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Metric Type II Solar Radio Emission associated with Coronal Mass Ejections: Some New Insights

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Generally, Type II bursts are narrow-band radio emissions, and when viewed on a radio dynamic spectra, they drift slowly from high to low frequency. The Type II radio bursts observed in the outer corona and interplanetary medium are usually referred to as DH-Type II bursts as seen in decameter, hectometer, and kilometer wavelength ranges. However, near-sun or coronal Type II radio bursts are usually referred to as metric Type II bursts as they are seen in metric wavelength ranges. It is widely accepted that Type II bursts are produced by shocks moving from the solar corona through the heliosphere. The shocks are mostly generated due to solar coronal mass ejections (CMEs). When CMEs move through the corona and interplanetary medium, they interact with the surrounding plasma and generate shock waves if their speed is more than the characteristic speed of the medium, known as Alfven speed. The shock waves thus produced are capable of accelerating electrons in the solar corona, which can excite plasma waves at local plasma frequency and/or its harmonics, and conversion of them into electromagnetic radiation is observed as Type II bursts. It is, therefore, important to study the correlation between different properties of Type II bursts and the associated CMEs. This, in turn, would be useful in understanding the impact of CMEs on space weather and geomagnetic activity. A recent study by Ramesh et al. 2024, ApJ, 926, 38 showed that an increase in CME angular width would increase the frequency bandwidth of metric Type II bursts. The authors attributed the increase in the frequency bandwidth to the increased angular width of the CME. The increase in CME angular width results in a broader shock front that leads to electron accelerations at multiple locations, producing a wider frequency width for the resulting Type II emission. We conducted a statistical analysis of the frequency bandwidth of 12 coronal Type II radio bursts in the frequency range 20-127 MHz for the period spanning 2007-2021, obtained using an e-Callisto spectrograph, with the true angular width of the associated CMEs, obtained from a forward fitting Graduated Cylindrical Shell (GCS) model. Our investigation showed a clear anti-correlation between the two quantities with a correlation coefficient of 74%, suggesting that the CMEs with large angular widths produce narrow-band Type II emissions, in stark contrast to the earlier report that they produce broad-band Type II emissions. We further deduced the height of the Type II bursts (R_{bursts}}) at the onset time of the burst and compared them with the estimated height of the associated CMEs/shocks (R_{CME}). For all of the Type II burst events, R_{bursts} was < R_{CME}, suggesting that the Type II emissions are produced in the flank region of the CME-driven shock rather than at the shock front, as reported by the earlier study. Our study provides some new insights to the importance of the quasi-perpendicular shock geometry that plays a crucial role for generating coronal Type II radio emissions.

Keywords: Solar Coronal Mass Ejections, Solar Radio Emission, Radio Bursts