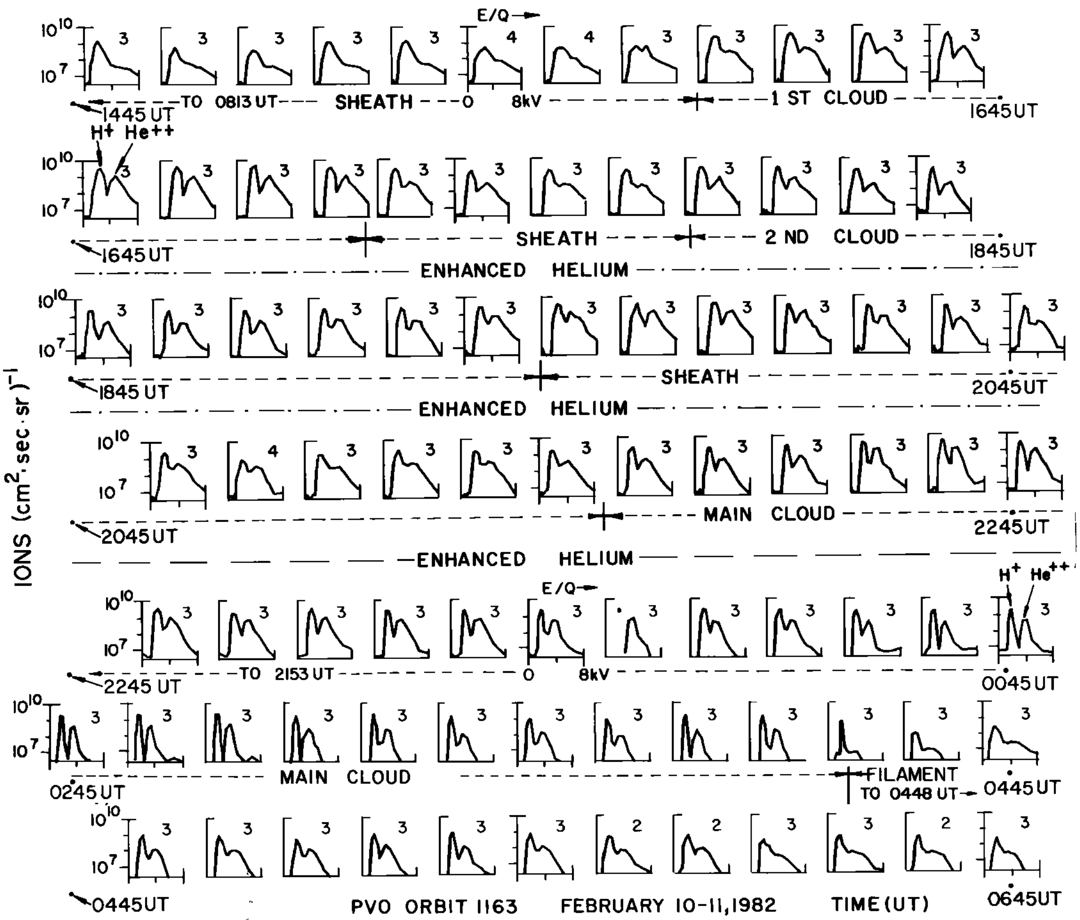

Fig. 2. PVO plasma ion distributions from 1445 UT on Feb. 10 to 0650 UT on Feb. 11, 1982. The periapsis interval (~ 0050 to 0240 UT) is omitted. The energy per unit charge (E/Q) range of 0-8 kv is presented. The time interval between the beginning of each spectrum is ~ 9 min. The instantaneous variation of flux with time is shown where the beginning and end of each E/Q scan is precisely aligned in time (Intriligator and Scarf 1984). The number of the collector measuring the peak flux in each E/Q spectrum is indicated in each box. Changes in the spectra are evident and associated with the features indicated (e.g., enhanced helium, sheath, cloud).

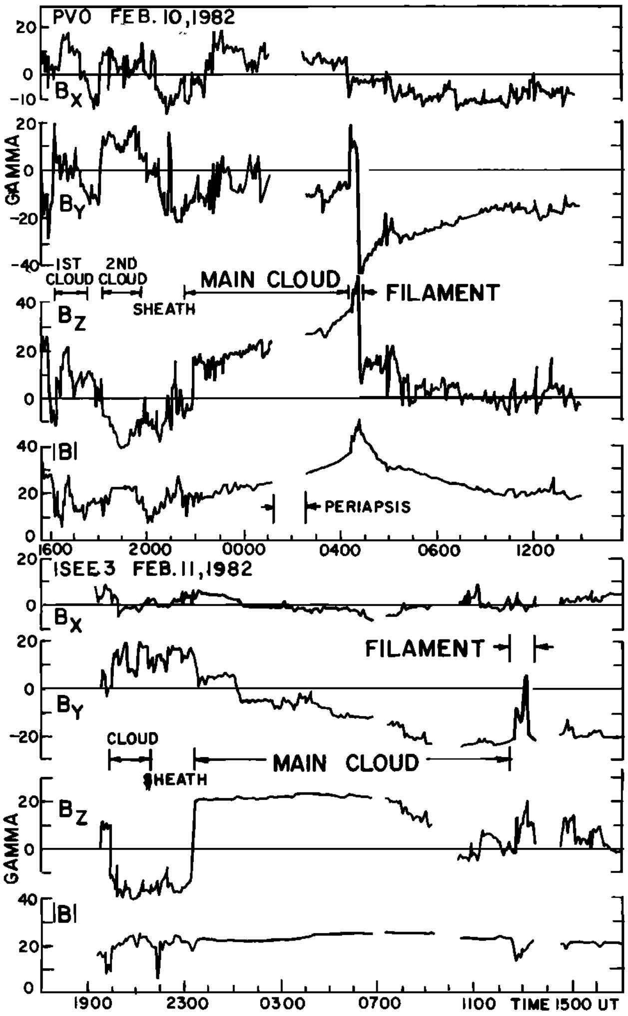

Fig. 3. PVO and ISEE-3 magnetic field measurements. The sheath, main cloud, and trailing filament are evident in both data sets.

Figure 6, adapted from Burlaga et al. (1981), shows the Helios 2 and IMP data from an event in 1978. These data show, for example, that |B| increases and decreases more abruptly in the sheath at Helios than at IMP, and the overall shape of |B| in the cloud is different at the two spacecraft. There are striking differences in B_θ at the two spacecraft (e.g., before the shock, after the cloud). Thus, even though the features are distinct at both spacecraft, they are not identical. This is similar to the case shown in Figure 3 at ISEE-3 and PVO. The features are distinct but they are not identical (e.g., after the cloud), and they clearly show that a discontinuity was seen at both spacecraft.

Conclusion: Origin of Events

The study presented above indicates that a series of events of solar origin were observed at PVO on February 10, 11, 1982. The increase in the solar wind He^{++}/H^{+} ratio from ~ 2% to more than 10% provides unambiguous evidence of a solar and not a cometary origin for these events. Thus, we assert that the Russell et al. (1983, 1984) cometary association of these events is erroneous.

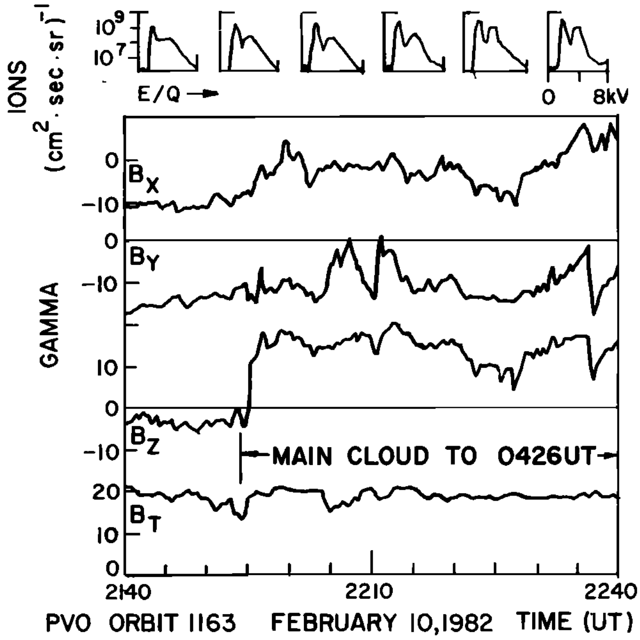

Fig. 4. Simultaneous high resolution PVO magnetic field and plasma observations near the arrival of the main cloud. The sharp change in field orientation in this high field region is indicative of the arrival of the magnetic cloud. Note the associated change in the shape of the plasma spectra.

The solar origin of these events is further confirmed by the subsequent near earth ISEE-3 observation of a comparable He^{++} enhancement.

For completeness, we note that a change in the solar wind He^{++} content cannot be attributed to

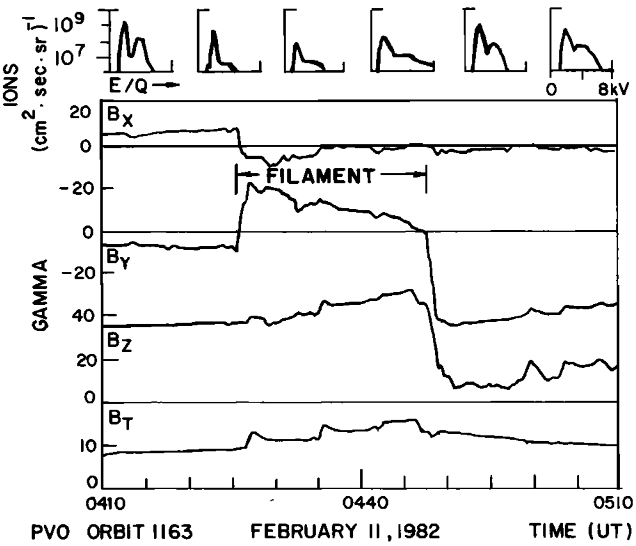

Fig. 5. Simultaneous high resolution PVO magnetic field and plasma observations near the trailing filament. The thin boundaries of the filament are evident. The increase in field magnitude and the decrease in plasma flux are consistent with a total solar wind pressure balance across the filament.

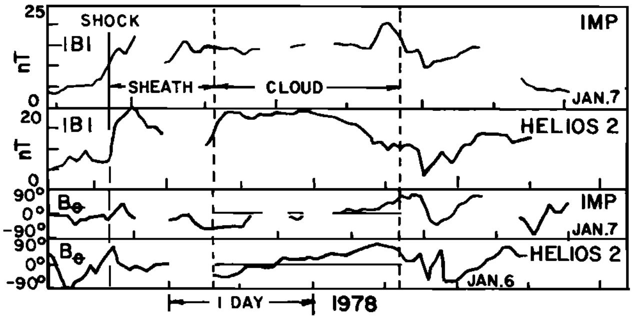

Fig. 6. IMP and Helios 2 data associated with a cloud in 1978. The overall shape of |B| in the cloud is different at the two spacecraft. B_θ is very different at the two spacecraft before the shock and after the cloud.

an interplanetary origin of the event (e.g., a stream-stream interaction). A change in the solar wind He^{++} abundance can only be of coronal origin.

Acknowledgments. This study was funded by NASA Ames Research Center under NAS2-10926 and NASA Headquarters under NASW-3914 and NASW-4019. The author is indebted to K. Ogilvie for providing ISEE-3 plasma data and to C.T. Russell for providing PVO magnetic field data.

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(Received September 4, 1984;
revised February 21, 1985;
accepted February 27, 1985.)