Height of shock formation in the solar corona inferred from observations of type II radio bursts and coronal mass ejections

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Abstract

Employing coronagraphic and EUV observations close to the solar surface made by the Solar Terrestrial Relations Observatory (STEREO) mission, we determined the heliocentric distance of coronal mass ejections (CMEs) at the starting time of associated metric type II bursts. We used the wave diameter and leading edge methods and measured the CME heights for a set of 32 metric type II bursts from solar cycle 24. We minimized the projection effects by making the measurements from a view that is roughly orthogonal to the direction of the ejection. We also chose image frames close to the onset times of the type II bursts, so no extrapolation was necessary. We found that the CMEs were located in the heliocentric distance range from 1.20 to 1.93 solar radii (Rs), with mean and median values of 1.43 and 1.38 Rs, respectively. We conclusively find that the shock formation can occur at heights substantially below 1.5 Rs. In a few cases, the CME height at type II onset was close to 2 Rs. In these cases, the starting frequency of the type II bursts was very low, in the range 25–40 MHz, which confirms that the shock can also form at larger heights. The starting frequencies of metric type II bursts have a weak correlation with the measured CME/shock heights and are consistent with the rapid decline of density with height in the inner corona.

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1. Introduction

Type II solar radio bursts appear as slowly drifting features in radio dynamic spectra and are produced by electrons accelerated by MHD shocks (Nelson and Melrose, 1985). Although flare blast waves and CME-driven shocks have been considered as the source of type II bursts, recent observations indicate that all type II bursts may be due to CMEs (see Gopalswamy, 2011 and references therein for a discussion on this topic). The CME height at the time of type II burst onset indicates the time the CME becomes super-Alfvénic to drive a fast mode MHD shock. In other words, the CME height at the time of type II onset indicates where and when the corresponding shock forms in the corona. The height of shock formation is important

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