HEIGHT OF SHOCK FORMATION IN THE SOLAR CORONA INFERRED FROM OBSERVATIONS OF TYPE II RADIO BURSTS AND CORONAL MASS EJECTIONS

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The height of shock formation in the solar corona is an important parameter crucial for understanding the shock acceleration mechanism responsible for type II radio bursts and large solar energetic particle events. In a preliminary study of 10 type II radio bursts, which occurred in the declining phase of solar cycle 23, Gopalswamy et al. (2009) found that the height of shock formation is typically less than about 1.5 solar radii. This estimate was possible due to the availability of coronagraphic and EUV observations close to the solar surface that became available after the launch of the Solar Terrestrial Relations Observatory (STEREO) mission. The heliocentric distance of the coronal mass ejection (CME) at the starting time of the metric type II burst was taken as the height of shock formation. During the rise phase of solar cycle 24, nearly 80 metric type II radio bursts have been observed, which we analyze in this study to obtain statistically meaningful values of the CME height at the time of metric type II bursts. We identify the CMEs associated with the metric type II bursts and measure their heights at the time of metric type II burst using one or more of STEREO/COR1, STEREO/EUVI, and Solar Dynamics Observatory instruments. We minimize projection effects by making the measurements from a view that is roughly orthogonal to the direction of the ejection. Our study conclusively finds that the shock formation can occur at heights substantially below 1.5 solar radii. We discuss the implications of such low heights for the Alfvén speed profile commonly used in describing the ambient corona.