Evolution of the Alfvén Mach number associated with a coronal mass ejection shock

Ciara Maguire¹,², Eoin Carley¹,², Joseph McCauley¹, and Peter Gallagher¹,²
¹School of Physics, Trinity College Dublin, Dublin, Ireland (cmaguir4@tcd.ie)
²School of Cosmic Physics, Dublin Institute for Advanced Studies, Dublin, Ireland

The Sun regularly produces large-scale eruptive events, such as coronal mass ejections (CMEs) that can drive shock waves through the solar corona. Such shocks can result in electron acceleration and subsequent radio emission in the form of a type II radio burst. However, the early-phase evolution of shock properties and its relationship to type II burst evolution is still subject to investigation. Here we study the evolution of a CME-driven shock by comparing three commonly used methods of calculating the Alfvén Mach number (\(M_A\)), namely: shock geometry, a comparison of CME speed to a model of the coronal Alfvén speed, and the type II band-splitting method. We applied the three methods to the 2017 September 2 event, focusing on the shock wave observed in extreme ultraviolet (EUV) by the Solar Ultraviolet Imager (SUVI) on board GOES-16, in white-light by the Large Angle and Spectrometric Coronagraph (LASCO) on board SOHO, and the type II radio burst observed by the Irish Low Frequency Array (I-LOFAR). We show that the three different methods of estimating shock \(M_A\) yield consistent results and provide a means of relating shock property evolution to the type II emission duration. The type II radio emission emerged from near the nose of the CME when \(M_A\) was in the range 1.4-2.4 at a heliocentric distance of \(\sim 1.6 R_{\odot}\). The emission ceased when the CME nose reached \(\sim 2.4 R_{\odot}\), despite an increasing Alfvén Mach number (up to 4). We suggest the radio emission cessation is due to the lack of quasi-perpendicular geometry at this altitude, which inhibits efficient electron acceleration and subsequent radio emission.