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Forbush decrease in relation with geomagnetic storms and coronal mass ejections during solar cycle 23

Ragni Tamrakar[1], P. L. Verma[2*], Anshu Gupta[3]
[1]Research Scholar, Department of Physics, APS University, Rewa, M.P., India
[2,3]Department of Physics, Govt. Vivekanand P.G. College, Maihar, Satna, M.P., India
E-mail: plverma2010@gmail.com
* Corresponding Author

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Abstract
We have studied Forbush decreases magnitude ≥5% observed at Oulu super Neutron Monitor with geomagnetic storms and coronal mass ejections during the period of solar cycle 23 .We have determined that all the Forbush decreases are found to be associated with geomagnetic storms and a large positive correlation with correlation coefficient 0.63 has been found between magnitude of Forbush decreases and magnitude of associated geomagnetic storms .Further the main phase duration and recovery duration of Fds are found to be unrelated to the main phase and recovery duration of associated geomagnetic storms .From the study of Forbush decreases and coronal mass ejections, it is seen that the most of the Forbush decreases (89.13%) are found to be associated with halo and partial halo coronal mass ejections (CME) .The association rates of H type and P type CMEs are 92.68% and 7.31% respectively. Positive correlation with correlation coefficient 0.43 has been found between magnitude of Forbush decreases and speed of associated CME.
Keyword: -Forbush decreases. Geomagnetic storms and Coronal Mass Ejections.

1. Introduction

Continuous monitoring of cosmic ray intensity has revealed that in some cases, on a global scale, cosmic ray intensity has decreased from a few percent to about 30%. The drop in cosmic ray intensity occurs quite suddenly, within a few hours or less, but a return to previous levels then takes days or even weeks is called the Forbush decreases (Forbush, 1954). Although the details are still unknown, the general mechanism causing Forbush depletion is generally considered to be the effect of the solar wind. Many works have focused on quantifying the influence of ICME structure on FD properties (Dumbović et al.2011; Richardson and Cane 2011; Abunin et al.2012; Abunina et al.two thousand and thirteen; Belov et al.2014, 2015).These reductions are closely related to coronal mass ejections (CMEs) and their interplanetary manifestations (Cane et al.1996, Badruddin 1997,2000,2002, Subhrmanayam et al.2005, Cane and Richardson , 2003, Badruddin, 1997, Kota 2001, Morfill, 1979, Richardson et al.1996, Richardson et al.1999, Richardson, 2004, Cliver et al.2003, Cane et al.1996, Hubert G.and the whole year 2019).Cane et al (1997) reported that the depth of Forbush events depends on the trajectory of the interplanetary coronal mass ejection. However, the characteristics of the occurrence and development of FD caused by different combinations of interacting SW perturbations are still under debate. The current theoretical understanding is that there are two basic processes that contribute to the observed FDs:(i) the change in the turbulent region of the envelope leads to a decrease in the radial diffusion coefficient of the GCR (Belov et al.1976; Wibberenz et al.1998), and (ii) a decrease in the local intensity of the GCR is controlled by the closed-circuit field geometry of the ICME ejecta magnetization occurs when the ICME moves above the observation point (Cane 2000; Krittinatham & Ruffolo 2009; Richardson & Cane 2011).As a result, two-phase FD is marked.Such FDs refer to a major subset of the GCR reduction for observers (e.g., Earth) with orbits passing through both shocks and magnetized projectiles of the ICME (Belov 2009; Jordan et al .2011).At the same time, the majority of observed (i.e.recorded) FDs are one-step FDs.

2. Data Reduction and Analysis

In this investigation, we have studied Forbush decreases magnitude ≥5% with geomagnetic storms and coronal mass ejections during the period of solar cycle 23. For this study, hourly data of cosmic ray intensity observed at Oulu super Neutron monitor has been used to determine Forbush decreases. The data of different types of coronal mass ejections are taken from SOHO – large-angle spectrometric, coronagraph (SOHO / LASCO), and extreme ultraviolet imaging telescope (SOHO/EIT) data. To determine geomagnetic storms, hourly data of Dst index are used and these data are taken from Omni web data.

3.Analysis and Results

3.1. Forbush decreases (Fds) with Coronal Mass Ejections (CMEs)

From the examination of Forbush decrease and coronal mass ejection for solar cycle 23. We have found total numbers of Forbush decreases (Fds) observed during the period of solar cycle 23 are 46. Out of these 46 events 41 (89.14%) Forbush decreases (Fds) have been found to be associated with coronal mass ejections. The majority of associated CMEs are halo CMEs, the association rate of H Type and P types CMEs have been found 92.69% and 7.32 % respectively.

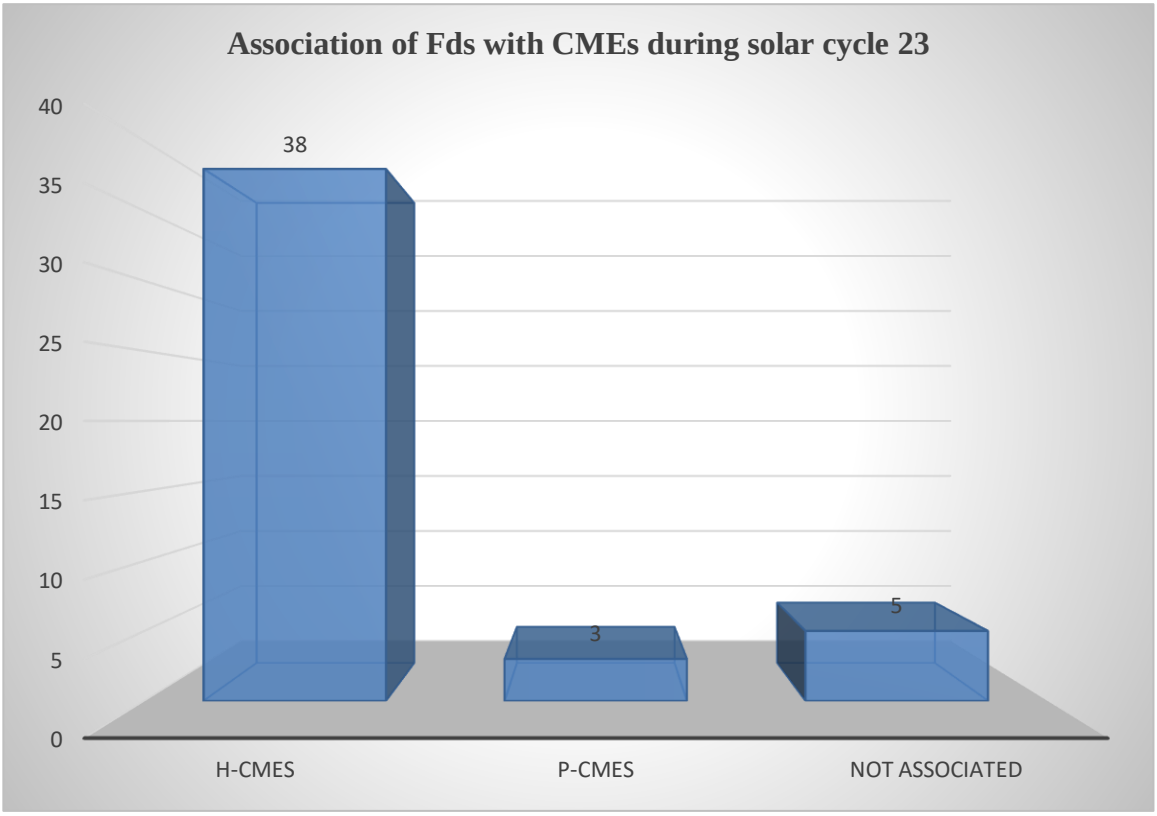

Figure-1 Shows bar diagram of Forbush decreases (Fds) and types of associated CMEs observed during the period of solar cycle 23.

3.2. Correlation between magnitude of Fds and speed of associated CMEs

A scatter plot has been plotted between magnitude of Forbush decreases and speed of associated CMEs for the determination of statistical relation between magnitude of Forbush decreases and speed of associated CMEs for solar cycle 23 and the scatter plot obtained between magnitude of Forbush decreases (Fds) and speed of associated CMEs are shown Figure 2. From the scatter plot between magnitude of Fds and speed of associated CMEs it is clear that most of the Fds which have high magnitude are associated with such CMEs which have relatively higher speed, but the magnitude of Fds and speed of CMEs do not have any fixed proportion. We have found some Forbush decreases which have high magnitude but they are associated with such CMEs which have low speed and some Forbush decreases which have small magnitude but they are associated with such CMEs which have higher speed. These results indicates that although these events do not have any quantitative relation but the Fds of higher magnitude are generally associated with such CMEs which have relatively higher speed. Further from the trend line of the figure shows positive correlation between magnitude of Forbush decreases (Fds) and speed of associated CMEs. Using the formula of correlation coefficient positive co-relation with correlation coefficient 0.43 has been found between magnitudes of Forbush decreases (Fds) and speed of associated CMEs.

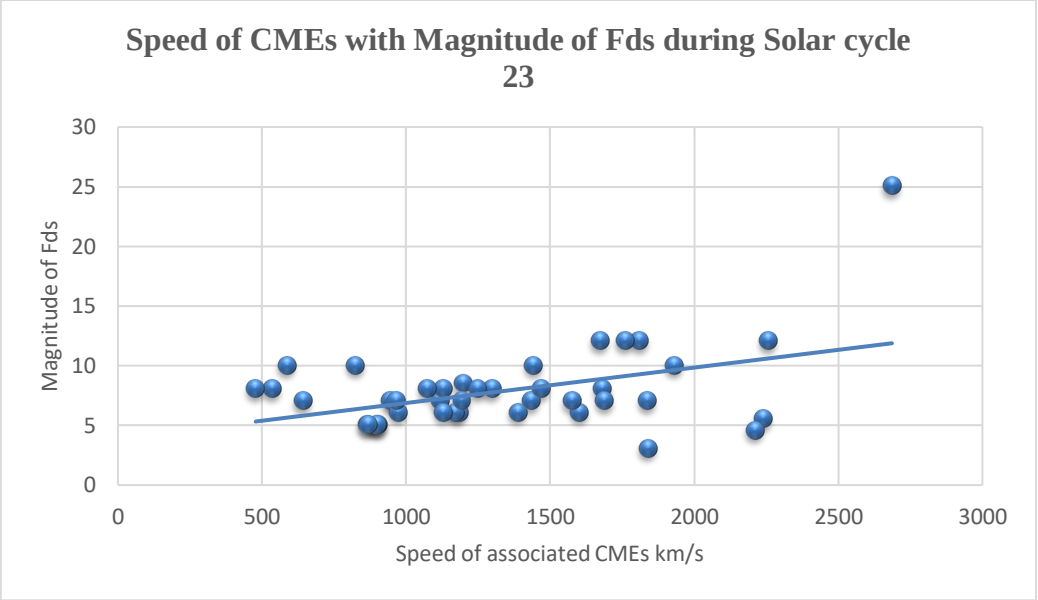

Figure-2 Shows Scatter plot between speed of CMEs and magnitude of Forbush decreases (Fds) for the period of solar cycle 23 showing positive correlation with correlation coefficient 0.43.

4. Association of Forbush Decreases (Fds) With Geomagnetic Storms

4.1. Correlation between magnitude Fds and magnitude of geomagnetic storms

Forbush decreases ≥5%, observed during the period of solar cycle 23 at Oulu super neutron monitor has been studied with geomagnetic storms. From the data analysis, we have found 46 total number of Forbush decreases during the period of solar cycle 23. Out of these 46 Forbush decreases all Forbush decreases have been found to be associated with geomagnetic storms. Further we have plotted a scatter diagram between magnitude of Forbush decreases and magnitude of associated geomagnetic storms. The scatter plots obtained between these two parameters are shown in Figure 3.From the figure between the magnitude of Forbush decreases and magnitude of associated geomagnetic storms it is clear that most of the Fds which have higher magnitude are associated with such geomagnetic storms which have relatively higher magnitude , but the magnitude of these two events do not have any fixed proportion, we have found some Forbush decreases which have higher magnitude but they are associated with such geomagnetic storms which have small magnitude and some Forbush decreases which have small magnitude but they are associated with such geomagnetic storms which have high magnitude. These results indicates that although these events do not have any quantitative relation but the Fds of higher magnitude are generally associated with such geomagnetic storms which have relatively higher magnitude. Further from the trend line of the figure shows positive correlation between magnitude of Forbush decreases and magnitude of geomagnetic storms. Positive co-relation with co-relation with correlation coefficient 0.63 has been found between magnitudes of Forbush decreases and magnitude associated geomagnetic storms.

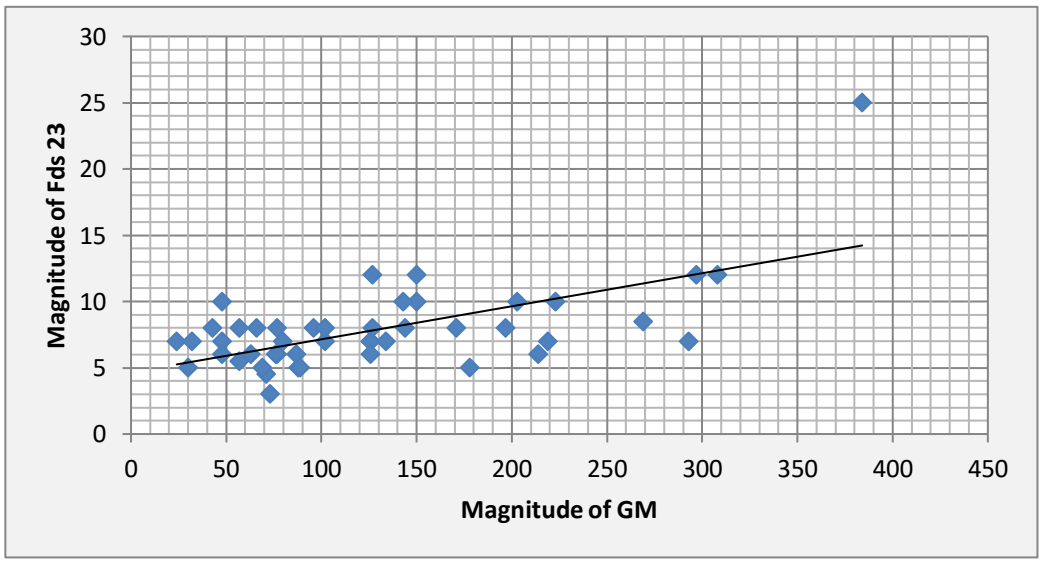

Figure-3 Shows scatter plot between magnitude of associated geomagnetic storms and magnitude of Fds for the period of solar cycle 23. showing positive correlation with correlation coefficient 0.64.

4.2. Correlation between main phase duration of Fds and main phase duration of geomagnetic storms

Further we have plotted a Bar diagram between main phase duration of Forbush decreases and main phase duration of associated geomagnetic storms. The bar diagram obtained between these two parameters are shown in Figure 4. From the bar graph between the main phase duration of Forbush decreases and main phase duration of geomagnetic storms it is clear that most of the Fds which have long main phase duration are associated with such geomagnetic storms which have relatively long main phase duration , but the main phase duration of these two events do not have any fixed proportion, we have found some Forbush decreases which have long main phase duration but they are associated with such geomagnetic storms which have short main phase duration and some Forbush decreases which have short main phase duration but they are associated with such geomagnetic storms which have long main phase duration. These results indicates that although these events do not have any quantitative relation but the Fds of higher main phase duration are generally associated with such geomagnetic storms which have relatively higher main phase duration.

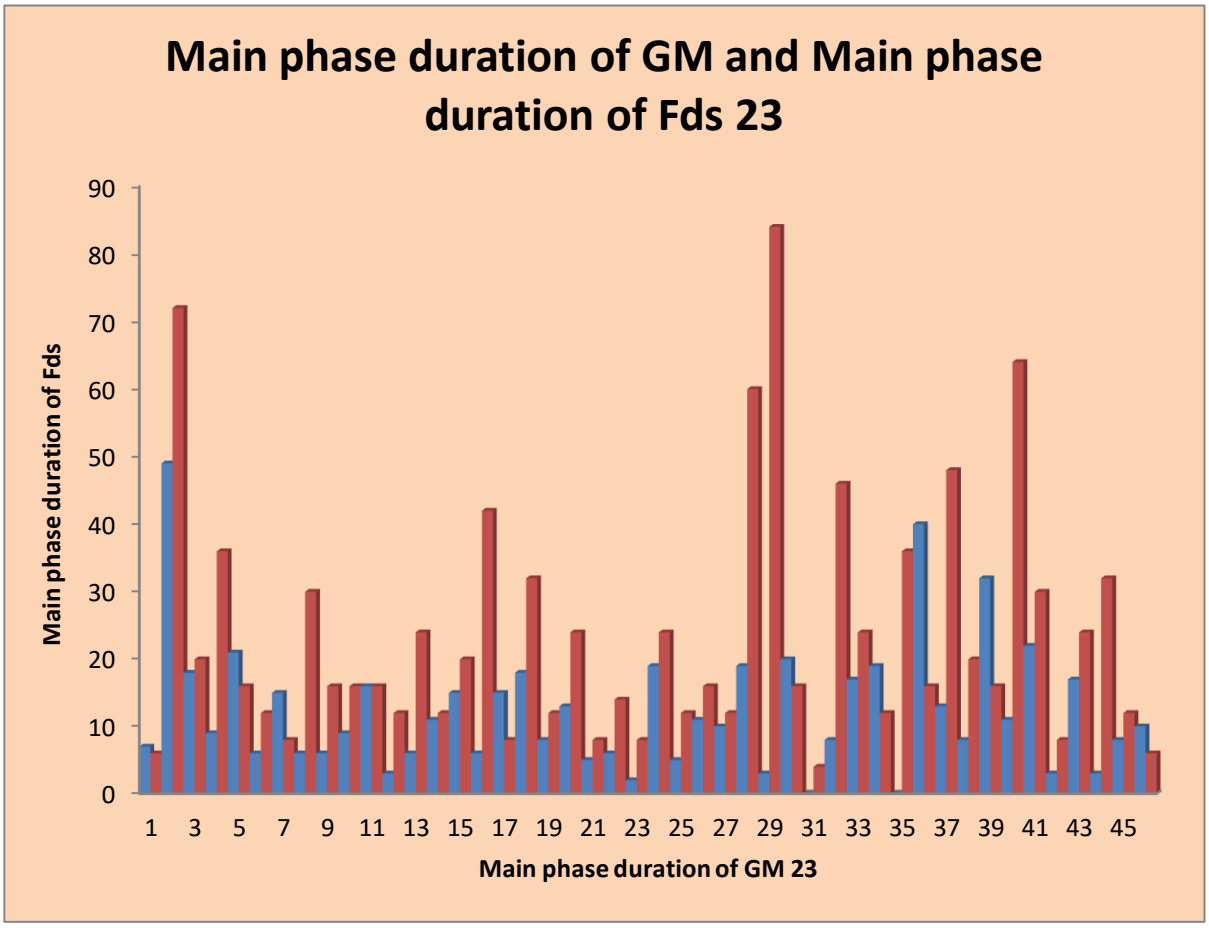

Figure-4 Shows bar diagram between main phase duration of associated geomagnetic storms and main phase duration of Fds for the period of solar cycle 23.

4.3. Correlation between recovery duration of Fds and recovery duration of geomagnetic storms

Further we have plotted a Bar diagram between recovery duration of Forbush decreases and recovery duration of associated geomagnetic storms. The bar diagram obtained between these two parameters are shown in Figure 5. From the bar graph between the recovery duration of Forbush decreases and recovery duration of geomagnetic storms it is clear that most of the Fds which have long recovery duration are associated with such geomagnetic storms which have relatively long recovery duration , but the recovery duration of these two events do not have any fixed proportion, we have found some Forbush decreases which have long recovery duration but they are associated with such geomagnetic storms which have short recovery duration and some Forbush decreases which have short recovery duration but they are associated with such geomagnetic storms which have long recovery duration. These results indicates that although these events do not have any quantitative relation but the Fds of higher recovery duration are generally associated with such geomagnetic storms which have relatively higher recovery duration.

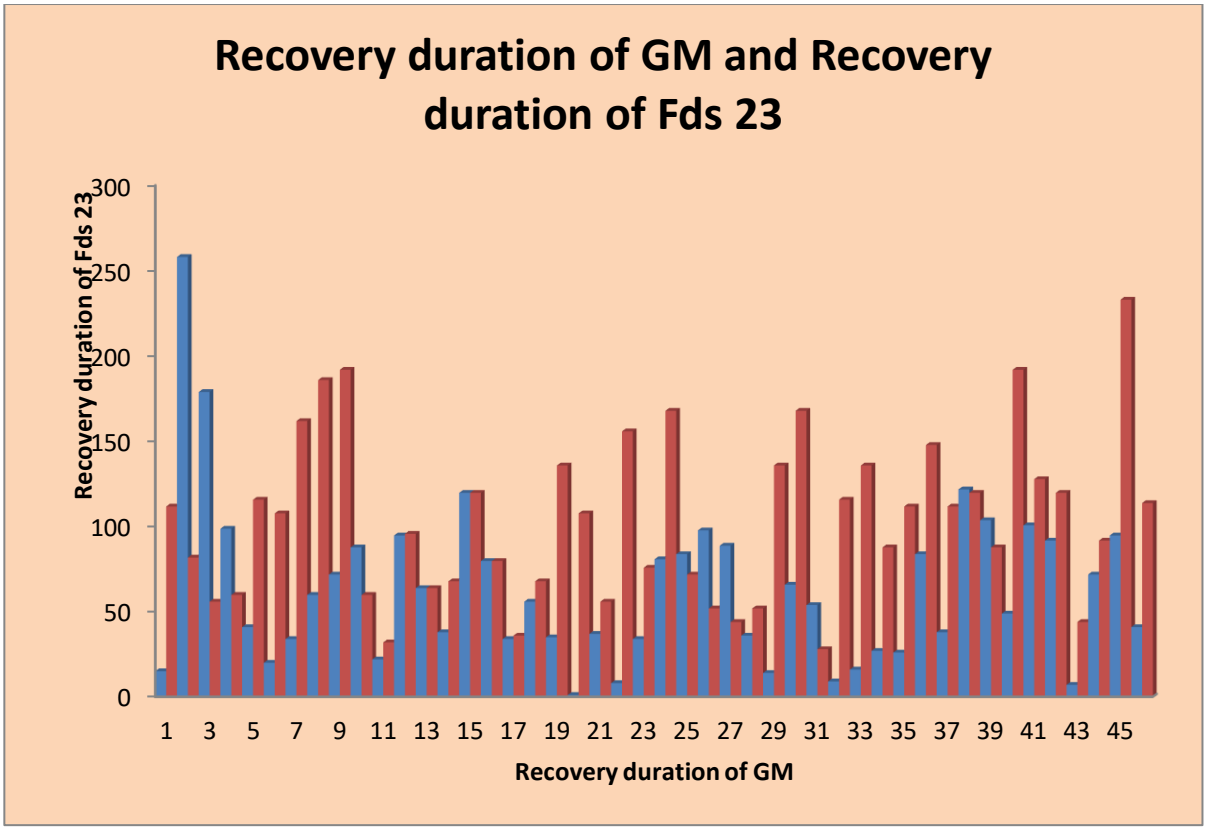

Figure-5 Shows bar diagram between recovery duration of associated geomagnetic storms and recovery duration of Fds for the period of solar cycle 23.

5. Results and conclusion

The study of Forbush decreases and coronal mass ejections shows that Forbush decreases in cosmic ray intensity is directly /indirectly related to coronal mass ejections. Coronal Mass Ejections (CMEs) are plasma eruptions from the solar atmosphere involving previously closed field regions which are expelled into the interplanetary medium. Such regions, and the shocks which they generate, have pronounced effects on cosmic ray densities both locally and at some distance and are most potential cause of Forbush decreases in cosmic ray intensity .Further the study of Forbush decreases and geomagnetic storms, we have determined that all the Forbush decreases are found to be associated with geomagnetic storms and a large positive correlation with correlation coefficient 0.63 has been found between magnitude of Forbush decreases and magnitude of associated geomagnetic storms and the main phase duration and recovery duration of Fds are found to be unrelated to the main phase and recovery duration of associated geomagnetic storms .Although the magnitude of Fds and GM are strongly correlated but no any significant correlation has been found between main phase and recovery duration of these two events .Hence it is concluded that geomagnetic storms does play any fundamental role to generate Forbush decreases in cosmic ray intensity .It is also inferred that these two events are happening due common source origin .

Conflict of Interest

There is no conflict of interest in this manuscript.

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