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ORIGINAL ARTICLE

Characteristics of DH type II bursts, CMEs and flares with respect to the acceleration of CMEs

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Abstract A detailed investigation on DH-type-II radio bursts recorded in Deca-Hectometer (hereinafter DH-type-II) wavelength range and their associated CMEs observed during the year 1997–2008 is presented. The sample of 212 DH-type-II associated with CMEs are classified into three populations: (i) Group I (43 events): DH-type-II associated CMEs are accelerating in the LASCO field view ($a > 15\,\mathrm{m\,s^{-2}}$); (ii) Group II (99 events): approximately constant velocity CMEs ($-15 < a < 15\,\mathrm{m\,s^{-2}}$) and (iii) Group III (70 events): represents decelerating CMEs ($a < -15\,\mathrm{m\,s^{-2}}$). Our study consists of three steps: (i) statistical properties of DH-type-II bursts of Group I, II and III events; (ii) analysis of time lags between onsets of flares and CMEs associated with DH-type-II bursts and (iii) statistical properties of flares and CMEs of Group I, II and III events. We found statistically significant differences between the properties of DH-type-II bursts of Group I, II and III events. The significance (P_a) is found using the one-way ANOVA-test to examine the differences between means of groups. For example, there is significant difference in the duration ($P_a = 5\%$), ending frequency ($P_a = 4\%$) and bandwidth ($P_a = 4\%$). The accelerating and decelerating CMEs have more kinetic energy than the constant speed CMEs. There is a significant difference between the nose height of CMEs at the end time of DH-type-IIs ($P_a \ll 1\%$). From the time delay analysis, we found: (i) there is no significant difference in the delay (flare start—DH-type-II start and flare peak—DH-type-II start); (ii) small differences in the time delay between the CME onset and DH-type-II start, delay between the flare start and CME onset times. However, there are high significant differences in: flare duration ($P_a = 1\%$), flare rise time ($P_a = 0.5\%$), flare decay time ($P_a = 5\%$) and CMEs speed ($P_a \ll 1\%$) of Group I, II and III events. The general LASCO CMEs have lower width and speeds when compared to the DH CMEs. It seems there is a strong relation between the kinetic energy of CMEs and DH-type-II properties.

Keywords Sun · Coronal mass ejections · Solar flares · Type II bursts

1 Introduction

Coronal mass ejections (CMEs) that produce type II radio emission in the range Deca-Hecto metric (DH) wavelengths (1–14 MHz) are known as radio-rich CMEs (Gopalswamy et al. 2001b; Pappa kalaivani et al. 2010). Type-II radio bursts are emission stripes slowly drifting from high to low frequencies in the dynamic spectrum. The DH-type-II bursts drifting stripes are the signature of the shock waves associated with coronal mass ejections (Gopalswamy 2000). While the origin of type-IIs in the solar corona is still under debate (see, e.g., Vršnak and Cliver 2008), recent studies accept the CME origin of DH-type-IIs in the interplanetary medium. The DH-type-II radio emission originates in the

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