



Short-term modulation of cosmic ray intensity associated with corotating streams

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Abstract

Transient downfall events in the power of enormous cosmic bars have been analyzed using daylight based breeze limits. We analyzed specific Present moment lessens in 1993/94 near the sun based least stage. In this period, the corotating collaboration districts were seen over a piece of a year. Redundant additions of the sun fueled breeze speed were seen during this stretch of time, outlining corotating association locale. Simultaneously irregular enthusiastic proton events and monotonous lessening of inestimable tremendous pillars are assessed. The example counts of neutron screens was well adversary of related with the apex speed of daylight based breeze. It is recommended that sturdy redesigns of sun based breeze speed or corotating affiliation regions formed by them can make the excessively long decrease in the vast affected shaft force. Ground-based and space-borne tests assessing grandiose cosmic pillars (GCRs) have seen transient depressions in its power happening for a couple of days. Individual despondencies change in their size (adequacy) and shape (time profile). Evaluation of ground-based neutron screen tremendous pillar power data has driven us to portray them into symmetric and veered off distresses, dependent upon symmetric/amiss decrease and recovery times of individual depressions. Symmetric distresses supposedly had (I) Precise shape and (ii) bowl or U-shape. Uneven distresses have been characterized into (I) Forbush-like, (ii) composite, and (iii) wavy demoralizations. Looking at the sun arranged data, and analyzing the sun fueled breeze plasma/field data we have searched for the sun based and interplanetary explanations behind these miseries. Evaluations and assessment of simultaneous assortments in sun arranged plasma speed, its thickness and temperature, close by interplanetary appealing field, its significance and instabilities in it, has driven us to perceive possible structure(s) like ICMEs, shock/sheath regions (formed on account of tension of enveloping alluring field by quick CMEs), affiliation regions (outlined by collaboration among slow and fast sun based breeze) and strain areas (molded by correspondence between languid CMEs and high speed streams from coronal openings). Associations between GCR force and different sun arranged breeze limits, during the passage of these specific plans, have been investigated and possible instrument (s) making different sort of symmetric and astray tragedies have been suggested.



Key word: Grandiose beam regulation, heliosphere, sun oriented and interplanetary drifters, sun powered breeze.

1. Introduction

Prior investigations of Transient balance of infinite beam power associated with corotating streams lasting a few days, were restricted with chiefly two explicit sort of dejections, in particular corotating and Forbush decline (see surveys, Lockwood, 1971; Venkatesan and Badruddin, 1990; Stick, 2000; Richardson, 2004). Forbush diminishes, described by a quick lessening inside ~1 day followed by a more progressive almost dramatic recuperation north of a couple of days, have been noticed consistently with neutron screens since the 1950's. Repetitive balances of cosmic grandiose beams, portrayed by a sluggish reduction and a continuous recuperation inside a time of ~27 days, nearly, are less great changes in vast beam force. Since their revelation through overall appropriation of particle chambers, Forbush diminishes have been widely read up to look for their sun powered source interplanetary design capable (Barouch and Burlaga, 1975; Badruddin et al., 1986; Iucci et al., 1989; Nagashima et al., 1990; Lockwood et al., 1991; Stick, 1993; Bavassano et al., 1994; Zhang and Burlaga, 1988; Badruddin, 2000, 2002; Stick, 2000; Ifedili, 2004) and the mechanism(s) assuming significant part in this peculiarity (Barouch and Burlaga, 1975; Venkatesan and Badruddin, 1990; Stick, 2000). Mathematical (balance) models also have been produced for the investigation of Forbush diminishes in one, two and three-aspects, in the internal as well as external heliosphere. Disregarding significant endeavors, because of intricacy of the peculiarity, nothing from what was just mentioned angles are obviously perceived with practically no uncertainty. Albeit less great than Forbush diminishes, a class of unassuming infinite beams power variety happening at stretches ~27 days were deduced, to be firmly connected with repeating unipolar attractive field locales over the photosphere of the sun and were more conspicuous during sunspot least. These unipolar attractive field areas were subsequently related to coronal openings and wellspring of corotating rapid sun based breeze streams. Multispacecraft estimations in interplanetary space related to ground-based perception worked with in recognizing the sun oriented source(s) of repetitive dejections, interplanetary structure(s) (for example corotating communication locales, rapid streams, heliospheric current sheet) and conceivable mechanism(s) (convection, dissemination or potentially floats) Badruddin, 1997; Morfill et al., 1979; Richardson et al., 1996, 1999; Kota and Jokipii, 2001; Richardson, 2004; Singh and Badruddin, 2005). Albeit sun powered polar coronal openings have been recognized as possible sun based wellspring of corotating diminishes, the overall job of corotating collaboration areas, fast streams and heliospheric current sheet in corotating balance is up in the air. Thus, the system that assumes a predominant part during corotating



diminishes isn't plainly perceived. In the vast majority of early examined of momentary adjustments, most laborers centered more than either of the two phenomena, i.e. corotating or Forbush decline. In this paper we have taken on a to some degree different methodology for the investigation of momentary melancholies in cosmic grandiose beam power. After assessment of extensive stretch of neutron screen perceptions, we have arranged all the noticed transient sorrows into symmetric and topsy-turvy despondencies, depending whether the 'abatement' and 'recuperation' parts in their time profile are symmetric or awry. 'Symmetric' despondencies are seen to have

- (a) Angular shape and
- (b) bowl or U-shape.

Uneven melancholies are ordered into

- (a) Forbush diminishes,
- (b) composite reductions, and
- (c) wavy-diminishes,

in view of the time profile of the downturn. After arrangement of melancholies into these classifications, one occasion each from five classes was chosen for itemized review. Occasions were chosen to the point that persistent sun based plasma and field information (plasma speed, attractive field, thickness and temperature) were accessible, essentially however long occasions would last. Neutron screen perceptions along with interplanetary plasma and field boundaries were then broke down to concentrate on their sun oriented beginning, interplanetary field and stream setups/structures, and actual systems liable for these discouragements in vast beam power. The short-term recurrent cosmic ray modulation, which is significant at solar minima, is caused by corotating streams regions (CIRs). Superposed epoch analysis was done on the solar wind plasma characteristics for 53 and 43 events using the OMNI data sets during two times of low solar activity around the start and close of solar cycle 24, respectively in the years 2007–2008 and 2017–2018. Using the variance approach for each CIR, the solar wind's turbulent characteristics were investigated. For overlapping subintervals at stream interfaces (SIs), power spectra have been created. Parallel and perpendicular diffusion mean free pathways for cosmic-ray ions have been deduced based on two different theoretical formulations using observed correlation lengths and turbulence energies. Our findings indicate that for the two solar polarity-opposite times. Thus, in contrast to solar wind speed, the most recent period has seen substantially higher magnetic field strength, flow pressure, and proton density. At the SIs, we detect increased turbulent energy and decreased parallel transport coefficients of energetic particles. The coefficients of diffusion the same tendencies over both times. Nearly a day before SIs, the perpendicular diffusion begins to rise and is greater in rapid winds. The >120 MeV proton count rate recorded from the

CRIS instrument on board the ACE spacecraft for the identical events is subjected to superposed epoch analysis. The measured proton rates exhibit a strong anticorrelation with the perpendicular diffusion coefficient and peak half a day before a SI and approach their minimum more than a day after a SI.

2.Results and Discussion

Symmetric depressions

We have distinguished two classes of 'symmetric' dejections in astronomical beam power recorded at ground-based neutron screens. We allude miseries as 'symmetric' on the off chance that the time profiles of reduction stage (for example beginning to least power level) and recuperation stage (for example least level up to recover of steady level) are comparable. Two classes of symmetric dejections are (a) 'Angular shape' and (b) 'bowl' or 'U-shape' melancholies.

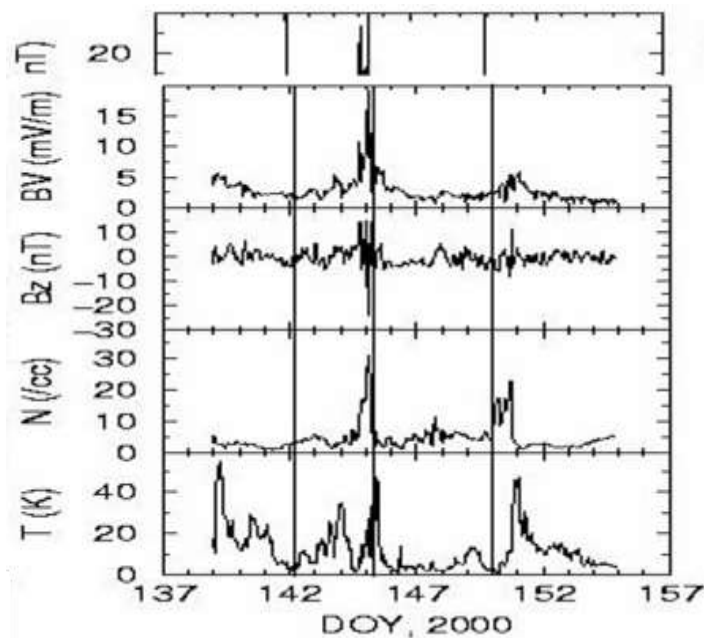


Fig. 1. A symmetric cosmic ray event (V-depression) that started on May 21,2000 at 0300 hours. Cosmic ray intensity as observed by neutron monitor together with the various interplanetary plasma and field parameters (V, B, σ_B , T, N, Bz and BV) are shown. Vertical lines indicate the start, minimum and end time of event.

Fig. 1 shows an Angular shape misery of around 5% as seen at Peak neutron screen (Scope = 39.37oN,

Longitude = 106.18° W, Cut-off unbending nature = 2.97 GV). The lessening began at 0300 hours on May 21, 2000 with the appearance of gradually speeding up stream. Plasma and field variety during this streams are with the end goal that, most probable, it is a corotating stream from coronal opening. Field strength likewise increments gradually inside the stream. At last a pressure locale is shaped after around 72 hour of beginning of the stream. This design is obvious in the interplanetary plasma and field information (V, B, σB , T, N and Bz) from the leap in the amplitudes of these boundaries. Power sadness follows the improvement in sunlight based breeze speed ($r = -0.82$). GCR power diminishes at a normal of 1.67(%) per 100 (km/sec) expansion in sun based breeze speed for this situation.

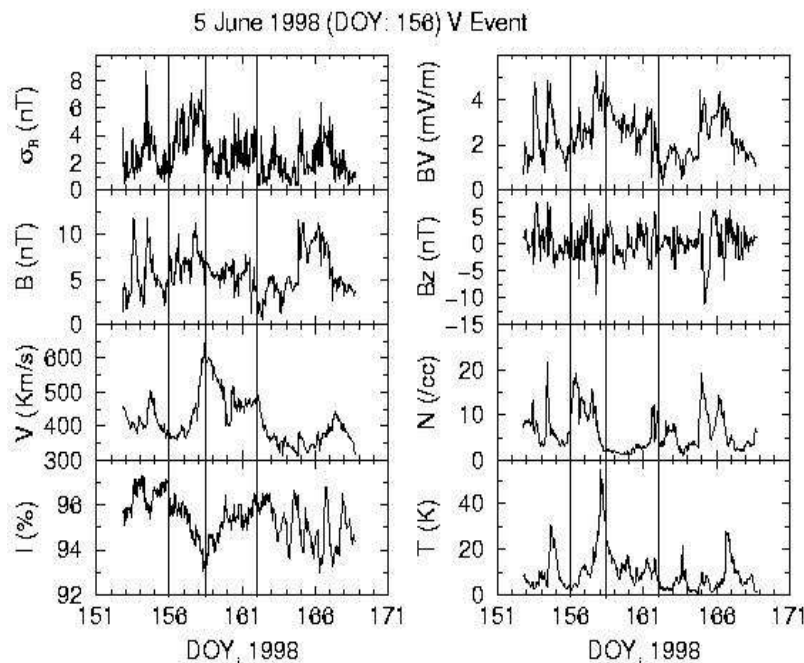


Fig. 2. Intensity time profile of a symmetric type (V-depression) of June 5, 1998 along with the various interplanetary plasma and field parameters are shown in this figure. Vertical lines indicate the start, minimum and end time of event.

Fig. 2 shows a V-sadness of around 4% that began at 0100 hour on June 05, 1998 with gradually speeding up, least force arrived at in around sixty hours at the hour of most extreme speed of the sunlight based breeze stream ($r = -0.80$). Albeit the IMF strength (B) and its difference (σB) and plasma thickness (N) stays upgraded during the diminishing period of this V-discouragement, the sun powered breeze speed is better corresponded ($r=-0.80$) with time variety in enormous beam force during this stage. This downturn

has all the earmarks of being brought about by upgraded convection and molecule dispersing. A GCR force decline with speeding up at a normal of 1.37(%) per 100 (Km/sec) decline in sun powered breeze speed is seen during recuperation stage. The power recuperates at a pace of 0.53% each hour as gotten by a straight fit ($r=0.78$). The recuperation happens during diminishing sun based breeze speed and section of somewhat low field and attractively calm locale. During recuperation stage, the relationship examination between GCR power (I) and sun oriented breeze boundary (V, B, σB and BV) yields better connection among's V and I ($r=-0.79$) as sun powered breeze speed is ceaselessly diminishing during this stage.

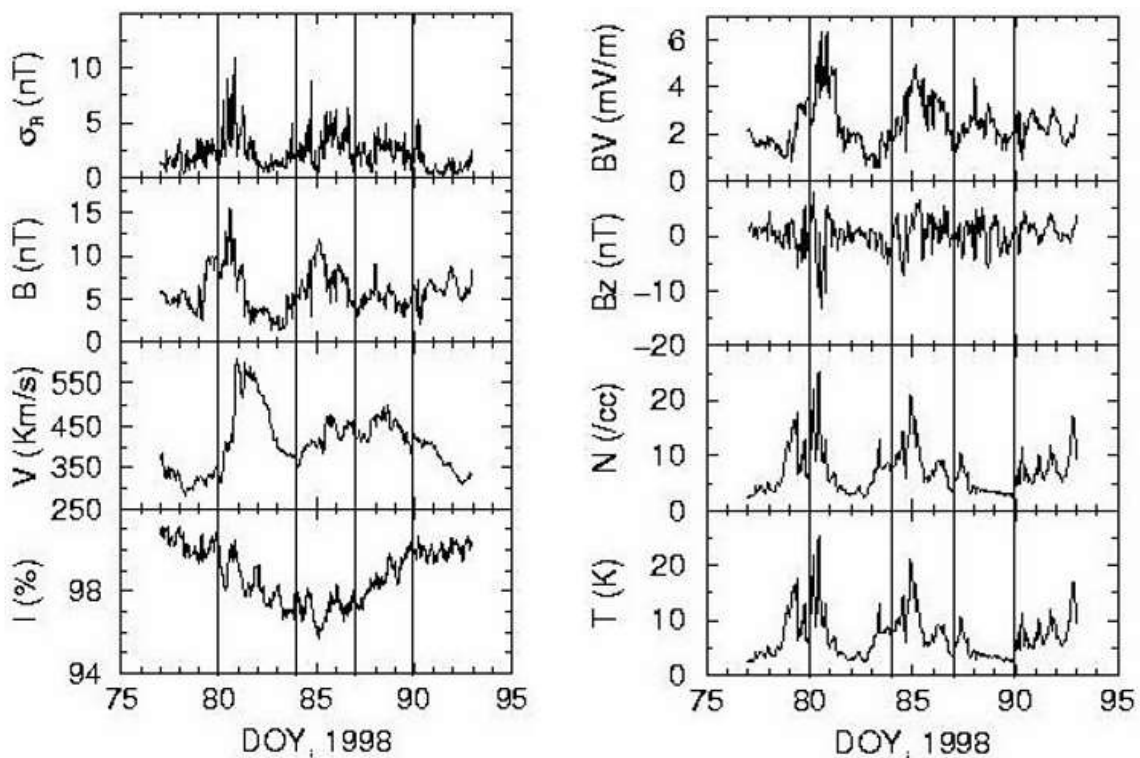


Fig. 3. A transient melancholy in grandiose beam power (U-wretchedness) beginning on Walk 21, 1998 appearance vast beam force time profile and plasma/field varieties. Outrageous vertical lines demonstrate the beginning and end season of enormous beam occasion. Two vertical in the middle between show interplanetary occasions during the downturn

Fig. 3 shows a U-melancholy of around 5% that endured ten days; five days decline time and same number of days it took to recuperate to pre-decline level. It began after the section of attractively calm field district with low temperature and thickness likely a sluggish CME (see Gopalswamy, 2004). As it shows up from the plasma and field improvements (V, B, σB , T, N and Bz), this CME was 'moved' by fast stream shaping

a cooperation district behind CME. This Walk 21, 1998 melancholy began with the appearance of collaboration area and fast stream. Indeed, even as the downturn was proceeding, one more stream of long length and similarly sluggish speed showed up. This U-wretchedness was a consequence of a CME, a cooperation district, a fast stream and an expansive stream of low speed. This U-wretchedness seem, by all accounts, to be brought about by various occasions and couldn't be credited to a solitary occasion in interplanetary space.

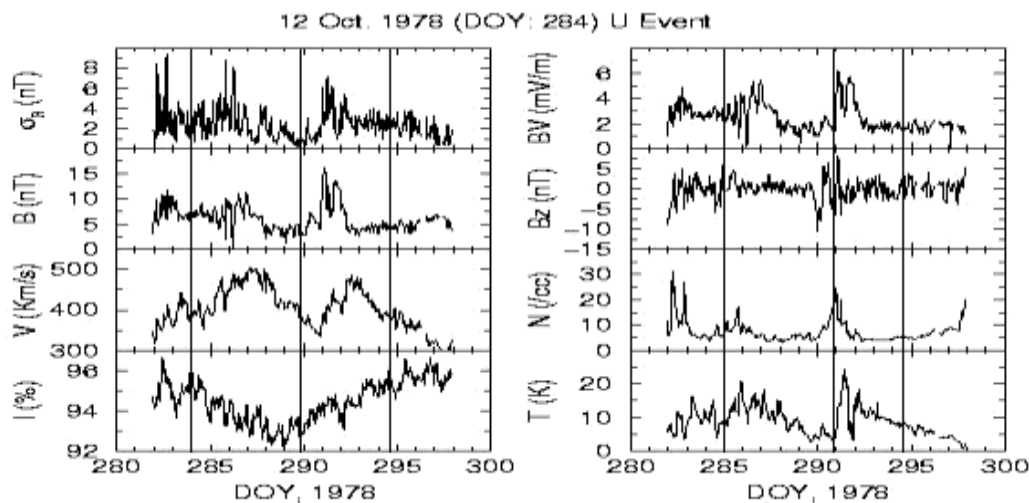


Fig. 4. Symmetric enormous beam sadness (U-type occasion) beginning on October, 12, 1978 appearance infinite beam force time profile and plasma/field varieties. Vertical lines left and right demonstrate the beginning and end season of vast beam event. Line in the center shows another interplanetary occasion A downturn in GCR force (Fig. 4) began on October 12, 2000 with the appearance of a sun based breeze stream with gradually expanding speed, this stream achieved most extreme speed after around five days' time. The field in the stream is fluctuating during decline stage. Power recuperation started when the stream began rotting and field become low and calm. After around three days of smooth recuperation, another construction, an ICME, showed up during the recuperation stage and delivered a little sufficiency lessening of brief length; notwithstanding, recuperation of U-gloom proceeded and it recuperated totally to predecease level in around five days' time. This ten-day U-discouragement of around three percent plentifulness shows some connection ($r = -0.43$) with plasma speed of the sun powered breeze stream as well as design that shaped in the interplanetary space. These discouragements cannot be credited to a solitary occasion in interplanetary space, and both improved convection and dispersing of enormous beam particles might be at the same time significant in creating this downturn.

Asymmetric depressions

A Forbush-like sadness (Fig. 5) of around 7% adequacy began at 1600 hours on September 17, 2000 concurrent with abrupt leap in V, B, σB , T and N of sun oriented breeze plasma/field boundary. A compacted plasma and violent field district (shock/sheath locale) is driven by a CME, a high field district with low σB , T and N, following the packed/fierce field area. A fast shock, a high-field, fierce locale prohibits the enormous beam particles bringing about decline stage information a pace of diminishes as 0.37% each hour. The recuperation begins gradually and it recuperates in seven days time. The recuperation intently follows the rotting sunlight based breeze speed ($r=-0.92$) and to same degree the field strength about ($r=-0.66$). Despite the fact that, recuperation is by and large ascribed to making up for of the shortfall made by spreading interplanetary structures, the speed of the sunlight based breeze in affecting the time profile (for example recuperation rate) is very conceivable.

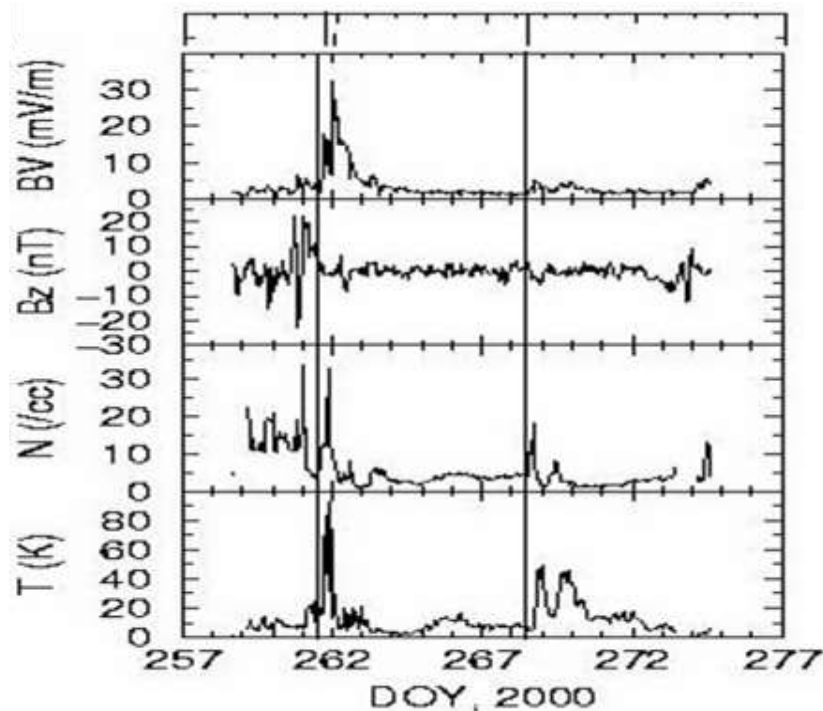


Fig. 5. A For bush-type cosmic ray depression starting on 1600 hour on September 17, 2000 alongwith plasma/field variations. Vertical lines indicate interplanetary events end of the Forbush-type cosmic depression.

A Forbush gloom (quick lessening and slow recuperation) began on November 11, 1978 with unexpected

leap in sun oriented breeze boundaries V , B , σ_B , T and N demonstrating that a shock showed up at the hour of beginning. IMF, its fluctuation, sunlight based plasma temperature and thickness stayed high for a couple of hours a while later; sign of a fierce sheath district. Be that as it may, power at least level remaining parts discouraged for a couple of hours during the section of high field and low σ_B district (a CME). Recuperation of the power began after the section of the sheath area followed by CME. Recuperation required about seven days time when the sunlight based breeze speed (and IMF strength) diminished gradually till the power recorded to pre-decline level. During decline stage the power was better connected with σ_B ($r = -0.78$) and V ($r = -0.68$) showing that speed of the shock and choppiness inside the sheath locale assume a significant part in this diminishing by dissipating astronomical beam particles. The relationship of the force with plasma speed ($r=-0.58$) and IMF strength ($r=-0.63$) during recuperation demonstrates that these boundaries may likewise impact the recuperation attributes (for example recuperation pace) of Forbush-type decline. Subsequently Forbush-type discouragement in enormous beam power may be brought about by a solitary ICME (a quick shock/sheath/CME structure); dissipating of particles by violent sheath assuming a significant part in delivering the lessening.

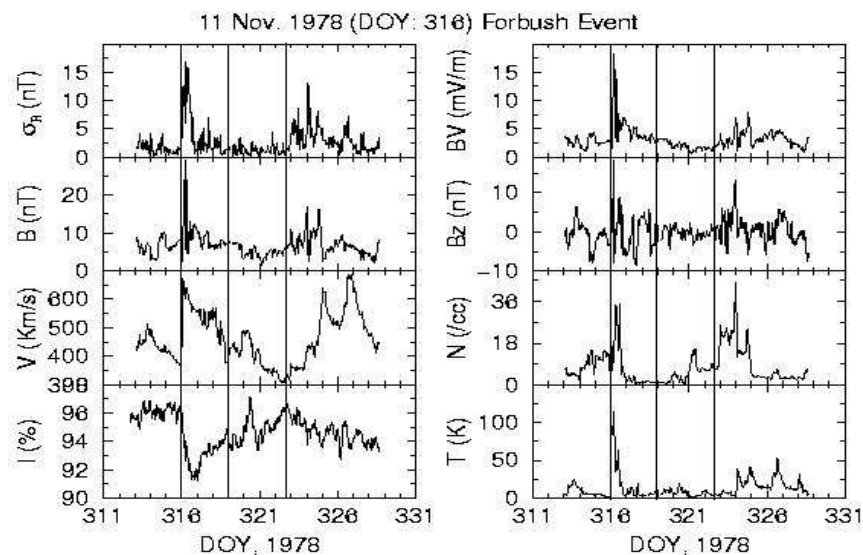


Fig. 6. A Forbush-type infinite beam sorrow beginning on November 11, 1978 appearance vast beam force time profile and plasma/field varieties. Vertical lines demonstrate interplanetary occasions end of the astronomical discouragement.

A 'composite' misery (quick lessening with slow recuperation in advances) began at 1000 hours on October 21, 2001. As abrupt lessening of around 5% in no less than few hours began with unexpected upgrade in sun oriented breeze boundaries V , B , σ_B , T and N . The span of upgraded σ_B , T and N endured exclusively

for around 12 hours in spite of the fact that field (B) was improved for ~36 hours demonstrating that a packed/fierce shock/sheath structure was trailed by a CME. Hence the underlying reduction in power can be credited to a quick shock/sheath driven by a CME. The recuperation began after the entry of this design. Be that as it may, before the power could recuperate totally, three more interplanetary disturbances, respectively on 25 Oct. 2001 (0800 hours), 28 Oct. 2001 (0200 hours) and 31 Oct (1300 hours) of more slow speed and lesser field strength kept the force discouraged till November 01, 2001. In this manner it

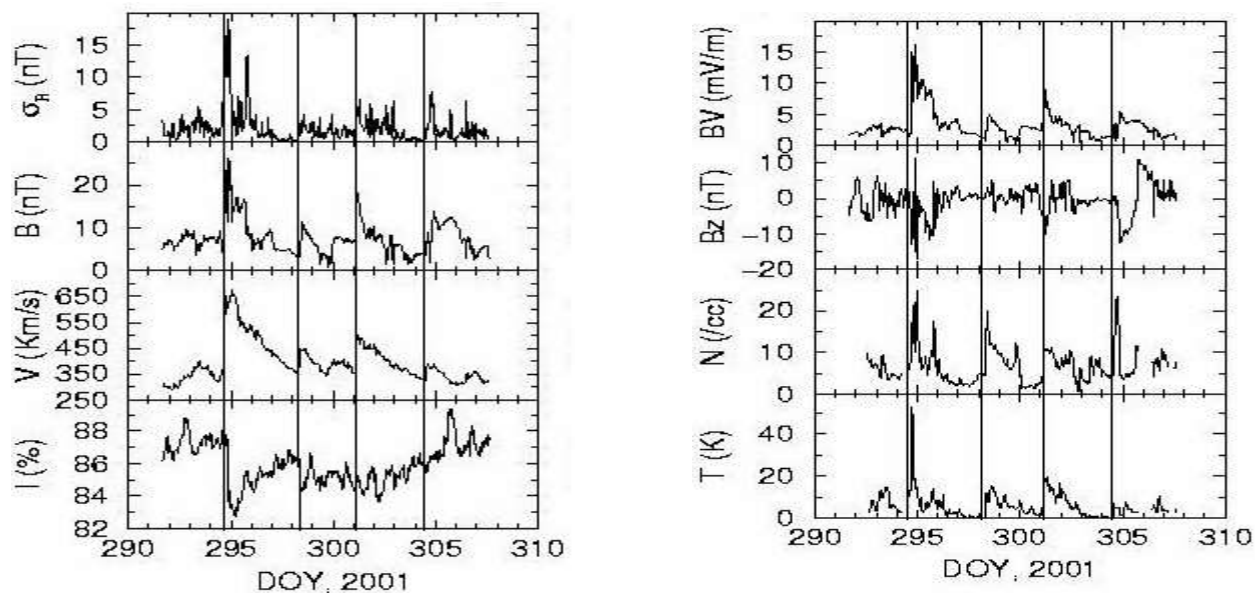


Fig. 7. A composite occasion showing variety in grandiose beam power sorrow beginning on October 21, 2001 alongwith plasma/field varieties

Vertical lines show the interplanetary occasions answerable for the downturn.required eleven days for the power to recuperate totally, that too in advances. The speed of the aggravations which, thusly, may choose the degree of pressure/disturbance in surrounding sun oriented breeze, strength of the shock framed and so on is better related with decline in grandiose beam power ($r = - 0.60$). The lessening of the power, during introductory stage, fitted with a straight bend gives a pace of force decline 1.42% each hour with $r = - 0.92$.

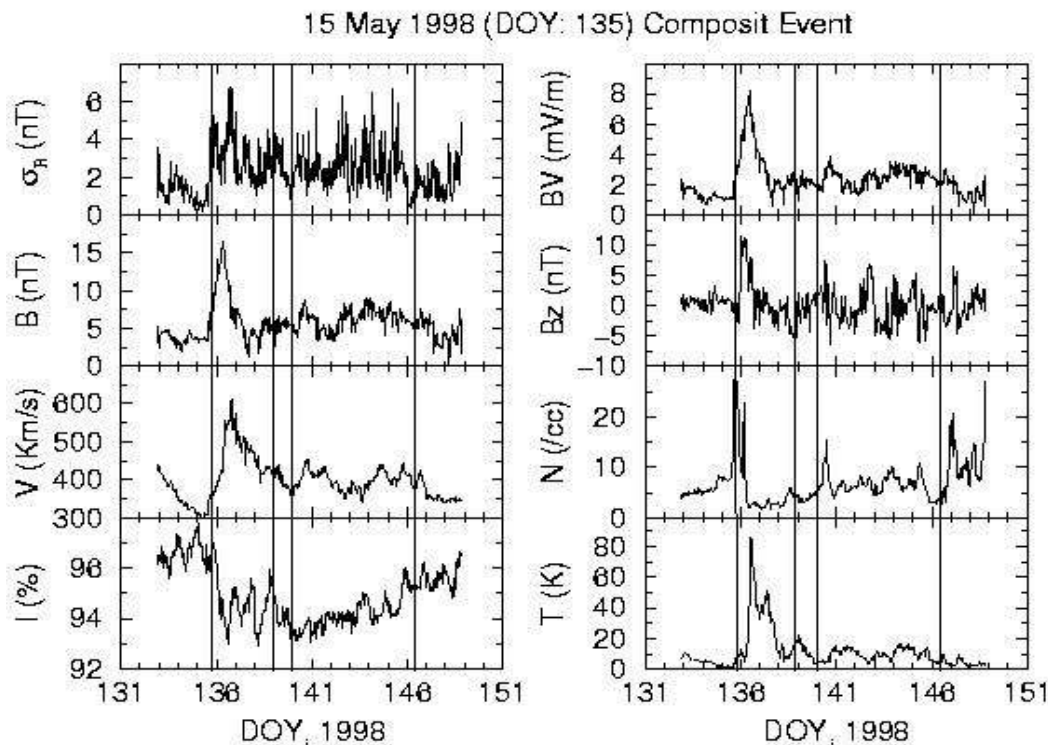


Fig. 8. A composite occasion showing variety in enormous beam force sadness beginning on May 15, 1998 alongwith plasma/field varieties. Vertical lines show the interplanetary occasions.

A composite lessening of around 4% began on May 15, 1998 at 2100 hours on appearance of a fast (V), high field (B) compacted (high N) and tempestuous (high σ_B) structure shaped in the interplanetary space. This decline, arriving at least power level in no less than 24 hour of its beginnings, recuperated gradually as another long-term aggravation of lower speed, improved and tempestuous field (high B and σ_B) and generally upgraded thickness controlled the force to practically same level for about seven days time, most likely through dissemination process. A straight fit for decline period of this composite gloom gives the pace of power decline as 7.3% each day with $r = -0.93$. A wavy melancholy began on February 17, 1998 (Fig. 9) with the appearance of CME (Gopalswamy et al., 2001) trailed by a collaboration area (high B, high σ_B , high T and N) and upgraded sun oriented breeze. An other construction, a packed locale of sun oriented plasma and field was dependable a slight sadness on February 22, 1998. A third move toward discouragement started with gradually expanding field and thickness in the surrounding sun oriented breeze.

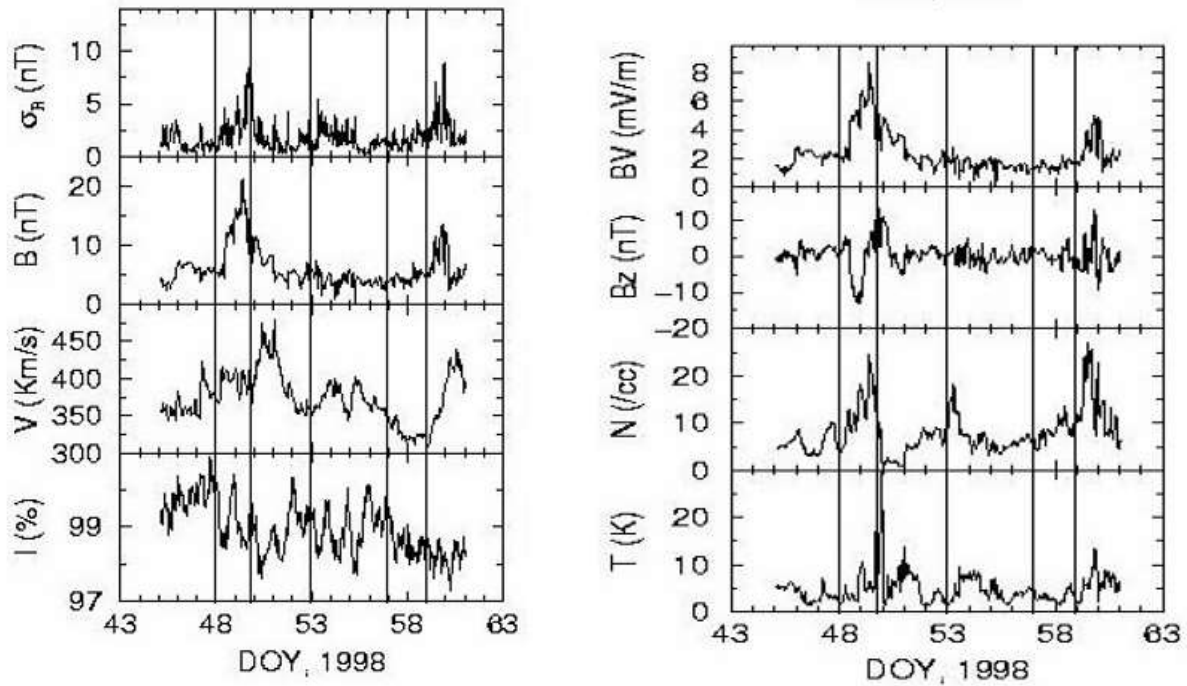


Fig. 9:A wavy dependency in enormous beam power on February 17, 1998 alongwith plasma/field varieties. Vertical lines show the interplanetary occasions

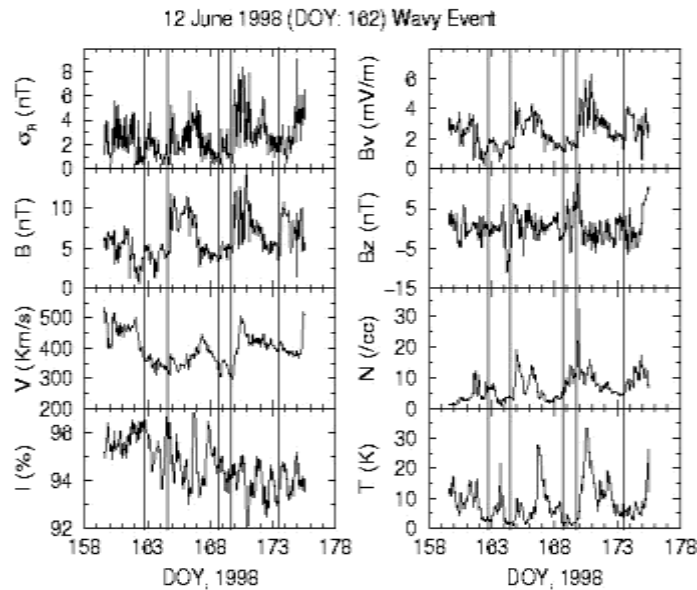


Fig. 10. A wavy sadness in enormous beam force at 2100 hr on June 12, 1998 alongwith plasma/field varieties. Vertical lines demonstrate the interplanetary occasions.



A wavy sadness began on February 17, 1998 (Fig. 10) with the appearance of CME like design (high B, low σB , low T) trailed by a connection area (high B, high σB , high T and N) and improved sun powered breeze. An other design, a compacted locale of sun powered plasma and field was dependable a slight melancholy on February 22, 1998. A third move toward wretchedness started with gradually expanding field and thickness in the surrounding sun based breeze. A sensible fit to this wavy wretchedness was gotten by a 10th request condition with $r = 0.70$.

Conclusions

We have ordered misery in astronomical beam thickness into various classes relying upon the state of the discouragements. Melancholies of every classification were chosen and plasma and field attributes were examined. We have recognized conceivable interplanetary designs and actual cycles assuming significant part during various sort miseries. Albeit the nitty gritty investigation of Forbush diminishes in astronomical beam power is critical to comprehend them completely, it is proposed that investigation of various kinds of transient sorrows in force along with the sun oriented sources and plasma/field normal for different interplanetary designs, answerable for delivering them, will help in better grasping the balance of enormous beams.

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