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A COMPARISON OF FAST AND SLOW INTERPLANETARY SHOCK PARAMETERS OBERSERVED NEAR EARTH

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ABSTRACT

Several types of Magnetohydrodynamic waves - MHD - can propagate in the interplanetary space. Shock waves can appear when the relative speed between these waves and the solar wind is higher than the characteristic of magnetosonic speed. The interplanetary shock waves may have two basic origins: the interaction between the fast and slow speed streams of the solar wind in the corotating interaction regions and the interplanetary remnants of the coronal mass ejections. We can identify the occurrence of those shocks and classify each type through the analysis of the interplanetary parameters of plasma (protons density, temperature and speed of the solar wind) and magnetic field, by observations in-situ of the solar wind. We have used plasma and magnetic field data from sensors onboard the ACE - Advanced Composition Explorer spacecraft. We have classified the shocks according the types fast or slow and forward or reverse, by looking at the plasma and magnetic field through the shocks. In this work we compare the solar wind upstream conditions (density, velocity, Alfvén and magnetosonic speeds) before interplanetary shocks and contrast these conditions for fast and slow shocks, during the solar cycle 23 decline (2002-2003).

INTRODUCTION

Interplanetary shock waves are generated when the relative speed between a fast solar wind stream (e. g., coronal mass ejection) and the slow solar wind is greater than the characteristic speed of the medium - the magnetosonic speed (Kivelson and Russell, 1995). A forward shock is a shock that moves away from the Sun relatively to the solar wind reference system. It may be classified in fast or slow depending on the mode of the MHD wave (Burlaga, 1995). A shock is fast when its relative speed to the solar wind is higher than the fast magnetossonic wave speed; a shock is slow when its relative speed is higher than the slow magnetossonic wave speed, but lower than the fast magnetosonic speed (Burlaga, 1995; E. Echer et al. 2003).

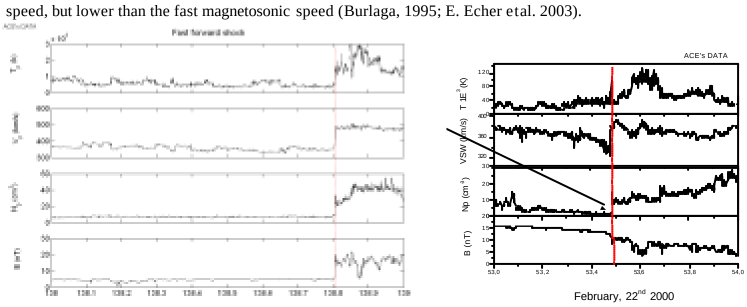

FIGURE 1 - Shock profile examples. On the left, a Fast Forward Shock on May 18th 2002, and on the right, a Slow Forward Shock on February 22nd 2000.

METHODOLOGY OF DATA ANALYSIS

We analyzed solar wind data from six fast forward shock (FFS), and four slow forward shocks (SFS). High resolution interplanetary magnetic field and plasma used in this study were obtained from sensors onboard WIND (60 and 90 s for magnetic field and plasma data, respectively) spececraft (Acuña et al. , 1995; Lepping et al., 1995) and ACE (64s) spacecraft (Stone et al., 1998).

RESULTS

In order to calculate the parameter variation across the shocks, three 10-min windows were defined, one centered on the shock, one before the shock, the upstream side, and one after the shock – the downstream side (Echer et. al., 2003). A comparason of shock parameter variations through fast and slow shocks is showed in Figures 2 and 3.

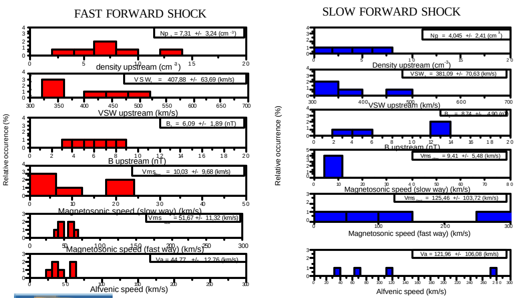

FIGURE 2 – Histograms comparing the fast and slow forward shock parameters: density, solar wind speed and magnetic field, upstream side, Magnetosonic speed to fast and slow mode of wave and alfvenic speed

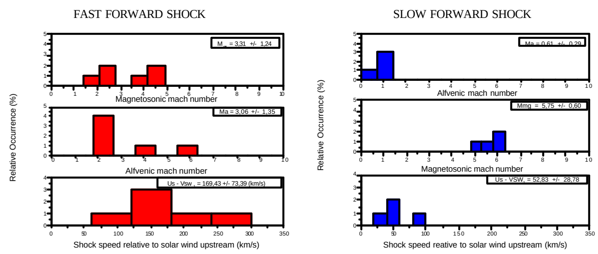

FIGURE 03 - Histogram comparing the fast and slow forward shock: parameters: magnetosonic mach numbers and shock speeds and shock speed.

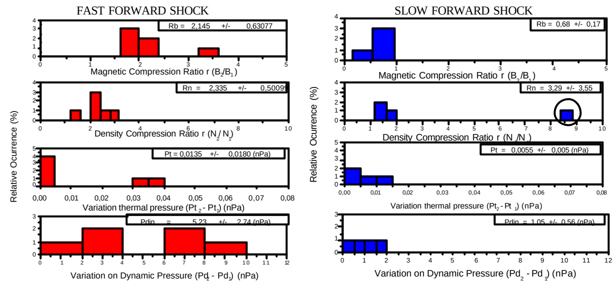

FIGURE 04 - Histogram comparing the fast and slow forward shock: parameters: magnetosonic and density compression, thermal and dynamic variation pressures.

CONCLUSION

We have studied in this work fast and slow forward interplanetary shocks during solar cycle 23. Upstream solar wind conditions and the shock strengths were determined. - Density and solar wind speed for the FFS are stronger than for the SFS, while magnetic field is stronger for the SFS than FFS. However, the variation (error) is also larger for SFS. - The Alfvenic speed is stronger for SFS than FFS. - The slow wave mode speed is similar for FFS and SFS, but, the fast wave mode is higher upstream of FFS. - The ratio compression (magnetic and density) are stronger to fast foward shocks. - The relative shock speed is also higher during FFS. - This was a first study to compare solar wind conditions upstream of slow and fast shocks. This study will be complemented with the study of detailed interplanetary magnetic structures present in solar wind and the origin of fast and slow shocks.

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