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ORIGINAL ARTICLE

Distinctions between the characteristics of before and after DH CMEs associated flares

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Abstract A detailed analysis of characteristics of coronal mass ejections and flares associated with deca-hectometer wavelength type-II radio bursts (DH-CMEs and DH-flares) observed in the period 1997–2008 is presented. A sample of 62 limb events is divided into two populations known as after-flare CMEs (AF-CMEs) and before-flare CMEs (BF-CMEs) based on the relative timing of the flare and CME onsets. On average, AF-CMEs (1589 $\mathrm{km\,s^{-1}}$) have more speed than the BF-CMEs (1226 $\mathrm{km\,s^{-1}}$) and the difference between mean values are highly significant ($P \sim 2\%$). The average CME nose height at the time of type-II start is at larger distance for AF-CMEs than the BF-CMEs (4.89 and 3.84 R_o, respectively). We found a good anti-correlation for accelerating ($R_a = -0.89$) and decelerating ($R_d = -0.78$) AF-CMEs. In the case of decelerating BF-CMEs, the correlation seems to be similar to that for decelerating AF-CMEs ($R_d = -0.83$). The number of decelerating AF-CMEs is 51% only; where as, the number of decelerating BF-CMEs is 83%. The flares associated with BF-CMEs have shorter rise and decay times than flares related to AF-CMEs. We found statistically significant differences between the two sets of associated DH-type-II bursts characteristics: starting frequency ($P \sim 4\%$), drift rate ($P \sim 1\%$), and ending frequency ($P \sim 6\%$). The delay time analysis of DH-type-II start and flare onset times shows that the time lags are longer in AF-CME events than in BF-CME events ($P \ll 1\%$). From the above results, the AF-CMEs which are associated with DH-type-II bursts are found to be more energetic, associated with long duration flares and DH-type-IIs of lower ending frequencies.

Keywords Sun · Coronal mass ejections · Solar flares · DH-type-II bursts

1 Introduction

The electromagnetic radiation in solar type-II radio bursts is generally assumed to be generated by plasma emission mechanism. In the surrounding area of fast mode MHD shocks, plasma oscillations (Langmuir waves) are generated by accelerated nonthermal electrons. The MHD shocks are observed as type-II radio bursts in the metric type-II bursts (herein after m-type-II bursts), deca-hectometer (herein after DH-type-II bursts) and kilometric domains. These type-II radio bursts are the earliest indicators of shocks, one should look at the radio emission characteristics near the Sun and in the interplanetary medium (see e.g., Gopalswamy et al. 2008a, 2008b). While it is generally accepted that interplanetary deca-hectometer wavelength type-II bursts (herein after DH-type-II bursts) are caused by CMEs, the origin of coronal shocks, causing m-type-II bursts, is still under debate. Similarly, the relationship between solar flares and coronal mass ejections has been a matter of debate for a long time. Since from the early CME observations, it is well known that CMEs are associated with flares and eruptive prominences (Munro et al. 1979). The statistical studies show that faster CMEs are associated with more powerful flares (e.g., Moon et al. 2002). Furthermore, case studies indicate that there is a distinct relationship between the SXR burst and the CME acceleration. The acceleration phase is more or less simultaneous with the impulsive

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