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Radio Emission from Interplanetary Coronal Mass Ejections

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Coronal mass ejections (CMEs) along with associated eruptive flares are among the most spectacular, large-scale phenomena on the Sun and in the solar system. CMEs are known to be associated with variety of important solar, interplanetary (IP), and terrestrial phenomena, such as solar energetic particle (SEP) event, IP shock, geomagnetic storm (GS), and so on, which form important ingredients of the contemporary space weather research. The powerful CME events are known to generate shocks in the coronal and interplanetary medium, which are identified as type II bursts in radio observations. The type II emission is essentially an escaping electromagnetic radiation in the radio domain; hence they arrive to the observer at Earth in ≈8.3 minutes, providing the advance warning of arrival of interplanetary shock. Depending on the energetics of CMEs, the type II bursts are observed in metric (m; 30 MHz ≤ f ≤ 300 MHz), decametric–hectometric (DH; 300 kHz ≤ f ≤ 30 MHz), and kilometric (km; 30 kHz ≤ f ≤ 300 kHz) wavelength domains. The extension or origin of type II radio bursts in the DH domain implies the cases of stronger MHD shocks propagating from the inner corona and entering the IP medium. Hence the study of shocks in DH domain, together with their associated CME-flare events, becomes extremely important to infer not only the propagation characteristics of CMEs but also to develop their forecasting tools.

In this study, we explore the characteristics of DH type II bursts and associated CMEs for the Solar Cycles 23 and 24. The bursts are classified according to their end frequencies into three categories: Low-Frequency Group (LFG; 20 kHz ≤ f ≤ 200 kHz), Medium-Frequency Group (MFG; 200 kHz < f ≤ 1 MHz), and High-Frequency Group (HFG; 1 MHz < f ≤ 16 MHz). We find that the sources for LFG, MFG, and HFG events are homogeneously distributed over the active region belt. Our analysis shows a drastic reduction of the DH type II events during Solar Cycle 24, which includes only 35% of the total events (i.e., 179 out of 514). Despite having smaller number of DH type II events in the Solar Cycle 24, it contains a significantly higher fraction of LFG events compared to the previous cycle (32% versus 24%). However, within the LFG group, the cycle 23 exhibits significant dominance of type II bursts that extend below 50 kHz, suggesting rich population of powerful CMEs traveling beyond half of the Sun– Earth distance. The events of LFG group display strongest association with faster and wider (more than 82% events are halo) CMEs, whereas at the source location, they predominantly trigger large M/X class flares (in more than 83% cases). Our analysis also indicates that CME initial speed or flare energetics is partly related to the duration of type II burst and that survival of CME-associated shock is determined by multiple factors/parameters related to CMEs, flares, and state of coronal and interplanetary medium. The profiles relating CME heights with respect to the end frequencies of DH type II bursts suggest that for HFG and MFG categories, the location for majority of CMEs (≈ 65%–70%) is in well compliance with ten-fold Leblanc coronal density model, whereas for LFG events, a lower value of density multiplier (≈ 3) seems to be compatible.