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Interplanetary (IP) shocks arrival in the ascending phases of solar cycle - 23 & 24

BALENDRA PRATAP SINGH[1], ACHYUT PANDEYA[2], P.K. SRIVASTAVA[2]

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Abstract

We have studied the interplanetary shock arrivals for the ascending phases of solar cycle-23 and 24(1996-2000, and 2008-2012). Total IP shocks (sum of forward and reverse shocks) are plotted with forward and reverse shocks for these times of intervals, and analysis of IP shocks, we found that occurrence of total IP shocks and Forward IP shocks are greater in the ascending phase of cycle-23 than that for the ascending phase of solar cycle-24, but the occurrence of the Reverse IP shocks are greater in ascending phase of solar cycle-24 than the ascending phase of cycle-23.

Key words: Interplanetary (IP) shocks, Ascending Phase of solar cycle-23 (1996-2000), Ascending Phase of solar cycle-24 (2008-2012).

1. Introduction

For many years interplanetary transient events are believed to be the major cause of nonrecurrent disturbances of geomagnetic field. These geomagnetic activities, such as geomagnetic storms, are known to be well associated with interplanetary (IP) shocks. Many models have been developed based on the relationship between features of solar activity and IP shocks. To this end, scientists proposed both empirical and physics-based models for solar disturbance propagation through the corona and interplanetary space[1].

The interplanetary (IP) shocks can bring changes to the terrestrial environment which, together with other space weather phenomena, might be able to damage the performance of space-borne and ground-based electronic technology systems. So it's very essential to build operational prediction models, based on very early solar (or near-sun) diagnostics, that can provide whether the shocks will arrive at the Earth, and the shock arrival times (SATs) and strength if they will[4].

The interaction of interplanetary (IP) shocks (usually fast forward shocks) with the magnetosphere includes several phases, including interaction with the bow shock, transmission through the magnetosheath, interaction with the magnetopause, transmission into the magnetosphere as fast and intermediate mode waves, modifications of the field-aligned and ionospheric current systems, and perturbations in ground magnetograms[6].

We obtain a linear fit to the relationship (r = -0.62) between IP shock traveltime T (in hours) and V_{CME} (in kilometer per second) during the solar maximum, which can be expressed as $T = 76.86 - 0.02V_{CME}$. In addition, we find that the IP shocks associated with the fast CMEs corresponding to strong SC/SI events have short traveltimes compared with other fast CMEs and that there is a negative correlation between the SC/SI strength and the IP shock traveltime. We suggest that this negative correlation is due to not only the V_{CME} but also the CME mass/density and discuss the influence of the mass/density of CME on the arrival time of IP shock at 1 AU[3].

The enhanced particle intensities associated with IP shock passage are commonly referred to as energetic storm particle (ESP) events due to their close association with geomagnetic storms. During an ESP event, the number of incident ions with energies above 10 MeV can increase by several orders of magnitude and some events show significant increases in fluence for ions above 30MeV. Because of the radiation hazards to astronauts and space-embedded technology posed by energetic particles, there is considerable interest in forecasting large IP shock-driven particle events[7].

Propagation of interplanetary discontinuities through the interplanetary space, their modification in the foreshock and interaction with the bow shock and magnetopause are key problem of the Space Weather Program because they are often connected with strong geomagnetic disturbances[2].

Geomagnetic disturbances are generally represented by geomagnetic storms and sudden ionosphere disturbance (SIDs). These are caused by the disturbances originated at solar atmosphere, interplanetary (IP) shocks and/or stream interfaces associated with high speed solar wind streams[5].

2. Data Detection and Method of Analysis:

The interplanetary (IP) shocks list is compiled from the website *http://www.ssg.sr.unh.edu/mag/ace/ACElists/obs_list.html#shocks* and also from the *http://umtof.umd.edu/pm/FIGS.HTML*. We have then used the different graph plots to study the arrival of interplanetary shock for the period 1996-2000 and 2008-2012 (the ascending phases of solar cycle-23 and 24).

3. Results and Discussion

Fig. 1, shows the occurrence pattern of IP shocks (total of forward and reverse shocks) during the period of 1996 to 2000, with forward and reverse shocks, whereas fig. 2, shows the occurrence pattern of Total IP shocks with forward and reverse shocks for the time of interval 2008-2012. From these two figures, we observed that in the time interval of 1996-2000, number of IP shocks and forward IP shocks occurrence is greater than that for the period 2008-2012, but in the period

2008-2012, the occurrence of reverse shocks are greater than that for the reverse shocks during 1996-2000.

Fig. 3, shows the percentage of occurrence of total IP shocks for the period 1996-2000 and 2008-2012. We see that the percentage of total IP shocks for the period 1996-2000 is 56%, whereas for the period 2008-2012 occurrences of Total IP shocks is 44%.

Fig. 4, shows the pai-diagram for the occurrence of forward IP shocks for the period 1996-2000 and 2008-2012, and we observed that the occurring percentage of forward IP shocks for these intervals (for the ascending phases of solar cycle-23 and 24) are 58% and 42% respectively.

Fig. 5, shows the occurring percentage of reverse IP shocks for 1996-2000 and 2008-2012, which are 42% and 58% for these period respectively.

Hence, we concluded that the ascending phase of solar cycle-23 is more disturbed than ascending phase of cycle-24 as the total interplanetary shocks (with forward shocks) arrival is greater in the ascending phase of solar cycle-23, whereas the arrival of reverse shocks are less during this period.

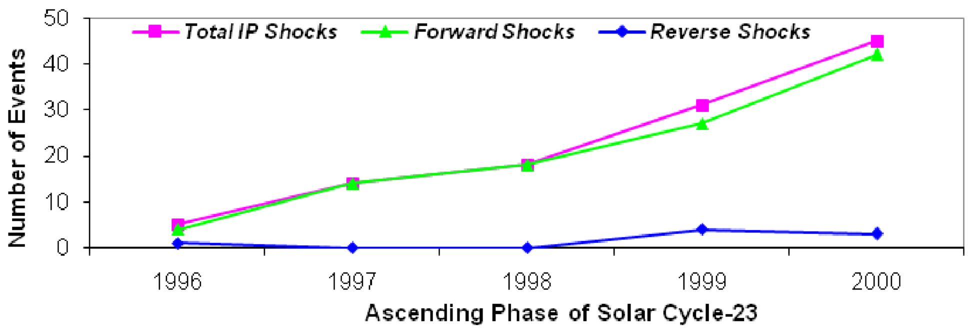

Fig. 1. shows the occurrence of total Interplanetary shocks with Forward & Reverse shocks during the ascending phase of solar cycle 23 (1996-2000).

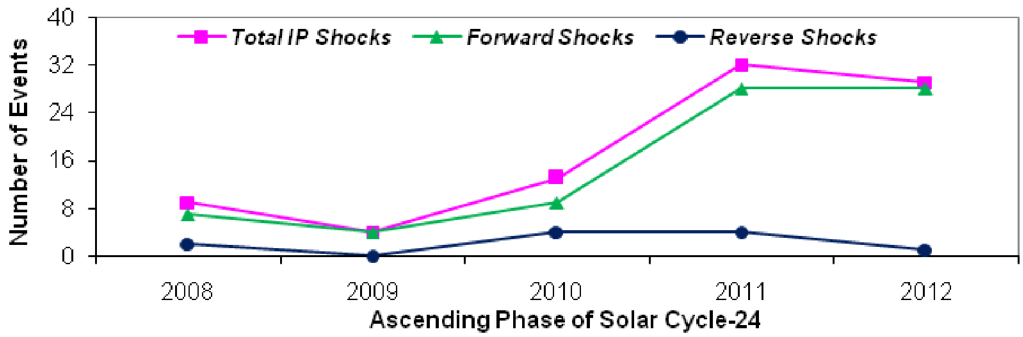

Fig. 2. shows the occurrence of total Interplanetary shocks with Forward & Reverse shocks for ascending phase of solar cycle 24 (2008-2012).

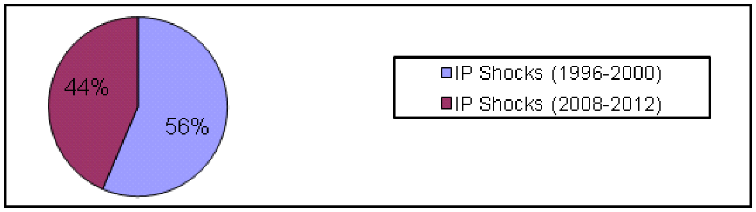

Fig.3, shows the pai-diagram of arrival of IP shocks percentage during the period 1996-2000 and 2008-2012.

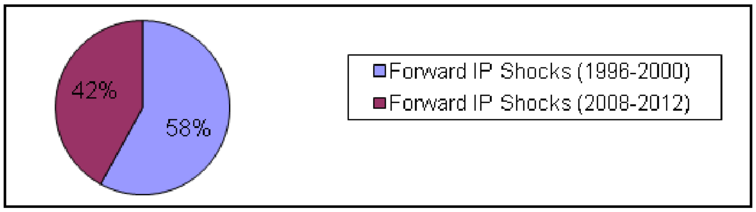

Fig.4, shows the pai-diagram of arrival of Forward IP shocks percentage during the period 1996-2000 and 2008-2012.

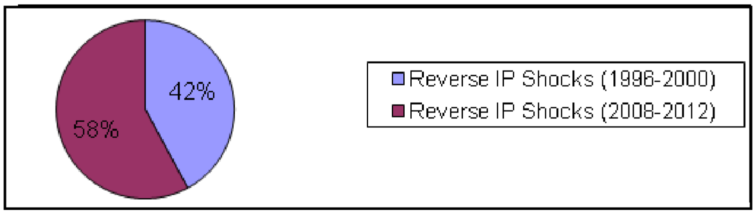

Fig.5, shows the pai-diagram of arrival of Reverse IP shocks percentage during the period 1996-2000 and 2008-2012.

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