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MULTI-SPACECRAFT IN-SITU OBSERVATIONS OF INTERPLANETARY TRANSIENT SHOCKS

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RESUMEN

Elaboramos una base de datos de observaciones in-situ de cinco sondas espaciales del plasma del viento solar y del campo magnético interplanetario para estudiar propiedades físicas de las ondas de choque transitorias (CT). El conjunto de observaciones cubre de agosto de 1977 a agosto de 1979. Revisando las mediciones de plasma y campo magnético identificamos: 38 CT's detectados por *Helios* 1, 37 CT's por *Helios* 2, 34 CT's por IMP, 38 CT's por *Voyager* 1, y 43 CT's por *Voyager* 2. Este conjunto de datos será empleado para desarrollar estudios observacionales y numéricos sobre la propagación y evolución de los CT's.

ABSTRACT

We produced a comprehensive data set of multi-spacecraft observations of solar wind plasma and interplanetary magnetic field parameters to study physical properties of transient shock waves (TS's). We combined in-situ observations by five spacecraft from August 1977 to August 1979. Scanning the plasma and magnetic field data we found: 38 TS's detected by *Helios* 1, 37 TS's detected by *Helios* 2, 34 TS's detected by IMP, 38 TS's detected by *Voyager* 1, and 43 TS's detected by *Voyager* 2. This data set will be used to study the propagation and evolution of TS's in observational and numerical studies.

Key Words: **INTERPLANETARY MEDIUM — SHOCK WAVES — SOLAR WIND**

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1. INTRODUCTION

The expanding solar wind plasma, and the interplanetary magnetic field carried by it, is the propagation medium for many different types of waves in interplanetary space, which becomes a "natural laboratory" for space plasma studies. Interplanetary shock waves are the strongest and fastest perturbations propagating through the solar wind and play a very important role in a range of phenomena in the interplanetary medium and solar-terrestrial relations. There are two different types of interplanetary shocks: corotating and transient. Corotating shocks are caused by the interaction of long living fast and slow solar wind streams (Smith 1985), whereas transient shocks (TS's) are related to transient solar events, in particular, with coronal mass ejections (Sheeley et al. 1985). From single-spacecraft observations it is found that about 40% of the TS's are followed by an ejecta (plasma cloud like signatures), and, on the other hand, about half of the ejecta are preceded by a TS (González-Esparza et al. 1996). From combining two-spacecraft observations we know that TS's decelerate as they propagate outward from the Sun and they can have longitudinal angular extensions of about 100° (González-Esparza & Bravo 1998).

The aim of this work is to combine simultaneous observations of solar wind plasma and interplanetary magnetic field parameters by five different spacecraft. This data set will be used to study the propagation and evolution of TS's in observational and numerical studies.

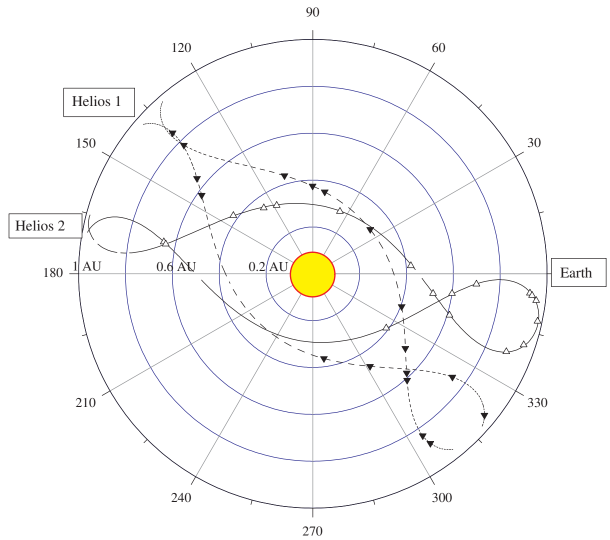

Fig. 1. *Helios* 1 and 2 trajectories from August 1977 to August 1978 as seen from a corotating reference frame where the line Sun-Earth is fixed. The triangles denote the location where the spacecraft detected the shocks.

2. OBSERVATIONS

The in-situ measurements of many interplanetary missions are world wide available through the National Space Science Data Center (NSSDC). In this work, we combined observations from August 1977 to August 1979 by five spacecraft covering different heliocentric ranges. The spacecraft *Helios* 1 and 2 were launched in 1974 and 1976 respectively, to study the inner heliosphere having orbits reaching from 0.3 to 1.0 AU. The satellite IMP-8 was launched in 1973 and continues measuring the incoming solar wind, with a 12-day orbit at 35 Earth radii. The Spacecraft *Voyager* 1 and 2 were launched in 1977 to study the outer heliosphere and passed by Jupiter in 1979. We obtained from the NSSDC the solar wind plasma and magnetic field data for the five spacecraft. Scanning the 27-day plots of plasma and field parameters we identified all the transient shocks detected by each spacecraft. We corroborate our identifications looking at the events in high-time resolution plots and checking the *Helios* shock list of Volkmer & Neubauer (1985), and the *Voyager* studies of Burlaga et al. (1984) and González-Esparza & Smith (1996).

3. RESULTS

We found: 38 TS's detected by *Helios* 1, 37 TS's detected by *Helios* 2, 34 TS's detected by IMP-8, 38 TS's detected by *Voyager* 1, and 43 TS's detected by *Voyager* 2. Figure 1 presents *Helios* 1 and 2 trajectories during the first year of the study. The triangles represent the shocks detected by the spacecraft. The figure shows that the trajectories covered a range of longitudinal angles with respect to the Earth and different heliocentric distances in the inner heliosphere.

Figure 2 presents the in-ecliptic trajectories of *Voyager* 1 and 2 from the Earth to Jupiter. The triangles denote the 38 shocks detected by *Voyager* 1 and the 43 shocks detected by *Voyager* 2. Note that the heliocentric scale is different than in the previous figure. During the two-year period of this study the five spacecraft had different positions with respect to each other. The combination of their observations provides us with information to study the physical characteristics and heliocentric evolution of every shock.

4. CONCLUSIONS AND FUTURE WORK

We reported the elaboration of a comprehensive data set of simultaneous in-situ measurements of TS's by five spacecraft. The next step is the analysis of every shock observed by each spacecraft. This study becomes

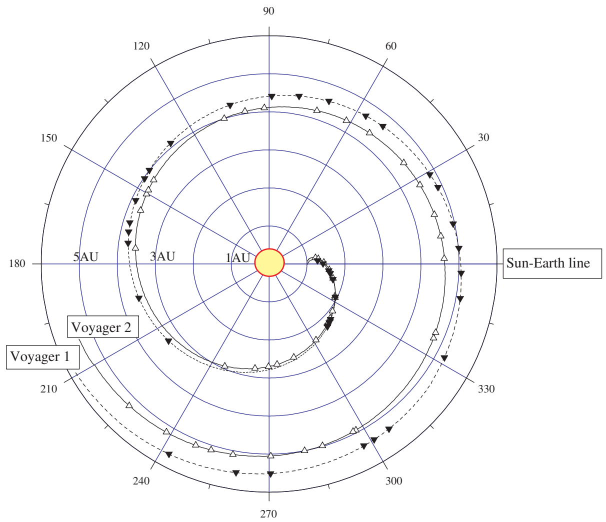

Fig. 2. *Voyager* 1 and 2 trajectories as seen from a corotating reference frame where the line Sun-Earth is fixed. The trajectories cover a heliocentric range from 1 to 5.4 AU.

difficult due to the intrinsic complexity of the solar wind dynamics. Two spacecraft located near each other can measure very different solar wind streams and magnetic fields. We found many events where the spacecraft were located within a small longitudinal range but the shock was detected only by one or two spacecraft. This has been reported before for particular events (Chao 1984), but to our knowledge there has not been a comprehensive study of multi-spacecraft observations to understand the physical conditions that produce this phenomenon. This study can help us to understand better the origin, formation, and heliocentric evolution of the shocks, and their role in the solar wind's large-scale dynamics and solar terrestrial-relations.

The data of this study was obtained through the National Space Science Data Center COHOWeb data base.

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