IPS OBSERVATIONS OF FLARE-GENERATED DISTURBANCES

Takashi Watanabe*
Space Environment Laboratory, NOAA/ERL
Boulder, Colorado 80303, U.S.A.

ABSTRACT

Dynamical behaviour of a flare-generated disturbance can be followed by IPS observations through a comparison between the IPS observations and a model of the disturbance. The highly turbulent post-shock plasma can be attributed to the contact surface of the disturbance. Two examples of IPS observations of flare-generated disturbances will be discussed.

It has been proved that the IPS (interplanetary scintillation) technique has an ability to determine large scale properties of flare-generated disturbances (e.g., Kakinuma and Watanabe, 1976). Since we have no direct method to estimate the position of a disturbance on a line of sight, there exists an ambiguity in interpretation of the IPS observations. Watanabe (1977) has proposed a method to improve this situation depending on a fact that IPS observations provide the transverse component of the flow vector of highly disturbed post-shock plasma. The change of observed flow speed with time reflects a combination of the projection effect, deceleration and anisotropic expansion of the disturbance. Dynamical characteristic and, consequently, the position of the disturbance at a given time can be estimated through a comparison between the IPS observations and a suitable model of the disturbance.

Several examples show that the highly turbulent post-shock plasma which produces high level scintillations is not distributed in the region immediately behind the shock front, but it appears at 2-6 hours after the shock-front passage at around 1 AU from the sun (Watanabe, 1977). This region seems to correspond to the high-density post-shock plasma which might be attributed to the contact surface, or the piston, of the disturbance (e.g., Dryer, 1972). Consequently, we can determine dynamical behaviour of the piston of the disturbance by the IPS observations.

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* NRC-NAS Associate. On leave from Res. Inst. Atmospherics, Nagoya Univ.

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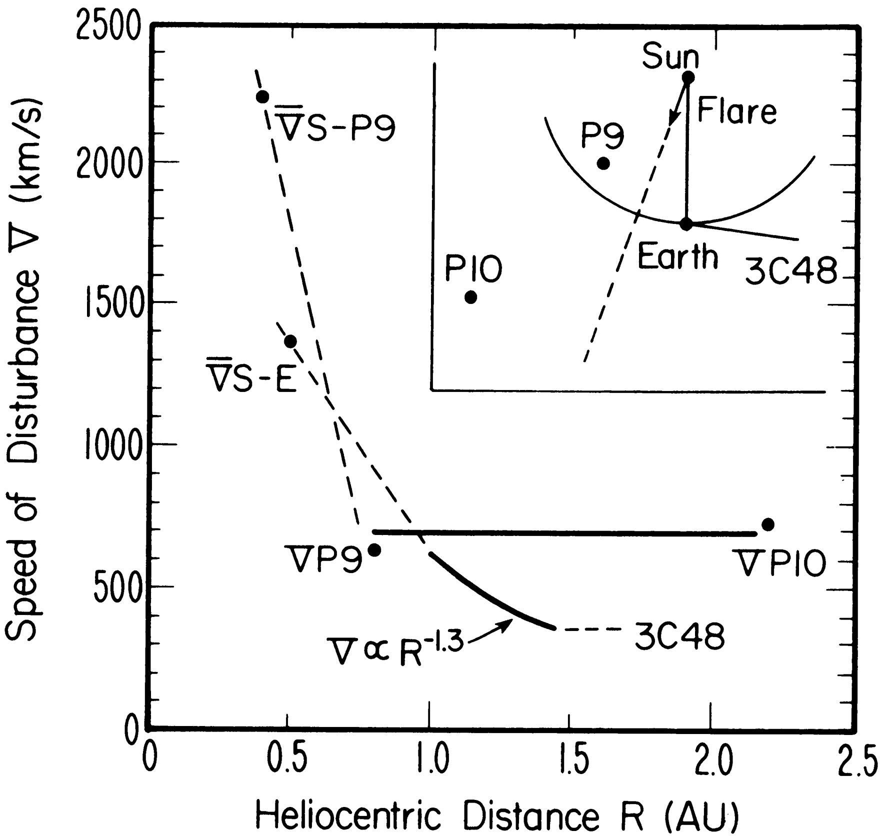
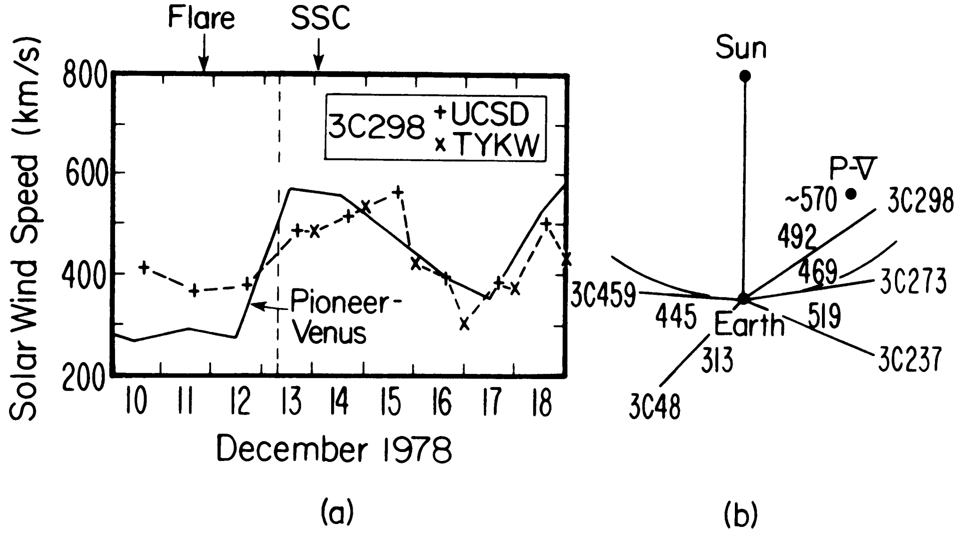


Fig 1. Speeds of the disturbance generated by the solar flare at 2035 UT on Aug. 2, 1972 as a function of heliocentric distance, R. VP9 and VP10 indicate the local shock speeds observed at Pioneer 9 and at Pioneer 10 respectively. $\overline{V}$S-P9 and $\overline{V}$S-E are mean speeds in the region between the sun and two points of Pioneer 9 and the Earth respectively.

The disturbance generated by the solar flare at 2035 UT on Aug. 2, 1972 has been well studied by many authors (e.g., review given by Smith, 1976) depending on observations made by Pioneer 9 (0.8 AU) and Pioneer 10 (2.2 AU) which were in radial alignment at about 20° east of the flare normal. Watanabe (1977) also discussed the dynamical nature of this disturbance depending on the IPS observations of 3C48 whose line of sight was in the region to the west of the flare normal. Figure 1 shows the dynamical behaviour of this disturbance determined by above-mentioned observations. In the direction of 20° east of the flare normal (Pioneer 9-Pioneer 10) the shock front propagated with approximate constant speed of about 700 km/sec in the region between Pioneer 9



(a) (b)

Fig. 2a. Solar wind speeds observed by Pioneer-Venus and IPS of 3C298. Approximate arrival time of the shock front at Pioneer-Venus is indicated by a vertical broken line (Mihalov, 1979). The arrival of the shock front at the Earth was known by SSC of geomagnetic storm.
Fig. 2b. A geometry of Pioneer-Venus (P-V) and the lines of sight. Numbers are observed flow speeds of the disturbance in km/sec.

and Pioneer 10 after very strong deceleration in the region between the sun and Pioneer 9 which is inferred from very high mean speed ($\overline{\text{VS-P9}}$) of 2220 km/sec. Small deceleration of the piston in the region between Pioneer 9 and Pioneer 10 is suggested. IPS observations of 3C48 showed that the western part of the disturbance was decelerated in the region between the sun and 1.4 AU from the sun until the expanding speed was slowed down to the ambient wind speed of 350 km/sec at about 70° west of the flare normal. These observations indicate an anisotropic nature of this disturbance.

Shortly after the Venus orbit insertion of Pioneer-Venus (PV), a flare-generated disturbance was detected by this space probe on Dec. 13, 1978 (Wolfe et al., 1979). The IPS observations made at UCSD and Toyokawa (TYKW) also detected this disturbance. Figure 2a shows the solar wind speeds observed by PV and IPS of 3C298 whose line of sight was situated in the region fairly close to PV. Figure 2b shows a geometry of PV and the lines of sight. Observed flow speeds are also indicated. All of the observed flow speeds by western radio sources (3C298, 3C273 and 3C237) can be explained by a model of the disturbance with constant speed of 520 km/sec in the region between 0.8 AU and 1.2 AU from the sun. The mean speed between the sun and PV

(0.8 AU) is about 820 km/sec (Mihalov, 1979) when we consider this disturbance was generated by one of the two solar flares observed around 18 UT on Dec. 11, 1978. Above-mentioned observations again suggest the small deceleration near the Earth's orbit after an amount of deceleration in the region between the sun and about 0.7 AU from the sun.

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DISCUSSION

Ivanov: Eroshenko *et al*. (Innsbruk, 1978) have interpreted the structure of interplanetary stream of August 4, 1972 in the following manner: near ∿ 06^h UT the boundary of flare ejecta was observed. Where is the high turbulence region: in the shock layer or in the ejecta?

Watanabe: IPS observations of 3C48 during August 4-5, 1972 seem to be well explained if we assume that the highly-turbulent post-shock plasma followed the shock front with a time-lag of 2-4 hours (namely at ∿ 06^h UT on August 4, 1972) in the region near the Earth's orbit. I have suggested that this turbulent region corresponds to the contact surface dividing the flare-ejecta from the shocked gas (Watanabe, 1977). The conclusion given by Eroshenko *et al*. (Innsbruk, 1978) seems to support my idea.