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A COMPARATIVE STUDY OF SHOCK PARAMETER VARIATIONS ACROSS TRANSIENT AND COROTATING SHOCKS

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ABSTRACT

In this work we study the variations in the plasma and magnetic field parameters across transient, ICME-driven shocks (fast forward), and corotating shocks (mainly fast reverse), associated with CIRs. The period analysed is the decline phase of the solar cycle 23 (2002-2003). Solar wind data were obtained through internet from the ACE - Advanced Composition Explorer database (http://www.srl.caltech.edu/ACE/ASC/level2/index.html). We plot and analyze solar wind data and classify every shock according to its propagation direction (forward or reverse) and MHD wave mode (fast or slow). Associated solar wind structures were also determined (ICMEs or CIRs). The jump of plasma and magnetic field across these shocks was then calculated and distributions obtained for each interplanetary shock type. These distributions are compared in this work.

INTRODUCTION

Transient and corotating shocks can be distinguished in plasma and magnetic field data because of their different signature. We analyse solar wind data during 2002-2003 and classified the shocks in these two classes. For some shocks, a unambiguous classfication was not possible and we included these in a doubt class.

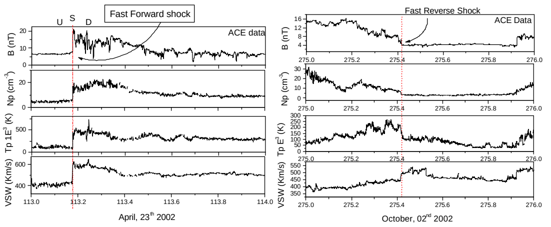

FIGURE 1 - Shocks profile of Transient Shock on April 23th 2002, and of Corotating Shock on October 2nd 2002.

We analyzed in this work solar wind data during the decline phase of solar cycle 23, years 2002-2003, in order to classify the interplanetary shocks occurring in this period. During these years, 88 probable shocks were observed by ACE spacecraft sensors near Earth, 55 in 2002 and 33 in 2003. We could classify 54 of these shocks as transients, 11 as corotating and for 23 events we could not unambiguously identify the shock type.

RESULT

The distributions for the interplanetary shocks studied in this workd are shown in Figures 2, 3 and 4.

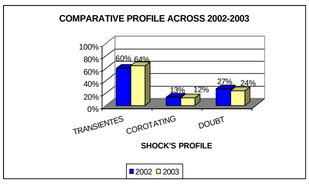

FIGURE 2 - Percentage of each type of interplanetary shock for 2002 and 2003.

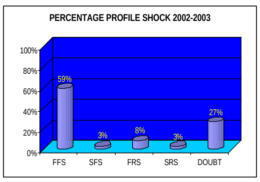

FIGURE 3 - Percentage of each type of interplanetary shock according to the plasma MHD wave mode (slow or forward) and propagation direction (forward or reverse). FFS is Fast Forward Shock, SFS is Slow Forward Shock, FRS is Fast Reverse Shock, SRS is Slow Reverse Shock and Doubt is the shock that we didn't get to identify the shock type.

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TRANSIENTS SHOCKS (2002-2003) | **COROTATING SHOCKS (2002-2003)**

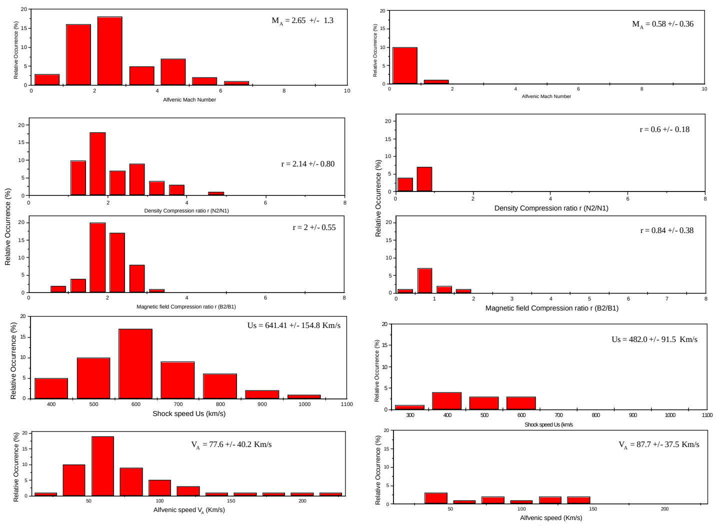

FIGURE 04 - Histogram comparing the Transiensts shocks with the Corotatings shocks happened in the period of 2002-2003. We used the plasma data of ACE.

CONCLUSION

We have determined the shock parameter variations across the shocks. Distributions of the following parameters: Alfvenic solar wind speed, Alfvenic Mach number, shock speed, density compression ratio and magnetic field strength compression ratio, were obtained for transient and corotating shocks.

Comparing these distributions, the next points can be stressed:

✍ Shock speed is higher (~ 640 km/s) for transient than for corotating (~482 km/s) shocks, but its distribution for cororating shocks is more homogeneous.

✍ As expected, Mach number and compression ratio averages are lower than 1 for corotating shocks, because most of them are of the reverse type, which indicates that the shock itself is propagating away from the spacecraft toward of the sun (and it is observed only they are being convected by solar wind). For transient shocks, values are higher than 1.0 because most of them are fast forward type, which shows both plasma and magnetic field positive jumps.

✍ Alfven speed is slightly higher before corotating (~88 km/s) than before transient shocks (~77 km/s), but extreme values are observed in the upstream region of transient shocks.

✍ We have found at least one transient shock with density compression ratio higher than 4.0, which is the limit of finite compression in the case of a monoatomic gas with high Mach number (Kivelson and Russell, 1995). Other
cases with values of compression higher than 4.0 have been reported (Echer et al., 2003). These cases are, however, a very small percentage of shocks and they be could caused by: i) some error of measurements - which seems to be
less likely, since these cases were observed by plasma sensors onboard both ACE and SOHO; ii) extreme cases in which the conditions assumed for deriving the limit of 4.0 compression (shock exactly perpendicular, monoatomic ideal gas, adiabatic processes) may not be valid.

✍ In this work we have compared the distributions of shock parameters for transient and corotating shocks. In a future work we will do a more refined classification, separating the shocks according both its plasma MHD mode (slow or fast) and to their propagation direction (forward or reverse).

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