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THE PIONEER VENUS ORBITER EVENT OF FEBRUARY 11, 1982: OF COMETARY OR SOLAR ORIGIN?

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Abstract. On February 11, 1982, an unusual cusp-shaped temporal variation in the interplanetary magnetic field was detected by the Pioneer Venus orbiter. While variations of the Helium content of the solar wind were detected on the preceding day, these changes had no obvious relationship to the occurrence of the cusp-shaped temporal variation in the IMF on February 11. In fact the solar wind He content was quite nominal on February 11. The magnetic variations were also quite unlike those previously reported to be magnetic clouds. Moreover, the scale size of the disturbance had to be smaller than 4×10^6 km and thus of cometary dimensions rather than of dimensions usually found in solar initiated events. Thus, we see no need to alter our original interpretation that the observations of Pioneer Venus on February 11, 1982 were consistent with the passage of a comet close to Venus.

Introduction

Intriligator (1985) has disputed our cometary interpretation of an unusual cusp-shaped temporal variation of the interplanetary magnetic field observed near Venus as first discussed by Russell et al. (1983). Intriligator suggests that the variations in helium content observed on February 10, 1982 support her view that the magnetic field variations seen on February 11, 1982 are solar related. We examined the helium content of the solar wind and its variation in our original paper. As stated in that paper, "The helium content was initially quite variable. At about 2000 UT, there were several short spikes of helium enhancement reaching 10%. However, after this period the helium variation settled down and ranged from 2 to 5% except for a temporary increase to 8% at 0520 UT. After this time the helium content continued to decline slowly. As these variations did not correlate with the magnetic structure centered around 0446 UT, the helium content suggests that the magnetic structure does not originate from some variation in the solar wind." Where Intriligator quotes a number, it is the same as our original value. Her data and ours both show that on February 11th, the day of the event, the helium content of the solar wind was at its normal value. Since there were no changes in the content correlated with the magnetic signature, the helium content of the solar wind cannot be relevant to the interpretation of this event.

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Intriligator proposes that the magnetic variation seen early on February 11, 1985 at Venus is a magnetic cloud (Klein and Burlaga, 1982) and that this same cloud is seen at earth with the delay expected for a solar wind convected feature. We also considered this hypothesis in our original paper and rejected it. Since this seems to be a key aspect of Intriligator's reinterpretation, let us examine this hypothesis in some detail.

A magnetic cloud is a feature of enhanced magnetic field strength with a roughly constant or slowly varying latitudinal component throughout the event (Burlaga et al., 1981; Klein and Burlaga, 1982). Neither the magnetic signature at Venus nor the one at earth resembles this definition. The magnetic field at Venus is sharply peaked in the center. The magnetic signature at earth has no change in field strength and no slow latitudinal rotation. It resembles neither a magnetic cloud nor the event seen at Venus. The fact that a helium enhancement was seen on the day preceding the event in question lends no support to Intriligator's interpretation because leading helium enhancements are not a reported magnetic cloud signature (Klein and Burlaga, 1982). The magnetic clouds as defined by Klein and Burlaga (1982) are day-long phenomena occurring on the order of once every three months. Arghavani (1985) has examined the Pioneer Venus records and finds a similar occurrence rate of clouds at Venus. Neither Klein and Burlaga (1982), nor Arghavani (1985) find cases in which there are three clouds in a twelve-hour period as Intriligator claims to have occurred on February 10, 11, 1982. In short, the features suggested by Intriligator to be clouds do not fit that classification as defined by Klein and Burlaga or by Arghavani.

The third element in Intriligator's reinterpretation of the February 11th event is that the peak in the field strength with its attendant current sheets is a filament in the solar wind. While seldom observed in the solar wind, filaments are a common feature on the sun. Filaments are the dense, cool tubes of matter seen in projection floating above the photosphere, presumably suspended by magnetic tubes of force. They are often seen to disappear prior to the arrival of a solar initiated geomagnetic disturbance at earth. Presumably, coronal mass ejections carry these filaments away from the sun. Since coronal mass ejections are thought to be responsible for at least some of the observed clouds (Burlaga et al., 1981) it would not be surprising to see an occasional filament associated with a magnetic cloud, although one might expect the filament to be on the leading edge of the cloud. Burlaga et al. (1981) report such a filament, but arriving after cloud passage. We note that they report only one such observation.

The filament identified by Burlaga et al. is quite unlike the "filament" identified by Intriligator. The density inside their filament increased a factor of 20, the magnetic field strength decreased about 30%, and the ion temperature dropped over a factor of two. In the region Intriligator identifies as a filament, the ion density increases at most a few tens of percent, the field strength increases, not decreases, a few tens of percent and the ion temperature increases, not decreases, a factor of 20 (Russell et al., 1984a). These signatures are those of a weak shock wave, not of a filament.

Intriligator also states erroneously in the figure caption of her Figure 5 that the increase in field magnitude and decrease in plasma flux are consistent with pressure balance. Had she correctly compared the thermal pressure change with the magnetic pressure change across the "filament" boundaries she would have found, as was found by Russell et al. (1984a), that they both increased as would occur across a cometary bow shock. There is not pressure balance across these boundaries. We also caution the reader that the field magnitude scales on her Figure 5 are incorrect.

One new feature of the Intriligator paper is the presentation of the E/Q spectra from the PVO plasma analyzer for February 10 and 11, 1982. These spectra clearly show the cooling trend throughout the event on February 11. Both the H^+ and He^{++} peaks narrow to a minimum at the magnetic field maximum. The ion temperature is in fact one of the plasma properties that is most clearly associated with the field structure in question (see also Russell et al., 1984a). When the ions cooled, the He^{++} peak became more evident but no change in percent composition occurred.

The commentary by Intriligator does not discuss the work subsequent to that of Russell et al. (1983). Since this work is consistent with our initial interpretation it is worth summarizing here. First, the event of February 11, 1982 is only one of a class of events seen at 0.72 AU by the Pioneer Venus spacecraft (Russell et al., 1984b) and at 1.0 AU by the ISEE-3 and IMP-8 spacecraft (Arghavani et al., 1985). The events at the two heliocentric distances are similar in overall morphology but they last longer and are weaker at 1 AU than at 0.7 AU (Arghavani et al., 1984; 1985).

A significant number of the events appear to be correlated with the passage of the asteroid 2201 Oljato through the inner solar system (Russell et al., 1984c) but none thus far have been associated with a visible comet. The event of February 11, 1982 has the strongest evidence for a cometary origin. This event is the largest both in duration and peak field strength and has the clearest, most symmetric profile in the magnetic field.

The cometary hypothesis is also consistent with the appearence of a weak bow shock wave near the peak of the disturbance (Russell et al., 1984c). The shock has a precursor wave structure as a weak quasi-parallel shock should have, has a normal in the expected direction, and is accompanied by a weak drop in flow velocity and slight increase in density as well as significant ion heating. Finally, even though the event lasts 10 hours at Venus, it is barely seen if at all at the Venera 13 and 14 spacecraft, only 6 million km away and only 4 million km from the Venus-Sun line (Russell et al., 1985). This suggests that the disturbance at Venus was caused by a slowly moving, localized disturbance rather than some large-scale disturbance moving outward from the sun at the solar wind velocity or greater.

In summary, we do not believe that Intriligator has provided an explanation that is consistent with the observations, nor one that is consistent with previous solar wind research. We considered carefully the possibility that the February 11 event was a magnetic cloud in our original paper and found that its properties were inconsistent with that of a cloud. The above reappraisal supports our earlier conclusion. We emphasize that our original paper and our later analyses (Russell et al., 1984a) included a careful examination of both the plasma and field behavior. We considered He content changes in our original paper and found them to be irrelevant to the interpretation. We do not question that the observed He changes were solar related nor that these same changes were later seen at the earth. The magnetic variations seen at Venus on February 11, 1982 were not correlated with the He changes and these magnetic changes were not seen at earth. It appears that the event of February 11 was superimposed on existing and normal solar wind conditions, and occurred only at Venus, not at Earth. Thus we see no need to alter our original interpretation that the phenomenon observed by Pioneer Venus on February 11, 1982 is consistent with the passage of a comet close to Venus.

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